Yields, Cost of Production and Economic Return to Management of Maize/Cassava Intercrop as Influenced by Different Tillage Practices.

Nyaudoh U. NDAEYO

Department of Crop Science, University of Uyo, Uyo, Nigeria
e-mail: dr_nundaeyo@yahoo.com

Abstract: A study was conducted in 1995/96 to 1997/98 cropping seasons at Epemakinde, a rainforest area of southwestern Nigeria to assess the effects of different tillage practices viz: conventional (CT), minimum (MT), traditional (TT) and zero (ZT) on the yields, cost of production and economic returns to management of maize (*Zea mays*) /cassava (*Manihot esculenta*) intercrop. A randomized complete block design with three replicates was used. Results showed that grain yield only differed significantly in 1998 with CT and ZT being lower than both MT and TT by 2 and 25%, respectively. Average of maize across the three years indicated that TT (3.15 t/ha) significantly out yielded both CT and ZT by 16%. Cassava fresh root yield differed significantly in 1998 with TT (44.72 t/ha) producing higher than other tillage practices by 2-24% while MT (40.60 t/ha) yielded higher than others by 3-19% in 1998 cropping season. The CT and MT treatments had the highest cost of production and economic returns and superseded ZT by 21% and 8%, respectively. This study has demonstrated the necessity of some level of tillage with MT treatment being the most desirable.

[Nyaudoh U. NDAEYO. Yields, Cost of Production and Economic Return to Management of Maize/Cassava Intercrop as Influenced by Different Tillage Practices. Researcher. 2010;2(10):68-74]. (ISSN: 1553-9865).

Keywords: *Zea mays, Manihot esculenta*, tillage, farm income.

1. Introduction

There is always a strong economic incentive to employ the tillage practice(s) that confer(s) the greatest return to management and entrepreneurial risk taking to be deducted from gross revenues. Farmers always consider the costs, economic return and other benefits before changing from one practice to another. What the farmers are doing in this case is evaluating the difference in net benefits between different practices, that is, the value of the benefits gained minus the value of the things expended. Farmers tend to change their practices in a gradual, stepwise manner by comparing their practice with alternatives, and seeking ways of cautiously testing new technologies. Couper *et al*. (1979) in Ibadan, southwestern Nigeria found that the total cost of inputs were lower under no till than conventional method while the gross income and net income were higher under no till than conventional, and concluded that even if the grain yields are the same with both tillage systems, net revenue would be more with no tillage.

Henderson and Stonehouse (1988) and Stonehouse (1991) stated that the empirical evidence on economic returns on comparative short term economics is contradictory and confusing but that in minority of cases, conventional systems appear to be economically superior especially in cooler temperate zones and where topsoil are deeper and/or less steeply sloping. Their study indicated the possibility of obtaining overall net reductions in total cost of production of substituting conservation tillage for conventional tillage but noted that the yield penalty attached to most conservation alternatives is sufficiently severe to more than compensate for the lower production costs.

Lyle and Bordovsky (1987) and Keeling *et al*. (1988) observed a favourable net returns in zero and minimum tillage over conventional and concluded that these systems are economically sound, and hence acceptable to producers. Others studies (Aiyelari et al., 2001; Hulugalle et al., 1985; Lal 1977, 1983; Maurya and Lal 1979) have shown diverse results in some agro-ecologies. Ndaeyo and Aiyelari (1997) evaluated some tillage practices in Ibadan, southwestern Nigeria and observed that in both first and second seasons, the highest cost of production was under no till (slash and burn) and the lowest under conventional and minimum tillage plots for the two seasons, respectively. No till (slash and burn) exceeded no till (herbicide applied), conventional and minimum tillage by 24%, 41% and

32% in the first season, and by 27%, 34% and 35% in the second season, respectively. They also reported that in both seasons, conventional tillage gave the highest economic return while the least was observed in no till (slash and burn) and no till (herbicide applied treatment), respectively. They attributed the higher cost of production observed in no till (slash and burn) treatment relative to other treatments in both seasons to the cost of a single operation (labour for land preparation).

