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Growth and Yield of Brazilian Spinach Plant (*Alternanthera Sissoo*) Under The Treatment of Types and Dosages of Organic Fertilizer

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Abstract
Brazilian spinach is a highly nutritious vegetable, offering a rich profile of essential components, including minerals, vitamins A, B6, and C, antioxidants, and folic acid. Given its significant potential, sustainable cultivation methods are encouraged, particularly through the application of organic fertilizers to meet the plant's nutritional needs. This study aimed to evaluate the impact of various types and dosages of organic fertilizers on the growth and yield performance of Brazilian spinach. The experiment took place at the Wet Laboratory, Faculty of Agriculture, Science, and Technology, Warmadewa University, located on Jalan Terompong No. 24, Denpasar. A factorial Randomized Block Design was employed, examining two factors: organic fertilizer type (J1: rabbit manure, J2: chicken manure, J3: goat manure) and fertilizer dosage (D1: 5 tons/ha, D2: 10 tons/ha, D3: 15 tons/ha, D4: 20 tons/ha). Results indicated that the highest total fresh economic yield per plant was achieved using rabbit manure (115.33 g), representing a 29.58% increase compared to the lowest goat manure treatment (89.00 g). Regarding the first harvest, the highest fresh economic yield per plant occurred with chicken manure (39.25 g), outperforming the lowest goat manure treatment (26.25 g) by 49.52%. Furthermore, a dosage of 5 tons/ha resulted in the maximum fresh economic yield for the third harvest (34.33 g), a 32.90% improvement over the lowest dosage (25.83 g).

Keywords: *Brazilian spinach; dosage of organic fertilizer; rabbit manure; chicken manure; goat manure*

1. Introduction

Brazilian spinach (Alternanthera sissoo) is a tropical vegetable that thrives year-round in suitable climates like West Nusa Tenggara [1]. To maximize productivity, this crop requires effective soil nutrient management, typically through the application of organic amendments [2]. Recent research suggests that while ruminant manures, such as goat manure, can enhance vegetative traits like plant height and leaf count [3], the specific nutrient profile of different organic sources is critical for optimizing final harvest yields [4].

Organic fertilizers enhance the soil's physical, chemical, and biological quality, positively affecting plant growth. Unlike synthetic alternatives, animal manure contains beneficial microorganisms that decompose soil waste into humus and synthesize compounds for plant use [5]. Suitable types of animal manure include rabbit, chicken, and goat manure.

Rabbit manure is a valuable organic fertilizer, providing essential N, P, and K nutrients (2.72%, 1.1%, and 0.5%, respectively). Its high protein content (approximately 18%) also allows for potential use as animal feed [6]. Chicken manure is often rich in nitrogen, supporting rapid growth and higher initial yields due to fast nutrient mineralization [7]. Conversely, goat manure serves as a stable soil amendment that promotes long-term structural improvements and consistent nutrient release [8]. Integrating these organic amendments provides essential macronutrients and organic matter, thereby enhancing soil moisture retention and overall fertility [9].

Chicken manure is an organic material widely used to improve soil structure and nutrient availability, which is essential for supporting optimal spinach growth [10]. Its high concentration of essential macronutrients nitrogen, phosphorus, and potassium facilitates efficient nutrient uptake, significantly enhancing biomass accumulation and overall crop yield. Furthermore, its low carbon-to-nitrogen ratio and lignin content promote rapid mineralization, ensuring a swift release of vital nutrients for plant absorption [11].

Goat manure, derived from goat droppings, is an easily accessible organic fertilizer rich in nutrients essential for plant growth [12]. It typically possesses a C/N ratio of 20-25, facilitating an efficient decomposition process that ensures nutrient availability. Moreover, goat manure offers a stable supply of nitrogen, phosphorus, and potassium, supporting long-term soil fertility. These amendments also boost biological activity and improve microbial substrate utilization, fostering a rhizosphere environment conducive to nutrient absorption [13].

Previous studies suggest varying optimal application rates for organic fertilizers: chicken manure at 10 tons/ha [14], goat manure at 20 tons/ha [15], and rabbit manure at 5 tons/ha [16]. These findings highlight the need to balance nutrient composition and dosage to prevent issues like excessive rhizosphere salinity [17] and inhibited root development [18]. Additionally, the rapid decomposition of poultry manure can accelerate plant growth, helping spinach outcompete pest damage [19]. This study aims to evaluate the effects of different organic fertilizer types and dosages on Brazilian spinach to identify optimal strategies for sustainable, high-yield vegetable production.

