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Full Length Research Article

Animal- Based Wastes as Sustainable Soil Conditioners Improve Morphometric Traits and Nutritional Compositions of *Amaranthus Hybridus* L.

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Abstract
The use of organic fertilizer plays significant roles on the reclamation of nutrient depleted soil, sustainable production of crops and realization of food security. This study evaluated some animal-based organic wastes and their effects on morphometric traits and nutritional compositions of *Amaranthus hybridus,* using standard procedures. Physical property of soil of the study site revealed that the soil is majorly sandy soil (82.8%). The nutritional compositions of poultry droppings (PDs) were significantly higher ($p<0.05$) compared with normal soil and cow dung. Tallest plant height (59.00 cm) was recorded in the vegetable treated with 10 g PDs, leaf length (15.67 cm) and leaf width (8.00 cm) in the vegetable grown under 10 g CD, and number of leaves (35.66) and number of branches (16.60) in the vegetable grown under 5 g PDs ($p < 0.05$). Dry matter (25.65 mg/100g) and fat (1.32 mg/100g) were substantially higher in the vegetable grown under 10g CD ($p < 0.05$). However, 10 g PDs + NPK produced higher ash (2.23 mg/100g), crude fibre (5.72 mg/100g), crude protein (4.80 mg/100g) and carbohydrate (11.96 mg/100g) in the vegetable ($p < 0.05$). Furthermore, sodium (6.52 mg/100g), calcium (13.09 mg/100g) magnesium (15.63 mg/100g) and phosphorus (28.57 mg/100g) were also higher in the vegetable treated with 5 g of CD + NPK ($p < 0.05$). In conclusion, although the three nutrient sources influenced the growth of Amaranthus, however, 10 g CD and 5 g PDs significantly improved the growth and nutritional compositions of the vegetable, therefore the use of the animal-based fertilizers should be encouraged.

Keyword: Vegetable production, Nutrient sources, Food security, Soil amendment.

Introduction

Amaranth is the collective name for the domesticated plant species of the genus *Amaranthus.* The vegetable is one of the oldest food crops known for its high nutritional values in human diet (Duya, 2017; Aderibigbe *et al.,* 2022). But then, depletion of soil nutrients is one of the cascading nutritional challenges facing sustainable production of crops (Fontaine *et al.,* 2024) and feeding patterns of people in developing countries such as Nigeria (Petrikova *et al.,* 2023; Ishaque *et al.,* 2022). Although Nigeria has been reported to be one of the largest producers and consumers of amaranth, production of the vegetable is inadequate to meet up with rapid increase in population and nutritional demand of the populace (Ogedegbe and Ezeh 2015).

Various ecological and biological challenges such as soil fertility, erosion, and fire outbreak (Rathod *et al.,* 2024) and inappropriate application of fertilizer for maximum production of the vegetable (Olubode *et al.,* 2015, Rashmi *et al.,* 2020) are often encountered during the vegetable production. Farmers in Nigeria often use capital intensive synthetic fertilizers, despite their detrimental effects on soil over time (Ononogbo *et al.,* 2024). The few fertilizers available are frequently not administered in the appropriate quantities on the vegetables including *Amaranthus hybridus* (Itelima *et al.,* 2018). Worthy of consideration are animal-wastes which have been regarded as one of the major environmental threats, as they are difficult to manage and contribute potentially to groundwater pollution most especially in livestock management (Riaz *et al.,* 2023). Despite these challenges, the wastes are known to be effective in supplying organic matter to soil, improving soil condition and boosting crop performance (Mbah *et al.,* 2019;; Bhunia *et al.,* 2021).

In an attempt to increase the sustainable production and quality of amaranth throughout the year, appropriate incorporation of nutritional rich and cost-effective soil amendments such as livestock wastes into crop farming system need further investigation. Hence, there is a need to grow vegetables such as amaranths with organic fertilizer as nutritional supplement in order to ensure food security safety as well as improvement in the healthy living of the poor (Emmanuel and Babalola, 2022). This study assessed animal-based wastes as sustainable soil conditioners on morphometric traits and nutritional compositions of *Amaranthus hybridus.*

Materials and Methods

Description of the Experimental Site: The experiment was conducted at Botanical Garden, Lagos State University (6.28° N and 3.11° E) Ojo Lagos, Nigeria. The area is close to the Lagos Lagoon, water front communities, mangrove swamp forest and low-lying coastal area, making the area prone to flooding and sea-level rises.

