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Comparative analysis of poultry manure and inorganic fertilizer on the growth of glycine max (Soybean)

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ABSTRACT

This study investigated the comparative effects of poultry manure and inorganic fertilizer on the growth performance of two soybean (Glycine max) varieties, TGS 1835 and TGX 1345, under controlled conditions in Kano, Nigeria. The experiment followed a randomized complete block design (RCBD) with three replications. Treatments included varying rates of NPK fertilizer (0, 1.3 g/pot, 1.5 g/pot, and 2 g/pot) and poultry manure mixtures (ratios of 5:1, 4:1, and 3:1 soil to manure). Growth parameters assessed included stem height, number of leaves, number of branches, chlorophyll content, and leaf area at 2, 4, and 6 weeks after planting (WAP). Data collected were analyzed using two-way Analysis of Variance (ANOVA), and means were separated using Least Significant Difference (LSD) at a 5% probability level. The results from this study reveal that the application of inorganic fertilizer, particularly at 1.3 g/pot, significantly enhances plant height, chlorophyll content, and leaf area. Similarly, poultry manure at a 5:1 ratio improves growth parameters compared to other organic treatments. Variety TGS 1835 consistently shows higher performance across all growth parameters compared to TGX 1345. These findings suggest that the combined and appropriate use of poultry manure and inorganic fertilizer can improve soybean growth and contribute to sustainable crop production in nutrient-depleted soils.

Contribution/Originality: This study contributes to the existing literature by evaluating the long-term effects of the combined usage of poultry manure and inorganic fertilizer on soybean growth. It presents novel data from Nigeria, a tropical agroecosystem, offering insights into improving soybean growth and advancing sustainable food production in nutrient-depleted soils.

1. INTRODUCTION

Soybean (Glycine max L.) is among the most economically important leguminous crops globally and is increasingly gaining attention in sub-Saharan Africa, particularly in Nigeria, due to its nutritional, agronomic, and industrial significance. Soybean was first successfully cultivated in Nigeria in 1937 using the Malayan variety, which was later found suitable for commercial production, especially in Benue State in North Central Nigeria. Since its introduction, soybean cultivation has expanded across several agro-ecological zones in the country, including the Guinea and Sudan savannas, owing to its adaptability to varying climatic and soil conditions.

In Sub-Saharan Africa, Nigeria produces more soybeans for food than any other country [1]. It is primarily grown for food. The crop is primarily cultivated for human consumption, where it serves as a major source of plant-based protein, but its importance extends beyond food use. Soybean stems, haulms, and post-processed residues are extensively used as animal feed, contributing to livestock nutrition and integrated farming systems [2]. This dual-purpose nature enhances its value in smallholder farming systems, where crop–livestock integration is common.

Soybeans are particularly favourable for cultivation in Nigeria due to their tolerance to a wide range of environmental stresses, including variable rainfall patterns, moderate pest pressure, and certain diseases. In addition, soybean requires relatively lower fertilizer inputs compared to many cereal crops, largely due to their ability to fix atmospheric nitrogen through symbiotic relationships with Rhizobium species in root nodules. This nitrogen-fixing capability improves soil fertility and makes soybean an excellent rotational crop, especially in regions where the availability and affordability of chemical fertilizers remain a major constraint to crop production. The inclusion of soybeans in crop rotations has been shown to enhance soil nitrogen status, improve subsequent crop yields, and reduce dependency on synthetic nitrogen fertilizers.

Among the plant-based foods, soybean is fairly unique due to the high quality of their protein. The protein contained in soybean I considered one of the most complete plant proteins, as it contains approximately 36-56% protein on a dry weight basis, making it superior to many other legumes and cereals in protein content. In addition to being rich in protein, soybeans are also high in carbohydrates and fats, providing both energy and essential fatty acids. Soybean products contain little to no cholesterol, low levels of saturated fats, and are lactose-free, making them suitable for individuals with lactose intolerance or cardiovascular health concerns [3].

Approximately 80% of soybean protein consists of two major storage proteins, glycinin (11S globulin) and β-conglycinin (7S globulin). While these proteins contribute significantly to the nutritional value of soybeans, they have also been identified as potential allergens capable of triggering allergic reactions in susceptible individuals [4]. This has generated interest in agronomic and breeding strategies aimed at improving soybean quality while maintaining high yield performance.

