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Effect of Tillage Methods and Fertilizer Types on Some Selected Physicochemical Properties of Soil and Cowpea (*Vigna unguiculata*) Yield in Awka, Southeastern Nigeria

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ABSTRACT

Background and Objective: Objective: This study aimed to evaluate the effects of different tillage methods and fertilizer types on selected soil physicochemical properties and the growth and yield performance of cowpea. The experiment was conducted at the Department of Soil Science and Land Resource Management Research Farm, Ifite-Awka, Anambra State.

Materials and Methods: A Randomized Complete Block Design (RCBD) with eight treatments replicated three times was employed. Treatments included: No tillage with no amendment; No tillage + NPK (5 kg ha^{-1}); no tillage +NPK (5 kg ha^{-1}) + poultry manure (2 kg); no tillage + poultry manure (2 kg ha^{-1}), conservation tillage with no amendment; conservation tillage + NPK (5 kg ha^{-1}), conservation tillage + NPK (5 kg ha^{-1}) + poultry manure (2 kg ha^{-1}) and conservation tillage +poultry manure (2 kg ha^{-1}). The experiment was conducted on a 25 m×10 m field. Soil physicochemical properties were analyzed in the laboratory, while plant growth and yield parameters (plant height, number of leaves, number of pods and pod weight) were recorded.

Results: The treatments showed no significant effects on exchangeable Mg, Na, H, Al and total nitrogen. In contrast, soil pH, Cation Exchange Capacity (CEC), organic carbon, available phosphorus and exchangeable K and Ca exhibited significant treatment effects. Soil texture remained unchanged across treatments, whereas bulk density decreased relative to initial values. Soil moisture content increased considerably after the experiment. Cowpea grown under conservation tillage combined with poultry manure produced the greatest plant height and highest number of leaves among all treatments.

Conclusion: Overall, conservation tillage supplemented with poultry manure (deep litter) was the most effective treatment, enhancing cowpea growth and yield while improving key soil physicochemical properties. This integrated management approach is therefore recommended for optimizing soil productivity and cowpea performance in the study area.

INTRODUCTION

Soil fertility and land preparation are fundamental determinants of crop productivity and long-term agricultural sustainability[1]. As noted by Sheikh et al.[2] soil fertility challenges in many tropical regions are exacerbated by inappropriate tillage practices, which accelerate soil erosion, nutrient leaching, compaction and deterioration of soil structure. Improving the nutrient status and overall quality of tropical soils can be achieved through the application of mineral fertilizers, organic amendments, or integrated nutrient management strategies that combine both approaches[3].

Cowpea (*Vigna unguiculata*) is an important legume widely consumed across Africa and valued for its ability to fix atmospheric nitrogen, thereby improving soil fertility while providing a protein-rich food source. Although cowpea exhibits relatively good resistance to many regional pests and diseases, making it a low-input and environmentally friendly crop, its performance remains highly sensitive to soil conditions and nutrient availability[4]. Despite its agronomic and nutritional advantages, cowpea productivity is often constrained by pest pressure, disease incidence and suboptimal yields.

Land preparation practices play a critical role in shaping soil structure, organic matter content and water infiltration capacity[5]. Among these practices, soil tillage remains one of the most influential factors determining soil quality and crop performance, accounting for up to 20% of all crop production factors[6]. In regions experiencing rapid population growth and agricultural intensification-such as Nigeria-maintaining soil quality under intensive land use poses a major sustainability challenge[7]. Tillage influences nutrient cycling by modifying the soil's physical and biological environment; for instance, intensive tillage increases aeration, stimulating microbial decomposition of organic matter and temporarily enhancing nutrient release[8].

Similarly, fertilizer application is essential for supplying nutrients required for optimal plant growth, though its effectiveness depends on soil characteristics and crop nutrient demands[9]. NPK (15:15:15), a commonly used mineral fertilizer composed of equal proportions of nitrogen, phosphorus and potassium, is applied to enhance soil fertility and plant development. Organic manures, such as poultry manure, provide not only macro- and micronutrients but also organic matter that supports microbial activity, improves soil structure and enhances physicochemical properties[10]. Poultry droppings (deep litter), consisting of fecal matter and bedding material from poultry houses, are particularly valuable for boosting soil biological activity and nutrient status.

