STUDIES ON RABBIT MANURE AND NPK FERTILIZER SYNERGY FOR OPTIMIZING SOIL CONDITIONS IN AMARANTHUS (*Amaranthus hybridus* L.) CULTIVATION

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ABSTRACT

This study investigated the synergistic effects of rabbit manure and NPK 15-15-15 fertilizer on soil properties and the growth performance of *Amaranthus hybridus* in the forest-savannah transition zone of Ekiti State, Nigeria. Field experiments were conducted at two locations - Ayede-Ekiti and the Teaching and Research Farm of Ekiti State Polytechnic, Isan-Ekiti - using a randomized complete block design (RCBD) with six treatment combinations replicated three times. Treatments included varying combinations of rabbit manure (1- 4 t/ha) and NPK fertilizer (50 - 200 kg/ha), with applications split between one and three weeks after transplanting (WAT). Standard agronomic practices were followed, and seedlings were spaced at 20 cm × 20 cm to achieve a density of 250,000 plants/ha. Throughout the growing period between September and December of 2024, growth parameters and yield components were recorded. Soil samples were analyzed before planting and after harvest to assess changes in physicochemical properties, and proximate analyses were conducted on the edible plant parts. Data were statistically evaluated using ANOVA, with treatment means separated by Tukey's HSD test at a 95% confidence level ($P < 0.05$). Results from the study showed that the combined application of rabbit manure (RM) and NPK fertilizer significantly improved soil fertility, plant growth, and marketable yield compared to sole applications. The best performance of *Amaranthus hybridus* cultivated in Isan-Ekiti was obtained from the plots with the combination of RM 3 t/ha and NPK 50kg/ha and the combination of RM 1 t/ha and NPK 150kg/ha in Ayede-Ekiti. Nutritional quality, particularly protein and fat content, was also positively increased. The findings underscore the potential of integrated nutrient management in promoting sustainable A. hybridus production, with site-specific responses. Isan-Ekiti was obtained to be the best site with lesser inorganic fertilizer application and maximum yield.

Keywords: Rabbit manure, NPK fertilizer, soil quality, soil physicochemical properties, *Amaranthus hybridus*

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1. | Introduction

Amaranth is a member of the family Amaranthaceae and the genus Amaranthus (Adeleye *et al.*, 2021). Amaranth (Amaranthus spp.) is well acknowledged for its nutraceutical and agronomic advantages (Romero Rom no *et al.*, 2021). Amaranthus species is vital in combating food and nutrition insecurity (Amulu *et al.*, 2021), as it thrives on marginal soils and is drought-tolerant. *Amaranthus hybridus* (also known as smooth pigweed or green amaranth) is a rapidly growing and nutrient-intensive crop that can be maximized through an adequate fertilizer application to achieve the largest possible growth and yield (Awopegba & Awodun, 2023). A. hybridus represents a potential source of nutrients and medications in the diet because of the abundance of vitamin A and flavonoids in its leaves (Ekeke *et al.,* 2019). Leaves are also edible and rich in protein; hence, they can be a versatile crop in grain and vegetable production (Kumar *et al.,* 2016). Drought is one of the adverse climate factors that Amaranth has survived and has led to its cultivation across the globe, aiming to fight food scarcity and malnutrition (Weerasekara and Waisundara, 2020).

Organic and inorganic fertilizers tend to be effective with A. hybridus, but the nature and quantity of fertilizer applied influence response. Studies conducted on similar types of organic fertilizers including cow dung and poultry manure indicate that *Amaranthus hybridus* responds to growth and production tremendously (Ikani *et al.,* 2024). In the same manner, compost and cow dung enhance morphological aspects like height of the plant, its stem girth, and leaf size, occasionally exceeding NPK (Inyang *et al.,* 2018; Sanni, 2016). However, NPK fertilizers tend to be more uniform in raising certain parameters such as protein content and crude fibre (Adekiya *et al.,* 2019; Oyedeji *et al.,* 2014).

The soils of Nigeria are highly diverse. Research undertaken in other parts of Nigeria has shown to have inadequate levels of major nutrients, which present significant issues to soil fertility. In the Southwest, soils are being destroyed because of inadequate land use and extraction of nutrients (Ande *et al.,* 2017). A significant loss of soil organic carbon and total nitrogen was observed when forests had been transformed into cultivated land in Nigeria, which is why forest soils could be significant in sustaining the concentration of nutrients in the soil (Onyegbule *et al.,* 2023). The application of fertilizer presents major issues worldwide, especially in areas like Sub-Saharan Africa (SSA), where insufficient funding makes application inefficient (Dimkpa *et al.,* 2023).). Others cited barriers to using of fertilizer are inefficiency and effect on the environment (Zaib *et al.,* 2023). There are environmental and health risks to the community related to the senseless use of fertilizers (Zaib *et al.,* 2023). The runoff of nutrients also pollutes the water resources and leads to diseases, such as methemoglobinemia and high cancer risks (Zeeshan *et al.,* 2024). These are the excessive loss of nitrogen that leads to greenhouse gas emissions, such as nitrous oxide, and fertilizer runoff that lead to the harm of the ecosystems (Aziz *et al.,* 2022). The application of synthetic fertilizers raises questions about sustainability, even though they are essential for food production (Guye, 2015).

One factor that influences the growth of crops and the quality of soil is organic manure (Verma *et al.,* 2024). Organic manure, including farmyard manure, composted manure, etc., has been shown to enhance microbial activity, soil fertility, soil structure, and access to nutrients (Goldan *et al.,* 2023; Ahlawat *et al.,* 2023). A:ropriate use of organic manure can increase organic carbon content of soil, microbial biomass, and nutrients; these improvements can facilitate sustainable farming practices and crop production (Yan *et al.,* 2023). Rabbit and pig manure, among other organic fertilizers, increases soil phosphorus, nitrogen, and organic carbon content (Zhang *et al.,* 2023). This has a favourable impact on the physico-chemical properties of the soil as well as its microbial communities, which in turn promotes the growth and production of vegetables (Zhang *et al.,* 2023). Due to its low moisture, lignocellulose composition, and good fertilizer effect, rabbit manure has been researched widely in its influence on numerous crops. It is proved that rabbit manure compost can significantly increase the growth parameters of different plants (Li *et al.,* 2022).). Fresh rabbit excrement (faecal pellets) has the highest percentage of nitrogen among livestock manures, with 2.4% nitrogen, 0.6% potassium, and 1.4% phosphorus (Awopegba *et al.,* 2024). Maize plants treated with rabbit compost tea exhibited improved growth parameters such as plant height, stem girth, number of leaves, and leaf area, highlighting the effectiveness of rabbit manure as an organic fertilizer (Awopegba *et al.,* 2024).

