Libyan Agriculture Research Center Journal International 1 (3): 161-170, 2010
ISSN 2219-4304

Bush Clearing, Tillage Methods and the Performance of Maize/Cassava Intercrop on an Ultisol in Southwestern Nigeria

Nyaudoh U. Ndaeyo and EmilOlorun A. Aiyelari

Department of Agronomy, University of Uyo, Uyo, Nigeria
Department of Agronomy, University of Ibadan, Ibadan, Nigeria

Abstract: A three season (1995/96 - 1997/98) study was conducted on an Ultisol at Epemakinde, a primary forest area of southwestern Nigeria, to assess the effects of bush clearing and tillage methods on the growth and yields of maize/cassava intercrop. A randomized complete block design with spilt-plot arrangement and three replicates was used with the bush clearing (Bulldozed and windrowed (BW), Bulldozed not windrowed (BNW) and Clear-fell, slashed and burned (CSB)] and tillage methods (Conventional (CT), Minimum (MT), Traditional (TT) and Zero (ZT) as the main and sub-treatments, respectively. Results indicated that maize and cassava heights and number of leaves were generally better in CSB than in BW and BNW plots. Cassava storage root yield was better in the BNW plots, whereas maize grain yield in the CSB plots was 5-6%, 8-11% and 15-20% better than in BW and BNW plots after the first, second and third cropping cycles, respectively. Among the tillage methods, no definite pattern was shown for crop heights and number of leaves but TT and MT treatments were significantly ($P<0.05$) better than CT and ZT except for number of maize leaves. The best yield was obtained in MT plots for maize and in TT plots for cassava. The interaction effects of bush clearing and tillage methods were significant on the crop yields with the CSB + ZT or TT combination supporting crop yields better. However since the CSB is slow, inefficient and labourious, it would hardly meet the food demands of the ever-increasing population. Therefore, the adoption of BNW + MT combination would be more appropriate in primary forests of the humid tropics.

Key words: Bush clearing, Tillage methods, Crop yields, Nigeria.

INTRODUCTION

The food deficit gap is regrettably widening in all the sub-Saharan African countries. The rapid population growth with its increased food demands has resulted in a great stress on the land resource base [1]. Long periods of fallows that once characterized the viability of the slash and burn land use system now belong to the past in most countries as the demographic pressure (both human beings and livestock) no longer permits such periods of fallowing. In desperation, more forest and even marginal lands are being cleared and cultivated and yet there is no appropriate soil management technologies that would enhance and maintain agricultural production without causing serious environmental degradation.

In Nigeria, emphasis has shifted from slash and burn agriculture to the use of sophisticated bush clearing and tillage equipment for the cultivation of large areas of land [2]. This perhaps explains why the Federal Government of Nigeria set up the National Agricultural Land Development Authority (NALDA) in 1991. However, attempts at mechanizing agriculture in Nigeria are yet to give the much desired changes in food production as in the temperate countries. Eneji *et al.* [3] reported severe crop yield reduction of up to 52% when mechanical bush clearing method was used compared to slash and burn. Similar findings have also been reported by Okore *et al.* [4], Eneji *et al.* [5] and Lal [6].

Tillage or soil manipulation may induce profound changes in the soil fertility and this may be manifested in good or poor performance of crops [7-9]. The no-tillage systems have been evaluated and reported to have shown some promising yield results compared to conventional system [10]. Some researchers, Ogban *et al.* [7], Ndaeyo *et al.* [9], Agele *et al.* [11], Ezumah [12] and Olaniyan [13] reported superiority of crops grown on tilled plots over that of zero-tilled plots in some agro-ecological zones. Others, Ndaeyo and Aiyelari [14] and Ohiri and

Corresponding Author: Nyaudoh U. Ndaeyo, Department of Agronomy, University of Uyo, Uyo, Nigeria.

Ezumah [15] reported no significant difference among tillage treatments. Despite this, it has been opined that the expansion of new lands cannot increase output by over 1% without accelerating environmental degradation. This implies that the productivity of land currently under cultivation needs to be increased by at least 3% per annum [16]. Consequently, any programme aimed at increasing food supply by reversing the declining trend in agricultural productivity and preserving the environment for present and future generations in Nigeria should first begin with the development of relevant and appropriate soil management strategies. Against this background, a study was conducted at Epemakinde, a primary forest area of southwestern Nigeria to evaluate the growth and yield performances of maize/cassava intercrop.

MATERIALS AND METHODS

The Study Site: The study was conducted on 2-hectares of the IBSRAM'S experimental field at the Ondo State afforestation project in Epemakinde (4^0 5'E and 6° 45'N), southwestern Nigeria. It is a highly forested area underlain by a sedimentary deposit of coastal plain sands. The soils, as characterized by Agboola and Ogunkunle [17], are mainly *Ultisols* and with some patches of *Alfisols* (with *Typic Kandiudalf* and *Typic Kandiudalt* as the Modal profiles). Some of the physico-chemical characteristics of the soils revealed that they are slightly to fairly acidic (pH 4.9 to 6.7); medium textured (sandy loam to sandy clayey loam top and sandy clayey loam to sandy clayey below) and moderately well structured (granular/crumb top and sub-angular blocky below). The rainfall pattern is bimodal with long (April to August) and short (September to November) rainy seasons separated by a short dry spell of uncertain length usually during the month of August. The daily temperature ranges from 25°C to 37°C and the mean annual temperature is 24°C to 26°C, while the relative humidity is between 65 and 80%. The site used for the study has been under high forest for over 70 years with diameters of standing trees ranging from 3 to 6m.