This study seeks to support the advancement of sustainable agricultural practices and improved cowpea production in Awka, with broader implications for food security, environmental sustainability and policy development. The overarching objective is to assess the effects of different tillage methods and fertilizer types on soil physical and chemical characteristics, as well as on the growth and yield performance of cowpea (*Akidi ani*) in Ifite-Awka.

MATERIALS AND METHODS

Description of experimental area: The experiment was conducted at the Teaching and Research Farm of the Department of Soil Science and Land Resource Management, Nnamdi Azikiwe University, Ifite-Awka Campus, Anambra State. The study area is located between latitude 6°15'N and longitude 7°6'E, characterized by a mean annual temperature of approximately 27°C and an average relative humidity of about 70%. The region receives an annual rainfall exceeding 1,450 mm, predominantly concentrated in the wet season[11]. The field experiment was implemented during the 2024 late rainy season on a 25 m × 10 m plot (35 m²).

Treatments of the experiment:

T1 : Control (no-tillage +0 amendment)
T2 : No-tillage+NPK (5 kg/ha)
T3 : No-tillage+NPK (5 kg/ha) +PM (2 kg/ha)
T4 : No-tillage+PM (2 kg/ha)
T5 : Control (conservational tillage+ 0 amendment)
T6 : Conservational tillage +NPK (5 kg/ha)
T7 : Conservational tillage+NPK (5 kg/ha)+PM (2 kg/ha)
T8 : Conservational tillage +PM (2 kg/ha)

Layout and experimental design: The study employed a 2×4 factorial arrangement consisting of two tillage practices (no tillage and conservation tillage) and four fertilizer combinations, resulting in a total of eight treatment combinations. These treatments were arranged in a Randomized Complete Block Design (RCBD) with three replications, giving a total of 24 experimental units.

Land preparation and fertilizer application: The experimental field was manually cleared using cutlasses. The area was measured, mapped and pegged, after which 24 beds were raised to delineate blocks and plots. Twelve plots were tilled using hoes, whereas the remaining twelve plots were left undisturbed to represent the no-tillage condition. Fertilizers were applied by the broadcasting method according to the treatment specifications.

Crop data collection: Data collection commenced at 2 Weeks after Sowing (WAS) and continued at 2-week intervals until harvest (2, 4, 6 and 8 WAS). The number of leaves was determined by direct counting on sampled plants within each plot. Plant height was measured from the soil surface to the tip of the longest vine. The number of pods per plant was obtained by counting mature pods on each sampled plant. Pod weight was recorded using a digital electronic scale and values were expressed in g $plant^{-1}$.

Soil sampling and laboratory analysis: Baseline and post-harvest soil samples were collected for laboratory analysis. Disturbed soil samples were obtained using an auger, while undisturbed samples were collected with a core sampler at a depth of 0-10 cm. Baseline samples were randomly collected and composited, while post-treatment samples were collected at crop maturity for each treatment. Samples were processed and analyzed for the following parameters:

- **Bulk density:** It was determined using the core method as described by Anderson and Ingram[12].
- **Particle size distribution:** Its was assessed using the Bouyoucos hydrometer method[13].
- **Soil texture:** Soil texture was classified using the textural triangle.
- **Soil organic carbon and organic matter:** They were measured by the Walkley-Black wet oxidation method as modified by Nelson and Sommers[14].
- **Total nitrogen:** It was determined using the Kjeldahl digestion method[15].
- **Available phosphorus:** It was analyzed using the Bray 1 extraction method[16].
- **Exchangeable bases (Ca, Mg, K, Na):** They were extracted using 1 N ammonium acetate at pH 7, Ca and Mg were quantified using an atomic absorption spectrophotometer, while K and Na were measured with a flame photometer[17].
- **Exchangeable acidity (H and Al^{3+}):** It was determined using 1 N KCl extraction[17].
- **Cation exchange capacity (CEC):** It was obtained by summing exchangeable base and acid cations[18].

