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Tillage Methods and Wood Ash Effect on Soil Properties and Yield of Castor

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ABSTRACT

The effect of tillage methods and rates of wood ash on soil properties and yield of castor bean plant was studied in field trial at Abakaliki in three different planting seasons. The experiment was a split plot in randomized complete block design with three tillage methods (mound, ridge, flat) and four rates of wood ash (0tha^{-1}, 2tha^{-1}, 4tha^{-1} and 6tha^{-1}) replicated three times. Crop start version 7.2 was used to analyse data collected and mean separation was done using least significant difference (LSD) at 5% alpha level. The results obtained showed that tillage methods had no effect on seed yield in first and second years planting season, but had significant effect on the parameter in third year planting season. The values decrease as the year of planting increased. Mound was found to give the highest seed yield among the other tillage methods (TM). The value of this parameter obtained from 4tha^{-1} (Md4, Rd4, and Ft4) rate of wood ash (WA) was higher in value than the other rates in first and second year planting. While 6tha^{-1} (Md6, Rd6, Ft6) rate of WA gave the highest value in third year planting. The TM and wood ash (WA) interaction result show significant differences among the tillage methods and rates of WA, the values increased as the rates of WA applied increased. The result of soil properties showed that TM increased the value of the nutrients assessed in second year, but decreased in the third year planting. The value of these parameters observed in ridge method was found to be higher when compared to the values of mound and flat. The WA amendment was found to change the soil from slightly acidic to alkaline in second year to slightly acidic in third year. There were significant differences (P<0.05) among the rates in all the soil parameters tested. The control soil remained acidic throughout the three years of study. The TN and OC were greatly influenced by the addition of WA. Their values decreased as year of planting increased with exception of OC contents that increased in the third year. TM and WA interaction show significant differences (P<0.05) on the soil properties tested. Their values increased as the rates of WA increased and higher nutrient values were obtained more on WA treated soil than on non-treated soil. Based on the results of the study, it is evident that the tillage and wood ash can optimise soil productivity, increase the nutrient status of soil and yield of castor and that 6tha^{-1} rate of WA will be ideal, if the cropping season is to be observed beyond two years as it had strong residual effect on the tested parameters.

INTRODUCTION

Castor oil has been found useful for domestic, medicinal and industrial purposes. It is used in paints and vanishes, as lubricant in machinery and as purgative and laxative medically, (Singh, et al., 2003). In proximate analysis of castor seed and cake, Annogu and Joseph (2008) observed that the castor seed and cake are rich in nutrients with potentials of meeting the nutritional requirements of farm animals, if given proper treatments and supplementation with the deficient limiting amino acids. The deep root system, drought hardiness and quick growth make the growth of castor encouraging to dry land agriculture (Singh, et al., 2003).

With all these potentials of castor and climatic conditions of Nigeria, many castor bean farmers in south east Nigeria neither use soil amendments nor refer to any tillage method in their production even though they grow this crop on marginal soils. Hence, they do not obtain maximum return for their labour input in castor production. The research to identify the best management practices that will optimize the fertility status of these soils for high-level castor production is very important. This is because in tropical country like Nigeria, all round development in Agriculture depend on wise and efficient management of the soil, which is a medium for crop production, supplies the plant root and micro-organism with oxygen, water and nutrient needed for cell metabolism. For a given soil to effectively perform these functions, it must have good physical and chemical properties. Hence, the maintenance of these soil properties for productive agricultural activities becomes a major source of concern to any practicing farmer in south east Nigeria. There is a serious concern that intensive cultivation of some Agricultural soils may lead to the deterioration in soil structure and other physical properties of soil and, in turn decrease crop yields (Herman and Cameron, 1993; Wasswa et al., 2003; Eynard et al., 2004; Nweke, 2015; Nweke and Nnabude, 2015). Therefore, the success or failure of continuous cropping system depends largely on the physical and chemical conditions of the soil after each cropping season. This created the awareness and subsequent search for the best approaches that could be employed for achieving this particular purpose. The whole idea become more pertinent when one is equipped with the knowledge that the restoration of soil physical status unlike chemical properties once destroyed takes a considerable period of time before it can sustain profitable agricultural production.