Experimental Design: The bush clearing study started in 1994 with the initial operation of line tracing to demarcate the land into three blocks of nine plots each. Each plot measured 40m x 30m with 3m and 4m inter-plot and inter-block spacings, respectively. The three bush clearing methods investigated were: Bulldozed and windrowed (BW), bulldozed not windrowed (BNW) and cutting with powered saw followed by slashing and burning (CSB) as described by Aiyelari and Agboola [18]. The bush clearing methods, which constitute the main treatments, were randomly arranged such that each of the three methods appeared in each replicate, thus giving 9 main plots in all. In 1995, four tillage treatments: zero (ZT), conventional (CT), minimum (MT) and traditional method - mounding (TT) were applied to the three bush clearing treatments and replicated three times. In other words, each of the bush clearing method had the four tillage methods randomly applied to it. The bush clearing treatments were assigned to the main-plots, while the tillage treatments were assigned to the subplots. Each sub-plot was separated from the other by 2m. Throughout the investigation period, the MT and CT plots were prepared with a tractor mounted disc plough once (at about 25cm soil depth). The CT plots were further harrowed once (at 25cm soil depth), while the MT plots were not harrowed. Plots that received ZT treatment had no mechanical soil manipulation but only manual clearing (with machetes), followed by burning of the debris after sun-drying. Traditional tillage treatment involved manual clearing as in ZT, followed by the making of mounds prepared with traditional (native) hoe. A 41 Kilowatts Steyr tractor (Explorer Special 80 Model with 56 Horsepower) was used for the ploughing and harrowing operations. The tillage treatments were randomly assigned to the plots at the beginning of the study. In the assessment of the macro-nutrients, the adjoining natural forest (NF) was also incorporated as a treatment. The study was conducted for three growing seasons: 1995/1996, 1996/97 and 1997/98.

Cultural Details: Maize and cassava inter-cropping system was adopted. A yellow maize cultivars, *"Oba Super II"*, which is streak resistant, high yielding and matures at about 90 days after planting (DAP) was planted in the first two years, while a white variety, *TZE comp 3ci*, which matures at about 60 DAP was used in the third cropping cycle. The change in the maize variety was necessitated by the then prevailing weather conditions. There was sudden long dry spell which subsequently shortened the usual rainy period from 4 to 2½ months. Pre-planting treatment of the seeds was done using Apron plus 50 DS at 10g to 1 kg of maize seeds. Maize was planted manually in the second week of May 1995 during the 1995/96 cropping cycle, second week of June in 1997 during the 1996/97 and second week of September in 1997 for the 1997/98 cropping cycle. The spacing for maize was 1m x 1m (at about 3 cm depth) and four grains were sown per hill and thinned to three seedlings at 14 days after planting. This gave 30 hills per row, 20 rows per plot, 10,000 hills or 30,000 plants per hectare. Cassava cultivar, TMS 30572, which is early maturing, early branching, highly tolerant to cassava mosaic virus and cassava bacterial blight, moderately tolerant to green spider mite and mealy bug, was intercropped with the maize within row (i.e. within each row, one hill of cassava alternated with one hill of maize) at one week after maize emergence at a spacing of 1m x 1m (10,000 plants per hectare). Only healthy cuttings of about uniform length (20-25cm long) with about 7-10 nodes each were planted manually at an angle of about 45° with $^2/_3$ of the cutting length buried in the soil. Weeding was done manually at 4, 8 and 24 weeks after planting (WAP) in each cropping cycle.

Data Collection and Analysis: The following crop growth and yield parameters were determined:

Height: Twenty seven and twenty maize and cassava plants per plot, respectively were randomly tagged. Their heights were measured from soil surface level to the tip of the longest leaf for maize and of the main shoot for cassava using a measuring tape graduated in centimeters.

Number of Leaves per Plant: The number of functional leaves from the tagged maize and cassava plants in each plot were recorded at bi-weekly and bio-monthly intervals, respectively.

Maize Ears and Grain Yields: Maize plants in an area of $12m^2$ were harvested at 3 months after planting (MAP) for "*Oba superII* and 2 MAP for *TZE comp 3ci* variety from three locations (top, middle and bottom) in each plot and the per hectare ears and grain yields determined at 13% moisture content.

Cassava Storage Root Number per Plant and Yield per Hectare: At 12 months after planting, cassava plants in an area of $12m^2$ were harvested at three locations (top, middle and bottom) in each plot and the storage root number per plant and storage root yield (tonnes per hectare) were determined.

Soil Sample: Soil sample was obtained at 0 to 30cm soil depth and analyzed for some physico-chemical properties using standard procedures as outlined by IITA [19].

The data were subjected to analysis of variance and treatment means that indicated significant differences were separated using the least significant differences at $P<0.05$ [20].

RESULTS AND DISCUSSION

Soil Physico-Chemical Characteristics: The soil physico-chemical characteristics of the experimental site before and after the study are shown in Table 1. The total N and organic matter values before bush clearing were 0.30 and 3.73 $g100g^{-1}$. At the end of the study, total N and organic matter values were significantly higher ($P<0.05$) in the CSB bush clearing method than in both BW and BNW by 14 to 21 and 15 to 22, respectively. Available P content differed among bush clearing methods with CSB method having 12-15% more available P than the BW and BNW. Among the tillage methods, ZT indicated the highest total N and organic matter values irrespective of the bush clearing method. The values of Ca, Mg and K at the end of the investigation showed that Ca, Mg and K in CSB bush clearing method were 11 to 17%, 25 to 42% and 14 to 27% higher than in BW and BNW, respectively. The values of Ca, Mg and K were significantly higher in ZT than CT, MT and TT irrespective of the bush clearing method. Similarly, CEC and base saturation were higher in CSB than other bush clearing methods. Also, the ZT had more CEC and base saturation than other tillage methods. The clay, silt and sand fractions in the soil after the study showed no significant difference in sand and silt contents for both bush clearing and tillage methods. Clay content however differed significantly for both bush clearing the tillage methods. Clay fraction was the highest in the BW bush clearing method and the lowest in the CSB. Among the tillage methods, it was the highest in the CT and the lowest in the ZT method irrespective of the bush clearing method. The observations could be ascribed to differences in the methods of land preparation. The complete removal of vegetation cover in the BW method in particular, compared to CSB and BNW, which exposed the land to the battering effects of torrential rainfall typical of the study area accounted for the observed differences in some of the soil properties after the study. These results are in agreement with the findings of Ojeniyi [21]. Also, the turning (inversion) and subsequent mixing of the top soil with sub soil in the CT relative to other tillage methods apparently accounted for the increase in clay fraction in CT than other tillage methods. Maduakor [22], Lal [23] and Ogban and Babalola [24] had earlier made similar observations.

