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Physicochemical properties of an acid ultisol subjected to different tillage practices and wood-ash amendment: Impact on heavy metal concentrations in soil and Castor plant

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Highlights

- Soil hydraulic conductivity and porosity increased in woodash amended tillage.
- Rise in soil base saturation, organic C, P, N, CEC, pH in woodash amended tillage.
- Decrease in exchangeable acidity in wood ash amended tillage practices.
- Increased heavy metals in soil and plant, but to non-toxic level in woodash amended.
- Woodash improved soil properties at applied rate, no adverse effect on soil & crops.

Physicochemical properties of an acid ultisol subjected to different tillage practices and wood-ash amendment: impact on heavy metal concentrations in soil and Castor plant.

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Abstract

A field experiment was conducted in 2016 and 2017 cropping seasons to determine the effects of tillage practice alone and tillage practices amended with woodash on soil physicochemical properties and soil concentration, shoot and seed uptake of heavy metals (Fe,Zn,Cu,B,Pb) . The experiment was laid out as split plot in Randomized Complete Block Design with six treatments and three replications. The treatments were: Flat tillage alone (FO) Mound tillage alone (MO),Ridge tillage alone (RO) Flat tillage + 4 t ha^{-1} woodash, Mound tillage + 4 t ha^{-1} and Ridge tillage + 4 t ha^{-1} . Results of the study showed significant (p=0.05) increase in soil hydraulic conductivity and total porosity (%) in tillage practices relative to woodash amended tillage practices. Results of the study also showed significant (p=0.05) increase in soil base saturation, organic carbon, available P, soil total N, effective cation exchange capacity ,pH and decrease in exchangeable acidity in wood ash amended tillage practices relative to tillage practices alone. Significant (p=0.05) increases in heavy metals concentration in soil, shoot and seed of castor but to non-toxic level except Fe concentration in soil were observed in tillage practices amended with woodash and tillage practices alone. On the average RW was observed to have the highest improvement in the studied parameters. Use of woodash as soil amendment at applied rate improved soil properties does not constitute any negative effect on soil and crops.

Keywords: Acid Ultisol, Physicochemical, Heavy metal, Tillage, Woodash

Introduction

Selection of tillage to suit crop type, soil and climatic condition is very important to ensure crop productivity. However, there has been conflicting reports on the influence of tillage on soil chemical properties and crop performance. For instance, manual tillage system including heaps, ridges or beds have been reported by Ojeniyi, (1991) to degrade soil quality, reduce chemical and biological qualities especially in case of Alfisols in the rain forest of southwest Nigeria. Conversely, Sanjh and Singh (2001) reported that tillage operations and its attendant soil surface disturbance generally result to an increase in soil aeration, residue decomposition, organic N mineralization and availability of N for plant use.

Soils of the tropics are highly susceptible to degradation under cultivation, if conservative measures are not put in place or if mechanized land clearing and tillage practices are not carefully implemented. The impact of such degradation according to Kirchof and Salako (2000) is difficult to reverse depending on the severity of the degradation. For instance, Ogboghodo *et al*. (2005) observed that land degradation due to oil contamination leads to alteration of soil physicochemical properties such as structure, reduction in permeability, compaction, sealing and decrease in macropores. Changes in the chemical nature of the soil brought about by the addition of pollutants may present a hazard and toxicity to soil flora and fauna including cultivated crops or may lead to the accumulation of toxic substances in harvested crops making them unsuitable for human consumption. This is in tandem with the earlier report by Ezeaku (2012). Davies ((1983) observed that cultivated crops take up heavy metals as mobile ions present in the soil solution. Heavy metal concentration excess of critical limits could have agronomic and environmental implications and this could be a major source of concern to environmentalists and particularly farmers, who put the land into intensive crop cultivation as is the case in the study area.

Wood-ash as soil manure has been observed to have strong explicit influence on soil architecture and crop yield. Adeleye *et al*. (2005) observed that soil properties, growth and yield parameters of yam increased with increasing rates of wood-ash treatment with 4 t ha^{-1}

recording the highest yield. Mbah *et al*. (2010) in an Ultisol in south eastern Nigeria reported increased maize grain yield following wood-ash application with non-significant effect observed between 4 t ha^{-1} and 6 t ha^{-1} rate of application. Studies (Ojeniyi *et al.*, 2002; Odedina, *et al.,* 2003; Odum, 2007, Mbah *et al*.,2018) showed improvement in vegetables, cowpea yield and enhancement in soil Ca, K, P and N when wood-ash was used as soil amendment.