In view of these facts, ideas and suggestions have been propounded. One of such is tillage. Tillage is an aspect of soil management that affect not only crop performance but also the maintenance of the integrity of the soil (Brady and Weil, 2002). Tillage implements affect the soil structure both directly and indirectly. By direct action, they create and destroy the soil aggregates. While indirectly they modify the conditions and affect the factors of the formation and disaggregating of soil structure. On the positive side, tillage has been found to be beneficial by helping to break down clods, incorporate organic matter into the soil and create a favourable seed bed which permits or allows better drainage, aeration and root penetration. However, it has been proved that over long periods, tillage operations have detrimental effect by causing degradation of soil structure (Karunatilake and Van Es, 2002; Khormali and Snamsi,2009, Six et al., 2000; Martins et al., 2003;Majaliwa et al., 2010.), as well as nutrient (Nael et al., 2004; Hartemink, 2006).

Wood ash as soil amendment has been found to have positive effect on soil characteristics and yield of crops. Mbah *et al.,* (2010) reported increased maize grain yield in acid ultisol with increased rates of wood ash. They further observed that there was no significant difference in the grain yield between 4tons/ha and 6t/ha application and therefore, any application higher than 4t/ha may increase soil nutrient but not necessarily yield. Ojeniyi and Adejobi (2002), Odedina *et al.,* (2003), Odum, (2007) and Awodun ,(2007) found that wood ash increased soil P, K, Mg, Ca and yield of vegetables and cowpeas respectively. While Owolabi *et al.,* (2003) observed that wood ash treatment applied to the soil increases the organic matter content of the soil, N, P, K, Ca, and Mg content and leaf K, Ca, and Mg status of maize and yam. They also found that the organic matter content increases are attributable to the nutrient supplied by the type of ash used. Odum *et al.,* (2007) found that the maize performance and nutrient status were enhanced in soil amended with sawdust ash plus urea.

Tillage with soil amendment has been found to be the most effective in soil management practice to ameliorate or minimize these problems. Even in the driest years, tillage improved soil productivity and crop yield with time, especially when tillage is combined with fertilization and the use of crop residues (Klaij and Hoogmoed 1993). While Akinola et al (2012), Agbede and Adekiya (2011), Ojeniyi et al (2012) and Agbede and Ojeniyi (2010) observed increases in crop yield and improvement in soil productivity when tillage was combined with organic wastes in Alfisol of southwest, Nigeria. Blevins et al., (1983) however recognized that the crop response to tillage plus organic manure depend on interacting factor including nature of organic manure, soil properties, crop characteristics and prevailing climatic conditions.

Tillage method (ridging and mounding) are used extensively, while flat (zero) are rarely used by farmers in Nigeria especially with castor bean plant production, under varying conditions of climate and soil. The choice of a particular method or technique is guided more by tradition and less by scientific enquiry. The influence of tillage on soil productivity has been reported to be location specific (Anazodo, 1987; Mbagwu, 1992; Ofori, 1993) who also observed a pronounced effect of various cultivation techniques on loss of soil and plant nutrients in run-off erosion. Thus the main objective of this study was to determine the effect of tillage practices (Mound,

Ridge, Flat) and wood ash on soil properties and yield of castor.

MATERIALS AND METHODS

Location of Experiment

This study was carried out in three different cropping seasons at Teaching and Research Farm of Faculty of Agriculture and National Resources Management (FARM), Ebonyi State University, Abakaliki: The area of the study is located within latitude 06°19[1] N and Longitude 08°06[1] of the southeast in the derived savannah agro-ecological zone of Nigeria. The rainfall distribution is bimodal with wet season from April to July and peak in June and September to November. It has an average annual rainfall range of 1700 – 1800mm. The temperature of the area ranges from 27°C – 31°C. The relative humidity of the study area is between 60 – 80% and the soil is ultisol and classified as Typic Haplustult by FDALR (1985). The vegetation of the area is dominated by *Andropogon gayamus, Panicum maximum, Pennisetum purpurem*, shrubs and some other weed species.

