Growth of Butterfly Pea under Different Types and Rates of Organic Fertilizers in Ultisols

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Abstract. This study comprehensively evaluates the effects of various organic fertilizers on the growth of butterfly peas cultivated in ultisols, known for their nutrient deficiency and acidity, which present significant challenges to crop productivity. Butterfly peas are increasingly recognized for their natural pigments, which offer potential food, health, and biotechnology applications. This recognition underscores the rising need for sustainable agricultural practices. Employing a factorial design, the study examines three types of organic fertilizers—chicken manure, cow manure, and water hyacinth bokashi—administered at varying dosages to assess their effects on plant growth. The results indicate neither fertilizer type nor dosage significantly influenced early growth metrics. However, it was observed that chicken manure notably enhanced the growth rates of leaf tillers and compound leaves in comparison to water hyacinth bokashi. This finding is consistent with previous studies that highlight the effectiveness of chicken manure in promoting leafy growth, thereby suggesting its suitability for crops like butterfly peas, which benefit from rich foliage for pigment extraction. The findings emphasize the importance of selecting appropriate organic fertilizers to facilitate sustainable cultivation, particularly in challenging soil types such as ultisols. Chicken manure has emerged as a viable organic option, enhancing growth while reducing dependence on synthetic fertilizers, thus supporting environmentally conscious farming practices. Future research should investigate the impact of organic fertilizers on the secondary metabolite content of butterfly peas to optimize their utility within the food and pharmaceutical industries, thereby expanding their economic and ecological benefits.

Keywords: *Clitoria ternatea* L., organic fertilizers, plant growth, sustainable cultivation, suboptimal lands

1 Introduction

Butterfly Pea (*Clitoria ternatea* L.) is highly economically valued for its health benefits, primarily due to its ability to produce bright, pH-sensitive natural pigments[1], [2], [3]. These pigments have diverse applications across consumer goods, agriculture, biotechnology, and pharmaceuticals[4], [5]. Growing concerns about the environmental and health impacts of synthetic

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dyes have further enhanced the popularity of this plant[6], [7], [8]. Butterfly pea has broad applications, including direct consumption, use as livestock feed, and potential roles in traditional medicine and the food industry[9], [10], [11]. A photograph of a butterfly pea is shown in Figure 1.

Fig. 1. Butterfly Pea (Source: Personal Documentation, 2024)

The production of butterfly peas is steadily increasing due to their striking blooms and a wide range of applications as a medicinal plant, ornamental species, and natural food colorants. In various regions of Indonesia, local cultivation is responding to the rising consumer demand. Consequently, the market value of butterfly peas has grown, with the fresh and dried plants now available and seeds increasingly accessible for commercial purchase[12].

Considering this context, advancing cultivation practices for butterfly peas is necessary. Expansion efforts have targeted ultisols, which require careful management due to challenges such as low organic matter content, soil acidity, low base saturation (<35%), high aluminum saturation, low cation exchange capacity, and low nitrogen, phosphorus, and potassium levels, as well as high susceptibility to erosion. Improving ultisols productivity entails enhancing nutrient availability and soil chemical properties, which can be achieved by applying organic fertilizers. Organic fertilizers contribute essential nutrients to the soil as organic matter undergoes decomposition.

Fertilization is a key factor influencing plant growth and productivity. Previous studies indicate that fertilizer type and dosage, whether organic or inorganic, significantly impact plant growth and quality[13], [14], [15]. However, excessive synthetic fertilizers can reduce soil organic matter, harm pahal beneficial soil organisms, inhibit plant growth, and lead to greenhouse gas emissions[16], [17]. Research has shown that organic fertilizers can boost plant productivity and improve soil's chemical, physical, and biological properties[18], [19], [20]. Nevertheless, optimal organic fertilizer type and dosage for butterfly pea cultivation have not yet been established. This study aims to promote sustainable, environmentally friendly, and efficient cultivation practices for butterfly peas while supporting their potential as a functional food source to enhance food security and provide farmers with additional income.

The cultivation of butterfly peas has not yet reached optimal, sustainable practices. Fertilization significantly affects butterfly pea plants' growth, yield, and quality. Utilizing organic fertilizers in its cultivation can help preserve ecosystem quality. However, limited research specifically evaluates the effects of different organic fertilizer types and dosages on butterfly peas. Additionally, investigating the influence of organic fertilizers on secondary metabolite content offers an intriguing avenue for enhancing the nutritional value and sustainable cultivation of butterfly peas.

2 Methods

The research was conducted from June to September 2024 in the greenhouse of the Agronomy Department, Faculty of Agriculture, Lambung Mangkurat University, Banjarbaru. The materials and tools used in this research include butterfly pea seeds, ultisols soil, chicken manure, cow manure, water hyacinth bokashi, polybags, water, dolomite lime, stakes, sieves, measuring tape, scales, watering can, writing tools, and a camera.