Despite its numerous advantages, soybean productivity in Nigeria remains below its potential, largely due to declining soil fertility, poor soil structure, and limited access to appropriate nutrient management options. In many tropical soils, continuous cultivation without adequate nutrient replenishment has resulted in soil degradation, nutrient depletion, and reduced microbial activity. To enhance soybean growth and productivity, fertilization plays a vital role, particularly in degraded soils where native nutrient levels are insufficient to support optimal crop performance.

Chemical fertilizers, although very effective in supplying essential nutrients, have been reported to affect the microflora of the soil by altering the chemical constitution and physical characteristics of the soil [5-8]. Long-term and indiscriminate use of inorganic fertilizers can lead to soil acidification, imbalance of nutrients, reduction in microbial diversity, and environmental pollution. However, low yields and a shortage of fertilizer restrict the ability of some countries, especially developing countries, to increase soybean production. As such, in Nigeria, soybean residues such as haulms and post-harvest mulch serve as vital sources of animal feed and organic matter, contributing to farm sustainability [1].

According to Sandrakirana and Arifin [9] poor soil fertility has been identified as the main impediment to maximizing crop yield. The use of fertilizers, both organic and inorganic, to improve crop yield is encouraged. Fertilizers are materials containing one or more nutrient elements in the form of chemical compounds of organic or inorganic nature. They occur either as natural deposits or are manufactured in a chemical factory. The two main types of Fertilizer include: (i) Organic Fertilizer, (ii)Inorganic Fertilizer.

Organic fertilizers are natural materials of either plant or animal origin, including livestock manure, poultry droppings, compost, green manures, crop waste, domestic waste, and work primarily as a source of plant nutrients and indirectly improve the soil [10]. Organic fertilizers play major roles by satisfying plants' nutritional needs as well as improving the physical, chemical, and biological characteristics of the soil, such as soil structure, water holding capacity, microbial activity, and nutrient cycling. They are advantageous in many ways in crop management as they can be used as a source of micro- and macro-nutrients for plants [11-13] as they occur in slow-release form, thereby reducing nutrient losses and improving nutrient use efficiency.

Inorganic fertilizers, on the other hand, are those fertilizers that are synthesized artificially, manufactured, and mined from nonliving materials and contain nutrients in readily available forms that are easily absorbed by plants. These fertilizers swiftly improve crop yield and growth rate [14] by correcting nutrient deficiencies and encouraging crop improvement and growth. Despite the many advantages, the exclusive use of inorganic fertilizers is not popular among farmers and is very much discouraged because of their unfavorable effects on the environment, such as soil acidification, pollution of water bodies through nutrient leaching, greenhouse gas emissions, their scarcity, and high cost [15]. These factors limit their use among smallholder farmers in Nigeria and in other developing countries.

Given these challenges, there is an increasing interest in evaluating the combined and comparative effects of organic and inorganic fertilizers on soybean growth and development. Understanding how different fertilizer sources influence growth parameters such as stem height, leaf number, branching, chlorophyll content, and leaf area is essential for developing integrated nutrient management strategies that enhance soybean productivity while maintaining soil health.

2. MATERIALS AND METHODS

2.1. Study Area and Seed Collection

The seeds of the selected soybean varieties were collected from the International Institute of Tropical Agriculture (IITA), Kano station, Nigeria. Two improved varieties, TGS 1835 and TGX1345, were evaluated. The study was conducted in round plastic pots of 9x11 cm at the botanical garden in the Department of Plant Biology, Bayero University, Kano. The area is located in the Sudan Savannah ecological zone, which lies between Latitude 22°89N, Longitude 58°82W of Kano, Nigeria.

2.2. Experimental Design and Treatment

The experiment was arranged in an RCBD with three replications (blocks). The two factors were the rate of NPK fertilizer application and the rate of poultry manure application. The NPK rates consisted of control (0), 1.3g/pot,1.5g/pot and2g/pot. Poultry manure potting mixture consisted of control (0), sandy loam soil, and poultry manure in the ratios 5:1,4:1 and 3:1. Two varieties of soybean were used in the research. Each block consisted of 7 pots, making a total of 21 pots per variety. Two plants stand per pot, and the experiment was terminated at week 6 after planting.

