



Economic Analysis and Response of Cassava (*Manihot esculenta* Crantz) to Different Tillage Practices in Coastal Plain Soil of Akwa Ibom

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Abstract

Background: Cassava (*Manihot esculenta* Crantz) is economically significant because it serves as both a staple food and a major source of income, driving food security, rural employment, and industrial growth in many tropical countries. Its production varies with different agronomic practices.

Aims: The experiment aimed to evaluate the effects of tillage practices on growth and yield of cassava.

Methods: The field experiment was conducted at Akwa Ibom State University, Teaching and Research farm. The experiment was laid out in randomized complete block design, replicated three times. Treatments were three tillage practices: ridges, mounds, and flat. Growth and yield data were collected and subjected to analysis of variance (ANOVA). Significant means were tested at 5% probability level.

Result: The results showed no significant difference ($p > 0.05$) in all growth data, except for leaf area and plant height at 6 and 8 months after planting (MAP). Leaf area recorded in the ridge treatment at 6 MAP was 231.33 and 241.29 cm² in 2024 and 2025 cropping seasons, while the corresponding mean leaf area of 223.35 and 221.15 cm² was recorded at 8MAP. In mound treatment, 233.31 and 240.56 cm² were recorded in both cropping seasons, while at 8MAP, 223.30 and 220.01 cm² were recorded. In both cropping seasons, the leaf area observed in flat treatment, at 6 MAP, were 221.15 and 201.81 cm², while the leaf area declined to 184.63 and 198.13 cm² at 8MAP. The results of tillage practices showed no significant difference ($p > 0.05$) on storage root yields. Ridge treatment had 28.90 and 28.73 ton/ha storage root yield. Mound treatment produced 28.75 and 28.64 ton/ha of storage root yield. Cassava grown on flat tillage produced 28.03 and 28.11 ton/ha of storage root yield in both cropping seasons. Cost of production and economic returns to management showed that flat tillage, which had least cost of production, resulted to higher economic returns to management.

Conclusion: The result showed that flat tillage which received less farm input and resources should be adopted by cassava farmers as higher economic return to management was recorded on flat tillage among other treatments.

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1. Introduction

Cassava (*Manihot esculenta* Crantz), has its origin from America, and is one of the world's main root crops and makes up the most important food crop of rural dwellers and urban households in

Sub-Saharan Africa (SSA) behind rice, wheat, and maize and forms part of the diet of more than a million of people in Sub-Saharan region. The top cassava-producing country on the continent is Nigeria, with an average production of 7-8 tons/ha (FAO, 2023). Despite breakthroughs in cassava disease management and new high-yield cassava varieties development in Nigeria, yields per hectare have not increased substantially. The average cassava yield in Africa is 8.9 tons per hectare (ton/ha), ranging between 5.7 and 10.5 tonnes from 1961 to 2022 (FAOSTAT, 2020).

Cassava is becoming increasingly popular as feed and raw material worldwide, making it one of the commodities that supports food security (Onyediako & Adiele, 2022). Cassava products serve as a dietary staple in Nigeria, including items such as cassava flakes (abacha), garri, flour, and starch, all derived from the tuberous storage roots of cassava (Ikeh *et al.*, 2023; Ekwere *et al.*, 2023a; Akata *et al.*, 2024). The plant's ease of cultivation, adaptability to a range of soil types, and drought tolerance have significantly contributed to the growth of cassava cultivation in various regions of Nigeria (Ikeh *et al.*, 2016; Akpaninyang *et al.*, 2015; Enyong *et al.*, 2025).

Tillage encompasses various soil operations or cultivation activities conducted using mechanical or manual equipment for planting (Magani and Shave, 2011; Ben *et al.*, 2024; Udounang *et al.*, 2022b). The research conducted by Polizeli *et al.* (2024) indicated that the plant growth and yield characteristics were both affected by the tillage systems. Tillage creates optimal seeding conditions that promote plant emergence, development, and unobstructed root growth (Licht and Al-Kaisi, 2005; Udounang *et al.*, 2021; Inyang *et al.*, 2022).

