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Combined Application of Poultry Manure, *Gliricidia sepium* and NPK Fertilizer on Soil Nutrients Status and Maize Performance in South West, Nigeria

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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Abstract

Soil fertility decline caused by continuous cultivation is a major constraint to sustainable maize production in tropical regions. Integrated nutrient management, which combines organic sources such as poultry manure and *Gliricidia sepium* with inorganic NPK fertiliser, can improve soil nutrient status, enhance soil properties and increase crop yield more effectively than sole applications. A field experiment was conducted to evaluate the effects of combined poultry manure, *Gliricidia sepium* and NPK 15:15:15 on soil nutrient status and maize yield in a 3 by 2 factorial experiment involving 5 t ha^{-1} poultry manure, 5 t ha^{-1} *Gliricidia sepium* leaves and 150 kg ha^{-1} NPK 15:15:15 arranged in a randomised complete block design. The treatment combinations were replicated three times. Data were collected on maize growth, grain-yield parameters and soil chemical characteristics, and were subjected to analysis of variance using SPSS Version 16.0. The results showed that growth, yield and soil nutrient content were significantly ($P < 0.05$) influenced by the treatments. The highest growth parameters were obtained with the combined application of poultry manure and *Gliricidia*

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sepium, while the combined use of NPK 15:15:15, *Gliricidia sepium* and poultry manure produced the highest maize grain-yield parameters. The combined use of poultry manure with *Gliricidia sepium* significantly improved soil nutrient status. Sole NPK 15:15:15 application reduced soil pH compared with the combined use of poultry manure, *Gliricidia sepium* and NPK 15:15:15. Organic wastes should therefore be integrated with inorganic fertiliser to enhance soil nutrient status and crop yield in the study area.

Keywords: Poultry manure; Gliricidia sepium; NPK fertilizer; soil nutrients status; maize performance.

1. Introduction

Sustainable food production necessitates continued investigation into strategies for preserving and enhancing soil productivity. In the context of Nigerian soils, productivity and long-term sustainability tend to deteriorate under continuous cultivation practices (Adeleye et al., 2018). Consequently, the pursuit of improved soil-management approaches has encouraged the application of both organic and inorganic external inputs to improve soil fertility and crop yields.

Historically, soil fertilisation in Nigeria relied predominantly on organic amendments; however, their adoption by farmers declined because of several constraints, including their bulky nature, high transportation and application costs, handling difficulties, slow nutrient release and concerns relating to heavy metal contamination (Jaja & Barber, 2017). Farmers subsequently adopted inorganic fertilisers, which initially resulted in substantial increases in crop productivity. However, it was later observed that such yield gains were sustained only over a limited period, as prolonged use contributed to declining base saturation, soil acidification and nutrient imbalances. Moreover, the continuous application of mineral fertilisers in tropical soils has been linked to reductions in crop yield and deterioration of soil physical quality (Abdulraheem et al., 2022). The management of soil through organic nutrient sources to promote soil health, crop yield and nutritional quality has attracted considerable interest worldwide. Research information on the use of poultry manure in arable crop production is abundant in the literature. Research trials have indicated increased crop yield as a result of improved quantities of essential nutrients in the soil, improved soil structure and increased microbial population (Bai et al., 2018; Schrama et al., 2018). *Gliricidia sepium* is one of the tree legumes that has been widely used in alley cropping and planted fallows in the humid lowlands of West Africa. The protective role of *Gliricidia sepium* canopy and its litterfall results in the creation of a favourable physical and chemical environment for the development of soil microflora, macroflora and fauna, which are essential for fertility regeneration, improvement of soil physical condition and preservation of ecosystem stability (Alamu et al., 2023).