Statistical analysis: All collected data were subjected to one-way analysis of variance (ANOVA) using GenStat software[19]. Where significant differences occurred, treatment means were separated using Duncan's Multiple Range Test (DMRT) at a 5% probability level.

RESULTS AND DISCUSSION

Initial soil properties: Initial soil analysis was carried out to assess the soil fertility status at the study area before experiment. The results of the initial soil analysis are presented in Table 1, the soil texture is Sandy loam.

Effect of land preparation methods and fertilizer types on some selected soil physical properties after harvest: Table 2 presents the effects of land preparation methods and fertilizer types on selected soil physical properties, including bulk density, moisture content, particle size distribution and soil texture. Bulk density was highest in plots subjected to conservational tillage +NPK (1.70 mg cm^{-3}) and lowest in no-tillage + NPK plots (1.36 mg cm^{-3}). This pattern may be attributed to the partial soil disturbance associated with conservation tillage, which can promote surface compaction. This observation aligns with the findings of Koch and Stockfisch[20], who reported that although conservation tillage increases soil organic matter, inadequate soil management can result in topsoil compaction and consequently higher bulk density compared with other tillage practices. The result is also supported by Olufemi and Akinyemi[21], who noted that the application of NPK fertilizer enhances soil particle aggregation, thereby reducing pore space and increasing bulk density.

Soil moisture content was highest under conservational tillage+poultry manure (12.70%) and lowest in no-tillage with no amendment (10.68%). The elevated moisture content in the conservational tillage+poultry manure treatment may be attributed to the combined effects of manure addition and minimal soil disturbance, both of which promote improved soil aggregation and structural stability. Similar observations were reported by Onunwa et al.[22], who found that poultry manure application reduced bulk density and enhanced the water-holding capacity of soils in Awka. This consistency reinforces the role of organic amendments in improving soil physical conditions under conservation-oriented land management practices.

Table 1: Initial soil physicochemical properties

Soil properties	Values
Sand (%)	62.40
Clay (%)	9.60
Silt (%)	28.00
Soil texture	Sandy loam
pH	6.80
Bulk density (mg/cm^3)	1.88
Moisture content (%)	10.56
Organic carbon (%)	0.62
Available P (mg/kg)	3.43
Total nitrogen (%)	0.053
Exchangeable potassium (Cmol/kg)	0.17
Exchangeable sodium (Cmol/kg)	0.11
Exchangeable calcium (Cmol/kg)	2.00
Exchangeable magnesium (Cmol/kg)	1.60
Exchangeable hydrogen (mg/dm^3)	0.20
Exchangeable aluminum (mg/dm^3)	0.50
Cation exchange capacity	4.48

Table 2. Effect of land preparation methods on some soil physical properties after harvest

Land preparation	Fertilizer	Bulk density (Mg/cm^3)	Moisture content (%)	Sand (%)	Clay (%)	Silt (%)	Soil texture
No tillage	No Fertilizer	1.64	10.68	61.07	60.00	31.37	Sandy loam
	Npk (5 kg)	1.36	10.93	64.40	10.93	24.67	Sandy loam
	Npk (5 kg)+pm (2 kg)	1.65	11.27	63.07	9.60	27.33	Sandy loam
	PM (2 kg)	1.46	11.59	64.40	7.60	26.67	Sandy loam
Conservational tillage	No Fertilizer	1.55	12.36	63.07	10.27	26.00	Sandy loam
	Npk (5 kg)	1.70	11.47	61.73	10.93	27.33	Sandy loam
	Npk (5 kg)+pm (2 kg)	1.61	12.07	61.07	10.27	28.67	Sandy loam
	PM (2 kg)	1.51	12.70	59.07	10.93	30.00	Sandy loam
LSD (p = 0.5)		0.09	0.53	0.49	0.37	0.11	Sandy loam

LSD: Least significant different

Table 3: Effect of land preparation methods and different fertilizer types on some soil chemical properties after harvest

