Effects of Animal Manures on Growth and Yield of Maize (*Zea mays L.*) and Soil Physicochemical Properties in Awka, Anambra State, Nigeria

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ABSTRACT

Objective: Soil fertility decline in Southeastern Nigeria, particularly in Anambra State, significantly limits maize (*Zea mays* L.) productivity. This study aimed to evaluate the effectiveness of Poultry Dropping (PD), Cattle Dung (CD) and their combined application (PD+CD) in improving soil properties and enhancing maize germination, growth and yield.
Materials and Methods: A field experiment was conducted at the Teaching and Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Nigeria. Treatments were arranged in a Randomized Complete Block Design (RCBD) with four treatments: Control (no manure), poultry dropping (PD; 4.4 t ha^{-1}), cattle dung (CD; 2.2 t ha^{-1}) and a combined application of PD+CD (2.2 t ha^{-1} each), replicated three times. Growth variables assessed were plant height (PH), number of Leaves per Plant (LPP) and number of Cobs per Plant (CPP). Data were analyzed using Analysis of Variance (ANOVA) and treatment means were separated using the LSD test at a 5% significance level.
Results: Organic amendments significantly improved soil physical (moisture content, bulk density, total porosity, saturated hydraulic conductivity) and chemical properties (pH, organic matter, nutrient content and effective cation exchange capacity). The combined application of PD+CD produced the greatest improvement in maize performance, resulting in higher plant height at 2 and 6 Weeks after Planting (WAP), increased number of leaves per plant at 2 and 4 WAP and a significantly higher number of cobs per plant at 8 WAP.
Conclusion: The integrated use of poultry dropping and cattle dung (PD+CD) is an effective and affordable soil fertility management strategy. It enhances soil quality and significantly improves maize growth and yield in Awka and similar agro-ecological zones in Southeastern Nigeria.

INTRODUCTION

Maize (*Zea mays* L.), also known as corn, is a major staple crop supporting more than 1.2 billion people across sub-Saharan Africa and Latin America, following its introduction in the 1500s[1]. It is the third most important cereal crop globally after wheat and rice and serves as a significant source of carbohydrates, vitamins A, C and E, approximately 9% protein, essential minerals, dietary fibre and energy[1]. In Nigeria, where maize is consumed by over 200 million people, national production has reached 12.95 million tonnes[2]. Beyond its contribution to human nutrition, maize is widely utilized as livestock feed and as an industrial raw material, leading to increasing domestic demand that frequently exceeds supply[3].

Despite its socio-economic importance, maize production in Southeastern Nigeria-particularly in Awka, Anambra State-remains below potential. Major limiting factors include declining soil fertility, erratic rainfall, erosion, land degradation and over-reliance on costly inorganic fertilizers[4-8]. Continuous cultivation, nutrient depletion and inappropriate land management practices accelerate soil fertility decline, reducing the availability of essential macronutrients such as nitrogen (N), phosphorus (P) and potassium (K), which are critical for maize growth and yield[8].

Although, inorganic fertilizers can restore soil nutrients, their adoption among resource-poor farmers is constrained by high cost, limited accessibility and environmental concerns. Excessive or prolonged fertilizer use contributes to soil acidification, crusting, biodiversity loss, pest resurgence, nutrient leaching, pollution and adverse human health impacts[9-11].

Sustainable maize production therefore requires soil management practices that improve soil fertility, structure and resilience. Organic amendments such as poultry droppings and cattle dung represent cost-effective and environmentally friendly alternatives. These inputs enhance soil organic matter content, improve structure and water-holding capacity and stimulate microbial activity. Poultry manure is nutrient-dense, particularly in N, P and K and decomposes rapidly, providing nutrients for early crop establishment. In contrast, cattle dung decomposes more slowly, prolonging nutrient release and improving soil tilth, porosity and cation exchange capacity[12,13]. The combined effects of poultry droppings and cattle dung may integrate the benefits of both materials, thereby improving soil fertility and crop productivity[14].