Land preparation and treatment application

A land area measuring 41m x 15m (0.0615ha) was mapped out and used for the study. The experimental site was cleared of the natural vegetation using cutlass and the debris removed. Tillage operation was done manually using hoe. The tillage treatments are Mound (Md), Ridge (Rd) and Flat (Ft). Wood ash of different levels was spread uniformly on the soil surface and buried in their respective plots immediately after cultivation. The details of treatments used are as follows:

1. Md0 – Mound without wood ash (Md0)
2. Rd0 - Ridge without wood ash (Rd0)
3. Ft0 - Flat without wood ash (Ft0)
4. Md + 2 t/ha of wood ash (Md2)
5. Md + 4 t/ha of wood ash (Md4)
6. Md + 6t/ha of wood ash (Md6)
7. Rd + 2t/ha of wood ash (Rd2)
8. Rd + 4t/ha of wood ash (Rd4)
9. Rd + 6t/ha of wood ash (Rd6)
10. Ft + 2t/ha of wood ash (Ft2)
11. Ft + 4t/ha of wood ash (Ft4)
12. Ft + 6t/ha of wood ash (Ft6)

Two castor seeds per hole were planted at a spacing of 0.9m between rows and 0.45m within row at a depth of 8cm. There was basal application of NPK fertilizer to all plots two weeks after plant. The seedlings were thinned down to one plant per stand two weeks after germination. Weeding was done manually with hoe at 3-week intervals till harvest. Harvesting was done when the capsules containing the seed turn brown. The harvested spikes was dried in the sun 2-3 days and then threshed to release the seeds. The seeds were in turn weighed and the yield expressed in tha^{-1}. The same procedure was repeated in the second and third year of the experiment but without application of wood ash in the third year to test the residual effect.

Experimental design

The total land area used for the study was 41m x 15m (0.0615ha). The experiment was laid out as split plot in a randomized complete block design (RCBD), with 12 treatments replicated 3 times to give a total of 36 plots each measuring 3m x 4m ($12m^2$). A plot was separated by 0.5m alley and each replicate was 1m apart. Four (4) rates of wood ash viz., control ($0tha^{-1}$); wood ash (WA) at the rate of 2t/ha equivalent to 2.4kg/plot, WA at 4t/ha equivalent to 4.8kg/plot and WA at 6t/ha equivalent to 7.2kg/plot were used for the study. Each treatment was replicated 3 times along with the three tillage methods (Mound, Ridge and Flat) used for the study.

Soil Sample Collection

Auger soil samples were randomly taken from ten (10) observational points in the experimental area at the depth of 0 – 20cm prior to planting. The Auger soil samples were mixed thoroughly to form a composite soil sample and used for pre-planting soil analysis of which the result is shown in Table I. Also the wood ash treatment used was analyzed for determination of its nutrient values, quantity and chemical composition. The result is presented in Table 2. At the end of each cropping season that is after crop harvest auger soil samples were collected from three observational points in each plot, the soil samples were air dried, sieved and used for chemical analysis.

Labouratory Methods

Chemical Properties

The soil sample collected for chemical analysis was air dried and sieved with 2mm sieve and used for chemical properties determination.

Total Nitrogen

This was determined using modified Kjeldahl digestion procedure as described by Bremmer and Mulvancy, (1982).

Organic matter and Organic carbon

Carbon occur in the soil in the form of carbonates (mainly $CaC0_3$), elementary carbon (Charcoal), littered plant and animal residues and humus which is the colloidal organic matter of the soil that no longer show the recognizable structure of leaves, wood, animal tissue

etc from which it has been derived. The organic carbon determination was done by the method of Nelson and Sommers (1982) and the value for the organic matter (OM) was obtained by multiplying the carbon value by the conventional Van Bemmelar factor of 1.724.

Agronomic parameter

The fertility status and productivity of any soil environment is physically observed or monitored and directly measured or quantified by measuring the agronomic parameters or properties of a crop growing on the soil. The measurement of which ranges from seed germination test to crop yield or seed yield depending on the desired parameter to be measured. For this particular study seed yield was studied and measured.

Seed Yield (tha $^{-1}$)

The seed yield per plot was measured when the capsule matures, dries and then threshed to release the seeds. Ten (10) castor plants per plot were selected and tagged. The seeds harvested from the tagged plants were weighed to get the yield per plot and then expressed to its hectare equivalent.

Data Analysis

The data generated were subjected to an analysis of variance test based on RCBD using CropStat software version of 7.2, while statistically significant difference among treatment means was estimated using the least significant difference (LSD < 0.05).

RESULT

Chemical contents of the soil and wood ash before application

The initial soil properties presented in Table 1 show that the soil contains low level of organic carbon (1.09%) and total nitrogen (0.056%). Hence the soil of the experimental site is considered poor in these essential plant nutrient elements. The ash also contains lower levels of organic carbon (OC) and total nitrogen (TN).