The relevance of castor oil in pharmaceutical and beverage industries, household and other industrial uses cannot be over emphasized. Singh *et al.* (2003) reported that castor oil is useful in various products such as laxative and purgative drugs in the area of medicine, as grease in machinery to reduce wear and friction, in vanishes and paint factories. The prevailing environmental condition in Nigeria and qualities of castor notwithstanding, farmers in southeast Nigeria do not use any particular tillage practice or soil amendment in castor production, even when the crops are grown on degraded soils. In view of this, the return on the farmers' investment for the farmers' effort is poor. Again, there has been little study on the concentration of heavy metals on the soil and its uptake by crops grown in the study area. The metal is non-essential element to human and a toxic potential for all biological systems, if present in high concentrations. Thus, it becomes paramount importance to identify ideal soil conservation option that will enhance the fertility status of these soils for improved Castor production. The objective of this study was to evaluate the effect of different tillage practices and wood-ash on soil physico-chemical properties and its effect on soil, shoot and seed contents of heavy metals (Cu, Zn, Fe, Pb and B) by Castor in an acid Ultisol in southeast Nigeria.

Materials and Methods

Study area

The experiment was conducted at the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Farm, Ebonyi state university, Abakaliki southeast Nigeria in 2016 and 2017 cropping seasons. Abakaliki is located between latitude 06^0 04^1N and longitude 08^0 65^1E in the derived savannah zone of the south east agro-ecological zone of Nigeria. The area has high temperature with high annual rainfall range of 1800 – 2000 mm concentrated between April and November. The area has a minimum and maximum temperature of 27^0C and 31^0C , respectively (Ofomata,1975). The mean relative humidity is between 65 – 80% during the rainy period. The soil is an Ultisol and classified Typic Haplustult (FDALR, 1985). Farming is a major economic activity even in urban areas where patches of subsistence farms are found.

A land area measuring 1.56 ha was mapped out from department research farm and a portion this land measuring 11 m by 15 m equivalent to 0.0165 ha was used for the study. The treatments were arranged as split plot in Randomized Complete Block Design (RCBD) with 6 treatment and 3 replications. The area was demarcated into 18 plots with each plot measuring 3 m by 4 m separated by 0.5 m alley and each replication was 1m apart. The treatment consist of mound tillage alone (MO); Ridge tillage alone (RO); Flat tillage alone (FO); Mound tillage + 4 t ha^{-1} wood-ash ; Ridge tillage + 4 t ha^{-1} wood-ash and Flat tillage + 4 t ha^{-1} wood-ash. The wood-ash was made from *Carpolobea alata*. The tillage practices were the main plot while the woodash was the subplot. The woodash was spread uniformly and incorporated into their respective plots during cultivation. Two Castor seeds were planted per hole at a spacing of 0.9 m between rows and 0.4 m within rows at a depth of 8 cm. The seedlings were thinned down to one plant per stand two weeks after germination. Weeding was done manually with hoe at three weeks interval till maturity. At maturity (when the capsules containing the seed turned brown) the capsules were harvested and the spike dried in the sun for 2-3 days and threshed to release the seed. The seeds were weighed and the yields expressed in t ha^{-1} .Ten plants were pulled from each plot, air dried and the root cut off. The seeds and the dry shoots were analysed for the heavy metal (Cu, Zn, Fe, Pb, and B) contents. The same procedure was repeated in the second cropping season without application of wood-ash in the second cropping season to test the residual effect.

Soil sample collection

At the beginning of the experiment auger soil samples were randomly collected from ten different spots at a depth of 0 – 20 cm. The auger samples were thoroughly mixed to form a composite sample and analyzed for initial soil properties. The wood-ash was also analysed for its composition. At the end of the each cropping season (after harvest) undisturbed core samples were collected from each plot and used for the determination of soil physical properties. Similarly, auger samples were collected from the plots air dried, sieved and used for determination of chemical properties.

Plant sample collection

Ten Castor plants per plot were sampled and tagged. The seed yield was measured per plot when the capsules matured and were harvested, dried and threshed to release the seeds. The seeds were weighed to get the yield per plot and then expressed to hectare equivalent. The roots were cut off and the shoot and seed air-dried for 3 – 4 days. The dried shoot and seed samples were analysed for heavy (Fe,Zn,Cu,Pb,B) metal content.