Land preparation	Fertilizer	CEC	Soil pH	OC (%)	Ava.P (%)	Exch. Cations (Cmol/kg) K	Ca	Mg	Na	Exch. acid (mg/dm^3) H	Al	Total N
No tillage	No fertilizer	5.27	6.56	0.68	3.08	0.20	2.47	1.47	0.14	0.33	0.67	0.06
	NPK (5 kg)	5.59	6.40	0.62	3.22	0.20	2.67	1.53	0.13	0.27	0.70	0.05
	NPK (5 kg)+PM (2 kg)	5.08	6.79	0.58	3.18	0.28	2.40	1.47	0.13	0.33	0.60	0.05
	PM (2 kg)	5.68	5.80	0.77	2.87	0.16	2.67	1.73	0.09	0.33	0.73	0.06
Conservation	No Fertilizer	5.85	6.43	0.80	4.35	0.23	2.87	1.60	0.15	0.23	0.77	0.07
	NPK (5 kg)	4.72	6.07	0.61	2.78	0.21	2.07	1.47	0.14	0.33	0.60	0.05
	NPK (5 kg) +PM (2 kg)	4.71	6.31	0.66	4.20	0.20	2.33	1.20	0.12	0.33	0.77	0.05
	PM (2 kg)	6.05	5.54	0.72	3.43	0.22	3.13	1.60	1.10	0.33	0.67	0.06
LSD (p = 0.5)		0.21	0.76	0.14	0.23	0.12	0.13	Ns	Ns	Ns	Ns	Ns

CEC: Cation exchange capacity, OC: Organic carbon, Available phosphorus, K: Potassium, Ca: Calcium, Mg: Magnesium, Na: Sodium, H: Hydrogen and Al: Aluminum

Effect of land preparation methods and fertilizer types on some selected soil chemical properties after harvest: Table 3 shows that Cation Exchange Capacity (CEC) was highest under conservational tillage + poultry manure (6.05 Cmol kg^{-1}) and lowest under conservational tillage +NPK+poultry manure (4.71 Cmol kg^{-1}). This trend is likely attributable to the high organic matter content supplied by poultry manure, which enhances soil structure and increases CEC. This observation is consistent with Babalola and Akinremi[23], who reported that poultry manure applied alone results in a greater accumulation of soil organic matter, thereby improving CEC. Similarly, Agbede[24] noted that although NPK fertilizer supplies essential nutrients, it does not contribute to organic matter buildup to the same extent as poultry manure.

Soil pH was highest in the no tillage+NPK+poultry manure treatment (6.79) and lowest in the conservational tillage+poultry manure treatment (5.54), with significant differences observed among treatments. The relatively higher pH under no tillage +NPK+poultry manure may be due to the rapid increase in nutrient availability associated with NPK fertilizer, which can more immediately influence soil pH than organic amendments under conservation tillage. This finding corroborates Agbede[24], who observed that inorganic fertilizers can rapidly enhance nutrient availability, although excessive use may induce nutrient leaching and long-term soil degradation.

Organic carbon content also differed significantly among treatments. The highest value occurred in conservational tillage + no amendment (0.88%), followed by no tillage+poultry manure (0.77%), conservational tillage+poultry manure (0.72%), no tillage +no amendment (0.68%), conservational tillage +NPK+poultry manure (0.66%), no tillage+NPK (0.62%), conservational tillage +NPK (0.61%) and the lowest in no tillage+NPK+ poultry manure (0.58%). The elevated organic carbon in conservation tillage plots without amendments may be explained by the reduced soil disturbance characteristic of conservation tillage, which minimizes the oxidation of soil organic matter and promotes carbon sequestration. This aligns with the findings of Lal[1], who demonstrated that conservation tillage enhances soil organic carbon accumulation by limiting soil disruption and reducing organic matter decomposition. Conversely, the lower organic carbon levels observed in no-tillage systems receiving both NPK and poultry manure may reflect a focus on nutrient supply without sufficient residue incorporation, which can accelerate organic matter turnover. Balesdent et al.[26] similarly reported that nutrient-focused management without adequate organic matter incorporation can enhance organic matter degradation without replenishing deeper soil layers.