While previous studies have demonstrated the positive effects of organic manures on maize production, limited research has examined the comparative and combined-effects of poultry droppings and cattle dung under the soil and climatic conditions of Southeastern Nigeria, particularly in Anambra State[15-17]. This study was therefore conducted to evaluate the effects of poultry droppings, cattle dung and their combination on soil physicochemical properties, maize growth and yield in Awka, Southeastern Nigeria.

MATERIALS AND METHODS

Study area: The field experiment was carried out at the Teaching and Research Farm, Department of Soil Science and Land Resources Management, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. The site is located at latitude 6°24'N and longitude 7°11'E, at an elevation of 422 m above sea level. The region is characterized by a humid tropical climate, with an annual rainfall range of 1,650-2,000 mm, occurring in a bimodal pattern from April-July and September-November, separated by a short dry spell in August. Mean daily temperatures range from 27-30°C and relative humidity averages 75-80% throughout the year[18]. The natural vegetation consists predominantly of secondary regrowth, with common weed species including *Mimosa pudica*, *Aspilia africana*, *Imperata cylindrica*, *Sida acuta* and *Senna occidentalis*.

Soil sampling and pre-experimental analysis: Before land preparation, composite soil samples were collected randomly from the experimental field at a depth of 0-15 cm using a soil auger. The samples were air-dried, gently crushed, sieved through a 2 mm mesh and analyzed for selected physicochemical properties using standard laboratory procedures. Particle size distribution was determined using the Bouyoucos hydrometer method[19], while bulk density was determined using the core method[20]. Soil pH was measured in a 1:2.5 soil-water suspension using a glass electrode pH meter[21]. Organic carbon was analyzed by the wet oxidation method as described by Nelson and Sommers[22,23]. Total nitrogen was determined using the macro-Kjeldahl digestion and distillation procedure[24]. Available phosphorus was extracted using the Bray-1 method[25]. Exchangeable cations (Ca, Mg, K, Na) were extracted with 1 N ammonium acetate (NH OAc) at pH 7.0, Ca and Mg concentrations were quantified by atomic absorption spectrophotometry, while K and Na were measured using a flame photometer. Exchangeable acidity (Al^{3+} and H^+) was determined by extraction with 1 N KCl and subsequent titration[26,27]. Total porosity was calculated from Bulk Density (BD) and Particle Density (PD) was calculated using the following formula:

$$TP(\%)=\left(\frac{BD}{PD}\right)\times 100$$

Where:

TP : Total porosity (%)
BD : Bulk density ($Mg\ m^{-3}$)
PD : Particle density ($Mg\ m^{-3}$), commonly assumed as 2.65 $Mg\ m^{-3}$ for mineral soils

Effective cation exchange capacity (ECEC) was calculated by adding the exchangeable bases and exchangeable acidity[28]:

$$ECEC\ (cmol\ kg^{-1}) = Ca^{2+} + Mg^{2+} + K^{+} + Na^{+} + Al^{3+} + H+$$

Base Saturation (BS) expressed as the total exchange bases relative to ECEC:

$$BS(\%)=\left(\frac{Ca^{2+}+Mg^{2+}+K^{+}+Na^{+}}{ECEC}\right)\times 100$$

Organic amendments: Poultry droppings and cattle dung used in the experiment were sourced from the Animal Science Farm, Faculty of Agriculture, Nnamdi Azikiwe

University. The cattle dung was sun-dried for several days to reduce excess moisture prior to application. Both organic materials were analyzed for pH, organic matter, nitrogen, phosphorus, potassium, calcium, magnesium and sodium contents using the procedures previously described.

