Influence of Tillage Practices and Nutrient Application Rates on Performance of Cassava in Coastal Plain Sand, Etinan, Akwa Ibom State

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Abstract

This research was conducted to assess the performance of cassava (*Manihot esculenta* Crantz) under two tillage practice integrated with organic and inorganic fertilizers in 2022 and 2023 cropping seasons in Etinan, Akwa Ibom State, Nigeria. Initial soil samples were collected and analyzed for physicochemical properties. The experiment was a factorial arranged in a randomized complete block design, with treatments consisting of two tillage practices (conventional and reduced tillage), and eight fertilizer combinations (T1: NPK 15:15:15 400kgha^{-1} , T2: poultry manure (PM) 5 tha^{-1}, T3: microbial fertilizer (Bio fertilizer) 40l kgha^{-1},T4: NPK 400 kgha^{-1} + PM 5 tha^{-1}, T5: NPK 400 kgha^{-1} + PM 2.5 tha^{-1}, T6: NPK 400 kgha^{-1} + CHC 240l kgha^{-1}, T7: NPK 400 kgha^{-1} + CHC 120l kgha^{-1} T8: 0) replicated three times to give a total of 48 experimental units. In both cropping years, amended soils and those under different tillage methods showed significant ($p < 0.05$) difference in cassava P nutrient accumulation, while for cassava K and N nutrient accumulation only 2022 cropping season showed significant ($p < 0.05$) difference between the various treatments. The 2023 cropping year (residual effect) produced cassava with the heaviest dry roots, highest number of roots, heaviest fresh tubers and increased yield, which were associated with soil amended with NPK 15: 15: 15: 400 kgha^{-1} + PM 2.5 tha^{-1}. Hence, to optimize cassava yield on coastal plain sand, the integration of NPK 15: 15: 15: at 400 kgha^{-1} + PM 2.5 tha^{-1} using conventional tillage will give a better yield.

Keywords: Coastal plain sand, cassava performance, organic fertilizer, inorganic fertilizer, tillage practices

Introduction

Coastal plain sand soils across the globe are mostly characterized by coarse texture (Ogban and Essien, 2016), low organic matter, and high acidity (Essien and Ogban, 2018), which limits their ability to support healthy crop growth including cassava (Amalu and Isong, 2015; Ben *et al.,* 2024; Essien *et al.,* 2024 and Akpan *et al.,* 2025). Coastal plain sands are typically deficient in essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), and micronutrients (Akpan *et al.,* 2020; Essien *et al.,*2025a), further complicating cassava cultivation (Sam *et al.,*2025). To improve cassava production on these soils, it is essential to adopt agricultural practices that can enhance soil fertility and mitigate the adverse effects of soil acidity. In Akwa Ibom State, coastal plain sands are commonly found in many cassava-growing regions, this poses a particular challenge due to their low nutrient retention capacity, high leaching rate and poor soil structure (Ijah *et al.,* 2023; Essien *et al.,* 2022; Ogban *et al.,* 2022). These characteristics hinder the efficient uptake of nutrients and reduce crop yield potential.

Tillage is an important aspect of soil management that directly influences soil structure, water infiltration, and root development (Akata *et al.,* 2025; Mark *et al.,* 2024; Essien *et al.,* 2023). Conventional tillage practices, such as plowing, can help break compacted layers and improve root access to water and nutrients (Afolabi *et al.,* 2020; Reichert *et al.,* 2021; Onasanya *et al.,* 2021; Essien *et al.,* 2021), whereas, conservation tillage involves minimal soil disturbance, that help preserve soil moisture and reduce erosion, especially in sandy soils prone to degradation. In addition, a conservation tillage approach such as no-till systems, has been shown to improve soil health by enhancing organic matter retention and reducing compaction (Cavalieri *et al.,* 2006). However, the effectiveness of these practices can vary significantly based on local soil types and climatic conditions. Moreover, the application of fertilizer: both inorganic and organic, affects cassava growth and yield (Adeoye *et al.,* 2019). Inorganic fertilizers provide immediate nutrient availability, while organic fertilizers contribute to long-term soil fertility through improved microbial activity and nutrient cycling (Akpan *et al.,* 2021; Akpan *et al.,* 2024; Akata *et al.,* 2024b). Understanding the synergistic effects of tillage and fertilizer types on cassava performance is crucial for developing best management practices that enhance productivity while promoting environmental sustainability.