Source of seeds and manure

Seeds of *Amaranthus hybridus* were source from local farmers at Alabata Abeokuta, Ogun State, Nigeria. Fresh cow dung and poultry droppings were collected from Olaniyi Farm, Kinlehin camp Abeokuta, Ogun State, Nigeria. The organic wastes were allowed to decay for two weeks and dried at room temperature. NPK (15:15:15) was sourced from Solakad store, Agbeni market, Ibadan, Oyo State.

Preparation and characterisation of soil and animal base-nutrient

Soil samples used for his study were collected at depths of 0–8 cm using a soil auger. The soil samples, cow dung and poultry droppings were air-dried, sieved through a 2 mm sieve and assayed for organic carbon, total nitrogen, exchangeable bases such as calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na), and phosphorus (P) according to the method of Sun *et al.,* (2024). Organic carbon and organic matter were analyzed using atomic

absorption spectrophotometry as described in Walkley-Black wet oxidation method (Kanagaraj *et al.,* 2025). Available phosphorus was assayed according to procedure of molybdate blue procedure described by Wieczorek *et al.* (2022).

Nursery and preparation of experimental treatments and experimental design

Seedlings of *Amarathus hybridus* were grown for three weeks after which one seedling/plant was transplanted into each of the seventy-five (75) planting pots.

Five grams (5 g) and ten grams (10 g) of cow dung (CD), poultry droppings (PD), and NPK 15:15:15 fertilizer, as well as their respective combinations in equal proportions (CD + PD, CD + NPK, PD + NPK, and CD + PD + NPK), were weighed separately in five replicates. A control treatment was also prepared in five replicates. Each treatment was added to 75 planting pots, each containing 10 kg of soil, and thoroughly mixed to ensure uniform distribution of the amendments throughout the soil. The pots were arranged in a complete randomized design. The experiment was sprayed with 200 mL distilled water once daily and monitored for four weeks during which data were collected at two weeks interval. Thereafter agronomics data such as Plant height, number of leave, leaf length, leaf width and number of branches were determined prior reproductive stage of the vegetable according to the method of Ojewumi *et al.* (2024).

Analysis of nutritional compositions

The proximate compositions (Dry matter, fat, crude protein, ash, fibre, carbohydrate and moisture) in the leaves of the vegetable were determined following the procedure of the Association of Official Analytical Chemists (AOAC, 2000; Ojewumi *et al.,* 2024). The mineral compositions were assayed using atomic absorption spectrophotometer as outlined in AOAC (2000).

Statistical Analysis

A one-way analysis of variance (ANOVA) was performed using SAS 9.3 (SAS Institute Inc., Cary, NC, USA). Mean ± errors were calculated. Significant differences were determined using Tukey's HSD test at $p < 0.05$.

Results

Figure 1 shows that the soil used for this experiment is predominantly sandy soil (82.8 %), however, relative percentage of the soil constituted clay (7.92 %) and loamy (9.28 %). Nutritional compositions of nutrient sources (Normal soil, cow dung and poultry droppings) are presented in Table 1. Mineral element compositions of the treatments showed significant variations ($P \leq 0.05$). Nitrogen (0.47 %), phosphorus (295.56 mg/kg), sodium (3.69 cmol/kg), potassium (4.95 cmol/kg) and calcium (8.93 cmol/kg) were significantly higher in PDs compared with CD and normal soil. The significant higher values were also noticed in organic carbon (27.85 %), organic matter (47.68 %) and ratio of carbon to nitrogen (60.94) evaluated in PDs compared with other two nutrient sources investigated (Table 1).

Inclusion of the nutrient sources at various levels produced significant effects on height of *Amaranthus* and the effects increased with increase in experimental weeks of the study. Further observation showed that 5 g PDs produced significantly highest height of the vegetable at 2 weeks (57 cm) and 3 weeks (58 cm) after treatment (WAT). Similar observation was recorded on the influence of the 10 g CD on the parameter at 4 WAT (59 cm) (Table 2).