While the disadvantages of tillage are as significant as its advantages, it notably loosens and aerates the top layer of soil, facilitating crop planting (Udounang *et al.*, 2022a; Akpan *et al.*, 2025; Enyong *et al.*, 2021). Additionally, tillage serves as a mechanical method for weed destruction and aids in the even distribution of harvest residues, organic matter (humus), and nutrients throughout the soil (Bona & Richard, 2017; Akata *et al.*, 2025; Udounang *et al.*, 2023). However, some drawbacks of tillage include soil drying prior to planting, the breakdown of soil aggregates, the creation of a tillage pan, and nutrient loss from the soil (Atkinson *et al.*, 2007; Akpaninyang *et al.*, 2013; Udounang *et al.*, 2022c).

In terms of cropping systems and tillage management, main goal is to improve crop yield dan minimizing harm to the soil's health (Angon *et al.*, 2023). Soil tillage affects crop productivity by increasing soil moisture retention, water infiltration, weed control, root penetration, and nutrient supply from rapid decomposition of organic matter (Dauda & Maina, 2017). Consequently, this study was conducted to investigate the appropriateness and economic feasibility of various tillage practices on cassava yield.

2. Methods

The experiment was carried out at Akwa Ibom State University Mkpato, Akwa Ibom State Nigeria. The area is in the humid tropical region, characterized by two seasons; rainy and dry. The dry season spans from November through March, while the rainy season is experienced from April to October. There is a short dry spell in August, otherwise called "August break". The Monsoon air mass blowing over the Atlantic Ocean sweeps through this zone, resulting in heavy annual rainfall of 2000-2500mm in the wet season. The annual temperature range is 24°C- 30°C and the annual relative humidity range of 75-79% (Slus-Ak 1989). The vegetation of the area was originally tropical rainforest.

The experimental field measuring 114 m x 33 m (3762 m²) was cleared, marked out, ridged, mounded with a portion of flat land demarcated in line with the experimental design with three plots in each replicate comprising of (5) sub plot in each plot with a measurement of 10mx5m (50m²) and 1m separating both the main plot and the replicate, while 0.5m separates the sub plot respectively.

The cassava variety TME 419, sourced from the Akwa Ibom State Agricultural Development Programme (ADP) was used for this study. This particular variety is well-regarded for its high yield potential and adaptability to various agro-ecological conditions, making it an excellent choice for economic evaluation across different tillage practices.

The growth and yield data that were collected throughout the study underwent a comprehensive analysis of variance (ANOVA) to determine any significant differences among the treatments. Following the ANOVA, significant means were further assessed using the Least Significant Difference (LSD) test at a 5% probability level to identify which specific treatment differed from one another.

Plant height (cm) was measured from the base of the plant to the tip using a measuring tape on ten (10) tagged plants per sub plot. Numbers of nodes per plant were counted and recorded from the ten (10) tagged plant per sub plot. Numbers of petiole per plant was counted and recorded for Ten (10) tagged plant per sub plot. Number of root per plant was counted the total number of roots was divided by the number of plants harvested per sub plot to get the root mean value. Length of roots (cm) was taken from the sampled plants and the sum of the lengths were divided by the number of roots per plants sampled to obtain the mean root. Root yield in tonnes per hectare was determined by calculation:

$$\text{Root yield (ton/ha)} = \frac{\text{Root weight (kg/plant)} \times \text{number of roots/plant} \times \text{plant population/ha}}{1000}$$

3. Results

3.1 Response of cassava growth to soil tillage

The number of branches per plant as influenced by tillage practices and fertilizer applications is presented in Table 1. Result showed no significant difference ($P>0.05$) in the number of branches per plant recorded against the tillage treatment, in all the months under observation. The number of branches per plant, gradually increased from 2 to 8 MAP in both cropping seasons, although no significant difference was recorded.

Table 1. Number of branches per plant as influenced by tillage.