The high cost of inorganic fertiliser, application constraints and recent scarcity in Nigeria have stimulated interest in integrated plant nutrition research. Integrated nutrient management combines organic and inorganic fertilisers with soil conservation practices to supply nutrients to crops. This combination helps to maintain soil productivity and quality over time. Furthermore, reducing the quantity of either component may lower production and fertilisation costs, support balanced plant nutrition and improve growth, yield and crop quality (Kushwah et al., 2019). Integrated plant nutrition promotes more sustained improvement in soil physical, chemical and biological properties because it combines the attributes of both organic and inorganic fertilisers (Ayeni et al., 2023). The integrated use of high-quality organic manures and inorganic fertilisers represents a valuable approach for sustaining soil quality and promoting sustainable crop production. This combination supports the long-term build-up of soil productivity and quality (Selim, 2020). Chojnacka (2025) concluded that the combined use of organic and inorganic fertilisers may be an economically viable, ecologically sound and affordable technology for tropical smallholder farmers. However, published research on the direct combined application of raw organic wastes and inorganic fertilisers to soil quality and maize yield in Nigeria remains limited. This gap is particularly relevant for Alfisols in southwestern Nigeria, where nutrient depletion under continuous cultivation can constrain maize performance. This study aimed to evaluate the effects of the combined application of poultry manure, *Gliricidia sepium* and NPK 15:15:15 fertiliser on soil nutrient content, nutrient uptake and maize performance.

2. Materials and Methods

A field experiment was conducted in Ondo (07° 05′ N, 04° 55′ E) in the rainforest zone of southwestern Nigeria. The plot was gently sloping, free from trees and had previously been cultivated with arable crops. The soil is sandy loam, belongs to the Ondo series (EgbedaFasc) and is classified as an Alfisol (oxictropuldalf). The trial comprised three factors: poultry manure at rates of 0 and 5 t ha⁻¹; *Gliricidia sepium* at rates of 0 and 5 t ha⁻¹; and NPK 15:15:15 at rates of 0 and 150 kg ha⁻¹. These factors were combined in a 3 by 2 factorial experiment to produce eight (8) treatment combinations: N0P0G0, control (0 kg ha⁻¹ NPK + 0 t ha⁻¹ poultry manure + 0 t ha⁻¹ *Gliricidia*); N0P0G5 (0 kg ha⁻¹ NPK + 0 t ha⁻¹ poultry manure + 5 t ha⁻¹ *Gliricidia*); N0P5G0 (0 kg ha⁻¹ NPK + 5 t ha⁻¹ poultry manure + 0 t ha⁻¹ *Gliricidia*); N0P5G5 (0 kg ha⁻¹ NPK + 5 t ha⁻¹ poultry manure + 5 t ha⁻¹ *Gliricidia*); N150P0G0 (150 kg ha⁻¹ NPK + 0 t ha⁻¹ poultry manure + 0 t ha⁻¹ *Gliricidia*); N150P0G5 (150 kg ha⁻¹ NPK + 0 t ha⁻¹ poultry manure + 5 t ha⁻¹ *Gliricidia*); N150P5G0 (150 kg ha⁻¹ NPK + 5 t ha⁻¹ poultry manure + 0 t ha⁻¹ *Gliricidia*); and N150P5G5 (150 kg ha⁻¹ NPK + 5 t ha⁻¹ poultry manure + 5 t ha⁻¹ *Gliricidia*). The treatments were arranged in a randomised complete block design (RCBD) and replicated three times. The experimental site was divided into three blocks, and each block was further divided into eight 5 m by 5 m plots. Poultry manure and *Gliricidia* leaves were uniformly spread on the plots and incorporated into the soil with a hoe two weeks before planting the maize seeds. Two maize seeds were planted per stand and spaced at 75 cm by 45 cm. NPK 15:15:15 was applied by the ring method two weeks after germination of the maize seedlings. Manual weeding was carried out three and eight weeks after planting.

2.1 Soil Analysis

Prior to treatment application, surface (0-15 cm) composite soil samples were randomly collected from the experimental site using an auger, bulked, air-dried and passed through a 2 mm sieve for routine chemical analyses. At harvest, surface soil samples (0-15 cm) were collected according to treatment and processed for chemical analysis following the procedures described by AOAC (2000). Soil organic matter was determined using the wet dichromate oxidation method, while total nitrogen (N) was assessed using the Kjeldahl procedure. Available phosphorus (P) was extracted using the Bray-1 method and quantified by molybdenum blue colorimetry. Exchangeable cations were extracted with neutral ammonium acetate; potassium (K) was determined using a flame photometer, whereas calcium (Ca) and magnesium (Mg) were measured using an atomic absorption spectrophotometer. Soil pH was determined in a 1:2 soil-to-water suspension using a digital electronic pH meter.