2.3. Data Collection

- Chlorophyll: A SPAD-502 meter was used for the measurement of leaf chlorophyll concentrations at 2,4 and 6 WAP.
- Leaf area: Leaf Area meter was used to measure the leaf area of the plant at 2,4 and 6 WAP.
- Number of Leaves - The number of leaves was counted and recorded.
- Number of Branches-Number of leaves were counted and recorded.

2.4. Data Analysis

Data were analyzed using two-way Analysis of Variance (ANOVA), and means were separated using Least Significant Difference (LSD) at a 5% probability level.

3. RESULTS

The results of the effect of poultry manure and inorganic fertilizer rates on stem height are presented in Table 1. It was observed that the stem height varied between the varieties, with TGS 1835 significantly taller than TGX 1345.

It was observed that the control recorded the longest height statistically at 2 weeks after planting, while P3:1 recorded the shortest height. Four weeks after planting, the control recorded the tallest height; however, statistically similar values were observed in F1.3g, F1.5g, and F2g. At 6 weeks after planting, F1.3g was observed to produce plants with greater height; however, control, F1.5g, and F2g were recorded as statistically similar to F1.3g, while P3:1, P4:1, and P5:1 produced plants with shorter height. Table 2 shows that the interaction between the treatment and the varieties is analyzed. At 2 weeks after planting, TGS1835 has significantly shorter plants than TGX1345 under P3:1 and P4:1 treatments, while P5:1 under TGS1835 records the tallest plant. At 4 weeks, P5:1 and control have statistically similar values and are the tallest plants under TGS1835.

Table 1. Effect of poultry manure and inorganic fertilizer on stem height (cm) of Glycine max. (Soya Beans).

Sources of variation	Mean (2WAP)	Mean (4WAP)	Mean (6WAP)
Variety			
TGS 1835	9.26^{a}	11.06^{a}	13.72^{a}
TGX1345	5.21^{b}	7.91^{b}	11.52^{b}
LSD (0.05)	3.05	2.71	2.38
Treatments			
Control	10.35^{a}	13.72^{a}	17.52^{a}
F1.3g	8.87^{a}	13.48^{a}	17.98^{a}
F1.5g	9.20^{a}	12.62^{a}	16.68^{a}
F2g	8.35^{ab}	12.17^{a}	16.52^{a}
P3:1	3.05^{c}	3.30^{c}	4.12^{c}
P4:1	4.13^{c}	3.95^{c}	7.75^{b}
P5:1	6.70^{b}	7.18^{b}	7.80^{b}
LSD (0.05)	2.16	1.92	1.68
Interaction			
Variety x treatment	***	***	***
LSD (0.05)	0.80	0.71	0.63

Note: The alphabet in superscripts (a, ab, b, c) shows the rankings of the results based on statistical groupings using Least Significant Difference at 5% probability ($p < 0.05$). It indicates that Means with the same letter are NOT significantly different from each other, while means with different letters ARE significantly different.

Table 2. Interaction effects between treatments and variety.

Time period	Sources of variation	Control	F1.3g	F1.5g	F2g	P3:1	P4:1	P5:1
2WAP	TGS1835	9.73^{c}	9.83^{c}	10.17^{b}	9.40^{c}	5.20^{f}	7.07^{e}	13.40^{a}
	TGX1345	10.97^{b}	7.90^{de}	8.23^{d}	7.30^{e}	0.90^{g}	1.20^{g}	0.00^{h}
4WAP	TGS1835	14.10^{a}	13.23^{bc}	12.57^{c}	12.57^{c}	4.67^{f}	5.93^{e}	14.37^{a}
	TGX1345	13.33^{bc}	13.73^{ab}	12.67^{c}	11.77^{d}	1.93^{g}	1.97^{g}	0.00^{h}
6WAP	TGS1835	16.40^{c}	17.87^{b}	18.00^{b}	18.83^{a}	0.00^{i}	9.33^{f}	15.60^{d}
	TGX1345	18.63^{ab}	18.10^{b}	15.37^{d}	14.20^{e}	8.23^{g}	6.17^{h}	0.00^{i}

Note: Means with different letters in the column indicate significance ($p<0.05$). The alphabet in superscripts (a, ab, b, c) shows the rankings of the results based on statistical groupings using Least Significant Difference at 5% probability ($p < 0.05$). It indicates that Means with the same letter are NOT significantly different from each other, while means with different letters ARE significantly different. *WAP: = Weeks after planting.