The combination of organic with inorganic fertilizers is a superior means of controlling soil fertility (Yusuf & Olowoake, 2019). Nutritional deficits can be avoided by combining chemical fertilizers with organic components added to canola production like gypsum and quick-release elemental sulphur (Malhi *et al.,* 2013). According to the researchers, in research carried out in various parts of the country, it is believed that integrated a:roaches to controlling the fertility of the soil, which include incorporation and utilization of organic resources, mineral fertilizers and superior kinds of crops should be adopted in order to counter such problems (Ande *et al.,* 2017). This study aims to assess the effects of rabbit manure, NPK fertilizer and their combined application on the performance and proximate composition of A. hybridus L., and soil fertility.

2. | Materials and Methods

In this study, field experiments and laboratory analyses were incorporated to assess the impact of rabbit manure, NPK (15-15-15) fertilizer and a combination of both on the soil physicochemical properties and the growth and yield characteristics of *Amaranthus hybridus*. Field trials were conducted concurrently at two locations within Oye Local Government Area, Ekiti State, Nigeria-Ayede-Ekiti and the Teaching and Research Farm of Ekiti State Polytechnic, Isan-Ekiti-both situated in the forest-savannah transition zone with bimodal rainfall averaging 1320 mm annually. The experiment was laid out in a randomized complete block design (RCBD) with six treatment combinations replicated three times, totalling 18 plots (each 2 m × 2 m) per site. The land area for each experimental field was 190 m², with 1 m alleys separating plots. Manual land preparation was followed by nursery raising of A. hybridus seedlings for two weeks before transplanting at 20 cm × 20 cm spacing (equivalent to 250,000 plants/ha). The treatment combinations and levels were; T1 = 0 RD + 0 NPK, T2 = 100 kg ha-1 of NPK applied at 1 WAT + 100 kg ha-1 of NPK applied at 3 WAT, T3 = 2 t ha-1 of RD applied at 1 WAT + 2 t ha-1 of RD applied at 3 WAT, T4 = 2 t ha-1 of RD applied at 1 WAT + 100 kg ha-1 of NPK applied at 3 WAT, T5 = 3 t ha-1 of RD applied at 1 WAT + 50 kg ha-1 of NPK applied at 3 WAT, T6 = 1 t ha-1 of RD applied at 1 WAT + 150 kg ha-1 of NPK applied at 3 WAT. Rabbit manure was applied by broadcasting, while NPK (15-15-15) fertilizer was side-placed. Irrigation was done as needed using 20 litres of water per plot applied with a cordless sprinkler during the growing periods between September and December of 2024. Growth parameters-including stem girth, number of leaves, plant height, branch count, and leaf area-were recorded weekly starting two weeks after transplanting. Stem girth was measured using a digital vernier caliper (in cm), height with a meter rule (in cm), and leaf area (in cm²) estimated using the equation 1:

$$\text{Leaf area } (cm^2) = 0.654 \times (L \times W) \ldots\ldots (1)$$

Where *L* is leaf length and *W* is maximum leaf width (Managa & Nemadodzi, 2023). Yield components such as fresh biomass, root and shoot biomass, marketable yield, and edible yield were assessed using a digital weighing balance and standardized to tonnes per hectare using equation 2: (Falodun & Edafe, 2020).

$$\text{Yield (t/ha)} = \frac{\text{Plot yield (kg)}}{\text{Plot size } (m^2)} \times \frac{10{,}000 \ m^2 \text{ (hectare)}}{1{,}000 \text{ (tonnes)}} \ldots\ldots\ldots (2)$$

Soil samples (0–15 cm depth) were collected pre-planting and post-harvest for laboratory analysis. Physicochemical parameters analyzed included pH (1:2 soil-water suspension), texture (hydrometer method), exchangeable bases were extracted with Ammonium acetate (1M NH_4OAc at pH 7), cation exchange capacity (CEC) was determined according to Chapman (1965), organic carbon (wet digestion), total nitrogen (Kjeldahl), and available phosphorus (Bray's method). Organic matter was calculated as organic carbon × 1.742. Additionally, the edible portions of *A. hybridus* were analyzed for proximate composition—moisture, ash, fat, protein, crude fiber, and carbohydrate contents—following AOAC (1997) procedures. All collected data were subjected to analysis of variance (ANOVA) using the PROC GLM function in **STAR v2.0.1 (IRRI, 2013).** Treatment means were separated using **Tukey's HSD test at a 5% probability level (P < 0.05).**

3. | Results and Discussion

Soil analyses from two sites revealed contrasting textural and chemical properties, despite both being sandy (Table 1). Research Farm of Ekiti State Polytechnic, Isan-Ekiti (Site 1), classified as *Sandy Clay Loam*, had higher clay content (27.11%), whereas Ayede-Ekiti (Site 2), a *Sandy Loam*, showed greater silt (18.51%) and sand (61.29%) content. These textural differences suggest that Site 1 may offer improved water and nutrient retention, while Site 2 likely provides superior drainage and aeration. Soil pH values ranged from slightly to moderately acidic (Site 1: pH 6.05; Site 2: pH 5.74), which may influence nutrient availability and microbial dynamics (Oshunsanya, 2019). Organic carbon and Organic matter were notably higher at Site 1 (OC: 1.92%, OM: 3.31%), supporting greater fertility than at Site 2 (OC: 1.43%, OM: 2.47%). This trend was consistent across Total Nitrogen (Site 1: 0.19%, Site 2: 0.15%), Available Phosphorus (3.89 vs. 2.58 mg/kg), and Potassium (0.22 vs. 0.18 cmol/kg). Exchangeable cations, including Sodium (Na), Calcium (Ca), and Magnesium (Mg), were generally more abundant in Site 1, indicating better nutrient reserves (Irabor *et al.,* 2023). Notably, Site 2 exhibited a higher Cation Exchange Capacity (CEC) at 15.01 cmol/kg, possibly due to its higher silt content or mineralogical differences, despite lower overall nutrient levels.