Laboratory methods

Soil hydraulic conductivity was determined using the method described by Reynoids (1993). Total porosity obtained according to Danielsen and Sunderland (1980) method using the relationship between bulk density and particle density as follows:

TP = 100(1-Db/Pd). Where TP= total porosity, Db = bulk density, Pd = particle density assumed to be 2.65 Mg m^{-1}. Saturated hydraulic conductivity was determined using the method of Reynoids (1993).

Soil pH was measured in extract soil solution in water at a ratio of 1:2.5. After stirring for 30 minutes, the pH was read using glass electrode pH meter. Total nitrogen was determined using modified Kjeldahl digestion procedure as described by Bremner and Mulvancy (1982). Organic carbon was determined by the method of Nelson and Sommers (1982). Available P was obtained by the method described by Bray and Kurtz (1945). Base saturation was calculated by multiplying total exchangeable bases by 100 and dividing by the corresponding CEC value as follows:

BS= 100XTEB/CEC.

Exchangeable acidity was determined by the titrimetric method using 1 N KCL(Mclean, 1982) while effective cation exchange capacity (ECEC) was determined by summation as follows, ECEC=TEB+TEA where TEB=Total exchangeable bases. TEA=Total exchangeable acidity.

Determination of heavy metal concentration in soil.

Copper (Cu), Fe,Pb and Zn was determined by EDTA method of Clayton and Tiller (1979)

Determination of heavy metal concentration in shoot and seed of castor.

This was carried out using the analytical procedure by APHA *et al*. (1985)

Data analysis

Data collected were subjected to analysis of variance test based on RCBD using CropStat software version 7.0 while statistical difference among treatment means was estimated using the least significant difference ($LSD_{0.05}$).

Results and Discussion.

Tables 1 showed the initial properties of the soil . The table showed that the soil is a sandy loam. Table 2 showed nutrient content of woodash before application.

Results on the tables (1 and 2) showed that woodash was strongly alkaline with(pH =11.57) while the soil was acidic with pH(5.5). Higher levels of plant nutrients (except Total N and Organic C) were contained in the woodash (Table 2) compared to the soil (Table 1). Similarly, woodash contained higher levels of heavy metals (Cu, Zn, Fe, B, Pb) relative to soil (Table 1)

Table 1
Initial properties of the soil.

Parameter	Value
Sand	561 g kg^{-1}
Silt	369 g kg^{-1}
Clay	70g kg^{-1}
Texture	Sandy loam
Exchangeable bases	
Ca	2.8 $cmolkg^{-1}$
Mg	1.58 $cmolkg^{-1}$
Na	0.12 $cmolkg^{-1}$
K	0.07 $cmolkg^{-1}$
Available P	17.6 $mgkg^{-1}$
Base saturation	87%
Organic C	1.06%
Total N	0.07
pH (H2O)	5.5
Heavy metals	
Zn	134.5 $mgkg^{-1}$
Cu	25.61 $mgkg^{-1}$
Fe	240.0 $mgkg^{-1}$
B	5.50 $mgkg^{-1}$
Pb	46.8 $mgkg^{-1}$

Table 2
Nutrient composition of the woodash.

Parameter	Value
Organic C	0.68 %
Total N	0.04%
Available P	260.5 $mgkg^{-1}$
pH(H20)	11.57
Ca	47.8 $cmolkg^{-1}$
Mg	9.8 $cmolkg^{-1}$
K	0.28 $cmolkg^{-1}$
Na	0.39 $cmolkg^{-1}$
Fe	246.10 $mgkg^{-1}$
Zn	225.6 $cmolkg^{-1}$
B	50.0 $cmolkg^{-1}$
Pb	52.5 $cmolkg^{-1}$
Cu	147.6 $cmolkg^{-1}$

Effect of Tillage practices and woodash on soil hydraulic conductivity (HC).

Results of the study (Table 3) showed that hydraulic conductivity differed (p=0-05) significantly among the tillage practices in both cropping seasons.

Table 3
Effect of tillage practices and wood-ash on Hydraulic conductivity (HC).