In changing from their current practices to an alternative, the farmers must make an extra investment. It may appear that the farmers would choose to adopt the alternative treatment if the net benefit is higher, but the choice is not obvious, because farmers will also want to consider the increase in costs. Therefore, it is necessary to compare the extra (or marginal) costs with extra (or marginal) net benefits. Higher net benefits may not be attractive if they require higher costs. Against this conflicting background, a study was conducted to assess the yields, cost of production and economic returns to management of maize/cassava intercrop as influenced by different tillage practices in a rainforest ecology of southwestern Nigeria.

2. Materials and Methods

2.1 Description of the study site

The trial was conducted on a 2-hectare land of the IBSRAM's experimental field located at the Ondo State Afforestation Project site in Epemakinde ($4^0 45^1$ E and 6^0 45^1 N), Southwestern Nigeria between 1995/96 and 1997/98 cropping seasons. Epemakinde is a forested area underlain by a sedimentary deposit of coastal plain sands. The soils are Ultisols and Alfisols (Agboola and Ogunkunle 1993), slightly to fairly acidic (pH 4.9 – 6.7), medium textured (sandy loam to sandy clayey loam top and sandy loam to sandy clayey below) and moderately well structured (granular/crumb top and sub-angular blocky below). The farming system practiced in the area is shifting cultivation and the cropping system is mainly tree crop based – kola (*Cola nitida* (Ventenat) Schott and Endicher), cocoa (*Theobroma cacao* L.) and rubber (*Hevea brasiliensis* (Mull and Aurg) with some arable crops – maize (*Zea mays* L.) and cassava (*Manihot escuenta* Crantz), cocoyam (*Xanthosoma* sp. / *Colocasia* sp.) and plantain/banana (*Musa* sp.). The rainfall pattern is bimodal with long (April – August) and short (August – November) rainy seasons separated by a short dry spell of uncertain length, usually during the month of August. The mean daily temperature ranges from 25^0C to 37^0C and the annual temperature is 24^0C to 26^0C (Agboola, A. A. and Ogunkunle, A. O. (1993), while the relative humidity is between 65 and 80%. The site used for the trial was under high forest (over 70 years old) until 1994 when different bush clearing techniques (Bulldozed and windrowed, Bulldozed – not windrowed and Slash and burn) trials were carried out. Detailed description of the trials has been documented by Eneji *et al*. (1997a, b) and Aiyelari and Agboola (1998). In 1995, tillage experiment, was initiated and imposed across the bush clearing methods.

2.2 Experimental Design: The experiment was set up as a completely randomized block design with four tillage treatments with three replications. The tillage treatments consisted of Minimum (MT), Conventional (CT), Traditional (TT) and Zero (ZT). Throughout the investigation period, the MT and CT plots were prepared with a tractor mounted disc plough, that is, ploughed once (at about 25 cm soil depth), but the CT plots were further harrowed (at about 25 cm soil depth) once while the MT plots were not harrowed. Plots that received ZT treatment had no mechanical manipulation of the soil, but only involved manual clearing (with machete), followed by burning of the debris after drying. Traditional tillage treatment involved manual clearing as in ZT, followed by the making of mounds prepared with traditional (native) hoe. The tillage treatments were randomly assigned to the plots at the beginning of the study and retained in the same locations throughout the duration of the study. The plot size for each tillage treatment was 30 x 20 m. Each replicate was separated from the other by a 4.0 m alleyway while the interplot spacing was 3 m.

2.3 Cultural Details: Maize (*Zea mays* L.) and cassava (*Manihot esculenta* Crantz) intercropping system was adopted. A yellow maize cultivar, '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 bout 60 DAP was used in the third years. Maize was planted manually in the second week of May in the first year, second week of June in the second year and second week of September in the third year due to the year's pattern of rainfall and month of planting. The spacing was 1 x 1 m (at about 3 cm depth) and four seeds were sown per hill and thinned down to three seedlings at 7 DAP. This gave 30 hills per row, 20 rows per plot, 10,000 hills or 30,000 plants per hectare. Pre-planting treatment of the maize seeds was done using Apron plus 50 DS at 10 g to 1 kg of maize seeds. 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 (IITA,

1990) was intercropped (within row) with the maize one week after emergence of maize at a spacing of 1 x 1 m (10,000 plants per hectare). Only healthy cuttings of about uniform size (20 – 25 cm long) with about 7 – 10 nodes each were planted manually at an angle of about 45^0 with $^2/_3$ of the cutting buried in the soil. Weeding was done manually at 4, 8 and 24 weeks after planting (WAP) for each year.