2.2 Leaf Nutrient Contents Analysis

At eight weeks after planting, fully expanded mature leaves were sampled from five maize plants per replicate. The leaf material was finely chopped, oven-dried at 65 °C for 48 hours and subsequently ground for routine chemical analyses. Leaf nitrogen (N) concentration was determined using the micro-Kjeldahl digestion method. Phosphorus (P) was quantified colorimetrically using the vanadomolybdate procedure, potassium (K) was measured with a flame photometer, while calcium (Ca) and magnesium (Mg) were determined using atomic absorption spectrophotometry, following the Association of Official Analytical Chemists (AOAC, 2000) protocols.

2.3 Yield Data

At thirteen weeks after planting, ten maize plants per replicate were randomly selected for the assessment of growth and yield-related parameters. The harvested cobs from these plants were air-dried until a moisture content of 12% was attained. Subsequently, yield components, including number of cobs per plant, cob weight, number of seeds per cob and grain yield per hectare, were determined.

2.4 Data Analysis

Data on the soil chemical characteristics, growth and grain yield of maize were subjected to analysis of variance using SPSS Version 16.0, and the mean values were compared using Duncan Multiple Range Test (DMRT) at the 5% level of significance where the F-ratio was significant.

3. Results

The data on the initial physico-chemical properties of the soil at the experimental site (Table 1) indicated that the soil was sandy loam, acidic and low in organic matter content, total nitrogen, available phosphorus and cation exchange capacity (CEC). The soil contained adequate concentrations of exchangeable calcium (Ca), magnesium (Mg) and potassium (K). The soil contained high concentrations of micronutrients such as iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn).

Table 1. Pre-treatment soil chemical properties at the site of the field experiment

Soil Properties	Values
pH	5.74
organic Matter (%)	2.17
total N (%)	0.13
available P (mgkg)	7.35
Ca (Cmol kg^{-1})	1.25
Mg (Cmol kg^{-1})	0.63
Na (Cmol kg^{-1})	1.02
K (Cmol kg^{-1})	0.41
Ex. Acidity (Cmol kg^{-1})	0.08
CEC (Cmol kg^{-1})	3.39
Base Saturation (%)	97.64
Mn ($mgkg^{-1}$)	43.60
Fe ($mgkg^{-1}$)	16.60
Cu ($mgkg^{-1}$)	1.13
Zn ($mgkg^{-1}$)	13.41
Sand (%)	80.20
Clay (%)	10.40
Silt (%)	9.40

Table 2 shows the effect of the combined use of NPK 15:15:15, poultry manure and *Gliricidia sepium* on soil chemical properties. Soil chemical properties were significantly ($P < 0.05$) influenced by the treatments. Plots treated with 150 kg ha^{-1} NPK alone (N150P0G0) had the lowest soil pH (5.56), exchangeable acidity (0.11 cmol kg^{-1}) and organic matter content (1.50%). Plots without amendment had the lowest Mg (2.12 cmol kg^{-1}) and available phosphorus (17.51 mg kg^{-1}). The soil chemical properties of plots treated with only 5 t ha^{-1} *Gliricidia* (N0P0G5) and those treated with only 5 t ha^{-1} poultry manure (N0P5G0) were similar. Plots receiving the combined application of 150 kg ha^{-1} NPK and 5 t ha^{-1} poultry manure (N150P5G0) had relatively higher concentrations of total N, organic matter, available P and CEC than plots receiving 150 kg ha^{-1} NPK and 5 t ha^{-1} *Gliricidia* (N150P0G5). The combined application of 150 kg ha^{-1} NPK, 5 t ha^{-1} poultry manure and 5 t ha^{-1} *Gliricidia* (N150P5G5) produced the highest available P but relatively low total N. Percent base saturation was similar across all treated plots. Plots receiving combined organic wastes alone (poultry manure and *Gliricidia*) had relatively higher pH values than plots receiving combinations that included 150 kg ha^{-1} NPK fertiliser. Compared with the control, plots receiving external inputs from organic and inorganic sources contained higher concentrations of nutrient elements.

