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Preliminary Study on Zero Tillage and Bulldozing as Land Preparations on Oil Palm Growth, Yields and Soil Nutrient Status.

W. UBI and H. IGWE

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ABSTRACT

A comparative study on zero tillage and bulldozing, as land preparations for oil palm seedling transplanted into the field was conducted at Ayip Eku Oil Palm Estate between 1993 and 2000. The experimental site was a five-year fallow land in which *Panicum maximum* (Guinea grass) and *Centrosoma pubescence* were dominant fallow species. Three years after planting, the N, Mg, K and Na contents of the soil were reduced to half in the zero tillage plots and reduced approximately four fold in the bulldozed plots. The P content of the soil in the zero tillage plots was two times higher than that in the bulldozed plots. After 12 months of transplanting into the field, zero tillage exerted a highly significant ($P < 0.05$) effect on plant growth as evidenced in greater crown diameter and the proportion of green leaf blades of the zero tillage plots compared with bulldozed plots. At 8 years a more positive effect on yield of Fresh fruit bunches (FFB) and on soil nutrient status were recorded in the zero tillage plots compared with bulldozed soil.

KEY WORDS: Zero tillage and bulldozing, oil palm growth, yield and soil nutrient status

INTRODUCTION

The oil palm (*Elaeis guineansis Jacq*) is monoecious and cross-pollinated, and individual palms are usually very heterozygous. It strives in a wide range of soils in Nigeria, but the most important soils for oil palm cultivation are the acid sands derived from the coastal plan sands and basement complex soils of South eastern and Western Nigeria, (Omoti et al 1986). Yields are limited and very often drop drastically due to nutrient deficiency caused by previous cropping, nature of land preparation, cultivars planted, weather effect such as prolonged drought resulting in low water table, inadequate moisture resulting from low movement of inorganic solutes and heavy rains that cause flood, erosion, leaching and associated increase in soil acidity.

The basement complex soil of Ayip Eku Oil Palm Estate near Oban hills has basement rocks consisting mainly of gneisses, migritires, schists, quartzites and marbles but have emplaced within them smaller bodies of granite or synenite and intrusions of more basic amphibolites and olivinrich dykes (Mudoch et al 1976). The chief features of these basement complex soils include a sandy surface horizon inderlain by a weekly-developed clayey, mottled, and occasionally concretionary sub soil (FAO 1966). Bulldozing as a means of land preparation has widely been adopted in the establishment of farm lands and tree crop plantations in the tropics especially where a large scale plantation development is involved.

Some people seem to support the zero-tillage method, which is assumed to be cost effective and reduces nutrient losses. Much research into a comparative effect of zero-tillage with bulldozing in the plantation agriculture had not been done. The objective of this study is to estimate the influence of zero tillage compared with bulldozing, as means of land preparations, on growth parameters, yield and nutrient status of polybag seedlings transplanted into the field.

MATERIALS AND METHODS

The experiment was conducted at Ayip Eku Oil Palm Estate near Calabar, Nigeria and the rainfall values for the area during the growth period are given in Table 1. Polybag seedlings which had been planted as germinated seeds from Nigerian Institute for Oil Palm Research (NIFOR) and managed in a single stage nursery at Ayip Eku Oil Palm Estate as outlined by Aya (1976) were transplanted into the field at 10 months age, and used for this study.

This study was carried out for 8 years, 1993 – 2000. The experimental site was previously cropped with cassava followed by a four-year fallow in which *Panicum maximum* (Guinea grass) and *Centrosoma pubescens* were dominant fallow species.

