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Utilization of Organic Fertilizer Compost Made from Purple Sweet Potato Waste (*Ipomoea Batatas* L.) to Increase the Production of Pakchoi *(Brassica Chinensis* L.)

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A B S T R A C T

Compost is an organic fertilizer made from recycled organic materials. Fertilizers can be made from organic waste or unused organic waste. Purple sweet potato waste can be reused into compost. The purpose of this study was to examine the effectiveness of purple sweet potato waste compost inoculated with *Trichoderma harzianum* in increasing the production of pakchoi and to determine the treatment of purple sweet potato waste compost to increase the production of pakchoi. The research method used is the experimental method. The experimental design used was RBD (Randomized Block Design) with 1 factor. The experiment consisted of 4 treatments of purple sweet potato compost 25 (B) g, 50 g (C), 75 g (D), 150 g (E), and 1 control (A), and was repeated 5 times. The data analysis technique used analysis of variance (ANOVA). Parameters observed were the number of leaves, plant height, leaf width, plant wet weight, plant dry weight, and root length. The results showed that the application of purple sweet potato compost affected increasing the growth and production of pakchoi. The best treatment in increasing the growth of pakchoi is treatment E. This treatment) can increase the number of leaves (13.13), plant height (16.32 cm), leaf width (4.88 cm), wet weight (16.60 g), dry weight (6.35 g), and root length (15.80 cm).

1. INTRODUCTION

1.1. Research Background

Pakchoi (*Brassica chinensis* L.) is one of the horticultural crops that support food in Indonesia. Pakchoi is used as a food ingredient because Pakchoi has many benefits and vitamins such as carbohydrates, protein, fat, vitamin A, vitamin B, vitamin C [1]. The many benefits that exist in Pakchoi make the high demand for Pakchoi production, so many farmers in Indonesia cultivate Pakchoi plants. This is evidenced by the increase in Pakchoi yields in Indonesia. Pakchoi production in Indonesia in 2017 reached 627,598 tons and in 2018 increased by 635,988 tons [2].

The problem of Indonesian farmers in growing Pakchoi is the lack of availability of nutrients in the soil. This happens because of the long-term use of inorganic fertilizers. Excessive use of inorganic fertilizers in the long term can cause the soil to become hard. This problem can be solved by replacing inorganic fertilizers with organic fertilizers. Organic fertilizers can improve soil fertility and improve soil physical properties. The use of organic fertilizers also produces products that are healthier for consumption because they do not contain chemicals.

Organic fertilizer that can be used as a substitute for inorganic fertilizer is compost. Compost comes from the weathering of organic materials such as leaves, straw, rotten vegetables, rotten fruits, and other organic wastes. An example of organic waste that can be used as a material for making compost is purple sweet potato waste. The addition of purple sweet potato waste can increase the nutrient content contained in compost fertilizer. Another benefit is to increase the selling value of purple sweet potato waste because it can be used as compost and reduce the potential for environmental pollution.

1.2. Literature Review

Composting uses microbes to decompose organic materials so that they are easily absorbed by plants. Organic fertilizers made from waste must use a bio activator so it does not make a bad smell [3]. Microbes can speed up the composting process because it helps the decomposition process [4]. Microbes commonly used in composting are Trichoderma sp. [5]. *Trichoderma harzianum* is a microbe that can be used as a bioactivator. *Trichoderma harzianum* can inhibit the growth of pathogens in plants so that it helps plant growth. Trichoderma acts as a biofungicide that suppresses or inhibits the growth of microbes that cause various plant diseases.

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1.3. Research Objective

This research aimed to examine the effectiveness of purple sweet potato waste compost inoculated with *Trichoderma harzianum* in increasing the production of pakchoi and to determine the treatment of purple sweet potato waste compost to increase the production of pakchoi.

