Effects of Tillage Practices on Growth and Yield of Cassava (*Manihot esculenta* Crantz) and some Soil Properties in Ibadan, Southwestern Nigeria

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Keywords: Tillage- Cassava- Soil Properties- Economic Returns- Nigeria

Summary

Maintenance of soil fertility status and optimum crop yield has been a great task in Nigeria. Against this background, studies were conducted in 1994 and 1995 growing seasons at the Teaching and Research Farm, University of Ibadan, Nigeria to evaluate the productivity of cassava and soil properties and dynamics under some tillage practices. Randomized block design with four replications was used and the tillage treatments were Heaping [HP], No-Till + Herbicide [NTH], Ridging [RG] and No-Till-Slash and Burn [NSB].

Results revealed that tillage practices had no significant effect on sprouting percentage in 1994 but in 1995, HP treatment was significantly ($P < 0.05$) higher than others. Tillage had no marked effect on cassava height in both years while number of leaves only differed significantly ($P < 0.05$) 8 months after planting with HP treatment being higher than others. Stem girth showed no marked differences among treatments in both years. Similarly, in both years, cassava fresh root yield and yield components were not significantly affected by tillage practices. NSB showed significantly higher soil bulk density at planting in both years than other treatments. Generally, soil chemical properties were not markedly affected by the tillage practices. The highest cost of production was observed under NSB while RG produced the highest returns. The study suggests that successful growing of cassava under reduced tillage practices is practicable in an Alfisol in this agro-ecological zone.

Résumé

Effets des pratiques de labour sur la croissance et le rendement du manioc (*Manihot esculenta* Crantz) et certaines propriétés des sols à Ibadan au sud-ouest du Nigeria

Le maintien du statut de la fertilité du sol et la production optimale des cultures est une grande priorité au Nigeria. Une recherche a été menée pendant les saisons culturales de 1994 et de 1995 à la station de recherche «Teaching and Research Farm», Université d'Ibadan, Nigeria pour évaluer la productivité du manioc et les propriétés dynamiques du sol sous certaines pratiques culturales. Des blocs aléatoires avec quatre répétitions ont été utilisés. Les traitements étaient: Amoncellement (A), Pas de labour + herbicide (PLH), Billon (B) et Pas de labour, taille et brûlis (PTB).

Les résultats obtenus révèlent que les pratiques de labours n'avaient pas d'effets significatifs sur le pourcentage de bourgeons en 1994 alors qu'en 1995, le traitement A était significativement ($P < 0,05$) plus élevé par rapport aux autres traitements. Le labour n'avait aucun effet significatif sur la hauteur du manioc pendant les deux années tandis que le nombre de feuilles était seulement influencé de manière significative ($P < 0,05$) à partir de 8 mois après plantation; le traitement A étant plus élevé par rapport aux autres traitements. La circonférence de la tige ne montrait aucune différence significative parmi les traitements pendant les deux années. La production de tubercules et les constituants de ces derniers n'étaient pas également affectés de manière significative par les pratiques de labour. PTB a montré de manière significative une plus grande densité volumétrique pendant la plantation durant les deux années comparativement aux autres traitements. Généralement, les propriétés chimiques du sol n'étaient pas affectées d'une manière significative par les pratiques de labour. Le plus grand coût de production était observé sous PTB alors que B montrait le plus grand bénéfice. L'étude suggère qu'il est possible de planter le manioc avec succès en pratiquant des labours réduits sur un alfisol dans cette zone agro-écologique.

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Received on 28. 07. 00. and accepted for publication on 29. 01. 02.

Introduction

Growth, development and consequently, yield of crops are more highly influenced by the available soil water than any other single factor (3). In most cases, the available soil water is highly associated with the precipitation of the season. Crop stresses most often become severe when the available soil water is reduced considerably during seasons with short or prolonged dry spells. As a result, crop production varies significantly from season to season and yields are unstable. Consequently, appropriate tillage practice has been one of the agronomic measures adopted to ensure optimum soil moisture content and, invariably optimum crop yield in some location and soil type.