2.4 Data Collection and Analyses: At harvest, maize and cassava plants were harvested from an area of 12 m^2 each at the top, middle and bottom of each plot for grain and fresh root yields determination. Data collected were subjected to analysis of variance and means that showed significant differences were separated using the Least Significant Difference (LSD) at 5% probability level (Gomez and Gomez, 1984). Cost of production and the economic returns to management was determined using partial budgeting method described by CIMMYT (1988).

3.0 Results and Discussion

Maize grain yield (Table 1) differed significantly only in 1998 with CT and ZT treatment being lower than both MT and TT by 22 and 25%, respectively. Average maize yield across the three years indicated that maize grain yield from TT (3.15 t/ha) significantly out yielded those of CT and ZT by 16%. There was no significant difference in cassava fresh storage root yield in 1997 (Table 2). The values ranged from 29.92 t/ha under ZT to 40.74 t/ha under MT. However, cassava fresh root yield differed significantly in 1998 with TT (44.72 t/ha) treatment exceeding others by 2-24% while fresh storage root yield from the MT (40.60 t/ha) treatment superseded others by 3 to 19%, in 1998 cropping season (Table 2).

The detailed costs of inputs and other farm operations are presented in Table 3. The total cost of production across the three years indicated that ZT was 21, 20 and 18% lower than CT, MT and TT, respectively (Tables 3) and the cost of production was not stable as its changed with years. The economic returns to management under the different tillage practices in 1995/96 to 1997/98 cropping seasons are presented in Table 4. In 1995/96 cropping season, cassava crop gave 60% of the total gross revenue in CT, 72% in MT, 68% in TT and 56% in ZT. During the 1996/97 cropping season, cassava also gave 65, 81, 6 and 67% total gross revenue from CT, MT, TT and ZT while in 1997/98, 53, 55, 57 and 62% were respectively supplied by cassava with the balance obtained from maize (Table 3). The total gross returns across the years revealed that TT tillage practice exceeded those of CT, MT and ZT by 10, 0.02 and 10%, respectively. The net benefit (calculated as the difference between total gross returns and total costs) did not show any clear trend (Table 3). During the 1995/96 cropping season, MT tillage practice exceeded those of CT, TT and ZT by 20, 10 and 25%, respectively. In 1996/97, TT was 32, 16, and 9% higher than CT, MT and ZT respectively whereas MT again exceeded CT, TT and ZT by 9, 11 and 4% in 1997/98, respectively. However, average across the three years indicated that MT superseded CT, TT and ZT by 16, 1 and 8%, respectively (Table 4).

The marginal rate of returns (MRR) among the tillage practices, which compares the extra (or marginal) costs with the extra (or marginal) net benefit, did not show any definite pattern (Table 3). In 1995/96, it ranged from 18.95% under CT to 87.44% under MT treatment. During 1996/97, it ranged from –70.62% under CT to 31.29% under TT tillage treatment whereas in 1997/98, it ranged from –17.55% under TT to 11.56% under MT tillage treatment. However, average MRR across the three years revealed that MT (75.72%) exceeded CT and TT by 181 and 13%, respectively. The MRR across the years also indicated that for every ₦1 invested, ₦2.37, ₦2.96, ₦2.90 and ₦3.27 were recovered under CT, MT, TT and ZT tillage treatment, respectively. The MRR when the farmer changes from one form of tillage practice to the other (Table 5) revealed that if a farmer, for instance, changes from CT to MT, the MRR would be –815%, from MT to TT, it would be –95%, and as he changes from TT to ZT tillage practice, the MRR would be 121%. The acceptable minimum return under on-farm research condition had been put at 100% (CIMMYT, 1988).