2. Materials and Methods

The study was conducted from March to May 2025 at the Wet Laboratory of the Faculty of Agriculture, Science, and Technology, Warmadewa University (Jln. Terompong No. 24, Denpasar), situated at an altitude of 40 meters above sea level. It utilized a factorial Randomized Block Design featuring two experimental factors: the type of organic fertilizer (rabbit manure [J1], chicken manure [J2], and goat manure [J3]) and fertilizer dosage (5 tons/ha [D1], 10 tons/ha [D2], 15 tons/ha [D3], and 20 tons/ha [D4]). The observed parameters included plant height, leaf count, fresh economic weight, crop residue weight, and fresh harvest weights across three harvesting cycles. Harvesting was carried out on fully developed leaves at four weeks of age. Data were analyzed statistically based on the experimental design; where single treatments or interactions showed significant or highly significant effects, post-hoc analysis was performed using the 5% LSD and 5% Duncan tests. Finally, correlation analysis was employed to evaluate the strength of relationships between the observed variables.

3. Results and Discussion

3,1. Results

Based on the results of the statistical analysis of all observed variables in this study. The significance of the effect of type (J) and dose (D) of organic fertilizer as well as their interaction (JxD) on all observed variables is presented in Table 1.

Table 1. Significance of type (J) and dosage (D) of organic fertilizer as well as interaction

Observation Variables	J	D	JxD
Maximum plant height (cm)	ns	ns	ns
Maximum number of leaves per plant (pieces)	ns	ns	ns
Total economic fresh weight per plant (g)	**	ns	ns
Total fresh weight including stems per plant (g)	ns	ns	ns
Economic fresh weight of first harvest per plant (g)	*	ns	ns
Economic fresh weight of second harvest per plant (g)	ns	ns	ns

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Economic fresh weight of third harvest per plant (g)	ns	*	ns

Description: ns = Unreal effect (P>0.05); * = Have a real effect (P<0.05); ** = Very real effect (P<0.01).

The interaction between the type of manure fertilizer and the dosage of manure fertilizer (JxD) has no significant effect (P≥0.05) on all observed variables. The treatment of organic fertilizer type (J) has a significant effect (P<0.05) on the total fresh economic weight and the fresh economic weight of the first harvest of the crop, except it has no significant effect (P≥0.05) on the maximum plant height, maximum leaf number of the crop, total fresh weight of the crop, fresh weight of the second harvest of the crop, and fresh weight of the third harvest of the crop. Meanwhile, the dosage of manure fertilizer (D) has no significant effect (P≥0.05) on all variables, except it has a significant effect (P<0.05) on the fresh economic weight of the second harvest of the crop (Table 1).

Table 2. Average Growth and Yield of Brazilian spinach plants at type and dosage of manure fertilizer

Treatment	Plant Height (cm)	Number of Leaves Per Plant (pieces)	Total Economic Fresh Weight Per Plant (g)	Total Fresh Weight Including Stems (g)	Economic Fresh Weight of 1st Harvest (g)	Economic Fresh Weight of 2nd Harvest (g)	Economic Fresh Weight of 3rd Harvest (g)
Type of organic fertilizer (J)							
J1 (Rabbit)	37.99 a	56.58 a	113.58 a	27.42 a	38.67 a	30.25 a	41.92 a
J2 (Chicken)	33.51 a	48.58 a	115.33 a	26.08 a	39.25 a	34.75 a	41.33 a
J3 (Goat)	34.35 a	52.42 a	89.00 b	19.25 a	26.25 b	26.58 a	36.33 a
LSD 0,05	-	-	16.39	-	9.92	-	-
Organic fertilizer dose (D)							
D1 (5 ton/ha)	25.33 a	40.00 a	82.75 a	21.00 a	25.75 a	22.67 a	34.33 a
D2 (10 ton/ha)	24.81 a	37.25 a	77.83 a	14.75 a	22.83 a	23.25 a	31.75 ab
D3 (15 ton/ha)	25.25 a	39.38 a	79.42 a	19.50 a	26.17 a	23.75 a	27.67 ab
D4 (20 ton/ha)	30.47 a	40.50 a	77.92 a	17.50 a	29.42 a	21.92 a	25.83 b
LSD 0,05	-	-	-	-	-	-	8.23

Note: A number followed by the same letter in the same column means that there is no significant difference in the 5% LSD test. Significance description: ns = unreal; * = real; ** = very real.