The concept of tillage is to create a soil environment favourable to plant growth (27). Lal (30) defined tillage as the physical, chemical or biological soil manipulation to optimise conditions for seed germination, emergence and seedling establishment. However, soil manipulation induces profound changes in fertility status, and the changes may be manifested in good or poor performance of crops. The zero or minimum tillage systems have been tried and showed some promising results compared to conventional tillage systems (2, 25, 29, 39). Some workers (10, 16, 32, 41, 45) have on the other hand noted superiority of crops grown on tilled plots over that of zero-tilled plots in some agro-ecological zones; while others (36, 37, 38, 43) observed no significant differences among tillage treatments.

Since tillage operations loosen, granulate, crush or even compact soil particles, soil factors that influence plant growth such as bulk density, pore size distribution and hence the composition of the soil atmosphere may be affected (38). High bulk density decreases root length and increases average root diameter (18, 34). A low oxygen diffusion rate due to compaction is frequently associated with poor crop growth (42). Nutritionally, intense tillage leads to high oxidation of organic matter (15), with resultant soil structural deterioration and reduction of the potential nutrient supply (21). However, the trends and magnitude of their effects are known to vary among soils and ecological regions. The effects of some land preparation methods are transient, while others are long lasting (26). Lindstrom and Onstad (33) reported that ploughing reduced soil bulk density while zero tillage has been shown to increase soil moisture retention and infiltration and to lower soil temperature (5, 25, 31). Higher concentrations of organic carbon, total N, extractable P, exchangeable Ca, Mg and K have been shown in surface soil of zero till than tilled plots (7, 13, 20).

Cassava *(Manihot esculenta,* Crantz) is one of the most important calorie producing crops in tropical Africa where it is grown mainly for its tuberous roots and more than 8 percent of the minimum calorie requirements of some 750 million people in the tropics are met by cassava (19). Until the advent of tractorization, cassava was traditionally planted on the flat, ridges or mounds depending on location and soil type. In the past decade however, interest in reduced tillage-practices has increased in an attempt to limit soil erosion and promote water conservation (22). Against these backgrounds, studies were initiated to assess the applicability of some tillage practices to cassava production on an Alfisol (17) and their influence on some soil properties.

Material and methods

The experiments were conducted during the 1994 and 1995 planting seasons at the University of Ibadan Teaching and Research Farm located at Ajibode near the International Institute of Tropical Agriculture (IITA), Ibadan (Latitude 07°45N, Longitude 03°45E with an altitude of 220 m a. s. l). The zone has a bi-modal pattern of rainfall, with the first rainy season from April to July, a dry spell in August followed by the second rainy season in September to November. Tables 1 and 2 show detailed pedo-climatic information of the study area during the period of experimentation. The soil is well-drained sandy soil of Egbeda Series (44) and of the broad group of tropical Alfisol (17).

Table 1
Summary of weather data for 1994 in Ibadan

Month	Total rainfall (mm)	Total Pan-Evaporation (mm)	Mean wind speed (km/hr)	Solar radiation (mg/m2/day	Temperature (°C)			Relative Humidity (%)			No. of rainy days
					Minim.	Maxim.	Mean	Minim.	Maxim.	Mean	
January	1.4	120.7	3.3	14.07	20.1	32.8	26.4	46	88	67	1
February	9.2	134.4	3.5	14.98	21.6	34.7	28.1	39	94	66	1
March	51.0	155.9	4.7	16.05	22.9	35.1	29.0	47	96	72	4
April	57.4	135.3	4.6	15.51	22.6	33.5	28.0	54	92	72	6
May	101.3	133.8	3.8	17.28	21.7	31.8	26.8	57	88	73	11
June	75.6	120.7	4.4	17.04	21.4	30.5	26.0	56	85	70	8
July	159.8	71.4	3.9	10.70	21.3	27.8	24.6	69	88	79	14
August	72.5	76.7	3.9	12.24	21.4	28.2	24.8	66	87	77	13
September	250.2	97.0	3.8	14.04	21.9	29.6	25.7	64	89	76	20
October	269.7	100.4	2.5	15.95	21.3	30.0	25.7	65	96	80	18
November	15.8	123.8	1.7	16.90	20.4	31.9	26.1	50	95	73	3
December	0.0	146.7	2.6	16.11	17.4	32.8	25.1	36	79	58	0
MEAN	1063.9^T	1416.7^T	3.6	15.07	21.2	31.6	26.4	54	90	72	99^T