Maize grain and cassava storage root yields declined continuously with years of cultivation although it was more pronounced in CT that other tillage practices. However, the yields obtained from these crops were still enough to make the farmer break even. The observed results could be ascribed to vagaries of weather and gradual decline in soil fertility status which again was more pronounced in CT plots relative to other tillage plots. These findings are in consonance with the findings reported by other researchers for maize (Couper et al., 1979; Klute, 1982; Lal 1977, 1983; Maurya and Lal 1979; Ojeniyi, 1986; Osuji, 1984), cassava and other tuber crops (Aiyelari et al., 2001; Hulugalle et al., 1985; Maurya, 1986; Ndaeyo et al., 2003; Ohiri and Ezumah 1990; Ojeniyi and Agboola, 1995; Opara-Nadi and Lal, 1987).

Farmers always consider the cost implications, economic returns and others benefits before changing from one farm practice to another. In doing so, they weigh the benefits gained in the form of yield (or other useful products) against the cost in the form of labour and cash expended. Therefore, to make a good recommendation for farmers in on-farm research, researchers must be able to evaluate alternative technologies from the farmers' point of view (CIMMYT, 1988). Such evaluation must be based on the premise that farmers: (a) are concerned with the benefits and costs of particular technologies, (b) usually adopt innovations in a stepwise manner, and (c) will consider risks in adopting new practices. Based on the marginal rate of return (MRR) of the tillage practices employed in the study, if a farmer changes from CT to MT, the MRR would be –815%, from MT to TT, it would be –95%, and as he changes from TT to ZT, the MRR would be 121%. The first two possible changes showed negative and extremely lower values than acceptable minimum rate while the last possible changes was higher than the acceptable minimum rate. The acceptable minimum return under on-farm research condition has been put at 100% (CIMMYT, 1988). This implies that farmers might benefit only in changing from TT to ZT. The lower cost of production in ZT, which was 21, 17 and 18% lower than that in CT, MT and TT treatments, respectively, is responsible for the observed result. In Ibadan south-western Nigeria, Couper *et al*. (1979) found that the total cost of inputs were lower in ZT than tilled treatments while the gross and net income were higher in ZT than tilled treatments. They concluded that even if the grain yields are the same in both tillage systems, the net revenue would be more in zero tillage. Philips and Young (1973) also reported that no tillage significantly reduced production costs due to elimination of tillage operations when basic crop production practices were adopted. They however stated that this will not guarantee profit if a careful attention is not paid to the cost – reducing effects of economical cropping practices. Similar observations have been made in Nigeria by other researchers (Maurya, 1986; Triplett and Van Doran, 1977; Omidiji et al., 1985). The findings from this study however differed from the observation made by some researchers (Huxley, 1975; Narayanan, 1986; Malhi et al., 1988) where tilled treatments showed superiority over zero tillage. This contrast once again explains the need to exercise some caution in extrapolating results from one soil type/agro-ecology to other soil types and ecological zones and emphasizes the need for location – specific evaluation of tillage practices. The higher MRR and ZT notwithstanding, and considering the labour and time requirements in ZT system, there may be still be need for some degree of tillage operations. Such would help reduce some aspects of farm drudgery, save time and enhance some farm operations as well as improve soil and crop productivity. In such situations, TT and/or MT become(s) a more viable alternative.

Table 1. Effect of tillage practices on maize grain and cassava fresh root yields (t ha^{-1})

	Maize grain yield				**Cassava fresh root yield**			
Tillage Treatment	**1996**	**1997**	**1998**	**Mean**	**1996**	**1997**	**1998**	**Mean**
Conventional	2.86	2.62	2.45	2.64	35.88	34.20	39.22	36.43
Minimum	3.44	3.38	2.61	3.14	40.74	35.47	40.60	38.94
Traditional	3.13	3.38	2.94	3.15	39.11	44.72	32.85	38.89
Zero	2.78	2.54	2.63	2.65	29.92	43.64	35.80	36.45
SE ±	0.39	0.14	0.57		3.56	4.34	4.62	
CV (%)	15.72	5.81	26.42		15.89	18.68	14.17	
LSD (P<0.05)	NS	0.34	NS		NS	6.38	NS	