Table 3 reveals that nutrient uptake by maize was significantly ($P < 0.05$) influenced by the treatments. The leaf nutrient content of maize in the treated plots was higher than that in plots without amendment (N0P0G0). Maize grown in plots treated with the combined application of 150 kg ha^{-1} NPK, 5 t ha^{-1} poultry manure and 5 t ha^{-1} *Gliricidia* (N150P5G5) had the highest leaf nutrient concentrations in terms of nitrogen, phosphorus, potassium and magnesium, while plots without amendment had the lowest concentrations of N, P and K. Maize leaf nutrient contents in plots amended with the combination of 150 kg ha^{-1} NPK and 5 t ha^{-1} poultry manure (N150P5G0) and plots with the combined application of 150 kg ha^{-1} NPK and 5 t ha^{-1} *Gliricidia* (N150P0G5) were similar. There was no significant difference ($P > 0.05$) in maize leaf nutrient concentration between plots treated with only 5 t ha^{-1} poultry manure (N0P5G0) and plots treated with 5 t ha^{-1} *Gliricidia* alone (N0P0G5). Maize leaf nutrient concentration in plots treated with 150 kg ha^{-1} NPK alone (N150P0G0) was relatively higher than that in plots treated with 5 t ha^{-1} poultry manure only (N0P5G0) or 5 t ha^{-1} *Gliricidia* alone (N0P0G5).

Table 4 shows the effect of the combined application of NPK 15:15:15, poultry manure and *Gliricidia* on the growth and yield parameters of maize. All treatments significantly improved the growth and yield parameters compared with the control. The growth and yield parameters measured were significantly ($P < 0.05$) influenced by the treatments. Maize grown on plots amended with the combination of 5 t ha^{-1} poultry manure and 5 t ha^{-1} *Gliricidia* (N0P5G5) had the best growth parameters in terms of number of nodes and plant height, while the lowest growth parameters were obtained from plots without amendment (N0P0G0). Plots treated with 150 kg ha^{-1} NPK, 5 t ha^{-1} poultry manure and 5 t ha^{-1} *Gliricidia* (N150P5G5) had the highest seed number per cob, shelling percentage and grain yield per hectare. This was closely followed by maize grown on plots treated with

Table 2. Effects of combined application of poultry manure, Gliricidia sepium and NPK 15:15:15 fertilizer on soil chemical properties

Treatment	pH	Ca	Mg	K	Na	Ex.AC	ECEC	BASESAT	Total N	Org. Matter	AV. P
				Cmokg-1					%		($mgkg^{-1}$)
$N_0P_0G_0$	6.07a	6.02c	2.12c	0.14c	0.91a	0.83b	9.50bd	99.09a	0.15b	1.03c	17.51d
N0P0G5	6.18a	5.14c	2.20c	0.14c	0.44b	0.83b	8.01c	98.70a	0.14b	1.78b	25.05c
$N_0P_5G_0$	6.16a	7.99b	2.99a	0.19b	0.53b	0.80b	11.78b	99.27a	0.16b	1.92b	24.82c
$N_0P_5G_5$	6.27a	5.52d	2.52b	0.25a	0.68b	0.78b	10.41b	99.27a	0.18a	2.34a	25.62c
$N_{150}P_0G_0$	5.56b	6.30c	2.45b	0.17b	0.50b	0.11c	9.51b	98.81a	0.15b	1.50b	25.07c
$N_{150}P_0G_5$	5.86b	6.38c	2.42b	0.23a	0.57b	0.93a	9.89b	99.06a	0.16b	1.87b	24.84c
$N_{0150}P_5G_0$	6.14a	7.03b	2.24c	0.21a	0.55b	0.83b	10.11b	99.17a	0.18a	2.25a	30.91b
$N_{0150}P_5G_5$	5.99b	11.89a	2.57b	0.23a	0.61b	0.85b	15.18a	99.39a	0.14b	1.79b	41.30a

Means with the same letter in the same column are not significantly different at ($p > 0.05$) using DMRT

150 kg ha⁻¹ NPK alone (N150P0G0). However, there was no significant difference (P > 0.05) in the yield parameters of maize grown on plots receiving the combined application of 150 kg ha⁻¹ NPK and 5 t ha⁻¹ *Gliricidia* (N150P0G5). The yield obtained from plots treated with 5 t ha⁻¹ poultry manure alone (N0P5G0) compared favourably with that from plots treated with 5 t ha⁻¹ *Gliricidia* alone (N0P0G5). Maize grown on plots without amendment had the poorest yield parameters.