Tillage Practices	2024				2025			
	Months after Planting				Months after Planting			
	2	4	6	8	2	4	6	8
Ridge	3.50	6.83	10.40	24.91	3.11	6.39	15.25	24.86
Heap	3.48	6.81	10.31	25.01	3.39	6.46	15.75	24.75
Flat	3.43	6.70	1.29	24.61	3.41	6.51	14.68	22.81
LSD($p<0.05$)	NS	NS	NS	NS	NS	NS	NS	NS

The leaf area, as influenced by tillage practices and fertilizer application, is shown in Table 2. The result showed significant difference ($p>0.05$) in both cropping seasons at 6 and 8 MAP. In 2024. The results showed an increase in leaf area from 2 MAP to 6 MAP, followed by a decline at 8 MAP, in both cropping seasons. Leaf area recorded in the ridge treatment at 6 MAP was 231.33 and 241.29 cm^2 in 2024 and 2025 cropping seasons, while the corresponding mean leaf area of 223.35 and 221.15 cm^2 was recorded at 8MAP. In mound treatment, 233.31 and 240.56 cm^2 were recorded in both cropping seasons, while at 8MAP, 223.30 and 220.01 cm^2 were recorded. In both cropping seasons, the leaf area observed in flat treatment, at 6 MAP, were 221.15 and 201.81 cm^2 while the leaf area declined to 184.63 and 198.13 cm^2 at 8MAP.

Table 2. Leaf area of cassava as influenced by tillage practices

Tillage Practices	2024				2025			
	Months after Planting				Months after Planting			
	2	4	6	8	2	4	6	8
Ridge	87.67	185.52	231.33	223.35	85.03	184.44	241.29	221.15
Heap	87.77	187.61	233.31	223.30	86.11	183.61	240.56	220.01
Flat	86.91	187.11	221.15	184.63	86.23	183.11	201.81	198.13
LSD($p<0.05$)	NS	NS	5.62	6.78	NS	NS	5.88	7.16

Plant height as influenced by tillage practices varied significantly at 6 and 8 MAP Table 3. The treatment of ridge had plant height at 146.11 in 2024. In 2024, planting season, plant height of 141.800 m and 223.86 cm was recorded. Treatment (ridges) had plant height of 146.11 and 226.11 cm at 6 and 8 MAP in 2023 planting season, respectively. In 2024, plant height of 141.80 and 223.86 cm

were recorded. Treatment of mound had plant height of 225.72 and 220.79cm at 8 MAP. The shortest plant, 119.16 and 175.62 cm at 6 and 8 MAP, was recorded in the flat treatment.

Table 3. Plant height (cm)

Tillage Practices	2024				2025			
	Months after Planting				Months after Planting			
	2	4	6	8	2	4	6	8
Ridge	15.60	43.61	146.11	226.11	16.31	42.71	141.80	223.86
Heap	15.33	43.20	144.11	225.72	15.60	42.60	140.71	220.76
Flat	15.15	41.33	119.16	175.62	15.21	42.01	115.33	177.61
LSD(p<0.05)	NS	NS	2.62	3.16	NS	NS	2.33	2.37

Number of lobes per plant as influenced by tillage practices is shown in table 4. Number of lobes per plant showed increase in lobe from 2 to 6 and decrease at 8 MAP in ridges and in mound treatments. Result showed decline in number of lobe at 8 MAP in all the treatment. There was no significant difference (p>0.05) at 2, 4, 6 and 8 MAP. The number of lobes per plant recorded in the ridges treatment at 6 MAP was 9.00 and 9.20 in 2024 and 2025 planting season respectively, 9.00 and 8.15 lobes was recorded in mound at 6 MAP, while 7.00 and 7.33 lobes per plant was recorded in flat Treatment.

Table 4. Number of lobes per plant.

Tillage Practices	2024				2025			
	Months after Planting				Months after Planting			
	2	4	6	8	2	4	6	8
Ridge	5.00	6.31	7.10	8.10	5.00	6.20	9.20	8.12
Heap	5.00	6.33	7.00	8.10	5.00	6.30	9.11	8.15
Flat	5.00	6.30	7.00	7.00	5.00	6.10	8.16	7.33
LSD(p<0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Number of storage root per plant as influenced by tillage practices showed no significant different (P>0.05) (table 5). In 2024 and 2025 cropping season, cassava planted on ridges had 2.36 and 3.01 marketable roots, respectively. Cassava planted on flat tillage recorded marketable storage root of 2.01 and 2.69 in 2024 and 2025 cropping year, respectively.

