



World Scientific News

An International Scientific Journal

WSN 216 (2026) 136-149

EISSN 2392-2192

Interactive Effects of Soil Texture and SAMNUT Varieties on Early Growth of Groundnut in Semi-Arid Northern Nigeria

Asimya Lemuel¹, Michael Nkereuwem^{1*}, Obinna Ikechukwu Osuagwu²

¹Department of Biological Sciences, Federal University Dutse, Jigawa State, Nigeria.

Department of Soil Science, Federal University Dutse, Jigawa State, Nigeria.

²Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, China.

¹E-mail address: asimyalemuel@gmail.com, michael.n@fud.edu.ng.

<https://doi.org/10.65770/WYJP1050>

ABSTRACT

Groundnut (*Arachis hypogaea* L.) productivity in Nigeria has declined in recent years, partly due to the mismatch between improved varieties and prevailing soil conditions. This study evaluated the influence of contrasting soil textures on the early vegetative performance of selected SAMNUT groundnut varieties under controlled conditions. A completely randomized design was employed in a 3 × 3 factorial arrangement, comprising three soil textures (sand, loam, and clay) and three varieties (SAMNUT 22, SAMNUT 24, and SAMNUT 27), with three replicates. Key growth parameters assessed included germination percentage, plant height, number of leaves, and number of nodes. Soil analyses confirmed distinct differences in textural composition among the treatments. Results revealed that varietal differences exerted a stronger influence on early growth performance than soil texture as a main factor. SAMNUT 22 and SAMNUT 27 consistently exhibited superior germination and vegetative growth across soil types. While loamy and sandy soils generally supported better overall performance, clay soil recorded the highest mean plant height at four weeks after sowing. The findings indicate significant genotype-environment interactions influencing early groundnut development. SAMNUT 22 and SAMNUT 27 are identified as promising varieties for enhanced establishment and early growth, particularly under loamy and sandy soil conditions in semi-arid Northern Nigeria. These results provide a basis for targeted variety selection and warrant further validation under field conditions.

Keywords: Groundnut, Soil texture, Genotype-environment interaction, Early growth, SAMNUT varieties.

(Received 16 April 2026; Accepted 20 May 2026; Date of Publication 30 June 2026)

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most important grain legumes cultivated globally, serving as a major source of edible oil, plant protein, and livestock feed in tropical and subtropical regions [1,2]. In sub-Saharan Africa, particularly Nigeria, groundnut plays a critical role in food security, income generation, and soil fertility improvement through biological nitrogen fixation [3,4]. The crop is deeply integrated into smallholder farming systems, where it functions both as a subsistence and cash crop with significant domestic and export value [5,6]. Despite its importance, groundnut productivity in Nigeria remains below its potential, largely due to suboptimal agronomic practices, environmental constraints, and inappropriate matching of varieties to local growing conditions [7,8].

The performance of groundnut in farmers' fields is governed by complex interactions among genotype, environment, and management ($G \times E \times M$) [9,10]. Among these factors, genotype \times environment ($G \times E$) interaction is particularly critical, as it determines the adaptability and stability of varieties across diverse agroecological conditions [11,12]. Understanding $G \times E$ interactions enables breeders to identify superior genotypes with consistent performance and to recommend varieties tailored to specific environments [13,14]. In groundnut, varietal differences in early growth traits such as germination, seedling vigor, and canopy development are key determinants of final yield, especially under marginal conditions [15,16].

In Nigeria, improved groundnut varieties such as the SAMNUT series have been developed to enhance yield, disease resistance, and adaptability [17,18]. However, adoption and effective utilization of these varieties are often constrained by limited farmer awareness and inadequate understanding of their performance under varying soil conditions [19]. Traditional beliefs among farmers such as assumptions regarding seed size and germination performance further complicate varietal selection and use [20]. Consequently, many farmers continue to cultivate varieties without considering their suitability for specific soil environments, leading to inconsistent productivity.

Soil properties, particularly soil texture, play a fundamental role in determining groundnut growth and development. Soil texture influences key physical and biological processes, including water retention, aeration, nutrient availability, root penetration, and microbial activity within the rhizosphere [21,22]. In groundnut, these factors are especially important because of the crop's unique reproductive biology, which involves pegging and pod development below the soil surface [23]. Sandy and loamy soils are generally considered favorable for groundnut production due to their loose structure and good drainage, whereas clay soils may restrict root growth and pod formation due to compaction and poor aeration [24,25].