Experimental design and treatments: The experiment was laid out in a Randomized Complete Block Design (RCBD) with four treatments, each replicated three times. The treatments were as follows:

- T1: Control (no amendment)
- T2: Poultry dropping (4.4 t ha^{-1})
- T3: Cattle dung (4.4 t ha^{-1}),
- T4: Poultry dropping+cattle dung (2.2 t ha^{-1} each)

Each plot measured 3×3 m, with 1 m alleys between plots and 3 m spacing between blocks. The organic amendments were cured prior to incorporation based on established decomposition periods: Poultry droppings (3-4 weeks), cattle dung (6-8 weeks) and the composite mixture (4-6 weeks)[28-30]. The cured materials were incorporated into the soil one week before planting to allow partial mineralization.

Crop establishment and management: Maize (*Zea mays* L., Oba-Super 2 variety) was obtained from the Agricultural Development Programme (ADP), Awka, Anambra State. Seeds were treated with Apron Plus (a fungicidal seed dressing) to prevent seed-borne diseases and sown at a spacing of 75×25 cm, giving a total of 12 plants per plot. Standard agronomic practices were adopted throughout the study. Manual weeding was carried out as required and irrigation was applied using a watering can to maintain adequate soil moisture during dry spells.

Data collection

Soil properties: Soil samples were collected after amendment incorporation and at harvest from each plot and analyzed for the same physicochemical parameters assessed during pre-experimental soil characterization.

Plant growth and yield parameters: Four plants per plot were randomly tagged for data collection:

- **Plant height (cm):** measured from soil surface to the tip of the tallest leaf at 2, 4 and 6 Weeks after Planting (WAP) using a meter rule
- **Number of leaves per plant:** Counted at 2, 4 and 6 WAP
- **Yield parameter (number of cobs per plant):** Determined at physiological maturity (8 WAP)

Statistical analysis: Data on soil and plant variables were subjected to Analysis of Variance (ANOVA) using SPSS software (Version 31). Where significant treatment effects were detected, mean separation was performed using the Least Significant Difference (LSD) test at a 5% probability level. Visualizations were done using R studio package version 2025. 09.1 + 401 for bar charts, histograms, linegraphs, and radar chart.

RESULTS AND DISCUSSION

Soil physicochemical properties before the experiment: Pre-experimental soil characterization (Table 1) indicated that the soil was sandy clay loam, slightly acidic (pH 5.48) and low in organic matter (1.88%) and total nitrogen (0.104%). Available phosphorus was also low (18.1 mg kg^{-1}). The bulk density (1.53 g cm^{-1}) and porosity (42.26%) suggested moderate compaction. These findings are consistent with earlier reports that soils in Southeastern Nigeria are inherently low in fertility and require external nutrient inputs for sustainable crop production[31].

Nutrient composition of organic amendments: Chemical analysis of the organic materials (Table 2) showed that poultry droppings contained higher concentrations of nitrogen (3.2%), phosphorus (2.3%) and organic matter (63.54%) compared to cattle dung (2.16% N, 1.77% P, 36.91% OM). Cattle dung contained slightly higher

Table 1: Physicochemical properties of the initial soil sample (0-15 cm depth) before amendment application

Parameters	Values
Moisture content (%)	25.85
Bulk density (g cm^{-3})	1.53
Total porosity (%)	42.26
Hydraulic conductivity (cm hr^{-1})	8.80
Sand (%)	58.4
Silt (%)	20.2
Clay (%)	21.4
Textural class	Sandy clay loam (SCL)
pH	5.48
Available phosphorus (mg kg^{-1})	18.1
Total nitrogen (%)	0.104
Organic matter (OC×1.724) (%)	1.88
Calcium (cmol kg^{-1})	4.8
Magnesium (cmol kg^{-1})	1.0
Potassium (cmol kg^{-1})	0.321
Sodium (cmol kg^{-1})	0.277
Effective CEC (cmol kg^{-1})	8.18
Base saturation (%)	78.23
Exchangeable acidity (cmol kg^{-1}): Al^3	0.68
Exchangeable acidity (cmol kg^{-1}): H^+	1.10