Table 1: Effects of bush clearing and tillage methods on some soil chemical properties at 0-30cm soil depth at the end of the study

Treatment		Total N ($g\ 100\ g^{-1}$)	Org. matter ($g\ 100\ g^{-1}$)	Av. P ($mg^{-}Kg^{-1}$)	Ca (Cmol Kg^{-1})	Mg	K	CEC	Base Saturation ($g\ 100\ g^{-1}$)	Clay (%)	Silt	Sand
	Initial	0.30	3.73	5.84	2.47	0.21	0.39	3.62	94.48	2.66	7.10	90.24
	NF	0.37	5.35	7.46	3.29	0.33	0.34	4.32	97.06	2.57	8.37	89.06
	CT	0.10	2.08	2.08	1.92	0.06	0.12	2.16	88.39	8.40	9.51	82.09
	MT	0.10	2.17	2.86	2.01	0.07	0.16	2.31	89.31	7.34	11.63	81.03
BW	TT	0.11	2.46	3.11	2.77	0.08	0.18	2.89	91.03	6.81	13.08	80.11
	ZT	0.11	2.84	3.14	3.61	0.08	0.19	3.06	92.94	6.67	12.11	81.22
	Mean	0.11	2.39	2.80	2.55	0.07	0.16	2.61	90.42	7.31	11.58	81.11
	CT	0.10	2.10	2.10	1.85	0.07	0.16	2.53	89.03	6.22	12.98	82.01
	MT	0.11	2.25	2.89	2.23	0.08	0.18	2.61	90.14	5.79	11.72	81.06
BNW	TT	0.13	2.98	2.62	3.30	0.10	0.19	3.21	91.29	5.61	14.07	80.14
	ZT	0.15	3.11	3.22	3.66	0.12	0.22	4.08	92.01	5.01	13.21	81.18
	Mean	0.12	2.61	2.71	2.76	0.09	0.19	3.11	90.62	5.66	13.25	81.10
CSB	CT	0.13	2.13	2.14	1.89	0.08	0.19	2.63	89.53	6.01	14.13	81.00
	MT	0.14	3.06	3.39	2.31	0.10	0.19	3.22	92.01	5.75	12.98	81.01
	TT	0.14	3.51	3.71	3.41	0.12	0.24	4.10	94.15	5.56	13.22	81.03
	ZT	0.16	3.60	3.43	4.73	0.17	0.26	4.55	94.71	4.87	13.37	81.07
	Mean	0.14	3.08	3.17	3.09	0.12	0.22	3.63	92.60	5.55	13.43	81.03
LSD (P<0.05)	Bush clearing	0.03	0.09	0.48	0.19	0.02	0.03	0.15	1.25	1.08	NS	NS
	Tillage method	0.02	0.45	0.27	0.32	0.02	0.01	0.03	NS	0.92	NS	NS

BW = Bulldozed and Windrowed; BNW = Bulldozed Not Windrowed; CSB = Clear fell, slashed and burned land clearing methods.

NS = Not significant; CT = Conventional; MT = Minimum; TT = Traditional and ZT = Zero tillage methods.

Table 2: Effects of Bush Clearing and Tillage Methods on Maize Height and Number of Leaves per Plant

		Height (m)									Number of leaves per plant								
		1996			1997			1998			1996			1997			1998		
		2	4	6	2	4	6	2	4	6	2	4	6	2	4	6	2	4	6
Treatment		Weeks after planting									Weeks after planting								
	CT	0.68	2.37	2.64	0.65	1.20	1.74	0.77	1.80	2.01	7.62	10.42	14.01	5.42	7.82	10.06	7.08	10.01	9.62
	MT	0.69	2.40	2.66	0.67	1.22	1.98	0.82	1.99	2.05	8.29	10.80	15.04	8.69	8.14	10.81	7.13	11.03	10.09
BW	TT	0.70	2.42	2.67	0.70	1.24	1.76	0.85	1.90	2.02	6.89	10.71	15.04	7.03	7.85	10.04	7.90	10.42	10.09
	ZT	0.67	2.01	2.40	0.58	1.02	1.78	0.72	1.94	2.04	6.88	11.10	15.06	7.11	8.06	10.09	7.78	10.36	10.15
	Mean	0.69	2.30	2.59	0.65	1.17	1.82	0.79	1.91	2.03	7.42	10.76	14.79	7.06	7.97	10.25	7.47	10.46	9.99
	CT	0.69	2.39	2.66	0.67	1.20	1.80	0.80	1.83	2.04	7.84	10.48	14.08	5.66	8.06	10.11	7.12	10.04	9.78
	MT	0.69	2.41	2.67	0.71	1.25	2.06	0.84	2.08	2.09	8.31	11.17	15.04	8.92	8.21	11.03	7.18	11.02	10.14
BNW	TT	0.72	2.43	2.68	0.71	1.26	1.89	0.86	1.93	2.06	7.71	11.12	15.04	7.17	8.49	10.10	7.92	10.51	10.14
	ZT	0.67	2.07	2.42	0.60	1.05	1.92	0.76	1.98	2.03	7.00	11.06	15.09	7.20	8.10	10.16	7.81	10.44	10.19
	Mean	0.69	2.33	2.61	0.67	1.19	1.92	0.82	1.96	2.06	7.72	10.96	14.81	7.24	8.22	10.35	7.51	10.50	10.06
	CT	0.70	2.43	2.69	0.71	1.23	1.84	0.81	1.87	2.11	7.76	11.84	16.01	5.92	8.12	10.70	7.14	10.12	9.82
	MT	0.72	2.50	2.68	2.72	1.27	2.01	0.86	2.06	2.18	8.35	12.16	15.18	9.16	8.29	11.02	7.22	11.01	10.11
CSB	TT	0.75	2.54	2.69	0.74	1.26	1.92	0.87	1.94	2.17	7.74	11.36	15.13	7.27	8.61	10.36	8.30	10.58	10.12
	ZT	0.68	2.09	2.42	0.60	1.06	1.94	0.78	1.99	2.09	7.02	11.24	15.16	7.36	8.27	10.19	7.84	10.47	10.22
	Mean	0.71	2.39	2.62	0.69	1.21	1.93	0.83	1.97	2.14	7.72	11.65	15.37	7.43	8.32	10.57	7.63	10.55	10.07
LSD (P<0.05)																			
Bush clearing methods		NS	NS	NS	0.01	NS	0.03	NS	0.02	0.07	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tillage methods		NS	0.04	0.17	0.08	0.06	0.07	0.04	0.06	0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS

BW = Bulldozed and Windrowed; BNW = Bulldozed Not Windrowed; CSB = Clear fell, slashed and burned land clearing methods.

NS = Not significant; CT = Conventional; MT = Minimum; TT = Traditional and ZT = Zero tillage methods

Table 3: Effects of Bush Clearing and Tillage Methods on Cassava Height and Number of Leaves per Plant

		Height (m)									Number of leaves per plant								
		1996			1997			1998			1996			1997			1998		
		2	4	6	2	4	6	2	4	6	2	4	6	2	4	6	2	4	6
Treatment		Months after planting									Months after planting								
	CT	0.71	1.49	2.08	0.52	1.50	1.90	0.65	1.10	1.90	26.01	86.20	147.80	27.00	121.01	190.92	35.16	78.88	108.12
	MT	0.63	1.45	2.11	0.57	1.62	1.98	0.67	1.08	1.78	22.96	101.05	159.21	31.16	147.31	190.98	37.10	80.14	109.08
BW	TT	0.65	1.60	2.29	0.61	1.72	2.31	0.68	1.04	1.40	24.22	106.14	163.11	28.33	148.09	198.16	36.82	84.10	120.20
	ZT	0.62	1.28	2.21	0.60	1.68	2.20	0.60	1.06	1.53	24.06	89.07	158.13	21.09	142.71	194.91	36.01	82.39	106.22
	Mean	0.65	1.46	2.17	0.58	1.63	2.10	0.65	1.07	1.65	24.31	95.62	157.06	26.90	139.78	193.74	36.27	81.38	110.91
	CT	0.72	1.50	2.11	0.57	1.54	1.95	0.69	1.16	1.91	25.11	89.96	158.82	27.12	120.98	192.96	36.11	88.41	160.10
	MT	0.68	1.43	2.12	0.60	1.68	2.01	0.68	1.10	1.80	24.13	105.12	162.06	30.09	149.51	194.19	38.01	86.02	155.09
BNW	TT	0.69	1.62	2.31	0.62	1.76	2.46	0.66	1.06	1.42	25.81	110.12	179.11	29.02	146.18	212.16	32.52	88.01	116.01
	ZT	0.66	1.34	2.18	0.61	1.70	2.23	0.61	1.05	1.54	24.01	88.11	172.26	20.16	140.72	291.14	34.09	85.11	99.11
	Mean	0.69	1.47	2.18	0.60	1.67	2.16	0.61	1.09	1.67	24.77	98.33	168.01	26.60	139.35	222.61	34.09	85.11	132.58
	CT	0.71	1.51	2.16	0.56	1.60	1.97	0.73	1.20	1.97	25.61	91.10	160.12	27.26	127.62	197.10	38.16	90.16	163.21
	MT	0.66	1.46	2.13	0.63	1.72	2.04	0.69	1.09	1.83	24.45	103.61	163.07	31.42	151.71	197.11	39.12	87.11	155.20
CSB	TT	0.68	1.68	2.35	0.64	1.78	2.50	0.65	1.08	1.47	25.88	112.91	178.32	28.52	152.68	225.11	35.18	84.23	114.61
	ZT	0.64	1.33	2.20	0.60	1.74	2.36	0.62	1.04	1.56	23.22	86.12	176.13	22.14	142.27	296.12	38.14	83.11	96.20
	Mean	0.67	1.50	2.21	0.61	1.71	2.22	0.67	1.10	1.71	24.79	98.44	169.41	27.34	143.57	228.86	37.65	86.15	132.31
LSD (P<0.05)																			
Bush clearing methods		NS	NS	NS	NS	0.04	0.05	NS	NS	NS	NS	NS	NS	NS	NS	8.11	NS	2.37	15.17
Tillage methods		0.06	0.09	0.04	0.04	0.06	0.11	0.05	0.07	0.17	NS	6.28	8.11	NS	5.29	10.46	NS	5.12	11.36

BW = Bulldozed and Windrowed; BNW = Bulldozed Not Windrowed; CSB = Clear fell, slashed and burned land clearing methods.

NS = Not significant; CT = Conventional; MT = Minimum; TT = Traditional and ZT = Zero tillage methods.

Maize and Cassava Heights and Number of Leaves per Plant: The effects of bush clearing and tillage methods on heights and number of leaves of maize and cassava per plant are presented in Tables 2 and 3. Maize height differed significantly (P<0.05) among the bush clearing methods in 1997 and 1998 and not in 1996, the first cropping cycle (Table 2). The CSB bush clearing method produced taller maize plants than BW and BNW methods although maize height in the BNW was more or less at par with those of CSB at some sampling stages. Among the tillage methods, there was no clear trend but the TT and MT treatments generally produced taller maize plants than CT and ZT. The number of maize leaves per plant was not affected by both bush clearing and tillage methods (Table 2). In the second cropping cycle, the CSB plot had taller cassava plants than the BW and BNW plots. Among the tillage treatments, cassava height differed significantly throughout the study period except that no clear pattern was maintained. However, the mean value across the three cropping cycles and bush clearing methods indicated that the use of MT and TT tillage methods resulted in taller plants than in CT and ZT. The number of cassava leaves per plant only differed significantly among the bush clearing methods at 6 months after planting (MAP) in the second cropping cycle and at 4 and 6 MAP in the third cropping cycle with CSB and BNW having more number of leaves (Table 3). Among the tillage methods, significant differences were observed only at 4 and 6 MAP in each of the cropping cycles. Although no trend was maintained, the mean value across the three cropping cycles and bush clearing methods indicated that the TT plots produced more number of cassava leaves (Table 3). The interaction effects between bush clearing and tillage methods were significant on maize and cassava heights and number of leaves during some of the growing periods.