The soil pH was lowest in control plots and increased significantly with organic and combined treatments (Tables 2 and 3). The highest pH values were recorded in plots treated with RM alone or in combination with NPK (above 6.1), indicating reduced acidity and improved pH balance (Otieno & Zingore, 2018). Ahmad *et al.,* (2013) reported

Table 1 | Pre-experimental Soil Analysis

Physical properties	Site 1	Site 2
Sand	60.15	61.29
Clay	27.11	20.2
Silt	12.74	18.51
Textural class	Sandy Clay Loam	Sandy Loam
Chemical properties		
pH (1:2 in H_2O)	6.05	5.74
OC (%)	1.92	1.43
OM (%)	3.31	2.47
N (%)	0.12	0.34
P (mg/kg)	3.89	2.58
K (cmol/kg)	0.22	0.18
Na (cmol/kg)	0.42	0.05
Ca (cmol/kg)	1.49	2.04
Mg (cmol/kg)	1.44	1.1
CEC (cmol/kg)	16.41	15.01

Site 1: Experimental field values for *Amaranthus hybridus* at EKSPOLY, Isan-Ekiti
Site 2: Experimental field values for *Amaranthus hybridus* at Ayede-Ekiti

Table 2 | Post-experimental Soil Analysis at Teaching and Research Farm of EKSPOLY, Isan-Ekiti

Treatments	pH (1:2 in H_2O)	OC (%)	OM (%)	N (%)	P (mg/kg)	K (cmol/kg)	Na (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC (cmol/kg)	Sand	Clay	Silt	TC
Control	5.27e	1.08b	1.86d	0.20d	2.27e	0.40e	0.55b	1.17f	0.61d	8.41f	72.00a	15.20e	12.80f	SL
NPK at 200 kg/ha	6.10b	1.48ab	2.55c	0.29c	3.29a	1.05d	0.38f	1.32e	0.96a	13.71a	63.82c	17.35c	18.83c	SL
RM at 4 tons/ha	6.16a	1.69a	2.91b	0.44a	3.03bc	1.81a	0.47e	1.34d	0.68bc	12.44b	55.40d	11.35f	33.25a	SL
RM at 2 tons/ha + NPK at 100 kg/ha	5.99d	1.67a	2.88b	0.43a	3.10b	1.41c	0.49d	1.46c	0.62cd	12.00d	54.00e	18.13b	27.87b	SL
RM at 3 tons/ha + NPK at 50 kg/ha	6.17a	1.40ab	2.41c	0.43a	2.91d	1.58b	0.67a	2.04a	0.66bcd	12.38c	65.40b	16.35d	18.25d	SL
RM at 1 ton/ha + NPK at 150 kg/ha	6.04c	1.76a	3.03a	0.35b	2.95cd	1.76a	0.50c	1.87b	0.71b	10.86e	65.22b	19.13a	15.56e	SL

Means with the same letter in the same column are not significantly ($p > 0.05$) different, as indicated by Tukey's HSD test.
RM: Rabbit manure; TC: Textural class; SL: Sandy loam; CEC: Cation exchange capacity.

Table 3 | Post-experimental Soil Analysis at Ayede-Ekiti

Treatments	pH (1:2 in H_2O)	OC (%)	OM (%)	N (%)	P (mg/kg)	K (cmol/kg)	Na (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	CEC (cmol/kg)	Sand	Clay	Silt	TC
Control	5.57e	0.97b	1.67f	0.27e	2.63e	0.29d	0.38e	1.21f	0.83c	8.40f	67.82a	19.40a	12.78e	SL
NPK at 200 kg/ha	6.01bc	1.74a	3.00c	0.41c	3.34d	1.46ab	0.41c	1.42e	1.12b	11.12a	66.35b	17.21b	16.44d	SL
RM at 4 tons/ha	5.98d	1.71a	2.95cd	0.42c	4.71b	1.27c	0.75b	1.60e	1.25a	10.81b	63.58c	13.19d	23.23b	SL
RM at 2 tons/ha + NPK at 100 kg/ha	6.00cd	1.96a	3.38a	0.54a	4.19c	1.52a	0.41c	2.11d	1.07b	9.87e	54.78e	16.24c	28.98a	SL
RM at 3 tons/ha + NPK at 50 kg/ha	6.13a	1.81a	3.12b	0.48b	4.67b	1.47ab	0.78a	2.04b	1.19a	10.21d	61.23d	17.19b	20.87c	SL
RM at 1 ton/ha + NPK at 150 kg/ha	6.03b	1.56a	2.69e	0.34d	5.76a	1.41b	0.40d	1.88c	1.21a	10.31c	63.52c	13.19d	23.29b	SL

Means with the same letter in the same column are not significantly ($p > 0.05$) different, as indicated by Tukey's HSD test.
RM: Rabbit manure; TC: Textural class; SL: Sandy loam; CEC: Cation exchange capacity.

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organic amendments, such as farmyard manure and compost, increase soil pH, organic matter, and nutrient content. Substantial increases in OC and OM were observed in RM and combined treatments. This suggests that rabbit manure effectively enriches soil organic content, enhancing soil structure, microbial activity, and water retention. According to Gross & Glaser (2021) findings, farmyard manure, cattle manure, and pig manure all considerably raise the amount of soil organic carbon (SOC) and its storage in agricultural soils. All treated soils showed improved NPK levels compared to the control. The highest nitrogen and phosphorus levels were seen in plots with RM + NPK, indicating a synergistic effect of integrated nutrient management. Potassium was significantly higher in RM-treated plots, reinforcing the importance of organic matter in replenishing base nutrients. CEC increased across all treated plots, especially in those with combined RM and NPK (Kapoor *et al.,* 2022). Treatments improved the availability of calcium and magnesium, critical for nutrient retention and plant health. These findings suggest that combined treatments improve the soil's ability to hold and exchange nutrients, enhancing fertility and productivity. Soil texture remained consistent as sandy loam in all plots. Slight variations in sand, silt, and clay percentages were observed but were not statistically significant.

All fertilizer treatments significantly increased plant height compared to the control at both locations and across all growth stages (Table 4). This improvement is evident as the control consistently had the lowest values and unique letter designations. Combining RM and NPK generally produced superior results compared to a:lying either alone at the tested rates. Ngala *et al.,* (2021) also demonstrated that integrating NPK, biofertilizers, and poultry manure produced the highest maize plant height and biomass. The combinations often achieved heights comparable to or exceeding the full NPK rate (200 kg/ha) while using less inorganic fertilizer (Awopegba *et al.,* 2024). Plant heights and treatment rankings showed some variation between the two locations, indicating site-specific responses. In Ayede-Ekiti the combination of 1 ton/ha RM + 150 kg/ha NPK consistently produced the tallest or among the tallest plants from Week 5 onwards, achieving the highest final height (75.05 cm at Week 7). On the other hand, in Ekiti State Polytechnic (EKSPOLY), Isan-Ekiti, the combination of 3 tons/ha RM + 50 kg/ha NPK consistently produced the tallest or among the tallest plants from Week 5 onwards, achieving the highest final height (74.40 cm at Week 7) statistically with other treatments that had combined RM and NPK combinations. NPK (200 kg/ha) fertilizer significantly boosted height over the control and RM alone, especially at EKSPOLY. It was often statistically similar to the best combinations in the mid-stages but was generally surpassed by at least one combination by Week 7 at both sites. Similarly, Awopegba *et al.,* (2024) reported that combining rabbit compost tea with NPK fertilizer significantly improved maize growth parameters compared to individual applications. While beneficial, a:lying rabbit manure alone (4 tons/ha) was less effective for promoting height than NPK alone or any of the RM+NPK combinations. RM (4 tons/ha) improved height over the control but was consistently the least effective fertilizer treatment, significantly lower than NPK alone and all combinations at later stages in both locations.

