Growth and Yield of Stevia (*Stevia rebaudiana*) under Shade and Liquid Organic Fertilizer of Banana Waste

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Abstract

Stevia rebaudiana is a plant that can produce a natural sweetener and is used as a natural medicine. This research aims to study the growth and production of stevia plants under shade and liquid organic fertilizer from banana waste using an automated drip irrigation system. This research used a randomized complete block design (RCBD) method with a nested pattern (Nested Design) consisting of two factors. Namely, the first factor was the influence of shade consisting of two levels, namely the use of 50% shade (F1) and no shade (F2). The second factor was a liquid organic fertilizer (LOF) consisting of four concentrations, namely: 0 ml L^{-1} (P1), 20 ml L^{-1} (P2), 40 ml L^{-1} (P3), and 60 ml L^{-1} (P4). Each treatment was repeated five times so that there were 40 experimental units. Each experimental unit consists of four plant samples, so the total plant samples were 160 plants. The results showed that providing shade significantly increasing plant height, stem diameter, number of leaves, number of flowers, and fresh weight of leaves. Meanwhile, giving LOF significantly increasing plant height, stem diameter, number of leaves, and number of flowers. Based on research results, the best treatment for stevia cultivation is 20 ml L^{-1} LOF fertilization in 50% shade.

Keywords: organic, stevia, sweetener.

Introduction

Cane sugar production in Indonesia dropped by 2,270 thousand tons. In 2022, production was 2,405.9 thousand tons, resulting in a 135.9 thousand ton difference in production value between 2022 and 2023 (1). In addition to cane sugar, several synthetic sweeteners, such as saccharin and sodium cyclamate, are widely used in Indonesia. These sweeteners have a much higher sweetness level than cane sugar. Due to health issues caused by various sweeteners, research has been carried out towards discovering safe, natural, low-calorie or no-calorie, and inexpensive sweeteners. Stevia has emerged as a natural sweetener with this potential (24).

Stevia rebaudiana is a plant that produces natural sweeteners and is used as a natural medicine. Stevia is a natural sweetener plant that can serve as a sugar substitute for individuals with diabetes. It is also suitable for carbohydrate diets due to its glycoside compounds, antioxidants, and anti-cancer properties. In Indonesia, stevia has been cultivated conventionally and developed as an artificial sweetener (16). In addition, this stevia plant contains glycoside stevioside, a compound that functions to replace sucrose due to its high sweetness level and low-calorie content (15).

The success of plant cultivation is intricately tied to the environment in which the agricultural commodity grows. Biophysical factors such as soil type and climate (light intensity, rainfall, humidity, and temperature) can either present opportunities or pose challenges in agricultural development, depending on the farmers' ability to manage and utilize these natural resources. Therefore, it is crucial to develop plant cultivation strategies that can adapt to various environments, from highlands to lowlands. One such environmental modification that can be made in the lowlands is the use of shade. Sunlight, a key component in the process of photosynthesis, also plays a significant role in plant growth and production. The intensity of light affects various plant processes, including photosynthesis, respiration, transpiration, protein synthesis, hormone production, translocation, and aging. The differences in the climate of origin of stevia plants necessitate different cultivation methods, especially in tropical areas with relatively high temperatures.

Stevia plant cultivation presents its own set of challenges. The high-water requirement of *Stevia rebaudiana* plants and the rarity of stevia cultivation in the lowlands due to high temperatures and low humidity are significant hurdles (16). As a result, shade is often used to cultivate stevia outside its optimal growing environment. These challenges underscore the need for further research and innovation in stevia cultivation.

Organic fertilizer is a material used to change the soil's physical, chemical, or biological properties to make it better for plants. Each plant requires at least 16 nutrients for average growth. However, the 13 elements are very limited in quantity in the soil, and sometimes, the soil does not contain these elements completely because these elements have been entirely absorbed by plants that are not continuously cultivated without being balanced with fertilization (16). In addition to the high cost of chemical fertilizers, long-term use can cause soil quality to decline. Decreased soil quality can cause plant cultivation to decline due to reduced nutrient adequacy in the soil. However, the chemical fertilizers can cause several small animals, such as worms, and several good microorganisms, such as *Bacillus, Nitrite, Aeromonas*, and *Aspergillus niger* bacteria found in the soil, to die due to disruption of oxygen exchange and unstable soil pH, causing the level of productivity not to be optimal (30). The purpose of this research was to study the growth and production of stevia under shade conditions and different concentrations of liquid organic fertilizer from banana waste.