Recent studies have demonstrated that soil texture not only affects plant growth directly but also alters rhizosphere microbial communities and nutrient cycling processes, thereby influencing plant health and productivity [26,27]. Furthermore, root-soil interactions have been identified as a key mechanism underlying crop adaptation to environmental stress, including drought and nutrient limitations [28]. These findings highlight the importance of evaluating crop varieties across contrasting soil environments to better understand their adaptive responses and optimize their performance.

Morphological characterization of groundnut under different environmental conditions is an essential step in varietal evaluation and selection [29]. Early vegetative traits, such as germination percentage, plant height, leaf production, and node formation, provide valuable indicators of plant vigor and establishment potential [30]. These traits are particularly important in semi-arid regions, where early growth determines the crop's ability to withstand environmental stresses and achieve optimal yield [31].

In northern Nigeria, groundnut is cultivated across a wide range of soil types, from sandy soils in arid zones to heavier clay soils in more humid areas [32]. Despite the availability of improved SAMNUT varieties, there is limited empirical evidence comparing their performance across these contrasting soil textures under controlled conditions. Such information is crucial for developing site-specific recommendations and improving varietal deployment strategies.

Therefore, this study aimed to evaluate the effects of three contrasting soil textures (sand, loam, and clay) on the early vegetative growth of three groundnut varieties (SAMNUT 22, SAMNUT 24, and SAMNUT 27). The specific objective was to determine the influence of soil type and variety on germination percentage, plant height, number of leaves, and number of nodes during the first six weeks after sowing. The findings are expected to contribute to improved understanding of genotype-environment interactions and support evidence-based recommendations for groundnut production in semi-arid Northern Nigeria.

2. MATERIALS AND METHODS

2.1. Study Area

The experiment was conducted at the Botanical Garden of the Federal University Dutse, Jigawa State, Nigeria (11°45'N, 9°20'E). The area lies within the Sudan savanna agroecological zone, characterized by a semi-arid climate with a unimodal rainfall pattern. Annual rainfall ranges between 500 and 800 mm, concentrated between June and September, while mean daily temperatures range from 25°C to 38°C. The soils of the region are generally sandy to loamy, with low organic matter content and variable fertility status, making it suitable for evaluating crop responses to contrasting soil textures. The study was conducted under controlled pot conditions to minimize environmental variability and isolate treatment effects.

2.2. Experimental Materials

The experimental materials included perforated polythene bags (30 cm × 35 cm), hand tools (shovel and hoe), irrigation equipment (watering can and hose), a meter rule for growth measurements, and a digital weighing balance. Organic manure used in the study was well-decomposed farmyard manure.

Three improved groundnut (*Arachis hypogaea* L.) varieties: SAMNUT 22, SAMNUT 24, and SAMNUT 27 were used as planting materials. These varieties are widely promoted for cultivation in northern Nigeria due to their yield potential and adaptability. The seeds were sourced from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Kano, Nigeria. Botanical identification and verification of the plant materials were carried out at the Department of Biological Sciences, Federal University Dutse.

2.3. Soil Collection and Preparation

Three distinct soil types: sand (S₁), loam (S₂), and clay (S₃) were collected from different locations within the Faculty of Agriculture Teaching and Research Farm, Federal University Dutse. Soil samples were collected from the topsoil layer (0 – 20 cm depth), air-dried, and sieved through a 2 mm mesh to remove debris and ensure uniformity. Each experimental unit consisted of a perforated polythene bag filled with 10 kg of processed soil. To improve nutrient status and simulate typical smallholder management practices, well-decomposed manure was incorporated into each soil type at a rate of 5 % (w/w), equivalent to 500 g per bag. The soil-manure mixtures were thoroughly homogenized and watered to approximately field capacity prior to sowing to ensure uniform moisture conditions at planting.

2.4. Experimental Design and Crop Establishment

The experiment was arranged in a 3×3 factorial combination of soil texture (sand, loam, and clay) and groundnut variety (SAMNUT 22, SAMNUT 24, and SAMNUT 27) in a completely randomized design (CRD). The nine treatment combinations were replicated three times, resulting in a total of 27 experimental units. Three seeds were sown per bag at a uniform depth of 3 – 4 cm. After emergence, seedlings were thinned to one healthy plant per bag to ensure uniform competition and growth conditions.

The experimental units were randomly arranged within the garden to minimize positional effects. Irrigation was applied uniformly to all treatments at two-day intervals, depending on prevailing weather conditions, to maintain near-field capacity moisture without waterlogging. No synthetic fertilizers or pesticides were applied during the experimental period in order to focus on soil texture and varietal effects. For data analysis and presentation, the varieties were coded as follows:

$V_1 = \text{SAMNUT 22}$, $V_2 = \text{SAMNUT 24}$, and $V_3 = \text{SAMNUT 27}$.