Treatment	Hydraulic conductivity ($cmhr^{-1}$)	
	2016	2017
FO	4.11	3.35
MO	4.76	3.70
RO	5.35	4.30
Mean	4.74	3.78
FW	16.32	15.32
MW	16.32	15.31
RW	16.45	15.41
Mean	16.36	15.35
FLSD (0.05)		
Tillage	0.86	1.11
WA	NS	NS
WXA	NS	NS

Hydraulic conductivity ranged between 4.11-5.35 and 16.32-16.45 respectively in tillage practices alone and tillage practices with woodash in the first cropping season . Highest HC value of 16.45 $cmhr^{-1}$ was observed in RW plots in the first cropping season. The value corresponds to 1%,1%,75%,71% and 67% increase relative to the values observed in MW,FW,FO, MO and RO , respectively. In both cropping seasons the observed values in HC were lower in tillage practices alone compared to the values in tillage practices amended with woodash. The order of increase in HC in the second cropping season was RW>FW>MW>RO>MO>FO. Soil hydraulic conductivity did not differ significantly (p=0.05) in woodash amended tillage practices in both cropping seasons. Soils with low porosity, few large pores and poor interconnectivity between pores have low HC values. Rawls *et al*.(1982)

compiled the HC values of 1,323 soils collected from 32 states and reported that HC were higher in coarse textured than fine texture soils due to larger pores due to larger pores in the former In a study on the effect of rice husk dust to ameliorate heavy clay loams and its effect on soil properties ,Anikwe (2000) reported increased soil HC in amended soil relative to the control. Similarly, Nwite *et al*.(2011) and Mbah *et al*.(2009) observed increased HC in plots amended with organic wastes relative to the unamended plots. Okenmuo *et al*. (2018) observed positive impact of organic waste on soil physical and organic properties, including higher HC levels which improved soil quality.Similarly, Nwite, and Okolo, (2016) observed increased HC in organic waste amend soils relative to unamended soils in southeastern Nigeria. Also, Eusufzai and Fujii, (2012) and observed higher HC levels and number of macropores in organic matter amended soils.showed increased HC values in plots amended with organic wastes relative to the control. Alvarez *et al* .(1995) observed high values of HC on sandy loam soil amended with organic wastes . Ezeaku and Anikwe (2006) attributed such high values of HC result to bioactivity leading to creation of channel of flow of water. High HC values means better water transmission and hence reduction in water logging while low HC means increased water logging and hence reduction in physiologic activity which may translate to lower plant height and seed yield (Anikwe, 2000). Observed HC values were higher in the first cropping season compared to the second cropping season. The fact that high HC values observed in the cropping first season compared to the second cropping season showed that HC responds to woodash application. In this study application of woodash to the different tillage practices increased soil porosity (Table 2) leading to higher HC values

Effect tillage practices and woodash on soil total porosity(%).

Total porosity (TP) values observed at 30, and 60 days after planting (DAP) differed significantly (p-0.05) in tillage practices (Table 4) in both cropping seasons.

Table 4
Effect of tillage practices on tillage practices and woodash on soil total porosity (%) in days after planting (DAP).

Treatment	2016			2017		
	30 (DAP)	60 (DAP)	90 (DAP)	30 (DAP)	60 (DAP)	90 (DAP)
FO	42	50	42	49	49	42
MO	47	49	44	53	48	43
RO	49	52	43	50	49	42
Mean	54	50.3	43	52.7	48.7	43.3
FW	57	53	49	55	52	45
MW	58	53	51	55	52	44
RW	58	52	50	54	49	45
Mean	57.7	52.7	51.3	54.7	51	45
FLSD (0.05)						
Tillage	1.08	1.02	NS	4.01	0.86	NS
WA	NS	NS	NS	NS	NS	NS
TXWA	NS	NS	NS	NS	NS	NS

In the first cropping season total porosity values were higher in tillage practices amended with woodash compared to tillage practices alone. Lowest TP value of 53% at 30 DAP in the first cropping season was observed in RO. The order of increase in TP at 60 and 90 DAP in the first cropping season was MW=FW>RW >RO>FO>MO and MW>RW>FW>MO>RO>FO, respectively. Similarly, TP was significantly (p=0.05) increased in tillage practices relative to the tillage practices amended with woodash in the second cropping season. The order of increase at30 DAP was MW>RW>FW>FO>RO>MO in this season. In both cropping seasons TP values were higher at 30 DAP compared to 60 and 90 DAP . Similarly, observed TP values in tillage practices amended with woodash did not vary significantly in both cropping seasons. Porosity affects water movement and gas exchange. The increase in TP of woodash amended tillage practices relative to tillage practices alone tend to potray that woodash amended soils contain required water and oxygen that are important for soil organisms to survive. Increased in TP is expected since organic materials are known to have low densities and therefore , can improve the soil porosity and make it less dense (Mbah *et al.,*2004). Nnabude and Mbagwu (1998) observed that application of fresh and burnt rice mill waste at the rate of 0,25 and 50 Mgha^{-1} increased soil total porosity relative to the control. Anikwe (2000) reported increase in soil total porosity in plots amended with 4.5 and 6 t ha^{-1} rice husk dust at 45 and 60 DAP relative to the control. Using poultry droppings and woodash as soil amendment *Mbah et al*.(2018) reported increased soil total porosity relative to the control.