Material and Methods

Place and Time

The research, conducted from March to July 2024, was a comprehensive study of significant scale. This research was conducted on Gunadarma University Technopark (UG-TechnoPark), located in Jamali Mulyasari Village, Mande District, Cianjur Regency, West Java, at an altitude of 392 meters above sea level. This study used a complete randomized block design method with a nested design consisting of two factors: Factor I is the provision of shade, consisting of two levels, namely 50% shade (F1) and no shade (F2). Factor II is a liquid organic fertilizer consisting of four concentrations, namely 0 ml L^{-1} (P1), 20 ml L^{-1} (P2), 40 ml L^{-1} (P3), and 60 ml L^{-1} (P4). Each treatment was repeated 5 times, so there were 40 experimental units. Each experimental unit consisted of 4 plant samples, so the total plant samples was 160.

Tools and Materials

The tools used in this study included measuring cups, Thermo-hygrometers, 35 x 35 cm polybags, 50% paranet, vernier calipers, dehydrator ovens, soxhlet, evaporators, digital scales, and refractometers. The materials used were *Stevia rebaudiana* seedlings, LOF from banana waste, stevia seedlings, eco enzyme, soil, dolomite lime, 96% alcohol, and distilled water.

Research Procedures

The media used in this study was soil applied to polybags measuring 35 x 35 cm. The stevia seedlings used were seedlings from the Naramos garden. The seedlings used were 42 days old after sowing (DAS). In this study, stevia seedlings were placed in a shady place to adapt to the new environment (12). The following week, the plants were transferred to the research site, where they were exposed to two conditions: 50% shade and no shade.

Fertilization is given at intervals once a week, with concentrations of 20 ml L^{-1}, 40 ml L^{-1}, and 60 ml L^{-1}. Banana waste LOF is shown at the age of 1 week after planting (WAP), after transplanting at intervals of once a week. Before applying, banana waste LOF is dissolved in 1 L of water at concentrations of 20 ml L^{-1}, 40 ml L^{-1}, and 60 ml L^{-1}. The time interval for administering banana waste LOF has a good effect on the growth of height, number of leaves, and weight per plant (22). Pest and disease control is performed mechanically, using eco enzyme plant pesticides with one ml L^{-1} dose. This eco enzyme can be used for intensive pest control. Maintenance includes pest and disease control (14).

Harvesting is carried out when the plants are 100 days old after sowing (DAS) by pruning the plants using pruning shears. The pruning height is 10 cm from the base of the main stem. After pruning, many new shoots will appear from the remaining stem. After that, 4-6 new shoots are left with an evenly spread growth direction. The following pruning is carried out after the new shoots reach a height of 20-25 cm at a pruning height of about 20 cm from the ground surface. The following pruning is harvesting, which is carried out routinely every 1.5-2 months, depending on the speed of the flowering plant (26). The leaves from the hulling process or leaves plus twigs are dried using a drying tool, such as an oven dehydrator, at a temperature of 400 °C for 4 hours. Then, the dried leaves will be extracted (5). Stevia extraction process using the soxhletation method (29).

Data Analysis

The data obtained were analyzed using the SAS System for Windows 9.0 program by conducting a normality test. Then, data processing was performed using Analysis of Variance (ANOVA) with a level of α = 5%. If the analysis results indicate a significant treatment effect (F > F table), further tests will be conducted using the Duncan Multiple Range Test (DMRT).

Results and Discussion

Based on the results of soil tests conducted at the Soil and Fertilizer Instrument Standards Center (BPSI Soil and Fertilizer), in this study, the soil media that was tested contained C 0.32%, N 0.04%, C/N 8%, P_2O_5 0.2 ppm, K_2O 52 ppm, and pH H_2O 5.1. In addition, the LOF of banana waste that has been tested in the laboratory of the Indonesian Center for Biodiversity and Biotechnology (ICBB) has a content of C-Organic 1.08%, N Total 3.20%, P_2O_5 Total 0.01%, K_2O Total 0.58%, and other micronutrients. The altitude of the place is directly related to the local climate, such as temperature, light intensity, and rainfall, which affect plant growth (Table 1).

Table 1. Microclimatology of the experimental land at UG-TechnoPark, Cianjur

Month	Temperature (°C)		Relative Humidity (%)		Light Intencity (FC)	
	F1	F2	F1	F2	F1	F2
April	25.8^{0}C	26.5^{0}C	81%	79%	14423 FC	31560 FC
May	26.9^{0}C	27.3^{0}C	79%	78%	22475 FC	40558 FC
June	28.7^{0}C	29.3^{0}C	76%	74%	36007 FC	67222 FC

Description: Daily observation results April-June 2024; F1: 50% shade; and F2: no shade

Plant Height (cm)

The results of the analysis of the F1 (50% shade) on the plant height variable from Week 1 (W1) – Week 5 (W5) showed a significant different response with an average plant height of 33.51 cm because the light intensity obtained on W1-W5 provided sufficient lighting for the growth of stevia plants, we can see in Table 1 showing a light intensity of 14423-22475 FC (footcandles) with a temperature of 25.8-26.9°C. Meanwhile, W6-W8 showed no significant different response to the plant height variable because the light intensity received by the plants was very high, so it could affect the growth of stevia plants. We can see this in Table 1, showing a light intensity of 22475-36007 FC with a temperature of 26.9-28.7^{0}C. In addition, the 50% shade treatment could not provide sufficient temperature and light intensity for the growth of stevia plants on M6-M8. The results of the analysis of the banana waste LOF treatment on the plant height variable in W1-W3 showed no significant response because these weeks are the transition phase of the plant from when it was transplanted, so it takes time for the plant to absorb nutrients.