2.5. Data Collection

Data collection focused on early vegetative growth parameters, which are critical indicators of crop establishment and vigor. The following variables were measured:

- (a). Germination Percentage (%): Determined at 7 days after sowing (DAS) as the ratio of emerged seedlings to the number of seeds sown, multiplied by 100.
- (b). Plant Height (cm): Measured from the soil surface to the apical meristem using a meter rule.
- (c). Number of Leaves: Counted manually as fully expanded leaves per plant.
- (d). Number of Nodes: Determined by counting the number of distinct nodes along the main stem.

Vegetative growth measurements were recorded at 4, 5, and 6 weeks after sowing (WAS), and mean values per treatment were computed.

2.6. Soil Analysis

Prior to planting, composite soil samples from each soil type were analyzed to determine their physicochemical properties.

Physical properties: Particle size distribution (sand, silt, and clay fractions) was determined using the hydrometer method.

Chemical properties:

Soil pH was measured in a 1:2.5 soil-water suspension using a digital pH meter.

Electrical conductivity (EC) was determined using a conductivity meter.

Organic carbon (OC) was analyzed using the Walkley-Black method.

Available phosphorus (AP) was determined using the Bray-1 extraction method.

Exchangeable bases (K and Na) and exchangeable acidity (EA) were determined using standard extraction and titration procedures.

2.7. Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) appropriate for a two-factor factorial experiment in a completely randomized design using GenStat statistical software (Version 17, VSN International Ltd., UK). The statistical model included the main effects of soil texture and variety, as well as their interaction effect. Where significant differences were detected ($p \leq 0.05$), treatment means were separated using Fisher's Least Significant Difference (LSD) test at the 5 % probability level. Prior to analysis, percentage data (germination) were arcsine-transformed where necessary to stabilize variance, although untransformed means are presented for clarity. Assumptions of ANOVA, including normality and homogeneity of variance, were checked and satisfied.

3. Results and Discussion

3.1. Soil Chemical Properties

The chemical properties of the experimental soils are presented in Table 1. Soil pH ranged from 6.71 to 7.07, indicating slightly acidic to neutral conditions across all treatments. This pH range is considered optimal for groundnut (*Arachis hypogaea* L.) production, as it enhances nutrient availability and supports beneficial microbial activity, particularly biological nitrogen fixation. The absence of strongly acidic or alkaline conditions suggests that soil pH did not impose any limitation on early crop establishment in this study.

Table 1. Chemical properties of the experimental soils prior to planting.

Sample	pH	EC (dS/m)	OC (%)	AP	K+	Na	EA
S1	7.07	0.19	0.99	11.74	0.17	0.44	0.12
S2	6.71	0.39	3.27	18.78	0.65	0.48	0.18
S3	6.83	0.37	1.82	13.62	0.48	0.66	0.16

Electrical conductivity (EC) values ranged from 0.19 to 0.39 dS m⁻¹, indicating that all soils were non-saline. These values fall well below the threshold known to affect germination and early seedling growth in groundnut, confirming that salinity stress was not a contributing factor to variation in plant performance observed among treatments. Organic carbon (OC) content varied among the soil types, with the lowest levels recorded in sandy soil (S₁) and the highest in loamy soil (S₂). This pattern reflects the inherent characteristics of soil texture, where sandy soils typically have poor organic matter retention due to high permeability, whereas loamy soils exhibit greater capacity to retain and stabilize organic matter. The relatively higher OC content in S₂ suggests improved nutrient supply, enhanced moisture retention, and increased microbial activity, which are critical for early vegetative growth.

Available phosphorus (AP) ranged from 11.74 to 18.78 mg kg⁻¹, indicating moderate phosphorus availability across the soils. Phosphorus plays a crucial role in root development, nodulation, and energy transfer processes during early plant growth. The observed variation in AP among soil types may have contributed to differences in early growth performance of the groundnut varieties, particularly in relation to root establishment and leaf development.

Exchangeable acidity (EA) remained low across all soil types, further confirming the absence of acidity-related constraints such as aluminum toxicity. This is consistent with the near-neutral pH values observed and suggests a chemically favorable environment for groundnut growth.

Overall, the results indicate that while all soils were within suitable chemical ranges for groundnut cultivation, the relatively higher organic carbon and balanced nutrient status of the loamy soil (S₂) likely provided a more favorable environment for early plant development. However, given the minimal variation in chemical properties across soils, it is likely that differences in plant performance observed in subsequent sections are more strongly influenced by soil physical properties, particularly texture-related effects on water retention and aeration.