Table 5 presents the effect of rabbit manure (RM) and NPK fertilizer, both individually and in combination, on the number of leaves of *Amaranthus hybridus* L. at different weeks after transplanting across two locations: EKSPOLY, Isan-Ekiti, and Ayede-Ekiti. At EKSPOLY, the highest number of leaves was observed at 7 weeks after transplanting (WAT) in the treatment with NPK at 200 kg/ha, reaching 68.20 leaves. The control group consistently recorded the lowest leaf counts across all weeks. Treatments involving the combined application of RM and NPK significantly outperformed those with only RM or control, suggesting a synergistic effect that enhanced vegetative growth. In support, studies on *Moringa oleifera* (Sarwar *et al.,* 2018) and

Table 4 | Effect of rabbit manure and NPK fertilizer on plant height of *Amaranthus hybridus* L. at different stages of growth

Treatments	Weeks after Transplanting											
	2	3	4	5	6	7	2	3	4	5	6	7
	EKSPOLY, Isan-Ekiti						Ayede-Ekiti					
Control	8.81f	12.72f	21.28f	30.69f	38.25f	47.24f	9.05b	12.88c	20.45e	29.11f	35.62f	42.14f
NPK at 200 kg/ha	9.95a	17.66a	24.87a	40.56b	57.64b	72.15b	9.14ab	18.24b	25.12bc	39.69b	58.22b	73.14b
RM at 4 tons/ha	8.89e	14.99e	22.05e	36.23e	50.20e	65.80e	9.11ab	18.04b	21.42d	34.06e	52.44e	61.23e
RM at 2 tons/ha + NPK at 100 kg/ha	9.04d	16.44b	24.74b	38.78c	51.10d	71.05c	9.38a	19.12a	25.36b	35.24d	54.26d	62.11d
RM at 3 tons/ha + NPK at 50 kg/ha	9.61b	15.23c	23.51c	41.23a	58.14a	74.40a	9.41a	19.08a	26.43a	38.28c	56.23c	71.23c
RM at 1 ton/ha + NPK at 150 kg/ha	9.10c	15.16d	22.23d	38.23d	53.48c	70.20d	9.34ab	18.24b	24.89c	40.27a	61.02a	75.05a

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

Table 5 | Effect of rabbit manure and NPK fertilizer on the number of leaves of *Amaranthus hybridus* L. at different stages of growth

Treatments	Weeks after Transplanting											
	2	3	4	5	6	7	2	3	4	5	6	7
	EKSPOLY, Isan-Ekiti						Ayede-Ekiti					
Control	7.50d	9.40e	11.00f	24.80f	32.80f	39.50f	7.84c	9.13e	12.14e	19.12f	29.51f	38.08e
NPK at 200 kg/ha	8.20a	13.80a	13.20a	35.20a	50.25a	68.20a	8.50a	13.07b	20.05a	34.55b	48.94c	68.23a
RM at 4 tons/ha	7.20e	12.20d	12.50d	34.40b	46.45d	58.54e	8.35ab	11.94c	16.68d	29.26e	42.18e	53.34c
RM at 2 tons/ha + NPK at 100 kg/ha	7.80c	13.10c	12.90b	32.80d	45.40e	61.40d	8.15b	12.85b	17.70c	30.95d	43.61d	52.06d
RM at 3 tons/ha + NPK at 50 kg/ha	7.60d	13.45b	12.70c	33.60c	49.62b	66.12b	8.42ab	14.04a	18.05b	35.06a	50.04b	60.22b
RM at 1 ton/ha + NPK at 150 kg/ha	8.00b	8.00f	11.94e	31.25e	47.40c	62.50c	8.40ab	11.29d	17.86bc	34.24c	53.21a	67.94a

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

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chilli (Kamrunnahar *et al.,* 2024) consistently show improved vegetative growth parameters when using combined treatments. Among the combinations, balanced applications of RM and NPK produced optimal leaf development. In Ayede-Ekiti, the highest number of leaves was also recorded at 7 WAT, specifically in the treatment with NPK at 20 kg/ha, which produced 68.23 leaves, and RM at 1 ton/ha plus NPK at 150 kg/ha, which resulted in 67.94 leaves. Similar to EKSPOLY, the control treatment had the least number of leaves, while the integrated use of RM and NPK led to significantly greater leaf production compared to the control or RM at 4 tons/ha.

The control consistently produced the smallest stem girths at both experimental locations (Table 6) across all growth stages ($p < 0.05$). NPK fertilizer alone (200 kg/ha) produced the thickest stems during early growth (weeks 2–4) at EKSPOLY, while combinations of rabbit manure (RM) and reduced NPK outperformed sole applications in later stages (weeks 5–7). The optimal combination was location-specific: 1 ton/ha RM + 150 kg/ha NPK yielded the thickest stems at Ayede-Ekiti (peak: 1.31 cm at week 7), whereas 3 tons/ha RM + 50 kg/ha NPK was most effective at EKSPOLY (peak: 1.31 cm at week 7). Rabbit manure alone (4 tons/ha) matched NPK alone at Week 4 but lagged significantly thereafter (Shaji *et al.,* 2021). Fertilization effects intensified over time, with the greatest treatment differences occurring at Weeks 6–7. Critically, combinations like 3 tons/ha RM + 50 kg/ha NPK achieved superior or comparable results to full-rate NPK using 75% less synthetic fertilizer, demonstrating significant potential for sustainable nutrient management.

Fertilization significantly enhanced leaf area in *Amaranthus hybridus* compared to the control at both EKSPOLY (Isan-Ekiti) and Ayede-Ekiti from Weeks 5 to 7, although no significant differences were observed among treatments at Week 4 in EKSPOLY (Table 7). At EKSPOLY, treatments such as the combined application of rabbit manure (RM) plus NPK, NPK treatments alone and RM treatment alone statistically had similar results. Conversely, at Ayede-Ekiti, the combination of 1 ton/ha RM + 150 kg/ha NPK produced the greatest leaf area at week 6 (28.81 cm^2) and week 7 (35.02 cm^2), outperforming the full-rate NPK treatment (34.21 cm^2 at week 7). Rabbit manure alone at 4 tons/ha significantly improved leaf area over the control. The integrated RM-NPK treatments showed a notable synergistic effect at Ayede-Ekiti, where they surpassed NPK alone in the later weeks, highlighting the potential for site-specific nutrient optimization.