These findings have the potential to significant influence for future agricultural practices, particularly in the cultivation of stevia plants. Meanwhile, W4 in the P2 (20 ml L^{-1}) showed a significantly different response to plant height with an average of 31.03 cm because the nutrients in this banana waste LOF have a total N content of 3.20%. Hence, the nutritional needs for plant height growth are sufficient. However, M5 in the banana waste LOF treatment showed no significant response because even though the N content in this banana waste LOF is high with a banana waste LOF concentration of 20 ml L^{-1}, it is not enough to meet the nutrient needs for plant height growth. However, in W6-W8 in the P4 (60 ml L^{-1}), banana waste LOF showed a significantly different response to the plant height variable with an average of 44.16 cm; this is by providing a concentration of 60 ml L^{-1} can provide optimal concentration for stevia plant height growth. The growth rate of plant height in the F1 treatment with 50% shade showed a plant growth rate of 2.79 cm week^{-1}, while the F2 (no shade) showed a plant growth rate of 2.78 cm week^{-1}. The growth rate of plant height in the P1 with the control treatment showed a plant growth rate of 2.41 cm week^{-1}, in the P2 with a concentration of 20 ml L^{-1} showed a plant growth rate of 2.87 cm week^{-1}, in the P3 with a concentration of 40 ml L^{-1} showed a plant growth rate of 2.69 cm week^{-1}, and in the P4 with a concentration of 60 ml L^{-1} showed a plant growth rate of 3.16 cm week^{-1}

Table 1. Stevia plant height (cm) under shade and various concentrations of banana waste LOF

Treatment	Plant age (week/weeks)								PGR
	1	2	3	4	5	6	7	8	(cm week^{-1})
Shade									
F1 (50% shade)	19.3a	23.1a	27.2a	30.9a	33.5a	35.6	38.2	41.6	2.79
F2 (No shade)	17.3b	20.1b	24.0b	28.7b	31.0b	34.2	36.4	39.5	2.78
LOF									
P1 (0 ml L^{-1})	18.5	21.5	21.5	29.7ab	32.5	35.3ab	37.0ab	37.8b	2.41
P2 (20 ml L^{-1})	18.4	22.1	22.1	31.0a	33.4	35.3ab	38.1ab	41.4ab	2.87
P3 (40 ml L^{-1})	17.5	20.9	20.9	27.78b	29.7	31.9b	34.6b	39.1ab	2.69
P4 (60 ml L^{-1})	18.8	21.9	21.9	30.78a	33.3	37.0a	39.5a	44.1a	3.16

Description: PGR: plant growth rate; and numbers followed by the same letter in the same column are not significantly different in the DMRT test at the 5% level.

Providing shade can reduce the intensity of light that directly hits the plant, reduce the temperature, and maintain air humidity. It can increase the growth of stevia plants by reducing the loss of nutrients through runoff and increasing the availability of groundwater used for nutrient translocation, one of which is nitrogen, which supports the vegetative growth of stevia plants (*Stevia rebaudiana*). If the plant receives too much or too little light, it will inhibit its growth and metabolism, so efforts are needed to adjust the plant's light requirements by providing shade (2).

Organic fertilization can increase the growth of stevia plants by providing micro and macro nutrients as a substitute for inorganic fertilizers. Organic fertilizer also considered better because it reduces environmental pollution (20). In addition, liquid organic fertilizers quickly overcome nutrient deficiencies and can provide nutrients quickly, where plants can directly absorb these nutrients. Liquid organic fertilizers generally do not damage the soil and plants, even if used regularly or as often as possible (9).

Stem Diameter

The results of the analysis of the shade treatment on the stem diameter variable in W1 showed no significant response because the intensity of 14423 FC was still not enough for the growth of the stem diameter of the stevia plant. Meanwhile, W2-W5 in the F1 (50% shade) showed a significant different response with an average of 3.32 mm because sufficient intensity can affect the stem diameter growth of the stevia plant. The light intensity in W2-W5 was 14423-22475 FC (Table 1), with a temperature of 25.8-26.9^{0}C. However, in W6-W8, the shade treatment showed no significant response to the stem diameter variable (Table 1). The light intensity and temperature in W6-W8 were very high at 36007 FC with a temperature of 28.7^{0}C, so providing 50% shade was still not enough to withstand the light intensity and temperature on the growth of the stevia plant. Analyzing the treatment of banana waste LOF on the stem diameter variable in W1-W8 showed a significant different response to the stem diameter variable because the high total N content in banana waste LOF could provide sufficient nutrients for stem diameter growth. We can see it in total N content in banana waste LOF of 3.20%. In W1-W2, the P3 (40 ml L^{-1}) gave a significantly different response with an average of 2.46 mm.