3.2. Soil Physical Properties

The physical properties and textural classification of the experimental soils are presented in Table 2. Based on particle size distribution, soil S₁ was classified as sand, S₂ as loamy sand, and S₃ as loamy clay according to the USDA soil texture classification system. These classifications confirm the presence of distinct textural contrasts among the soils used in the study, providing a suitable basis for evaluating soil texture effects on groundnut growth.

Table 2. Particle size distribution and textural classification of the experimental soils.

Sample	Sand (%)	Silt (%)	Clay (%)	Textural class
S1	90.5	3.63	5.85	Sand
S2	40.0	39.50	20.0	Loam
S3	25.5	19.61	55.0	Clay

The sandy soil (S₁) was characterized by a high proportion of sand particles and minimal silt and clay fractions, indicating low water-holding capacity, rapid drainage, and limited nutrient retention. Such soils typically promote good aeration and root penetration but may impose constraints on plant growth due to poor moisture and nutrient availability. In contrast, the loamy sand (S₂) exhibited a more balanced composition of sand, silt, and clay, resulting in improved water retention, moderate aeration, and enhanced nutrient-holding capacity. These properties make loamy soils generally more favorable for crop growth, particularly during early vegetative stages.

The loamy clay soil (S₃), with a higher clay fraction, is expected to possess greater water-holding capacity and nutrient retention compared to the other soil types. However, increased clay content may reduce soil aeration, increase bulk density, and restrict root penetration, especially under high moisture conditions. For groundnut, which requires loose and well-aerated soil for effective peg penetration and pod development, such conditions may limit optimal growth despite adequate nutrient availability.

The observed differences in soil texture are particularly significant for groundnut production due to the crop's geocarpic nature, where pods develop below the soil surface. Soil structure and porosity directly influence peg penetration, root development, and subsequent pod formation. Therefore, sandy and loamy soils are generally considered more suitable for groundnut cultivation than clay-rich soils.

Overall, the contrasting physical characteristics of the soils used in this study are expected to play a major role in determining differences in germination, plant establishment, and early vegetative growth observed among treatments. In particular, the relatively balanced properties of the loamy sand (S_2) may provide optimal conditions for early growth, while the limitations associated with sandy (S_1) and clayey (S_3) soils may differentially influence plant performance.

3.3. Germination Percentage

The effects of soil type and varietal differences on germination percentage of groundnut are presented in Figure 1. Significant variation was observed among the varieties, while the effect of soil type and the soil \times variety interaction were not statistically significant ($p > 0.05$), as indicated by the ANOVA results.

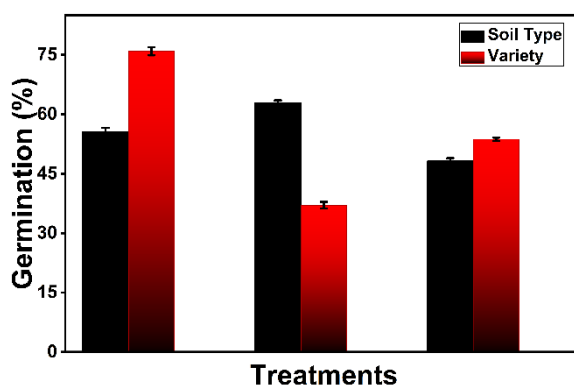


Figure 1. Effect of soil type and variety on germination percentage of groundnut. Bars represent mean values, and error bars indicate standard error (SE).

Among the varieties, V_1 (SAMNUT 22) recorded the highest germination percentage, followed by V_3 (SAMNUT 27), while V_2 (SAMNUT 24) exhibited the lowest germination performance. The superior germination observed in SAMNUT 22 suggests greater seed vigor and viability, which are critical determinants of rapid and uniform seedling emergence. Similarly, the relatively high germination in SAMNUT 27 indicates good adaptability during the establishment phase. In contrast, the lower germination observed in SAMNUT 24 may be attributed to inherent varietal differences in seed quality, dormancy characteristics, or sensitivity to environmental conditions. The absence of significant differences among soil types indicates that germination was not strongly influenced by soil texture under the controlled conditions of this experiment. This suggests that the initial phase of groundnut establishment is more dependent on seed physiological quality than on soil physical or chemical constraints, provided that moisture conditions are adequate. The favorable pH range and non-saline conditions observed across all soils (Tables 1 and 2) may have further contributed to the uniformity in germination response.