The significant effects of bush clearing treatment on plant growth in the second and third cropping cycles could be linked with the effects of the equipment used in the clearing operation of which the impact of CSB method was less severe and negative on the soil (e.g compaction) and invariably on the plant height. These findings are in agreement with that of Alli *et al*. [25] and Ojeniyi [21] who reported better maize growth under manual clearing than other methods. The detrimental effects of soil compaction, following the use of heavy bush clearing equipment

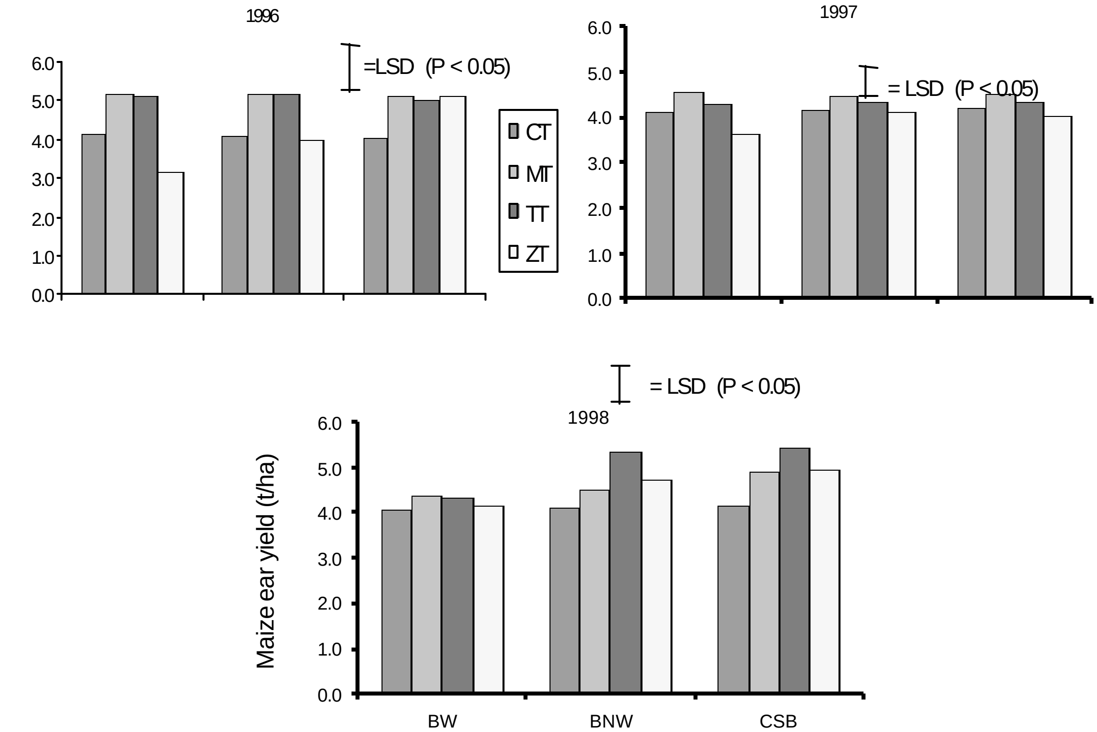

Fig. 1: Effects of bush clearing and tillage methods on maize cob yield