The results of the effect of inorganic fertilizer and poultry manure rates on the number of leaves per plant are presented in Table 3. It was observed that the number of leaves varied between varieties at 2 weeks after planting, where TGS1835 recorded a higher number of leaves.

Two weeks after planting, Control was observed to produce more leaves; however, statistically similar values were observed with F1.5g and F2g. P3:1 produced the least number of leaves. 4 weeks after planting, F1.3g and F1.5g produced the highest number of leaves; however, statistically similar values were seen with Control, and F2g, P3:1, and P5:1 produced the least number of leaves. 6 weeks after planting, F2g produced the highest number of leaves, and P3:1 produced the least number of leaves.

Table 3. Effect of poultry manure and inorganic fertilizer on the number of leaves of Glycine max. (Soya Beans).

Sources of variation	Mean (2WAP)	Mean (4WAP)	Mean (6WAP)
Variety			
TGS1835	8.00^{a}	8.29^{*}	12.57^{*}
TGX1345	5.05^{b}	7.10^{*}	11.14^{*}
LSD (0.05)	2.79	NS	NS
Treatments			
Control	9.17^{a}	9.67^{a}	12.33^{b}
F1.3g	6.83^{b}	11.00^{a}	13.83^{ab}
F1.5g	8.33^{a}	11.00^{a}	14.67^{ab}
F2g	8.17^{a}	10.00^{a}	16.00^{a}
P3:1	2.50^{e}	2.33^{b}	5.67^{c}
P4:1	4.67^{c}	3.33^{b}	11.67^{bc}
P5:1	6.00^{bc}	2.33^{b}	8.83^{c}
LSD (0.05)	1.97	3.02	3.44
Interaction			
Variety x treatment	**		
LSD (0.05)	0.74	NS	NS

Note: The alphabet in superscripts (a, ab, b, c) shows the rankings of the results based on statistical groupings using Least Significant Difference at 5% probability ($p < 0.05$). It indicates that Means with the same letter are NOT significantly different from each other, while means with different letters ARE significantly different.

Table 4 shows the interaction between variety and treatment at 2 weeks after planting, with Control and F2g producing the highest number of leaves. Statistically similar values were observed with P5:1 under the TGS1835 variety. TGX1345 produced the fewest leaves.

Table 4. Interaction effects between variety and treatment.

Time Period	Plant variety	Control	F1.3g	F1.5g	F2g	P3:1	P4:1	P5:1
2WAP	TGS1835	9.67^{a}	8.00^{b}	9.00^{ab}	9.67^{a}	2.67	7.67^{c}	9.33^{a}
	TGX1345	8.67^{b}	5.67^{e}	7.67^{c}	6.67^{d}	2.33^{fg}	1.67^{g}	2.67^{f}

Note: Means with different letters in the column indicate significant ($p<0.05$). Note: The alphabet in superscripts (a, ab, b, c) shows the rankings of the results based on statistical groupings using Least Significant Difference at 5% probability ($p < 0.05$). It indicates that Means with the same letter are NOT significantly different from each other, while means with different letters ARE significantly different. *WAP: Weeks after planting.

The results of the effect of inorganic fertilizer and poultry manure rates on the number of branches per plant are presented in Table 5. It was observed that there was no significant difference between the two varieties at 2 weeks and 4 weeks after planting. 6 weeks after planting, TGS1835 produced a higher number of branches. 6 weeks after planting, P5:1 produced the highest number of branches, and P3:1 recorded the lowest number of branches.

Table 5. Effect of poultry manure and inorganic fertilizer on the number of branches of Glycine max. (Soya Beans).