Improvement in soil TP following organic waste application have also been reported by Adeleye *et al*.(2009) and Nwite *et al*.(2011). The higher TP values in woodash amended tillage practices may have contributed to the higher HC values (Table 1) observed in this plots.

Effect of tillage practices and woodash on soil Total N, available P, organic carbon and pH

Result of the study in Table 5 show that tillage practices amended with woodash significantly (p=0.05) increased Total nitrogen (TN), available P and Organic carbon (OC%) relative to tillage practices alone in the both cropping season.

Table 5
Effect of tillage practices on tillage practices and wood-ash on total N, organic carbon, available P and pH.

Treatment	2016				2017			
	Total N (%)	Available P (mgkg^{-1})	Organic C (%)	pH	Total N (%)	Available P (mgkg^{-1})	Organic C (%)	pH
FO	0.06	14.80	0.57	5.80	0.06	8.60	0.52	5.00
MO	0.07	16.40	0.67	5.60	0.06	7.80	0.50	5.10
RO	0.05	14.00	0.60	5.70	0.06	6.20	0.45	5.00
Mean	0.06	15.1	0.61	5.70	0.06	7.53	0.49	5.03
FW	0.12	15.50	1.90	7.00	0.08	10.30	0.83	6.50
MW	0.13	20.90	1.21	6.80	0.11	18.70	0.95	7.20
RW	0.10	24.90	1.29	6.80	0.12	13.20	0.97	7.30
Mean	0.12	20.43	1.47	6.87	0.10	14.1	0.92	7.00
FLSD (0.05)								
Tillage(T)	NS	NS	NS	NS	NS	NS	NS	NS
WA	0.23	1.22	0.45	0.25	0.02	1.56	0.10	0.70.
TXWA	NS	NS	NS	NS	NS	NS	NS	NS

In the first cropping season TN ranged between 0.05-0.07 in tillage practices alone and between 0.10 – 0.13 in the woodash amended tillage practices. Highest TN value of 0.13 was observed in MW. The value 0.13 was 8, 23, 46, 54 and 62% higher than TN values in FW,RW,MO,FO and RO, respectively. The order of increase in OC% in the first cropping season was FW>RW>MW>MO>RO>FO. In this season pH was observed to significantly (p=0.05) increased in woodash amended tillage practices compared to tillage practices alone. Total N, available P and OC% values were lower in tillage practices alone compared to woodash amended tillage practices in the second cropping season. Available P had the highest value (18.7) in MW in the second cropping season. This value was higher than available P values in FW by 45% , 29% for RW, 54% for FO, 46% for MO and 67% for RO. The order of decrease in pH in the second cropping season was RW>MW>FW>MO>FO=RO.

Soil pH and nutrient availability are influenced both the cropping systems and soil management practices like tillage methods, soil organic matter and biological activity. Strudley et al.(2008) observed that the depth and intensity of tillage methods affect soil chemical properties which affect plant growth and yield. According to Awodu *et al*. (2007) the liming effect of woodash creates a more favourable pH which increases soil nutrient content. Mbah and Onweremadu (2009) observed significant increase in available P levels of soils amended with organic wastes relative to the control. A recent study by Lemming *et al*. (2019) observed that exchangeable residual P was sustained three years after long term organic waste application was ended. Also, Lee (2016) observed that cumulative P uptake was higher in manure waste compost than inorganic fertilizer. Similarly, Farell e*t al*. (2010) reported significant effect of biochar application on P availability in calcerous soils relative to the control. Ayeni *et al*. (2008) observed increased soil pH in ash amended soil compared to non-ash amended soil. Haynes and Naidu (1998) showed that acid soils are normally flocculated at low pH. The authors observed that as pH increase by the addition of ash, the net negative charge on soil surface increase and the ratio of net negative and net positive charge increases. The low values of chemical properties observed in tillage practices alone is in line with the report of Ojeniyi *et al.* (1991) who observed that tillage systems including heaps, ridges or beds can degrade soil quality, reduce chemical and biological properties.