Table 1: Initial soil parameters before treatment application

Test Parameter	Value
Total nitrogen	0.056%
Organic carbon	1.09%
Organic matter	1.88%

Table 2: Chemical composition of the wood ash before application

Test Parameter	Value
Total nitrogen	0.042%
Organic carbon	0.657%
Organic matter	1.13%

Effect of Tillage and Wood ash on TN and OC

The effect of tillage methods presented in Table 3 for TN showed non-significant (P <0.05) differences among the tillage methods except for 1st year planting period. The Mound method showed that the highest TN value observed in 1st year planting, followed by the 3rd year result, while the least value was obtained from the 2nd year planting. The Ridge result indicated that the TN increased as the planting year increased, though decreased values were observed in residual year. The Flat result showed a contrary result of decreased value of TN as year of planting increased, hence the order 1st year > 2nd year > 3rd year. In comparison of the 3 TM for the years under study, the 1st year result of TN showed that highest value of TN was obtained in Mound, next in rank was Ridge while the least value was obtained from Flat. The 2nd and 3rd year planting result presented a different order of result which showed that in 2nd year the order was Ridge > Flat > Mound, for 3rd year the order was Ridge > Mound > Flat. The 2nd and 3rd year result indicated that highest value of TN was obtained from Ridge method.

The result of OC for the case of Mound showed highest value in residual year of which the percentage decrease in 2nd and 1st year planting respectively were 54.61% and 32.89 %. This simple infers that much OC was lost in the 2nd year planting either by plant up take, leaching or immobilization by soil organisms in building their tissue. The result of OC from Ridge and Flat showed a different result to that of the Mound for the years under study. The values of OC from Ridge and Flat showed that OC increased in soil as the years of planting increased, hence the order 1st< 2nd year < 3rd year planting for the two TM (Ridge and Flat). When the 3 TM are compared with regard to years of planting, it showed that higher value of OC was obtained in Mound next in rank was Ridge and least from Flat in 1st year planting. In 2nd year planting, the Flat showed a higher value among the 3 TM. The percentage difference in

value from that of Ridge and Mound relative to Flat value was 7.2% and 39.5% respectively. The residual year result presented an order of Ridge > Mound > Flat. Generally, the result showed that there was a variation in the value of OC obtained from the 3 years of study and the tillage methods studied.

The rates of wood ash application in Mound (Table 3) in the 1st year planting indicated that the value of TN increased with the rate of increase in wood ash. Among all the rates Md6 gave the highest value of TN in 1st year planting. The 2nd year and 3rd results were similar in the sense that the value of TN increased as the rate of wood ash increased to Md4, but the value decreased in Md6 showing that Md4 produced the highest value TN among all the rate of wood ash studied in 2nd and 3rd year planting results. In comparison of the three years of the study higher values of TN from the rates of WA were obtained from 1st and 3rd year planting compared to the 2nd year result. The result of WA on ridge did not present any particular order in any of the 3 years' studied. The result of 1st year planting showed an order of Rd6 > Rd2 > Rd4 > Rd0, 2nd year planting, Rd6 > Rd4 > Rd0 > Rd2. The 1st and 2nd year result showed that higher value of TN was observed in Rd6 among all the rates of WA. The residual year (3rd year) result however, presented a different order in the result obtained whereby Rd2 > Rd6 > Rd4 > Rd0. For the 3 years' study, the result of the rates of WA on Ridge indicated a decrease in value as the years of planting increased to 3 years for Rd4 and Rd6. Hence lower values for these two rates were obtained from the residual year compared to the other years of study. The result of WA on Flat for the 1st year planting showed that the content of TN was more in Ft0 compared to the values of the other rates of WA. Its percentage decrease in value in Ft6 the next in rank was 88.8%. The result differed greatly from the yield result presented in Table 3. Since this element is important element in chlorophyll cum leaf formation and photosynthesis, it is expected that the leaf area result of Ft0 should have been higher than the order rates rather the Ft4 that gave the least value of TN, yield the highest value of leaf area in Table 3. Showing that though the TN value in Ft4 is small, most are in available form for the uptake of the castor plant.