Although soil texture did not significantly affect germination, slight numerical differences observed across soils may still reflect variations in moisture retention and aeration. Sandy soils (S_1), characterized by rapid drainage, may have experienced quicker moisture loss, while clay-rich soils (S_3) may have retained more water but potentially limited oxygen diffusion. However, these differences were not sufficient to produce statistically distinct effects, likely due to the controlled watering regime applied throughout the experiment. The lack of significant interaction between soil type and variety further indicates that varietal ranking for germination remained consistent across all soil types. This stability suggests that the observed differences in germination are primarily genetically controlled rather than environmentally driven.

Overall, the results highlight the importance of varietal selection in ensuring optimal crop establishment. SAMNUT 22 and SAMNUT 27 demonstrated superior germination performance and may therefore provide a more reliable stand establishment under varying soil conditions in semi-arid environments.

3.4. Number of Leaves

The number of leaves was significantly influenced by both soil type and variety at different stages of growth (Table 4). At 4 weeks after sowing (WAS), significant differences were observed among soil types, with loamy soil (S₂) producing the highest mean number of leaves compared to sandy (S₁) and clayey (S₃) soils. However, as the plants progressed to 5 and 6 WAS, the effect of soil type became less pronounced, suggesting that early vegetative growth is more sensitive to soil physical conditions.

Table 4. Main effects of soil type and variety on the number of leaves at 4, 5, and 6 weeks after sowing (WAS).

Treatment	4 WAS	5 WAS	6 WAS
Soil type			
S1	14.33b	22.3	22.3
S2	23.56a	24.9	28.4
S3	16.00b	23.3	26.0
LSD	4.60	NS	NS
Variety			
V1 (SAMNUT 22)	22.67a	25.67a	29.67a
V2 (SAMNUT 24)	11.22b	14.22b	16.44b
V3 (SAMNUT 27)	20.00a	30.67a	30.67a
Interaction (Soil × Variety)	*	*	*

Table 5. Interaction of soil type and variety on number of leaves at 4, 5, and 6 WAS.

Soil type	Variety	4 WAS	5 WAS	6 WAS
S1	V1	8.00c	15.00c	15.00b
S1	V2	11.00c	16.00c	16.00b
S1	V3	24.00b	36.00a	36.00a

S2	V1	36.00a	28.00ab	36.00a
S2	V2	10.67c	10.67c	13.33b
S2	V3	24.00b	36.00a	36.00a
S3	V1	24.00b	34.00a	38.00a
S3	V2	12.00c	16.00c	20.00b
S3	V3	12.00c	20.00bc	20.00b

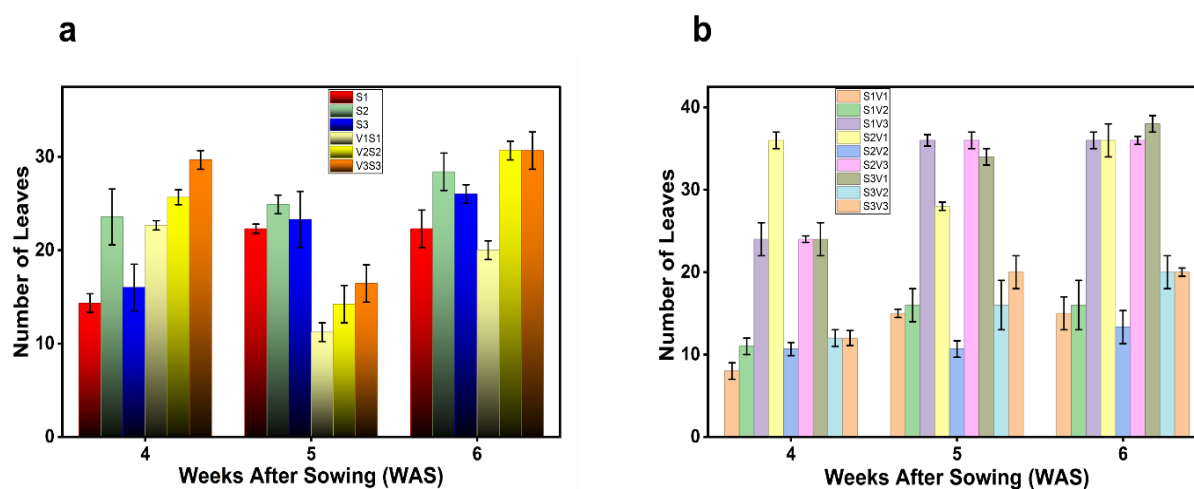


Figure 2. Combined effect of soil type and variety on leaf production of groundnut at different growth stages (4, 5, and 6 WAS). Bars represent mean values \pm SE. Significant interaction between soil type and variety was observed, with means separated using LSD at the 5 % probability level.