Note: Rainy day is when rainfall > 0.2 mm; T = Total for the parameter

Table 2
Summary of weather data for 1995 in Ibadan

Month	Total (mm)	Total Pan-Evaporation (mm)	Mean wind speed (km/hr)	Solar radiation (mg/m2/day	Temperature (°C)			Relative Humidity (%)			No. of rainy days
					Minim.	Maxim.	Mean	Minim.	Maxim.	Mean	
January	0.0	144.9	2.4	14.86	18.3	33.6	25.9	31	79	55	0
February	1.0	157.8	3.6	16.66	21.5	35.7	28.6	30	94	62	1
March	143.0	153.0	4.3	16.57	22.1	33.5	27.8	54	96	75	8
April	173.7	133.1	4.1	17.13	22.7	32.7	27.7	60	97	78	9
May	208.6	123.3	3.5	16.59	21.6	31.8	26.7	63	97	80	12
June	146.6	102.2	3.5	14.41	21.3	31.1	26.2	67	97	82	10
July	211.3	72.1	4.0	12.03	21.7	28.5	28.1	73	97	85	15
August	157.9	76.6	3.9	12.16	22.0	29.0	25.5	74	96	85	18
September	3.4	8.0	0.3	0.54	2.2	2.8	2.5	7	8	7	2
October	140.2	96.4	3.0	14.91	21.5	30.1	25.8	67	95	81	13
November	36.3	110.9	2.1	15.81	20.1	31.5	25.8	51	96	73	3
December	7.4	111.5	2.6	12.90	21.0	33.1	27.0	45	95	76	1
MEAN	1435.9^T	1373.6^T	3.4	15.00	21.3	31.7	26.5	57	95	76	101

T= Total for the parameter.
Source of Tables 1 & 2: International Institute of Tropical Agriculture (IITA), Agroclimatology Unit, Ibadan, Nigeria (1995)

Experimental design and treatment

In each year, there were four treatments, randomized in each of the four blocks. Block size was 46 x 10 m with inter block spacing of 2 m while a plot size was 10 x 10 m with interplot spacing of 2 m. The tillage treatments consisted of:

a) No tillage, plots slashed manually, followed by *in-situ* burning of the debris after drying (NSB);
b) No tillage, vegetation sprayed with an herbicide (glyphosphate) at the rate of 1.0 kg. ha^{-1} (NTH);
c) Heaping, top soil was gathered into a heap using a native hoe after burning the dried vegetation debris earlier slashed with a cutlass; and
d) Ridging, with ridges made with a tractor-drawn disc ridger after ploughing (RG).

The same tillage method was maintained on each plot for the entire period of investigation.

Cultural details

In both years, planting was done in July. The cassava cultivar TMS 30572 (high yielding, low cyanide content and resistant to bacterial blight and mosaic disease) obtained from Agronomy Department, University of Ibadan, Nigeria was planted manually at a spacing of 1 x 1 m thereby giving 10,000 stands per hectare. One stem cutting of about 25 cm length was planted per stand at an angle of about 45° with almost 3/4 of its length buried in the soil. Weeding was done manually from the fourth week after planting (WAP).

Measurements

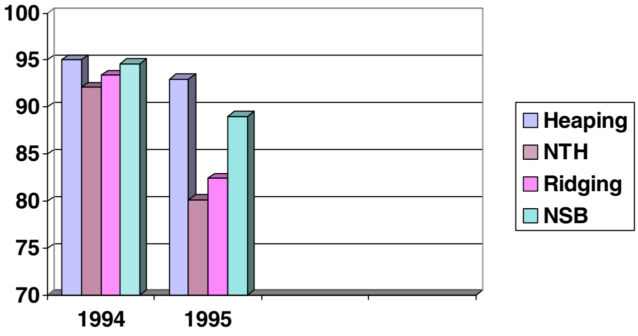
The parameters measured were sprouting percentage, plant height, number of leaves, stem girth, cassava fresh root yield and yield components, cost of production and economic returns to management. Sprouting count was taken at 3 WAP by counting the total number of sprouted stands against total number of cuttings planted and expressed in percentage. Twenty plants per plot were tagged for plant height, stem girth and number of leaves determination. Yield and yield components were determined by harvesting cassava from areas of 4 m^2 each, at the top, middle and bottom of each plot and the averages pooled. Soil moisture content and bulk density were determined using core method (6). Ten cores were randomly taken from each plot.