Response on number of leaves of the vegetable to varying level of inclusion of the nutrient sources showed that the number of leaf was significantly higher in the vegetable grown under 5 g PDs mainly at 4 WAT (35.66) (Table 4). In addition, similar significant increase was noticed on leaf length of the vegetable treated with 10 g CD at 4 WAT (15.67cm) compared with other levels of nutrient sources either singly or in combined form (Table 4). Leaf width (6.50 cm) showed substantial increase in

Amaranthus treated with 5 g PDs. Similar trend was observed in the parameter at 4 WAT (8.00 cm) in the vegetable treated with 10 g CD (Table 5).

Furthermore, number of branches of the vegetable showed substantial increase from 2 WAT through 4 WAT, however, the highest number of branches (16.60) was observed in the vegetable treated with 5 g PDs (Table 6).

Table 7 revealed that dry matter (25.65 mg/100g) and fat (1.32 mg/100g) were positively influenced by application of 10 g CD. Also, combination of 10 g PDs and NPK produced higher ash (2.23 mg/100g), crude fibre (5.72 mg/100g), crude protein (4.80 mg/100g) and carbohydrate (11.96 mg/100g) compared with other treatments either singly or in combined form. A Similar observation was noticed in moisture content (85.64 mg/100g) recorded in the leaves of the vegetable treated with 10 g DP+ NPK. Sodium (6.52 mg/100g), calcium (13.09 mg/100g) magnesium (15.63 mg/100g) and phosphorus (28.57 mg/100g) were significantly higher ($p<0.05$) in the vegetable treated with 5 g CD+NPK (Table 8).

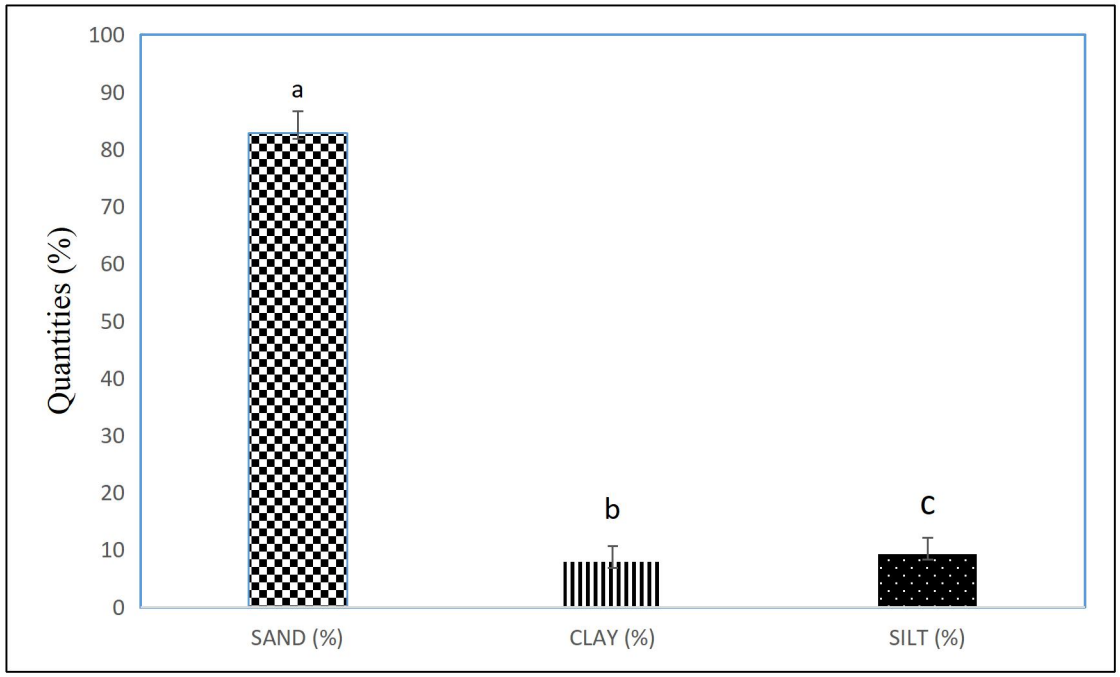


Figure 1: Soil types of the experimental site

Differences in lowercase letters on bars indicate significant differences among the soil types at p<0.05.

