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Sugar and Fiber Content in Sorghum Seeds (*Sorghum bicolor* (L.) Moench) From the Application of Rice Husk Biochar and Liquid Cow Urine Organic Fertilizer

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Abstract: Sorghum (*Sorghum bicolor* (L.) Moench) is a resilient cereal crop with high potential as a source of food, feed, and bioenergy. This study investigates the effect of applying rice husk biochar and liquid organic fertilizer (POC) from cow urine on the sugar and fiber content of sorghum seeds. The experiment was conducted in two phases: field trials using a randomized block design with nine treatment combinations (3 biochar doses × 3 POC doses) and laboratory analysis of sugar and fiber contents. Results show that the application of 4 t/ha biochar and 750 ml/L cow urine POC produced the highest yield in terms of seed weight per plot (0.36 t/ha) and total production. However, the highest sugar content (63.32%) was obtained in the control biochar treatment with 250 ml/L POC, suggesting that lower POC doses are more effective in enhancing sugar concentration. Fiber content showed no statistically significant differences among treatments, although a tendency for increased fiber was observed at moderate POC doses. These findings highlight the potential of using rice husk biochar and cow urine POC to improve sorghum productivity and nutritional quality while supporting sustainable and organic agricultural practices.

Keywords: Biochar; Cow Urine POC; Sorghum Seeds

Introduction

The development of agricultural practices focused on food crops has made significant progress with the aim of achieving regional food self-sufficiency. Authorities have implemented several key strategies, including intensification, extensification, diversification, and rehabilitation, with a balanced and equitable approach to promote sustainable agricultural systems (Mukhlis *et al.*, 2015; Mukhlis *et al.*, 2024).

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the cereal crops with great potential as a source of food and animal feed, as well as a raw material for bioenergy. This plant has a high content of carbohydrates, fiber, and protein, making it an important alternative in global food security, especially in areas affected by climate change and drought (Semida *et al.*, 2019; Shoudho *et al.*, 2024). Sorghum can grow well in less fertile soil and with minimal water, making it a plant resistant to abiotic stress (Galyuon et al, 2011; Gidi, 2023). However, the improvement in the quality of sorghum seeds, particularly in terms of sugar and fiber content, highly depends on proper soil management and fertilization.

One of the approaches that is gaining increasing attention in improving soil quality and agricultural yields is the use of biochar and liquid organic fertilizers. biochar, which is produced from the combustion of

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biomass at high temperatures in low-oxygen conditions, has been proven to improve soil quality by increasing cation exchange capacity (CEC), enhancing soil structure, and increasing water retention and nutrient availability (Islami, 2019; Lehmann and Joseph, 2024). The application of biochar can also play a role in reducing greenhouse gas emissions by sequestering carbon in the soil (Ernsting and Smolker, 2009; Woolf *et al.*, 2010; Ayaz *et al.*, 2021; Xu *et al.*, 2023). On the other hand, liquid organic fertilizers made from cow urine are rich in nutrients such as nitrogen, phosphorus, and potassium, all of which are important for supporting plant growth and the quality of agricultural yields (Pangaribuan et al, 2017; Khan *et al.*, 2024). The use of this liquid organic fertilizer not only enhances soil fertility but also provides additional benefits such as increased sugar and fiber content in plants (Hossain et al., 2020).

Previous studies have shown that the combination of biochar and liquid organic fertilizer can have a positive impact on plant quality. For example, research by Premalatha *et al* (2023); Manimekala *et al* (2024) showed that the application of biochar can increase the sugar content and protein levels in corn plants. Similarly, liquid organic fertilizers have been proven to increase the fiber content and quality of rice plants (Siavoshi *et al.*, 2011; Shah and Shah, 2018; Hartati et al, 2019). However, research examining the effects of the combination of rice husk biochar and liquid organic fertilizer from cow urine on the sugar and fiber content in sorghum seeds is still limited. Therefore, this study aims to determine the effects of applying rice husk biochar and liquid organic fertilizer from cow urine on the sugar and fiber content in sorghum seeds, as well as to understand the interaction between these two treatments in improving the quality of sorghum seeds.