Sources of variation	Mean (2WAP)	Mean (4WAP)	Mean (6WAP)
Variety			
TGS1835	1.71^{*}	3.00^{*}	5.86^{a}
TGX1345	1.38^{*}	3.24^{*}	4.48^{b}
LSD (0.05)	NS	NS	1.34
Treatments			
Control	1.50^{*}	3.17^{*}	5.50^{ab}
F1.3g	2.00^{*}	3.50^{*}	5.83^{ab}
F1.5g	1.83^{*}	3.50^{*}	5.67^{ab}
F2g	1.33^{*}	3.00^{*}	5.33^{b}
P3:1	1.33^{*}	3.17^{*}	3.50^{c}
P4:1	1.50^{*}	3.00^{*}	4.00^{c}
P5:1	1.33^{*}	2.50^{*}	6.33^{a}
LSD (0.05)	NS	NS	0.95
Interaction			
Variety x treatment			***
LSD (0.05)			0.35

Note: * (Asterisk) indicates that there is no significant difference between the different varieties, control, and treatment across weeks after planting.

Table 6 shows the interaction between the varieties and treatments. It was observed that P5:1 of the TGS1835 variety produced the highest number of leaves, and P3:1 of the TGX1345 variety produced the least number of branches.

Table 6. Interaction effects between varieties and treatments.

Planting Time	Plant variety	Control	F1.3g	F1.5g	F2g	P3:1	P4:1	P5:1
6WAP	TGS1835	6.33^{b}	5.33^{cd}	5.67^{c}	5.67^{c}	5.33^{cd}	5.67^{c}	7.00^{a}
	TGX1345	4.67^{d}	6.33^{b}	5.67^{c}	5.00^{d}	1.67^{e}	2.33^{e}	5.67^{c}

Note: Means with different letters in the column indicate significant (p<0.05). The alphabet in superscripts (a, ab, b, c) shows the rankings of the results based on statistical groupings using Least Significant Difference at 5% probability (p < 0.05). It indicates that Means with the same letter are NOT significantly different from each other, while means with different letters ARE significantly different, WAP: Weeks after planting.

The results of the effect of inorganic fertilizer and poultry manure rates on the chlorophyll content per plant are presented in Table 7. It is observed that there is a significant difference at two weeks after planting, with no significant difference at four and six weeks after planting.

Two weeks after planting, F1.3g recorded the highest chlorophyll content; however, F2g recorded statistically similar values. P3:1 recorded the least chlorophyll content.

Table 8 shows the interaction between the varieties and the treatment. It is observed that the TGS1835 variety with treatment F1.3g records the highest chlorophyll content; however, F2g records a statistically similar value. The TGX1345 variety with treatment F2g recorded the least chlorophyll content.

Table 7. Effect of poultry manure and inorganic fertilizer on chlorophyll content of Glycine max. (Soya Beans).

Sources of variation	Mean (2WAP)	Mean (4WAP)	Mean (6WAP)
Variety			
TGS1835	35.66^{a}	34.94*	35.06*
TGX1345	32.22^{b}	35.82*	33.68*
LSD (0.05)	3.40	NS	NS
Treatments			
Control	33.12^{bc}	35.35*	35.50*
F1.3g	37.35^{a}	37.50*	36.87*
F1.5g	32.57^{bc}	34.68*	32.28*
F2g	35.08^{ab}	35.58*	33.59*
P3:1	31.35^{c}	34.60*	33.08*
P4:1	33.48^{bc}	35.50*	30.10*
P5:1	34.63^{b}	34.47*	39.17*
LSD (0.05)	2.41	NS	NS
Interaction			
Variety x treatment	***		
LSD (0.05)	0.90		

Note: The alphabet in superscripts (a, ab, b, c) shows the rankings of the results based on statistical groupings using Least Significant Difference at 5% probability (p < 0.05). It indicates that Means with the same letter are NOT significantly different from each other, while means with different letters ARE significantly different.

Table 8. Interaction effects between varieties and treatments.

Planting period	Plant variety	Control	F1.3g	F1.5g	F2g	P3:1	P4:1	P5:1
2WAP	TGS1835	35.33^{c}	40.03^{a}	32.20^{ef}	39.97^{a}	31.50^{f}	32.93^{e}	37.63^{b}
	TGX1345	30.90^{fg}	34.67^{cd}	32.93^{e}	30.20^{g}	31.20^{f}	34.03^{d}	31.63^{f}

Note: Means with different letters in the column indicate significant(p<0.05), WAP: Weeks after planting.

The results of the effect of inorganic fertilizer and poultry manure rates on the leaf area per plant are presented in Table 9. It was observed that there is a significant difference between the varieties at two, four, and six weeks, with TGS1835 having the highest leaf area.

