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Impact of Different Animal Manures on Root Growth Performance of Sorghum (*Sorghum bicolor L. Moench*) Varieties

M.K. Haruna,*[1] O.O. Maji,[2] I.U. Zungum[a] & T. Yakubu[1]

[1].Department of Biological Science,
Federal University,
Gashua,
Yobe State,
Nigeria.

[2].Department of Plant Science and Technology,
Prince Abubakar Audu University,
Anyigba,
Kogi State.

Email: mokharry2013@gmail.com
Haruna, M.K. -https://orcid.org/0000-0002-5020-025X
Maji, O.O. -https://orcid.org/0009-0006-8415-0322
Zungum, I.U. -https://orcid.org/0000-0003-2079-5771

Abstract
The study evaluated the performance of Sorghum *root Varieties grown under different types of animal manures. The experiment was carried out using a Randomized Complete Block Design (RCBD) with treatments consisting of selected animal manures namely poultry manure, cow dung, goat manure, and a control (no manure) including three varieties of sorghum (samsorg 47, samsorg 17,and samsorg 45). Data were collected on mean number of roots, mean root length, mean fresh root weight, mean dry root weight and mean number of roots per plant. The results obtained showed that the application of animal manures significantly influenced root development of sorghum. Goat manure generally produced the highest performance across most parameters, followed by cow dung, while the control and poultry manure recorded the lowest values. The superior performance of goat manure is attributed to its higher nutrient content and faster mineralization rate, which enhance soil fertility and nutrient availability. The study concludes that goat manure is the most effective organic amendment for improving root performance of* Sorghum.

Keywords: Impact; Root growth; Animal manure; Sorghum genotypes, Performance.

INTRODUCTION

Sorghum bicolor (L.) Moench (sorghum) is a major cereal crop grown worldwide, valued for its adaptability to drought, heat and poor soils. (Kadzo *et al.,* 2023). As a staple for millions across semi-arid regions, sorghum contributes to food security, animal feed and industrial raw

**Author for Correspondence*

materials (starch, ethanol). Anchorage, and resilience to abiotic stresses, (Mwamahonje *et al.*, 2025) Root traits (root length, root biomass, root depth, root:shoot ratio and root architecture) strongly influence sorghum's performance under low-input and stress environments, (Muluken *et al*., 2023).

Organic amendments such as animal manures (cow, poultry, goat, sheep, and mixed farmyard manures) remain an important, accessible source of plant nutrients and organic matter for small holder farmers, (Oluwatoyosi *et al.,* 2026). Manures can improve soil physical properties, enhance microbial activity, and supply macro and micro nutrients if it is slow and support root growth and function. However, response to manure application is genotype-dependent (Parra-Londono *et al.,* 2018). Understanding these genotype × amendment interactions is essential to recommend sustainable, site-adapted practices that will maximize resource use efficiency and maintain productivity, (Ahmood *et al*., 2022).

Globally, sorghum is cultivated across Africa, Asia, Australia, and the Americas, particularly where rainfall is low or unreliable, (Olumuyiwa, 2023). International research institutions (e.g., ICRISAT, national agricultural research systems) have prioritized root trait research as part of breeding for drought tolerance and nutrient use efficiency. Studies worldwide show that rooting depth and root density are major determinants of yield stability under water deficit; organic amendments such as compost and animal manures often enhance root biomass and rooting depth in marginal soils, improving drought buffering and nutrient uptake, (Oluwatoyos**i** *et al*., 2026). There is growing interest in integrating genotype selection with organic soil fertility management to promote resilient agroecosystems and reduce dependence on mineral fertilizers, (Dereje, 2019).