Sustainable agricultural systems are farming practices that do not harm the environment, but instead work in harmony and equilibrium with it. These systems can be executed through four approaches: 1) organic farming, 2) integrated farming, 3) low input farming, and 4) integrated pest management (Salikin, 2011; Rasyid *et al.*, 2024). According to Mukhlis *et al* (2023) the integrated farming model between maize and cattle has the potential to be implemented and scaled up as farmers can earn much more than the prevailing bank interest rates.

The results of this study are expected to provide useful information to improve the quality of sorghum products as more nutritious and environmentally friendly food, as well as to provide a scientific basis for sustainable agricultural practices based on the use of local organic materials.

Method

Time and Place of Research

This research was conducted in two stages. The first stage was field research conducted in Sidera Village, Biromaru District, Sigi Regency, Central Sulawesi Province. The second stage was conducted at the Animal Husbandry Laboratory, Faculty of Animal Husbandry and Fisheries, Tadulako University, to analyze the sugar and fiber content of sorghum seeds. The research was conducted from March to July 2024.

Equipment and Materials

Equipment: shovel, analytical balance, sprayer, dryer, oven, spectrophotometer, desiccator, hotplate, extraction flask

Materials: Super I sorghum seeds, rice husk biochar, cow urine POC, for laboratory analysis: distilled water, sulfuric acid, sodium hydroxide, acetone

Research Method

This study used a Randomized Block Design (RBD) with a factorial pattern consisting of two factors:

Factor I (Rice Husk Biochar):
- B0 = Without biochar
- B1 = 2 tons/ha
- B2 = 4 tons/ha

Factor II (Cow Urine POC):
- U1 = 250 ml/L water
- U2 = 500 ml/L water
- U3 = 750 ml/L water

The combination of the two factors resulted in 9 treatments, each repeated 3 times, yielding a total of 27 experimental units.

Research Stages

Land and Material Preparation: includes land preparation, creation of experimental plots, and preparation of biochar and cow urine POC.

Planting: sorghum seeds are planted directly in the field in each experimental plot.

Crop Maintenance: including irrigation, weeding, and application of treatments according to the specified doses.

Harvesting and Observation: conducted when sorghum reaches physiological maturity; observed parameters include flowering age, number of panicles, and production yield.

Laboratory Analysis: sorghum seed samples were dried and analyzed for total sugar content and crude fiber content in the laboratory.

Data Analysis

The data obtained are analyzed using Analysis of Variance (ANOVA) to determine the effect of the treatments. If significant differences are found, further tests (BNJ test) are conducted at a 5% confidence level. The analysis is performed using statistical software such as SPSS.

Translated with DeepL.com (free version)The research consists of two stages, where the first stage is field research conducted in Sidera Village, Sigi City District, Sigi Regency, Central Sulawesi Province. The second stage is conducted in the Animal Science Laboratory for the analysis of sugar and fiber content in sorghum seeds.

This research uses a randomized block design (RBD) with a factorial pattern. The first factor is the dose of rice husk biochar, and the second factor is the dose of cow urine POC. Rice husk biochar dose (t/ha). Cow urine POC dose (ml/l water).

Tabel 1. Thus, 9 treatment combinations were obtained, each treatment combination was repeated 3 times, resulting in 27 experimental plots

Dosage of rice husk charcoal Biochar (t/ha)	Dosage of cow urine POC (ml/l water)		
	250 (P1)	500 (P2)	750 (P3)
kontrol (B0)	B0P1	B0P2	B0P3
2 t/ha (B1)	B1P1	B1P2	B1P3
4 t/ha (B2)	B2P1	B2P2	B2P3

Observation Parameters

Flowering age (days)

The flowering age is determined after 50% of the entire sorghum plant population in one plot has flowered.

Weight of seeds per ear (g)

The weight of seeds per ear is measured by weighing all the seeds per ear on each sample plant after they have been dried (sun-dried for 7 days) and weighed using an analytical scale.