Tillage practices combined with appropriate nutrient application are vital management techniques that can influence soil properties, nutrient availability and crop performance. Tillage is well known to affect soil aeration moisture retention, and root penetration (Maduakor *et al.,* 1984; França *et al.,* 2021), while fertilizer replenishes the nutrients that are deficient in soil, especially soil with history of low fertility. The combination of appropriate tillage techniques and balanced nutrient application can play a significant role in improving the growth and yield of cassava on acid sand soils (Ogunniyi *et al.,* 2020).

Cassava (*Manihot esculenta*) is a crucial staple crop in many tropical regions, known for its adaptability and resilience under varying environmental conditions. As global food security becomes increasingly threatened by climate change and soil degradation, optimizing cassava production through sustainable agricultural practices is essential. The performance of cassava (*Manihot esculenta*)in Nigeria is significantly influenced by agronomic practices, particularly tillage methods and fertilizer applications. Previous studies have established that these practices can affect soil health, nutrient availability, and crop yields (Afolabi *et al.,* 2020; Reichert *et al.,* 2021; Onasanya *et al.,* 2021; França *et al.,* 2021).Understanding the interplay between these factors is crucial for optimizing cassava production, which is vital for food security and economic stability in Nigeria. The aim of this study is to assess the performance of cassava under different tillage practices combined with both inorganic and organic fertilizer applications.

Materials and methods

Location of the study area

The experiment was conducted in 2022 and 2023 in FEYRep (Family Empowerment and Youth Re-orientation Programme) farm in Etinan Local Government Area, Akwa Ibom State, Nigeria. The study area is located between latitudes 4°44'23" and 4°45'10"N and longitudes 7°50'35" and 7°59'55' 'E Southern Iman in Etinan, Akwa Ibom State, Nigeria, which is about 48 m above sea level. The soils is derived from coastal plain sand (CPS), dominated by Kaolinite with low organic matter content (Essien *et al.,* 2025b). The area has mean annual rainfall ranging between 2500 - 3000 mm distributed between April and October with a mono-modal rainfall pattern. The mean annual temperature ranged between 26 ^{0}C -35^{0}C while the average relative humidity ranges from 69 to79 %. (Peters *et al.,* 1989). The vegetation of the area is rain forest characterized by multiple plant species ranging from herbs to shrubs and trees. Oil palm trees are predominant over other tree species in the study area.

Experimental Design

The experiment was factorial arranged in a Randomized Complete Block Design (RCBD). The treatments were two tillage practices (conventional and reduced tillage), and eight fertilizer treatment combinations (T1: NPK 15:15:15 400kgha^{-1} , T2: poultry manure (PM) 5 tha^{-1}, T3: microbial fertilizer (Bio fertilizer) 40l kgha^{-1},T4: NPK 400 kgha^{-1} + PM 5 tha^{-1}, T5: NPK 400 kgha^{-1} + PM 2.5 tha^{-1}, T6: NPK 400 kgha^{-1} + CHC 240l kgha^{-1}, T7: NPK 400 kgha^{-1} + CHC 120l kgha^{-1} T8: 0).

Field Method

Initial soil samples were collected at a depth of 0-20 cm for laboratory analysis.

The conventional tillage (CT) was mechanically ridged at 1 m apart after ploughing and harrowing. For reduced tillage (RT) treatment cassava cuttings were sown directly without ridging at 1 m interval between the ridges after demarcation of the field into plots. In control plot, no treatment was applied. Each plot measured 4 m by 5 m (four ridges; 5 m long) and a total of 48 experimental units for the research. Improved cassava variety (TMS 419) was used as test crop for the research, which matured within 8-12 months, high starch content tall without branching and high yielding of about 35 t ha^{-1}, gotten from National Research Institute, Umudike, Abia State.

The cassava (TMS 419) cutting was sown manually, twenty cutting per plot at an intra-row spacing of 1m and slanted at an angle of 45. The planting of twenty cuttings per plot give a plant population of 960 plants. Weeds were controlled by the application of glyphosate at two weeks before land preparation. Subsequently, manual weeding, which involved the use of hoe, was employed twice in all the 48 plots (at 8 weeks after planting and 16 weeks after planting before harvesting. The application rates for fertilizers used were: NPK 15: 15: 15 at the rate of 400 kg ha^{-1}, poultry manure (PM) at 2.5 t ha^{-1} and 5 t ha^{-1} and microbial fertilizer (Bio fertilizer) at 120 and 240 gha^{-1}. All combinations were applied to all plot at first season of planting, while in the second season there was no application of fertilizer. Nitrogen, phosphorus and potassium fertilizers (NPK 15:15:15) was applied at 8 weeks after sowing in first season.