In sub-Saharan Africa, sorghum is a key staple and a cultural crop with wide agroecological distribution from Sahelian drylands to wetter savannahs., (Khalifa and Eltahir, (2023)). Many African farmers rely on organic resources (farmyard manure, poultry litter, crop residues) due to limited access to or high cost of synthetic fertilizers. Research across African countries has documented beneficial effects of animal manures on soil organic matter, water holding capacity and root development in cereal crops including sorghum, (Olasupo *et al.,* 2025). At the same time, heterogeneous genotype responses and variable manure quality (nutrient content, maturity, handling) complicate universal recommendations. Therefore, locally-driven studies that compare sorghum variety under common manure types are needed to provide actionable guidance for farmers, (Florence *et al.,* 2025).

Nigeria ranks among the top sorghum-producing countries in Africa, (Musa *et al.,* 2023) Northern Nigeria, where sorghum is a traditional staple, contributes the bulk of national production. Soil fertility constraints, low levels of inorganic fertilizer application, and frequent dry spells are common problems in many sorghum-growing areas. Research in Nigeria has emphasized yield improvement through improved varieties and fertilizer use; relatively fewer studies have targeted root traits or systematically compared genotype responses to different animal manures. (Zhang *et al.,* 2015). Given limited fertilizer access for many small holders, demonstrating which genotype × manure combinations optimize root development and yield under Nigerian soils would support more sustainable, low-cost productivity gains, (Muhammad et al., 2023).

Yobe State, in northeastern Nigeria, lies largely within the Sudan and Sahel agroecological zones where rainfall is low and variable. (Faith, 2024). Sorghum is a dominant staple crop in Yobe, cultivated by small holder farmers under rainfed conditions. Gashua and surrounding agricultural communities are typical of the region: soils often exhibit low organic matter, limited fertility and susceptibility to erosion; animal husbandry and mixed cropping systems are common, meaning animal manures are locally available resources, (Assen, 2025). However, manure use is frequently suboptimal applied at low rates, irregularly, or not sufficiently blended with soil management practices. There is limited local research comparing how different sorghum variety respond at the root level to specific animal manures under Yobe conditions. Studying root performance in Gashua's climatic and edaphic context will therefore produce locally-relevant recommendations for farmers seeking to improve productivity while conserving soil health, (Monther *et al*., 2020).

Animal manures supply macro- and micro-nutrients and organic carbon that can: - Improve soil aggregation, porosity, and water-holding capacity; - Enhance cation exchange capacity and buffer pH; - Stimulate microbial activity and nutrient cycling; - Reduce bulk density, enabling deeper root penetration; - Provide slow-release nutrient pools that synchronize better with crop uptake, (Monther *et al*., 2020).

Nutrient profiles differ across manure sources: poultry manure typically has higher N and P and faster mineralization; ruminant manures (cattle, sheep/goat) often contribute more to structural stability and long-term organic matter buildup but mineralize more slowly. The choice of manure and rate can thus shape root growth dynamics: early nutrient availability may stimulate root branching and surface area, while improved structure facilitates deeper rooting and drought avoidance, (Wang *et al.,* 2016).

MATERIALS AND METHODS

Study Area

The study was carried out at the biological garden of the Department of biological Science, Federal University, Gashua, the headquarter of Bade Local Government Area, Yobe State, Nigeria. Gashua is located at 12°87'N latitude and 11°04'E longitude, with an elevation of 339 meters above sea level. It has a population of 125,817 (https://citypopulation.de/en/nigeria/admin/NGA036__yobe/#) and shares boundaries with Jakusko, Karasuwa, Yusufari, and Bursari Local Government Areas. The area has a semi-arid climate suitable for sorghum cultivation.

Research Design

The experiments were laid out using a Randomized Complete Block Design (RCBD) with three replicates and four treatments (**T_1** – Control (no manure), **T_2** – Cow Dung, **T_3** – Goat Manure and **T_4** – Poultry Manure). Each manure type was applied at a standardized rate (2:1 ratio) (Haruna *et al.,* 2025).