Varietal differences were consistent across all sampling periods, with V₁ (SAMNUT 22) and V₃ (SAMNUT 27) producing significantly higher numbers of leaves compared to V₂ (SAMNUT 24). This indicates superior vegetative vigor in these varieties, which may be attributed to genetic factors such as better nutrient utilization efficiency and adaptation to the growing environment.

The interaction between soil type and variety was significant, indicating that the response of groundnut varieties to leaf production depended on the soil type. This suggests that certain varieties performed better under specific soil conditions. For instance, the superior performance of V₁ and V₃ in loamy soil (S₂) may be linked to the balanced properties of this soil type, including moderate water-holding capacity, good aeration, and adequate nutrient availability, which collectively promote vegetative growth. In contrast, the relatively lower leaf numbers observed in sandy soil (S₁) could be attributed to its low water and nutrient retention capacity, while clayey soil (S₃) may have restricted root development due to poor aeration and higher bulk density. These findings highlight the importance of soil physical properties in influencing early crop growth and development.

Overall, the results demonstrate that both genetic and environmental factors play critical roles in determining leaf production in groundnut, with loamy soil (S₂) providing the most favorable conditions for vegetative growth, particularly for high-performing varieties such as SAMNUT 22 and SAMNUT 27.

3.5. Number of Nodes

The number of nodes was significantly influenced by varietal differences and the interaction between soil type and variety at all sampling periods (4, 5, and 6 WAS), as presented in Figure 3.

Across the observation period, V₁ (SAMNUT 22) and V₃ (SAMNUT 27) consistently produced a higher number of nodes compared to V₂ (SAMNUT 24), indicating superior vegetative development in these varieties. The increased node production observed in V₁ and V₃ suggests enhanced growth vigor and a greater potential for branching and reproductive development, as node formation is closely associated with canopy expansion and pod-bearing capacity in groundnut. Although the main effect of soil type showed some variation, the significant interaction between soil type and variety indicates that node production was strongly dependent on the specific combination of soil and genotype. This suggests that certain varieties responded more favorably to particular soil conditions. In particular, the better performance observed in loamy soil (S₂) may be attributed to its balanced physical properties, including optimal water retention, aeration, and nutrient availability, which support active vegetative growth.

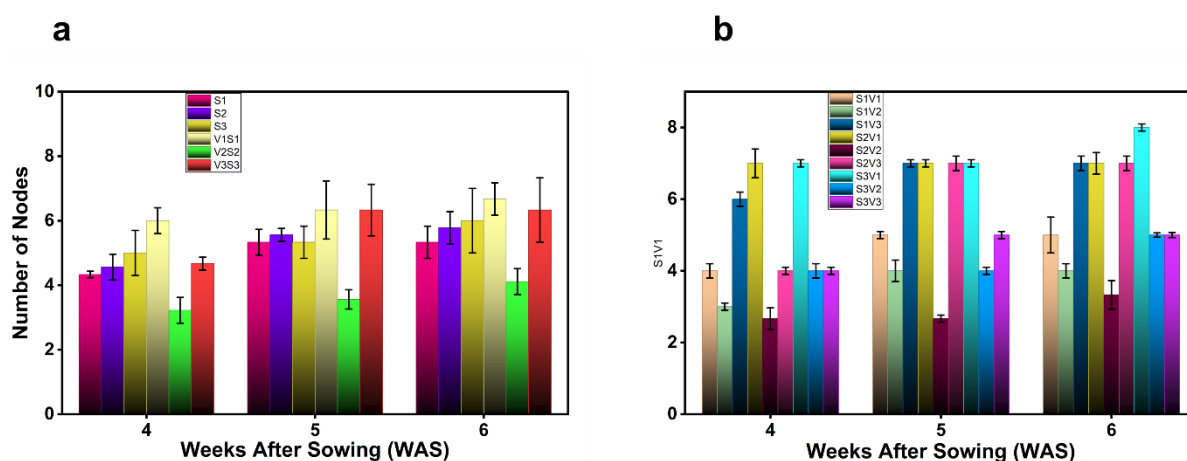


Figure 3. Interaction effect of soil type and variety on number of nodes of groundnut at 4 WAS, 5 WAS, and 6 WAS. Bars represent mean values \pm standard error (SE).

In contrast, reduced node numbers in sandy soil (S₁) may be linked to low moisture and nutrient retention, while clayey soil (S₃) may have imposed limitations due to poor aeration and higher resistance to root penetration. These constraints can restrict plant growth and reduce node formation. The significant interaction effect further demonstrates that varietal performance was not uniform across soil types, reinforcing the importance of matching groundnut varieties with suitable soil conditions to optimize growth. The consistent superiority of SAMNUT 22 and SAMNUT 27 across most soil conditions highlights their adaptability and potential for better field performance. Overall, the results emphasize that both genetic factors and soil characteristics play a crucial role in determining node development in groundnut, with implications for subsequent yield formation.