Table 3 Effect of Tillage and wood ash on TN and OC

Treatment	1st Year		2nd Year		3rd Year	
	%N	%OC	%N	%OC	%N	%OC
Mdo	0.070	0.770	0.070	0.810	0.056	0.720
Md2	0.094	0.970	0.084	0.610	0.070	1.980
Md4	0.126	1.210	0.112	0.650	0.140	1.640
Md6	0.140	1.130	0.098	0.690	0.126	1.740
Mean	0.107	1.020	0.091	0.690	0.098	1.520
Rdo	0.056	1.010	0.063	0.970	0.056	1.690
Rd2	0.113	1.090	0.056	1.300	0.140	1.830
Rd4	0.096	1.290	0.140	0.930	0.098	1.200
Rd6	0.156	0.570	0.206	0.850	0.112	1.740
Mean	0.105	0.980	0.116	1.013	0.102	1.615
Fto	0.750	1.090	0.056	1.450	0.085	1.800
Ft2	0.070	0.890	0.098	0.930	0.070	1.300
Ft4	0.056	0.610	0.126	1.330	0.126	1.540
Ft6	0.084	0.720	0.182	0.630	0.077	1.780
Mean	0.073	0.828	0.115	1.085	0.089	1.480
LSD0.05						
TM	0.02	0.18	NS	0.19	NS	NS
WA	0.03	0.22	0.03	0.25	0.02	0.27
TM x WA	0.02	0.07	0.01	0.06	0.01	0.09

Mdo = Mound without wood ash (WA); Md2 =Mound +2t/ha WA; Md4 = Mound + 4t/ha WA; Md6 = Mound + 6t/ha WA; Rdo = Ridge without WA ; Rd2 = Ridge +2t/ha WA; Rd4 = Ridge + 4t/ha WA; Rd6 = Ridge + 6t/ha WA; Fto = Flat without WA; Ft2 = Flat + 2t/ha WA; Ft4 = Flat + 4t/ha WA; Ft6 = Flat + 6t/ha WA

The 2nd year result showed that the value of TN increased as rates of WA increased, with the least value observed in Ft0 while 3rd year planting showed an order of Ft4 > Ft0 > Ft6 > Ft2. Also the 3 years' study showed that the values obtained from the 2nd year in all the rates are higher in value compared to 1st and 3rd year results though Ft0 result of the 3 years' study presents a contrary result to the acclaimed result. The result of OC indicated increase in value as the rates of WA increased to Md4 with a decrease in value in Md6 in 1st year planting result. The 2nd year result indicated a decrease in value as the rates of WA increased showing an order of Md2< Md4< Md6< Md0 while the 3rd year result showed an order of Md2 > Md6 > Md0 > Md4. In

comparison of the 3 years' of the study, the lowest value of OC was observed in Md2 in 2nd year planting, while higher values among the rates of WA studied was observed in the 3rd year planting period. In 1st year planting result for WA on Ridge; the highest value of OC was observed in Rd4, the percentage difference in value in Rd6, Rd0 and Rd2 relative to Rd4 were 72%; 28% and 20% respectively. The percentage difference in value indicated that Rd6 had the lowest OC value which might have risen from many factors like crop up take which might have influenced the yield result in Table 4.

The 2nd year result, however, showed a contrary order of Rd2 > Rd0 > Rd4 > Rd6, though least value of OC was still observed in Rd6 like in the 1st year planting result. The 3rd year which is the residual year presented a contrary result with an increased value of OC in all the rates of WA applied compared to 1st and 2nd year results. The order of result variation was Rd2 > Rd6 > Rd0 > Rd4. The rates of WA on Flat showed that the value of OC decreased with an increase in the rates of WA applied, though an increased value was observed in Rd6 but not commensurate in increased value with the value obtained in Rd0. In fact, the percentage decrease in value of OC in Rd6 relative to Rd0 was 33.94%. The 2nd year presented a scenario of Rd2 > Rd0 > Rd4 > Rd6. The 1st and 2nd year result showed that least value of OC was obtained from Rd6. The residual year result showed an increased value of OC in all the rates of WA visa – vie the values of OC in 1st and 2nd year rates of WA. The lowest value of 1.20% OC was observed in Rd4 in the 3rd year result. The rates of WA on Flat for the 1st year planting result presented an order of Ft0 > Ft2 > Ft6 > Ft4 which showed that lowest value of OC was obtained from Ft4. The 2nd year result however showed an increased value of OC compared to the 1st year result. The highest value of 1.45 % OC was observed in Ft0 and the next in rank was Ft4, while the least value was obtained in Ft6. The residual year (3rd year) result again showed greater increase in the value of OC in all the rates of WA applied when compared to the 1st and 2nd year results of rates of WA on Flat. The result variation showed Ft0 > Ft6 > Ft4 > Ft2. The result of the rates of WA for two parameters (TN & OC) for the 3 years of study showed significant differences among the rates of WA applied. The TN and OC content of the soil were greatly influenced by the application of WA.