Laboratory Analysis

Initial soil samples were air-dried, ground, and passed through a 2 mm sieve, and used to determine some physico-chemical characteristics of the soils. Mechanical analysis was determined by the Bouyoucos hydrometer method (Udo *et al.*, 2009). Soil pH was determined in 1: 2.5 soil and water ratio, read with pH meter. Organic carbon was determined by Walkley and Black Dichromate Oxidation Method (Gee and Or, 2002). Total nitrogen (N) was determined by the micro – Kjeldahl method (Udo *et al.,* 2009). Available phosphorous (P) was extracted by the Bray 1 extraction method and the content of P was determined colorimetrically using a Technico AAII auto analyse (Technico, Oakland, Calif) (Udoh *et al.,* 2009). Exchangeable bases (K, Na, Ca, and Mg) were extracted with O. I N ammonium acetate; K and Na were read with a flame photometer while Ca and Mg were determined through the EDTA titration method (Thomas, 1982). Exchangeable acidity was determined by leaching the soils with IN KCI and titrating aliquots with 0.01 NaOH (Mclean, 1982). Effective Cation Exchange Capacity (ECEC) was calculated as sum of exchangeable bases (Ca, Mg, K and Na) and exchangeable acidity. Base saturation was calculated by dividing the sum of exchangeable bases by ECEC and multiplying by 100.

Data Collection

Data from cassava plant within the net plot were collected. The cassava tubers harvested were weighed fresh and dried, and expressed in per hectare basis. The shoot biomass was recorded after sun-drying and expressed on per hectare basis. Number of fresh tubers were recorded, weighed and expressed per stand per plot in both seasons.

Statistical Analysis

Data collected were subjected into statistical analysis of variance (ANOVA). Significant mean values were compared using Duncan Multiple Range Test at 0.05 level of probability (Frey, 2010).

Results

Physicochemical properties of the studied soil before planting

The properties of the experimental soil before planting are shown in Table 1. The results showed that the texture of the studied soil was sand. The pH of the soil was 4.8, implying that the soil was strongly acidic. The organic carbon (OC) and organic matter (OM) contents were 0.92 and 1.59 %, respectively. These values indicated that the soil was low in OC and OM. Total nitrogen was also low (0.09 %), far below critical limit (0.2 - 0.5 %). The available phosphorus obtained was 7 mg/kg and was also below the critical limit (8 – 20 mg/kg). The exchangeable cations (Ca, Mg, K and Na) were all low. The contents of Ca, Mg, K and Na were 1.44, 1.20, 0.02 and 0.05 cmol/kg, respectively. The exchangeable acidity Al^{3+} and H^{+} were 0.48 and 5.44 cmol/kg, respectively. The ECEC was 8.15 cmol/kg, while base saturation was 33.25 % and they were also low.

Effect of organic and inorganic amendments on growth and yield performance of cassava

Number of tubers

The effect of amendments on number of cassava roots in both 2022 and 2023 cropping year are presented in Table 2. In the 2022 cropping year, the result showed significant ($p<0.05$) difference in number of cassava roots between soils treated with different amendments. From the results it was observed that the control soil had the highest number of roots (3.45), which was higher compared with all the amended soils, except those receiving NPK 15: 15: 15 400 kgha^{-1}, which had the least number of roots (2.66). However, in the 2023 cropping year, the result showed no significant ($p>0.05$) difference in number of cassava tubers among soils treated with different amendments. Nevertheless, it was observed that soil amended with NKP 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1} had the highest number of cassava tuber (3.87), which was closely followed by soil amended with BF 240 gha^{-1} (3.79), while soil amended with NPK 15: 15: 15 400kg ah^{-1} + BF 120 gha^{-1} had the least number of cassava tuber (2.96). However, the results from the two cropping years, showed that the 2023 cropping year produced cassava with highest number of tubers (3.87 and 3.79), which were traceable to application of NPK 15: 15: 15 400 kgha^{-1} + PM 2.5t ha^{-1} and BF 240 gha^{-1} compared to 3.272 produced in 2022 cropping year under the control soil.

Fresh tuber weight

Effect of soil amendments on fresh tubers weight of cassava in both 2022 and 2023 cropping year are presented in Table 2. In the 2022 cropping year, the result showed significant ($p<0.05$) difference in fresh tubers weight of cassavas between soils treated with different amendments and control. From the results, it was observed that the soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1} had the highest fresh tuber weight (2.83 kgha^{-1}), which was high compared with soils amended with BF 240 gha^{-1} (2.56 kgha^{-1}), NPK 15: 15: 15 400 kgha^{-1} + BF 120 gha^{-1} (2.61 kg), NPK 15: 15: 15 400 kgha^{-1} + BF 240 gha^{-1} (2.56 kgha^{-1}), but significantly ($p<0.05$) higher than those receiving NPK 15: 15: 15 400 kgha^{-1} (2.20

kgha^{-1}), NPK 15: 15: 15 400 kgha^{-1} + PM 5t ha^{-1} (2.41), and PM 5t ha^{-1} (2.09 kgha^{-1}) and the control soil (1.75 kgha^{-1}). However, control soil had the least dry root weight (1.75 kgha^{-1}).