3.6. Plant Height

Plant height was significantly influenced by soil type at 4 weeks after sowing (WAS), but no significant differences were observed at 5 and 6 WAS (Tables 8 and 9). At 4 WAS, clay soil (S₃) produced the highest mean plant height compared to sandy (S₁) and loamy (S₂) soils.

The superior plant height observed in clay soil at the early growth stage may be attributed to its higher water-holding capacity, which likely ensured a more consistent moisture supply during initial plant establishment. Adequate moisture availability is critical at early growth stages, as it promotes cell expansion and elongation, resulting in increased plant height. However, the absence of significant differences among soil types at later stages (5 and 6 WAS) suggests that the initial advantage provided by clay soil was not sustained over time. This may be due to limitations associated with clay soils, such as poor aeration and higher bulk density,

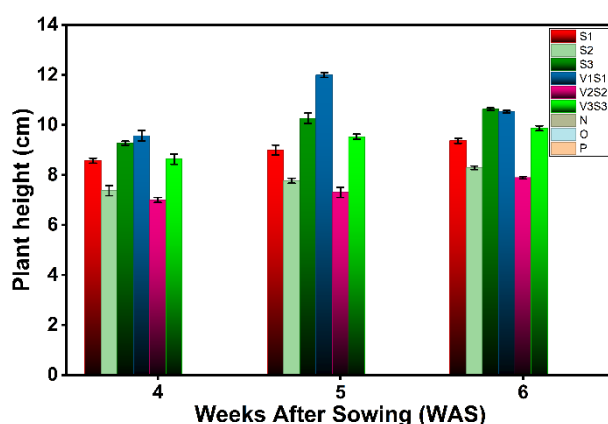


Figure 4. Interaction effect of soil type and variety on plant height (cm) of groundnut at 4 WAS, 5 WAS, and 6 WAS. Bars represent mean values ± standard error (SE).

Which can restrict root growth and reduce nutrient uptake as plants develop. As a result, plant growth across all soil types tended to converge at later stages.

Varietal differences in plant height were less pronounced compared to other growth parameters such as number of leaves and nodes, indicating that plant height may be less sensitive to genetic variation under the conditions of this experiment. Nevertheless, slight numerical differences observed among varieties may reflect inherent genetic potential for stem elongation. The interaction between soil type and variety was not consistently significant across all sampling periods, suggesting that plant height was influenced more by early soil moisture conditions than by specific soil–variety combinations. This contrasts with the strong interaction effects observed for leaf and node production, highlighting that different growth parameters respond differently to environmental and genetic factors.

Overall, the results indicate that soil type plays a role in early plant height development, particularly under moisture-influenced conditions, but its effect diminishes as the crop progresses. This suggests that plant height may not be a reliable standalone indicator of overall plant performance under varying soil conditions.

4. CONCLUSION AND OUTLOOK

This study demonstrated that both soil type and varietal differences significantly influenced early vegetative growth of groundnut under controlled pot conditions. While soil chemical properties were generally favourable across treatments, variations in soil texture played a key role in shaping plant responses. Loamy soil supported superior leaf development at early growth stages, whereas clay soil promoted greater plant height at 4 WAS, indicating that no single soil type was optimal for all growth parameters.

Varietal performance was more consistent across traits, with SAMNUT 22 and SAMNUT 27 exhibiting superior germination, leaf production, and node development compared to SAMNUT 24. These findings highlight the importance of genetic factors in early crop establishment and confirm that varietal selection is a critical determinant of groundnut performance.

The significant interaction between soil type and variety for most growth traits further emphasizes that varietal response is environment-dependent. This suggests that blanket varietal recommendations may be less effective than targeted approaches that consider specific soil conditions. Consequently, matching suitable groundnut varieties with appropriate soil types could enhance early growth performance and potentially improve overall productivity.

However, the study was limited to early vegetative growth under pot conditions and did not include reproductive or yield-related parameters. Therefore, the results should be interpreted as indicative of early-stage performance rather than final agronomic productivity.

Future research should extend these findings through field-based trials across diverse agroecological zones, incorporating yield and quality parameters such as pod number, pod weight, and seed yield. In addition, multi-location and multi-season evaluations would provide deeper insights into genotype × environment interactions and varietal stability. Such studies will be essential for developing robust, location-specific recommendations for groundnut production, particularly in semi-arid regions.