2. MATERIALS AND METHODS

The research was conducted at the Green House Experimental Garden, Biology Study Program, Faculty of Mathematics and Natural Sciences, Udayana University, and Biopesticide Laboratory, Udayana University. The research was carried out from January 2021 to March 2021. The basic material used in this study was purple sweet potato waste produced by wine and purple sweet potato yogurt, Biopesticide Laboratory, Udayana University. The bioactivator used was obtained from *Trichoderma harzianum* isolate belonging to the Biopesticide Laboratory of Udayana University. This study used a 1-factor Randomized Block Design (RBD) with 4 treatments and 1 control. One treatment consisted of 3 units of plants test and was repeated five times, so the total units were 75 plants.

2.1. Rejuvenation and Propagation Trichoderma harzianum

Fungal rejuvenation was carried out by inoculation of 1 cork borer isolate of *Trichoderma harzianum* belonging to the Biopesticide Laboratory of Udayana University into a petri dish containing PDA media and incubated for 7 days at room temperature [6]. Re-identification was carried out to ensure that the fungus growing was *T. harzianum*. Propagation of T. *harzianum* using medium cooked rice as much as 2.5 kg. The media was sterilized in an autoclave at 121^{o}C for 15 minutes and allowed to stand for 3 hours. The next step is the inoculation of *T. harzianum* and incubated for 2 weeks [7].

2.2. Compost Fertilizer Making

Compost is made using the anaerobic method. Composting uses purple sweet potato waste consisting of 20 kg of sweet potato skin and pulp. The large purple sweet potato waste is cut into small pieces using a knife. Purple sweet potato waste that has been cut is mixed with 2.5 kg of compost starter mixture. The mixture of waste and compost starter is put into a composting hole measuring 1x1 m^2. The composting hole is tightly closed using plastic and Asbestos so that it is not exposed to rain. Compost is turned over every 7 days [8]. The composting process lasts for 30 days. Mature fertilizer is characterized by a color change to blackish brown, does not have a strong odor, and the texture is easy to crush.

2.3. Testing the Nutrient Content of Compost Fertilizer

Testing the nutrient content of purple sweet potato waste compost was carried out at the Analytical Laboratory of Udayana University. The nutrients in the tested fertilizers were Nitrogen (N), Phosphorus (P), Potassium (K), and C-organic. Nitrogen (N) content was analyzed using the Kjeldahl method, Phosphorus (P) using spectrophotometry, Potassium (K) using spectrophotometry, and C-Organic using the Walkey and Black method.

2.4. Planting

Pakchoi planting begins by preparing the seeds, the seeds are soaked in water for 6 hours. The sinking of the seed indicates that the seed is still viable and there is an embryo in the seed. Furthermore, the seeds are planted in a tray, a hole is made as deep as 0.5-1 cm, then Pakchoi seeds are spread in the tray and covered again with soil. Seedlings that are 14 days old and have appeared 4-5 leaves are transferred to polybags measuring 20x20 cm [9]. Polybags are filled with 1.5 kg of soil and mixed with compost according to the treatment that has been determined. The treatments tested were 1 control (A) and purple sweet potato waste compost: 25 g (B), 50 g (C), 75 g (D), and 150 g (E). Pakchoi is harvested when it is 30 days old, with the characteristics of growing large young leaves [9]. The pakchoi was removed directly from the soil and then the wet weight, dry weight, and root length were calculated.

2.5. Observation and Data Collection

Observations were made when the plants were 14 DAS (Days After Seedling) after the plants were transferred to polybags. Observations were made every 5 days for 30 days. 1) The number of leaves was observed by counting the number of leaves that had fully opened. 2) Plant height was calculated using a cm ruler. Plant height was calculated from the base of the stem to the tip of the highest leaf of the plant. 3) Leaf width is calculated using a cm ruler, the leaf width is calculated as leaves that have bloomed or opened. 4) wet weight was calculated after the plants were harvested, the plant weight was calculated using a gram scale and calculated without roots. 5) Observation of dry weight was carried out after harvest, plant weight was calculated using a scale in grams. Dry weight was calculated after the plants were dried in an oven at 85^{o}C for 48 hours. 6) Calculation of plant root length using a cm ruler by calculating the longest root length of the plant.