Available phosphorus was highest in conservational tillage+no amendment (4.35 mg kg−^{1}), followed by conservational tillage+NPK+poultry manure (4.20 mg kg−^{1}) and lowest in conservational tillage+NPK (2.78 mg kg−). This suggests that in systems without amendments, existing soil organic matter and microbial activity may effectively sustain phosphorus availability. This result supports Dodds et al.[27], who reported that excessive use of synthetic fertilizers can disrupt natural soil nutrient dynamics, potentially leading to nutrient imbalances.

Exchangeable cations (Ca, Mg, K and Na) also responded differently to the treatments. Exchangeable Mg and Na did not vary significantly, whereas exchangeable K and Ca differed significantly. The highest exchangeable K (0.28 Cmol kg−^{1}) was recorded in no tillage+NPK +poultry manure, while the lowest (0.16 Cmol kg−) occurred in no tillage+poultry manure. This may be due to the fact that when organic fertilizers are applied at rates equivalent to the nutrient supply of inorganic fertilizers, they may exert similar effects on soil potassium status. This is in agreement with Agbede et al.[28], who reported that combined applications of poultry manure and NPK under no-tillage conditions can enhance potassium availability more effectively than organic manure alone.

Exchangeable Ca also differed significantly among treatments, with the highest value observed under conservational tillage +poultry manure (3.13 Cmol kg−^{1}) and the lowest under conservational tillage+NPK

Table 4: Effect of tillage and fertilizer types on growth of Cowpea at 2, 4 and 6 Weeks after planting

Land preparation	Fertilizer	Plant height (cm) at 2 WAP	Plant height (cm) at 4 WAP	Plant height (cm) at 6 WAP	No of leaves at 2 WAP	No. of leaves at 4 WAP	No. of leaves at 6 WAP
No tillage	No fertilizer	22.60	54.91	71.27	12.44	37.89	46.78
	NPK (5 kg)	16.16	19.14	33.93	9.78	13.22	23.33
	NPK (5 kg)+PM (2kg)	18.66	44.12	91.73	10.44	24.33	50.22
	PM (2 kg)	25.17	53.33	113.47	11.33	56.89	64.00
Conservation tillage	No fertilizer	22.72	54.69	102.02	12.22	37.89	65.33
	NPK (5 kg)	19.58	33.40	86.16	12.33	31.67	55.89
	NPK (5 kg)+PM (2 kg)	22.80	32.58	43.87	10.83	19.33	39.44
	PM (2 kg)	30.73	67.57	125.91	15.33	64.44	73.00
LSD (p = 0.5)		5.05	6.88	23.21	6.88	5.05	20.92

(2.07 Cmol kg^{-1}). The elevated Ca in conservation tillage with poultry manure reflects the contribution of organic amendments to soil cation retention. The continuous decomposition of poultry manure enhances soil organic matter, thereby improving the soil's capacity to retain divalent cations such as Ca. Fageria and Baligar[29] similarly reported that mineral fertilizers such as NPK supply nutrients in readily available forms but contribute little to soil organic matter accumulation, thereby limiting their long-term influence on soil quality parameters. Total nitrogen did not differ significantly among treatments.

Effect of tillage methods and fertilizer types on plant growth at 2, 4 and 6 weeks after planting: Table 4 presents the mean response of cowpea to the various land preparation methods and fertilizer treatments at 2, 4 and 6 WAP. The combination of conservational tillage + poultry manure produced the highest number of leaves (15.33) and the greatest plant height (30.73 cm) at 2 WAP, whereas the no-tillage + NPK treatment recorded the lowest values, with 9.78 leaves and a height of 16.16 cm. Cowpea growth parameters increased progressively with time. Under conservational tillage+poultry manure, the number of leaves increased markedly from 15.33 at 2 WAP to 64.44 at 4 WAP, while plant height increased from 30.73-67.57 cm over the same period.

At 6 WAP, plant height differed significantly among treatments ($p<0.05$). The no-tillage+NPK plot continued to produce the lowest number of leaves (23.33) and shortest plant height (33.93 cm). In contrast, conservational tillage+poultry manure resulted in the highest leaf number (73.00) and plant height (125.91 cm). The superior performance observed under the poultry manure treatments may be attributed to the ability of organic fertilizers to improve soil structure, enhance moisture retention and stimulate microbial activity, thereby creating a more favorable environment for root development and nutrient absorption compared with NPK fertilizer.