Table 5. Yield and yield components of cassava as influenced by tillage practices

Tillage Practices	2024				2025		
	Storage Root Length (cm)	Storage Root Circumference (cm)	Storage Root Yield (ton/ha)	Storage Root Length (cm)	Storage Root Circumference (cm)	Storage Root Yield (ton/ha)	
	Ridge	29.33	18.13	28.90	27.18	17.30	28.73
Heap	28.16	18.18	28.75	28.02	17.48	28.64	
Flat	27.12	17.95	28.63	27.01	16.78	28.51	
LSD(p<0.05)	NS	NS	NS	NS	NS	NS	

The number of non-marketable storage root per plant as influenced by tillage practices showed no significant difference (P>0.05) Table 5. Cassava planted on ridges had 4.83 and 4.92, while cassava planted on Mounds had 4.75 and 4.81 non-marketable storage roots per plant in 2024 and 2025 planting season respectively.

The total number of storage root per plant as influenced by tillage practices is shown in Table 5. Cassava planted in ridges produced higher total number of storage root per plant, although the total number of storage roots per plant recorded in ridges was not statistically significant difference (P>0.05) when compared to total number of storage roots per plant recorded in mound and flat treatments. The number of rotten storage root per plant as influenced by tillage practices varied not

significantly (Table 5) no rotten storage root was recorded in all the tillage treatment, irrespective of the cropping season.

Storage Root Length as influenced by tillage practices is presented in table 4.8. Among the tillage practices, the result showed no significant difference ($P>0.05$) on storage root length in both cropping seasons. The cassava planted in ridges and storage root length of 29.33 and 27.18cm, Treatment of mound recorded storage root length of 28.16 and 28.02cm in 2024 and 2025 cropping seasons. Flat tillage had storage root length of 28.63 and 28.51cm in 2024 and 2025 cropping seasons, respectively.

Storage root circumference as influenced by tillage practices in Table 5. The result showed no significant difference ($P>0.05$) on storage root circumference recorded in all the treatment in both cropping seasons. The storage root circumference was between 17.95 and 18.18cm in 2024 cropping year, while the circumference recorded in 2025 cropping season was between 16.78 and 17.48cm.

Storage root yield as influenced by tillage practices differed not significantly in both cropping years. Storage root yield recorded in ridges treatment was 28.90 and 28.73 ton/ha. 28.75 and 28.64 ton/ha of storage root yield was recorded in Mound, while cassava grow on Flat tillage produced 28.03 and 28.11 ton/ha of storage root yield in 2024 and 2025 cropping seasons respectively.

3.2 Cost of Production and Economic Returns

Total Cost Analysis: - The total cost of production for cassava shows a slight variation among the different tillage methods across both years (2024 and 2025). The flat tillage method consistently has the lowest total cost in both years, indicating it may be the most economical choice for production. - In 2024, the total costs range from ₦1,500,000 to ₦1,570,800, while in 2025, they show a range from ₦1,543,000 to ₦1,619,300. This suggests overall increased costs in 2025, which may be attributed to inflation, increased input costs, or other economic factors.

Gross Revenue: Gross revenue is strongly influenced by the yields. In both years, gross revenue is highest for the ridge method, followed by the mound and then the flat method. For example, in 2024, the gross revenue ranges from ₦4,723,950 (flat) to ₦4,768,500 (ridges). - The increase in gross revenue from 2024 to 2025 across all methods indicates a positive market or increased demand for cassava.

Table 6. Cost of Production and Economics Returns

Cost of Production	2024			2025		
	Ridges	Mound	Flat	Ridges	Mound	Flat
Land Preparation	240,000	233,000	170,000	250,500	240,500	175,000
Soil Analysis	20,000	20,000	20,000	20,000	20,000	20,000
Planting materials	224,000	224,000	224,000	224,000	224,000	224,000
Planting	85,000	85,000	85,000	95,000	95,000	95,000
Fertilizer	236,800	236,000	236,000	239,000	239,000	239,000
Fertilizer Application	150,000	150,000	150,000	150,000	150,000	150,000
Weeding (3x)	360,000	340,000	340,000	360,000	360,000	360,000
Harvesting	175,000	175,000	175,000	180,000	180,000	180,000
Miscellaneous	100,000	100,000	100,000	100,000	100,000	100,000
Total Cost	1,570,800	1,564,300	1,500,000	1,619,300	1,608,800	1,543,000
Storage Root Yield	28.9	28.75	28.63	28.73	28.64	28.51
Gross Revenue	4,768,500	4,743,750	4,723,950	4,884,100	4,868,800	4,846,700
Net Revenue	3,197,700	3,179,450	3,223,950	3,264,800	3,260,000	3,303,700
Cost Benefit	2.04	2.03	2.15	2.02	2.03	2.14