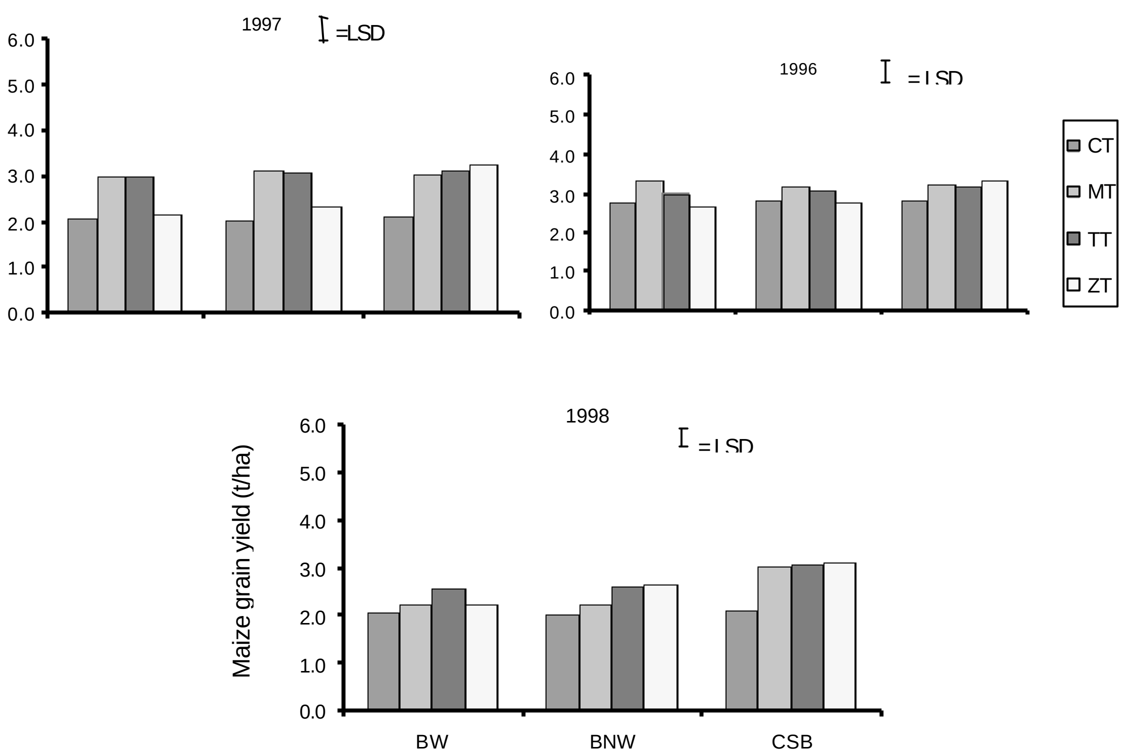

Fig. 2: Effects of bush clearing and tillage methods on maize grain yield

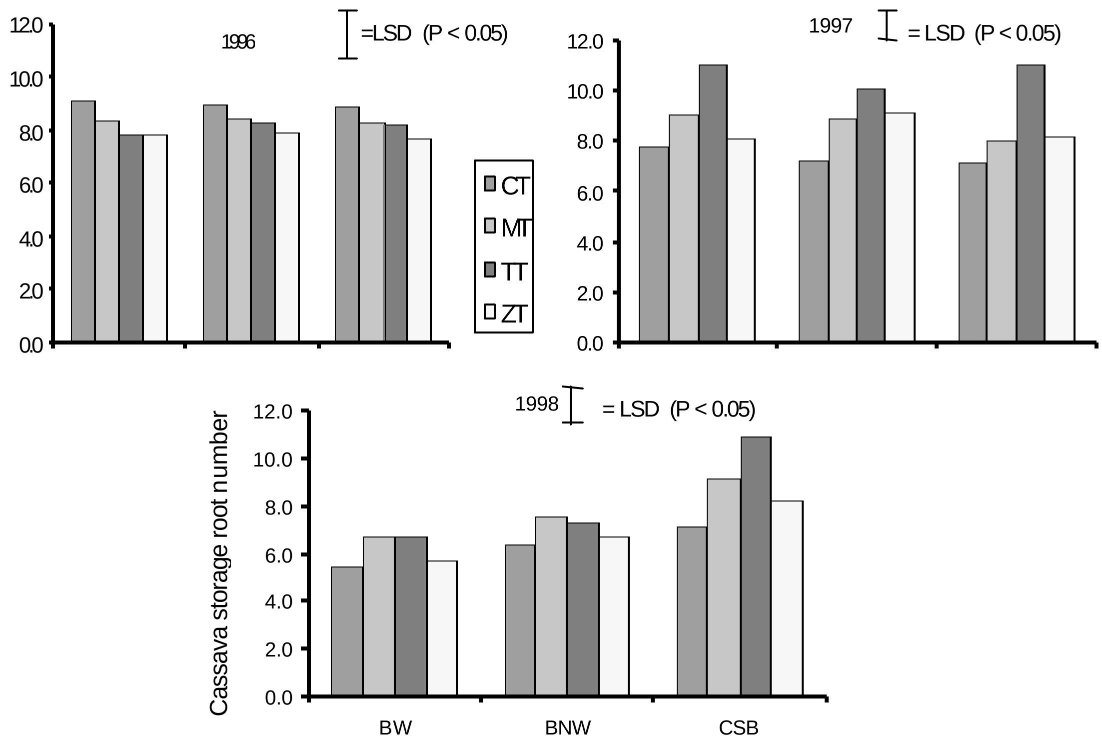

Fig. 3: Effects of bush clearing and tillage methods on storage root number

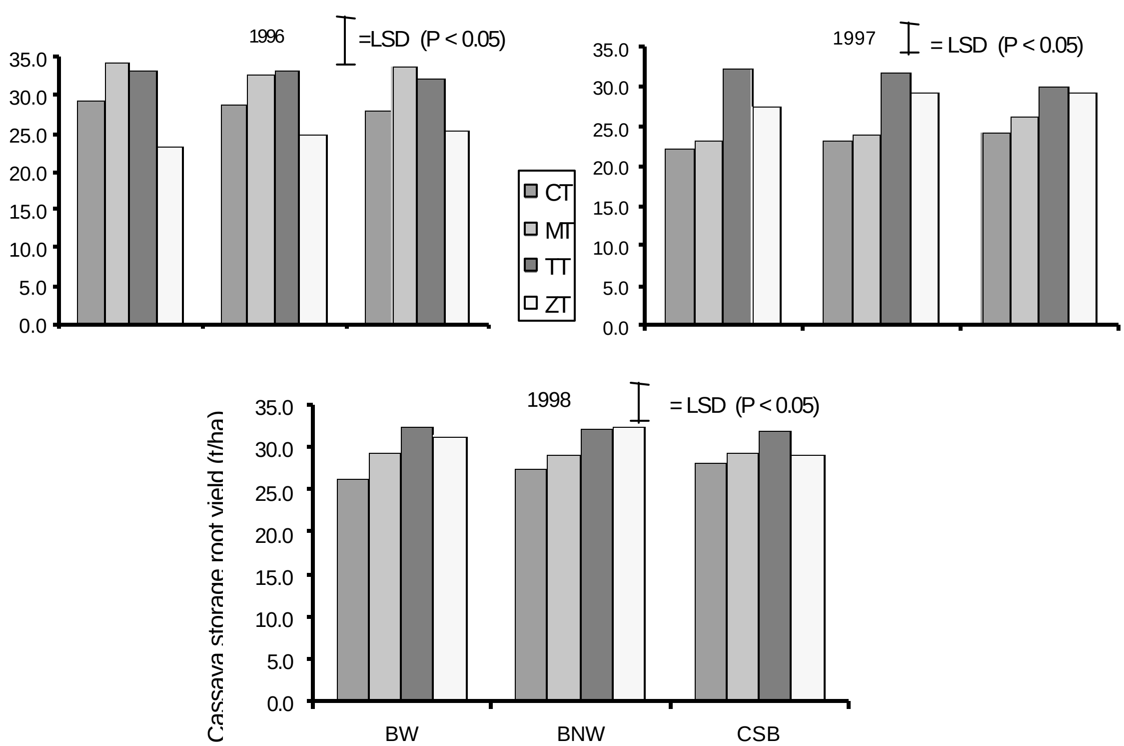

Fig. 4: Effects of bush clearing and tillage methods on storage root yield

(as in BW treatment) on crop growth and yield have been also observed by Maduakor [22]. The relative better performance of crop height and number of leaves under the TT tillage method relative of others could be ascribed to more conducive soil temperatures and temperature gradients in TT than under other tillage methods [26].