The experiment employs a nested factorial design with two factors. The first factor is the type of organic fertilizer, comprising three treatments: cow manure (P1), chicken manure (P2), and water hyacinth *bokashi* (P3). The second factor is the fertilizer dosage, with four levels: 5 t ha^{-1} (D1), 10 t ha^{-1} (D2), 15 t ha^{-1} (D3), and 20 t ha^{-1} (D4). This setup results in 12 treatment combinations, each replicated three times, totaling 36 experimental units.

The research procedure includes several stages: preparation of water hyacinth bokashi, preparation of the planting medium, seed preparation, planting, maintenance, and observation. Observations focus on growth characteristics, including germination time (days after planting, DAP), stem length (cm), stem diameter (mm), number of branches, number of leaf tillers, number of compound leaves, leaf tillers growth rate (leaf tillers/day), and compound leaf growth rate (compound leaves/day). The data will be analyzed using analysis of variance (ANOVA) at a 5% significance level to determine the treatment effects, followed by a Least Significant Difference (LSD) test to identify the best treatment, with Microsoft Excel used for data processing.

3 Results and Discussion

The analysis of variance showed that the type and dosage of organic fertilizers had no significant effect on germination time, plant height, stem diameter, and branch count. Similarly, research by Irawati and Rahmawati found no interaction between the type and dosage of organic fertilizer across all variables[12]. The influence of organic fertilizer types and dosages on germination time, plant height, stem diameter, and branch count at three weeks after sowing (WAS) is presented in Table 1.

Table 1. Influence of Organic Fertilizer Type and Dosage on Germination Time, Plant Height, Stem Diameter, and Branch Number at 3 WAS.

Treatment	Germination Time (DAP)	plant height (cm)	Stem diameter (mm)	Number of branches
Type of Organic Fertilizer	tn	tn	tn	tn
P1	7,31	27,89	2,33	0,03
P2	7,83	29,07	2,29	0,17
P3	8,17	26,13	2,28	0,11
Dose | Type of Organic Fertilizer	tn	tn	tn	tn
P1D1	8,78	29,28	2,11	0,00
P1D2	5,33	26,33	3,00	0,11
P1D3	7,78	30,06	2,00	0,00
P1D4	7,33	25,89	2,22	0,00

Treatment	Germination Time (DAP)	plant height (cm)	Stem diameter (mm)	Number of branches
P2D1	6,44	23,72	2,22	0,11
P2D2	7,33	27,06	2,89	0,11
P2D3	9,44	29,28	1,61	0,22
P2D4	8,11	36,22	2,44	0,22
P3D1	8,44	28,22	2,44	0,22
P3D2	7,11	31,06	2,67	0,00
P3D3	10,22	22,56	2,22	0,11
P3D4	6,89	22,67	1,78	0,11

Germination time refers to the period needed for seeds to sprout radicles and plumules, which can be measured by counting the days required for this emergence. In this study, germination times ranged from 5.33 to 10.22 days after planting (DAP), consistent with the 6 - 8 day range established by Reformasintansari and Waluyo[21]. Plant height at 3 WAS ranged from 22.56 to 36.22 cm, which remains below the maximum height description for butterfly pea plants of 3 m. This discrepancy may be due to the slow-release nature of organic fertilizers, where plant roots absorb nutrients more gradually. Organic fertilizers supply essential macro- and micro-nutrients that support plant growth and development[12], [22], [23]. This indeterminate growth characteristic means these plants continue to increase in height even after flowering.

The type and dosage of organic fertilizer did not significantly influence stem diameter or branch number. This may be due to limited water and nutrient availability, restricting optimal plant development. According to Zulyana, continuous cell division and enlargement drive plant growth[24], and stem diameter can be influenced by macro-nutrient availability, especially nitrogen, which promotes diameter growth. Zulyana noted that adequate nutrients, water, and sunlight enhance photosynthesis, yielding photosynthates supporting growth, flower formation, seed development, and fruit[24]. This study employed ultisols soil, known for its clay-rich subsoil layer formed through leaching, making it less permeable to water and lower in nutrient content. As observed by Triharto, acidic soils impede nutrient absorption due to the binding of essential nutrients by aluminum (Al) and iron (Fe) ions. This limitation underscores the importance of soil pH management in agricultural practices[25].

The number of leaf tillers and compound leaves from 1–3 WAS showed no significant effect of fertilizer type or dose. However, a notable effect of fertilizer type was observed on compound leaf numbers at 3 WAS, with chicken manure producing the highest leaf counts, not significantly different from cow manure. Table 2 presents the effect of organic fertilizer type and dose on the number of leaf tillers and compound leaves from 1–3 WAS.

