



Enhancing Agroforestry Productivity through Organic Nutrient Management: The Case of Pinto Bean Intercropped with Kakawate in La Union, Philippines

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Abstract: Agroforestry systems offer promising solutions for sustainable land use, yet there remains limited research on optimizing legume-based intercropping strategies, particularly regarding organic fertilization within hedgerow systems. This study evaluated the growth and yield performance of Pinto beans (*Phaseolus vulgaris* L.) under different organic fertilizer treatments within a Kakawate (*Gliricidia sepium*) hedgerow alley cropping system. The experiment employed a Randomized Complete Block Design (RCBD) with three blocks and tested four treatments: goat manure, cattle manure, chicken manure, and an unfertilized control. Results showed that the application of animal manures significantly influenced productivity, with goat and cattle manure producing notably higher yields and net income compared to chicken manure and the control. Although key growth parameters, such as survival rate, days to emergence, flowering, and plant height, showed no significant differences across treatments, the overall pod yield and marketable seed weight were significantly improved using goat and cattle manure. Interestingly, the number of non-marketable seeds increased with higher yields, indicating a positive correlation between productivity and seed grading outcomes. It is noteworthy that intercropping Pinto beans did not adversely affect the growth of Kakawate hedgerows, demonstrating the compatibility of this agroforestry model. These findings underscore the potential of integrating leguminous crops like Pinto beans into agroforestry systems using appropriate organic fertilization. Such practices enhance land productivity, diversify farm income, and contribute to sustainable soil management, making them highly relevant for smallholder farmers aiming to maximize the ecological and economic benefits of agroforestry.

Keywords: Agroforestry; Alley cropping; Planting distance; Animal manure; Pinto beans.

INTRODUCTION

Intercropping pinto beans (*Phaseolus vulgaris* L.) with kakawate (*Gliricidia sepium*) presents a promising agroforestry strategy that enhances land productivity while promoting sustainable farming particularly beneficial for smallholder farmers. Kakawate, a nitrogen-fixing tree, improves soil fertility and supports the growth of companion crops like legumes (Sileshi et al., 2008). Pinto beans, in turn, contribute significantly to food security as a protein-rich, nutrient-dense crop with global appeal due to

their mild flavor and health benefits (Beam, 2022; Butler, 2020).

Intercropping or cultivating two or more crops simultaneously on the same plot is a time-tested farming practice that maximizes resource use, improves yields, and reduces environmental impact (Vale, 2017). When combined with organic amendments like animal manure, which enriches soil with essential nutrients and organic matter (Agegnehu et al., 2016), the system becomes even more sustainable. The integration of these components, intercropping and organic fertilization, forms a holistic agroecological approach. It not only supports crop growth

but also promotes long-term soil health and resilience, making it a viable model for regenerative agriculture in tropical farming systems.

MATERIALS AND METHODS

Study Location

The study was conducted in an 31,2 m² portion of the Agroforestry Farm of the College of Agroforestry and Forestry, DMMMSU, Sapiliang, Bacnotan, La Union. The site is slightly sloping with an elevation typically of upland farms, and the soil is a mix of clay loams, suitable for growing both trees and crops. It is an open area that receives full sunlight, with nearly hedgerows and other experimental plots used for agroforestry research. The climate in the area is characterized by a distinct dry season from November to April and a rainy season from May to October, conditions common in the Ilocos Region. These site features make it favorable for evaluating the performance of kakawate hedgerows intercropping with pinto bean (Figure 1).

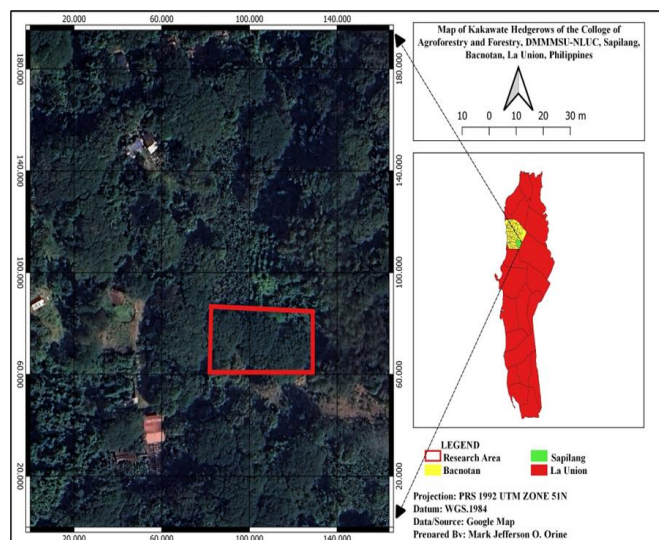


Fig. 1. Map of the Study Area

Research Design

The study was laid out using the Randomized Complete Block Design with three blocks. The treatments used in the study are as follows:

- T0- Control (no application)
- T1- Goat manure
- T2- Cattle manure
- T3- Chicken manure

Planting Materials

The materials used in the study included Pinto bean seeds, basic agricultural tools, and three types of organic fertilizers: goat manure, cattle manure, and chicken manure. The Pinto bean seeds were sourced from the municipality of Santol, La Union. Before application, all

manure types were properly pulverized to ensure uniform texture and readiness for use as treatment.

Land Preparation

An area of 31.2 m² was prepared through brushing and cleaning by removing the undesirable weeds and litter using a sharp bolo and grab hoe. After which, field layout was conducted. Organic fertilizers were then pulverized before being applied to each plot. Each plot measured 1.10 m² and was manually cultivated and pulverized using a spading fork and a grab hoe.

Treatment Preparation

The different organic manure treatments, such as cattle, chicken and goat manure were weighed and applied at a rate of 2 kg per plot, then thoroughly incorporated into the soil one week before sowing.

Seed Sowing and Harvesting

Four seeds were sown per hole, and irrigation was carried out every other day. Thinning was conducted two weeks after sowing, leaving two healthy and vigorous plants per hill. Harvesting of pinto beans was conducted when the plants reached physiological maturity, indicated by the browning and drying of the pods. At this stage, the seeds inside the pods have fully developed and hardened, ensuring maximum yield and quality. Timely harvesting is crucial to prevent shattering losses and potential damage from pests or fungal infections, which are more likely to occur if mature pods are left too long in the field. After harvesting, the pods were air-dried under shaded conditions to further reduce moisture content, facilitating easier threshing before gathering pertinent data needed.

Data Analysis

The Shapiro-Wilk Normality Test was conducted to assess the normality of the data gathered. Results revealed that all the data were normally distributed. All data were then tested using the Analysis of Variance (ANOVA) in a Randomized Complete Block Design (RCBD). If the data were found to be significantly different, then comparison among treatment means was employed using Tukey's Honest Significant Difference (HSD) test. All data were analyzed using RStudio Statistical Software v. 2024 (Posit team, 2024).

RESULTS AND DISCUSSIONS

Days to Emergence

The days to emergence of Pinto beans, as shown in Table 1, ranged from 5.06 to 5.28 days across the different animal manure treatments. Statistical analysis revealed no significant differences among treatments, indicating that the type of animal manure used as organic fertilizer did not significantly influence the emergence time of Pinto beans. Although plants applied with goat manure had numerically

the earliest to shoot emergence with 5.06 days, the difference observed is not enough to cause a significant effect. The slight difference could be attributed to goat manure’s well-balanced nutrient composition, particularly its faster nitrogen mineralization rate, which may enhance early seedling vigor (Mahimairaja et al., 2019; Sharma & Garg, 2017). All other treatments had the same days to emergence with plants under control treatment or without the application of organic fertilizers, with 5.28 days respectively. Organic fertilizers primarily contribute to long-term improvements in soil fertility rather than immediate effects on seed germination. This is because the nutrients in organic materials are typically released slowly through microbial decomposition. If nutrients are not readily available during the early stages of growth, their impact on shoot emergence is likely to be minimal (Agegnehu et al., 2016). However, goat manure, which is generally finer and more decomposed compared to other manures, may have facilitated a slightly faster release of nutrients, particularly nitrogen, potentially accelerating emergence. Nonetheless, this difference is usually too small to cause a significant effect on days to emergence (Mahimairaja et al., 2019).