Weight of seeds per plot (g)

The calculation of the weight of seeds per plot is done by combining the dried sorghum seeds in one plot (sun-dried for 7 days), threshing them, and then weighing them using an analytical scale. The following method stages include laboratory analysis to determine sugar and fiber content, which consists of total sugar content tests and crude fiber content.

Total Sugar Analysis (Anthrone Method)

This method is used to determine the total sugar content in sorghum seed samples, both soluble and bound.

Preparation of Sugar Extract:

- Take about 0.5 g of sorghum seed powder.
- The extraction is carried out by adding 10 mL of distilled water to the sample and heating it at 80°C for 30 minutes. After that, the sample is filtered using filter paper.

Preparation of Anthrone Reagent Solution:

- Prepare the anthrone solution by mixing 0.2 g of anthrone in 100 mL of concentrated sulfuric acid.

Staining Procedure:

- Add 1 mL of the anthrone solution to a test tube containing 1 mL of the sample extract.
- React at 100°C for 10 minutes. This reaction produces a green or blue color that can be measured using a spectrophotometer at a wavelength of 620 nm.

Calculation:

- The sugar content is calculated based on the calibration curve created using a glucose standard.

Crude Fiber Analysis (Gravimetric Method)

Crude fiber is the part of the plant that is insoluble in acid and base. This procedure measures the crude fiber content, which includes cellulose, hemicellulose, and lignin.

Sample Preparation:

- Take 1 g of finely ground sorghum seed sample.

Extraction Process:

- Boil the sample with a 1.25% sulfuric acid (H_2SO_4) solution for 30 minutes to remove acid-soluble components.
- After that, the sample is boiled in a 1.25% sodium hydroxide (NaOH) solution to remove base-soluble components.
- The sample is then washed with water until its pH is neutral.

Drying and Weighing:

- After washing and drying, the sample is then heated in an oven at 105°C until a constant weight is achieved.

Calculation of Crude Fiber:

- The weight of the sample before and after the gravimetric process is calculated to obtain the percentage of crude fiber.

Data Analysis

The obtained data undergoes variance analysis. If the results of the diversity analysis show a significant or

highly significant effect, it will be followed by a Honest Significant Difference test. (BNJ).

Result and Discussion

Growth and yield of sorghum plants

The results of the first stage included flowering age, number of panicles, and sorghum production, followed by laboratory analysis of sugar and fiber content. The analysis of variance results showed that the treatment with rice husk biochar and the treatment with cow urine POC had no significant effect. The average observation of the flowering age of the sorghum plants is presented in Figure 1.

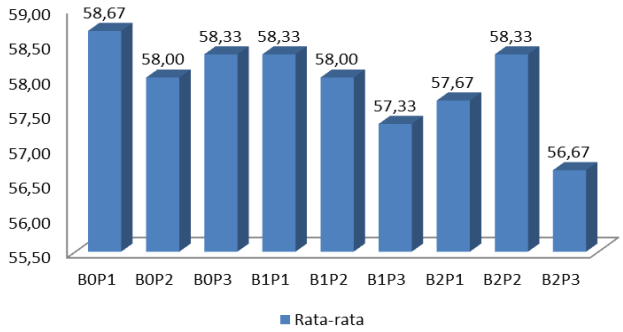

Figure 1. Average flowering age of sorghum plants with the application of rice husk biochar and cow urine POC.

Based on the figure above, the application of rice husk biochar and cow urine POC did not have a significant effect but showed a tendency for faster flowering in the treatment with 4 t/ha rice husk biochar and 750 ml/L water cow urine POC (B2P3), which was 56.67 compared to other treatments. This indicates that although there is no significant effect from the B2P3 treatment combination, it has a positive effect on improving soil cation exchange capacity aeration, which can influence nutrient availability for the plants. Additionally, cow urine POC is rich in macro and micronutrients that can support plant growth, especially in the vegetative phase, which promotes flowering acceleration. Wijaya et al (2018) Tu *et al* (2020); Thomas (2021) revealed that the application of cow urine POC can accelerate the flowering time of several horticultural plants, thanks to the increased availability of essential nutrients for the development of flowers and fruits.