Soil samples (0 – 15 cm) were collected before and after the investigations to determine changes in soil nutrient status. The soil samples were processed and analyzed for the following parameters: soil pH by the glass electrode pH meter in 1:1 soil to water ratio; particle size by the hydrometer method (8); organic carbon by the Walkley – Black method (4); total N by Micro-Kjedahl method (9); while the available P was measured by the Bray's P1 method. Exchangeable cations were determined by extracting with neutral normal NH_4OAC. The flame photometer was used to read K, Na and Ca while Mg was read on the atomic absorption spectrophotometer. Exchangeable acidity was determined by titration method, while CEC was determined as the sum of exchangeable bases and exchangeable acidity. Base saturation was obtained as the percent ratio of the total exchangeable bases to the effective cation exchange capacity. The data generated from the field was subjected to Analysis of Variance and LSD used to test for significance. Partial budgeting was used to assess the cost of production and economic returns to management under different tillage practices (11).

Results and discussion

Sprouting percentage and plant height

In 1994, there was no significant treatment effect on cassava sprouting (Figure 1).

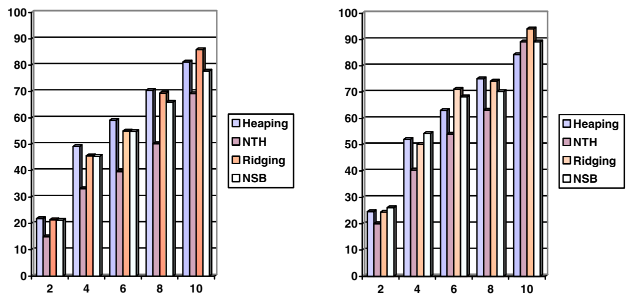


NTH = No-Till + Herbicide; NSB = No-Till + Slash and burn

Figure 1: Effect of tillage practices on cassava sprouting (%)

However, significant (P< 0.05) differences were observed in 1995 with heaping treatment (92.98%) showing superiority over no-till + herbicide (80.16%), ridging (82.44%) and no-till + manual slashing (89.05%) treatments.

Plant height showed no significant differences at all growth stages in both years (Figure 2).



1994
Months after planting

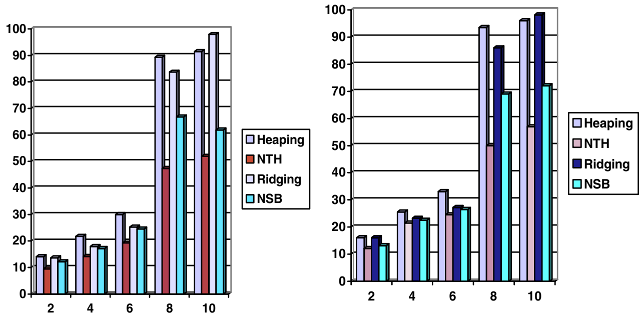
1995
Months after planting

Figure 2: Effect of tillage practices on cassava height (cm)

However, average for the two years showed that plants from ridging treatment were taller than other treatments. The absence of significant differences in sprouting in 1994 could be attributed to adequate and well distributed rainfall at the planting time which ensured adequate soil moisture (Table 4) and reduced the influence of soil bulk density. Similarly, the significant differences observed in sprouting in 1995 is due to differences in soil bulk density at planting (Table 4), coupled with uneven rainfall distribution which probably accentuated the influence of the bulk density. Huxley (24) had observed that with adequate rainfall, crop establishment was very similar on no till and tilled plots while Iwuafor and Kang (26) noted lower emergence or sprouting under no tillage due to shallow planting depth consequent upon high soil bulk density.

Number of leaves and stem girth

In both years, there was no significant difference in number of leaves of cassava up to 6 months after planting (MAP). However, from 8 MAP, significant differences (P< 0.05) were observed with the heaping and ridging treatment being significantly higher and no-till + herbicide treatment consistently lower in both years (Figure 3).



