

Performance Analysis of Brazilian Spinach (*Alternanthera sissoo*) by the Application of Different Types and Concentrations of Local Microorganism

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Abstract

Organic fertilizers derived from local microorganisms (LMOs) offer an alternative to reduce chemical fertilizer dependency in agricultural practices. This study aimed to evaluate the effectiveness of different types and concentrations of LMO-based organic fertilizers on the growth of Brazilian spinach (*Alternanthera sissoo*). The research was conducted in a greenhouse in Summersari using a factorial Completely Randomized Design (CRD) with two factors: LMO type (bamboo shoots - B1; banana corms - B2; cattle rumen - B3) and LMO concentration (10 ml - P1; 20 ml - P2; 30 ml - P3 per polybag). There were nine treatment combinations, each replicated three times. Observed parameters included plant height, number of branches, root volume, fresh weight, shoot volume, and number of leaves. Results indicated that cattle rumen LMO (B3) was the most effective, yielding a plant height of 17.3 cm, shoot volume of 21.8 ml, and 188.6 leaves. The interaction of B3 and P2 significantly enhanced branch number, fresh weight, and leaf count, indicating this combination as the optimal treatment for Brazilian spinach cultivation.

Keywords: Brazillian Spinach, Local Microorganism, LMO Concentration, LMO Type, Organic fertilizer

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1. Introduction

Chemical fertilizers remain the primary choice among farmers, including those cultivating Brazilian spinach in Indonesia. However, continuous use of chemical fertilizers can pollute the environment, reduce soil microorganism populations, and degrade land quality over time (Mulyadi et al., 2020). The Indonesian Institute of Sciences (LIPI) has also warned that persistent application of inorganic fertilizers may destroy farmland within 25 years if left unchecked and has advocated for the use of biological and organic fertilizers to mitigate these risks. Excessive fertilizer use has been shown to increase greenhouse gas emissions and negatively impact soil and water quality, highlighting the urgent need for more sustainable nutrient management in Indonesian agriculture. In response, the government encourages the adoption of organic fertilizers as part of broader environmental conservation efforts.

Despite the abundance of agricultural and livestock waste that could be transformed into organic fertilizers through simple processes and technologies, actual utilization remains limited. Organic fertilizers supply macronutrients, micronutrients, and organic acids, and improve the soil's physical, chemical, and biological fertility (Mulyadi et al., 2020). Recent research confirms that organic fertilizers enhance soil structure, water retention, and microbial activity, which are crucial for sustainable crop production (Suparwata & Jamin, 2024). However, challenges such as limited access, cost, and knowledge continue to hinder widespread adoption among farmers.

One promising organic fertilizer is local microorganisms (LMO). LMOs serve as starters for fermenting organic materials into solid or liquid organic fertilizers. They consist mainly of carbohydrates, glucose, and microorganisms, and contain nutrients, decomposing bacteria, growth stimulators, and agents for controlling plant pests and diseases. LMO solutions can be produced from agricultural products, industrial by-products, and household organic waste (Indasah & Fitriani, 2021)

2. Material and Methods

This research was conducted in the Summersari greenhouse from April to May 2024. The tools used in this study included latex gloves, rectangular trays, black plastic sheets, knives, sieves, scissors, adhesive tape, analytical scales, measuring cups, 5-litre water containers, bottles, rulers, and hoses. The materials utilized were bamboo shoots, banana corms, cattle rumen, Brazilian spinach (*Alternanthera versicolor*) seeds, soil media, rice husk ash, and brown sugar.

