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Research Article

Enhancement of Butternut Squash (*Cucurbita moschata*) Growth and Yield Through Sugarcane Waste and Banana Hump Extract Application

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Abstract

Background and Objective: The butternut squash (*Cucurbita moschata*) is one of the horticultural crops that has high economic potential. To increase its sustainability, organic fertilizers is needed, which is abundantly available and has not been optimized much, such as sugarcane waste and banana hump extract. Therefore, the research aims is to determine the growth response of butternut squash (*Cucurbita moschata*) with the application of sugarcane waste (blotong) and banana hump extract. **Materials and Methods:** This study was carried out in Pitumpidange Village, Libureng District, Bone Regency, South Sulawesi Province, from August to November, 2022. A two-factor factorial experiment was adopted with a randomized complete block design as the environmental design. The first factor was the dose of sugarcane waste and the second factor was the concentration of banana hump extract, both comprised of 4 levels. Observation parameters included tendril length, days to flowering, days to harvest, number of fruit per plot, fruit weight and yield. The data obtained were analyzed using analysis of variation and polynomial analysis. **Results:** There was no interaction between sugarcane waste treatment and banana hump extract in all observations of growth and production of butternut squash. Meanwhile, the treatment had a sharp linear graph with a maximum point of 30 tons ha⁻¹. The 100 mL L⁻¹ banana hump extract treatment indicated a quadratic dominant curve response as the optimal concentration point. **Conclusion:** Therefore, both 100 mL L⁻¹ banana hump extract and 30 tons ha⁻¹ doses of sugarcane waste were recommended as part of butternut squash planting package.

Key words: Banana hump extract, butternut squash, organic fertilizer, sugarcane blotong, polynomial regression, sugarcane waste, sustainable farming

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Butternut squash (*Cucurbita moschata*) is a relatively new horticultural crop commodity¹. In Indonesia, the term butternut squash is not widely known because people are more familiar with pumpkin. The physical shape of this commodity resembles a tuber with a soft flesh texture and distinctive taste^{1,2}. Furthermore, the sugar content increases with the length of storage time (maximum storage of six months). Butternut squash is included in the climacteric category, where ethylene levels and respiration activity increase during the ripening phase³.

Butternut squash has a soft flesh texture with a distinctive taste and contains fiber, beta-carotene, carotenoids, phenolic acid, flavonoids, minerals and vitamins, carotenoids and polyphenols^{4,5}. The plant has high amounts of carbohydrates, antioxidants, fiber, minerals and vitamins, which can fight free radicals and increase the resistance of the body. Therefore, development is needed to increase the potential and quality of supporting the economic value of the fruit.

Planting of butternut squash is relatively minimal and focuses on using chemical fertilization¹. The relatively large use of chemical inputs is a challenge in determining how to reduce these inputs^{1,6}. Continuous input of chemicals can damage soil fertility levels and physical properties^{7,8}. In addition, excess fertilizer can be toxic to plants and indirectly affect fruit quality^{9,10}. The use of organic fertilizer is a good alternative to increase the production and quality of butternut squash.

The use of organic fertilizer has different benefits, specifically in increasing soil fertility levels, aggregates and microorganism content. Increasing soil physical properties improves the strength, water retention, aeration and drainage^{6-8,11}. In addition, optimal application can reduce the input of inorganic fertilizer use to reduce production costs and provide benefits for farmers^{6,8}. The application and research of organic fertilizer on butternut squash should be conducted and some components used are sugarcane waste (blotong) and banana hump extract.

Sugarcane waste is an abundant by-product of sugar factories and its availability can be used as organic fertilizer^{12,13}. This is an effort to use industrial waste towards zero¹² and sugarcane wastes many nutrients, contains, such as carbon, nitrogen, phosphate, calcium, potassium, iron, manganese and magnesium^{13,14}. The use of sugarcane waste on butternut squash has been reported by Dlamini *et al.*¹⁵ and banana weevil is also an organic material underused by many people. Farmers leave banana weevils during the harvest

process as a source of organic fertilizer to support growth¹⁶. The weevil extract contains cytokinins and gibberellins, which can be used as growth regulators and many plant nutrient contents¹⁷. The weevil is a good source of microorganisms for its growth⁴ and liquid organic fertilizer^{18,19}. Therefore, this research aims to determine the best combination of sugarcane waste fertilizer and banana weevil liquid to support the growth and production of butternut squash.