Similarly, in the 2023 cropping year, the result showed significant ($p<0.05$) differences in fresh root weight of cassavas between soils treated with different amendments. Soil amended with NPK 400 kgha^{-1} + PM 2.5 t ha^{-1} was superior over other treated soils. However, this treated soil had values higher than those amended with NPK 15: 15: 15 400 kgha^{-1} + PM 5 t ha^{-1}, but significantly ($p<0.05$) higher than the control soil (2.40 kg) and those of other treatments. Furthermore, the results showed that 2023 cropping year produced heaviest cassava fresh tubers of 3.29 kgha^{-1}, which was associated with soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 t ha^{-1} compared to 2.83 kgha^{-1} produced in 2022 cropping year under soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 t ha^{-1}.

Dry tuber weight

The effects of soil amendments on dry tuber weight of cassava in both 2022 and 2023 cropping year are presented in Table 2. In the 2022 cropping year, the result showed significant ($p<0.05$) difference in dry tuber weight of cassavas between soils treated with different amendments. From the result, it was observed that the soil amended with NKP 15: 15: 15 400 kgha^{-1} + PM 2.5 t ha^{-1} had the highest dry root weight (1.63 kg), which was at par with soils amended with BF 240 gha^{-1}, NPK 15: 15: 15 400 kgha^{-1}+ BF 120 gha^{-1}, NPK 15: 15: 15 400 kgha^{-1}+ BF 240 gha^{-1}, but significantly ($p<0.05$) higher than the control soil (1.002 kg) and those receiving NPK 15: 15: 15 400 kgha^{-1} (0.638 kg), NPK 15: 15: 15 400 kgha^{-1}+ PM 5 tha^{-1} (1.21), and PM 5 tha^{-1} (0.86 kg) as treatment.

Similarly, in the 2023 cropping year, the result showed significant ($p>0.05$) difference in dry tuber weight of cassavas among soils treated with different amendments, with soil amended with NKP 15: 15: 15 400 kgha^{-1} + PM 2.5t ha^{-1} being superior to other treated soils. However, this soil was at par with those amended with BF 240 gha^{-1} and NPK 15: 15: 15 400 kgha^{-1} + BF 240 gha^{-1} but significantly ($p<0.05$) higher than the control soil (1.16 kg) and those receiving NPK 15: 15: 15 400 kgha^{-1} (0.8 kg), NPK 15: 15: 15 400 kgha^{-1} + BF 120 gha^{-1} (0.93 kg), NPK 15: 15: 15 400 kgha^{-1} + PM 5 tha^{-1} (0.87 kg) and PM 5 tha^{-}1 0.99 kg) as treatment. The results further indicated that for the two cropping years, 2023 cropping year produced cassava with the heaviest dry roots (1.82 kg) which was associated with soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1} compared to 1.63 kg produced in 2022 cropping year under soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1}.

Dry matter content

In the 2022 cropping year, the result indicated significant ($p<0.05$) difference in dry matter among soils treated with different amendments. From the results, it was observed that the soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1} gave the highest dry matter (823 gha^{-1}), which was soils amended with NPK 15: 15: 15 400 kgha^{-1} + BF 120 gha^{-1} (655 gha^{-1}) and NPK 15: 15: 15 400 kgha^{-1} + PM 5 tha^{-1} (636 gha^{-1}), but significantly ($p<0.05$) higher than the control soil (466 g) and those that received other treatments.

Similarly, in the 2023 cropping year, the result indicated significant ($p<0.05$) difference in dry matter among soils treated with different amendments. From the result, it was observed that the soil amended with BF 240 gha^{-1} gave the highest dry matter (644 gha^{-1}), which was compared with soils amended with NPK 15: 15: 15 400 kgha^{-1} + BF 120 gha^{-1} (573 gha^{-1}) and NPK 15: 15: 15 400 kgha^{-1} + PM 5 tha^{-1} (593gha^{-1}), but significantly ($p<0.05$) higher than the control soil (269 g) and those receiving other treatments. From this experiment, the soil amended with NPK400 kgha^{-1} gave the least dry matter contents (231 g). However, between the two cropping years, 2022 cropping year produced cassava with more dry matter content (823 g) which was associated with soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1}compared to 644 g produced in 2023 cropping year under soil amended with BF 240 gha^{-1}.