Soil samples were collected from the experimental site for the chemical analysis at a sampling depth of 0.20cm 20 – 40cm, 40 – 60cm, 60 – 80cm of four samples per depth. (Table 2). Soil analysis was done at Alabama Agric and Mechanical University, U. S. A., Soil samples were analysed for organic carbon by dichromate oxidation). Total N (by Kjeldahl digestion) Bray – 1P; and for I N ammonium acetate extractable Ca, Mg and K. Effective cation exchange capacity (ECEC) was obtained by summation of NH_4 OAC – exchangeable bases plus Kcl exchangeable acidity. Soil PH was by the use of PH meter (Pye model 291). Potassium – chloride – acidity (H^+ + $A1^{3+}$) was determined by titration with 0.05 N NaOH). The standard procedure as contained in the method of soil analysis by Black et al (1965) were used for the analysis of all the samples. At 3 years of the experiment, soil samples were again analysed to determine the values of the exchangeable cations. A randomised complete block design was used with four replications, and 25 palms per plot, and plot size was 50m x 50m at a spacing of 8.8m triangular. The zero tillage area was cleared packed and removed. The second treatment involved a mechanical use of a bulldozer in the land preparation, in which the top 30cm of the soil was scraped off.

A planting hole deep and wide to just accommodate the entire polyethylene bag in which the seedling was growing was dug at each planting site in the field just prior to the planting exercise. The bag was then stripped off from the soil ball encampossing the seedling roots, taking care to avoid injury to the latter and disturbance to the soil ball. The intact ball of

W. UBI, Director / Head of Department Ministry of Agriculture, 3 Barrack Road Calabar, Nigeria.
H. IGWE, Ministry of Agriculture, 3 Barrack Road Calabar, Nigeria.

Table 1: Ave-age rainfall values (mm) for 1993 – 2000

Months	1993	1994	1984	1996	1997	1998	1999	2000	Rainfall (mm)
	Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		Rainfall (mm)		
January	15.6	16.0	8.1	9.0	24.8	25.0	21.6	22.7	9.6
February	40.8	39.9	28.6	27.2	26.2	27.1	20.4	21.4	19.2
March	41.2	40.6	35.4	36.4	48.1	49.2	31.2	32.0	24.1
April	52.1	53.0	29.2	28.7	40.7	39.5	52.7	51.6	48.5
May	81.4	80.6	92.5	93.0	67.2	68.0	127.5	126.3	97.2
June	121.7	122.4	124.1	124.3	158.9	157.8	121.6	122.4	134.8
July	97.6	98.1	98.7	97.8	162.5	163.0	101.2	102.0	98.2
August	65.2	64.9	78.5	79.0	107.6	107.5	92.4	93.1	85.6
September	82.5	83.0	91.2	92.1	92.5	93.2	91.0	92.3	71.4
October	49.3	48.5	52.7	53.1	87.4	88.1	41.5	42.4	16.9
November	31.0	32.1	29.4	28.9	42.5	43.2	9.1	9.0	10.4
December	10.4	10.2	11.2	11.3	15.2	15.4	4.8	4.6	5.1
Mean	57.4	57.4	56.6	56.7	72.8	73.1	59.6	60.0	51.8

Source: Metrological station, Ayip Eku Oil Palm Estate near Calabar, Nigeria.

Table 2: Fertilizer applied Year of Planting

	0	1	2	3	4	5
			Rates kg/Palm year			
N as Urea	0.23	0.46	0.57	0.57	0.57	0.00
P as Super phosphate	0.23	0.46	0.68	0.68	0.68	0.00
K as Muriate of potash	0.46	0.53	0.75	0.75	0.75	0.00
Mg as Magnesium Sulphate	1.02	2.05	2.27	2.27	2.27	0.00

earth was then lowered into the prepared hole adjusting its depth where necessary by partial filing or further excavation until the top of the soil ball was flushed with the surrounding soil surface. The seedlings were finally consolidated in position by gently firming the soil around the palm base with the foot while maintaining the palm in an upright position. A uniform spacing of 8.84cm (29ft) triangular was adopted for this study Aya, (1978). Fertilizer and weeding routine operations (Hartley, 1967; Gunn et al 1961) were uniformly applied to all palms.

To safeguard the palms against depredation by rodents in the field, each palm was protected by a cylindrical collar of wire netting mesh of 2.5cm, height 50.0cm, and radius of 15.0cm. Yields recorded for 3, 4 and 5 years from the zero tillage were compared with those from the bulldozed plots. This is because, the oil palm has variously been shown to follow a 3 – 5 years yield cycle (Haines 1959).