MATERIALS AND METHODS

Experimental design: This research was carried out in Pitumpidange Village, Sibureng District, Bone Regency, on former rice field from August to November, 2022. The location was at an altitude of 115 m above sea level and was carried out in the form of a two-factor factorial experiment with a Randomized Complete Block Design (RCBD) as the environmental design. The first factor was the application of sugarcane waste, which consisted of 4 levels, namely without sugarcane cake (S0), a dose of 10 tons ha⁻¹ (S1), a dose of 20 tons ha⁻¹ (S2) and a dose of 30 tons ha⁻¹ (S3). The 2nd factor was administering banana hump extract, consisting of 4 levels, namely without banana hump extract (B0), concentration 100 mL L⁻¹ (B1), concentration 200 mL L⁻¹ (B2) and concentration 300 mL L⁻¹ (B3). From these 2 factors, 16 treatment combinations were obtained and each was repeated three times to yield 48 experimental plots. Furthermore, each plot consisted of 4 plant samples to produce 192 plant samples.

The study was set using a factorial design with a randomized complete block design as an environmental design. The first factor was the application of OPEFB compost consisting of 3 levels, namely: Control (C0), OPEFB compost 10 tons ha⁻¹ (C1) and 20 tons ha⁻¹ (C2). The 2nd factor was the combination of *Trichoderma harzianum* + *Pleurotus ostreatus* (Tri-Po) consisting of 4 levels namely, Tri-Po with a dose of 4+2 g/tree (P1), 4+4 g/tree (P2), 4+6 g/tree (P3) and 4+8 g/tree (P4), respectively. The treatment was repeated 3 times so that there were 36 experimental units. Each experimental unit has a plot size of 4 × 3 m.

Research procedure: The research preparation started with tilling the land using a hand tractor. The land area used was 17 × 8 m and each experimental plot had an area of 1 m⁻² with a distance of 50 cm. After the plot is formed, the soil is loosened and smoothed to provide good growing space for plants to develop. Subsequently, seed preparation is carried out using the F1 butternut squash variety and sowing is

conducted in a seedling house measuring 2 × 1.5 m. The planting medium used is a combination of soil and manure in a ratio of 2:1. Sowing is performed for 21 days until butternut squash seedlings have institutional leaves and reach a height of 5-7 cm. Meanwhile, planting is carried out with a spacing between plants of 50×50 cm in the afternoon.

Caring for butternut squash consists of several activities, namely watering, weeding, installing stakes, fertilizing, pruning, pollinating and controlling pests and diseases. Watering is carried out twice a day in the morning and evening during the vegetative phase. Meanwhile, it is only conducted once in the morning during the generative phase. Weeding is performed manually, scheduled 2 weeks after planting (WAP) and carried out regularly. Installation of stakes is also performed 1 WAP, using bamboo 150 cm high. Fertilization is divided into three types of inorganic chemical fertilizer, namely general, solid sugarcane waste and liquid fertilizer derived from banana hump extract. The 2 treatments are explained further in the subsections below, while the inorganic chemical uses Grand-K fertilizer at a rate of 3 g/hole or 120 kg ha⁻¹. The addition of Grand-K inorganic fertilizer with potassium content is half the recommended dose to provide sufficient nutrient availability for the plant. In addition, pruning focuses on water shoots to maintain and optimize the growth of stems and primary branches. Pollination is carried out when fruit ovaries appear and are accompanied by female flowers. The male flowers are taken and pollinated to produce good fruit and the process is conducted in the morning from 08:00-10:00 WITA. Pest control is also achieved by sanitizing the land and using the insecticide Regen 50 sec to combat mealybugs, whiteflies, oteng-oteng, ants and ladybugs as the main pests on butternut squash. Harvesting is performed 60-70 days after planting (DAP) with the characteristics of shiny brown fruit stalks and shiny fruit skin color.

Sugarcane waste fertilizer: Sugarcane waste was taken from the milling process waste disposal site at the Camming Sugar Factory, Libureng District, Bone Regency, South Sulawesi.

This waste taken on this area was 72 kg. Sugarcane waste possesses a smooth texture, exhibits a deep black hue, has undergone extended aging and maintains a dry consistency. The application is carried out a week before planting by sowing in experimental plots according to the treatment.