At both locations (EKSPOLY, Isan-Ekiti, and Ayede-Ekiti), fertilization considerably enhanced the number of branches in *Amaranthus hybridus* as compared to the control from weeks 5 to 7, while there were no significant differences between treatments at week 4 at either location (Table 8). The EKSPOLY site's highest branch counts during weeks 5–7 were regularly produced by a combination of 3 tons/ha rabbit manure + 50 kg/ha NPK and NPK fertilizer applied alone at 200 kg/ha, reaching a peak of 6.50 and 6.10 branches in week 7, respectively. At Ayede-Ekiti, statistically, the highest branch counts were obtained by 1 ton/ha rabbit manure and 150 kg/ha NPK and NPK alone application. The combination treatments demonstrated location-specific efficacy, with RM 3 tons/ha + NPK 50 kg/ha performing well at EKSPOLY and RM 1 ton/ha + NPK 150 kg/ha excelling at Ayede-Ekiti, both achieving results comparable to or exceeding full-rate NPK while reducing synthetic fertilizer inputs by 50–75%. Treatment effects amplified progressively, with the greatest divergence from the control occurring at Week 7.

NPK alone (200 kg/ha) maximized root biomass at EKSPOLY (5.04 t ha^{-1}) and Ayede-Ekiti (5.61 t ha^{-1}). At EKSPOLY, 3 tons/ha rabbit manure + 50 kg/ha NPK yielded the highest fresh weight (26.50 t ha^{-1}) and matched NPK alone in shoot biomass, marketable yield, and edible yield (Table 9). It's noteworthy that statistically all the treatments performed the

Table 6 | Effect of rabbit manure and NPK fertilizer on stem girth of *Amaranthus hybridus* L. at different stages of growth

Treatments	Weeks after Transplanting											
	2	3	4	5	6	7	2	3	4	5	6	7
	EKSPOLY, Isan-Ekiti						Ayede-Ekiti					
Control	0.20d	0.27f	0.43f	0.58f	0.72f	0.91f	0.21a	0.26c	0.44d	0.66e	0.81e	0.99e
NPK at 200 kg/ha	0.23a	0.39a	0.62b	0.79b	1.02c	1.24b	0.22a	0.40a	0.66a	0.83a	1.14b	1.27b
RM at 4 tons/ha	0.20d	0.32d	0.64a	0.74d	0.93e	1.09e	0.21a	0.34b	0.66a	0.76c	0.99d	1.12d
RM at 2 tons/ha + NPK at 100 kg/ha	0.21c	0.35b	0.50d	0.75c	0.95d	1.12d	0.21a	0.36b	0.52c	0.73d	0.97d	1.13d
RM at 3 tons/ha + NPK at 50 kg/ha	0.21c	0.34c	0.60c	0.71e	1.09a	1.31a	0.20a	0.36b	0.62b	0.80b	1.10c	1.24c
RM at 1 ton/ha + NPK at 150 kg/ha	0.22b	0.29e	0.48e	0.80a	1.05b	1.22c	0.23a	0.41a	0.59b	0.82ab	1.18a	1.31a

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

Table 7 | Effect of rabbit manure and NPK fertilizer on leaf area of *Amaranthus hybridus* L. at different stages of growth

Treatments	Weeks after Transplanting							
	4	5	6	7	4	5	6	7
	EKSPOLY, Isan-Ekiti				Ayede-Ekiti			
Control	12.04a	14.14d	15.12c	17.52b	12.11e	14.69e	18.00d	22.74f
NPK at 200 kg/ha	13.46a	18.23a	24.50a	26.74a	14.28a	20.13a	28.70a	34.21b
RM at 4 tons/ha	12.54a	15.33bcd	20.12b	25.24a	13.64c	16.34d	25.53c	30.45d
RM at 2 tons/ha + NPK at 100 kg/ha	13.06a	16.95abc	20.67b	25.38a	13.35d	16.45d	25.65c	29.48e
RM at 3 tons/ha + NPK at 50 kg/ha	13.50a	17.91ab	25.40a	26.41a	14.05ab	18.72c	27.92b	33.86c
RM at 1 ton/ha + NPK at 150 kg/ha	12.11a	15.22cd	21.66b	25.14a	13.87bc	19.13b	28.81a	35.02a

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

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same way for marketable and edible yield except the control. Conversely, at Ayede-Ekiti, 1 ton/ha rabbit manure + 150 kg/ha NPK dominated fresh weight (28.26 t ha-^{1}), shoot biomass (22.94 t ha-^{1}), marketable yield (22.06 t ha-^{1}), and edible yield (15.02 t ha-^{1}), surpassing NPK alone in three parameters. Rabbit manure alone (4 tons/ha) improved yields versus the control but was consistently outmatched by optimized combinations. Ikani *et al.,* (2024) and Inyang *et al.,* (2018) established that combined application of organic and inorganic fertilizers improved plant height, leaf number, stem girth, and yield.

Across both locations, fertilizer treatments tended to reduce carbohydrate levels while increasing protein and fat content (Table 10). The treatments affected the proximate composition differently, and treatments with combined RM and NPK generally enhanced protein levels compared to the control. There were no significant differences in the crude fibre contents across all the treatments in EKSPOLY, Isan-Ekiti, whereas, noticeable differences were obtained significantly for the crude fibre contents among the treatments in Ayede-Ekiti. Rabbit manure (RM) alone (4 tons/ha) produced the maximum protein content in the two locations (Utomo *et al.,* 2019). The RM 1t/ha + NPK 150kg/ha treatment resulted in the highest moisture (6.43%) and crude fibre (4.07%) at Ayede but with the lower protein (20.86%) at EKSPOLY, indicating nutrient trade-offs. Site-specific responses were pronounced, with Ayede favouring fat optimization and EKSPOLY favouring protein enhancement.

Table 8 | Effect of rabbit manure and NPK fertilizer on number of branches of *Amaranthus hybridus* L. at different stages of growth

Treatments	Weeks after Transplanting							
	4	5	6	7	4	5	6	7
	EKSPOLY, Isan-Ekiti				Ayede-Ekiti			
Control	0.10a	0.60c	1.10c	1.67c	0.57a	1.67d	2.45d	2.85d
NPK at 200 kg/ha	0.33a	2.27a	4.20a	6.10a	0.81a	3.21ab	5.60a	7.34a
RM at 4 tons/ha	0.17a	0.83bc	3.40b	4.50b	0.71a	2.07c	4.24c	5.84c
RM at 2 tons/ha + NPK at 100 kg/ha	0.27a	1.13b	3.20b	4.30b	0.68a	2.32c	4.31c	5.69c
RM at 3 tons/ha + NPK at 50 kg/ha	0.33a	2.33a	4.40a	6.50a	0.82a	2.93b	5.20b	6.81b
RM at 1 ton/ha + NPK at 150 kg/ha	0.17a	1.00bc	3.60b	4.40b	0.81a	3.40a	5.82a	7.46a

Means with the same letter in the same column are not significantly ($p > 0.05$) different, as indicated by Tukey's HSD test.