Yield of tuber per plot

The effects of soil amendments on cassava yield per plot in both 2022 and 2023 cropping year are presented in Table 3. In the 2022 cropping year, the result indicated significant ($p<0.05$) difference in yield between soils treated with different amendments. From the result, it was evident that the soil amended with NPK15:15:15 400 kgha^{-1} + BF 240 gha^{-1} gave the highest yield (41.3 kg/plot), which was at par with soils amended with BF 240 gha^{-1} (39.7 kg/plot) and NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1} (41.3kg/plot), but significantly ($p<0.05$) higher than the control soil (33 kg/kg) and those that received other treatments.

Similarly, in the 2023 cropping year, the result indicated significant ($p<0.05$) difference in cassava yield between soils treated with different amendments. From the result, it was observed that the highest yield was associated with soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1} (62.48 kg/plot), which was significantly ($p<0.05$) higher than the yield obtained from the control soil (34.62 kg/plot) and those that received other treatments. From this experiment, the soil amended with NPK 15: 15: 15 400 kgha^{-1} gave the least cassava yield (23.54 kg/plot). However, between the two cropping years, 2023 cropping year produced cassava with more yield (62.48 kg/plot) which was associated with soil amended with NPK 15: 15: 15 400 kgha^{-1} + PM 2.5 tha^{-1} compared to 43.6 kg /plot produced in 2022 cropping year under soil amended with NPK 15: 15: 15 400 kgha^{-1} + BF 240 gha^{-1}.

The effects of tillage practices on growth of cassava

Number of tubers

The tillage methods did not significantly ($p\leq 0.05$) influenced number of tubers in cassava (Table 4). In 2022 cropping year, soil under conventional tillage (CT) had more yield, which was not significantly ($p<0.05$) more than those observed under reduce tillage (RT). Similarly, in 2023 cropping season, soil under conventional tillage (CT) had more tuber that was not significantly ($p<0.05$) more than what was obtained under reduced tillage (RT). The number of roots in both soil under reduce tillage (RT) and conventional tillage (CT) were more in 2023 cropping season.

Fresh tuber weight

The tillage methods did not significantly ($p\leq 0.05$) influence fresh root weight of cassava in both 2022 and 2023 cropping seasons (Table 4). However, fresh tuber weight in both soil under reduced tillage (RT) and conventional tillage (CT) were more in 2023 cropping season than in 2022 cropping year.

Dry tuber weight

The tillage methods showed significant ($p\leq 0.05$) influence on dry root weight of cassava in 2023 cropping season, conversely, in 2022 cropping year, soil under conventional tillage (CT) had more dry root weight, which was not significantly ($p<0.05$) more than those observed under reduced tillage (CT).

Dry matter content of cassava

In 2022 cropping year, cassava under conventional tillage (CT) had more dry matter content which was significantly ($p<0.05$) higher than those observed under reduce tillage (RT). Conversely, in 2023 cropping season, soil under reduced tillage had more dry matter that was significantly ($p<0.05$) more than what was obtained under conventional tillage (CT). The dry matter contents in both soil under reduced tillage (RT) and conventional tillage (CT) were more in 2022 cropping season.

Yield of tuber per plot

The effect of tillage on cassava yield measured on plot basis significantly ($p\leq 0.05$) influenced yield of cassava. In 2022 cropping year, soil under conventional tillage (CT) had more yield which was significantly ($p>0.05$) more than those observed under reduced tillage (RT). Similarly, in 2023 cropping season, soil under conventional tillage (CT) had more yield that was significantly ($p>0.05$) more than what was obtained under reduced tillage. The result further showed that yield in both soil under reduced tillage (RT) and conventional tillage (CT) were more in 2023 cropping season.

The effects of organic, inorganic amendments and tillage practices on growth and performance of cassava

Number and fresh weight of cassava tubers

Interaction effect of soil amendments and tillage did not have any significant ($p>0.05$) difference on number of tubers in cassava plant in both 2022 and 2023 cropping years. Also, the interaction effect of soil amendment x tillage practices did not show any significant ($p<0.05$) difference in fresh root weight of cassava plant in both 2022 and 2023 cropping years. However, in 2022 cropping year, soil amended with NPK400 kgha^{-1}+PM 2.5t ha^{-1} x RT gave the highest number of roots, while in 2023 cropping year, soil amended with NPK 15; 15; 15 400 kgha^{-1}+PM 2.5t ha^{-1} x CT gave the highest number of roots.