NS = Not significant

Table 2. Partial budget analysis for maize and cassava intercrop as influenced by tillage practices at Epemakinde, south-western Nigeria

	Tillage practice											
	Conventional (CT)			Minimum (MT)			Traditional (TT)			Zero (ZT)		
	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998
(a) Average crop yield (t ha$^{-1)}$)												
(i) Maize	2.86	2.62	2.45	3.44	3.38	2.61	3.13	3.38	2.94	2.78	2.54	2.63
(ii) Cassava	35.88	34.20	39.22	40.74	35.47	40.60	39.11	44.72	32.85	29.92	43.64	35.80
(b) Gross return for:												
(i) Maize at ₦17,000 t^{-1}	48,620	44,540	41,650	58,480	57.460	44,370	53,210	57,460	49,980	47,260	43,180	44,710
(ii) Cassava at ₦2000 t^{-1}	71,700	68,400	78,440	81,480	70,940	81,200	78,220	89,440	65,700	59,840	87,280	71,600
Total gross return + (N/ha^{-1}) (Revenue)	120,380	112,940	120,090	139,960	128,400	125,570	131,430	146,900	115,680	107,100	130,460	116,310
(c) Labour/machine (₦ ha^{-1}) for:												
(i) Land preparation*	12,000	14,000	14,000	10,333	12,000	12,000	12,000	12,000	12,000	5,000	6,166.67	6,666.67
(ii) Planting	4,166.75	4,333.33	4,333.33	4,166.75	4,333.33	4,333.33	4,166.75	4,333.33	4,333.33	4,166.75	4,333.33	4,333.33
(iii) Weeding	10,000	10,200	10,200	10,000	10,200	10,200	10,000	10,200	10,200	10,000	10,200	10,200
(iv) Harvesting	5,000.1	5,200	5,200	5,000.1	5,200	5,200	5,000.1	5,200	5,200	5,000.1	5,200	5,200
(d) Cost of farm input (₦ha^{-1})												
(i) Maize	375	562.5	637.5	375	562.5	637.5	375	562.5	637.5	375	562.5	637.5
(ii) Cassava	1,042	1,042	1,042	1,042	1,042	1,042	1,042	1,042	1,042	1,042	1,042	1,042
(iii) Apron plus 50^{DS}	562.5	562.5	562.5	562.5	562.5	562.5	562.5	562.5	562.5	562.5	562.5	562.5
Total Costs	33,146.35	35,900.33	35,975.33	31.479.35	33,900.33	33.975.33	33,146.35	33,900.33	33,975.33	26,146.35	28,067	28.642
Net benefit (₦ha^{-1}) ++	87,233.65	77,039.67	84,114.67	108,480.65	94,499.67	91,594.67	98.283.65	112,999.67	81,704,67	80,953.65	102,393	87,668
Marginal rate of return (%)**	18.95	-70.62	-9.88	87.44	-23.28	11.56	52.28	31.29	-17.55	-	-	-

Note: * Cost for clearing and packing for all treatments; heaping for TT, ploughing for MT and ploughing and harrowing for CT.

$$** \text{ Marginal rate of return} = \frac{\text{Extra benefit from new technology}}{\text{Marginal cost}} \times \frac{100}{1}$$

+ Total gross returns = Field price/t x average yield (t/ha).

++ Net benefit = This is calculated by subtracting the total costs that vary from the total gross returns.

Note: ₦42.00, ₦43.00 and ₦45.00 = US $1 in 1996, 1997 and 1998, respectively.

Table 3. Marginal analysis for maize and cassava intercrop as influenced by tillage practices at Epemakinde, south-western Nigeria (1996-1998).

Treatment	Variable cost (₦)	Marginal cost*	Net benefit (₦ ha^{-1})	Marginal net benefit **	Marginal rate of return (%)
Conventional	105,022.01		248,387.99		
		5,667.00		-46,187.00	-815
Minimum	99,355.01		294,574.99		
		-1,667.00		1,587.00	-95
Traditional	101,022.01		292,987.99		
		18,166.66		21,973.34	121
Zero	82,855.35		271,014.65		

* Marginal cost = Change in costs from one treatment to another.