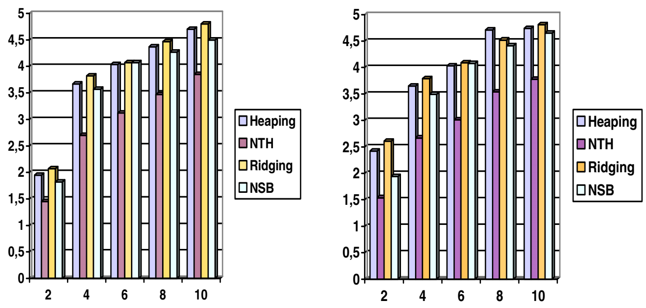
1994
Months after planting

1995
Months after planting

NTH = No-Till + Herbicide; NSB = No-Till + Slash and Burn

Figure 3: Effect of tillage practices on number of leaves of cassava

Cassava also indicated no significant differences in stem girth (Figure 4) in both years.



1994
Months after planting

1995
Months after planting

NTH = No-Till + Herbicide; NSB = No-Till + Slash and Burn

Figure 4: Effect of tillage practices on cassava stem girth (cm)

However, average for the two years revealed that ridging had higher stem girth while no-till + herbicide gave the least. The non-significant differences observed in number of leaves and stem girth of cassava could be linked with the influence of optimum soil moisture in all the treatments (Table 4) during most parts of the growing period which probably provided optimum temperature needed for the cassava establishment and growth. These findings conform with those of other workers (3, 12, 31) who stated that difference in plant growth under different tillage treatments were usually due to a combination of high soil temperature and low soil moisture regimes, as in dry spells or drought periods.

Cassava yield and yield components

In both years, fresh root yield and yield components (root number per plant, root length and diameter) were not significantly influenced (Table 3) by tillage practices. It is apparent that the use of heap or ridge gave no significant advantage over no-till practice.

Table 3
Effects of tillage practices on cassava storage root yield and yield components

Treatment	1994 No. of roots per plant	1994 Root length (cm)	1994 Root diameter (cm)	1994 Yield (t. ha^{-1})	1995 No. of roots per plant	1995 Root length (cm)	1995 Root diameter (cm)	1995 Yield (t. ha^{-1})
Heaping	6.1	39.6	16.9	21.6	7.3	41.7	18.1	23.1
No-Till + Herbicide	4.5	36.3	15.5	17.7	5.6	40.1	16.9	18.3
Ridging	7.0	41.5	17.3	24.0	7.7	42.5	21.2	25.9
No-Till + Slash and Burn	4.7	37.8	15.8	18.5	5.1	39.7	19.9	20.1
Standard Error (±)	0.8	3.4	2.1	4.3	0.4	5.6	4.2	5.4
CV (%)	6.7	15.1	12.3	13.4	10.5	4.4	11.2	17.2
	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

However, on the average, heaping and ridging indicated some promising fresh root yield results with 18.1 and 14.4; 26.3 and 22.9 percent in 1994, and 20.8 and 13.0; 29.3 and 22.4 percent in 1995 over no-till + herbicide and no-till + slash and burn treatments, respectively. The absence of significant differences in root yield and yield components could be ascribed to the similarity in the crop establishment and growth performance among the treatments (Figures 3 and 4); rainfall, moisture content and bulk density (Tables 1, 2 and 4) during most parts of the growing periods. These findings confirm the results of other researchers (23, 24, 35, 38) who reported no significant differences between no-till and tilled treatments due to adequate moisture supply during the study period.

Soil moisture content and bulk density

Significant differences ($P < 0.05$) in soil moisture content and bulk density (Table 4) were observed only at planting in both years.

However, on the average, no-till + herbicide and no-till + slash and burn consistently exhibited a higher bulk density than the other treatments. Soil moisture content did not differ significantly throughout the study periods. The reason for this could be the availability of sufficient soil water throughout the growing periods (Tables 1, 2 and 4) which apparently prevented one treatment from taking an advantage over the other treatments. Alem (3) had also reported similar findings.

Soil pH, exchangeable acidity, organic carbon and total nitrogen

Tillage treatments showed no significant effect on soil pH, exchangeable acidity, organic carbon and total nitrogen values (Table 5).