Table 3. Effect of combined application of poultry manure, Gliricidia sepium and NPK 15:15:15 fertilizer on leaf nutrients content of maize

Treatment	N	P	K	Na	Ca	Mg
			(%)			
N0P0G0	1.09d	0.12d	1.03c	1.05b	3.17a	0.61a
N0P0 G5	1,30c	0.17b	1.33a	1.30a	3.75a	0.60a
N0P5G0	1.49b	0.20b	1.26b	1.22b	3.13b	0.59b
N0P5G5	1.41b	0.18b	1.10d	1.17b	3.10b	0.59b
N150P0G0	1.37c	0.18b	1.03c	1.07b	3.29a	0.68a
N150P0G5	1.42b	0.16c	1.37a	1.35a	3.44a	0.76a
N150P5G0	1.45b	0.20b	1.18b	1.21b	3.45a	0.56b
N150P5G5	1.62a	0.28a	1.39a	1.34a	3.37a	0.60a

Means with the same letter in the same column are not significantly different at (p > 0.05) using DMRT

Table 4. Effects of combined application of poultry manure, gliricidia and NPK fertilizer on growth and yield parameters of maize

Treatment	Node/Stand	Height(cm)	Cob Weight(g)	Seed no/Cob	Shelling Percentage	Grain Yield(t/ha)
$N_0P_0G_0$	13.57a	163.93c	69.77e	235.33d	60.53c	1.54d
$N_0P_0G_5$	15.00a	178.42c	98.40d	253.67d	61.13c	2.21c
$N_0P_5G_0$	15.10a	195.93b	132.63c	374.33a	67.40a	2.30d
$N_0P_5G_5$	16.12a	212.93a	148.10b	370.11a	70.83a	2.41b
$N_{150}P_0G_0$	15.62a	198.67b	177.53a	370.67a	74.23a	2.60a
$N_{150}P_0G_5$	16.33a	219.53a	169.80a	367.10b	74.27a	2.54a
$N_{150}P_5G_0$	15.33	187.26b	144.77b	329.00c	68.83a	2.53a
$N_{150}P_5G_5$	15.54a	188.60b	178.37a	371.00a	75.43a	2.62a

Means with the same letter in the same column are not significantly different at (P>0.05) using DMRT

4. Discussion

The pre-treatment soil analysis revealed that the experimental soil contained less than 3% organic matter, approximately 0.15% total nitrogen and 8-10 mg kg⁻¹ available phosphorus. These values are below the critical nutrient requirements for optimum crop production in southwestern Nigeria, as reported by Adeleye et al. (2024). This indicates that the soil was inherently low in fertility, thereby justifying the need for appropriate soil management practices to sustain soil fertility and enhance crop productivity.

The high sand content observed in the experimental soil may be attributed to the intense rainfall characteristic of the study area, which promotes the leaching and erosion of finer soil particles such as silt and clay. Similarly, the slightly acidic soil reaction could be a consequence of prolonged nutrient leaching under high-rainfall conditions. The low organic matter content was likely associated with the continuous cultivation of the site for arable crop production without adequate replenishment of organic residues. Furthermore, the low cation exchange capacity (CEC) recorded indicates a limited ability of the soil to retain and supply essential nutrients to crops. Consequently, the application of inorganic fertiliser alone may not adequately improve soil productivity because nutrients are susceptible to leaching losses, particularly in sandy soils under high-rainfall conditions. Therefore, the integration of organic and inorganic nutrient sources is necessary to improve nutrient retention, enhance fertiliser-use efficiency and sustain crop production.