Table 1: Nutritional compositions of nutrient sources used for production of *Amaranthus hybridus*.

Nutrients sources	N (%)	Av. P (mg/kg)	Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	Org. C (%)	Org. M(%)	C:N
Normal soil	0.19±0.01^{c}	11.93±0.04^{c}	0.32±0.01^{c}	0.55±0.01^{c}	0.30±0.01^{c}	0.35±0.01^{c}	0.66±0.02^{c}	1.13±.01^{c}	3.47±0.02^{c}
Cow dung	0.37±0.01^{b}	282.12±0.51^{b}	3.15±0.03^{b}	4.41±0.02^{b}	16.61±0.22^{b}	8.06±0.03^{b}	7.16±0.04^{b}	12.61±.23^{b}	20.45±1.79^{b}
Poultry droppings	0.47±0.02^{a}	295.56±0.58^{a}	3.69±0.05^{a}	4.95±0.03^{a}	18.98±0.50^{a}	8.93±0.10^{a}	27.85±1.2^{a}	47.68±0.32^{a}	60.94±0.42^{a}

Mean± standard errors followed by different subscripts on the same columns are significantly different according to Tukey's HSD test at p <0.05

Table 2: Effects of different nutrient sources on plant height (cm) of *Amaranthus hybridus*.

Nutrients sources (g)	Week after treatments		
	2WAT	4WAT	6WAT
Control (0)	39.00±0.57^{gf}	40.50±0.28^{cdef}	46.33±0.66^{bc}
5 CD	43.50±0.28^{de}	43.00±0.00^{cdef}	52.50±3.28^{b}
10 CD	45.50±0.28^{cd}	46.50±0.28^{bcd}	59.00±3.05^{a}
5 PD	57.00±0.57^{a}	58.00±0.57^{a}	58.33±1.20^{ab}
10 PD	49.00±0.57^{bc}	44.50±0.28^{cde}	48.66±5.36^{bc}
5 NPK	37.00±0.57^{fg}	49.00±0.57^{abc}	49.00±5.00^{bc}
10 NPK	38.00±0.00^{f}	38.66±0.66^{defgh}	56.00±0.57^{b}
5 CD+PD	51.00±0.57^{b}	53.50±0.28^{ab}	54.50±3.12^{b}
10 CD+PD	59.50±0.28^{a}	56.50±0.28^{a}	58.00±1.00^{ab}
5 CD+NPK	32.00±6.00^{gh}	47.75±1.87^{bc}	48.33±2.66^{bc}
10 CD+NPK	38.66±0.66^{ef}	29.66±0.33^{h}	32.50±1.44^{e}
5g PD+NPK	29.00±0.57^{ef}	31.83±1.09^{gh}	33.00±1.52^{e}
10 PD+NPK	29.50±0.28^{h}	34.33±1.20^{fgh}	36.83±1.48^{d}
5 CD+DP+NPK	32.50±0.28^{h}	36.33±2.84^{efg}	38.50±.28^{cd}
10 CD+DP+NPK	30.50±0.28^{h}	42.83±0.167^{cdefg}	48.33±1.66^{bc}

Mean± standard errors followed by different subscripts on the same columns are significantly different according to Tukey's HSD test at p <0.05 WAT = Week after treatment, CD= Cow dung, PD= Poultry droppings.

Table 3: Effects of different nutrient sources on number of leaves *Amaranthus hybridus.*