Source: Field data

Table 2: Nutrient composition of the organic amendments used in the experiment

Parameters	Poultry dropping	Cattle dung
pH	8.87	8.60
Nitrogen (%)	3.20	2.16
Phosphorus (%)	2.30	1.77
Potassium (%)	1.38	1.22
Calcium (%)	0.84	0.60
Magnesium (%)	0.49	0.52
Sodium (%)	0.30	0.26
Organic matter (OC×1.724) (%)	63.54	36.91
C/N ratio	11.50	9.90

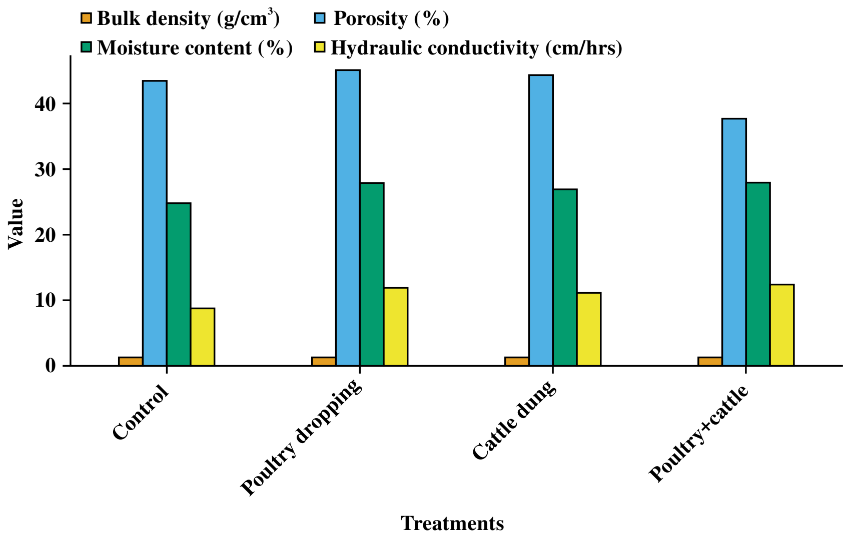

Fig. 1: Effect of organic amendments on soil physical properties

Table 3: Effect of organic amendments on soil physical properties after maize cultivation

Treatments	Sand (%)	Silt (%)	Clay (%)	TC (%)	MC (%)	BD (Mg m^{-3})	TP (%)	Ksat (cm hr^{-1})
Control (C)	66.7	12.63	20.63	SCL	24.97	1.49	43.52	8.80
Poultry dropping (PD)	65.1	13.30	21.63	SCL	27.87	1.45	45.03	12.06
Cattle dung (CD)	62.4	14.97	22.63	SCL	26.90	1.47	44.40	11.57
PD+CD	61.7	15.63	22.63	SCL	28.17	1.45	45.03	12.53
LSD (0.05)	NS	NS	NS	–	0.45	0.03	1.15	0.38

TC: Textural class, SCL: Sandy clay loam, MC: Moisture content, BD: Bulk density, TP: Total porosity, KSat: Saturated hydraulic conductivity and NS: Not significant

Table 4: Effect of organic amendments on selected soil chemical properties after maize cultivation

		AP	TN	OM	Ca	Mg	K	Na	Al^{3+}	H^+	ECEC	
Treatments	pH	(mg kg^{-1})	------------(%)---------------			----------------------------(cmol kg^{-1})-------------------------------						BS (%)
Control (C)	5.17	14.10	0.087	1.71	3.00	0.70	0.084	0.078	0.65	1.13	5.61	68.24
Poultry dropping (PD)	6.10	21.80	0.283	2.76	7.40	3.30	0.386	0.309	0.21	0.45	12.03	94.50
Cattle dung (CD)	5.77	20.50	0.221	3.00	6.73	2.67	0.337	0.289	0.27	0.49	10.78	93.02
PD+CD	6.40	23.63	0.318	3.50	8.00	4.10	0.415	0.324	0.17	0.38	13.39	95.86
LSD (0.05)	0.12	1.09	0.030	0.27	0.41	0.38	0.026	0.007	0.07	0.004	0.61	0.79

AP: Available phosphorus, TN: Total nitrogen, OM: Organic matter, ECEC: Effective cation exchange capacity and BS: Base saturation

magnesium (0.52%). The higher nutrient concentration and rapid mineralization of poultry manure are consistent with previous studies[29,30], whereas the slower decomposition rate of cattle dung supports long-term soil fertility improvement.