Table 2. Influence of Organic Fertilizer Type and Dosage on the Number of Leaf Tillers and Compound Leaves from 1–3 WAS.

Treatment	Number of leaf tillers			Number of compound leaves		
	1 WAS	**2 WAS**	**3 WAS**	**1 WAS**	**2 WAS**	**3 WAS**
Type of Organic Fertilizer	**ns**	**ns**	**ns**	**ns**	**ns**	*****

P1	4,22	9,36	16,42	0,14	1,81	3,58
P2	3,92	9,47	17,19	0,11	1,89	3,83
P3	4,36	9,92	15,33	0,25	2,03	3,06
Dose | Type of Organic Fertilizer	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**
P1D1	3,67	8,00	15,78	0,11	1,44	4,00
P1D2	4,22	10,00	17,56	0,11	2,00	3,89
P1D3	4,67	10,00	16,89	0,22	2,00	3,22
P1D4	4,33	9,44	15,44	0,11	1,78	3,22
P2D1	3,56	8,78	16,11	0,00	1,67	3,44
P2D2	4,00	9,33	16,89	0,11	1,89	3,89
P2D3	3,89	10,11	18,33	0,11	2,11	4,11
P2D4	4,22	9,67	17,44	0,22	1,89	3,89
P3D1	4,56	10,56	16,89	0,33	2,00	3,11
P3D2	4,44	9,78	16,33	0,22	2,00	3,56
P3D3	4,11	9,56	13,78	0,22	2,11	2,89
P3D4	4,33	9,78	14,33	0,22	2,00	2,67

Research by Fatman et al. supports these findings, showing that chicken manure at specific dosages positively influences the growth and yield of mustard greens, including leaf count[26]. This suggests that chicken manure is an effective nutritional source for promoting vegetative growth. Virgundari et al. (2013) also found that chicken manure outperformed cow and goat manure in enhancing chili growth[27]. Rich in nitrogen, chicken manure is particularly effective in boosting leaf growth and overall plant productivity. The influence of organic fertilizer types on compound leaves number is depicted in Figure 2.

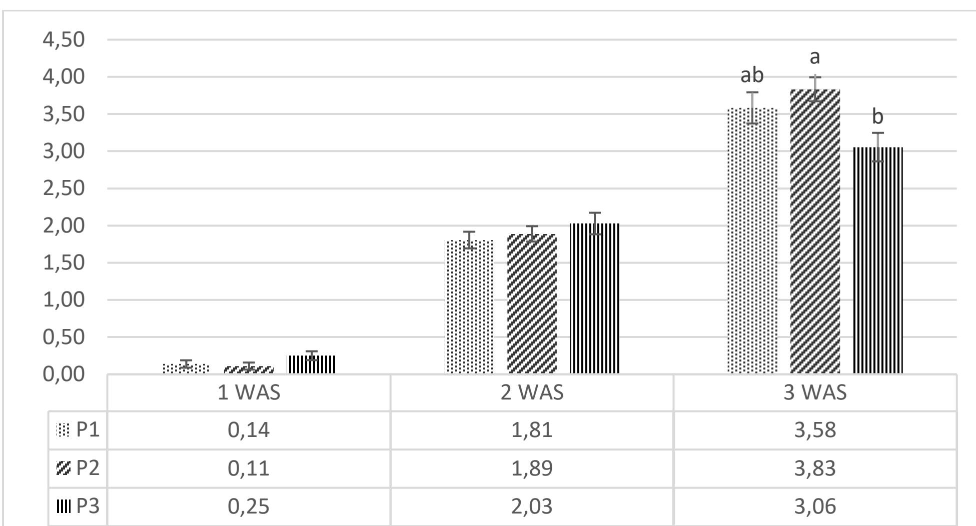

Fig. 2. Effect of Organic Fertilizer Types on Compound Leaves Number

The significant effect of organic fertilizer type was observed on the growth rate of leaf tiller at 2 → 3 WAS and the growth rate of compound leaf at 2 → 3 WAS, with chicken manure showing the highest growth rates, statistically similar to cow manure but differing from water hyacinth bokashi. The effect of organic fertilizer types and dosages on leaf tiller growth rate and compound leaf growth rate is presented in Table 3.