Dry tuber weight of cassava

The interaction effect of soil amendment x tillage did not show any significant ($p>0.05$) difference in dry root weight of cassava plant in both 2022 and 2023 cropping years. In 2022 cropping year, soil amended with NKP400 $kgha^{-1}$+PM 2.5t ha^{-1} x RT gave the highest number of tubers, while in 2023 cropping year, soil amended with NPK 15; 15; 15 400 $kgha^{-1}$+PM 2.5t ha^{-1} x RT gave the highest number of tubers.

Dry matter content of cassava tuber

The interaction effect of soil amendment x tillage did not show any significant ($p<0.05$) difference in dry matter contents of cassava plant in both 2022 and 2023 cropping years. However, in 2023 cropping year, soil amended with NPK 15; 15; 15 400 $kgha^{-1}$+PM 5t ha^{-1} x RT gave the highest dry matter, it may be due to the fact that under reduced tillage soil aggregate where not loosen as in the case of conventional tillage, exposing the soil to degradation either by erosion or adverse weather effect even though it was not considered inthis research ,while in 2022 cropping year, soil amended with NPK 15; 15; 15 400 $kgha^{-1}$+PM 2.5t ha^{-1} x CT gave the highest dry matter.

Yield of cassava

The result in Table 6 showed that the interaction effect of soil amendment × tillage did not show any significant ($p>0.05$) difference in yield of cassava plant in both 2022 and 2023 cropping years. However, in 2022 cropping year, soil amended with NPK 15; 5; 15 400 $kgha^{-1}$ + CHC 250 gha^{-1} × CT gave the highest yield, while in 2023 cropping year, soil amended with NPK 15; 15; 15 400 $kgha^{-1}$ + PM 2.5 t ha^{-1} × CT gave the highest yield.

Discussion

The study investigated the impact of soil amendments and tillage methods on cassava growth and yield, revealing significant effects on various growth parameters including number of roots, root weight, dry matter and yield. Incorporating soil amendments led to improved cassava growth compared to control soil in line with Akata *et al.*(2024); Figueiredo *et al.* (2018). Additionally, tillage practices were found to enhance cassava growth. Imakumbili *et al.* (2021) reported that reduced tillage is responsible for promoting soil moisture retention and reducing soil compaction. Conversely, conventional tillage methods were associated with decreased cassava growth due to soil structure disruption and increased soil erosion risk, as observed in Asfaw (2016). The combined application of soil amendments with reduced tillage demonstrated positive effects on cassava growth, enhancing nutrient availability and soil structure without compromising soil health. This is in line with several report including Alam *et al.* (2014). These findings underscore the importance of implementing appropriate soil management practices to optimize cassava growth and yield to ensure sustainable agricultural production.

Specifically, the highest number of roots were observed in all amended soil except those that received NPK 15; 15; 15 400 $kgha^{-1}$ in 2022 cropping year, while soil amended with NPK 15; 15; 15 400 $kgha^{-1}$+PM 2.5t ha^{-1} had the highest number of roots in 2023 cropping year. Soil under conventional tillage had high fresher root weight and number of roots, while soil under reduced tillage had high drier root weight. Incorporating soil amendments along with tillage practices, resulted in higher root numbers and increased root weight. These findings underscore the importance of integrating appropriate soil management techniques to optimize cassava productivity and promote sustainable agricultural practices.

Tillage practices also play a crucial role in determining cassava yield. Conventional tillage, which involves turning over the soil, to improve seedbed conditions was found to have greater dry matter in 2022 cropping year than reduced tillage. However, in 2023 cropping year, higher dry matter was observed under reduced tillage. Similarly, improved yield was recorded for soil under conventional tillage. The integration of soil amendments with conventional tillage practices appears to offer the most sustainable and productive approach, enhancing soil health and maximizing yield potential. Specifically, soil amended with NPK 15; 15; 15 400 kgha^{-1}+ BF 240 gha^{-1} x CT gave the highest yield in 2022 cropping year, while in 2023 cropping year, soil amended with NPK 15; 15; 15 400 kgha^{-1}+PM 2.5t ha^{-1} x CT gave the highest yield.