Maize and Cassava Yields: The effects of bush clearing and tillage methods on maize and cassava yields are shown in Figures 1-4. The ear yield of maize in the CSB plots was significantly higher than those in the BW and BNW plots by 5-9% in 1996/97 and by 4-13% in 1997/98 (Figure 1). In 1996/97, BNW gave 1-30% more maize ear yield than CSB and BW. On the other hand, the maize grain yield in the CSB plot was superior to those obtained in the BW and BNW plots by 5-6%, 8-11% and 15-20% after the first, second and third cropping cycles (Figure 2). The mean values of maize ear yield determined across the three bush clearing methods revealed that the MT tillage method produced 1-20% and 4-13% more ear yield than other tillage methods after the first and second cropping cycles, respectively. On the other hand, TT gave 8-19% more maize ear yield than other tillage methods after the third cropping cycle (Figure 1). The maize grain yield followed a similar pattern with MT having 1-14% and 1-32% more grains than other tillage methods after the first two cropping cycles (Figure 2). In the third cropping cycle, grain yields in MT plots superseded others by 9-25%.

The effect of bush clearing on the number of cassava storage roots was only significantly different after the third cropping cycle (Figure 3) with CSB having 8-19% more storage roots than BW and BNW. However, BNW and BW indicated higher mean values of cassava storage root number after the first and second cropping cycles, respectively. The cassava storage root yield neither showed a trend nor significant differences among bush clearing throughout the study period (Figure 4), but the mean values were the highest in the BW, CSB and BNW after the first, second and third cropping cycles, respectively. The mean values of cassava storage root number assessed across the three bush clearing methods showed that CT had 7-13% more storage roots than other tillage methods in 1995/96. In both 1996/97 and 1997/98 cropping cycles, TT plots produced 19-31% and 6-24% more cassava storage roots than other tillage methods (Figure 3). These observations could be ascribed to the adverse influence of complete removal of the vegetation cover in the BW plot compared to the BNW and CSB plots. Moreover, the disruption and removal of the topsoil and organic matter/materials during stumping and windowing operations contributed to the observed results. It has been reported that once the bush is cleared for cultivation, particularly by mechanical means, the soil organic matter and nutrients are rapidly lost with a subsequent drop in crop yield [18, 21]. Although the CSB bush clearing method favoured crop yields better than BW and BNW, it was observed to be rather slow, labourious and inefficient.

The fact that the best crop yields were obtained using of either MT or TT tillage method strongly suggests the need for some degree of tillage operation for maize and cassava production in this agro-ecology. The ZT, MT and TT methods have been found to be slow in the breakdown and subsequent release of soil organic matter/materials and nutrients compared to CT plot and could have contributed to the findings of this study. These observations are in consonance with the findings from earlier studies [24, 21, 25-28] that appropriate tillage can decrease initial bulk density, increase nutrient concentration/availability, promote crop emergence/ establishment and general crop performance.

The cassava root yield per hectare was highest in MT plots in 1996/97 by 2-27% than CT, TT and ZT plots (Figure 4). Interestingly, of the trends noticed for the number of cassava storage roots per plant in 1996/97 and 1997/98 cropping cycles, TT plots produced 19-31% and 6-24% more number of cassava storage roots than other tillage methods (Figure 3). The cassava root yields per hectare was the highest in MT plots in 1996/97 by 2-27% than CT, TT and ZT plots. Interestingly, the trends noticed fort he number of cassava roost per plant in 1996/97 and 1997/98 cropping cycles were also maintained for cassava root yield per hectare. The cassava r oot yield per hectare in TT plots was 9-26% and 4-15% more than those in other tillage treatment plots after the second and third cropping cycles. The interaction effects of bush clearing and tillage methods on maize and cassava yields were significant ($P<0.05$). The growth and yields of maize and cassava declined with time. This was more pronounced in the BW plot than in both BNW and CSB. In general, MT and TT in combination with CSB bush clearing method produced more maize and cassava yields than other bush clearing and tillage combinations.

CONCLUSIONS

- The use of BW bush clearing methods caused significant reductions in the growth and yields of the crop++s after the second cropping cycle irrespective of the tillage method adopted.

- A combination of CSB + TT or MT supported the growth and yields of maize and cassava better than other combinations.
- The use of CSB + TT as bush clearing and tillage method is however labourious and inefficient. Therefore, to meet the food demand of the population, the adoption of BNW + MT combination would be more appropriate in the humid agro-ecologies.

