



**RESPONSE OF SOYBEAN (*GLYCINE MAX* (L) Merrill) TO VARYING RATES OF POULTRY MANURE AND PHOSPHORUS FERTILIZER IN BAUCHI STATE, NIGERIA**

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**ABSTRACT**

A field experiments were conducted at Abubakar Tafawa Balewa University, Teaching and Research Farm, Gubi Campus, Bauchi, during the 2023 and 2024 rainy seasons to determine the response of soybean (*Glycine max* (L) Merrill) to varying rates of poultry manure and phosphorus fertilizer. The experimental treatments comprised of three (3) levels of poultry manure (0, 2.5 and 5.0 t/ha) and four (4) levels of phosphorus fertilizer (0, 13.2, 26.4 and 39.6 kg P/ha). These factors were combined factorially and laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on plant height, leaf area, number of branches, 100 seed weight and grain yield. All the data collected were subjected to analysis of variance (ANOVA) and duncan's multiple range test (DMRT) was adopted in separating the means. The results showed that, application of poultry manure at 5.0 t/ha significantly ( $P \leq 0.05$ ) gave taller plants, higher number of branches, wider leaves, 100 seed weight and grain yield compared to other levels. Similarly, application of 2.5 t/ha of poultry manure significantly ( $P \leq 0.05$ ) increased leaf area, and 100-seed weight relative to the control. Phosphorus fertilizer application at 26.4 and 39.6 kg P/ha also significantly ( $P \leq 0.05$ ) produced higher plant height. However, the application of 39.6 kg P/ha resulted in the highest number of branches. The interaction between 5.0 t/ha of poultry manure and 39.6 kg P/ha of phosphorus yielded the highest grain output. therefore, combine application of poultry manure at 5.0 t/ha and 26.4 kg P/ha of phosphorus is recommended for sustainable soybean production in the study area.

**Keywords:** Soybean, Poultry, Manure, Phosphorus, Growth, and Yield,

**INTRODUCTION**

Soybean (*Glycine max* (L.) Merrill), a member of the *Fabaceae* family, is a versatile legume which originated from East Asia and has become a global cornerstone for food security (Karoshi, *et al.*, 2022). Historically valued for its role in nitrogen fixation within crop rotation systems, soybean is famously dubbed the "Golden Bean" due to its exceptional nutritional profile and economic utility (Karoshi, *et al.*, 2022). In the current global market, soybean production has reached unprecedented levels, with 2024/2025 estimates exceeding 400 million metric tons to meet the rising demand for protein and vegetable oil (OECD-FAO, 2025). The crop's nutritional value is unparalleled among legumes, typically containing 40% good quality protein and 20% oil (Karoshi, *et al.*, 2022). It provides a complete amino acid profile specifically rich in lysine, tryptophan, and glycine, making it an essential alternative to animal protein in developing regions such as Nigeria (Karoshi, *et al.*, 2022). Furthermore, soybean is a significant source of essential minerals such as calcium, phosphorus, and iron, as well as bioactive compounds like lecithin and vitamins A and D, which underscore its industrial and dietary importance (Karoshi, *et al.*, 2022).

Despite its potential, soybean production in Nigeria faces significant hurdles, primarily driven by declining soil fertility and the high cost of synthetic fertilizers (Ayilara, *et al.*, 2025). Sustainable intensification through organic amendments, such as poultry manure, has gained traction (Dzvene & Chiduzza, 2024). Poultry manure is recognized as one of the most nutrient-dense livestock wastes,



offering high concentrations of nitrogen, phosphorus, and organic carbon (Rascón, *at el.*, 2024). Beyond direct nutrient supply, soybean improves soil structure, enhances microbial activity, and buffers soil pH, which is essential for the acidic soils typical of the Sudan Savanna of Nigeria (Qasim, *at el.*, 2023). Phosphorus is often the most limiting nutrient in tropical soils due to phosphorus fixation ("P-fixation"), where the nutrient becomes chemically bound and unavailable to plants (Qasim, *at el.*, 2023). Recent studies suggest that integrating organic sources such as poultry manure with phosphorus fertilizers can significantly enhance phosphorus use efficiency and soybean grain yield (Qasim, *at el.*, 2023). Therefore, this study was designed to evaluate the synergistic effects of poultry manure and phosphorus fertilizer on the growth and yield characters of soybean.