3.1.1 Maximum Plant Height (cm)

The maximum plant height for the rabbit manure type (J1) is 37.99 cm, which is not significantly different from the goat manure type (J3) at 34.35 cm, showing an increase of 13.91% and 2.99% compared to the lowest maximum plant height for the chicken manure type (J2) at 33.35 cm. The maximum plant height is higher at a dose of 20 tons/ha, which is not significantly different from other treatments (Table 2).

3.1.2 Maximum Number of Leaves Per Plant (pieces)

The highest maximum number of leaves per plant was found in the rabbit manure fertilizer type (J1), which was 56.58 pieces, which was not significantly different from the goat manure fertilizer type (J3), which was 52.42 pieces, or experienced an increase of 16.47% and 7.90% compared to the lowest maximum number of leaves per plant in the chicken manure fertilizer type (J2), which was 48.58 pieces. The highest maximum number of leaves per plant was found at a dose of 20 tons/ha, which was not significantly different from other treatments.

3.1.3 Total Economic Fresh Weight Per Plant (g)

The total economic weight of the crops was highest for the chicken manure type (J2) at 115.33 g, which was not significantly different from the rabbit manure type (J1) at 113.58 g, experiencing an increase of 29.58% and 27.61% compared to the lowest total weight of the goat manure type (J3) at 89.00 g. The fresh economic weight of the total crops was higher at a dose of 5 tons/ha, which was not significantly different from the other treatments.

3.1.4 Total Fresh Weight Including Stems Per Plant (g)

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The fresh total biomass weight of the highest planting type with rabbit manure (J1) is 27.42 g, which is not significantly different from the treatment type with chicken manure (J2) at 26.08 g, representing an increase of 42.44% and 35.48% compared to the lowest total weight from goat manure (J3) at 19.25 g. The fresh total biomass weight of the planting is higher at a dosage of 5 tons/ha and is not significantly different from other treatments.

3.1.5 Economic Fresh Weight of First Harvest Per Plant (g)

The economic weight of the first harvest of the highest planting using chicken manure (J2) was 39.25 g, which is not significantly different from the rabbit manure (J1) at 38.67 g, or an increase of 49.52% and 47.31% compared to the lowest total fresh weight of goat manure (J3) at 26.25 g. The economic weight of the first harvest of the planting was higher at a dose of 20 tons/ha, and not significantly different from other treatments.

3.1.6 Economic Fresh Weight of Second Harvest Per Plant (g)

The economic weight of the second harvest of the highest planting using chicken manure (J2) was 34.75 g, which is not significantly different from the rabbit manure (J1) at 30.25 g, or an increase of 30.73% and 13.80% compared to the lowest total weight of goat manure (J3) at 26.58 g. The economic weight of the second harvest of both plantings was higher at a dose of 15 tons/ha, and not significantly different from other treatments.

3.1.7 Economic Fresh Weight of Third Harvest Per Plant (g)

The economic weight of the third harvest of the highest planting using rabbit manure (J1) was 41.92 g, which is not significantly different from the use of chicken manure (J2) at 41.33 g, representing an increase of 15.38% and 13.76% compared to the lowest total weight using goat manure (J3) at 36.33 g. The economic weight of the third harvest for the highest planting was greater at a dosage of 5 tons/ha, which was not significantly different from other treatments (Table 2).

3.2. Discussion

The results of the statistical analysis indicate that the interaction between the type and dose of manure (JxD) had no significant effect ($P \geq 0.05$) on all observed variables. The treatment of organic fertilizer type (J) had no significant effect on all variables, except for the variables of economic fresh weight and the first harvest, which had a significant effect ($P<0.05$). Meanwhile, the treatment of manure dose (D) had no significant effect ($P \geq 0.05$) on all variables, except for the third harvest, which had a significant effect ($P<0.05$) (Table 1). This variation in yield potential suggests that although nutrient composition differs among organic sources, application rates should be adjusted to match the plant's specific nutrient uptake phase [20]. The observed lack of significant interaction underscores that soil nutrient availability derived from these amendments likely exceeds the immediate assimilation threshold of the spinach during early development stages. Furthermore, the superiority of animal manures such as chicken and rabbit litter in promoting higher biomass accumulation aligns with previous findings where organic amendments significantly enhanced yield metrics compared to inorganic controls.