Table 2. Average seed weight per sorghum plant plot (g) with the application of rice husk biochar.

Biochar	Average	BNJ 5%
Control	0.13[a]	
2 t/ha	0.17[b]	
4 t/ha	0.21[c]	0.02

Note: Numbers followed by the same letter in the column are not significantly different at the BNJ=0.05 test level

Table 3. Average seed weight per sorghum plant plot (g) with the application of rice husk POC.

POC (ml/L air)	Average	BNJ 5%
250	0.15[a]	
500	0.17[ab]	
750	0.19[b]	0.02

Note: Numbers followed by the same letter in the column are not significantly different at the BNJ=0.05 test level

The 5% BNJ test (Table 2) shows that the highest seed weight per plot of sorghum plants was observed with the application of rice husk biochar at a rate of 4 t/ha, which was 0.21 and significantly different from other treatments. Meanwhile, the application of cow urine with a treatment of 750 ml/L of water resulted in 0,19 which was significantly different from the 250 ml/L of water treatment but not different from the 500 ml/L of water treatment.

Research by Joseph *et al* (2021); Hui (2021); Kozioł *et al* (2024) shows that biochar can improve water retention in the soil, reduce water stress, and enhance the availability of essential nutrients for plants. This supports the results obtained in this study, where rice husk biochar was able to increase the seed weight of sorghum plants. This result is consistent with the research by Islami (2019); Lehmann and Joseph (2024); Haddad *et al* (2024), which found that biochar can improve crop yields in various types of plants, including cereal crops, by enhancing soil structure and increasing nutrient use efficiency.

Table 4. Average production tons/ha of sorghum plants with the application of cow urine POC

POC L air (ml/	Average	BNJ 5%
250	0.26a	
500	0.29ab	0.03
750	0.31b	

Note: Numbers followed by the same letter in the column are not significantly different at the BNJ=0.05 test level

Table 5. Average production tons/ha of sorghum plants with the application of rice husk biochar.

Biochar	Average	BNJ 5%
Control	0.21a	
2 t/ha	0.28b	0.03
4 t/ha	0.36c	

Note: Numbers followed by the same letter in the column are not significantly different at the BNJ=0.05 test level

The 5% BNJ test (Table 3) shows that the highest sorghum plant production in t/ha was achieved with the application of rice husk biochar at a rate of 4 t/ha, which was 0.36 t/ha and significantly different from other treatments. Meanwhile, the application of cow urine POC at a rate of 750 ml/L of water resulted in 0.31 t/ha, which was significantly different from the 250 ml/L of water treatment but not different from the 500 ml/L of water treatment. POC cow urine is rich in nutrients such as nitrogen (N), phosphorus (P), and potassium (K), all of which are very important for supporting plant growth and development, especially during the generative phase such as seed formation.

According to Verdiana et al (2016) in their research showed that liquid organic fertilizers can increase crop yields because they provide the nutrients needed for plant growth. The application of cow urine liquid organic fertilizer at higher doses is capable of increasing the availability of nutrients in the soil, which contributes to the improvement of crop yields. However, at a certain point, the addition of further liquid fertilizer doses does not always increase yields, as the plants may have reached the maximum limit in nutrient absorption.

These results are consistent with the research by (Widowati et al (2014); Shankar et al (2023), which revealed that the application of cow urine POC at high doses can indeed increase crop yields, but significant differences were only recorded at certain doses, after which the impact becomes limited. Therefore, it is important to determine the optimal dosage to achieve the best results.

Table 6. Average Results of Total Sugar Content Analysis (%) in Sorghum Seeds (g) with the Application of Rice Husk Biochar and Cow Urine POC.