The tillage methods and WA effects indicated significant differences among the parameters tested, showing that the effect of tillage and wood ash were very effective on the two nutrients tested. In most of the results higher values were recorded in ash amended soils than the control soils. Also values increased as the year of planting period increased with respect to OC while some results showed dependency of values obtained on the quantity of rates of WA applied.

Effect of Tillage and Wood ash on Weight of Seed (tha^{-1})

The result presented in Table 4 showed the result of seed yield. The result showed that TM had non-significant differences in 1st and 2nd year planting, but significantly affected the seed yield of castor in residual year (3rd). The result of the Mound indicated decreased value as the planting year increased, hence the order 1st year result > 2nd year result > 3rd year result. The percentage decrease in value of seed yield (SY) in the residual year relative to the 1st planting year result was 60.129%. The same result scenario of Mound was observed in both Ridge and Flat, but the decrease in value of SY of their 3rd year results relative to the 1st year result varies, they were observed to be 54.014% for Ridge method and 70.58% for Flat respectively. These values indicated that the greatest reduction in SY was very much observed in Flat and the next in rank was Mound. The 1st and 2nd year planting however, present a result order of Mound > Flat > Ridge, while the 3rd year showed a result order of Mound > Ridge > Flat. The 3 year results clearly showed that Mound method consistently recorded the highest seed yield. While the lowest seed yield values for the years of the study was recorded in Flat in the residual year.

The rates of WA on Mound for the 1st and 3rd planting year showed that the seed yield value was dependent on the rates of WA applied since result order for both was Md6 > Md4 > Md2 > Md0 while the 2nd year result showed a different order of Md4 > Md6 > Md2 > Md0. For the 3 years of study, the lowest SY values were obtained from Md0 in the residual year and the highest value from Md6 in 1st planting year. The result of ash on Ridge for the seed yield value was dependent on the quantity of ash applied since the value increased with increasing rate of ash. The 3rd year result presented a result order of Rd6 > Rd2 > Rd0 > Rd4. The findings from the 3 years' study showed that least value of seed yield was observed in Rd4 of residual year among all the other rates and the highest value from Rd6 of 1st year planting. The WA application on Flat indicated independent of the SY values on the quantity of ash applied except for the result residual year. The 1st and 2nd year planting result showed a variation of Ft4 > Ft6 > Ft2 > Ft0, while the 3rd year presented an order Ft6 > Ft4 > Ft2 > Ft0. For the 3 years study, the least and highest value of SY was observed in Ft0 in the residual year and Ft4 in the 1st year planting respectively.

Table 4 Effect of Tillage and wood ash on Weight of Seed (tha^{-1})

Treatment	1st Year	2nd Year	3rd Year
Mdo	0.640	0.527	0.337
Md2	1.803	1.687	0.713
Md4	2.353	2.437	0.867
Md6	2.447	2.333	1.050
Mean	1.861	1.746	0.742
Mdo	0.590	0.473	0.420
Rd2	1.177	1.067	0.863
Rd4	1.650	1.540	0.380
Rd6	1.913	1.800	0.970
Mean	1.333	1.220	0.613
Fto	0.790	0.677	0.313
Ft2	1.387	1.277	0.320
Ft4	2.063	1.953	0.527
Ft6	1.687	1.577	0.587
Mean	1.482	1.371	0.437
LSD 0.05			
Tillage method (TM)	NS	NS	0.27
Wood ash (WA)	0.57	0.55	0.29
TM x WA	1.0	0.97	0.47

Mdo = Mound without wood ash (WA); Md2 =Mound +2t/ha WA; Md4 = Mound + 4t/ha WA; Md6 = Mound + 6t/ha WA; Rdo = Ridge without WA ; Rd2 = Ridge +2t/ha WA; Rd4 = Ridge + 4t/ha WA; Rd6 = Ridge + 6t/ha WA; Fto = Flat without WA; Ft2 = Flat + 2t/ha WA; Ft4 = Flat + 4t/ha WA; Ft6 = Flat + 6t/ha WA