** Marginal net benefit = Change in net benefit from one treatment to another.

4.0 Conclusion

The development of appropriate tillage practices is among the challenges facing successful farm management in the tropics, particularly at subsistence level. Therefore, appropriate tillage practice(s) could be one of the panaceas for reducing cost of production and hence increasing farm profit. This study showed that for yield enhancement, some level of soil tillage is desirable. Therefore for improved yield and farm profit, the MT treatment is the most appropriate.

Correspondence to:
Nyaudoh U. Ndaeyo
Department of Crop Science
Faculty of Agriculture
University of Uyo
P.M.B. 1017
Uyo, Akwa Ibom State
Nigeria.
Cellular Phone: +2348023285242
+2348027519138
Email: dr_nundaeyo@yahoo.com.

References

1 Agboola, A. A. and Ogunkunle, A. O. (1993). *Site characterization at Epemakinde, Ondo State, Nigeria. Technical Report on Land Development for Sustainable Agriculture in Africa.* IBSRAM/AFRICALAND 1938 – 1992, Bangkok, Thailand.

2 Aiyelari, E. A. and Agboola, A. A. (1998). Evaluation of three hush clearing methods in primary forests of the humid tropics. *Agricultural Mechanization in Asia, Africa and Lation America (AMA)* 29 (4): 67-72.

3 Aiyelari, E. A., Ndaeyo, N. U. and Agboola, N. U, (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.

4 CIMMYT (International Wheat and Maize Improvement Center), (1988). From agronomic data to farmer recommendations: An Economic Training Manual. Mexico, D. F. 33. pp. 16-26.

5 Couper, D. C., Lal, R. and Classen, S. (1979). *Mechanized no-till maize production on an Ultisol in tropical Africa.* In: Soil tillage and crop production, (editor). Lal, R. pp. 147-160. IITA Proceedings No. 2: Ibadan, Nigeria: IITA.

6 Eneji, E. A., Aiyelari, E. A. and Agboola, A. A. (1997a). Influence of forest clearing methods on weed incidence and maize yield at Epemakine, South Western Nigeria. *Nigeria Journal of Weed Science*, 10: 21-26.

7 Eneji, A. E., Aiyelari, E. A., Agboola, A.A., Kutu, F.R., Ndaeyo, N.U. and Akinbola, G.E. (1997b). Preliminary Investigations on the effect of bush clearing on soil nutrients status. *Journal of Tropical Forest Resources*, 13 (1): 16 – 26.

8 Gomez, K. A. and Gomez, A. A. (1984). *Statistical procedures for Agricultural Research (2nd edition).* John Wiley and Sons, New York, pp. 187-240.

9 Henderson, J. S. W. and Stonehouse, D. P. (1988). Effect of soil tillage and time of planting on corn yield and farm profits in Southern Ontario. *Canadian Journal of Agricultural Economics*, 36 (1): 127-141.

10 Hulugalle, N. R., Lal, R. and Opara-Nadi, O. A. (1985). Effect of tillage system and mulch on soil properties and growth of yam (*Dioscorea rotundata*) and cocoyam (*Xanthosoma sagitifolium*) on an Ultisol. *Journal of Root Crops*, 11: 9-22.

11 Huxley, P. A. (1975). *Zero-cultivation studies at Morogoro, Tanzania*. In: Proceeding of IITA Collaborators, meeting on grain legume improvement. 8-13 June 1975, IITA. Ibadan, Nigeria. pp. 153-154.

12 IITA (International Institute of Tropical Agriculture) (1990). *Cassava in tropical Africa: A reference Manual.* IITA, Ibadan, Nigeria. pp. 53-81.

13 Keeling, J. W., Wendt, C. W., Gannaway, J. R., Onken, A, B., Lyle, W. M., Lascano, R. J. and Abernathy, J. R. (1988). *Conservation tillage cropping systems for the Texas Southern High Plains.* In: Proceedings of the 1988 Southern Conservation Tillage Conference (Tupelo, 1988). (editor). K. H. Remmy, 19-21. Mississippi Agriculture and Forestry Experiment Station. Special Bulletin 88-1. Mississippi: MAFES.