## MATERIALS AND METHODS

The experiment was conducted at Abubakar Tafawa Balewa University, Teaching and Research Farm, Bauchi in northern guinea savannah zone of Nigeria during the 2023 and 2024 rainy seasons. Bauchi state situated between 10°N 49E and 17N 90E and 690.2m above sea level. The rainy season lasts for about five months spanning between the month of June to October and dry season lasts for seven months spanning between the months November to May with an average annual rainfall of 1095mm per annum. The soybean variety used was TGX 1448-2E, obtained from the Bauchi State Agricultural Supply Company (BASAC). Poultry manure (PM) and Single Super Phosphate (SSP) were used as the organic and inorganic phosphorus sources, respectively. The treatments consisted of three (3) levels of poultry manure (0, 2.5 and 5.0 t/ha) and four (4) levels of phosphorus fertilizer (0, 13.2, 26.4 and 39.6 kg P/ha). These factors were combined factorially and laid out in a Randomized Complete Block Design (RCBD) with three replications. Prior to planting composite soil samples were collected at depths of 0–15 cm and 15–30 cm using a soil auger. These samples were analyzed for physical and chemical properties. All cultural practices of soybean were dually followed from land preparation to harvest.

Data were collected from ten randomly tagged plants from the net plot on Plant height (cm), Leaf area (cm<sup>2</sup>), Number of branches, hundred seed weight and Grain yield. The data collected were subjected to analysis of variance (ANOVA) to test the treatments effects for level of significance using a SAS, Duncans Multiple Range Test (DMRT) was adopted for means separation.

## RESULTS AND DISCUSSIONS

### Chemical Properties of Soil of the Experimental Site

The data in Table 1 showed the physical, chemical, and textural class of the soil at the experimental site in 2023 and 2024 both rainy seasons. Results indicated that, the physical composition of the soil consisted of sand, silt, and clay, and the soil textural class was sandy loam. The soil was found to be slightly acidic. It is low in total nitrogen, available phosphorus, and organic carbon across both seasons. However, the results revealed that Manganese (Mn) and Iron (Fe) levels were moderate in both seasons, while Zinc (Zn) and Copper (Cu) levels were very low.

**Table 1:** Physico-chemical Properties of Soil of the Experimental Site during 2023 and 2024 Rainy seasons

Parameter	2023 (0–15 cm)	2023 (15–30 cm)	2024 (0–15 cm)	2024 (15–30 cm)
<b>Physical composition</b>				
Silt (%)	3.28	5.28	6.2	6.25
Clay (%)	28.32	30.32	26.32	28.02
<b>Textural class</b>	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
<b>Chemical composition</b>				
Soil pH (water)	6.15	5.86	6.25	6.09
Organic carbon (g/kg)	0.93	0.64	0.95	0.45
Available P (mg/kg)	8.64	7.29	6.66	4.98
Total N (g/kg)	0.1	0.08	0.09	0.06
<b>Exchangeable bases (mg/kg)</b>				
Cation Exchange Capacity	4.75	3.62	3.75	3.25
Ca	2.68	2.13	2.88	2.11
Mg	0.58	0.44	0.71	0.49
K	0.24	0.17	0.22	0.16
Na	0.11	0.1	0.18	0.15
<b>Micronutrients</b>				
Zn	0.26	0.36	0.18	0.14
Cu	0.17	0.25	0.09	0.09
Fe	8.13	10.54	7.1	10.34
Mn	18.06	21.51	17.21	23.23

### Chemical Composition of the Poultry Manure

The result in Table 2 showed the chemical composition of the poultry manure used during the 2023 and 2024 rainy seasons. The nutrient breakdown for both the 2023 and 2024 rainy seasons respectively, were as follows: Nitrogen is 3.16 and 3.10%, Phosphorus is 1.34 and 1.32%, Potassium is 4.4 and 1.82%, Calcium is 1.93 and 2.25%, Magnesium is 0.56 and 0.50% Organic Carbon is 20.95 and 20.95%.