Banana hump extract fertilizer: Making banana hump extract solution was conducted by chopping 10 kg of banana weevil. The bananas were taken in Cina Subdistrict, Bone Regency, South Sulawesi as the 2nd highest production of banana. Every kilogram of chopped banana weevil was put in a 10 L bucket with 1 L of air and the process was carried out until the container was full. Subsequently, EM4 decomposer was added for the fermentation process for 14 days and banana hump extract was ready to be filtered before being sprinkled around the plant. Application of the extract was conducted in the afternoon according to the treatment concentration.

Data observation and statistical analysis: Observation parameters included tendril length, days to flowering, days to harvest, number of fruit per plot, fruit weight and yield. The data obtained were analyzed using analysis of variation with an error rate of 5% and significant characters were tested using a polynomial analysis approach.

RESULTS

The variance results can be seen in Table 1 and the characteristics of tendril length, fruit weight and yield are influenced by two treatments, namely sugarcane waste fertilizer and banana hump extract. The characteristics of flowering days and the number of fruits per plot were only influenced by sugarcane waste (SW) treatment. Meanwhile, the character of the day before harvesting was affected by the treatment of banana hump extract (BHE). The interaction between the two treatments showed no significant influence on the observed growth characteristics.

Based on Fig. 1, tendril length is influenced by treatments (BHE and SW) independently, or the interaction of the two

Table 1: Analysis of variance from several butternut squash growth

Characteristics	S	B	S×B	Error	CV (%)
Tendril length	16.83**	2.04**	1.98	1.23	14
Days to flowering	16.83**	2.04	1.98	1.23	17
Days to harvesting	3.00	188.70**	13.00	8.7	36
Number of fruits per plot	3.30**	0.60	0.30	0.20	22
Fruit weight	69210.60**	40934.10**	1116030	5532.00	14
Yield	207.3*	175.90**	28.00	17.60	23

S: Sugarcane waste, B: Banana hump extract, CV: Coefficient of variance and **Significant effect at 1% level error

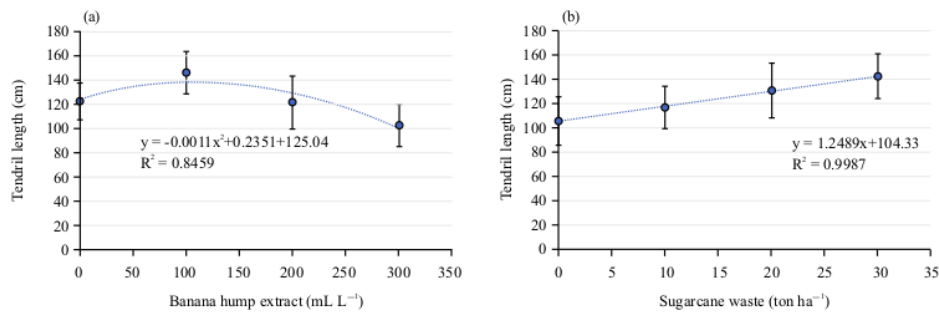


Fig. 1(a-b): Graph of the effect of (a) Banana hump extract and (b) Sugarcane waste to tendril length

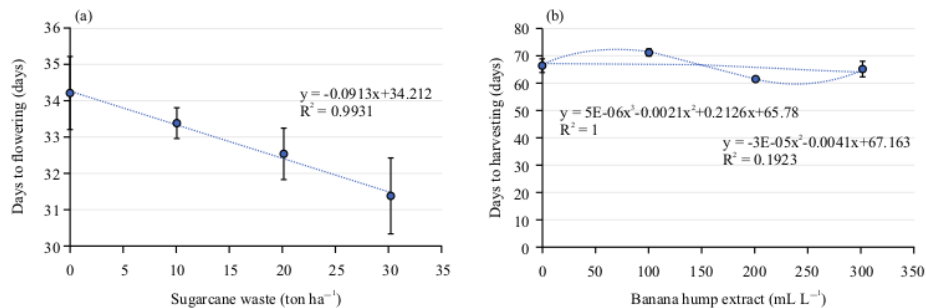


Fig. 2(a-b): Graph of the effect of giving banana weevil (a) Extract on the day of flowering and (b) Bagasse on the day before harvest

does not have a significant effect. These show curves with high determination values (0.8459 for BHE and 0.9987 for SW), but both have different curve responses. Banana hump extract treatment reported a quadratic pattern towards tendril length with an optimal concentration of 100 mL L⁻¹ (Fig. 1a). Meanwhile, sugarcane waste processing indicated a linear pattern regarding tendril length with a maximum dose of 30 tons ha⁻¹ (Fig. 1b).