References

- [1] FAOSTAT. FAOSTAT Statistical Database on Groundnut Production. FAO, Rome (2023).
- [2] S. N. Nigam, R. W. Gibbons. Groundnut Breeding. In: Smartt J. (ed.) *The Groundnut Crop*. Chapman and Hall (1985) 23–65.
- [3] D. Hoisington, M. Khairallah, T. Reeves, et al. Plant Genetic Resources: What Can They Contribute toward Increased Crop Productivity? *Proc. Natl. Acad. Sci. USA* 96 (1999) 5937–5943.
- [4] M. Desmae, P. Janila, S. Okori, et al. *Grain Legumes Handbook*. ICRISAT (2019).
- [5] A. Gelaye, X. Luo. Advances in Groundnut Production Systems. *Field Crops Research* 310 (2024) 109321.
- [6] O. Ola. Economic Importance of Groundnut in Global Trade. *Journal of Agribusiness* 12 (2024) 45–53.

- [7] P. Puppala, S. K. Kona, R. K. Varshney. Genotype × Environment Interaction in Groundnut. *Field Crops Research* 295 (2023) 108876.
- [8] S. Kona, P. Janila, M. B. Pandey. Groundnut Adaptation to Variable Environments. *Field Crops Research* 305 (2024) 109102.
- [9] H. Gupta, S. K. Rai, R. Kumar. Stability Analysis in Groundnut. *Euphytica* 204 (2015) 1–12.
- [10] A. Ajeigbe, F. Waliyar, M. Echekwu. *Guide to Groundnut Production in Nigeria*. ICRISAT (2015).
- [11] M. Yunusa, A. Bello, S. Garba. Farmer Perception of Improved Groundnut Varieties in Nigeria. *Nigerian Journal of Agricultural Extension* 26 (2025) 15–28.
- [12] R. Brady, R. Weil. *The Nature and Properties of Soils*. Pearson Education (2016).
- [13] D. Hillel. *Introduction to Environmental Soil Physics*. Elsevier (2004).
- [14] J. Weiss. *Oilseed Crops*. Blackwell Science (2000).
- [15] O. Okeleye, S. O. Akinrinde. Soil Suitability for Groundnut Production in Nigeria. *Nigerian Journal of Agronomy* 14 (1999) 12–20.
- [16] X. Li, Y. Zhang, L. Chen. Soil Texture Effects on Rhizosphere Processes in Peanut. *Soil Biology & Biochemistry* 165 (2022) 108520.
- [17] H. Wang, Q. Liu, J. Sun. Soil–Plant Interactions in Peanut Cropping Systems. *Plant and Soil* 482 (2023) 233–248.
- [18] Y. Lan, X. Zhao, L. Wu. Soil Microbial Dynamics under Peanut Cultivation. *Applied Soil Ecology* 195 (2025) 105020.
- [19] A. Gelaye, P. Janila, R. Varshney. Root–Soil Interactions in Peanut under Stress. *Agronomy* 15 (2025) 1123.
- [20] G. Peratoner, F. Florian, H. Grausgruber. Morphological Characterization of Crop Varieties. *Genetic Resources and Crop Evolution* 63 (2016) 123–135.
- [21] R. Singh, D. Oswalt. *Groundnut Production Practices*. ICRISAT (1995).
- [22] P. Craufurd, R. Vadez, S. Jagadish. Adaptation of Groundnut to Semi-Arid Conditions. *Experimental Agriculture* 39 (2003) 123–137.
- [23] B. Bationo, B. Waswa, J. Kihara. *Soil Fertility Management in Africa*. Springer (2007).
- [24] R. Yan, M. Kang. *GGE Biplot Analysis*. CRC Press (2003).
- [25] S. Ceccarelli. Efficiency of Plant Breeding. *Crop Science* 55 (2015) 87–97.
- [26] H. Annicchiarico. *Genotype × Environment Interactions*. FAO Plant Production Paper (2002).
- [27] G. Gauch. *Statistical Analysis of Yield Trials*. Cambridge University Press (2013).

- [28] M. Cooper, G. Hammer. Plant Adaptation and Crop Improvement. CAB International (1997).
- [29] S. Kamara, A. Ajeigbe, S. Omoigui. Adoption of Improved Groundnut Varieties in Nigeria. African Journal of Agricultural Research 6 (2011) 102–110.
- [30] S. Taru, I. Kyagya. Economic Analysis of Groundnut Production. Journal of Agriculture 5 (2010) 45–52.
- [31] P. Ntare, F. Waliyar, A. Ramouch. Groundnut Production in West Africa. ICRISAT (2008).
- [32] Institute for Agricultural Research (IAR). SAMNUT Variety Release Bulletin. ABU Zaria (2018).