Conclusion

The integration of appropriate soil amendments and tillage practices significantly enhanced soil chemical properties contributing to improved soil health and cassava yield. These results highlight the importance of adopting sustainable soil management practices to maintain and enhance soil fertility. The strategic use of soil amendments and appropriate tillage practices significantly enhance nutrient accumulationin cassava, contributing to better cassava growth and yield. The integration of soil amendments and conventional tillage practices appears to be particularly effective in optimizing the availability in cassava tuber. Soil amended with NPK 15; 15; 15 400 kgha^{-1}+PM 2.5t ha^{-1} consistently produced highest contents of cassava. For the production of cassava with the heaviest dry roots, highest number of roots, heaviest fresh roots and increased yield adequate organic and inorganic amendments combined with good tillage practices are needed.

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Table 1: Physicochemical properties of the experimental soil before and after planting

		Soil value	
Physical property:	Units	Before	After
Sand	g/kg	932.0	930.0
Silt	g/*kg*	32.0	36.0
Clay	g/kg	36.0	34.0
Texture		Sand	Sand
Chemical property:			
pH		4.77	5.40
EC	dS/m	0.15	0.18
OC	%	0.92	1.76
OM	%	1.59	3.04
TN	%	0.09	0.20
Av.P	mg/kg	7.00	12.56
Ca	cmol/kg	1.44	2.50
Mg	cmol/kg	1.20	1.31
K	cmol/kg	0.02	0.21
Na	cmol/kg	0.05	0.18
Al^{+}	cmol/kg	0.48	0.79
H+	cmol/kg	5.44	5.84
ECEC	cmol/kg	8.15	10.06
BS	%	33.25	41.75

Note: OC = organic carbon (%), OM = organic matter, TN = total nitrogen (%), AP = available phosphorus ($mgkg^{-1}$), Ca = exchangeable Ca ($cmolkg^{-1}$), Mg = exchangeable Mg ($cmolkg^{-1}$), K = exchangeable K ($cmolkg^{-1}$), Na = exchangeable Na ($cmolkg^{-1}$), H^{+} = exchangeable hydrogen ($cmolkg^{-1}$), Al^{+++} = exchangeable aluminum ($cmolkg^{-1}$), ECEC = effective cation exchange capacity ($cmolkg^{-1}$) and BS = base saturation (%)

Table 2: The effects of organic and inorganic amendments on growth and yield performance of cassava

Treatment	Fresh tuber weight		Dry root weight		Number of tuber		Dry matter	
	2022	2023	2022	2023	2022	2023	2022	2023
Control	1.75e	2.28c	0.638e	0,80d	2.668b	3.24a	360c	231e
CHC240 gha^{-1}	2.56abc	2.89b	1.368abc	1.46ab	3.407a	3.79a	463bc	644a
NPK400 $kgha^{-1}$	2.20cd	2.40c	1.002cde	1.16bcd	3.452a	3.34a	466bc	269de
NPK400 $kgha^{-1}$+CHC120 gha^{-1}	2.61ab	2.92b	1.412ab	0.93cd	3.282a	2.96a	655ab	573ab
NPK400 $kgha^{-1}$+CHC 240 gha^{-1}	2.56abc	2.82b	1.368abc	1.38abc	3.438a	3.61a	478bc	383cd
NPK400 $kgha^{-1}$+PM 2.5t ha^{-1}	2.83a	3.29a	1.630a	1.82a	3.435a	3.87a	823a	491bc
NPK400 $kgha^{-1}$+ PM 5t ha^{-1}	2.41bcd	3.03ab	1.208bcd	0.87cd	3.272a	3.37a	636ab	593ab
PM 5t ha^{-1}	2.09de	2.94b	0.867de	0.99bcd	3.037ab	3.38a	305c	423c

Note: Means within a column not sharing a letter in common differ from other means significantly following Duncan's Multiple Range Test (DMRT) at 5 %, NPK = NPK fertilizer, PM = poultry manure, CHC = microbial fertilizer, CT = conventional tillage, RT = reduced tillage.

Table 3: The effects of organic and inorganic amendments on yield of cassava

Treatment	Yield per plot			
	2022	2023	2022	2023
Control	18.4e	23.54e	16.8d	23.6c
CHC240 gha^{-1}	39.7abc	47.82b	46.1a	55.8a
NPK400 $kgha^{-1}$	33.0bed	34.62cd	32.0bc	35.2bc
NPK400 $kgha^{-1}$+CHC120 gha^{-1}	33.7bcd	38.47c	46.2a	29.5c
NPK400 $kgha^{-1}$+CHC 240 gha^{-1}	43.6a	46.86b	49.5a	49.3ab
NPK400 $kgha^{-1}$+PM 2.5t ha^{-1}	41.3ab	62.48a	50.3a	49.9ab
NPK400 $kgha^{-1}$+ PM 5t ha^{-1}	30.7cd	30.89d	39.9ab	29.5c
PM 5t ha^{-1}	28.6d	36.58c	26.4cd	33.8bc
NPK400 kgha-1+ PM 5t ha-1 x RT	28.7a	25.39a	32.8a	34.1a
PM 5t ha^{-1} x RT	18.7a	30.61a	27.0a	36.3a