Net Revenue: - Net revenue, calculated as gross revenue minus total cost, reflects the profitability of each method. The flat method provides the highest net revenue in both years (₦3,223,950 and ₦3,303,700), indicating it might be the most financially viable option for farmers. The least net revenue, ₦3,179,450 and ₦3,260,000 in both cropping seasons was recorded in the flat treatment.

Cost-Benefit Ratio: - The cost-benefit ratio reveals how much revenue is generated for every unit of cost. All methods show a cost-benefit ratio of around 2, indicating that for every unit of currency spent, approximately two units are made in revenue. - The flat tillage had slightly higher cost-benefit ratios in 2024 compared to 2025 (Table 6). The higher cost/benefit ratio showed that flat tillage

could be a more economically viable way of planting cassava in the study area. An economic analysis in a study conducted by [Aliyu et al \(2026\)](#) also shows higher net benefits and better returns on investment for cassava cultivation systems on flat land, even though labor costs are also higher.

The results of the study indicate that the different tillage methods ridges, mounds, and flat did not exhibit significant variations in the growth, yield, and yield parameters of cassava across both the 2024 and 2025 cropping seasons. This finding aligns with similar studies conducted in Nigeria, where variations in tillage systems have been shown to have minimal effects on the growth of cassava ([Aiyelari et al, 2002](#)).

Research by [Edet et al \(2025\)](#) supports these findings, indicating that cassava grown under different tillage practices demonstrated comparable results in terms of tuber yield and biomass production. The study also showed that soil management practices, including tillage type, did not significantly affect cassava yield, suggesting that environmental factors or soil conditions might play a more critical role in crop performance. Research conducted by [Reichert et al \(2021\)](#) shows that improving soil structure through tillage does not affect the yield of cassava tubers stored in sandy clay soil. This indicates that a no-tillage management system is the best management system, where soil loosening is only carried out when forming furrows for planting cassava stems.

The absence of significant differences in the number of stems, branches, and lobes per plant reported in this experiment could also be attributed to the adaptability of cassava to varying soil conditions. This observation agrees with [Ikeh et al \(2016\)](#) that some cassava genotypes adapt to wide range of environmental conditions. As emphasized by [Aiyelari et al \(2002\)](#), cassava is a resilient crop that can thrive in diverse environmental conditions, which may diminish the impact of different tillage methods on growth parameters. Additionally, the results indicate that irrespective of fertilizer application, there were no significant differences in growth parameters. In terms of economic value, cassava businesses need to be more involved in adding value to cassava, as this has the potential to increase income ([Okebiorun, 2024](#)).

In conclusion, while this study found no significant differences in growth and yield parameters due to different tillage practices or it reinforces the notion that the choice of tillage method in the study may be less critical than previously thought. The researchers argue that conservation tillage can enhance soil structure and moisture retention, potentially leading to better yields. However, other studies ([Aiyelari et al, 2002](#); [Edet et al, 2025](#)) highlight that the benefits of tillage and fertilization may be overshadowed by other factors such as soil type, climate conditions, and crop variety. Ultimately, these results may imply that while tillage and fertilization are critical components of effective agricultural practices, their interactions might not be as influential as expected in optimizing storage root yields.

4. Conclusions

A study on the effects of various tillage practices on cassava (*Manihot esculenta* Crantz) in the Coastal Plain Soil of Akwa Ibom revealed key insights into their influence on growth and yield. While no significant differences were found in overall growth parameters, except for leaf area and plant height ridge and mound tillage methods produced greater leaf area compared to flat tillage, suggesting better conditions for early growth. Despite variations in growth metrics, storage root yields were comparable across all treatments, indicating that factors beyond tillage may affect productivity. The economic analysis showed that flat tillage had lower production costs and higher returns, suggesting it could be more advantageous despite the benefits of ridge and mound tillage. This research underscores the importance of considering both agronomic and economic factors when selecting tillage practices for cassava.

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