2.6. Data Analysis

The data obtained from this study is quantitative data, which is derived from measurements of the number of leaves, plant height, leaf width, wet weight, plant dry weight, and root length. Data analysis was performed using the ANOVA (Analysis of Variance) method.

3. RESULT AND DISCUSSION

3.1. Bacteria Purple Sweet Potato (Ipomoea batatas L.) Waste Compost Fertilizer

The purple sweet potato waste compost changes color from purple to blackish brown, the texture of the fertilizer is like soil, and smells like soil or does not smell bad. Purple sweet potato waste compost is shown in Picture 1.

The change in odor in mature compost is caused by the material contained in the fertilizer already containing soil nutrients. The color change in the fertilizer indicates that the organic matter in the fertilizer has stabilized. The texture of the fertilizer changes due to decomposition by the microbes used. If the final texture of the fertilizer is different from the initial texture of composting, then the fertilizer can be said to have good quality [10]. The composting process is strongly influenced by the

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decomposer microbes used during the composting process. During the composting process, *T. harzianum* can produce active compounds such as enzymes that can degrade cell walls and other secondary compounds. Trichoderma can degrade organic matter into nutrients that are easily absorbed by plants. *T. harzianum* decomposes organic matter enzymatically and produces materials with simpler compositions. Organic matter will be used for plant growth and as a source of energy during the decomposition process [11].

The results of the analysis of the nutrient content of N, K, and C-Organic purple sweet potato waste compost have met the standards of SNI 19-7030-2004. Meanwhile, the results of the analysis of the phosphorus content did not meet the standards of SNI 19-7030-2004. The results of the analysis of the nutrient content of fertilizers are presented in Table 1.

Table 1. Results of Analysis of Nutrient Content of Purple Sweet Potato Waste Compost Fertilizer

No	Parameter	Unit	Results	Quality Standard
1	Nitrogen (N)	%	0.66	0.40%
2	Phospfor (P)	mg/kg	58.467	0.10%
3	Potassium (K)	mg/kg	824.711	0.20 mg/kg
4	C-Organik	%	12.62	9.80%-12.62%

The results of the analysis showed that the nitrogen (N) content in compost was 0.66%, so the fertilizer had met the standards of SNI 19-7030-2004. Nitrogen plays an important role in the process of soil decomposition because nitrogen is a source of energy for soil microbes to decompose organic matter [12]. Nitrogen plays a role in plant photosynthesis because nitrogen is a constituent of protein and chlorophyll.

Phosphorus (P) contained in purple sweet potato waste compost is 58 mg/kg, when converted into percent the result is 0.0058%. This shows that the phosphorus content in the fertilizer does not meet the standards of SNI 19-7030-2004. Phosphorus deficiency is caused by the lack of microbes during composting, so that phosphorus is not utilized properly. This results in the reshuffling of organic matter do not run perfectly. The reshuffle of organic matter and the process of assimilation of phosphorus requires enzymes produced by microbes, namely phosphatase enzymes [13]. The addition of organic matter can increase the availability of phosphorus because it can help the mineralization process and the release of fixed phosphorus. Decomposition of organic matter can form chelation bonds with Al and Fe ions and can increase the P content because the solubility of Al and Fe ions decreases [14].

The results of the analysis of Potassium (K) of 824 mg/kg has met the standard of SNI 19-7030-2004. The function of potassium in plants is enzyme activation, regulating the use of water or stomata activation, the spread of sugar. Potassium also plays a role in the process of photosynthesis, protein synthesis, starch synthesis, and the distribution of nutrients and water [15].

C-Organic is an element that can determine soil fertility. The results of C-Organic analysis on purple sweet potato waste compost of 12.62% have met the quality standards of SNI 19-7030-2004. C-Organic is an element that affects soil fertility because it can affect the formation of soil structure and soil texture. C-Organic is important in the composting process and compost maturity because C-Organic is related to the decomposition process. Decomposing microbes need carbon as an energy source to build cells. Organic fertilizers can increase the C-Organic content in the soil because organic fertilizers contain nutrients such as N, P, K that plants need [16].