The average economic fresh weight was highest with chicken manure (115.33 g), a 29.58% increase compared to goat manure (89.00 g). This performance is supported by the fresh weights recorded across the first, second, and third harvests. Chicken manure improves soil structure, root growth, and water retention [21], and its widespread availability makes it a practical fertilizer choice. Research indicates that chicken manure significantly benefits soil fertility and plant growth, containing essential nutrients such as N, P, K, Ca, and Mg [22]. In contrast, goat manure provides beneficial nitrogen (0.55%), phosphorus (0.31%), and potassium (0.15%) for vegetative growth, including plant height and leaf development. Despite these profiles, poultry-based options frequently outperform caprine alternatives in biomass production due to a more favorable balance of essential macronutrients [23], [24].

Goat manure fertilizer is one type of organic fertilizer that has many benefits for soil fertility and plant growth. This fertilizer comes from goat droppings that have been processed or left to decompose until ready for use. Goat manure fertilizer can make the soil more loose and improve aeration, allowing plant roots to grow optimally [25]. Additionally, the structural benefits of goat manure facilitate superior soil aeration, which promotes a more favorable environment for root respiration compared to more compact substrates [26]. Moreover, the application of organic amendments like chicken manure enhances the friability of soil, facilitating improved water retention and essential nutrient availability for plant uptake.

The first harvest produced the highest fresh weight with chicken manure at 39.25 g, a 49.52% increase over the lowest yield obtained with goat manure at 26.25 g. This trend remains consistent across subsequent harvests. These results are attributed to the nutrient profile of chicken manure, which supplies essential macro and micronutrients such as nitrogen, phosphorus, potassium, magnesium, and manganese that help maintain soil nutrient balance and provide sustained plant nutrition [27]. The fertilizer contains 57% moisture, 29% organic matter, 1.5% nitrogen, 1.3% P_2O_5, 0.8% K_2O, 4.0% CaO, and has a C/N ratio of 9–11%. While chicken manure typically offers higher nutrient concentrations than other animal-based fertilizers, goat manure is noted for its higher potassium content. However, goat manure often contains lower nitrogen and phosphate levels than poultry-based options, which can result in reduced vegetative expansion for fast-growing crops [28].

In the manure fertilization given to Brazilian spinach plants, it only began to produce maximum doses at the third harvest growth. In contrast, the first and second harvests experienced delays due to the evenly mixed manure in the soil. Manure requires a longer time to be decomposed by soil microorganisms because of its complex organic material content [29]. The soil analysis contains total N 0.24%, available P 650 (ppm), 940, and available K 196.320 (ppm).

The differences between rabbit, chicken, and goat manures are outlined as follows [30]. Rabbit manure is a complex, micronutrient-rich fertilizer with balanced nutrients and relatively low water content, which simplifies handling compared to the wetter, more compact excreta of other livestock [31]. It exhibits superior nitrogen concentrations in both fecal and urinary components, suggesting high potential for promoting vigorous foliage development [32], and is well-suited for seedlings or young plants [33]. Chicken manure provides high levels of nitrogen and potassium to support vegetable quality and is quickly absorbed by plants [34]. Its disadvantages include the potential risk of carrying weed seeds or pests if not fully mature and a slower impact on growth due to its slow-release nature [34]. Goat manure is rich in phosphorus, which stimulates root, flower, and fruit growth, and potassium, which aids soil fertility and crop yield [35]. However, its hard granular form is difficult to break down, necessitating a composting process; consequently, it often yields more optimal results in the subsequent planting season [36].

4. Conclusion

The highest fresh weight of total economic yield per plant was obtained from the treatment with rabbit organic fertilizer, which is 115.33 g, representing an increase of 29.58% from the lowest goat organic fertilizer, which is 89.00 g. The highest fresh weight of the first harvest economic yield per plant was obtained with chicken organic fertilizer, which is 39.25 g, an increase of 49.52% from the lowest goat organic fertilizer at 26.25 g. A manure dose of 5 tons/ha resulted in the highest fresh weight of the third harvest economic yield per plant at 34.33 g, an increase of 32.90% compared to the lowest manure dose of 25.83 g.

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