Nutrients sources (g)	Week after treatments		
	2WAT	4WAT	6WAT
Control (0)	10.33±0.88^{b}	13.00±0.57^{bc}	13.83±0.73^{cd}
5 CD	6.50±0.28^{efg}	8.50±0.28^{de}	22.33±5.84^{b}
10 CD	14.50±0.29^{b}	13.50±0.28^{b}	22.66±5.45^{b}
5 PD	21.00±0.58^{a}	32.50±0.28^{a}	35.66±0.88^{a}
10 PD	9.50±0.29^{bc}	10.50±0.28^{bcd}	12.17±1.16^{cd}
5 NPK	8.50±0.29^{de}	12.50±0.28^{bc}	15.33±0.33c
10 NPK	10.67±0.67^{b}	10.66±0.66^{bdc}	12.67±1.45^{cd}
5 CD+PD	10.500±0.29^{b}	11.50±0.28^{bdc}	12.00±0.57^{cd}
10 CD+PD	14.50±0.29^{b}	11.00±0.57^{bcd}	12.00±0.00^{cd}
5 CD+NPK	11.000±1.00^{b}	10.16±1.58^{cd}	10.33±0.67^{d}
10 CD+NPK	11.000±1.00^{b}	8.50±0.76^{de}	8.83±0.17^{d}
5 PD+NPK	7.000±0.57^{efg}	8.83±1.92^{de}	9.32±0.67^{d}
10 PD+NPK	9.500±0.28^{bc}	6.83±1.09^{f}	8.17±0.44^{d}
5 CD+DP+NPK	5.500±0.28^{g}	11.16±1.42^{bcd}	10.00±0.00^{d}
10 CD+DP+NPK	8.000±0.00^{def}	13.00±1.00^{bc}	15.67±0.33^{c}

Mean± standard errors followed by different subscripts on the same columns are significantly different according to Tukey's HSD test at p <0.05, WAT = Week after treatment CD= Cow dung, PD= Poultry droppings.

Table 4: Effects of different nutrient sources on leaf length (cm) of *Amaranthus hybridus.*

Nutrients sources (g)	Week after treatments		
	2WAT	4WAT	6WAT
Control (0)	6.67±0.33^{bcd}	9.50±0.29^{cd}	11.00±1.00^{b}
5 CD	8.00±0.00^{bc}	14.50±0.28^{a}	15.00±1.52^{ab}
10 CD	13.00±2.88^{a}	10.50±0.22^{bc}	15.67±1.85^{ab}
5 PD	15.00±0.57^{a}	15.50±0.28^{a}	16.00±1.52^{a}
10 PD	9.50±0.28^{b}	9.50±0.28^{cd}	10.83±0.44^{b}
5 NPK	5.00±0.57^{bcd}	6.50±0.26^{e}	7.67±0.33^{c}
10 NPK	7.67±0.66^{bc}	7.33±0.33^{de}	7.97±0.57 ^{c}
5 CD+PD	.50±0.28^{bcd}	6.50±0.28^{e}	7.33±0.33 ^{c}
10 CD+PD	7.50±0.28^{bc}	7.00±0.57^{de}	8.00±0.00^{c}
5 CD+NPK	7.67±0.66^{bc}	6.83±0.92^{e}	8.33±0.66^{c}
10 CD+NPK	7.33±0.33^{bc}	7.50±0.28^{de}	9.83±0.16 ^{c}
5 PD+NPK	4.50±0.28^{d}	5.16±0.60^{e}	6.00±0.00^{c}
10 PD+NPK	5.50±0.28^{bcd}	5.17±0.44^{e}	6.00±0.00^{c}
5 CD+DP+NPK	4.50±0.28^{d}	7.50±0.76^{de}	8.00±0.00^{c}
10 CD+DP+NPK	5.50±0.28^{bcd}	11.83±2.08^{b}	11.67±0.33^{a}

Mean± standard errors followed by different subscripts on the same columns are significantly different according to Tukey's HSD test at p <0.05 WAT = Week after treatment, CD= Cow dung, PD= Poultry droppings.

Table 5: Effects of different nutrient sources on leaf width (cm) of *Amaranthus hybridus.*