Table 9 | Effects of rabbit manure and NPK fertilizer on *Amaranthus hybridus* yield parameters

Treatments	Fresh Weight Biomass (t ha^{-1})	Wet Shoot Biomass (t ha^{-1})	Wet Root Biomass (t ha^{-1})	Marketable Yield (t ha^{-1})	Edible Yield (t ha^{-1})	Fresh Weight Biomass (t ha^{-1})	Wet Shoot Biomass (t ha^{-1})	Wet Root Biomass (t ha^{-1})	Marketable Yield (t ha^{-1})	Edible Yield (t ha^{-1})
	EKSPOLY, Isan-Ekiti					Ayede-Ekiti				
Control	16.10f	12.52b	3.58c	11.15b	7.85b	17.12c	13.30c	3.83e	12.13c	8.56c
NPK at 200 kg/ha	26.30b	21.26a	5.04a	19.73a	13.56a	28.12a	22.51a	5.61a	21.71ab	15.97a
RM at 4 tons/ha	24.40d	20.34a	4.06bc	18.82a	12.72a	25.34b	21.12ab	4.22d	19.34b	12.58b
RM at 2 tons/ha + NPK at 100 kg/ha	24.60c	20.16a	4.44ab	19.08a	12.51a	25.32b	20.31b	5.01c	19.53ab	12.54b
RM at 3 tons/ha + NPK at 50 kg/ha	26.50a	21.82a	4.68ab	19.98a	13.51a	27.11ab	21.85ab	5.26bc	20.98ab	14.68ab
RM at 1 ton/ha + NPK at 150 kg/ha	23.53e	19.78a	3.72c	18.46a	12.04a	28.26a	22.94a	5.32b	22.06a	15.02ab

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.

Table 10 | Effects of treatments on proximate composition of *Amaranthus hybridus*

Treatments	Moisture (%)	Protein (%)	Fat (%)	CF (%)	Ash (%)	CHO (%)	Moisture (%)	Protein (%)	Fat (%)	CF (%)	Ash (%)	CHO (%)
	EKSPOLY, Isan-Ekiti						Ayede-Ekiti					
Control	5.13c	18.20f	17.27e	2.50a	3.87c	52.98a	3.56f	12.43f	13.46e	3.54a	4.17b	62.81a
NPK at 200 kg/ha	3.67f	24.11d	18.99b	2.80a	3.29f	47.10c	4.22e	19.13c	16.20c	2.78b	3.17f	55.17b
RM at 4 tons/ha	4.75d	28.00a	17.42d	2.99a	3.56e	43.23e	4.67c	21.24a	17.19b	3.07ab	3.55e	50.95e
RM at 2 tons/ha + NPK at 100 kg/ha	5.31b	24.54c	18.64c	3.19a	3.67d	44.58d	4.34d	20.83b	21.30a	3.16ab	4.56a	46.37f
RM at 3 tons/ha + NPK at 50 kg/ha	6.42a	26.20b	19.22a	3.10a	4.17a	40.83f	5.14b	17.45d	17.21b	3.47ab	3.74d	53.80d
RM at 1 ton/ha + NPK at 150 kg/ha	4.54e	20.86e	16.80f	2.76a	3.96b	51.00b	6.43a	16.61e	15.36d	4.07a	3.84c	54.84c

Means with the same letter in the same column are not significantly (p> 0.05) different, as indicated by Tukey's HSD test.
Tukey's HSD test.
CF = Crude fiber; CHO = Carbohydrate; EKSPOLY = Ekiti State Polytechnic

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5. | Conclusion

This study demonstrates that integrating rabbit manure (RM) with NPK fertilizer significantly improves soil fertility, plant growth, and yield of *Amaranthus hybridus.* Combined RM and NPK treatments outperformed individual applications, enhancing plant height, leaf production, stem girth, and yield while reducing synthetic fertilizer use by up to 75%. Nutritional quality also improved, with higher protein and fat contents. Results varied by location, underscoring the need for site-specific nutrient management to achieve sustainable and efficient crop production. The best performance of *Amaranthus hybridus* cultivated in Isan-Ekiti was obtained from the plots with the combination of RM 3 t/ha and NPK 50kg/ha and the combination of RM 1 t/ha and NPK 150kg/ha in Ayede-Ekiti. The findings underscore the potential of integrated nutrient management in promoting sustainable A. hybridus production, with site-specific responses. Isan-Ekiti was obtained to be the best site with lesser inorganic fertilizer application and maximum yield.

References

Adekiya, A. O., Aboyeji, C. M., Dunsin, O., Asamu, F., Owolabi, A. O., Aremu, C. O., Oyetunji, D.A., Oloye, A. D. & Owolabi, I. O. (2019). Poultry manure addition affects production, plant nutritional status and heavy metals accumulation in green Amaranth (Amaranthus hybridus). *International Journal of Agriculture & Biology*, *22* (5) : 993-1000.

Adeleye, A. O., Yerima, M. B., Nkereuwem, M. E., Sadiq, I. S., Shiaka, G. P., Onokebhagbe, V. O. and Amoo, A. O., 2021. Growth performance of grain amaranth (*Amaranthus cruentus* L.) on spent engine oil contaminated soil bioremediated with two bacterial co-cultures and organic amendments. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 69 (4) : 481 – 490.

Ahlawat, O. P., Gill, S. C., Venkatesh, K., Chhokar, R. S., Khi:al, A., Singh, G. and Singh, G. P. (2023). Impact of Long-Term A:lication of Organic Manure on Inceptisol Properties, Grain Protein Content and Yield of Wheat. *Communications in Soil Science and Plant Analysis*, 54 (13): 1848-1864.

Ahmad, W., Shah, Z., Khan, F., Ali, S., and Malik, W. (2013). Maize yield and soil properties as influenced by integrated use of organic, inorganic and bio-fertilizers in a low fertility soil. *Soil & Environment*, 32 (2, :121-129.

Amulu, L. U., Oyedele, D. J. and Adekunle, O. K. (2021). Effects of Sunn hemp (Crotalaria juncea) and Mexican sunflower (Tithonia diversifolia) soil amendments on yields and quality of two indigenous vegetables grown in a nematode-infested field. *Indian Phytopathology*, 74 (2): 729 - 737.