Table 1. Number of days to shoot emergence as affected by organic fertilizers

Organic Fertilizers	No. of Days to Shoot Emergence ⁺
T ₀ - Control	5.28
T ₁ - Goat manure	5.06
T ₂ - Cattle Manure	5.28
T ₃ - Chicken Manure	5.28

⁺= not significant at *p*< 0.05

Days to Flowering of Pinto Beans

The analysis of variance revealed no significant difference in the days to flowering of Pinto beans as affected by different organic animal manure fertilizers. This implies that the organic fertilizers used have a comparable effect on the growth of Pinto beans in terms of flower emergence. Despite the potential benefits of organic fertilizers for overall plant health, various factors such as soil composition, weather conditions, temperature and genetic factors of Pinto beans affect the flowering. Temperature is a critical environmental factor influencing early flowering in Pinto beans. Maintaining optimal temperatures (18–30 °C) ensures timely flowering and better reproductive success, while extremes can cause delayed flowering, flower abortion, and reduced yields (Tunc et al., 2023).

Table 2. Number of days to flowering as affected by organic fertilizers

Organic Fertilizers	No. of Days to Flowering ⁺
T ₀ - Control	26.54
T ₁ - Goat manure	26.51
T ₂ - Cattle Manure	26.60
T ₃ - Chicken Manure	26.54

⁺= not significant at *p*< 0.05

Plant Height (cm)

Table 3 shows the plant height of Pinto beans grown with different types of organic fertilizers, ranging from 30.61 cm to 35.02 cm. These heights fall within the normal growth range for the crop, suggesting that all treatments, whether goat, cattle, or chicken manure, supported healthy plant development. The slight differences in height indicate that these organic fertilizers had similar effects on Pinto bean growth. This may be due to factors such as the balanced nutrients they provide, the condition of the soil, the variety used, and environmental factors (Santosa et al., 2017). In addition to the fertilizers, the intercropping of Pinto beans with kakawate likely contributed to the good performance of the plants. Intercropping can offer several benefits, such as better soil fertility, improved moisture retention, and a more favorable microclimate. Kakawate, being a leguminous tree, may also help enrich the soil with nitrogen, which supports overall plant growth. These combined benefits could explain why Pinto beans grew well even without major differences between the fertilizers. It also suggests that the soil already had enough nutrients to support the plants’ height, and adding more organic fertilizer didn’t lead to significantly taller plants.

Table 3. Plant Height of Pinto Beans as Affected by Organic Fertilizers

Organic Fertilizers	Plant Height ⁺
T ₀ - Control	26.54
T ₁ - Goat manure	26.51
T ₂ - Cattle Manure	26.60
T ₃ - Chicken Manure	26.54

⁺= not significant at *p*< 0.05

Weight of Marketable (kg) and Non-marketable (g) seeds

Results revealed that there was a highly significant difference observed among the different animal manure used in the weight of marketable seeds (Fig.2). Cattle manure obtained the highest weight of marketable seeds with a mean of 6.03 kg per plot and was found comparable to plants applied with goat manure with a mean of 5.53 kg per plot. Likewise, plants without application of animal manure (control treatment) had the lowest weight of marketable seeds and were found comparable to plants applied with chicken manure with 3.90 kg and 3.93 kg per plot only. This result negates the findings of Widodo

(2019) and Sumarsono (2020), wherein they found that chicken manure, as fertilizer, had a significant effect on the weight of bean pods as well as on other parameters.

On the other hand, the weight of non-marketable seeds per plot showed that plants treated with cattle manure and goat manure produced significantly higher amounts of non-marketable seeds, with mean weights of 6.03 g and 5.53 g per plot, respectively (based on 9 hills per plot). These seeds were generally small, shriveled, or underdeveloped. This increase in non-marketable seed weight is directly related to higher overall yield, as the number of marketable seeds increases, the number of non-marketable seeds also tends to rise due to greater total seed production. In contrast, chicken manure resulted in the lowest weight of non-marketable seeds. However, this is not necessarily an indication of superior seed quality. Rather, it reflects the overall lower productivity of the plants under this treatment. Since chicken manure produced fewer marketable seeds, it also resulted in fewer non-marketable ones. While the amount of non-marketable seeds was minimal and considered negligible, this outcome underscores the connection between total yield and the volume of both marketable and non-marketable seeds. Therefore, treatments that produced higher yields also tended to have more non-marketable seeds, as a natural result of increased seed production.