The following recommended fertilizer applications were carried out, Omoti, (1986). Surface application was carried out two times each year of the experiment. No fertilizer application was carried out during the 5th year of the experiment in which the final soil analysis was done.

Ten palms per plot were sampled for the determination of growth parameters 12 months after transplanting, Iremiren (1982). Crown diameter was determined by measuring the width of the crown in two directions – North – South and East and West and eventually finding the average of the two measurements. Five palms from the ten palms were randomly selected and the leaves and fronts separated into green leaf blades and dead leaf blades. A leaf was regarded green when it had over 50% of its length green. The two components were dried at a temperature of 60°C for 48 hours in a Galenkamp forced air oven, and then by the sum of all components (sum of green leaf blades wt, of sum of dead leaf blades wt) and multiplied by 100 to express each proportion as percentage on dry matter basis (Wilman et. al. (1999).

Total yields of fresh fruit bunches (FFB) were determined for each year (from the 5th year to the 8th year). Fruits were w ighed at the weight –bridge and the yield for each year expressed in tones per hectare.

Statistical analysis

Crop data were subjected to analysis of variance (ANOVA) and means compared with the Fisher's Least Significant Difference (LSD) at 5% level.

RESULTS

One of the most important underlying principles in the oil palm soil study has been to attain the potential yield of the palms and to maintain the soil fertility of the plantation soil throughout the life span.

The results of growth parameters from zero-tillage and bulldozed plots, after 12 months of field planting are presented in Table 4.

Table 3: Chemical Characteristics of Soils used in the experiment.

Horizon	Profile depth (cm)	Fine sand (0.5-8) 05m%)	Coarse sand (2mm-0.05mm%)	Silt (0.056 5-0.00 2m%)	Textural Class	Clay (0.00 2mm%)	PH		CEC	C %	N /Kg	Avail P mg/kg	Exchangeable Bases Cmol(+) kg-[1]				BS %
							H_2O	HCL					Ca	Mg	K	Na	
A	0.20	18-20	42.7	3.29	Scl	10.01	5.6	5.1	48.91	1.05	0.39	5.02	1.60	0.81	0.230	0.058	72.51
B1	20-40	16.00	41.4	3.16	Scl	13.40	5.4	5.2	38.42	0.95	0.36	3.43	1.56	0.69	0.148	0.68	67.03
Bt1	40-60	17.29	40.5	2.04	Sc	14.61	5.5	5.0	45.01	0.98	0.36	2.64	1.44	0.72	0.113	0.052	65.67
Bt 2	60-80	16.51	38.2	1.25	Sc	14.00	5.8	5.0	46.33	0.87	0.28	1.85	1.29	0.59	0.106	0.048	55.48

Table 4: Average growth parameters of zero tillage compared with bulldozed soil after 12 months of field planting.

	Zero Tillage	Bulldozed	LSD P=0.05
Crown diameter	988.6	873.1	86.2
Proportion of green leaf blades (%)	63.1	46.5	14.6
Proportion of dead leaf blade (%)	26.7	38.4	8.1
% Survival	99.7	90.4	8.5

Table 5: Average yield of FFB on zero tillage and bulldozed soils over 8 years of planting. Mean yield of FFB tones/ha/year

Years of planting	Zero tillage	Bulldozed soil	LSD (P < 0.05)
5	0.9	0.4	0.2
6	2.7	1.3	0.8
7	3.8	2.1	1.2
8	4.7	3.4	1.6
Mean	3.0	2.4	

Crown Diameter, Proportion of Green and Dead Leaf Blades

At 12 months of the experiment, zero tillage exerted significant in"uence on g crown diameter, and the proportion of green leaf blades were significantly (P= 0.05) higher in the zero tillage plots than in the bulldozed plots. The average crown diameter of 988.6cm was obtained from zero tillage and this value was significantly higher than the value (873.1) obtained from the bulldozed soil. There was a 13.2% (873.1 – 988.6) increase in crown diameter in zero tillage compared with bulldozing. The proportion of green leaf blades on the average was highest in the zero tillage (63.1%) and this value was significantly (P < 0.05) higher than that (46.5%) obtained in bulldozed soil. There was on the average, a 35.6% (46.5 – 63.1) unit increase in the leaf blades from the zero tillage plots compared with the bulldozed soil.