	250 ml/L air	500 ml/L air	750 ml/L air	BNJ 5%
Control	q63.32c	q59.36b	p54.34a	
2 t/ha	q56.36c	q51.36b	p47.51a	0.39
4 t/ha	q58.18c	q55.69b	p52.50a	
BNJ 5%				0.39

Note: Numbers followed by the same letter in the column are not significantly different at the BNJ=0.05 test level

The results of the 5% BNJ test show that the treatment without biochar combined with the application of cow urine POC 250 ml/L of water resulted in the highest sugar content, which was 63.32%, and did not differ from the application of biochar at 2 t/ha and 4 t/ha with each application of cow urine POC 250 ml/L. Specifically, the sugar content in the treatment with 250 ml/L of water was higher compared to 500 ml/L and 750 ml/L of water, indicating that lower doses of liquid fertilizer yield better results in increasing the sugar content in sorghum seeds. This is in line with the findings by Siavoshi *et al* (2011); Hartati et al (2019) which show that excessive fertilization can inhibit the photosynthesis process, ultimately reducing the sugar content in the plants.

Several studies show that excess nitrogen in organic fertilizers can cause plants to focus more on vegetative growth (leaves and stems), resulting in reduced sugar accumulation in seeds or poorly developed seeds Premalatha *et al* (2023); Manimekala *et al* (2024).

Based on the Figure 2, the control treatment of rice husk biochar and cow urine POC 500 ml/L water, namely 2.183%, tends to have higher fiber content compared to other treatments. Plant fiber generally functions as a support for plant structures and can be influenced by the content of lignin, cellulose, and hemicellulose in plant tissues. Therefore, the increase in fiber content seen in the treatments can be interpreted as the impact of improved soil quality and nutrient availability provided by biochar and cow urine POC. However, it should be noted that the effect of biochar and POC on fiber content is not always linear, and other factors such as crop type, appropriate dosage, and application time can significantly affect the results.

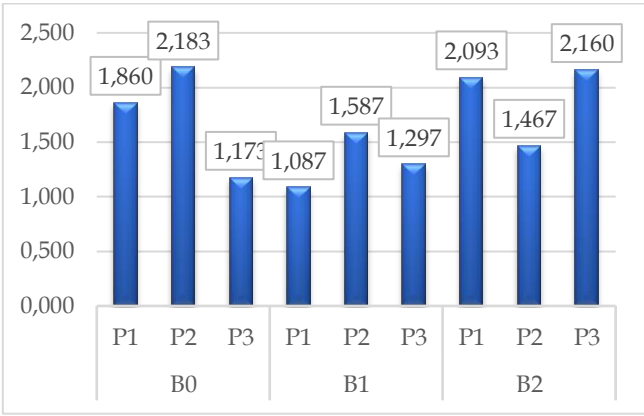

Figure 2. Fiber content (%) of sorghum seeds

The results of this study indicate that the combination of biochar and liquid organic fertilizer (POC) from cow urine has the potential to increase the productivity and nutritional quality of sorghum plants, particularly in terms of sugar content. The application of biochar contributes to improved soil structure and nutrient use efficiency, while cow urine-based liquid organic fertilizer provides additional nutrients that support generative growth. However, increasing the dose of liquid organic fertilizer does not always correlate with improved plant nutritional quality, particularly sugar content, which is actually optimal at lower doses. Therefore, these findings can be generalized to suggest that an organic fertilizer application approach using locally available organic materials, with measured and appropriate doses, can enhance

Conclusion

Based on the results of this study, it can be concluded that the application of 4 tons/ha rice husk biochar combined with 750 ml/L of cow urine liquid organic fertilizer (POC) significantly enhances sorghum seed yield and overall productivity. The highest sugar content was observed in sorghum seeds treated with 250 ml/L cow urine POC without biochar, suggesting that lower doses of POC are more favorable for sugar accumulation. Although fiber content did not show statistically significant differences across treatments, slight variations indicate that fiber development is influenced by multiple factors beyond fertilization. Overall, rice husk biochar improves soil physical and chemical properties by enhancing nutrient retention and promoting plant growth, while cow urine POC serves as an effective organic fertilizer rich in essential nutrients.

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Author Contributions
S.S., I.K.: Conceptualization, developing ideas, analyzing data, writing, reviewing, responding to reviewers' comments; M.H., M.M., R.R.: analyzing data, overseeing data collection, reviewing scripts, and writing; R.Z., N.S., N.H.: analyzing data, reviewing scripts, and writing.

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Conflicts of Interest
The authors declare no conflict of interest.

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