Ande, O. T., Huising, J., Ojo, A. O., Azeez, J., Are, K. S., Olakojo, S. A., Fademi, I. O. and Ojeniyi, S. O. (2017). Status of integrated soil fertility management (ISFM) in southwestern Nigeria. *International Journal of Sustainable Agricultural Research*, 4 (2) : 28-44.

AOAC. (1997). Official Methods of Analysis. Association of Official Analytical Chemists. 16th ed. Cunniff, P. (Ed.). A.O.A.C., Washington D.C.

Awopegba, T. M. and Awodun, M. A. (2023). Effect of jatropha mulch types and inorganic fertilizers on amaranth (Amaranthus hybridus) growth in Akure Southwestern Nigeria. *Research Journal of Agriculture and Forestry Sciences. Res. J. Agriculture & Forestry Sci.,* 11 (2) : 33-38.

Awopegba, T. M., Adeboye, K. A. and Samuel, F. F. (2024). The Effects of Rabbit Compost Tea and NPK Fertilizer on the Growth Parameters of Maize (Zea mays L.). *Turkish Journal of Agriculture-Food Science and Technology*, 12 (6) : 899-904.

Aziz, T., Maqsood, M. A., Kanwal, S., Hussain, S., Ahmad, H. R. and Sabir, M. (2015). Fertilizers and environment: issues and challenges. *Crop production and global environmental issues*, : 575-598.

Dimkpa, C., Adzawla, W., Pandey, R., Atakora, W. K., Kouame, A. K., Jemo, M. and Bindraban, P. S. (2023). Fertilizers for food and nutrition security in sub-Saharan Africa: an overview of soil health implications. *Frontiers in Soil Science*, *3*, p.1123931.

Ekeke, C., Manga, T. T., and Mensah, S. I. (2019). Research Article Comparative Phytochemical, Morphological and Anatomical Studies of *Amaranthus hybridus* L. and Amaranthus spinosus L.(Amaranthaceae). *Res. J. Med. Plants*, *13*, 53-63.

Falodun, E. J. and Edafe, V. E. (2020). Productivity, nutrient concentration, uptake and quality of Amaranthus (*Amaranthus cruentus* L.) as influenced by cutting heights and fertilizer type. *Notulae Scientia Biologicae*, 12 (3) : 719-728.

Goldan, E., Nedeff, V., Barsan, N., Culea, M., Panainte-Lehadus, M., Mosnegutu, E., Tomozei, C., Chitimus, D. and Irimia, O. (2023). Assessment of manure compost used as soil amendment—A review. *Processes*, 11 (4), 1167.

Gross, A. and Glaser, B. (2021). Meta-analysis on how manure application changes soil organic carbon storage. *Scientific reports*, 11 (1), : 5516.

Guye, M. (2015). Common pitfalls in use of chemical fertilizer: o:ortunities vis-à-vis challenges of chemical fertilizer application in agriculture. District of Anna Sorra in Oromia regional State, Southern Ethiopia, : 67 -73.

Ikani, V. O., Zakari, B. G., Jimeta, Z. G. and Ahmad, I. D. I. (2024). Comparative efficacy of NPK fertilizer and poultry dro:ings on the growth and yield of *Amaranthus hybridus* L. *Journal of Plant Development*. 31 (1) : 91-96.

Inyang, J. O., Abu, T., Emmanuel, A. U., Friday, J. O., Bobai, N. and Oise, E. (2018). Growth and performance analysis of Amaranthus hybridus L. Enriched with organic (sugarcane bagasse-based) fertilizer. *International Journal of Basic, Applied and Innovative Research*, 7 (2) : 55-61.

Irabor, E. E. I., Esanukpe, L., Imafidon, M. I., Ogbeide, O. K., Okunzuwa, I. G., Unuigbe, C. A. and Omoruyi, U. (2023). Evaluation of the Influence of pH on the Release of Exchangeable Cations from a Mixed Clay Mineral Deposit for Replenishment of Soil Nutrients. *Walisongo Journal of Chemistry*, 6 (1) : 87-96.

Kamrunnahar, K. V., Rayhanul, H., Jannatul, F, Md. Alamin, Ruba, S. A., Shahinur, A., Saila, M., Latif, M. T. and Rahman, S. M. (2024). Enhancing Chili Growth and Yield: The Synergistic Effects of Biochar and Inorganic Fertilizers on Soil Properties and Nutrient Use Efficiency. *International Journal of Biological Engineering and Agriculture,* 3 (4) : 552-564.

Kapoor, A., Sharma, R., Kumar, A. and Sepehya, S. (2022). Biochar as a means to improve soil fertility and crop productivity: a review. *Journal of Plant Nutrition*, 45 (15) : 2380-2388.

Kumar, S. S., Aruna, M. C. and Giridhar, P. (2016). Improvement of Green Leafy

Vegetables: The Role of Plant Tissue Culture and Biotechnology. *Plant Tissue Culture: Propagation, Conservation and Crop Improvement*, 547-582:.

Li, R., Hao, H., Yang, C., Wang, L. and Wang, H. (2022). Rabbit manure compost as a peat substitute for compound growing media: Proportioning optimization according to physiochemical characteristics and seedling effects. *Frontiers in Plant Science*, *13*, 1008089.

Malhi, S. S., Vera, C. L. and Brandt, S. A. (2013). Relative effectiveness of organic and inorganic nutrient sources in improving yield, seed quality and nutrient uptake of canola. *Agricultural Sciences*, *2013*.

Managa, G. M. and Nemadodzi, L. E. (2023). Comparison of agronomic parameters and nutritional composition on red and green amaranth species grown in open field versus greenhouse environment. *Agriculture*, 13 (3, : 685.

Ngala, A. L., Digmari, F. U., Ndirmbula, J. B. and Abdullahi, R. (2021). Effects of NPK, bio-fertilizers and manures on growth of maize (Zea mays L.) and soil nutrients content in maiduguri, Nigeria. *European Journal of Agriculture and Food Sciences*, 3 (5) : 117-122.

Onyegbule, U. N., Onwudike, S. U., Opara-Nadi, N. and Opara-Nadi, O. (2023). Soil fertility evaluation and land-use effects on soil properties, carbon and nitrogen sequestration in the rainforest of Nigeria. *Eurasian Journal of Soil Science*, 12 (4) : 310-319.

Oshunsanya, S. (Ed.). (2019). *Soil pH for nutrient availability and crop performance*. BoD–Books on Demand.

Otieno, H. M. and Zingore, G. N. C. W. S. (2018). Effect of farmyard manure, lime and inorganic fertilizer applications on soil pH, nutrients uptake, growth and nodulation of soybean in acid soils of western Kenya. *Journal of Agricultural Science*, 10 (4) : 199-208.