14 Klute, A. (1982). Tillage effects on hydraulic properties of soil. A review. In: predicting tillage effects on soil physical properties and processes. *ASA Special Publication* No. 44: 27-43.

15 Lal, R. (1977). *Importance of tillage systems in soil water management in the tropics.* In: Lal, R. (editor), Soil tillage and crop production. IITA, Ibadan, Nigeria. pp. 25032.

16 Lal, R. (1983). *Soil conservation techniques in Nigeria.* In: Proceedings First National

Tillage Symposium held at Ilorin, Nigeria. pp. 39-50.

17 Lyle, W. M. and Bordovsky, L. P. (1987). *Integrating irrigation and conservation tillage technology*. In: conservation tillage: Today and tomorrow (Proceedings, Texas, 1987), (editor) T. J. Gerik and B. L. Harris, pp. 67-71. Texas Agriculture Experiment Station, Publication No. MP-1636. College Station, Texas: TAES.

18 Malhi, S. S., Mumey, G., O'Sullivan, P. A. and Harker, K. N. (1988). An economic comparison of barley production under zero and conventional tillage. *Soil and Tillage Research*, 11: 159-166.

19 Maurya, P. R. (1986). Effect of tillage and residue management on maize and wheat yield and on physical properties of an irrigated sandy loam soil in northern Nigeria. *Soil and Tillage Research*, 8: 161-170.

20 Maurya, P. R. and Lal, R. (1979). *No tillage system for crop production on an Ultisol in eastern Africa.* In: Lal, R. (ed.) Soil tillage and crop production. IITA, Ibadan, Nigeria. pp. 207-220.

21 Narayanan, A.V. S. (1986). Long-term on-farm economic effects of crop land erosion in the black soil zone of Alberta. *Canadian Farm Economic*, 20 (2): 27-38.

22 Ndaeyo, N. U. and Aiyelari, E. A. (1997) Evaluation of different tillage practices for monocultural cowpea (*Vigna unguiculata* (L.) Walp) Production in Ibadan, South Western Nigeria. *Tropicultura*, 15 (4): 195 – 202.

23 Ndaeyo, N. U., Ekpe, E. O., Edem, S. O. and Umoh, U. G. (2003). Growth and yield process of *Colocasia esculenta and Xanthosoma saggitifolium* to tillage practices in Uyo, Southeastern Nigeria. *Indian Journal of Agricultural Sciences,* 73 (4): 194 – 198.

24 Ohiri, A. C. and Ezumah, H. C. (1990). Tillage effects on cassava (*Manihot esculentai*) production and some soil properties. *Soil and Tillage Research*, 17: 221-229.

25 Ojeniyi, S. O. (1986). Effect of zero tillage and disc ploughing on soil water, soil temperature and growth and yield of maize (*Zea mays* L.). *Soil and Tillage Research*, 7: 173-182.

26 Ojeniyi, S. O. and Agboola, A. A. (1995). A review of tillage requirement of food crops in Africa. *African Soils*, 28: 259-266.

27 Omidiji, M. O., Oyedokun, J. B. and Ajunwon, S. O. (1985). *Evaluation of some tillage methods for food crop production in Southwestern Nigeria*. Proceedings International Society of Soil Science, (Commission IV and VI) organized by the Soil Sci. Soc. Nigeria, 21-26 July 1985, Ibadan.

28 Opara-Nadi, O. A. and Lal, R. (1987). Effect of no till and disc ploughing with and without residue mulch on tropical root crops in southeastern Nigeria. *Soil and Tillage Research*, 9: 231-240.

29 Osuji, G. E. (1984). Water storage, water use and maize yield for tillage system on a tropical Alfisol in Nigeria. *Soil and Tillage Research*, 4: 339-348.

30 Philips, S. H. and Young Jr., H. M. (1973). *No tillage farming*. Reiman Associates, Milwaukee, Wisconsin. 224p.

31 Stonehouse, D. P, (1991). The economics of tillage for large-scale mechanized farms. *Soil and Tillage Research*, 20: 333-351.

32 Triplett, G. B. and Van Doran, D. M. (1977). *Agriculture without tillage*. Scientific America, 236 (1): 28-33.

25/09/2010