When it comes to the concentration of banana waste LOF, precision is key. In W3-W8, the P2 (20 ml L^{-1}) demonstrated a significantly different response to the stem diameter variable, with an average of 3.71 mm. This underscores the importance of providing banana waste LOF at the optimal concentration of 20 ml L^{-1} for the nutrient needs of stevia stem diameter growth. The growth rate of plant stem diameter in the F1 with 50% shade showed a plant growth rate with a diameter of 0.25 mm week^{-1}, while the F2 (no shade) showed a plant growth rate with a diameter of 0.24 mm week^{-1}. The growth rate of plant stem diameter in P1 with control treatment showed a plant growth rate with a diameter of 0.19 mm week^{-1}, in P2 (20 ml L^{-1}) showed a plant growth rate with a diameter of 0.27 mm week^{-1}, in treatment P3 with a concentration of 40 ml showed a plant growth rate with a diameter of 0.26 cm week^{-1}, and in treatment P4 with a concentration of 60 ml showed a plant growth rate with a diameter of 0.26 cm week^{-1}.

Table 3. Stevia stem diameter (mm) under shade and various concentrations of banana waste LOF

Treatment	Plant age (week/weeks)								PGR
	1	2	3	4	5	6	7	8	(mm week^{-1})
Shade									
F1 (50% Shade)	1.64	2.44a	2.83a	3.13a	3.32a	3.41	3.52	3.64	0.25
F2 (No Shade)	1.53	2.18b	2.56b	2.82b	3.03b	3.22	3.36	3.46	0.24
POC									
P1 (0 ml L^{-1})	1.48b	2.18b	2.45b	2.62b	2.76b	2.87b	2.94b	3.01b	0.19
P2 (20 ml L^{-1})	1.59ab	2.30ab	2.81a	3.07a	3.29a	3.46a	3.59a	3.72a	0.27
P3 (40 ml L^{-1})	1.70a	2.46a	2.86a	3.17a	3.36a	3.52a	3.66a	3.78a	0.26
P4 (60 ml L^{-1})	1.58ab	2.30ab	2.68ab	3.06a	3.29a	3.42a	3.57a	3.69a	0.26

Description: PGR: plant growth rate; and numbers followed by the same letter in the same column are not significantly different in the DMRT test at the 5% level.

Stevia, known for its preference for low temperatures in highland areas, has shown surprising adaptability in our study. We found that medium-land areas, typically not considered ideal for Stevia, have a positive effect on their growth. Furthermore, stevia plants can even thrive in high-temperature areas with lower humidity levels, as demonstrated in the 50% shade treatment (15).

The provision of liquid organic fertilizer quickly overcomes nutrient deficiencies and can provide N nutrients quickly, where plants can directly absorb these nutrients. Liquid organic fertilizers generally do not damage the soil and plants, even if used regularly or as often as possible. The growth of a plant can be shown, for example, in the growth of stem diameter. If more nutrients are absorbed, photosynthesis will run better and produce more photosynthate, which is more supportive of plant growth (9).

Number of Leaves

The results of the analysis of the shade treatment in W1 on the variable number of leaves showed no significant response because the intensity of 14423 FC was still not enough for the growth of the number of leaves of the stevia plant so that the photosynthesis process that occurred would be hampered. Meanwhile, in W2-W8, the F1 treatment (50% shade) showed a significant different response to the variable number of leaves, with an average of 142.90. High light intensity can provide good results so that it can facilitate the leaves to photosynthesize (Table 1). Thus, optimal light intensity can respond well to the number of leaves of stevia plants. Light has a significant influence on the growth of cultivated plants, primarily because of its role in the process of photosynthesis, opening and closing stomata, and chlorophyll synthesis. Thus, if the light intensity is optimal for plant growth, it can provide a good response for the plants (3). The results of the analysis of the P3 (40 ml L^{-1}) of banana waste LOF on the variable number of leaves in M1 showed a significantly different response with an average number of leaves of 46.20 leaves because the total N content in this LOF can provide good nutrition for the growth of the number of leaves.