Effects of organic amendments on soil physical properties: Application of organic amendments significantly affected soil bulk density, porosity, moisture content and hydraulic conductivity (Table 3). Bulk density decreased from 1.49 g cm^{-3} in the control to 1.45 g cm^{-3} under poultry droppings and the combined poultry droppings +cattle dung (PD+CD) treatment, accompanied by increases in porosity and hydraulic conductivity. The PD+CD treatment also maintained the highest soil moisture content (28.17%). Figure 1 illustrates that amended plots-particularly PD+CD-exhibited improved soil structure relative to the control. These improvements are attributed to increased organic matter, which enhances soil aggregation, reduces compaction and promotes water retention. Similar reductions in bulk density and increases in porosity following organic amendment application have been reported in tropical soils[4].

Effects of organic amendments on soil chemical properties: Organic amendments significantly improved soil chemical fertility indicators (Table 4). Soil pH increased from 5.17 (control) to 6.4 under PD+CD, reducing acidity and creating conditions favorable for nutrient uptake. Organic matter and total nitrogen contents were highest under the PD+CD treatment (3.5% OM; 0.318% N) and available phosphorus increased significantly (23.63 mg kg^{-3}). Exchangeable bases (Ca, Mg, K, Na) and Effective Cation Exchange Capacity (ECEC) were also higher in amended plots, whereas exchangeable acidity declined markedly.

The superior performance of the combined amendment reflects nutrient complementarity: Poultry droppings provide readily mineralizable nutrients, while cattle dung