The tillage method and wood ash effect significantly affected the seed yield obtained from the 3 years' of study (Table 4). The highest seed yield was recorded in Mound and the least in Ridge. The values decreased generally as the planting year increased with the residual recording the lowest value of seed yield. There was much influence of ash on the parameter tested as higher values were recorded on the ash amended soils relative to the control soils. To attest to this, lowest values of seed yield were observed on control soils (Md0, Rd0 and Ft0). The plots that received $6tha^{-1}$ rate of WA (Md6, Rd6 and Ft6) consistently gave the highest seed yield values in the residual year. This particular result shows strong residual effect of $6tha^{-1}$ WA on the seed yield compared to other rates of WA.

DISCUSSION

Properties of the Soil and Wood ash at the Beginning of the Study

The soil analysis of the experimental site before the initiation of the study indicates that the soil of the area had values of total nitrogen 0.05% (TN), organic carbon 1.09% (OC), organic matter 1.88% (OM) of which was generally low, indicating that the soils of experimental site are poor and deficient in these nutrient elements. The TN content of the soil is much below the critical kevel for soils of south eastern, Nigeria (FMANR) and for crop production in most of the soils of the region. The low values might probably be due to agricultural activities taken place in the study area over the years or leaching activities. Since the parameters are at their lowest levels it is expected that both the soil and test crop will benefit from wood ash application in the long term. For manure is known to influence soil parameters positively. Tillage improved soil productivity and crop yield with time especially when tillage is combined with soil amendments (Klaji and Hoogmoed, 1993). The content of TN, OC, and OM in wood ash were found to be very small and hence classified and rated as been low in these nutrients.

Soil Properties

Soil structural modification through tillage is aimed at optimising soil conditions for improved soil-water infiltration and retention, minimise soil erosion and recycle organic matter cum soil nutrient for healthy growth and development of crops. The soil chemical parameters assessed indicated that tillage methods had effect on the chemical properties of the soil. Although after 3 years of study some of the parameters measured were found to be non- significant at $P < 0.05$. The non-statistical significant differences observed among the tillage methods on some of the parameters studied and the cropping years observed may be that the 3 years

study was not enough time for detecting changes in soil properties. Gomez *et al*., (2001) in their studies hypothesised that 5 years was enough time for detecting changes in soil properties.

The TN, OC result differed among the TM with the Ridge result taken the lead in 2nd and 3rd year planting result compared to Mound and Flat. The result of the two parameters however differed with the observations of McCarty *et al*., (1998) and Aon *et al*., (2001) especially with the N values when they observed that TM showed smaller or no differences in TN content retains in the 1st year of treatment and generally relative differences did not become significant until 3 years. The works of the following authors: Heenan *et al*., (2004); Green *et al*., (2007) Madejon, *et al*., (2007) and Battacharyya *et al*., (2008) showed that OC, TN increased in no-till (NT) and reduced tillage (RT) compared to conventional tillage (CT) and that the effect of tillage practices on TOC and TN in the surface layer of soil probably resulted from lowering of the TOC and TN contents of the soils. The potential differences in production between the three tillage methods (Mound, Ridge, Flat) and differences in waste distribution in the soil also might have influenced the result of chemical parameters. Nutrient availability is influenced by cropping systems and soil management practices like tillage methods, soil organic matter and biological activity. This scenario might have influenced greatly the result of the third year planting season.

The nature of the result of the tillage methods with regard to the chemical nutrients obtained may be linked to the environmental condition, type of soil and intensity of the tillage system that might have been done on the soil previously and those acting together with the type of crop species, soil properties and their complex interactions, according to Ishaq *et al*., (2002), might have influenced the nature of results obtained. Strudley *et al*., (2008) observed that the depth and intensity of tillage methods affect the soil chemical properties that affect plant growth and yield. This probable may be the reason why the results of the soil chemical properties obtained from Mound and Ridge differed much from that of Flat. The TN and OC contents of the soil were found to be influenced by the application of WA. However, their values decreased irrespective of TM the WA was applied in 2nd year and 3rd year planting period with the exception of OC values that increased in the 3rd year period though the decrease in values with regard to the aforementioned parameters in the 3rd year were inconsistent. The positive contributions of WA to soil OC and TN relative to the control plots were in line with the observations of Eggball (2002) and Okonkwo (2011).