The proportion of dead leaf blades (38.4%) was highest in the bulldozed soil, on the average, and this value was significantly (P < 0.05) higher than the value obtained from zero tillage plots. There was on the average a 43.8% (26.7 – 38.4) unit increase in dead leaf blades in the bulldozed soil compared with zero tillage plots given the same treatment. About 99.7% of palms transplanted into the field survived from zero tillage plots compared with 90.4% obtained from bulldozed plots.

Yield of FFB

The data indicate that nature of land preparation for planting of oil palm seedlings in the field exert a highly significant effect on the yield of fresh fruit bunches (FFB). The FFB produced from zero tillage plots (0.8, 2.7, 3.8, and 4.7 t/ha-[1]) for 5, 6, 7, and 8 years respectively, were significantly (P < 0.05) higher than values obtained from bulldozed soil.

On the average, the FFB yields in the 5[th] and 6[th] years 0.9 and 2.7 t/ha-[1]) respectively from the zero tillage plots were more than double that of bulldozed soil. There was a 25.0% (2.4 – 3.0) unit increase in FFB on the average from the zero tillage plots compared with bulldozed soil.

Table 6 shows the *influence* of zero tillage and bulldozing of land on the soil nutrient status after 3 years of transplanting oil palm seedlings into the field. The chemical characteristics of the soil used for the experiment before transplanting contained on the average, 22.2g/KgN 2.764 cmol (+) kg-[1] Ca, 1.268 coml(+) kg-[1]Mg, 0.278cmol(+) kg-[1]K, O,304 coml.(+) kg-[1] Na; and 2.868 mg/kg P.

At 3 years after field planting, the N, mg, K and Na contents in the soil were reduced to more than half in the zero tillage plots and approximately four fold reduction in the bulldozed plots. The Ca and P contents of the zero tillage plots after 3 years were *more* than double that of the bulldozed plots.

Soil Nitrogen and Organic Matter

The significant differences in organic C and total N levels in the profile 0 – 80cm layer between the zero tillage and bulldozed soil indicates the higher level of organic matter in the zero tillage plots. The values of organic carbon and nitrogen from the zero tillage plots were significantly (P < 0.05) higher than those values obtained from bulldozed soil, with moderately larger amount of total N accumulation in the layers of zero tillage than in the bulldozed soil (Table 9).

Soil PH and exchangeable Ca and Mg

After 3 and 5 years of *planting*, both zero tillage plots and bulldozed soil resulted in a decrease in soil PH in soil horizon, up to a depth of about 80cm (Tables 7 & 9) compared with the initial soil PH before the experiment. Zero tillage maintained a high level of Ca, and Mg, after 3 and 5 years of planting and these values were significantly (P 0.05) higher than values obtained from bulldozed soil. (Tables 7 & 9).

Potassium, phosphorus and sodium

Zero tillage resulted in accumulation of available P (Bray 1P) and exchangeable K and Na in the soil profile 0-20 cm layer, after 3 and 5 years. Although the values are lower than those obtained at the beginning of the experiment but are significantly (P < 0.05) higher than those obtained from bulldozed soil (Tables 7 and 9). There was considerable down wards movement of P together with the higher levels of available P in both treatments and relatively lower available P (Bray I P) levels in the surface horizons of bulldozed soil.
The greater mobility of K in the soil profile is generally expected, particularly in the plowed plots, in view of the

Table 9: Effect of zero tillage and bulldozing on the soil nutrient status after 3 years of field planting.