**Table 2:** Chemical Composition of the Poultry Manure Used

Parameter	2023	2024
<b>Nitrogen (g/kg)</b>	3.10	3.16
<b>Phosphorus (mg/kg)</b>	1.32	1.34
<b>Potassium (mg/kg)</b>	1.82	2.01
<b>Calcium (mg/kg)</b>	2.25	1.03
<b>Magnesium (mg/kg)</b>	0.50	0.36
<b>Organic carbon (g/kg)</b>	10.00	20.95

### Plant Height (cm)

The result on effect of poultry manure and phosphorus fertilizer rates on plant height of soybean during 2023 and 2024 rainy seasons is presented in Table 3. The result showed that application of 5.0 t/ha of poultry manure significantly ( $P \leq 0.05$ ) produced taller plants throughout the growing period compared to the lower application levels and the control.

Similarly, application of phosphorus at 39.6 (kg P/ha) significantly ( $P \leq 0.05$ ) gave taller plants throughout the growing periods, and outperformed the lower application rates of 0, 13.2, and 26.4 kg P/ha.

Poultry manure is highly enriched with essential macronutrients primarily Nitrogen, Phosphorus, and Potassium alongside vital micronutrients. The prominent growth response at the 5.0 t/ha rate indicates that this moderate to high organic loading improves the soil environment, facilitating a steady release of nutrients that matches the crop's demand during critical vegetative periods.

Furthermore, the pronounced increase in plant height linked to the highest phosphorus rate (39.6 kg P/ha) highlights the indispensable role of phosphorus in early crop establishment. Phosphorus is foundational for vigorous root development, energy transfer (ATP synthesis), and cellular division, all of which directly accelerate vertical vegetative growth in legumes.

The findings of this study closely align with those of Okore, *et al.* (2016), who reported that soybean plant height scales significantly with higher rates of phosphorus due to accelerated vegetative development. Similarly, these results corroborate the observations of Zafar *et al.* (2023), who noted that mineral phosphorus applications substantially boost the structural and vegetative parameters of soybean plants.

**Table 3:** Effect of Poultry Manure and Phosphorus Fertilizer on Plant Height (cm) of Soybean Grown during the 2023 and 2024 Rainy Seasons

Treatments	Plant height (cm)			
	2023		2024	
	8	10	8	10
<b>Poultry Manure (t/ha)</b>				
<b>0</b>	32.84 <sup>c</sup>	34.39 <sup>c</sup>	33.37 <sup>c</sup>	33.32 <sup>c</sup>
<b>2.5</b>	39.57 <sup>b</sup>	41.22 <sup>b</sup>	40.15 <sup>b</sup>	42.37 <sup>b</sup>
<b>5.0</b>	48.58 <sup>a</sup>	51.72 <sup>a</sup>	49.17 <sup>a</sup>	52.29 <sup>a</sup>
<b>LS</b>	**	**	**	**
<b>SE±</b>	1.70	0.94	1.13	0.96
<b>Phosphorus Fertilizer (kg P/ha)</b>				
<b>0</b>	35.59 <sup>b</sup>	38.82 <sup>b</sup>	36.54 <sup>b</sup>	39.94 <sup>b</sup>
<b>13.2</b>	38.72 <sup>b</sup>	41.10 <sup>b</sup>	39.34 <sup>b</sup>	41.84 <sup>b</sup>
<b>26.4</b>	39.33 <sup>b</sup>	45.91 <sup>b</sup>	40.10 <sup>b</sup>	42.72 <sup>b</sup>
<b>39.6</b>	47.67 <sup>a</sup>	44.76 <sup>a</sup>	47.64 <sup>a</sup>	48.72 <sup>a</sup>
<b>LS</b>	**	**	**	**
<b>SE±</b>	1.40	1.09	1.31	1.09
<b>Interaction</b>				
<b>PM x PH</b>	NS	NS	NS	NS

Means followed by the same letter (s) within a column of each treatment group are not statistically different using DMRT. WAS – Week after sowing, NS = Not Significant, \*\* = significant at (P=0.01) \* = significant at (P=0.05)

### Leaf Area (cm<sup>2</sup>)

The result of effect of poultry manure and phosphorus fertilizer rates on leaf area of soybean during 2023 and 2024 rainy seasons is presented in Table 4. The result revealed that, between the poultry manure levels, application of 5.0 (t/ha) consistently produced a significantly (P≤ 0.05) larger leaves throughout the entire experimental period compared to the lower rates and the control. However, at 10 weeks after sowing (WAS), both the 2.5 and 5.0 t/ha performed statistically at par, with both significantly (P≤0.05) outperformed the control in both seasons. Regarding the phosphorus fertilizer treatment, the highest application rate of 39.6 (kg P/ha) significantly (P≤0.05) influenced leaf area throughout the duration of the study. observably, at the advanced growth stages of 8 and 10 WAS, the differences between the 26.4 and 39.6 kg P/ha rates narrowed, with both treatments proving particularly effective and significantly (P≤0.05) producing larger leaves than the lower application rates and the control across all growing periods.