In W2-W3, the banana waste LOF treatment did not show a significant response, as indicated in Table 3, due to the N content in banana waste LOF being 3.20%. This concentration was not optimal for the growth of the number of leaves of stevia plants. However, in W4-W8, the banana waste LOF treatment with a concentration of 20 ml L^{-1} showed a significantly different response to the number of leaves variable, with an average number of leaves of 136.90 strands. This is because the high total N content in this banana waste LOF, at 3.20%, when given at a concentration of 20 ml L^{-1}, provides optimal results for the growth of the number of leaves of stevia plants. The growth rate of the number of leaves of plants in the F1 with 50% shade shows a plant growth rate with several leaves of 12.31 leaves $week^{-1}$, while the F2 (no shade) showed a plant growth rate of 9.19 leaves $week^{-1}$. The growth rate of the number of plant leaves in the P1 treatment with the control treatment showed a plant growth rate of 7.14 strands $week^{-1}$, in the P2 with a concentration of 20 ml showed a plant growth rate with several leaves of 11.94 strands $week^{-1}$, in the P3 with a concentration of 40 ml showed a plant growth rate with a number of leaves of 12.09 strands $week^{-1}$, and in the P4 with a concentration of 60 ml showed a plant growth rate with a number of leaves of 11.84 strands $week^{-1}$.

Table 4. Number of stevia leaves (strands) under shade and various concentrations of banana waste LOF

Treatment	Plant age (week/weeks)								PGR
	1	2	3	4	5	6	7	8	(Strands $week^{-1}$)
Shade									
F1 (50% Shade)	44.4	69.8a	86.4a	106.9a	120.3a	130.6a	137.2a	142.9a	12.31
F2 (No Shade)	38.0	53.6b	68.8b	86.1b	96.3b	102.0b	107.7b	111.6b	9.19
POC									
P1 (0 ml L^{-1})	33.0b	58.0	69.0	78.2b	82.8b	85.7b	88.5b	90.1b	7.14
P2 (20 ml L^{-1})	41.4ab	61.4	76.4	97.7ab	113.0a	124.1a	131.1a	136.9a	11.94
P3 (40 ml L^{-1})	46.2a	67.1	86.6	108.3a	123.5a	129.7a	137.1a	142.9a	12.09
P4 (60 ml L^{-1})	44.40a	60.4	78.5	101.9a	114.0a	125.7a	133.1a	139.1a	11.84

Description: PGR: plant growth rate; and numbers followed by the same letter in the same column are not significantly different in the DMRT test at the 5% level.

The optimal plant photosynthesis process will increase the number of leaves in response to the light intensity received by the plant. The increase in the number of leaves is closely related to the rate of photosynthesis. Increasing the photosynthesis rate will use large amounts of carbohydrates (18). Carbohydrate compounds are essential for synthesizing proteins and other compounds to compose plant organs and plant life activities, thus allowing for more leaf synthesis (2). Macro and essential nutrients are very much needed by plants, including N, P, and K nutrients, which are needed by plants sufficiently and act as the main components in the formation of amino acids and nucleic acids, namely nitrogen nutrients. In addition, the growth of the number of leaves is greatly influenced by the availability of nutrients such as nitrogen and phosphorus (22). If more nutrients are absorbed, photosynthesis will run better, producing more photosynthesis, which better supports plant growth. Plant growth and yield will increase if photosynthate, including proteins and enzymes produced, are more because proteins and enzymes are raw materials for forming new cells that accelerate the growth of the number of leaves (28).

Number of Flowers

The results of the analysis of the shade treatment in M1-M4 on the variable number of flowers showed no significant response because, in these weeks, the generative growth was still not very visible. The generative phase of plant growth is a crucial period where the plant starts to produce flowers and fruits. In W5, the F1 (50% shade) showed a significantly different response to the variable number of flowers, with an average of 2.41 flowers, due to the generative phase of stevia plant growth already visible. We can see in Table 1 shows that with a light intensity of 22475 FC with a temperature of 26.9^{0}C it gives sufficient results for the growth of the number of flowers. However, in M6-M8, the shade treatment responded similarly to the variable number of flowers (Table 1). However, the light intensity is high in W6-W8, and the temperature and humidity in these weeks are inferior for the growth of the number of flowers. We can see that the temperature in W6-W8 is 360070C and that humidity is 76%. Thus, the provision of shade still needs to be optimal for the growth of the number of flowers. The results of the analysis of the treatment of banana waste LOF in W1-W2 on the variable number of flowers showed no significant response because the generative phase of stevia growth was still not very visible. In W3-W5, the P3 (40 ml L^{-1}) showed a significantly different response to the variable number of flowers, with an average of 2.49 flowers; this can be seen in the high N content, which can accelerate plant growth in the vegetative phase. However, in W6-W8, the shade treatment gave no significant response to the variable number of flowers. We can see that, in addition to the N element, which functions to accelerate growth in the vegetative phase, the P element also has a function for flower growth in plants. However, the P element in this banana waste LOF is low at 0.01%. Thus, the provision of banana waste LOF on W6-W8 still does not provide optimal results for the growth of the number of flowers.