Table 3. Effect of Organic Fertilizer Types and Dosages on Leaf Tiller Growth Rate and Compound Leaf Growth Rate

Treatment	**Leaf tiller growth rate**		**Compound leaf growth rate**	
	1 → 2 MSK	**2 → 3 MSK**	**1 → 2 MSK**	**2 → 3 MSK**
Type of Organic Fertilizer	**ns**	*	**ns**	**
P1	0,73	1,01	0,24	0,25
P2	0,79	1,10	0,25	0,28
P3	0,79	0,77	0,25	0,15
Dose | Type of Organic Fertilizer	**ns**	**ns**	**ns**	**ns**
P1D1	0,62	1,11	0,19	0,37
P1D2	0,83	1,08	0,27	0,27
P1D3	0,76	0,98	0,25	0,17
P1D4	0,73	0,86	0,24	0,21
P2D1	0,75	1,05	0,24	0,25
P2D2	0,76	1,08	0,25	0,29
P2D3	0,89	1,17	0,29	0,29
P2D4	0,78	1,11	0,24	0,29
P3D1	0,86	0,90	0,24	0,16
P3D2	0,76	0,94	0,25	0,22
P3D3	0,78	0,60	0,27	0,11
P3D4	0,78	0,65	0,25	0,10

Research by Khadijah et al. has shown that manure has a more pronounced impact on plant growth than water hyacinth bokashi, likely due to the higher nutrient content of manure, which is essential for vegetative development[28]. This study indicates that while bokashi has benefits, manure gives better results regarding the number of leaves and overall plant growth. This could be due to the higher nutrient content in manure, which is essential for plant vegetative growth.

Nurmi et al. found that chicken manure enhances the growth and yield of peanut plants, including leaf count, underscoring the importance of selecting appropriate fertilizer types to boost crop productivity[29]. This study highlighted the importance of choosing the right fertilizer to increase plant productivity. With its higher nutrient content, chicken manure proved to be more effective in enhancing plant growth than water hyacinth bokashi. The impact of organic fertilizer types on leaf tiller growth rate and compound leaf growth rate is illustrated in Figure 3.

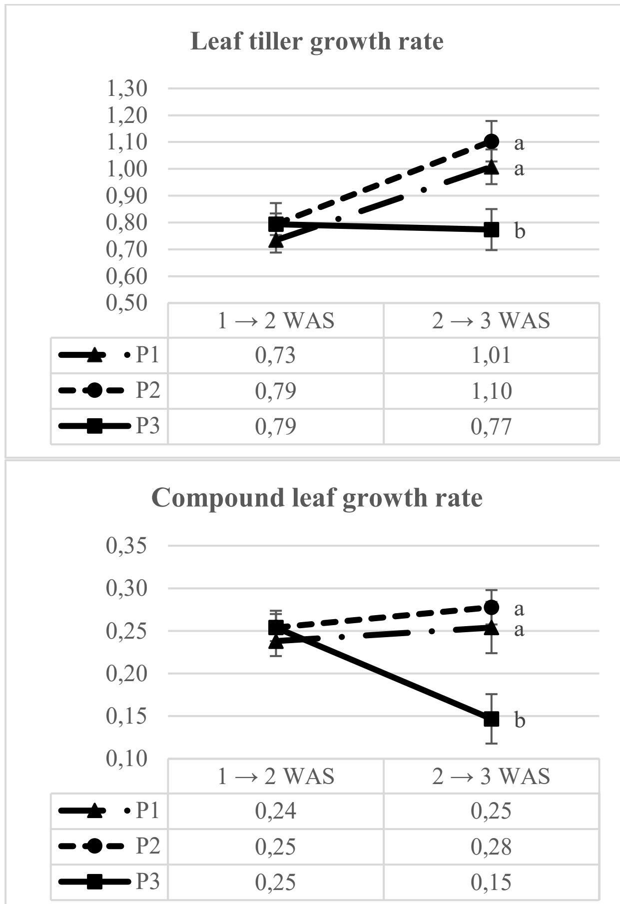

Fig. 3. Effect of Organic Fertilizer Types on Leaf Tiller Growth Rate and Compound Leaf Growth Rate

In conclusion, although all fertilizers, including chicken and cow manure and water hyacinth bokashi, contribute to plant growth, chicken manure generally produced superior results compared to water hyacinth bokashi and showed comparable results to cow manure regarding vegetative growth. Existing studies indicate that optimal agricultural outcomes depend on carefully selecting fertilizer type, appropriate dosage, and timing.

4 Conclusions

This study explored organic fertilizers' effects on butterfly pea growth in ultisols. While no significant differences were observed in germination, height, stem diameter, or branching, chicken manure notably improved leaf tiller and compound leaf growth rates compared to water hyacinth bokashi, likely due to its higher nitrogen content. This finding highlights the importance of fertilizer choice for sustainable cultivation in nutrient-poor, acidic soils. Promoting organic fertilizers like chicken manure supports eco-friendly farming and reduces dependency on synthetics. Future research could examine the impacts on butterfly pea metabolites for broader agricultural applications.

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