Nutrients sources (g)	Week after treatments		
	2WAT	4WAT	6WAT
Control (0)	6.00±1.53^{ab}	6.50±0.25^{cde}	7.03±1.15^{a}
5 CD	4.50±0.29^{bcde}	6.50±0.27^{cde}	6.66±0.88
10 CD	4.50±0.29^{bcde}	7.50±0.28^{a}	8.00±1.00^{a}
5 PD	6.50±0.29^{a}	6.54±0.29^{cde}	7.00±0.58^{abc}
10 PD	5.00±0.58^{bcd}	5.00±0.57^{cde}	5.33±1.20^{abc}
5 NPK	2.00±0.00^{f}	3.50±0.28^{e}	3.66±0.66^{bc}
10 NPK	3.00±0.00^{def}	3.67±0.67^{e}	6.00±0.57^{abc}
5 CD+PD	5.50±0.29^{bc}	5.50±0.28^{cde}	6.83±0.93^{abc}
10 CD+PD	5.50±0.29^{bc}	5.00±0.00^{cde}	5.00±0.00^{abc}
5 CD+NPK	3.33±0.33^{def}	5.00±1.74$^{5\ cde}$	5.33±0.33^{abc}
10 CD+NPK	4.00±1.00^{cde}	5.00±0.57^{cde}	5.02±0.57^{abc}
5 PD+NPK	3.50±0.289^{def}	4.16±0.60^{de}	4.66±0.88^{ab}
10 PD+NPK	3.50±0.26^{def}	3.50±0.27^{e}	3.58±0.28^{c}
5 CD+DP+NPK	3.00±0.57^{ef}	4.17±0.44^{de}	4.75±0.14^{bc}
10 CD+DP+NPK	3.50±0.26^{def}	6.33±1.33^{cde}	6.37±0.44^{b}

Mean± standard errors followed by different subscripts on the same columns are significantly different according to Tukey's HSD test at p <0.05, WAT = Week after treatment, CD= Cow dung, PD= Poultry droppings.

Table 6: Effects of different nutrient sources on number of branches of *Amaranthus hybridus.*

Nutrients sources(g)	Week after treatments		
	2WAT	4WAT	6WAT
Control (0)	7.00±1.57^{d}	9.50±0.28^{cd}	11.00±1.57^{b}
5 CD	8.00±1.00^{cd}	9.50±0.28^{cd}	12.83±0.10^{b}
10 CD	7.50±1.28^{cd}	9.50±0.28^{cd}	13.83±1.17^{b}
5 PD	13.00±0.57^{a}	15.50±0.28^{a}	16.60±1.25^{a}
10 PD	11.00±1.58^{b}	11.50±0.28^{c}	11.66±2.40^{b}
5 NPK	8.50±1.28^{cd}	9.50±0.28^{cd}	10.66±1.66
10 NPK	7.00±1.00^{d}	7.33±0.33^{ef}	12.33±1.20^{b}
5 CD+PD	9.00±1.57^{c}	13.00±0.57^{b}	13.00±2.08^{b}
10 CD+PD	10.50±1.28^{b}	11.00±0.58^{c}	12.00±1.00^{b}
5 CD+NPK	8.00±1.00^{cd}	10.50±1.25^{c}	12.33±1.33^{b}
10 CD+NPK	7.66±1.66^{d}	8.50±0.28^{de}	8.83±1.16^{c}
5 PD+NPK	7.50±1.28^{d}	7.50±1.25^{ef}	8.33±1.66^{c}
10 PD+NPK	5.50±1.28^{e}	5.50±0.28^{g}	7.50±1.28^{c}
5 CD+DP+NPK	5.00±.57^{e}	6.16±0.44^{fg}	7.75±1.14^{c}
10 CD+DP+NPK	5.50±.28^{e}	7.66±0.66^{def}	7.50±1.28^{c}

Mean± standard errors followed by different subscripts on the same columns are significantly different according to Tukey's HSD test at p <0.05 WAT = Week after treatment, CD= Cow dung, PD= Poultry droppings.

Table 7: Effects of varying nutrient sources on proximate compositions (%) of *Amaranthus hybridus*.