Table 5. Number of stevia flowers (flowers) under shade and various concentrations of banana waste LOF

Treatment	Plant age (week/weeks)							
	1	2	3	4	5	6	7	8
Shade								
F1 (50% Shade)	0.16	1.24	1.86	2.25	2.41a	2.36	2.47	2.55
F2 (No Shade)	0.26	1.14	1.56	1.96	2.20b	2.27	2.38	2.47
POC								
P1 (0 ml L^{-1})	0.23	1.06	1.73ab	2.02	2.17b	2.26	2.34	2.42
P2 (20 ml L^{-1})	0.19	1.09	1.62ab	2.09	2.39ab	2.40	2.50	2.59
P3 (40 ml L^{-1})	0.31	1.44	2.01a	2.34	2.49a	2.45	2.59	2.67
P4 (60 ml L^{-1})	0.12	1.16	1.49b	1.98	2.18b	2.15	2.27	2.37

Description: numbers followed by the same letter in the same column are not significantly different in the DMRT test at the 5% level.

Stevia plants, when exposed to optimal sunlight intensity, demonstrate a remarkable increase in their growth rate (11). Conversely, plants subjected to lower light intensity, or a certain degree of shading show a limited potential for growth and reproduction (27). The nutrients present in LOF are a boon for plant growth and development. They not only enhance the greenness and freshness of plants, thanks to their high chlorophyll content, but also accelerate plant growth, increase plant protein content, and can be utilized across all types of plants, including food crops, horticulture, plantations, and even in livestock and fisheries businesses (8). However, banana waste LOF does have its drawbacks, one of which is its low nutrient content and its prolonged effect on plants (25).

Number of Seedlings, Shoot Fresh Weight, Leaf Fresh Weight, Shoot Dry Weight and Leaf Dry Weight

The analysis of the F2 (no shade) on the variable number of seedlings revealed a significant response, with an average of 1.0 seedlings. Table 1 illustrates that higher light intensity can yield favorable results for the number of seedlings without the need for shade. On the other hand, LOF did not show a significant response to the variable number of seedlings in banana waste. It's worth noting that the P element, in addition to its role in accelerating flowering, can also stimulate root growth. However, the low P content in banana waste LOF does not produce optimal results for the number of seedlings. While the high N content in banana waste LOF can influence root growth, stems and leaves also require N content, indicating that N alone cannot ensure the growth of seedlings.

The number of seedlings in the light-intensity treatment produced a significantly different number of seedlings. Differences in light-intensity treatment can affect the number of seedlings that grow on plants. Treatment without shade or 100% light intensity produced the most extensive shoots. The greater the light intensity the plant receives, the greater the number of shoots produced. In addition, the N nutrient contained in the banana waste LOF is absorbed more by plant height growth, stem diameter, and number of leaves (3). Thus, it is due to the difference in nutrient content that plants can utilize as material for photosynthesis.

On the other hand, the N element contained in liquid organic fertilizer can accelerate the photosynthesis process so that the formation of leaf organs is faster (19). The analysis of the shade treatment and banana waste LOF on the fresh weight of the shoot showed no significant response to the fresh weight of the shoot. Data showed that providing 50% shade and banana waste LOF has not been able to provide an optimal effect on the fresh weight of the shoot. Table 1 shows that the temperature, humidity, and light intensity in W6-W8 are insufficient for plant height and stem diameter growth, so they can affect the fresh weight of the shoot.

Table 6. Number of shoots (sprouts), shoot fresh weight (g), leaves fresh weight (g), shoot dry weight (g), and leaves dry weight under shade and various concentrations of banana waste LOF

Treatment	Number of shoots	shoot fresh weight	leaves fresh weight	shoot dry weight	leaves dry weight (g)

	(sprouts)	(g)	(g)	(g)	
Shade					
F1 (50% Shade)	0.80b	5.20	2.35a	1.44	0.68
F2 (No Shade)	1.00a	4.66	1.67b	1.69	0.60
POC					
P1 (0 ml L^{-1})	0,90	5.30	2.05	1.61	0.64
P2 (20 ml L^{-1})	0,84	5.47	2.23	1.78	0.69
P3 (40 ml L^{-1})	0,91	4.16	1.74	1.36	0.59
P4 (60 ml L^{-1})	0,95	4.80	2.02	1.51	0.65

Description: numbers followed by the same letter in the same column are not significantly different in the DMRT test at the 5% level

Fresh weight is greatly influenced by the intensity of sunlight on plants, where both forms assimilate a plant (4). In addition, plant weight is highly dependent on the adequacy of nutrients from root absorption and the additional supply of leaves through leaf stomata. Heavy plants indicate that they have many cells and are a place for photosynthate accumulation from photosynthesis. The availability of nutrients will increase plant growth vertically and laterally, affecting plant weight (11). The analysis of the F1 (50% shade) on the fresh leaf weight variable showed a significantly different response to the fresh leaf weight with an average of 2.35 g. We can see this in Table 1; the shade treatment provides optimal intensity, temperature, and humidity for stevia leaf biomass because providing shade can provide a better response than without providing shade. Meanwhile, the banana waste LOF showed no significantly different response to the fresh leaf weight variable. In addition, the fresh weight of stevia plant leaves can be influenced by nutrient absorption and photosynthesis accumulation in plants (6).