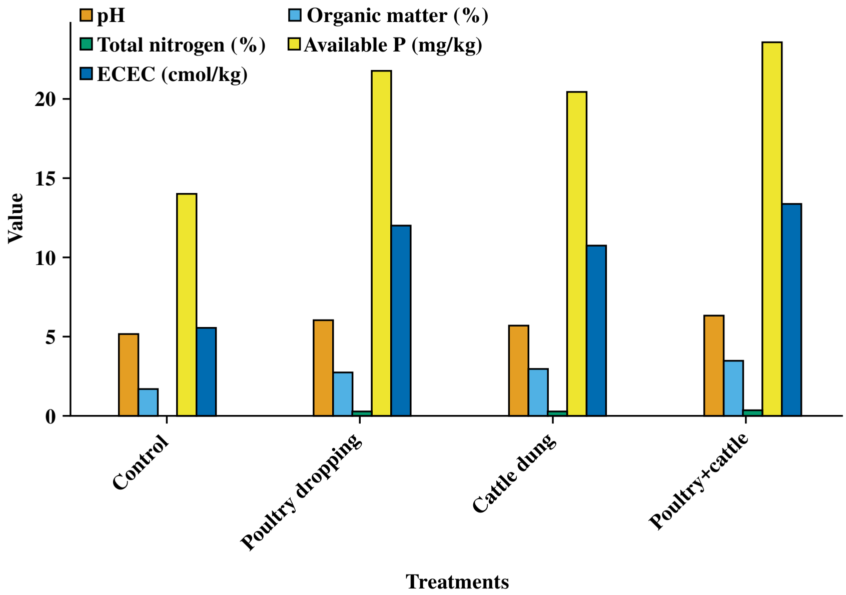

Fig. 2: Effect of organic amendments on soil chemical properties

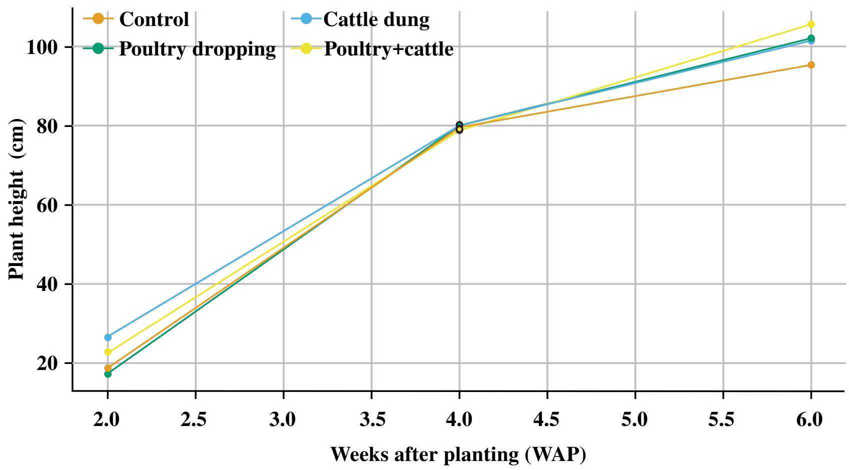

Fig. 3: Effect of organic amendments on maize plant height at 2, 4 and 6 weeks after planting (WAP)

Table 5. Effects of organic amendments on maize growth and yield parameters

Treatments	PH (cm) 2WAP	PH (cm) 4WAP	PH (cm) 6 WAP	LPP 2 WAP	LPP 4 WAP	LPP 6 WAP	CPP 8 WAP
Control (C)	18.60	79.50	95.40	5.67	10.25	14.10	1.50
Poultry dropping (PD)	17.20	80.10	102.30	6.10	10.35	13.78	3.25
Cattle dung (CD)	26.50	80.00	101.50	5.82	10.08	13.75	2.50
PD+ CD	22.70	78.70	105.70	8.30	11.65	13.66	3.50
LSD (0.05)	13.64	NS	13.41	2.20	2.54	NS	0.93

PH: Plant height, LPP: Leaves per plant, CPP: Cobs per plant and WAP: Weeks after planting

enhances soil organic matter and ensures sustained nutrient release. Similar improvements in soil chemical properties with organic amendments have been reported by Adeleye et al.[30], while Palm et al.[32] emphasized the benefits of integrating organic sources to enhance nutrient cycling in African soils. Figure 2 illustrates the improvement trends in pH, OM, N, P and ECEC across treatments.

Effects on maize growth: Maize growth parameters-Plant Height (PH) and number of Leaves per Plant (LPP)-varied significantly between treatments (Table 5). At 2 WAP, Cattle Dung (CD) produced the tallest plants (26.5 cm), likely due to improved moisture retention and gradual nutrient release. At 6 WAP, PD+CD resulted in the tallest plants (105.7 cm), reflecting rapid nutrient availability from poultry droppings combined with sustained release from cattle dung. PD+CD also produced the highest leaf number at 4 WAP (11.65 leaves). Growth trends shown in Fig. 3 and 4 demonstrate consistent increases in plant height and leaf number in amended plots relative to the control.