The significant expansion in leaf area as triggered by the application of 5.0 t/ha of poultry manure highlights the strategic importance of organic amendments in vegetative canopy development. This structural growth response aligns with the findings of Agba *et al.* (2017), who reported that poultry manure is heavily enriched with uric acid, an organic nitrogen form that converts rapidly in the soil into plant-available ammonium and nitrate. Nitrogen serves as the primary driver of leaf growth.

The corresponding increase in leaf area due to higher phosphorus rates, particularly at 39.6 (kg P/ha) underlines the nutrient's vital role in structural development. As observed by Kamara, *et al.*



(2019), who observed that the phosphorus is essential for the early development of leaf primordia, fueling energy-dependent cellular growth. The robust canopy expansion observed at 8 and 10 WAS under the higher phosphorus rates (26.4 and 39.6 kg P/ha) confirms that adequate phosphorus supply sustains the metabolic demands of the crop during its peak vegetative phase.

Furthermore, the overall growth patterns observed in this study agreed with the findings of Tiamiyu, *et al.* (2012), who reported that the integrated availability of rich organic fractions alongside targeted mineral nutrients promotes a significantly higher leaf area in soybean.

**Table 4:** Effect of Poultry Manure and Phosphorus Fertilizer on Leaf Area of Soybean Grown During the 2023 and 2024 Rainy Seasons

Treatments	Leaf area (cm <sup>2</sup> )			
	2023		2024	
	8	10	8	10
Poultry Manure (t/ha)				
<b>0</b>	34.84 <sup>c</sup>	38.48 <sup>b</sup>	37.11 <sup>b</sup>	37.81 <sup>b</sup>
<b>2.5</b>	38.12 <sup>b</sup>	43.82 <sup>a</sup>	39.28 <sup>b</sup>	43.74 <sup>a</sup>
<b>5.0</b>	41.10 <sup>a</sup>	47.42 <sup>a</sup>	45.27 <sup>a</sup>	46.92 <sup>a</sup>
<b>LS</b>	*	**	**	**
<b>SE±</b>	1.43	1.14	1.40	1.34
Phosphorus Fertilizer (kg P/ha)				
<b>0</b>	34.81 <sup>b</sup>	38.87 <sup>c</sup>	35.87 <sup>b</sup>	38.47 <sup>b</sup>
<b>13.2</b>	36.94 <sup>b</sup>	40.74 <sup>bc</sup>	37.63 <sup>b</sup>	40.97 <sup>b</sup>
<b>26.4</b>	40.08 <sup>a</sup>	46.12 <sup>a</sup>	43.03 <sup>a</sup>	45.90 <sup>a</sup>
<b>39.6</b>	40.23 <sup>a</sup>	47.22 <sup>a</sup>	45.68 <sup>a</sup>	46.00 <sup>a</sup>
<b>LS</b>	*	**	**	**
<b>SE±</b>	1.65	1.32	1.60	1.55
Interaction				
<b>PM x PH</b>	NS	NS	NS	NS

Means followed by the same letter(s) within a column of each treatment group are not statistically different at 5% level of probability using DMRT. WAS – week after sowing, NS = Not significant  
 \*\* = significant at (P=0.01), \* = significant at (P=0.05).

### Number of Branches per Plant

The result of effect of poultry manure and phosphorus fertilizer rates on number of branches of soybean during the 2023 and 2024 rainy seasons is presented in Table 5. The result showed that, the main effects of poultry manure significantly ( $P \leq 0.05$ ) influenced branching across all growth stages. The application of 5.0 t/ha of poultry manure consistently produced a significantly ( $P \leq 0.05$ ) higher number of branches throughout the entire growing period compared to the lower application levels and the control. Similarly, varying the rates of phosphorus fertilizer resulted in significant differences in branch production. The higher application rate of 39.6 kg P/ha significantly ( $P \leq 0.05$ ) increased the number of branches throughout the experimental period. However, a specific trend was observed at 8 weeks after sowing (WAS), where the application of both 26.4 and 39.6 kg P/ha were statistically effective, producing a significantly ( $P \leq 0.05$ ) higher number of lateral branches compared to the other rates.