Seed Source

The seed that were used in this research were gotten from ARI (Agricultural Research Institute, samaru, Zaria).Three sorghum genotypes were used: samsorg-47, samsorg-17, samsorg-45 variety

Soil Preparation

T_1 Two pans of garden soil each weighing at 11kg and 0kg pan of animal manure in the ratio 2:0 were mixed to homogeneity, **T_2** Two pans of garden soil each weighing at 11kg and one pan of cow dung weighing 10kg in the ratio 2:1 were mixed to homogeneity, **T_3** Two pans of garden soil each weighing 11kg and one pan of goat dropping weighing 10kg in the ratio 2:1 were mixed to homogeneity and **T_4** Two pans of garden soil each weighing at 11kg and one pan of chicken dropping weighing at 10kg in the 2:1 were mixed to homogeneity.

Sources of Manures

All manures were collected from Federal University Gashua's poultry and livestock farm. They were properly mixed before application to ensure equitable distribution of nutrient of animal manure (Haruna *et al*., 2026).

Filing of Poly bags

Each of the planting poly bag was filled with 1 kg of the mixed soil leaving a 1cm space above the soil in the poly bag and they were arranged according to treatment mixture (Haruna *et al*., 2025).

Seed Introduction and Planting

Two holes of 2cm were made on each replicate using calibrated stick and introduce one sorghum seed per hole. The space between planting bags in each replication was maintain at 0.7cm the space between different varieties were 0.7cm, and the space between different treatments was 1cm (Haruna *et al*., 2025).

Monitoring and Watering Management

Replicates was irrigated twice daily (6:30 am and 5:30 pm) with 300 mills per replicates of water to maintain adequate soil moisture for optimal growth. Regular weeding and pest monitoring were conducted to ensure uniform growth conditions (Haruna *et al*., 2025).

Data Collection

Data were collected on the following root growth parameters at the end of the six week:
Mean number of roots per plant, mean root length, mean fresh root weight, mean dry root weights. Counting was used to determine the number of roots per plant, while meter rule was used to measure the root length and digital weighing balance was used to determine the fresh and dry root weight .

Statistical Analysis

Collected data were analyzed using Analysis of Variance (ANOVA) with SPSS software version 25. Treatment means was compared using Least Significant Difference (LSD**)** at 5% probability level to determine significant differences among manure types and genotypes (Haruna *et al.*, 2025).

RESULTS

Figure 1 presents the highest (18) mean numbers of roots at variety 3 under treatment 3, while the lowest (5) mean numbers of roots were recorded at variety 2 under treatment 2, with no germination in treatments 2 and 4 in variety 1, treatment 4 in variety 2 and treatments 2 and 4 in variety 3.

Figure 2 presents the lengthiest (7cm) mean root length at variety 1 under treatment 3, while the shortest (3cm) mean root length was recorded at variety 2 under treatment 2, with no germination in treatments 2 and 4 in variety 1, treatment 4 in variety 2 and treatments 2 and 4 in variety 3.

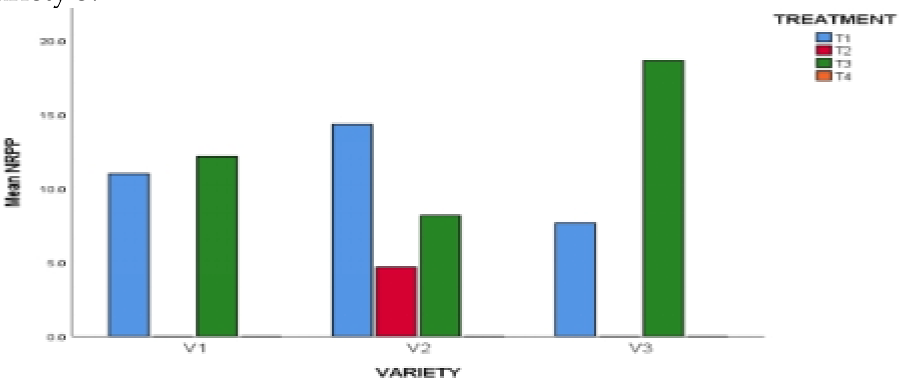

Figure 1: Effect of Different animal manures on mean number of roots per plants of sorghum varieties