3.2. Number of Leaves

The results of ANOVA analysis showed that the application of purple sweet potato waste compost showed a significant difference ($P<0.05$). The average growth of the number of pakchoi leaves is presented in Table 2.

Table 2. Average Number of Leaves Pakcoi

Treatment	Number of Leaves					
	Days to (5, 10, 15, 20, 25, 30)					
	5	10	15	20	25	30
Control (A)	4.23 ± 0.22 a	5.00 ± 0.00 a	5.53 ± 0.13 a	6.00 ± 0.00 a	8.33 ± 0.23 a	9.60 + 0.68 a
25 g (B)	4.93 ± 0.27 b	5.66 ± 0.33 b	7.46 ± 0.38 b	8.13 ± 0.38 b	9.73 ± 0.49 b	12.20 + 1.06 b
50 g (C)	4.93 ± 0.27 b	5.53 ± 0.50 b	7.13 ± 0.60 b	7.73 ± 0.43 b	10.13 ± 0.38 b	12.46 + 1.06 b
75 g (D)	4.93 ± 0.27 b	5.60 ± 0.27 b	6.86 ± 0.76 b	7.80 ± 0.73 b	10.20 ± 0.38 b	12.60 + 1.01 b
150 g (E)	5.06 ± 0.39 b	5.73 ± 0.27 b	7.26 ± 0.27 b	7.86 ± 0.38 b	10.26 ± 0.59 b	13.13 + 1.06 b

Note: Numbers followed by different notations in the same column, show a significant difference based on the Duncan Multiple Range Test (DMRT) 5%.

The results of the DMRT test analysis of the average number of leaves showed that the treatment of purple sweet potato waste compost had an effect on the growth of the number of leaves compared to no treatment/control (A). The highest increase in the number of leaves in the last observation was the 150 g (E) fertilizer treatment worth 13.13. While in other treatments, the growth of the number of leaves was relatively the same, namely the treatment of 25 g (B) 12.20, 50 g (C) 12.60, and 75 g (D) 12.46. The lowest leaf growth was in the control treatment (A) of 9.60. The growth of the number of leaves is influenced by nutrients N, P, K. Nitrogen can make young leaves fully formed faster because nitrogen helps the process of cell division and cell enlargement [17].

3.3. Plant Height

The results of ANOVA analysis showed that the application of purple sweet potato waste compost showed a significant difference ($P<0.05$). The average growth of pakchoi plant height data from the research is shown in Table 3.

Table 3. Analysis of the Plant Height of Pakchoi

Treatment	Plant Height (cm) Days to (5, 10, 15, 20, 25, 30)					
	5	10	15	20	25	30
Control (A)	5.74 ± 0.29 a	6.46 ± 0.13 a	6.89 ± 0.10 a	7.59 ± 0.21 a	8.82 ± 0.20 a	10.66 + 0.11 a
25 g (B)	6.72 ± 0.24 b	8.02 ± 0.20 bc	8.72 ± 0.34 bc	11.32 ± 0.67 b	12.75 ± 1.09 b	14.50 + 1.19 b
50 g (C)	6.86 ± 0.28 b	8.02 ± 0.44 bc	8.40 ± 0.87 b	11.49 ± 0.75 b	13.05 ± 1.58 b	15.02 + 1.22 b
75 g (D)	6.64 ± 0.19 b	7.66 ± 0.32 b	8.38 ± 0.44 b	11.55 ± 0.48 b	12.75 ± 0.99 b	15.08 + 0.52 b
150 g (E)	6.76 ± 0.44 b	8.10 ± 0.32 c	9.19 ± 0.18 c	12.51 ± 0.65 c	13.96 ± 1.47 b	16.32 + 0.60 c

Note: Numbers followed by different notations in the same column, show a significant difference based on the Duncan Multiple Range Test (DMRT) 5%.