Table 4
Effects of tillage practices on soil moisture content (%) and bulk density (g.cm^{-3})

Treatment	1994 At planting Moisture content	1994 At planting Bulk density	1994 6 MAP* Moisture content	1994 6 MAP* Bulk density	1994 9 MAP Moisture content	1994 9 MAP Bulk density	1995 At planting Moisture content	1995 At planting Bulk density	1995 6 MAP* Moisture content	1995 6 MAP* Bulk density	1995 9 MAP Moisture content	1995 9 MAP Bulk density
Heaping	12.47	1.35	10.55	1.39	13.15	1.38	18.30	1.33	15.01	1.36	18.8	1.35
No-Till + Herbicide	14.07	1.45	11.00	1.41	14.95	1.40	24.41	1.42	18.40	1.40	21.3	1.41
Ridging	12.05	1.34	10.15	1.38	13.13	1.37	19.80	1.32	16.31	1.36	18.7	1.38
No-Till + Slash and Burn	14.30	1.49	11.37	1.45	15.51	1.42	23.83	1.46	19.50	1.44	22.7	1.44
Standard Error [±]	3.42	0.12	3.80	0.32	3.04	0.31	4.40	0.14	3.27	0.39	2.39	0.39
CV [%]	12.42	13.40	8.32	17.21	12.41	9.49	14.56	15.03	14.31	12.41	14.11	13.42
LSD	NS	0.01	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

MAP*= Months after planting; NS= Not significant
Number of samples= 10 per plot

Table 5
Effects of tillage practices on soil chemical properties

Tillage Practice	Soil pH (H_2O)	Exch. Acidity	Org. C (g.kg-1)	Total N (g. kg-1)	Av. P mg .kg-1	Ca	Mg	Na	K	CEC	Base Sat.	Sand	Silt	Clay
		(Cmol.kg.1)						(Cmol. kg-1)				(%)		
Heaping														
(Initial)*	6.80	0.16	7.20	0.76	1.75	0.90	0.20	0.97	0.26	2.54	93.60	90.25	7.20	2.55
(Final)**	6.70	0.10	7.40	0.80	1.60	1.10	0.11	0.91	0.24	2.49	91.71	91.31	7.40	1.29
% Change	-1.50	-37.50	2.78	14.29	-8.57	11.11	-45.00	-6.19	-7.69	-1.97	-2.02	1.17	2.78	-49.40
NTH***														
(Initial)	6.70	0.16	7.40	0.60	1.74	0.87	0.13	0.94	0.18	2.20	92.95	90.10	7.40	2.50
(Final)	6.80	0.09	7.90	0.70	1.45	0.95	0.20	0.89	0.20	2.11	94.37	93.11	5.40	1.49
% Change	1.50	-43.73	6.76	16.67	-16.67	9.20	53.85	-5.32	11.11	-4.09	1.53	3.23	-27.03	-40.40
Ridging														
(Initial)	6.60	0.20	7.70	0.80	1.77	0.91	0.20	0.95	0.31	2.51	90.94	89.80	6.40	3.48
(Final)	6.70	0.11	7.50	0.70	1.49	0.86	0.16	0.78	0.20	2.14	92.16	91.80	5.40	2.80
% Change	1.50	-45.00	-2.60	-12.50	-15.82	-5.49	-20.00	-17.89	-35.48	-14.74	1.34	2.23	-15.63	-26.32
NSB***														
(Initial)	6.80	0.15	7.00	0.60	1.58	0.90	0.23	0.96	0.21	2.17	96.75	89.80	7.40	2.80
(Final)	6.80	0.09	7.90	0.70	1.36	0.92	0.21	0.78	0.16	2.00	92.73	89.80	7.42	2.78
% Change	0.00	-66.67	11.39	14.29	-13.92	2.22	-8.70	-18.75	-23.81	-7.83	-4.16	0.00	0.27	-0.71

* Initial – Sampling done immediately after land preparation during the 1994 Season.
** Final – Sampling done at harvest during the 1995 Season.
NTH*** = No-Till + Herbicide; NSB*** = No-Till + Slash and Burn.
Number of samples = 10 per plot.

However, soil pH value was more stable under no-till + slash and burn than other treatments, which showed either increase or decrease of 1.5%. This could be attributed to the alkaline effect of the ash deposited following burning (37). Organic carbon declined under ridging treatment (2.6%), while no-till + slash and burn showed the highest increase (11.39%). These observations could be ascribed in part to the effect of burning, and perhaps differential rates of leaching and mineralization among the treatments. Dick (13) had earlier made similar observations. Total nitrogen increased almost uniformly under all the treatments except ridging where it declined by 12.5%. This could be linked to leaching particularly as ridging had higher tillage intensity than others. Blevins *et al*. (7) reported higher concentrations of total nitrogen at surface soil of no-till than tilled plots.