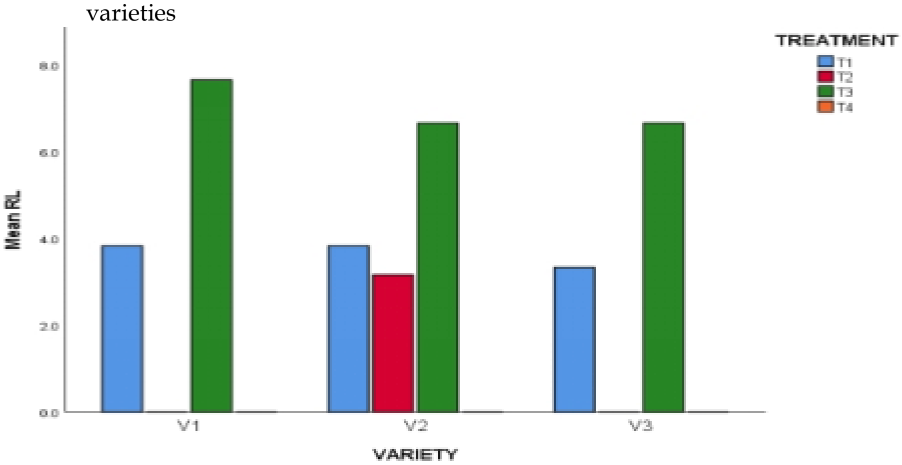

Figure 2: Effect of Different animal manures on mean root length of sorghum varieties

Figure 3 presents the weightiest (8g) Fresh root weight at variety 3 under treatment 3, while the lightest (0.5g) mean fresh root weight was recorded at variety 2 under treatment 2, with no germination in treatments 2 and 4 in variety 1, treatment 4 in variety 2 and treatments 2 and 4 in variety 3.

Figure 4 presents the weightiest (1.9g) dry root weight at variety 3 under treatment 3, while the lightest (0.02g) mean dry root weight was recorded at variety 2 under treatment 2, with no germination in treatments 2 and 4 in variety 1, treatment 4 in variety 2 and treatments 2 and 4 in variety 3.

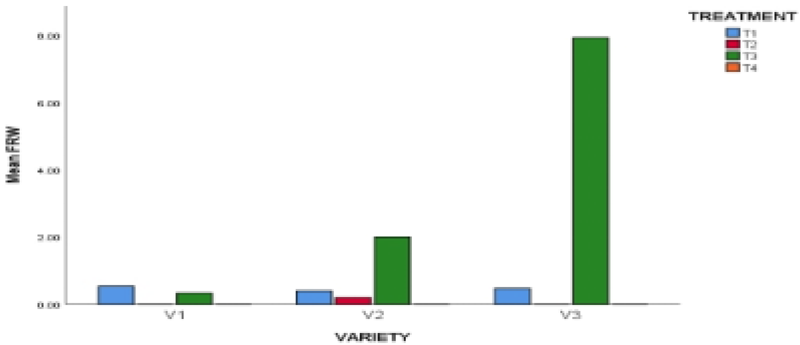

Figure 3: Effect of Different animal manures on mean Fresh root length of sorghum varieties