These findings support the observations of Mohamed and Abdelnaser[30], who reported that cowpea supplied with organic fertilizers exhibits higher growth rates and yields than when supplied with inorganic fertilizers. Poultry manure provides a broad spectrum of macro- and micronutrients, including nitrogen, phosphorus and potassium, released gradually to sustain plant growth, whereas NPK fertilizer supplies only specific nutrients in higher concentrations and lacks both micronutrients and organic matter essential for overall plant development. This outcome also aligns with Boateng et al.[31], who demonstrated that poultry manure enhances vegetative growth in various crops.

Regarding tillage practices, this study further showed that conservational tillage improved soil physical and chemical properties more effectively than no-tillage, resulting in enhanced crop growth. This observation is consistent with Aikins and Afuakwa[32], who noted that conservation tillage enhances soil structure and reduces erosion, thereby supporting more robust plant growth compared with no-tillage. Rashidi et al.[33] similarly reported that although no-tillage preserves soil biophysical properties, conservational tillage loosens the soil surface, facilitating faster crop establishment. Moreover, Dugan et al.[34] confirmed that integrating conservation tillage with poultry manure generates synergistic effects that further improve soil fertility and plant performance.

Effect of different tillage methods and fertilizer types on cowpea yield: Table 5 presents the effects of different land preparation practices and fertilizer treatments on cowpea yield at harvest. The number of pods per plant and fresh pod weight were significantly higher under conservational tillage+poultry manure (deep litter), whereas the lowest values were recorded in the conservational tillage+ NPK+poultry manure (deep litter) treatment. The superior performance observed under conservational tillage combined with poultry manure is likely attributable to its high organic matter content and its capacity to provide a sustained release of nutrients essential for optimal pod formation and yield.

These results are consistent with the findings of Kanimoli and Kumar[35], who reported that poultry manure supplies both macro- and micronutrients and owing to its slow nutrient release, sustains crop growth more effectively over time than synthetic fertilizers such as NPK. Comparative evidence further demonstrates that although NPK fertilizers may enhance short-term yield, poultry

Table 5: Effect of different land preparation methods and fertilizer types on yield of Cowpea at harvest

Land preparation	Fertilizer	No. of pods	Fresh pod weight (t/ha)
No tillage	No fertilizer	8.33	0.00003156
	NPK (5 kg)	2.00	0.00000767
	NPK (5 kg)+PM (2 kg)	5.67	0.0000210
	PM (2 kg)	8.11	0.00003122
Conservational tillage	No fertilizer	6.33	0.00002411
	NPK (5 kg)	5.67	0.0000215
	NPK (5 kg)+PM (2 kg)	1.33	0.00000217
	PM (2 kg)	13.56	0.00005611
LSD (p = 0.5)		6.51	0.00001942

manure contributes more substantially to long-term soil fertility and productivity. For example, Mavengahama[36] observed that cowpea grown with poultry manure exhibited improved nutrient uptake, higher yield and greater tolerance to drought stress compared with plants fertilized solely with NPK.

CONCLUSION

The findings of this study demonstrate that the combination of conservational tillage and poultry manure resulted in the highest growth and yield performance of cowpea. Overall, treatments incorporating organic amendments (poultry manure) enhanced soil organic matter and significantly improved key agronomic parameters, including plant height, number of leaves, number of pods and pod weight. Conservational tillage+poultry manure notably increased soil moisture content, exchangeable Ca and Cation Exchange Capacity (CEC), whereas conservational tillage+no amendment improved soil organic carbon, available phosphorus and exchangeable Na. In addition, no-tillage+NPK+poultry manure enhanced exchangeable K, while no-tillage+poultry manure increased exchangeable Mg.

Based on these outcomes, the adoption of conservational tillage in combination with poultry manure is recommended for farmers in the study area, as this practice consistently supported superior cowpea growth and yield while contributing to sustainable soil fertility and long-term agricultural productivity.

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