Note: Means within a column not sharing a letter in common differ from other means significantly following Duncan's Multiple Range Test (DMRT) at 5 %, NPK = NPK fertilizer, PM = poultry manure, CHC = microbial fertilizer, CT = conventional tillage, RT = reduced tillage

Table 4: The effects of two tillage practices on growth and yield performance of cassava

Treatments	Fresh tuber weight kgha-1		Dry root weight kgha-1		Number of tuber		Dry matter kgha-1	
	2022	2023	2022	2023	2022	2023	2022	2023
Tillage practices								
Conventional tillage	2.47a	2.85a	1.260a	1.06b	3.263a	3.56a	639a	416b
Reduced tillage	2.29a	2.79a	1.113a	1.29a	3.235a	3.33a	407b	486a

Note: means within a column not sharing a letter in common differ from other means significantly following Duncan's Multiple Range Test (DMRT) at 5 %, NPK = NPK fertilizer, PM = poultry manure, CHC = microbial fertilizer

Table 5: The effects of two tillage practices on growth and yield performance of cassava

Treatment	22Yield per plot			
	2022	2023	2022	2023
Conventional tillage	38.2a	45.48a	40.7a	38.6a
Reduced tillage	29.1b	34.67b	36.0a	38.1a

Note: means within a column not sharing a letter in common differ from other means significantly following Duncan's Multiple Range Test (DMRT) at 5 %.

Table 6: The effects of organic and inorganic soil amendments and tillage practices on growth and yield performance of cassava

Treatments	Fresh tuber weight kgha^{-1}		Dry root weight kgha^{-1}		Number of tuber		Dry matter kgha^{-1}	
	2022	2023	2022	2023	2022	2023	2022	2023
Control x CT	2.52a	2.71a	1.320a	0.85a	3.583a	3.19a	685a	316a
BF 240 gha^{-1} x CT	2.47a	2.80a	1.277a	1.45a	3.377a	4.10a	502a	639a
NPK 15; 15; 15 400 kgha^{-1} x CT	1.93a	2.24a	0.723a	0.76a	2.440a	3.24a	445a	243a
NPK400 kgha^{-1}+CHC120 gha^{-1} x CT	2.63a	2.94a	1.427a	0.83a	3.497a	2.99a	749a	559a
NPK400 kgha^{-1}+CHC 240 gha^{-1} x CT	2.74a	2.90a	1.543a	1.16a	3.513a	4.07a	588a	370a
Npk400 kgha^{-1}+PM 2.5t ha^{-1} x CT	2.67a	3.26a	1.497a	1.69a	3.530a	4.44a	1055a	279a
NPK400 kgha^{-1}+ PM 5t ha^{-1} x CT	2.57a	3.12a	1.373a	0.79a	3.390a	3.12a	731a	458a
PM 5t ha^{-1} x CT	2.18a	2.86a	0.920a	0.94a	2.770a	3.31a	361a	465a
Control x RT	1.88a	2.09a	0.683a	1.48a	3.320a	3.28a	246a	222a
CHC240 gha^{-1} x RT	2.66a	2.99a	1.460a	1.48a	3.437a	3.47a	424a	648a
NPK400 kgha^{-1} x RT	1.59a	2.32a	0.553a	0.84a	2.897a	3.44a	275a	219a
NPK400 kgha^{-1}+CHC120 g ha^{-1} x RT	2.59a	2.89a	1.397a	1.03a	3.067a	2.94a	561a	587a
NPK400 kgha^{-1}+CHC 240 g ha^{-1} x RT	2.39a	2.75a	1.193a	1.60a	3.363a	3.14a	367a	397a
NPK400 kgha^{-1}+PM 2.5t ha^{-1} x RT	2.96a	3.32a	1.763a	1.94a	3.340a	3.30a	590a	702a
NPK400 kgha^{-1}+ PM 5t ha^{-1} x RT	2.24a	2.95a	1.043a	0.94a	3.153a	3.62a	541a	728a
PM 5t ha-1	2.01a	3.02a	0.813a	1.05a	3.303a	3.45a	248a	382a

Note: Means within a column not sharing a letter in common differ from other means significantly following Duncan's Multiple Range Test (DMRT) at 5 %, NPK = NPK fertilizer, PM = poultry manure, CHC = microbial fertilizer, CT = conventional tillage, RT = reduced tillage