The study employed a factorial Completely Randomized Design (CRD) with two factors: LMO type (B) and LMO concentration (P). Each factor had three levels—LMO from bamboo shoots (B1), banana corms (B2), and cattle rumen (B3); and LMO

This study utilizes bamboo shoot LMO, banana corm LMO, and cattle rumen LMO. Bamboo shoot LMO stimulates vegetative plant growth—including leaf buds, roots, and stems—and can act as a decomposer in organic fertilizer production. Bamboo shoots are rich in essential vitamins and minerals for plant growth (Mentari et al., 2021). Banana corm LMO reduces banana plantation waste, adds economic value, inhibits the growth of *Ralstonia solanacearum*, and stimulates root length and hair development (Anasari et al., 2022). Cattle rumen LMO, derived from cattle feed residues, contains microorganisms such as bacteria, protozoa, yeast, and fungi that contribute to fermentation processes (Indasah & Fitriani, 2021). It includes bacteria such as *Cellulomonas* sp., *Bacillus* sp., and *Lactobacillus* sp. (Hudha et al., 2020), with *Bacillus subtilis* and *Bacillus licheniformis* acting as phosphate-solubilizing bacteria and nematode inhibitors.

Several studies have explored the effects of organic fertilizers on Brazilian spinach and other crops. For example, Sulistiani et al. (2023) found that liquid organic fertilizers derived from household waste improved soil quality and plant development in Brazilian spinach, particularly under non-shaded conditions. Muda et al. (2022) demonstrated that Brazilian spinach growth and yield respond positively to fertilization, especially with NPK, as indicated by increased SPAD values reflecting higher leaf chlorophyll and nitrogen content. These findings underscore the importance of effective fertilization management for optimizing Brazilian spinach production.

Given that these LMOs contain components beneficial to soil and plants, and considering the promising results of previous studies on organic fertilizers, research on their utilization in Brazilian spinach cultivation is essential. The determination of LMO concentrations is based on approaches used for other organic fertilizers. Therefore, this study aims to identify the optimal type and concentration of LMO to achieve the best growth results for Brazilian spinach

concentrations of 10 ml per polybag (P1), 20 ml per polybag (P2), and 30 ml per polybag (P3). This resulted in nine treatment combinations, each replicated three times, for a total of 27 experimental units.

The observed variables included plant height, number of branches, root volume, fresh weight, shoot volume, and number of leaves. Data were analyzed descriptively and statistically using Analysis of Variance (ANOVA). When significant differences were found, Duncan's Multiple Range Test (DMRT) was used for post hoc analysis.

To prepare the bamboo shoot LMO, the bamboo shoots were first finely chopped and placed into a plastic barrel. Then, LMOasses solution and water were added. A hole was drilled in the center of the

barrel lid to insert a hose. The inner end of the hose inside the barrel was positioned just above the LMO material, while the outer end was submerged in a bottle filled with three-quarters water to release gases produced during fermentation. The LMO was ready for use after 14 days, indicated by a cloudy brown liquid with a characteristic aroma. The banana corm The following data were obtained from the ANOVA results to determine the interactions of treatment combinations and single factors on the observed variables. Table 1 shows that the type of LMO treatment influences the observed variables of plant height, shoot volume, and number of leaves. The analysis results in Table 1 also show interactions

LMO was prepared using the same method as bamboo shoots, and was ready after 14 days when the liquid turned dark brown. Lastly, the cattle rumen LMO was prepared similarly, but the liquid solution appeared cloudy white.

3. Results and Discussion

between treatments on the observed variables of number of branches, fresh weight, and number of leaves. Independent treatments did not significantly affect the observed variables of number of branches, root volume, and fresh weight of Brazilian spinach plants.

Table 1. Analysis of Variance Results for the Observed Variables

Observed Variables	Treatment		Interaction (B x P)
	Type of LMO (B)	The dosage of LMO (P)	
Plant Height (cm)	4,741*	0,241ns	1,713ns
Number of Branches	0,781ns	1,78ns	3,904*
Fresh Weight (g)	3,4ns	0,144ns	3,194*
Shoot Volume (ml)	7,473**	0,006ns	1,748ns
Number of Leaves	6,910**	1,112ns	4,224*

ns = non-significant; * = statistically significant $p < 0.05$; ** = higher level of significance $p < 0.01$

Plant Height

The research showed that cattle rumen LMO applied to Brazilian spinach resulted in an average plant height of 17.9 cm, which was the highest among the treatments tested. This effect is attributed to the microbes and protozoa found in cattle rumen, which can suppress soil pathogens and increase nitrogen availability as well as soil microorganism populations (Nurkholis et al., 2019). Nitrogen plays a key role in stimulating vegetative growth, including plant height (Nata et al., 2020).