Treatments (g)	Proximate contents (mg/100g)						
	Moisture	Dry Matter	Fat	Ash	Crude Fibre	Crude Protein	Carbohydrate
Control (0)	78.78±0.13^{e}	21.04±0.02^{b}	1.03±0.05^{b}	1.89±0.02^{c}	4.63±0.03^{c}	3.79±0.03^{c}	9.76±0.02^{c}
5 PD	79.78±0.14^{d}	20.49±0.06^{c}	1.05±0.05^{b}	1.81±0.05^{d}	4.53±0.08^{d}	3.69±0.08^{c}	9.45±0.05^{d}
10 PD	82.65±0.21^{b}	17.73±0.01^{e}	0.95±0.02^{cd}	1.59±0.08^{f}	3.93±0.01^{g}	3.18±0.01^{e}	8.19±0.02^{g}
10 CD	74.92±0.05^{f}	25.65±0.28^{a}	1.32±0.01^{a}	2.18±0.05^{b}	5.55±0.02^{b}	4.49±0.02^{b}	11.68±0.05^{b}
5 CD+NPK	82.18±0.01^{b}	17.87±0.02^{e}	0.93±0.01^{d}	1.56±0.01^{g}	3.95±0.02^{f}	3.26±0.03^{d}	8.28±0.05^{g}
10 CD+NPK	80.55±0.01^{c}	19.53±0.03^{d}	0.98±0.02^{c}	1.73±0.05^{e}	4.23±0.01^{e}	3.48±0.05^{e}	9.13±0.05^{e}
10 PD+NPK	74.79±0.29^{f}	25.77±0.03^{a}	1.34±0.01^{a}	2.23±0.01^{a}	5.72±0.03^{a}	4.80±0.11^{a}	11.96±0.02^{a}
10 PD+NPK	85.64±0.29^{a}	14.94±0.04^{f}	0.78±0.01^{e}	1.33±0.08^{h}	3.27±0.05^{f}	2.68±0.08^{f}	6.93±0.04^{h}

Mean± standard errors followed by different subscripts on the same columns are significantly different according to Tukey's HSD test at p <0.05, CD= Cow dung, PD= Poultry droppings

Table 8: Effects of varying nutrient sources on mineral compositions of *Amaranthus hybridus*.

Treatments (g)	Mineral elements				
	Sodium	Potassium	Calcium	Magnesium	Phosphorus
Control (0)	5.29±0.03^{d}	229.39±0.04^{f}	11.18±0.08^{d}	15.13±0.08^{ab}	26.92±0.47^{abc}
5 PD	5.95±0.03^{c}	246.29±0.06^{a}	12.62±0.58^{ab}	15.07±0.24^{ab}	25.62±0.08^{abc}
10 PD	5.84±0.03^{c}	232.19±0.8^{e}	11.90±0.26^{c}	14.59±0.24^{b}	24.55±0.26^{c}
10 CD	6.67±0.19^{a}	237.73±0.35^{d}	10.87±0.08^{d}	13.41±0.02^{c}	25.38±0.04^{bc}
5 CD+NPK	6.52±0.02^{a}	239.12±0.05^{c}	13.09±0.49^{a}	15.63±0.30^{a}	28.57±0.27^{a}
10 CD+NPK	5.19±0.05^{d}	219.11±0.05^{h}	12.08±0.02^{bc}	15.56±0.26^{a}	21.66±2.56^{d}
10 PD+NPK	6.21±0.05^{b}	241.25±0.5^{b}	10.54±0.26^{d}	14.54±0.26^{b}	27.83±0.29^{ab}
10 PD+NPK	5.96±0.02^{c}	228.14±0.04^{g}	10.94±0.03^{d}	14.62±0.23^{b}	25.97±0.02^{abc}

Mean± standard errors followed by different subscripts on the same columns are significantly different according to Tukey's HSD test at p <0.05 CD= Cow dung, PD= Poultry droppings.

Discussion

Depletion of natural resources such as soil is a major concern in farming, food availability and safety (Wang, 2022). The condition has reflected in low food supply and a high rate of food scarcity (Utting, 2022). There is a drastic need for amending agricultural soil with organic fertilizer in order to ensure the reclamation of soil nutrients (Al-Shammary *et al.,* 2025). The soil used for the present study was predominantly sandy, with relatively low clay and loamy content. This sandy nature of the soil suggests that the soil has low water and nutrient holding capacity, necessitating external amendments for optimal crop performance (Schapel *et al.,* 2023). The highest essential nutrients, such as nitrogen, phosphorus, sodium, potassium, and calcium recorded in poultry droppings indicate that poultry droppings contain higher nutritional compositions required by the vegetables (Idowu *et al.,* 2023). The higher organic carbon and organic matter observed in poultry manure compared with cow dung and normal soil indicate the nutritional superiority of poultry manure to improve soil fertility (Ayamba *et al.,* 2021). The findings on other hand suggest that poultry manure is an important soil conditioner suitable for enhancing soil nutrient levels and improved crop performance (Olowokere and Akinbinu 2021; Agbede, 2025).