Nutrients	Soil chemical characteristics used in this study	Mean soil nutrient status after 3 years		
		Zero tillage	Bulldozed	LSD P = 0.05
N g/kg	33.2	11.2	4.200	3.5
Ca cmol (+) kg^{-1}	2.764	2.512	1.300	0.960
Mg cmol (+)Kg^{-1}	1.268	0.296	0.183	0.642
K cmol (+) Kg $^{-1}$	0.278	0.104	0.052	0.024
Na cmol (+) kg^{-1}	0.304	0.086	0.058	0.026
Pmg/kg	2.868	2.546	1.222	0.0586

predominance of Kaolinite throughout the profile. The zero tillage treatment appears to result to slight stratification of exchangeable K levels in the 0-80cm profile (Table 9). A similar phenomenon though not statistically confirmed, appeared to occur in the PH profile of the zero tillage plots after 5 years cropping.

Inspite of the active nutrient utilization by palms at the early years of planting, the average nutrient content of the soils for zero tillage at 5 years almost doubled that of the bulldozed plots (Table 8). The zero tillage plots have consistently exerted very significant effect on the nutrient status after 5 years of cropping, compared with bulldozed plots, throughout the study period.

DISCUSSIONS

These findings suggest that better results could be achieved with zero tillage than with bulldozing. This is because nutrient losses are minimized and oil palm seedlings will therefore utilize applied fertilizer for growth and development than in the bulldozed soil. Again, the period of high temperature with low rainfall during the season, helped to conserve soil nutrients with the absence of erosion and run-offs in the zero tillage plots and could account for the greater enhancement as evidenced in the proportion of green leaf blades and significant crown diameter observed than in the bulldozed plots. Lal (1975) reported high soil temperature as one of the factors that retard crop growth in the tropical soils.

The differences in crown diameter and proportion of green leaf blade in the zero tillage plots compared with bulldozed plots may be attributable to variation in soil nutrient status, a few years after planting(Table 3).

One of the most pronounced effects of zero tillage system is the maintenance of higher level of soil organic matter especially in the surface soil, compared with the bulldozed plots where crop residues are prolonged under the soil. The significant differences in organic and total N levels in the soil profile between the zero tillage and bulldozed soil may be due primarily to losses of surface soil by erosion and run- off experienced in bulldozed plots (Lal 1976a; 1979; Philip and Young 1973). In addition, the more rapid and fast rate of decomposition of fresh plant materials and immobilization activities of soil in the bulldozed plots (Juo and Lal 1977) may also result in a lower level of C and N, since about equal amounts of crop residue were returned to the soil under both treatments. The high soil organic matter in the zero tillage plots could be seen from the relatively low C/N ratio indicating that mineraliszation was highly induced by soil micro flora compared with immobilization activities resulting in the use-up of soil N in the bulldozed soil. Again, the moderately large amount of total N accumulated in the surface soil of the zero tillage suggests that mineralization may contribute an important portion of available N to plants, during the growing season and could account for the higher crown diameter and higher proportion of green leaf blades recorded in zero tillage plots compared with bulldozed soil. This can also be illustrated by the higher yield of FFB obtained from the zero tillage plots than the bulldozed soil.

Zero tillage system in its early stage of adaption may require higher rates of N.P.K fertilizers than the bulldozed soil, particularly for crops like oil palm as it was evidenced in the yields of FFB in the first 4 years of cropping (data not provided) nevertheless, the reverse was the case a few years