Two weeks after planting, P5:1 recorded the highest leaf area; however, the control recorded a statistically similar value. F1.3g, F1.5g, F2g, P3:1, and P4:1 recorded statistically similar values. At four weeks, P3:1 recorded the highest chlorophyll content, and control, F1.5g, P4:1, and P5:1, with statistically similar values, recorded the least leaf area. At six weeks after planting, F1.3g recorded the highest leaf area; P3:1 and F1.5g recorded statistically similar values. Control and P5:1, with statistically similar values, recorded the least leaf area.

Table 9. Effect of poultry manure and inorganic fertilizer on the leaf area of Glycine max. (Soya Beans).

Sources of variation	Mean (2WAP)	Mean (4WAP)	Mean (6WAP)
Variety			
TGS1835	15.40^{a}	18.60^{a}	23.94^{a}
TGX1345	11.34^{b}	15.20^{b}	19.75^{b}
LSD (0.05)	2.67	2.78	1.63
Treatments			
Control	15.46^{ab}	16.20^{b}	19.94^{c}
F1.3g	12.44^{b}	17.67^{ab}	23.45^{a}
F1.5g	14.37^{b}	16.28^{b}	23.03^{ab}
F2g	13.36^{b}	18.12^{ab}	20.27^{c}
P3:1	10.90^{b}	18.58^{a}	22.73^{ab}
P4:1	10.10^{b}	14.69^{b}	21.51^{b}
P5:1	16.96^{a}	16.79^{b}	20.61^{c}
LSD (0.05)	1.89	1.97	1.15
Interaction			
Variety x treatment	***	***	***
LSD (0.05)	0.70	0.73	0.43

Note: The alphabet in superscripts (a, ab, b, c) shows the rankings of the results based on statistical groupings using Least Significant Difference at 5% probability ($p < 0.05$). It indicates that Means with the same letter are NOT significantly different from each other, while means with different letters ARE significantly different.

Table 10 shows the interaction between the varieties and treatment at two, four, and six weeks after planting.

Table 10. Interaction table.

Planting period	Plant Variety	Control	F1.3g	F1.5g	F2g	P3:1	P4:1	P5:1
2WAP	TGS1835	14.59^{c}	16.83^{b}	19.45^{a}	14.64^{c}	12.92^{d}	10.31^{f}	19.05^{a}
	TGX1345	16.33^{b}	8.05^{h}	9.29^{g}	12.07^{e}	8.89^{g}	9.89^{fg}	14.86^{c}
4WAP	TGS1835	19.52^{b}	20.49^{a}	19.84^{ab}	20.21^{ab}	20.23^{ab}	13.30^{f}	16.59^{cd}
	TGX1345	12.87^{f}	14.84^{e}	12.71^{f}	16.04^{d}	16.92^{c}	16.07^{d}	16.99^{c}
6WAP	TGS1835	21.90^{h}	24.69^{b}	22.37^{g}	24.03^{c}	23.55^{d}	25.21^{a}	23.04^{f}
	TGX1345	17.97^{i}	22.22^{gi}	23.69^{e}	16.51^{j}	21.91^{h}	17.80^{i}	18.17^{i}

Note: Means with different letters in the column indicate significant($p<0.05$). The alphabet in superscripts (a, ab, b, c) shows the rankings of the results based on statistical groupings using Least Significant Difference at 5% probability ($p < 0.05$). It indicates that Means with the same letter are NOT significantly different from each other, while means with different letters ARE significantly different. WAP: Weeks after planting.

4. DISCUSSION

The results of this study demonstrated that both inorganic fertilizer and poultry manure significantly influenced the vegetative growth parameters of soybean, including stem height, number of leaves, number of branches, chlorophyll content, and leaf area. These findings emphasize the importance of appropriate nutrient management in optimizing soybean growth and varietal performance under the agro-ecological conditions of Kano, Nigeria.