When compared to other studies, such as Astuti et al. (2023), which reported an average plant height of 30 cm for Brazilian spinach treated with water hyacinth compost, the plant height observed in this study was lower. However, it is important to note that differences in experimental conditions, fertilizer types, and application methods may contribute to this variation. It is possible that in the present study, the nitrogen in cattle rumen LMO was preferentially used to increase leaf and branch development rather than plant height. This hypothesis is supported by Astuti et al. (2023), who observed a relatively low leaf count (around 50 leaves) despite the taller plants.

Shoot Volume

The research results indicate that the treatment with different types of LMO has a highly significant effect on the shoot volume of Brazilian spinach plants.

Specifically, the application of cattle rumen LMO (B3) resulted in a shoot volume of 21.8 ml, which is the best volume compared to other LMO treatments. Shoot volume is closely related to the fresh weight of the plant, encompassing factors like plant height and the number of leaves (Asngad et al., 2022). Previous studies have shown a significant interaction between cattle rumen LMO (B3) at a concentration of 20 ml per polybag (P2) and the fresh weight of the plant. This is further supported by the findings in this study, where the application of cattle rumen LMO (B3) also influenced plant height and leaf count. These three parameters—fresh weight, plant height, and number of leaves—are interconnected and contribute to the increase in the plant's shoot volume. Cattle rumen LMO contains abundant nutrient-solubilizing microbes that play a vital role in the nutrient absorption process for plants. The high shoot volume observed with the application of cattle rumen LMO is suspected to be due to the plant's more effective nutrient uptake compared to other types of LMO. Additionally, the research by Astuti T et al. (2022) demonstrated that cattle rumen LMO contains bioactivators consisting of bacteria and fungi, with protein as the main component. Protein is a primary constituent of plant tissues and can significantly increase the shoot volume of plants.

Number of Leaves

Treatment with cattle rumen LMO (B3) significantly increased the number of leaves, reaching an average of 188.6 leaves. The contents of cattle rumen are a source of nitrogen (Purnamasari et al., 2024). Besides containing microorganisms, cattle rumen LMO can also increase soil nitrogen content, thereby enhancing nitrogen availability. Adequate nitrogen serves as a raw material for synthesizing protein compounds, which are essential for leaf formation in Brazilian spinach plants. Febriantami and

Nusyirwan (2017) also stated that the greater the number of leaves, the better the plant's growth. Conversely, a small number of leaves indicates insufficient nutrient uptake. Furthermore, a study using rabbit urine as a liquid organic fertilizer (POC) by Alifatimah et al. (2023) reported that the nitrogen content in rabbit urine POC positively influenced the number of leaves in plants. This study also shows an interaction between LMO type and concentration on the number of leaves in Brazilian spinach, as presented in Table 2.

Table 2. Interaction between LMO type and LMO concentrations on the number of leaves

LMO type (B)	LMO concentrations (P)					
	P1		P2		P3	
B1	174.33	a	93.67	b	118.00	a
	a		b		a	
B2	120.67	a	157.33	b	151.67	a
	a		b		a	
B3	182.67	a	235.33	a	147.67	a
	a		a		b	

**) Note: Numbers followed by the same letter indicate no significant difference in Duncan's test at the 5% level. Numbers followed by capital letters (horizontal) show the simple effect of LMO type on LMO concentration. Lowercase letters (vertical) show the simple effect of LMO concentration on LMO type treatments.*

According to Table 2, the interaction between cattle rumen LMO (B3) and a concentration of 20 ml per polybag (P2) resulted in the highest number of leaves, at 235.33. Based on this, cattle rumen LMO at 20 ml per polybag is considered the optimal treatment. The microorganisms in cattle rumen LMO are believed to enhance nitrogen absorption from the soil. This is

supported by Kristanto and Aziz (2019), who noted that increased nitrogen uptake stimulates the growth of photosynthetic organs (leaves). Plants receiving sufficient nitrogen develop leaves with wider filaments and higher chlorophyll content. Consequently, this stimulates the production of carbohydrate assimilates, supporting vegetative growth in Brazilian spinach.