The superior branching observed with the application of 5.0 t/ha of poultry manure can be attributed to the sustained nutrient delivery characteristic of high-quality organic amendments. This finding strongly aligns with the observations of Suleiman, *et al.* (2016), who indicated that organic manure provides a steady, prolonged release of nitrogen, which is foundational for driving vegetative branching. Furthermore, as corroborated by Uko, *et al.* (2020), who reported highest rates of organic manure ensure a balanced supply of both primary macronutrients and essential micronutrients, such as Boron and Zinc. From an agronomic standpoint, a higher number of branches increases the total node



count per plant, directly translating to more potential sites for subsequent pod formation and yield expression.

The significant enhancement in branching due to elevated phosphorus rates particularly at 39.6 kg P/ha highlights the indirect structural benefits of mineral phosphorus. Legumes demand substantial energy for structural framework expansion. The application of 39.6 kg P/ha promotes aggressive root proliferation, which expands the root surface area and enhances overall nutrient and water uptake, thereby allowing the above-ground canopy to support a denser branch framework.

This mechanism is strongly supported by Zafar, *et al.* (2013), who demonstrated that adequate phosphorus levels enhance the structural framework of legumes, ultimately culminating in a more complex, robust, and highly productive branching architecture.

**Table 5:** Effect of Poultry Manure and Phosphorus Fertilizer on Number of Branches per Plant of Soybean Grown During the 2023 and 2024 Rainy Season

Treatments	Number of branches per plant			
	2023		2024	
	8	10	8	10
<b>Poultry Manure (t/ha)</b>				
<b>0</b>	11.00 <sup>c</sup>	11.00 <sup>b</sup>	12.00 <sup>b</sup>	12.00 <sup>b</sup>
<b>2.5</b>	12.00 <sup>b</sup>	12.00 <sup>b</sup>	12.00 <sup>ab</sup>	13.00 <sup>ab</sup>
<b>5.0</b>	13.00 <sup>a</sup>	13.00 <sup>a</sup>	13.00 <sup>a</sup>	14.00 <sup>a</sup>
<b>LS</b>	**	**	*	**
<b>SE±</b>	0.30	0.28	0.35	0.24
<b>Phosphorus Fertilizer (kg P/ha)</b>				
<b>0</b>	11.00 <sup>b</sup>	11.00 <sup>b</sup>	11.00 <sup>c</sup>	12.00 <sup>b</sup>
<b>13.2</b>	11.00 <sup>b</sup>	12.00 <sup>b</sup>	12.00 <sup>b</sup>	13.00 <sup>b</sup>
<b>26.4</b>	11.00 <sup>b</sup>	12.00 <sup>b</sup>	12.00 <sup>b</sup>	13.00 <sup>b</sup>
<b>39.6</b>	14.00 <sup>a</sup>	14.00 <sup>a</sup>	14.00 <sup>a</sup>	15.00 <sup>a</sup>
<b>LS</b>	**	**	**	**
<b>SE±</b>	0.26	0.25	0.40	0.27
<b>Interaction</b>				
<b>PM x PH</b>	NS	NS	NS	NS

Means followed by the same letter(s) within a column of each treatment group are not statistically different at 5% level of probability using DMRT. WAS – week after sowing, NS = Not significant \*\* = significant at (P=0.01), \* = significant at (P=0.05)

### 100-Seed Weight of Soybean and Grain Yield per Hectare

The result of effect of poultry manure and phosphorus fertilizer rates on 100-seed weight and grain yield of soybean grown during 2023 and 2024 rainy seasons is presented in Table 6: The result indicated that, highest 100-seed weights and grain yield were recorded under the application of 5.0 t/ha of poultry manure and phosphorus fertilizer rates of 26.4 and 39.6 kg P/ha. Result of the interaction of poultry manure and phosphorous fertilizer (Table 7) on yield of soybean revealed that, combine application of 5 t/ha PM and 39.6 kg/ha P. produced the highest yield of soybean during 2023 rainy season.

This outcome aligns with existing literature indicating that adequate phosphorus ensures proper embryonic development, while the diverse micronutrients found in organic manure are critical for seed "plumping" (Adewole, *et al.*, 2011).