The results on the effect of inorganic fertilizer and poultry manure on the stem height show that application of inorganic fertilizer at the rate of F1.3g significantly increased the stem height. This result can be attributed to the rapid availability of essential nutrients, particularly nitrogen, phosphorus, and potassium, supplied by inorganic fertilizers, which promote cell elongation and vegetative growth. Similarly, a study conducted by Espinoza [16] reported that nutrients in organic fertilizers are readily available for plant uptake upon application, while the organic fertilizers take longer to be absorbed. The application of poultry manure in the ratio 5:1 significantly increased the stem height of soybeans; this finding was similar to research conducted by Falodun and Osaigbovo [17] which reported that stem height was enhanced by organic and inorganic fertilizers.

The results on the effect of inorganic fertilizer and poultry manure on the number of leaves show that inorganic fertilizer application at the rate of F1.5g produced more leaves than other fertilizer rates; however, poultry manure in the ratio 4:1 produced more leaves than other ratios. Poultry manure is known to contain substantial amounts of nitrogen, phosphorus, potassium, calcium, and organic matter, which collectively enhance soil fertility and support sustained plant growth. As seen in a report by Chiezey and Odunze [18] poultry manure contains important plant nutrients that enhance cell division, which leads to increased growth and development.

The results on the effect of inorganic fertilizer and poultry manure on the number of branches show that poultry manure in the ratio 5:1 produced a greater number of branches at 6 weeks after planting compared to the other ratios, while fertilizer application at the rate of 1.5g produced the highest number of branches. The superior branching response to poultry manure at the 5:1 ratio suggests that the gradual release of nutrients from organic sources may be more conducive to sustained lateral growth and branch development compared to the rapid but potentially transient nutrient supply from inorganic fertilizers. Additionally, organic amendments improve soil physical properties such as structure, water-holding capacity, and aeration, which may indirectly promote root development and, consequently, support greater branching.

The results on the effect of inorganic fertilizer and poultry manure on chlorophyll content show that inorganic fertilizer application at the rate of F1.3g recorded the highest chlorophyll content at 2 weeks after planting. The result also shows that poultry manure in the ratio 5:1 recorded the highest chlorophyll content. The chlorophyll content was not significantly different at 4 and 6 weeks after planting. The higher chlorophyll content observed with inorganic fertilizer application at F1.3g can be attributed to the immediate availability of nitrogen, which is rapidly incorporated into chlorophyll synthesis during early growth stages. However, the performance of poultry manure at the 5:1 ratio demonstrates that organic amendments can also effectively support chlorophyll production, likely through sustained nitrogen availability and improved nutrient use efficiency. Interestingly, chlorophyll contents were not significantly different at 4 and 6 weeks after planting, suggesting that as plants matured and symbiotic nitrogen fixation became more established, the differential effects of fertilizer types diminished. This observation aligns with findings by Taj, et al. [19] who documented that chlorophyll content was higher in organically treated plots than in 100% NPK treatments, particularly at 30 days after sowing during the pre-flowering stage.

Chlorophyll content is a key indicator of plant photosynthetic capacity and overall nitrogen status, as nitrogen is a central component of the chlorophyll molecule.

The results on the effect of inorganic fertilizer and poultry manure on the leaf area show a statistical difference in 2,4 and 6 weeks after planting. Fertilizer application at the rate of F1.3g recorded the highest leaf area, while poultry manure in the ratio of P3:1 recorded the highest leaf area.

The results of this study demonstrated that both inorganic fertilizer and poultry manure significantly influenced the vegetative growth parameters of soybean, including stem height, number of leaves, number of branches, chlorophyll content, and leaf area. These findings underscore the importance of appropriate nutrient management in optimizing soybean growth and varietal performance. Recent research by Cigelske, et al. [20] demonstrated that the combined application of poultry manure and NPK fertilizer synergistically improved soil physicochemical parameters and nutrient availability in alkaline-calcareous soils, with a combination of 10 tons per hectare poultry manure and 75% NPK fertilizer increasing extractable soil phosphorus by 157.6%. This synergistic effect may explain the superior performance observed in treatments combining both fertilizer types, as improved soil conditions facilitate nutrient uptake and promote vegetative growth.

The observed effect of inorganic fertilizer and poultry manure on stem height revealed that inorganic fertilizer application at the rate of F1.3 g significantly increased stem height compared to other fertilizer rates. This result can be attributed to the rapid availability of essential nutrients, particularly nitrogen, phosphorus, and potassium, supplied by inorganic fertilizers, which promote cell elongation and vegetative growth. Similar observations were reported by Espinoza [16] who noted that nutrients in inorganic fertilizers are readily available for plant uptake immediately after application, whereas nutrients from organic fertilizers require microbial decomposition before becoming available to plants.