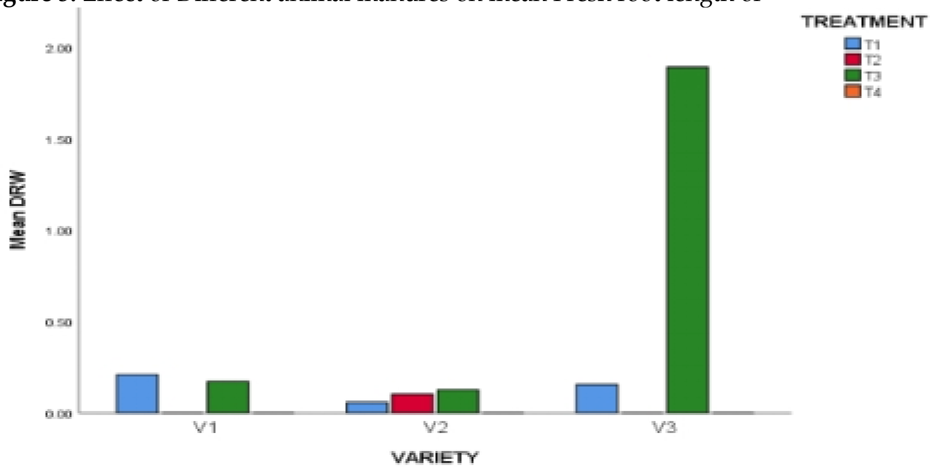

Figure 4: Effect of Different animal manures on mean dry root weight of sorghum varieties

DISCUSSION

This study examined how different animal manures (cow dung, goat manure, and poultry manure) affected the root performance of three sorghum genotypes (Samsorg 47, Samsorg 17, and Samsorg 45). Although most parameters did not show statistical significance, there were clear biological trends. Similar findings have been reported in recent agronomic studies where small sample sizes or high variability lead to non-significant p-values despite visible treatment differences (Akinwole *et al.,* 2025).

Number of Roots per Plant (NRPP)

Goat manure (T_3) produced the highest root numbers, especially in Samsorg 45, which recorded 18 roots. Cow dung (T_2) and poultry manure (T_4) produced the lowest values (figure 1). Although the treatment effect was not statistically significant ($p = 0.1044$), the biological superiority of goat manure was clear. Recent studies confirm that well-decomposed organic manure enhances root proliferation by improving soil aeration and microbial activity (Sudhanshu *et al.,* 2024; Musa *et al.,* 2023). The low root numbers under T_2 and T_4 may result from slow mineralization, which has been shown to temporarily reduce nutrient availability (Fageria and Adonis, 2011).

Root Length (RL)
Goat manure also produced the longest roots (7 cm in V1), whereas cow dung produced the shortest (figure 2). Although the effect was not significant ($p = 0.0618$), the numerical trend favours goat manure. Current soil fertility research shows that manures with moderate C:N (carbon to nitrogen) ratios improve soil porosity and water retention, which enhances root elongation (Amit and Yashbir, 2021). Goat manure falls within this category, explaining its positive influence on root length.

Fresh Root Weight (FRW)
The highest fresh root weight (8g) was recorded in Samsorg 45 under goat manure (figure 3). Although non-significant ($p = 0.3248$), the trend is supported by studies showing that goat manure promotes better nutrient release and biomass accumulation than bulkier manures like cow dung (Emeghara, 2023; Mbatha *et al.,* 2021). Poor fresh root weight under cow dung and poultry manure may be attributed to slow decomposition and nutrient lock-up—issues that have been highlighted in recent organic fertilizer studies (Ahmad and Imam, 2024).

Dry Root Weight (DRW)
Dry root weight also peaked in V_3 under T_3, with a value of 1.89g (figure 4). The statistical model showed no significant effect ($p = 0.4115$), but the biological trend remained consistent. Recent work has demonstrated that improved nutrient uptake from decomposed organic materials enhances dry matter accumulation in cereals (Mona, 2024). The low DRW values under cow dung and poultry manure align with reports that slow-decomposing manures delay nutrient availability (Oludele, 2025).

CONCLUSION
Goat manure (T_3) significantly enhances root number, root length, fresh weight, and dry weight compared to cow dung and poultry manure. This is consistent with recent findings on the superior nutrient mineralization efficiency of goat manure. Samsorg 45 (V_3) exhibited the best root performance and is the most responsive genotype to organic manure amendments, confirming recent genotype–manure interaction studies. Cow dung and poultry manure remain beneficial but require better decomposition before use. Although statistical significance was limited, the observable and consistent biological differences are agronomically important.

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