Seed Yield

The seed yield result showed that the highest seed yield for the 3 years of study among the TM was recorded in Mound and the least in Ridge except the 3rd year result whereby the seed yield of Ridge was higher than the Flat value. Bessam and Marbet (2003) observed that conventional tillage promotes greater aeration of the soil which increases the breakdown of OM that releases a large quantity of nutrients to support plant growth. The observed yield increase in Mound method may be attributed to better soil physical conditions and nutrient availability, no wonder the much variation in the yield result of Mound compared to the Ridge and Flat as rate of soil inversion during tillage is much in Mound and Ridge compared to Flat. These released nutrients which become available for the plant uptake provide a short term economic advantage for tillage. Hence the drastic reduction observed in the yield parameters of the 3rd year planting result. Agbede and Adekiya (2011) observed yield increases of sweet potato by 42-62% in conventional tillage in 3years study under poultry manure levels when compared with zero (manual clearing) tillage. Soil OC has been noted by Shah *et al*., (2009) to temporarily increase nutrient available to plants. This is a short term benefit to the crop producer but a long term detriment to the quality of soil. The nature of the yield result obtained might be dependent on the type of test crop and TM studied because the best TM of one crop can adversely affect the productivity of another crop and soil properties. Hence indicating that crops may not always respond to a given tillage method in the same manner and degree. Kurshid *et al*., (2006) reported that among the crop production factors tillage contribute up to 20%, as it affects the sustainable use of soil resources through its influence on soil properties. Tillage systems effect on yield according to Griffith *et al*., (1993) are highly dependent upon soil type, drainage and climate. Kombiok *et al*., (2005) assessed the effect of tillage systems (mounding, ridging, ploughing harrowing) and no-tillage (flat field) on cowpea growth and yield components under ferric luvisol in the northern guinea savannah zone of Ghana and found that disc ploughing followed by disc harrowing resulted in the growth and yield of cowpea plant compared with that under no tillage (flat).

The WA effect on the seed yield generally show that the values obtained decreased gradually from 1st to 2nd year planting and drastically at the 3rd year planting period. The seed yield result of WA on Mound was relatively higher than the result of the ash on Ridge and Flat. The differences in values of the parameters tested could be attributed to the differences in plant nutrients in the rates of wood ash applied. The higher seed yield result observed in WA amended plots and the Mound compared to the control plots, Ridge and Flat methods may be due to higher content of nutrients in the rates of WA applied than the soil, because addition of manure increases the soil water holding capacity, and that means that nutrients would be made more available to the castor plants where nutrients have been added to the soil and this scenario might have been effective in the Mound. Akinloa et al (2012) observed that the addition of ash of tillage method applied in Afisol of southwest, Nigeria significantly increased the yield of soybean seed. The studies of Nweke (2014), Nweke *et*

al., (2014) also showed that the application of organic amendments to soils increased yield of crops.

The data recorded from the combined effect of TM and WA on the seed yield of castor show that Mound and WA at the rate of 4tha^{-1} (Md4) consistently gave the highest seed yield value in 1st and 2nd year planting but decreased in the 3rd year planting where the plots that received 6tha^{-1} (Md6) rate of WA and Mound gave the highest seed yield.

CONCLUSION

The findings from this study has clearly shown that soil application of wood ash and tillage practices has the potential to cause positive and useful changes in the fertility and productivity status of the soil by improving the soil properties and seed yield of castor. Increasing the rates of WA application led to increase in seed yield of which the increases were more on the Mound than on the other tillage methods. Soil application of wood ash at the rates of 2tha^{-1}, 4tha^{-1}, and 6tha^{-1} significantly increased castor seed yield relative to control plots. The tested soil parameters were also found to be increased, though their values decreased as year of planting increased. However, OC did not decrease in the third year planting rather it increased. TM and WA interaction were found to be effective on the assessed parameters and higher nutrient values were more obtained in WA amended soil than in non-amended soil (control). Wood ash can easily be sourced and cheap in the study area and its integration with tillage improved soil productivity and castor yield as was revealed in this study. The application of WA at rate of 6tha^{-1} is recommended if the cropping season is to be observed beyond two years, because of its strong residual effect observed in the tested parameters. That single dose application of wood ash at the rate of 4tha^{-1} may be ideal for short term cropping period, since there was no much difference observed between the results of 4tha^{-1} and 6tha^{-1} at the short term planting period, therefore higher application in short planting period may not be cost effective for the farmer.

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