Based on the results of the DMRT test analysis, it can be concluded that the treatment of purple sweet potato waste compost has an effect on the average height of pakchoi plants compared to controls. Treatment of 150 g (E) showed the highest growth in the last observation (30 DAS) which was 16.32 cm. The growth of plant height in other treatments at 30 DAS was relatively the same, namely, 25 g (B) 14.50 cm, 50 g (C) 15.02 cm, and 75 g (D) 15.08 cm. While the control has the lowest height growth value of 10.66 cm. Nitrogen plays an important role in plant height growth because nitrogen can stimulate plant vegetative growth such as plant height growth. Organic matter in compost contains nitrogen which can activate plant cells and help the process of photosynthesis [18].

3.4. Leaf Width

Leaf width was calculated to see the growth of Pakchoi with purple sweet potato waste compost. The results of the analysis of the average leaf width of the pakchoi plant are shown in Table 4.

Table 4. The Average Width of Pakchoi Leaf

Treatment	Leaf Width (cm) Days to (5, 10, 15, 20, 25, 30)					
	5	10	15	20	25	30
Control (A)	1.37 + 0.27 a	1.60 + 0.02 a	1.87 + 0.08 a	2.42 + 0.16 a	2.83 + 0.13	3.42 + 0.98 a
25 g (B)	1.71 + 0.12 b	2.14 + 0.17 b	2.44 + 0.31 b	3.15 + 0.12 b	3.61 + 0.24	4.35 + 0.32 b
50 g (C)	1.80 + 0.14 b	2.10 + 0.13 b	2.40 + 0.08 b	3.09 + 0.24 b	3.58 + 0.23	4.55 + 0.29 b
75 g (D)	1.66 + 0.17 b	1.98 + 0.13 b	2.30 + 0.126 b	3.14 + 0.25 b	3.63 + 0.12	4.76 + 0.10 b
150 g (E)	1.67 + 0.15 b	2.09 + 0.12 b	2.46 + 0.07 b	3.40 + 0.06 c	3.95 + 0.25 c	4.88 + 0.26 c

Note: Numbers followed by different notations in the same column, show a significant difference based on the Duncan Multiple Range Test (DMRT) 5% test.

The results of the ANOVA test for purple sweet potato waste compost showed a significant difference ($P<0.05$). The results of the DMRT leaf width test analysis showed that the application of purple sweet potato waste compost could affect the growth of leaf width compared to the control. The average leaf width at the last observation (30 DAS), namely, treatment of 25 g (B) was 4.35 cm, 50 g (C) 4.55 cm, and 75 g (D) 4.76 cm. While the treatment of 150 g showed the highest growth yield of 4.88 cm and the control had the lowest value of 3.42 cm. The growth of leaf width indicates that the nutrients needed by the plant have been met. Plants need nitrogen to encourage plant organs that play a role in the photosynthesis process. The fulfillment of plant nitrogen needs can increase the chlorophyll content and make the leaf blade wider [19].

3.5. Wet Weight

The wet weight of the plant was calculated after the Pakchoi were harvested. The results of the analysis of the average wet weight of pakchoi plants can be seen in Table 5.

The results of the ANOVA test showed that there was a significant difference ($P<0.05$) in the application of purple sweet potato waste compost. Based on the results of the DMRT test analysis, the application of purple sweet potato waste compost affects increasing the wet weight. The appropriate treatment of compost in increasing the wet weight of plants is 150 g (E) worth 16.60 g. While the treatment of 25 g (B) is worth 15.20 g, treatment of 50 g (C) is 11.33 g, treatment of 75 g (D) is 14.20 g. The control treatment had the smallest wet weight value of 5.00 g. The number of leaves and leaf width can affect the wet weight

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of the plant because the leaves are the main organ of photosynthesis, so it can accelerate plant growth.

Table 5. Analysis of the Average Wet Weight of Pakchoi

Treatment	Wet Weight of the Plant
Control (A)	5.00 ± 0.40 a
25 g (B)	15.20 ± 1.50 cd
50 g (C)	11.33 ± 0.62 b
75 g (D)	14.20 ± 1.46 c
150 g (E)	16.60 ± 2.78 d

Note: Numbers followed by different notations in the same column, show a significant difference based on the Duncan Multiple Range Test (DMRT) 5%

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The addition of the wet weight of plants is influenced by the nutrients available in the soil. Fulfilling the needs of nutrients needed by plants can accelerate the photosynthesis process and produce a lot of photosynthates [20]. According to Ref. [21], wet weight can increase because plants contain protoplasm. Protoplasm in plants functions as a binder of water and CO_2. Protoplasm can bind water so that it can increase the wet weight of the plant.