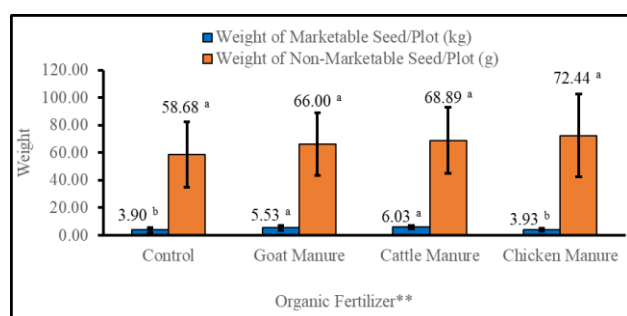


Fig.2: Weight of marketable (kg) and non-marketable (g) seeds per plot. **=highly significant at $p < 0.01$

Yield Per Plot (kg) and Computed Yield (tons/ha)

Figure 3 presents the yield per plot (kg) and computed yield (tons/ha) of Pinto beans as affected by organic fertilizers. Results revealed a highly significant difference on the yield of Pinto beans in both yield per plot and computed yield per ha. Plants applied with cattle manure and goat manure produced the highest yield with 6.09 kg and 5.58 kg per plot and 222.88 tons and 148.15 tons/ha. Moreover, plants without organic fertilizer application had the lowest yield in kilograms per plot and in tons/ha and were found comparable to plants applied with chicken manure, with only 3.95 kg and 4.0 kg per plot and 94.12 tons and 178.55 tons/ha.

The graph shows the yield per plot (g) and computed yield (tons/ha) of Pinto beans as affected by different organic fertilizers. Results revealed a highly significant

difference in the yield of Pinto beans in both yield per plot and computed yield per ha. Plants applied with cattle manure and goat manure produced the highest yields, with 6.09 kg and 5.58 kg per plot, corresponding to 50.36 tons/ha and 148.15 tons/ha, respectively. In contrast, plants without organic fertilizer application had the lowest yield in both kilograms per plot and tons per hectare. These were found comparable to the yields from plants applied with Chicken manure, which only produced 3.95 kg and 4.00 kg/plot or 32.68 tons/ha and 33.09 tons/ha, respectively.

The significantly higher yields observed from the use of cattle manure and goat manure can be attributed to their favorable nutrient composition and solve-release properties. Cattle manure is known to be rich in macronutrients such as nitrogen, phosphorus, and potassium, which are essential for vegetative growth, flowering, and pod development in legumes (Sarkar et al., 2018). Additionally, it improved soil structure, water-holding capacity, and microbial activity, all of which contribute to enhanced nutrient uptake and root development (Agbede, 2010). Similarly, goat manure contains relatively high levels of nitrogen and organic matter, which promote healthy plant growth and efficient nutrient use (Mkhabela & Warman 2005). The fibrous content in goat manure also enhances soil aeration and microbial diversity, further supporting plant productivity. These improvements in soil fertility and structure have likely created a more conducive environment for Pinto bean growth, resulting in higher yields.

The significant result implies that the different organic fertilizers used have different effects on the yield per plot and computed yield per ha.

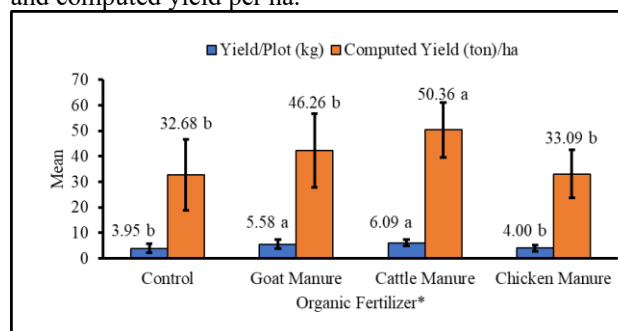


Fig.3: Yield per plot (kg) and computed yield (tons)/ha.

*=significant at $p < 0.05$

Percentage Survival (%)

Table 4 shows the percentage survival of Pinto beans as influenced by different types of organic fertilizers. Results revealed no significant difference in survival rates among the treatments, all recorded a 100% survival rate, including the control (no manure applied). This suggests that the use of goat, cattle, or chicken manure had no direct effect on plant survival under the conditions of the study.

The consistently high survival rate across treatments may be better explained by other contributing factors, such as favorable environmental conditions, good soil quality, and proper management practices. Moreover, the

intercropping of Pinto beans with kakawate likely played an important role in promoting survival. Kakawate, known for its soil-enriching properties and ability to create a favorable microclimate through partial shading and organic matter contribution, may have helped reduce stress on the Pinto beans, especially during the early stages of growth. This supportive growing environment likely contributed to the uniform and high survival rate observed in all plots.