Furthermore, seed size is heavily dependent on the concurrent availability of both potassium (K) and phosphorus (P), as reported by Khalil, *et al.* (2021). Because poultry manure serves as an excellent source of organic potassium, the 5.0 t/ha rate provided optimal nutrition to guarantee that the seeds were well-filled, dense, and heavy at harvest. These findings also broadly support the assertions of Yeboah (2016), who reported that poultry manure application significantly enhances seed weight and seed quality parameters in soybean.

These results validate the premise that integrated nutrient management is the most effective strategy for increasing soybean yields in tropical soils (Tiamiyu, *et al.*, 2012).

This significant yield improved is heavily attributed to the biological synergy between organic manure and mineral phosphorus, which enhances pod retention and extends the grain-filling period (Ayoola and Makinde, 2009). These findings conform directly with Not in the reference list, who evaluated soybean performance in the African Savanna and concluded that phosphorus fertilizer remains the single most critical mineral input driving final grain yield.

**Table 6:** Effect of poultry manure and phosphorus fertilizer on 100 seeds weight and grain yield (kg/ha) of soybean grown during the 2023 and 2024 rainy seasons

Treatments	2023		2024	
	100 seeds weight (g)	Grain yield (kg/ha)	100 seeds weight (g)	Grain yield (kg/ha)
<b>Poultry Manure (t/ha)</b>				
0	10.77 <sup>c</sup>	1962.03 <sup>b</sup>	11.28 <sup>b</sup>	2121.12 <sup>b</sup>
2.5	12.10 <sup>b</sup>	2265.31 <sup>ab</sup>	12.29 <sup>a</sup>	2357.89 <sup>ab</sup>
5.0	12.85 <sup>a</sup>	2608.62 <sup>a</sup>	12.90 <sup>a</sup>	2504.49 <sup>a</sup>
LS	**	*	**	*
SE±	0.17	87.50	0.20	85.90
<b>Phosphorus Fertilizer (kg P/ha)</b>				
0	11.04 <sup>b</sup>	1889.02 <sup>b</sup>	11.30 <sup>b</sup>	1970.26 <sup>b</sup>
13.2	11.38 <sup>b</sup>	1963.40 <sup>b</sup>	11.59 <sup>b</sup>	2042.40 <sup>b</sup>
26.4	12.37 <sup>a</sup>	2583.32 <sup>a</sup>	12.69 <sup>a</sup>	2580.92 <sup>a</sup>
39.6	12.80 <sup>a</sup>	2608.88 <sup>a</sup>	12.99 <sup>a</sup>	2717.76 <sup>a</sup>
LS	**	**	**	**
SE±	0.20	101.03	0.23	99.19
<b>Interaction</b>				
PM x PH	NS	*	NS	NS

Means followed by the same letter(s) within a column of each treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant \*\* = significant at (P=0.01)

\* = significant at (P=0.05) WAP = Week After Planting

**Table 7:** Interaction of Poultry Manure and Phosphorus Fertilizer on Grain Yield of Soybean Grown During 2023 Rainy Seasons

Phosphorus (kg P/ha)	Poultry Manure (t/ha)		
	0	25	50
0	1294.84 <sup>ef</sup>	1927.80 <sup>dc</sup>	2444.43 <sup>abcd</sup>
13.2	1406.77 <sup>ef</sup>	2111.13 <sup>cd</sup>	2372.30 <sup>ab</sup>
26.4	2638.77 <sup>ab</sup>	2416.73 <sup>abcd</sup>	2694.47 <sup>ab</sup>
39.6	250777 <sup>ab</sup>	2605.57 <sup>abc</sup>	2923.30 <sup>a</sup>
LS		*	
SE±		174.99	

\* = Significant at 5% level of probability. LS = level of significant

## CONCLUSION AND RECOMMENDATION

The study concluded that soybean performance is significantly enhanced by the application of poultry manure at rates of 2.5 and 5.0 t/ha. Furthermore, for sustainable soybean cultivation in the study area, the application of phosphorus fertilizer within the range of 26.4 to 39.6 kg/ha is highly effective in improving growth and yield parameters.

Based on these findings, an integrated nutrient management approach combining poultry manure with phosphorus fertilizer is essential for sustainable soybean production. Specifically, the application of 2.5 t/ha of poultry manure in conjunction with 26.4 kg/ha of phosphorus fertilizer is recommended for farmers in the study area to achieve optimal productivity.



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