Available P, Ca, Mg, Na, K and cation exchange capacity

Tillage treatment indicated no significant effect on available P, exchangeable Ca, Mg, Na, K and Cation Exchange Capacity (Table 5). However, on the average, available P showed general decrease, ranging from 8.57 to 13.92%, under all the treatments, perhaps due to leaching effect, uptake by the crop and a possible fixation in soil microbial cells (1, 14). Calcium increased in all the treatments, ranging from 2.22 to 11.11%, except ridging with a decrease of 5.49%. This is perhaps due to higher tillage intensity under ridging than other treatments (7). Mg, Na, K and cation exchange capacity exhibited almost a uniform trend with general decrease in all the treatments. The decline could be ascribed to the presence of ash under no-till + slash and burn plot, leaching and perhaps differential rates of solubilization and mineralization among the treatments.

Base saturation and soil texture

There were no significant changes in base saturation, sand, silt and clay contents among tillage treatments (Table 5). No-till + slash and burn showed higher decline in base saturation (4.16%) than others probably due to the effect of the ash deposited after burning. However, no-till + slash and burn showed more stable values for the soil texture than other treatments.

Cost of production and economic returns to management

In both years, the highest cost of production (Table 6) was observed under no-till + slash and burn plots (NSB) and the least under no-till + herbicide plots. No-till + slash and burn exceeded heaping, no-till + herbicide and ridging by 5.2, 16.7 and 10.4 percent, respectively in 1994, and by 5.2, 10.4 and 4.2 percent, respectively in 1995. Ridging gave the highest mean benefit-cost ratio of 2.8 (Table 6).

Table 6
Cost of Production and Economic Return to Management [N ha^{-1}] in Four Tillage Practices for Cassava Production

Farm operation	1994 Tillage practice				1995 Tillage practice			
	Heaping	NTH	Ridging	NSB	Heaping	NTH	Ridging	NSB
[A] Production Cost (N.ha^{-1})								
(1) Land preparation	3,500	1,400**	3,000	3,000	3,500	2,000**	3,600	3,000
(2) Weeding	3,000	4,000	3,000	4,000	3,000	4,000	3,000	4,000
(3) Other costs[a]	2,600	2,600	2,600	2,600	2,600	2,600	2,600	2,600
Total Cost of production (TC)	9,100	8,000	8,600	9,600	9,100	8,600	9,200	9,600
[B] Yield (t.ha^{-1})	21.6	17.7	24.0	18.5	23.1	18.3	25.9	20.1
[C] Gross revenue (GR)[b]	21,600	17,700	24,000	18,500	23,100	18,300	25,900	20,100
[D] Return to management	12,500	9,700	15,400	8,900	14,000	9,700	16,700	10,500
Benefit – Cost ratio	2.4	2.2	2.8	1.9	2.5	2.1	2.8	2.1

* US $1 = N80; a – other costs are planting materials and harvesting which were N600 and N2,000;
b – Yield x Unit Price of N1,000 per ton; NTH = No-Till + Herbicide; NSB = No-Till + Slash and Burn
** Cost of herbicide including application.

The highest cost of production under no-till + slash and burn was probably due to higher costs of labour used for land preparation and weeding operations which accounted for 34.7 and 39.6 percent of the total cost of production, respectively. Weed infestation was higher (data not shown) on no-till + slash and burn plots than in other treatments. The relatively lower cost of production and higher cassava root yield was accountable for the higher economic return under ridging. Other workers (24, 37, 40) had earlier observed cost of weeding to be responsible for a higher cost of production on zero-cultivated plots than cultivated ones. The instability of the local currency, which caused the labour costs to go up within a short period, was also partly responsible for the relative higher cost of production in the second year.

Conclusions

The results of this study suggest that different tillage practices on Alfisols have no additional benefits in cassava growth and yield performances. The optimum soil moisture available throughout most parts of the investigations eliminated some stress that could have caused disparity in the crop performance. With the absence of marked effects on cassava yield, it implies that a successful growing of cassava under reduced tillage practices is practicable in this agro-ecological zone. The least decline in soil fertility status under the reduced tillage practice makes it a preferred option, particularly where the cost of labour is low and the needs for water and soil conservation are imperative.

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