Table 7 Soil Characteristics After 3 Years of Planting

Profile Depth	Fine sand% (0.5-8mm)	Course sand% 92-0.5mm)	Silt%	Clay%	PH H20 (Sand: H20 Ratio)	HCl	ECEC cmol (+) Kg^{-1}		Pmg/kg	C%	N	Ca	Mg	K	Na	BS%
0-20	51	1.9	6.92	6.92	5.1	4.8	37.2	4.62	1.2	0.15	0.85	0.10	0.05	0.046	24.5	
20-40	33	1.8	25.30	25.30	5.0	4.6	37.8	2.46	1.03	1.02	0.79	0.12	0.04	0.044	22.3	
40-60	32	1.8	32.51	32.51	5.0	4.8	39.6	2.08	0.95	0.19	0.81	0.21	0.04	0.043	21.7	
60-80	29	1.2	25.23	25.23	4.8	4.9	36.5	1.95	0.72	0.17	0.72	0.41	0.03	0.041	18.9	
80-100	30	41	1.2	28.04	4.6	4.7	34.0	1.62	0.48	0.14	0.68	0.11	0.02	0.039	16.3	
Bulldozed Plots																
0-20	42	38	0.91	6.97	4.8	4.2	27.2	1.40	0.64	0.06	0.70	0.08	0.03	0.040	18.4	
20-40	41	39	0.64	26.1	4.8	4.4	26.8	1.08	0.58	0.05	0.80	0.07	0.03	0.031	17.8	
40-60	38	37	0.63	34.0	4.5	4.3	17.6	1.02	0.59	0.04	0.70	0.10	0.02	0.028	18.1	
60-80	31	36	0.59	27.2	4.8	4.5	16.7	0.75	0.42	0.03	0.65	0.15	0.03	0.026	16.2	
80-100	31	35	0.60	29.1	4.5	4.5	18.8	0.86	0.31	0.03	0.40	0.06	0.02	0.026	16.8	

Table 8: Chemical characteristics of the soils after 5 years of planting

Nutrients	Soil content before the experiment	Zero tillage plots 5 years after planting	Bulldozed 5 years after planting	LSD P = 0.05
Ng/kg	33.2	7.400	3.600	2.400
Ca cmol (+)kg^{-1}	2.764	1.732	0.984	0.372
Mg cmol(+)kg^{-1}	1.268	0.056	0.032	0.074
Kcmol(+)Kg^{-1}	0.278	0.074	0.034	0.022
Nacmol(+)Kg^{-1}	0.304	0.110	0.064	0.024
Pmg/kg	0.868	2.168	1.038	0.394

Table 9: soil Characteristic after 5 year of planting Zero tillage plots

Horizon	Profile	Fine sand %	Coarse sand%	Silt %	Clay % (0.002mm)	PH H20	PH HCl	CEC	Organic C %	N g/kg	P Mg/kg	Exchangeable Bases Cmol(+) kg-1 Ca	Mg	K	Na	%B.S
A	0-20	53	45	5	12	5.1	5.0	31.0	1.42	0.15	4.81	1.01	0.041	0.043	0.058	65.8
B1	20-40	41	45	4	38	5.0	5.0	32.1	1.15	0.12	3.45	1.02	0.060	0.044	0.056	58.5
Bt1	40-60	38	44	4	45	4.6	4.6	28.5	1.02	0.03	3.18	0.87	0.009	0.035	0.061	56.2
Bt2	60-80	35	43	4	31	4.9	4.89	27.9	0.97	0.04	2.75	0.93	0.017	0.020	0.052	51.1
Bulldozed plots																
A	0-20	42	37	0.84	27.14	4.8	4.2	27.9	0.84	0.06	1.09	0.57	0.030	0.020	0.042	20.1
B1	20-40	42	38	0.61	58.60	4.6	4.3	18.4	0.81	0.03	1.04	0.62	0.012	0.022	0.037	18.7
Bt1	40-60	37	38	0.58	61.37	4.5	4.5	20.5	0.69	0.03	1.04	0.38	0.024	0.015	0.021	17.5
Bt2	60-80	31	37	0.60	68.52	4.6	4.6	20.9	0.73	0.02	1.01	0.47	0.013	0.013	0.032	17.2

erosion, soil exhaustion and leaching and could account for the low nutrient status of these plots and low yields consequently. These reports are in consonance with the reports of Olivin (1986). In the present study, and in both treatments the nutrients content continued to dwindle from the first year to the 3rd and 5th years. This implies that more N P K Ca and Mg fertilizers will be required later in the season for high yields. From these findings it is obvious that the recommended fertilizer rates by Omoti (1986) for oil palm growth in this part of Nigeria may be considered too low to meet plants demand and a review is suggested if optimum yields are to be obtained, and is at present, the subject of another investigation. Since farmers especially at large scale production might not avoid the use of machine, appropriate machines could be employed by ensuring that the are adjusted or use tree dozers with manual clearing rather than bulldozer alone.

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