The analysis of the shade treatment and banana waste LOF on the dry weight variable showed no significant response to the dry weight variable. However, it's crucial to note that post-harvest handling plays a pivotal role in maintaining dry weight. Proper handling is essential to prevent the loss of water content in the fresh weight. For stevia plants, post-harvest handling during drying is particularly important until the water content reaches 10%, as any deviation can lead to a significant decrease in production yields by 75-80% (29).

Stevia Leaf Extract

The highest average initial and final extract mass values are the shade treatment and the administration of fertilizer concentration. At the initial extract mass of the shade treatment with a fertilizer concentration of 60 ml, it had a mass of 13.27 g, and at the final extract mass of the shade treatment with a fertilizer concentration of 40 ml, it had a mass of 47.16 g. However, in the yield calculation, the F2 (no shade) has a high yield value with an average of 3.46%. The F2 (no shade) differs very far from the final extract mass value and the initial extract mass value compared to the F1 (50% shade). Thus, to see the mass of extract in stevia leaves, the F1 (50% shade) gives the highest average value compared to the F2 (no shade). The light intensity, temperature, and humidity in the F1 (50% shade) give good results for the mass of stevia leaf extract, as shown in Table 1. The average value of the sugar content of plants shows that the F1 (50% shade) has a high sugar content with an average of 28.25^{0}Brix. The growth process of stevia plants, where the growth of the number of leaves in the F1 (50% shade) showed an excellent response to the number of leaves of the stevia plant with an average number of leaves of 142.90 compared to the F2 (no shade) with an average number of leaves of 111.69 leaves. Then, in the growth of flowers, the F1 treatment (50% shade) only affected W5 with an average number of flowers of 2.41 flowers, while the F2 (no shade) had an average number of flowers of 2.20. We can see in Table 1 that the F1 (50% shade) provided sufficient light intensity, temperature, and humidity for the growth of stevia, which was able to have a good effect on biomass in stevia plants. Thus, the plant environment affects the performance of plant metabolism, primarily influenced by environmental temperature. If the environmental temperature is too high, it will damage or even change the function of secondary metabolites. In this case, the total sugar content contained in stevia leaves (10). In addition, the plant environment, especially temperature, dramatically affects the total sugar content produced (17). Shading treatment affects the metabolism of stevia plants compared to stevia plants that are not shaded (13).

In addition, leaf growth is also influenced by the adequacy of plant nutrient content against the number of leaves. It can be seen in the P2 with a concentration of 20 ml L^{-1}, showing the number of leaves with an average of 136.90 strands. In the treatment of organic fertilizer has a high sugar content. Although stevia sugar tastes similar to sucrose, there are differences between the two. Drying is one of the stages of post-harvest processing of stevia leaves. The quality of the dried stevia leaves dramatically determines the result of stevia leaf processing in the form of stevia sweetener. Incorrect drying methods can cause a decrease in the levels of sweetener components in the leaves (7). The yield in the F1 (50% shade) with a control concentration (P1) of banana waste LOF had a value of 2.33%, a concentration of 20 ml L^{-1} (P2) of banana waste LOF had a value of 3.16%, a concentration of 40 ml L^{-1} (P3) of banana waste LOF had a value of 3.97% and a concentration of 60 ml L^{-1} (P4) of banana waste LOF had a value of 3.04% so that the yield value in the F1 treatment (50% shade) had an average of 3.13%. Meanwhile, the yield in the F2 (no shade) with a control concentration (P1) of banana waste LOF has a value of 2.94%, a concentration of 20 ml L^{-1} (P2) of banana waste LOF has a value of 3.31%, a concentration of 40 ml L^{-1} (P3) of banana waste LOF has a value of 3.64% and a concentration of 60 ml L^{-1} (P4) of banana waste LOF has a value of 3.96%, so that the yield value in the F2 (no shade) has an average of 3.46%. Thus, the highest value in the yield is the F2 (no shade), with an average yield value of 3.46%.