The characteristics of days to flowering were only influenced by sugarcane waste processing (Fig. 2a). This was different from the character of the day before harvest which was only influenced by banana hump extract (Fig. 2b). The SW treatment showed a decreasing linear curve with a determination value reaching 0.993 and the lowest point in days to flowering was at SW dose of 30 tons ha⁻¹. Meanwhile, the days to harvesting the BHE curve reported a cubic curve, reaching an absolute determined value of 1. This curve had one main peak and valley, namely 100 and 200 mL L⁻¹, respectively.

The character of the number of fruits also indicated a single influence from sugarcane waste (Fig. 3). This character

had an upward linear graph with a determination value reaching 0.781. The maximum dose related to the number of fruits and butternut squash was 30 tons ha⁻¹.

Based on Fig. 4, fruit weight was influenced by the two treatments with interaction effects. The treatments showed curves with quite high determination values (0.6459 for BHE and 0.96 for SW) and a quadratic curve. Banana hump extract treatment indicated a quadratic pattern of reduction in fruit weight with an optimal concentration of 100 mL L⁻¹ (Fig. 4a). Meanwhile, sugarcane waste processing reported an upward quadratic pattern with the dose trough and highest points at 30 tons ha⁻¹ (Fig. 4b). The SW dose curve also continued to increase as the compost dose increased.

Yield characteristics were also influenced by the 2 treatments, such as fruit weight and tendril length (Fig. 5). The BHE and SW treatments had curves with high determination values, namely 0.90 and 0.91, respectively. However, the two curves showed different response curves and banana hump extract treatment indicated a quadratic pattern with an optimal concentration of 100 mL L⁻¹ (Fig. 5a).

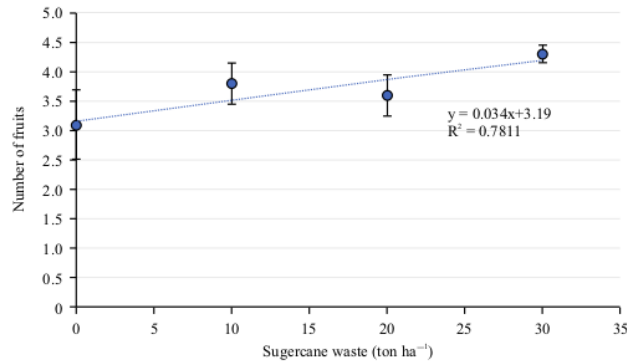


Fig. 3: Graph of the effect of sugarcane waste on the number of fruits per plot

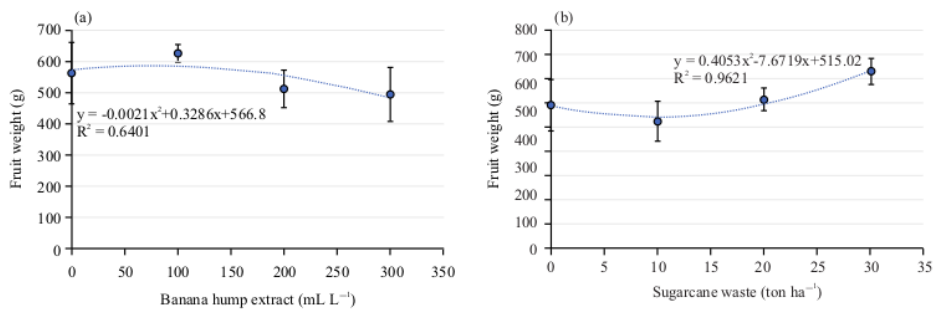


Fig. 4(a-b): Graph of the effect of (a) Banana weevil extract and (b) Sugarcane bagasse on fruit weight

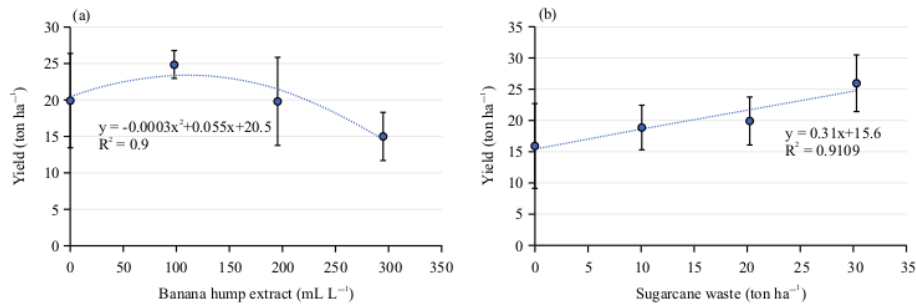


Fig. 5(a-b): Graph of the effect of (a) Banana weevil extract and (b) Sugarcane bagasse on results

Sugarcane waste processing showed an upward linear pattern in yield with a maximum dose of 30 tons ha⁻¹ (Fig. 5b).