REFERENCES

1. Ofori, C.S., 1999. The need for an integrated approach to soil fertility management in West Africa. In: Debrah, S. K. and Koster, W. G. (eds.) Linking soil fertility management to agricultural input and output market development: the key to sustainable agriculture in West Africa. pp: 17-30. International Fertilizer Development Center, Togo.
2. Agboola, A.A., 1981. The effects of different soil tillage and management practices on the physical and chemical properties of soil and maize yield in a rainforest zone of western Nigeria. Agronomy Journal, 73: 24-251.
3. Eneji, A.E., E.A. Aiyelari, A.A. Agboola, F.R. Kutu, N.U. Ndaeyo and G.E. Akibola, 1997. Preliminary Investigations on the effect of bush clearing on soil nutrients status. Journal of Tropical Forest Resources, 13(1): 16-26.
4. Okore, I.K., H. Tijani-Eniola, A.A. Agboola and E.A. Aiyedari, 2007. Impact of land clearing methods and cropping systems on labile soil C and N pools in the humid forest zone of Nigeria. Agriculture, Ecosystems and Environment, 120(2-4): 250-258.
5. Eneji, A.E., B.B. Ayade, B.F.D. Oko, S. Yamamoto, T. Honna and T. Endo, 2001. Influence of forest clearing methods on nutrient uptake of some tropical food crops. Journal of Forest Research, 6(1): 31-35.
6. Lal, R., 1985. Mechanized tillage system effects on properties of tropical Alfisol in watershed cropped to maize. Soil and Tillage Research, 6: 149-162.
7. Ogban, P.I.., W.N. Ogunewe, R.I. Dike, A.O. Ajaelo, N.I. Ikeata, U.E. Achumba and E.E. Nyong, 2008. Effect of tillage and mulching practices on soil properties and growth and yield of cowpea (*Vigna unguiculata* (L.) Walp) in Southeastern Nigeria. Agroscience, Journal of Tropical Agriculture, Food, Environment and Extension, 7(2): 118-128.
8. Awodun, M.A. and S.O. Ojeniyi, 2005. Response of groundnut yields nutrient status to tillage and wood ash. Nigeria Agric. J., 360: 80-87.
9. Ndaeyo, N.U., E.O. Ekpe, S.O. Edem and U.G. Umoh, 2003. Growth and yield responses of *Colocasia esculenta* and *Xanthosoma saggitifolium* to tillage practices in Uyo, Southeastern Nigeria. Indian Journal of Agric. Sci., 73(4): 194-198.
10. Ike, I.F., 1985. Soil and crop responses to different tillage practices in a ferruginous soil in the Nigerian savannas. Soil and Tillage Research, 6: 161-272.
11. Agele, S.O., G.O. Iremiren and S.O. Ojeniyi, 2000. Effects of tillage and mulching on the growth, development and yield of late season tomato (*Lycopersicon esculentum* L.) in the humid South of Nigeria. Journal of Agricultural Science (Cambridge), 134: 55-59.
12. Ezumah, H.O., 1983. Agronomic considerations of no-tillage farming. In: Akobundu, I. O. and Duetsch, A. E. (eds.) No-tillage crop production in the tropics. Proc. of a Symposium held on August 6-7, 1981 at Monrovia, Liberia. pp: 49.
13. Olaniyan, G.O., 1983. No-tillage production of maize, rice and cowpea in Nigeria. In: Akobundu, I.O. and Deutsch, A.E. (eds.) IPPC Document 46-B-83 Oregon State University, Cornallis, pp: 127-131.
14. Ndaeyo, N.U. and E.A. Aiyelari, 1997. Evaluation of different tillage practices for monocultural cowpea (*Vigna unguiculata* (L.) Walp) production in Ibadan, south-western Nigeria. Tropicultura, 15(4): 195-202.
15. Ohiri, A.C. and H.C. Ezumah, 1990. Tillage effects on cassava (*Manihot esculenta*) production and some soil properties. Soil and Tillage Research, 17: 21-229.
16. Bationo, A. and F. Lompo, 1999. Available technologies for combating soil nutrient losses in West Africa. In: Debrah, S.K. and Koster, W.G. (eds.) Linking soil fertility management to agricultural input and output market development: The key to sustainable agriculture in West Africa pp: 31-51. International Fertilizer Development Center, Togo
17. Agboola, A.A. and A.O. Ogunkunle, 1993. Site characterization at Epemakinde, Ondo State, Nigeria. Technical Report on Land Development for Sustainable Agriculture in Africa. International Board of Soil Research and Management/ Africa land 1988 - 1992. Bangkok, Thailand, pp: 120-131.
18. Aiyelari, E.A. and A.A. Agboola, 1998. Evaluation of three bush clearing methods in primary forests of the humid tropics. Agricultural Mechanization in Asia, Africa and Latin America, 29(4): 67-72.

19. IITA (International Institute of Tropical Agriculture) (1979). Selected methods for soil and plant analysis. Manual Series No. 1 IITA, Ibadan, Nigeria, pp: 70.
20. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research, 2nd edition John Wiley and Sons, New York, pp: 187-240.
21. Ojeniyi, S.O., 1990. Effect of bush clearing and tillage methods on soil physical and chemical properties of humid tropical Alfisols. Soil and Tillage Research, 15: 269-277.
22. Maduakor, H.O., 1993. Effect of soil compaction on leaf, stem and fibrous root growth of cassava (*Manihot esculenta*, Crantz). Soil and Tillage Research, 26: 69-78.
23. Lal, R., 1997b. Long-term tillage and maize monoculture effects on a tropical Alfisol in Western Nigeria. II. Soil chemical properties. Soil and Tillage Research, 42: 161-174.
24. Ogban, P.I. and O. Babalola, 1999. Preliminary evaluation of tillage systems on poorly-drained inland valley bottom soils. Trop. Agric., 76(4): 236-240.
25. Alli, A., O.O. Agbede and Ojeniyi, 1996. Effect of tillage on soil physical properties and maize in subhumid Savanna zone of Nigeria. Applied Tropical Agriculture, 1: 1-4.
26. Osuji, G.E., 1990. Tillage and mulching effects on seed-zone soil environment and cowpea seedling growth in the humid tropics. Soil Use and Management, 6(3): 152-156.
27. Aiyelari, E.A., N.U. Ndaeyo and A.A. Agboola, 2001. Effects of tillage practices on growth and yield of cassava (*Manihot esculenta*) and some soil properties in Ajibode, Southwestern Nigeria. Indian Journal of Agricultural Sciences, 71(3): 171-176.
28. Lal, R., 1997a. Long-term tillage and maize monoculture effects on a tropical Alfisol in Western Nigeria. I. Crop yield and soil properties. Soil and Tillage Research, 42: 145-160.