Romero-Romano, C. O., Ocampo Mendoza, J., Sandoval Castro, E., Navarro Garza, H., & Franco Mora, O. (2021). Plant densities and fertilization doses in the cultivation of amaranth. *Revista mexicana de ciencias agrícolas*, *12*(5), 937-944.

Sanni, K. O. (2016). Effect of compost, cow dung and NPK 15-15-15 fertilizer on growth and yield performance of Amaranth (Amaranthus hybridus). *International Journal of Advances in Scientific Research*, 2 (3) : 76-82.

Sarwar, M., Patra, J. K. and Jihui, B. (2018). Comparative effects of compost and NPK fertilizer on vegetative growth, protein, and carbohydrate of Moringa oleifera lam hybrid PKM-1. *Journal of Plant Nutrition*, 41 (12, : 1587-1596.

Shaji, H., Chandran, V. and Mathew, L. (2021). Organic fertilizers as a route to controlled release of nutrients. In *Controlled release fertilizers for sustainable agriculture* 231-245. Academic Press.

Utomo, R., Noviandi, C. T., Umami, N. and Permadi, A. (2019). Effect of composted animal manure as fertilizer on productivity of Azolla pinnata grown in earthen ponds. *Journal of Biological Sciences Original Research Paper*, 19 (4) : 232-236.

Verma, S., Pradhan, S. S., Singh, A. and Kushuwaha, M. (2024). Effect of Organic Manure on Different Soil Properties: A Review. *International Journal of Plant & Soil Science*, 36 (5) : 182-187.

Weerasekara, A. C. and Waisundara, V. Y. (2020). Amaranth as a pseudocereal in modern times: Nutrients, taxonomy, morphology and cultivation. In *Nutritional Value of Amaranth*. IntechOpen.

Yan, H., Fan, W., & Wu, J. (2023). Effects of Continuous Manure A:lication on the Microbial Community and Labile Organic Carbon Fractions. *Agriculture*, *13*(11), 2096.

Yusuf, T. M. and Olowoake, A. A. (2019). Rising to the challenge of low soil fertility in Nigeria; Sustainable maize crop production under *Moringa oleifera* technology. Invited paper presented at the 6th African Conference of Agricultural Economists, September 23-26, 2019, Abuja, Nigeria.

Zaib, M., Zubair, M., Aryan, M., Abdullah, M., Manzoor, S., Masood, F. and Saeed, S. (2023). A Review on Challenges and O:ortunities of Fertilizer Use Efficiency and Their Role in Sustainable Agriculture with Future Prospects and Recommendations. *Curr. Rese. Agri. Far*, 4 (4) : 1-14.

Zeeshan, A., Waqas, M., Ramzan, M. T., Ghafoor, F., Ibrahim, M. U., Fatima, N., Rauf, A., Hussain, A., Abbas, M., Zahid, N. and Hanif, S. (2024). From Fields to Families: Understanding the Health Impacts of Excessive Soil Fertilization. *Journal of Health and Rehabilitation Research*, 4 (2) : 990-995.

Zhang, X., Li, J., Shao, L., Qin, F., Yang, J., Gu, H., Zhai, P. and Pan, X. (2023). Effects of organic fertilizers on yield, soil physico-chemical property, soil microbial community diversity and structure of Brassica rapa var. Chinensis. *Frontiers in Microbiology*, *14*, 1132853.

Appendices

Table 11 | Mean squares from the ANOVA of growth parameters of *Amaranthus hybridus* L. planted in Ekiti State Polytechnic, Isan-Ekiti

Source	DF	PH (cm)	NoL	SG (cm)	DF	LA (cm²)	NB
Rep	2	119.410***	0.003***	0.176***	2	0.082***	0.039ns
Fertilizer (F)	5	281.247***	255.137***	0.093***	5	59.524***	9.799***
Time (T)	5	8904.986***	8003.399***	2.370***	3	478.734***	68.265***
F x T	25	47.173***	50.033***	0.013***	15	8.526***	1.618***
Error	70	0.0001	0.0000	0.0001	46	0.0001	0.059

*,**, *** = Significance at 0.05, 0.01 and 0.001 level of probability, respectively; ns = Not significant
DF= Degree of freedom; PH = Plant height; NoL = Number of leaves; SG = Stem girth; LA = Leaf area; NB = Number of branches

Table 12 | Mean squares from the ANOVA of growth parameters of *Amaranthus hybridus* L. planted in Ayede-Ekiti

Source	DF	PH (cm)	NoL	SG (cm)	DF	LA (cm²)	NB
Rep	2	0.003***	153.184***	0.089***	2	58.348***	1.267***
Fertilizer (F)	5	433.394***	434.234***	0.097***	5	95.951***	10.223***
Time (T)	5	8122.732***	6711.171***	2.551***	3	1112.730***	95.559***
F x T	25	69.152***	62.079***	0.009***	15	10.555***	1.536***
Error	70	0.0000	0.0022	0.0002	46	0.0139	0.017

*,**, *** = Significance at 0.05, 0.01 and 0.001 level of probability, respectively; ns = Not significant
DF= Degree of freedom; PH = Plant height; NoL = Number of leaves; SG = Stem girth; LA = Leaf area; NB = Number of branches

Table 13 | Mean squares from the ANOVA of yield parameters of *Amaranthus hybridus* planted in Ekiti State Polytechnic, Isan-Ekiti

Source	DF	FWB	WSB	WRB	MY	ED
Rep	2	29.261***	0.018***	0.011***	0.016***	0.018***
Fertilizer (F)	5	44.154***	34.927***	0.967***	33.471***	13.626***
Error	10	0.0006	0.0001	0.0001	0.0000	0.0001

*,**, *** = Significance at 0.05, 0.01 and 0.001 level of probability, respectively; ns = Not significant
DF= Degree of freedom; FWB = Fresh weight biomass; WSB = Wet shoot biomass; WRB = Wet root biomass; MY = Marketable yield; ED = Edible yield.

Appendices

Table 14 | Mean squares from the ANOVA of yield parameters of *Amaranthus hybridus* planted in Ayede-Ekiti

Source	DF	FWB	WSB	WRB	MY	ED
Rep	2	0.020***	0.020***	0.015***	0.033***	0.046***
Fertilizer (F)	5	52.11***	38.352***	1.456***	40.627***	21.313***
Error	10	0.0001	0.0000	0.0000	0.0004	0.0000

*,**, *** = Significance at 0.05, 0.01 and 0.001 level of probability, respectively; ns = Not significant
DF = Degree of freedom; FWB = Fresh weight biomass; WSB = Wet shoot biomass; WRB = Wet root biomass; MY = Marketable yield; ED = Edible yield

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