Nevertheless, poultry manure applied at a ratio of 5:1 also significantly increased soybean stem height, indicating its effectiveness as a nutrient source. Poultry manure is known to contain substantial amounts of nitrogen, phosphorus, potassium, calcium, and organic matter, which collectively enhance soil fertility and support sustained plant growth. This finding aligns with the results of Falodun and Osaigbovo [17] who reported enhanced stem height in crops treated with both organic and inorganic fertilizers. The gradual nutrient release from poultry manure may have contributed to steady growth over time, complementing the immediate effects of inorganic fertilizer.

The contrasting effects of inorganic fertilizer and poultry manure may be explained by their influence on soil biological activity. Poultry manure stimulates microbial biomass and enzymatic activity, enhancing nutrient mineralization and cycling. This increases nitrogen, phosphorus, and micronutrient availability, supporting sustained growth. Soils with poultry manure show higher microbial respiration and enzyme activities, improving nutrient synchrony with crop demand. Adeleye, et al. [21] and Lazcano, et al. [22]. This microbial-mediated nutrient release may partly explain the improved branching, chlorophyll content, and leaf area observed under higher poultry manure ratios in the present study.

Hungria, et al. [23] and Salvagiotti, et al. [24] opine that Soybean relies on soil nitrogen and biological nitrogen fixation (BNF) via Bradyrhizobium symbiosis. Excessive inorganic nitrogen can suppress nodulation and fixation, reducing efficiency. Organic nutrients enhance nodulation and fixation by improving soil conditions. Later growth stages may rely more on fixed nitrogen, reducing dependence on external sources. The lack of significant differences in chlorophyll content at later growth stages (4 and 6 WAP) in this study may therefore be linked to increased reliance on symbiotically fixed nitrogen as soybean plants mature, reducing dependence on externally supplied nitrogen.

The observed variations in leaf area across treatments have important physiological implications, as leaf area directly determines light interception and photosynthetic capacity, which ultimately influence biomass accumulation. Leaf area variations impact light interception and photosynthesis, influencing biomass. Treatments with larger leaf area (F1.3 g and P3:1) likely boosted canopy development and radiation use. Adequate nutrients increase leaf expansion and dry matter [25].

Integrated nutrient management (INM) strategies are recommended for soybean production. Combining organic and inorganic fertilizers improves efficiency, yields, and soil sustainability [26, 27]. Poultry manure + inorganic fertilizer proves to be a cost-effective, sustainable option for smallholder farmers.

The results of this study have important environmental and economic implications for smallholder farmers in Nigeria and other developing countries. The effectiveness of poultry manure at moderate application rates offers a sustainable alternative or complement to exclusive use of inorganic fertilizers, which are often costly and subject to supply constraints. Integrated nutrient management approaches that combine organic and inorganic sources can provide several benefits, including improved soil organic matter content, enhanced soil structure and water-holding capacity, reduced nutrient leaching, and lower production costs. Recent work has shown that organic amendments contribute to long-term soil health improvement and carbon sequestration, providing ecosystem services beyond immediate crop nutrition. However, successful implementation of integrated nutrient management requires proper planning, including soil testing, accurate estimation of nutrient content in organic amendments, and careful timing of applications to match crop nutrient demand.

While this study provides valuable insights into the comparative effects of poultry manure and inorganic fertilizers on soybean growth, several considerations should be acknowledged. The pot experiment, while allowing controlled conditions, may not fully replicate field conditions where factors such as spatial nutrient variability, pest pressure, and microbial communities can influence plant responses. Additionally, the study terminated at 6 weeks after planting, focusing on vegetative growth parameters, and did not assess reproductive development or final grain yield. Future research should extend observations through to physiological maturity and grain harvest to assess how early growth responses translate into yield outcomes.

5. CONCLUSION

Glycine max growth was significantly affected by the application of either NPK fertilizer or poultry manure, resulting in a notable increase in plant growth. NPK fertilizer was the most effective in promoting vegetative growth, while poultry manure in a 5:1 ratio showed the best response. TGS1835 exhibited a higher positive response to the treatment than the TGX1345 variety.

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