Table 7. Initial and final extract mass (g), yield (%), and sugar content (% Brix) in the provision of shade and various concentrations of banana waste LOF

Treatment	Extract mass (g)		Yield	Sugar content	Volume
	Before	After	(%)	(^{0}Brix)	(ml)

F1 (50% Shade)					
P1 (0 ml L^{-1})	11.25	26.26	2.33	24	25
P2 (20 ml L^{-1})	11.01	34.84	3.16	35	33
P3 (40 ml L^{-1})	11.86	47.16	3.97	25	48
P4 (60 ml L^{-1})	13.27	40.35	3.04	29	39.5
Average	11.85	40.78	3.13	28.25	36.38
F2 (no shade)					
P1 (0 ml L^{-1})	10.35	30.43	2.94	33	30
P2 (20 ml L^{-1})	11.51	38.2	3.31	26	38
P3 (40 ml L^{-1})	9.03	32.92	3.64	30	32
P4 (60 ml L^{-1})	9.29	36.8	3.96	21	36
Average	10.05	34.59	3.46	27.5	34

Description : Test results at the Basic Pharmacy Laboratory, Gunadarma University

The sugar content in the F1 (50% shade) with the control concentration (P1) of banana waste LOF has a sweetness of 24^0Brix with a volume of 25 ml. A concentration of 20 ml L^{-1} (P2) of banana waste LOF has a sweetness of 35^0Brix with a volume of 33 ml. A concentration of 40 ml L^{-1} (P3) of banana waste LOF has a sweetness of 25^0Brix with a volume of 48 ml. And a concentration of 60 ml L^{-1} (P4) of banana waste LOF has a sweetness of 29^0Brix with a volume of 39.5 ml. The sugar content value in the F1 (50% shade) has an average of 28.25^0Brix with a volume of 36.38 ml. Meanwhile, the sugar content in the F2 (no shade) with a control concentration (P1) of banana waste LOF has a sweetness of 33^0Brix with a volume of 30 ml. A concentration of 20 ml L^{-1} (P2) of banana waste LOF has a sweetness of 26^0Brix with a volume of 38 ml. A concentration of 40 ml L^{-1} (P3) of banana waste LOF has a sweetness of 30^0Brix with a volume of 32 ml. And a concentration of 60 ml L^{-1} (P4) of banana waste LOF has a sweetness of 21^0Brix with a volume of 36 ml. The sugar content value in the F2 (no shade) has an average of 27.5^0Brix with a volume of 34 ml. The F1 (50% shade) exhibits the highest sugar content, with an average sugar content value of 28.25^0Brix with a volume of 36.38 ml, indicating its potential for further research and application in the food industry.

Table 8. Result of Stevia leaf extraction

Treatment	Sugar content (^{0}Brix)	Criteria (Maks. 30)*
F1 (50% Shade)		
P1 (0 ml L^{-1})	24	Moderate
P2 (20 ml L^{-1})	35	High
P3 (40 ml L^{-1})	25	Moderate
P4 (60 ml L^{-1})	29	Moderate
Average	28.25	Moderate
F2 (no shade)		
P1 (0 ml L^{-1})	33	High
P2 (20 ml L^{-1})	26	Moderate
P3 (40 ml L^{-1})	30	High
P4 (60 ml L^{-1})	21	Moderate
Average	27.5	Moderate

Description: The laboratory analysis results at Basic Pharmacy Laboratory, Gunadarma University 2024, *based on SNI Glucose Syrup

Table 8 states that the F1 (50% shade) has a high average sugar content compared to the F2 (no shade). This is because the temperature, light intensity, and humidity in the F1 treatment are sufficient, so the rate of photosynthesis produced is excellent. It can also reduce plant transpiration, and the decrease in plant biomass is not too high. Transpiration events are usually associated with water loss through stomata, cuticles, and lenticels. Then, water is transpired by plants, and every kilogram of sucrose produces 1 kg of plant biomass, including leaves, stems, and roots. In addition, environmental factors can affect the opening and closing of stomata on the leaf surface, through which more than 90% of the water transpired and CO_2 passes (21).

In addition, stevia plants are C3 plants, a classification in plant physiology that refers to plants that use the Calvin cycle for carbon fixation. These plants require low temperatures, sufficient light intensity, and high humidity. Thus, this stevia plant can grow optimally with the use of shade so that the respiration and photosynthesis processes produced will be more optimal for growth and biomass yields in stevia plants, it is revealed that during the combustion and respiration process, electrons are released from carbon compounds and launched downwards, and then the electrons and H^+ combine with strong electron acceptors and O_2 to produce optimal H_2O. In this way, photosynthesis uses light energy to transport electrons upwards away from H_2O towards weaker electron acceptors (21).

Conclusion

The provision of 50% shade significantly increased plant height, stem diameter, number of leaves, flowers, and fresh leaf weight. Provision of banana waste LOF significantly increased plant height, stem diameter, number of leaves, and flowers. Based on the study's results, the recommendation for providing banana waste LOF for stevia is to use LOF treatment at P2 with a 20 ml L^{-1} concentration and F1 with 50% shade. This condition is because the provision of shade and banana waste LOF can provide an excellent response to the growth and biomass of stevia plants. On the other hand, the high N content can provide a good response so that a concentration of 20 ml L^{-1} can provide optimum concentration. These practical recommendations can inspire further research and application in the field of agricultural sciences and plant physiology.

Conflict of interest

The authors declare no conflict of interest.

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