Similar findings were reported by Smith et al. (2020), who noted that organic fertilizers tend to impact growth and yield more than survival in leguminous crops. Garcia and Lopez (2018) also emphasized the greater importance of soil conditions, microbial activity, and environmental factors in plant survival. Jones et al. (2019), in a study on beans, highlighted that while organic fertilizers improve soil fertility over time, their immediate effect on plant survival is minimal when other growing conditions are already favorable. These results reinforce the idea that while organic fertilizers are valuable for enhancing long-term soil health and productivity, intercropping with beneficial trees like kakawate and maintaining good environmental and management conditions may have a more immediate and stronger influence on plant survival.

Table 4. Percentage survival of Pinto beans as affected by organic fertilizers (%)

Organic Fertilizers	Percentage Survival (%)
T ₀ - Control	100
T ₁ - Goat manure	100
T ₂ - Cattle Manure	100
T ₃ - Chicken Manure	100

+ = not significant at $p < 0.05$

Gross Income (Php)

Figure 3 presents the gross income of Pinto beans as influenced by different types of organic fertilizers. The results show a significant difference in income based on the yield per plot. Plants treated with goat manure and cattle manure recorded the highest gross incomes, with means of ₱33.12 and ₱36.06, respectively. In contrast, the control group (no organic manure) had the lowest gross income, averaging only ₱23.70, which was statistically similar to that of plants treated with chicken manure. The ANOVA confirmed that the treatment means differed significantly, indicating that the type of organic fertilizer used had a clear impact on the gross income. While the treatment comparison suggests that chicken manure produced the highest gross income, this finding appears inconsistent with the actual recorded means and may reflect variability across replicates. Nonetheless, the result aligns with the findings of Poku and Kyere (2020), who reported that the application of chicken manure can improve crop productivity, thereby increasing yield and income. Beyond the influence of fertilizers, the integration of Pinto beans in an agroforestry system with kakawate likely contributed to the overall productivity. Intercropping Pinto beans with kakawate offers ecological and economic benefits such as enhanced soil fertility, improved

microclimate, and better resource use efficiency. Kakawate, being a nitrogen-fixing tree, helps enrich the soil naturally, which can reduce dependency on external inputs while supporting healthy crop development. These agroforestry benefits likely played a role in improving yields and supporting consistent income across treatments, especially in organically managed plots.

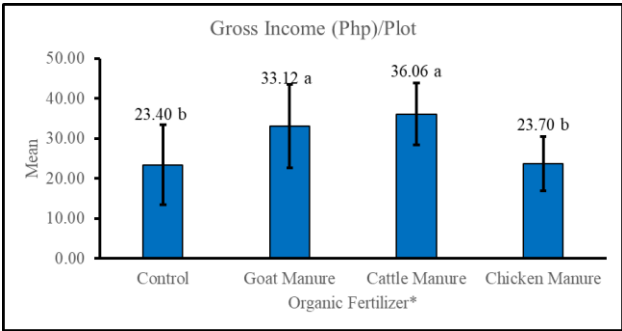


Fig.3: Gross income per plot (Php). * = significant at $p < 0.05$

CONCLUSION

The study demonstrated that the use of organic fertilizers such as goat, cattle, and chicken manure had varying effects on the performance of Pinto beans intercropped with kakawate. In terms of plant height and survival, all treatments supported normal growth, with no significant differences observed, suggesting that the existing soil conditions and benefits from intercropping with kakawate were sufficient to maintain healthy development and 100% survival across all plots. However, significant differences were found in gross income, where cattle and goat manure treatments resulted in the highest returns (₱36.06 and ₱33.12 per plot, respectively), due to higher yields. Although chicken manure showed the least weight of non-marketable seeds, this was attributed to its lower overall productivity, not necessarily better seed quality. Treatments that produced more marketable seeds also had more non-marketable seeds, indicating that greater seed production naturally increases both usable and unusable outputs.

The inclusion of kakawate in the intercropping system played a key role in maintaining favorable soil conditions, supporting consistent survival and growth. This highlights the potential of integrating leguminous trees into agroforestry systems to enhance sustainability, reduce input dependence, and improve economic returns. Overall, cattle and goat manure proved to be more effective organic fertilizers under this agroforestry setup, offering higher productivity and profitability without compromising plant health.

Conflict of Interest

There are no conflicts of interest declared by the authors.

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