3.6. Dry Weight

The next parameter is the dry weight of the plant, the dry weight is calculated after the plant is harvested and dried. The results of the analysis of the average dry weight of plants are shown in Table 6.

Table 6. Analysis of the Average Dry Weight of Pakchoi

Treatment	The Average Dry Weight of the Plant
Control (A)	1.31 ± 0.23 a
25 g (B)	5.45 ± 1.05 cd
50 g (C)	3.22 ± 0.58 b
75 g (D)	4.66 ± 0.97 c
150 g (E)	6.35 ± 0.85 d

Note: Numbers followed by different notations in the same column, show a significant difference based on the Duncan Multiple Range Test (DMRT) 5% test.

The results of the ANOVA test for purple sweet potato waste compost showed a significant difference ($P<0.05$). Based on the results of the DMRT test analysis, the application of purple sweet potato waste compost affects increasing dry weight. The 150 g (E) treatment had the highest plant dry weight value among other treatments, which was 6.35 g. Other treatments also affected the dry weight of the plant, treatment of 25 g (B) was 5.45 g, treatment 50 g (C) 3.22 g, treatment 75 g (D) 4.66 g. The control treatment (A) showed the lowest dry weight of 1.31 g. The dry weight of the plant determined the rate of plant growth and development. Plant dry weight describes the nutrient content of plants and organic compounds that have been successfully synthesized by plants [22]. The dry weight value also indicates the accumulation of inorganic compounds synthesized by plants such as CO_2 and water that are absorbed by the roots [21].

3.7. Root Length

ANOVA test results showed a real difference ($P<0.05$) to the provision of purple yam waste compost. Based on the results of the analysis of the provision of purple yam waste compost fertilizer has an effect in increasing the length of the roots. Root length growth between treatments of 25 g (B) 14.89 cm, 50 g (C) 14.88 cm, 75 g (D) 15.48 cm, and 150 g (E) 15.80 cm is relatively the same. The lowest average root length is without treatment (A) of 10.68 cm and the highest is a 150 g treatment worth 15.80 cm. The results of the analysis of the average root length are displayed in Table 7.

Table 7. Analysis of Average Length of Root

Treatment	The Average Root Length
Control (A)	10.68 ± 0.90 a
25 g (B)	14.89 ± 0.54 b
50 g (C)	14.88 ± 0.50 b
75 g (D)	15.48 ± 0.16 d
150 g (E)	15.80 ± 0.29 d

Note: Numbers followed by different notations in the same column, show a significant difference based on the Duncan Multiple Range Test (DMRT) 5%.

The use of *Trichoderma harzianum* in purple sweet potato waste compost can increase the number of roots in plants. *T. harzianum* can produce a good root system because it can colonize the root system so that it can increase root length [23]. Many root branches are formed because *T. harzianum* is associated with roots in the soil. Good root growth can affect plant growth. This is because roots function as nutrient absorbers which are very important for plant growth [24].

4. CONCLUSION

The use of purple sweet potato waste compost affects the growth and production of Pakchoi. The addition of purple sweet potato waste compost can increase plant height, several leaves, leaf width, wet weight, dry weight, and root length. The increase in plant height, number of leaves, leaf width, wet weight, dry weight, and root length indicated that the application of purple sweet potato waste compost could increase the production of Pakchoi. It is necessary to test the content of macronutrients and other micronutrients contained in purple sweet potato waste compost to find out more about the nutrient content. In addition, purple sweet potato waste compost needs to be tested on other plants to determine the effectiveness of compost fertilizer. Purple sweet potato waste compost needs to be added with other organic materials to increase the phosphorus content in the fertilizer so that it conforms to the SNI 19-7030-2004 standard.

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