Number of Branches

Table 3. Interaction between LMO type and LMO concentration on the number of branches

LMO type (B)	LMO concentrations (P)					
	P1		P2		P3	
B1	5.33	a	2.67	b	3.33	a
	a		b		a	
B2	2.67	b	4.00	b	5.00	a
	a		b		a	
B3	3.00	b	7.00	a	4.00	b
	b		a		b	

**) Note: Numbers followed by the same letter indicate no significant difference in Duncan's test at the 5% level. Numbers followed by capital letters (horizontal) show the simple effect of LMO type on LMO concentration. Lowercase letters (vertical) show the simple effect of LMO concentration on LMO type treatments.*

Table 3 shows that the highest number of branches (7 branches) was observed with the interaction between cattle rumen LMO (B3) and a concentration of 20 ml per polybag (P2). This indicates that cattle rumen LMO at 20 ml per polybag is an effective treatment. This study achieved an average of 7 branches, surpassing Astuti et al. (2023), who reported an average of 5.33 branches in Brazilian spinach

Fresh Weight

Table 4. Interaction between LMO type and LMO concentration on the fresh weigh (g)

LMO type (B)	LMO concentrations (P)					
	P1		P2		P3	
B1	32.50	a	12.90	b	18.57	a
	a		b		a	
B2	20.27	a	24.73	b	25.97	a
	A		a		a	
B3	25.80	a	41.90	a	28.57	a
	a		a		a	

**) Note: Numbers followed by the same letter indicate no significant difference in Duncan's test at the 5% level. Numbers followed by capital letters (horizontal) show the simple effect of LMO type on LMO concentration. Lowercase letters (vertical) show the simple effect of LMO concentration on LMO type treatments.*

Table 4 shows an interaction between cattle rumen LMO (B3) and a concentration of 20 ml per polybag (P2), yielding the highest fresh weight of 41.90 g. This indicates that cattle rumen LMO at 20 ml per polybag is an effective treatment. Asngad et al. (2022) stated that the highest increase in fresh weight is due to organic materials in liquid fertilizer, ensuring sufficient nutrient availability to support plant growth. Applying cattle rumen LMO at 20 ml per polybag supplies higher macronutrients and micronutrients than other concentrations of the same LMO type, enhancing

treated with water hyacinth compost. Therefore, cattle rumen LMO at 20 ml per polybag is optimal for increasing branch numbers. Putri R.R. and Putri S.D. (2023) stated that phosphorus (P) is a crucial nutrient for branch growth. Cattle rumen LMO contains phosphate-solubilizing bacteria believed to provide phosphorus to plants, thereby enhancing branch development.

Brazilian spinach growth. The increase in fresh weight is also influenced by plant height and leaf number; in this study, cattle rumen LMO treatment showed the highest values for both. The fresh weight observed here is higher than that reported by Kurnianto et al. (2023), who achieved 29.25 g using 0.2 ml per 3 kg planting media of sheep urine liquid organic fertilizer. Therefore, applying cattle rumen LMO at 20 ml per polybag is the best composition for increasing the fresh weight of Brazilian spinach.

4. Conclusions

This research demonstrated that using cattle rumen LMO at a concentration of 20 ml per polybag yielded the best results for Brazilian spinach plants. Specifically, it produced the highest number of leaves at 235.33, the greatest number of branches at 7, and a

fresh weight of 41.9 g. The cattle rumen LMO significantly enhanced these growth parameters. Utilizing natural resources like LMOs not only boosts plant vitality but also promotes sustainable agricultural practices

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