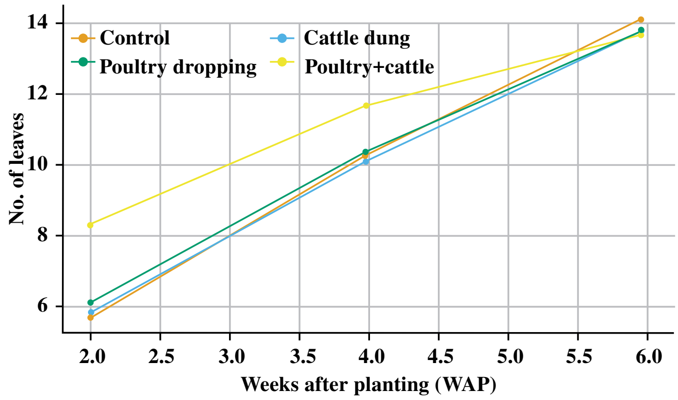

Fig. 4: Effect of organic amendments on maize leaf number at 2, 4 and 6 WAP

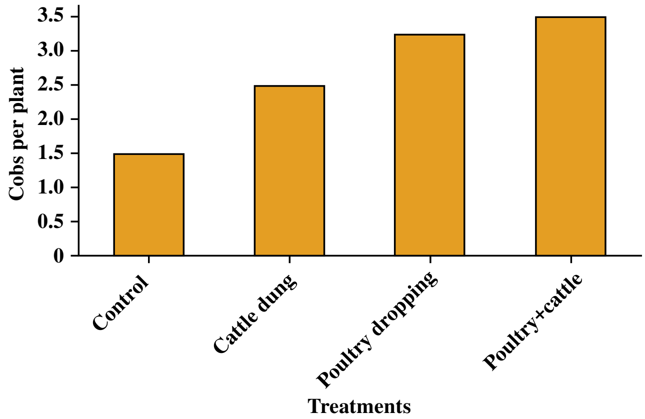

Fig. 5: Effect of organic amendments on maize yield (cobs per plant)

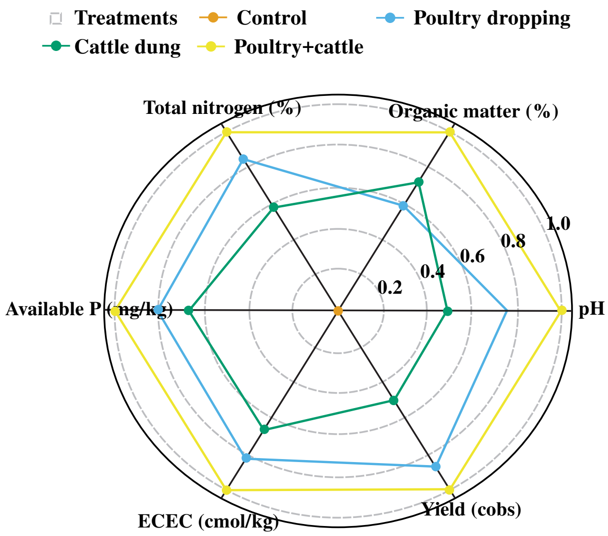

Fig. 6. Radar chart summarizing overall performance of organic amendments across soil fertility and maize yield parameters

These results are in agreement with earlier studies showing that poultry manure mineralizes rapidly to support early vegetative growth[30].

Effects on maize yield: Yield, measured as the number of Cobs per Plant (CPP), showed significant treatment effects (Table 5). The lowest yield occurred in the control (1.50 cobs per plant), while the highest yield occurred under PD+CD (3.50), followed by poultry droppings (3.25). Figure 5 demonstrates that PD+CD produced significantly more cobs per plant compared to either amendment alone.

The superior performance of the combined treatment demonstrates the advantage of integrating organic resources for balanced nutrient supply. Poultry droppings contributed high levels of N and P, promoting early vegetative growth, while cattle dung improved soil organic matter and nutrient retention. These findings corroborate previous studies showing that poultry manure enhances maize biomass and grain yield, whereas cattle dung improves crop performance through organic matter addition[30].

CONCLUSION

The findings of this study demonstrate that the application of organic amendments enhances soil fertility, structural stability and crop productivity, thereby decreasing dependence on expensive inorganic fertilizers. Among the treatments, the combined application of poultry droppings and cattle dung (PD+CD) produced the most favorable outcomes, followed by Poultry Droppings (PD), Cattle Dung (CD), the control (C). These results highlight the complementary effects of integrating multiple organic sources, with the PD+CD combination providing synergistic benefits in improving soil physicochemical properties and crop performance. This approach is particularly valuable in Southeastern Nigeria, where smallholder farmers often have limited access to chemical fertilizers. By improving soil health and increasing maize yields, organic amendments offer a sustainable pathway for enhancing food security, promoting soil restoration and supporting climate-resilient agricultural systems.

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