DISCUSSION

The ANOVA results showed that there was a single effect of BHE and SW treatments on all components of the

observed butternut squash yield. For some characters, the 2 treatments did not have a significant effect at the same time. These 2 treatments played an important and complementary role in supporting the development and growth of butternut squash yield components. Therefore, there was no difference in response changes between increasing BHE and SW. Additive changes showed that determining the optimal point

for each treatment was easier to predict and be used as a consistent reference in its application²⁰. Further analysis should become a reference in planting butternut squash, specifically with the concept of sustainable agriculture.

Based on polynomial tests, sugarcane waste has a relatively linear graph regarding the characteristics of the components produced. The results show that a good dose of sugarcane waste is 30 tons ha⁻¹ and are supported by Budiyanto²¹ and Tyasmoro and Saitama²² on corn and pak choy. Sugarcane waste has the same potential as other organic fertilizers for improving soil properties. The provisions have a big influence on improving the physical properties of the soil by applying other solid organic fertilizers^{13,23}. However, sugarcane waste fertilizer has good nutritional and sucrose potential in breeding colonies of microorganisms^{24,26}. This further supports plant growth and development, hence, the fertilizer dose has a linear graphic response with a high gradient. The sharp linear graph also shows that the dose can be increased beyond the maximum dose. A similar result was stated by Yassi *et al.*²⁷ regarding the sharp graphic patterns of compost treatment on rice growth. The dose still needs to be studied and considered more deeply regarding several other aspects, such as the availability of raw materials and costs in the implementation process. The addition of fertilizer is less effective than giving the doses periodically and consistently. Therefore, the recommended dose of 30 tons ha⁻¹ can be an initial reference in optimizing the growth and development of butternut squash.

Based on the polynomial tests, most of the responses to the influence of BHE had a quadratic curve with an optimal point at 100 mL L⁻¹. The curve with the optimal point shows that giving a concentration exceeding the optimal concentration will be increasingly ineffective^{16,28,29}. The provision of liquid organic fertilizer has certain limitations and this is based on the concentration of microorganisms, hormones and nutrients within the fertilizer formulation. The supply of liquid fertilizer becomes stagnant and even reduces productivity when the optimal limit is exceeded. Therefore, BHE administration must be based on the optimum point, namely 100 mL L⁻¹ in this research.

The combination of sugarcane waste dosage of 30 tons ha⁻¹ and BHE concentration of 100 mL L⁻¹ is the optimal point in supporting the growth and production of butternut squash. Even though significant positive interactions are not provided, the application optimizes the potential for the growth and production of butternut squash. The combination of these two treatments can be used as an

additional recommendation and research regarding the quality of butternut squash such as Brix and others also needs to be carried out in the future. This complements the potential benefits of combining the two treatments^{1,30}. Further exploration of the potential inherent in this combination is essential to ensure ongoing development. This leads to continual optimization, enhancing its capacity to support the production of butternut squash over time.

CONCLUSION

There was no interaction between sugarcane waste treatment and banana hump extract in the observations of the growth and production of butternut squash. Furthermore, the treatment had a sharp linear graph on the growth of butternut squash with a maximum point of 30 tons ha⁻¹ sugarcane waste. The 100 mL L⁻¹ banana hump extract treatment also indicated a dominant quadratic response and the combinations were recommended as part of the butternut squash planting package.

SIGNIFICANCE STATEMENT

Based on the study results, there was no interaction between sugarcane waste treatment and banana hump extract in all observations of growth and production of butternut squash. Meanwhile, the treatment had a sharp linear graph with a maximum point of 30 tons ha⁻¹ sugarcane waste. The 100 mL L⁻¹ banana hump extract treatment indicated a quadratic dominant curve response as the optimal concentration point. Therefore, both 100 mL L⁻¹ banana hump extract and 30 tons ha⁻¹ doses of sugarcane waste were recommended as part of butternut squash planting package.

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