The increase in soil organic matter observed in plots amended with organic wastes (N0P5G5) compared with the control (N0P0G0) and sole NPK fertiliser treatments (N150P0G0) can be attributed to the high organic carbon content of poultry manure and *Gliricidia* biomass. In contrast, the lower soil pH recorded in NPK-fertilised plots (N150P0G0, N150P0G5, N150P5G5 and N150P5G0) relative to the control (N0P0G0) and organically amended plots (N0P5G5) reflects the acidifying effect of mineral fertilisers. This observation is consistent with the findings of Wang et al. (2020), who reported that nitrification of ammonium-based fertilisers releases hydrogen ions (H^+), thereby increasing soil acidity. Continuous application of NPK fertiliser without organic amendments may therefore contribute to progressive soil acidification, which could negatively affect nutrient availability and crop productivity over time.

The relatively higher concentrations of soil nutrients recorded in plots receiving combined applications of poultry manure, *Gliricidia* and NPK fertiliser (N150P5G5) demonstrate the synergistic effects of integrated nutrient management. The mineral fertiliser component likely provided readily available nutrients that stimulated microbial activity and accelerated the decomposition of organic materials, leading to faster mineralisation and nutrient release. At the same time, the organic amendments improved soil organic matter content, enhanced nutrient retention and reduced nutrient losses through leaching. These findings agree with those of Imran (2024) and Wang et al. (2025), who reported that integrated application of organic and inorganic fertilisers enhances soil nutrient accumulation and improves soil fertility.

The improved nutrient status observed in plots amended solely with poultry manure (N0P5G0) or *Gliricidia* (N0P0G5) compared with the untreated control (N0P0G0) further suggests that these organic materials can serve as effective nutrient sources for sustainable maize production. This finding corroborates the work of Azeez et al. (2020), who reported that animal manures significantly increased soil macronutrient concentrations in southern Nigeria.

The nutrient concentrations observed in maize leaves closely reflected the nutrient status of the corresponding soils. Higher nutrient concentrations were recorded in plants grown in plots amended with organic wastes and NPK fertiliser (N150P5G5), whereas lower nutrient concentrations were observed in plants from untreated plots (N0P0G0). This relationship indicates that improved soil fertility enhanced nutrient uptake by maize plants.

The growth and yield responses of maize recorded in this study were consistent with the observed improvements in soil nutrient status resulting from the various treatments. The highest growth and yield parameters were obtained from plots that received the integrated application of 150 kg ha^{-1} NPK fertiliser, 5 t ha^{-1} poultry manure and 5 t ha^{-1} *Gliricidia* biomass. This superior performance can be attributed to improved nutrient availability, enhanced nutrient uptake and better soil physical and chemical conditions created by the combined amendments. Consequently, these factors contributed to increased maize grain yield.

This finding is consistent with the report of Mng'omba and Akinnifesi (2020), who observed that the combined application of *Gliricidia* and NPK fertiliser increased maize grain yield compared with the application of NPK fertiliser alone. Similarly, Adeyemo et al. (2019) reported that poultry manure-amended plots produced significantly higher maize grain yields than plots that did not receive manure treatments. The present study therefore demonstrates the effectiveness of integrating organic and inorganic nutrient sources for improving soil fertility, nutrient uptake and maize productivity under the prevailing soil conditions.

5. Conclusion

The study showed that integrating poultry manure, *Gliricidia sepium* and NPK 15:15:15 fertiliser improved soil nutrient status and maize performance under the conditions of the field experiment in southwestern Nigeria. The combined application of organic amendments and mineral fertiliser enhanced soil nutrient availability, supported better nutrient uptake and improved maize growth and grain-yield parameters compared with untreated plots and most sole nutrient-source treatments. Poultry manure and *Gliricidia sepium* contributed organic matter and supported nutrient retention, while NPK fertiliser supplied readily available nutrients for crop growth. The sole application of NPK fertiliser reduced soil pH relative to treatments containing organic amendments, indicating that mineral fertiliser should not be used alone where long-term soil fertility maintenance is required. Overall, the findings support integrated nutrient management as a practical approach for improving maize productivity and maintaining soil fertility in the study area. The results further indicate that combining organic and inorganic inputs can reduce dependence on a single nutrient source while sustaining crop performance.

6. Limitation

This study was conducted at a single location and within one cropping season; therefore, the findings may not fully represent longer-term soil fertility changes or responses across different agroecological zones. Further multi-season and multi-location trials are needed to confirm the consistency of the treatment effects on maize yield and soil nutrient dynamics.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Author has declared that no competing interests exist.

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