Application of different nutrient sources significantly influenced the morphometric indices of *Amaranthus* as reflected in the tallest plants recorded in the vegetable grown number 10 g PDs. This observation indicates that poultry manure effectively promotes stem elongation, meristematic development and biomass accumulation (Kamal *et al.,* 2024). Significant number of leaves and branches observed in vegetable treated with 5 g PDs, connote the ability of the soil conditioner to promote vegetative growth-markers (Kamal *et al.,* 2024). Also, higher leaf length and leaf width shown in vegetable grown in 10 g CD, suggests that cow dung enhance the development of meristems or cambia cells which are responsible for primary and secondary expansion in leaves (Bhunia *et al.,* 2021). It also implies that animal based organic amendments at various rate influenced agronomic characters of the vegetable (Bhunia *et al.,* 2021). Poultry droppings appeared to be more effective for overall biomass accumulation and cow dung better suited for improving leaf area development and as an attribute of the photosynthetic apparatus of the vegetable (Gani *et al.,* 2024).

The observation that vegetables treated with 10 g of cow dung produced the highest nutritional compositions such as dry matter and fat content indicate their potential to improve plant structural integrity and energy content (Dhiman *et al.,* 2021). Meanwhile, the effect of the combination of 10 g PDs and NPK which reflected the highest ash, crude fiber, crude protein, and carbohydrate suggests that integrating organic and inorganic fertilizers generates synergy which optimizes production of *Amaranthus hybridus,* than when the treatments were applied singly (Ngoroyemoto *et al.,* 2020). Furthermore, mineral analysis showed that 5 g of cow dung + NPK resulted in the highest mineral composition such as sodium, calcium, magnesium, and phosphorus, demonstrating its potential to enhance the vegetable's mineral content (Naveed *et al.,* 2023). These findings indicate that while poultry manure enhances growth and overall nutrient density, cow dung in combination with NPK improved mineral composition (Adekiya *et al.,* 2020). Similar observations made by Sarangi *et al.* (2023), who reported that poultry manure significantly increased the crude protein and fiber content of *Amaranthus*, making it a valuable organic amendment for improving nutritional quality.

Conclusion

The study confirms that animal-based organic waste significantly influences the growth and nutritional quality of *Amaranthus*, while poultry manure improved plant height and nutrient content and cow dung promoted leaf size and dry matter accumulation. The

combination of poultry manure and NPK produced the best overall nutritional profile, making it the most effective treatment for optimizing both growth and nutritional value.

Declarations

Ethics approval and consent to participate
Not applicable

Competing interests
Not applicable

Conflict of interest
The authors proclaim no conflict of interest

Authors' contributions
O.A.W. initiated the research idea and analyzed the data, O.A.W and R.F.K. interpreted the research data, A.D.O. and N.C.J. wrote the draft, A.J.O, S.M.G and O.T.H. wrote the literature review of the study, O.A.W. read the draft, S.M.G. conducted the field experiment, A.D.O, O.T.H and A.A.O. collected the data, O.A.W. corrected the whole manuscript.

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Abbreviation

PD / PDs	Poultry Droppings
CD	Cow Dung
NPK	Nitrogen–Phosphorus–Potassium (compound fertilizer)
C:N	Carbon-to-Nitrogen Ratio
Na	Sodium
K	Potassium
Ca	Calcium
Mg	Magnesium
P	Phosphorus
Org. C	Organic Carbon
Org. M	Organic Matter
WAT	Weeks After Treatment
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
HSD	Honestly Significant Difference (Tukey's HSD test)
cmol/kg	Centimole per Kilogram (unit of cation exchange capacity)
mg/kg	Milligram per Kilogram
mg/100g	Milligram per 100 Grams
Cm	Centimeter
NC	Nitrogen Content (contextual use in soil analysis)
SAS	Statistical Analysis System (software used: SAS 9.3)

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