Effect of tillage practices and woodash on Base saturation, Effective cation exchange capacity and Exchangeable acidity.

Result of the study in Table 6 showed that tillage practices amended with woodash showed significant difference (p=0.05) in soil base saturation (BS), effective cation exchange capacity (ECEC)and decreased exchangeable acidity (EA) relative to tillage practices alone in both cropping seasons.

Table 6
Effect of tillage practices and woodash on Base saturation (BS), Exchangeable acidity(EA) and Effective cation exchange capacity (ECEC).

Treatment	2016			2017		
	Base saturation	Ex.Acidity	ECE Capacity	Base saturation	Ex.Acidity	ECEC
FO	76	0.80	4.92	72	0.24	3.20
MO	68	0.40	5.58	75	0.20	4.38
RO	66	0.20	4.08	73	0.32	3.50
Mean	70	0.37	4.86	73.3	0.25	3.69
FW	97	0.08	6.91	80	0.28	5.42
MW	94	0.06	11.94	86	0.18	10.11
RW	95	0.08	15.00	90	0.08	10.80
Mean	95.3	0.073	11.28	85.3	0.018	8.78
FLSD (0.05)						
Tillage(T)	NS	NS	NS	NS	NS	NS
WA	1.02	0.38	3.77	6.00	0.86	0.80.
TXWA	NS	NS	NS	NS	NS	NS

The highest ECEC value (15.0 Cmolkg-^{1}) was observed in RW in the first cropping season.

The value was higher than ECEC values in FW,MW,MO,FO and RO by 54,20,63,67 and 73%, respectively in the first cropping season. Base saturation ranged between 66-76% in tillage practices alone compared to 94-97% observed in woodash amended tillage practices. Exchangeable acidity was higher in tillage practices alone compared to tillage practices amended with woodash. In the second cropping season exchangeable acidity values ranged between 0.08-0.32 Cmolkg-^{1} .The order of increase in ECEC in the second cropping season was RW>MW>FW>MO>RO>FO.

The improvements in ECEC could be due to high level of organic matter (OM) resulting from addition of woodas. Mbagwu (1992) showed that organic matter contribute to the CEC of soils with low activity clays while Asadu and Akamigbo(1990) showed that OM could contribute an average of 70% of CEC of Ultisols and oxisols in the tropics. The observed increase in ECEC in woodash amended tillage practices could be cold also be attributed to increase in soil exchangeable bases in line with the observation of Kayode and Agboola (1993). Using biochar as soil amendment Deluca *et al*.(2007), Agegnehu, *et al*.(2015) and Mbah *et al*.(2017) reported increase in soil CEC relative to the control. The decrease in exchangeable acidity (AL^{3+} + H) in woodash amended tillage practices could be as a result of the removal of of Al^{3+} from the exchange sites or tis neutralization following addition of woodash. Decrease in exchangeable acidity of soil following addition of organic wastes was reported by Mbah *et al*.(2001). In a study on the influence of rice husk dust on exchangeable bases and acidity of an ultisol In south eastern Nigeria, Uguru *et al*.(2016) reported increased base saturation , effective cation exchange capacity and decreased exchangeable acidity in rice husk dust amended plots relative to the control.

Effect of tillage practices and woodash on soil content of heavy metals (Zn,Fe,Pb,Cu).

Table 7 showed that tillage practices amended with woodash and tillage practices alone significantly (p=0.05) increased the heavy metal contents of the soil in both cropping season. In the first cropping season Cu concentration in tillage practices alone ranged from 3.90-5.60 Mgkg-^{1} while the range was between 25.2-54.6 Mgkg-^{1} in the woodash amended tillage practices.

Table 7
Effect of tillage practices on tillage practices and wood-ash on soil heavy metals (Cu, Zn, Fe, Pb and B) (mgkg^{-1}).

Treatment		2016				2017				
	Cu	Zn	Fe	Pb	B	Cu	Zn	Fe	Pb	B
FO	3.90	99.5	152.6	8.80	140.3	2.37	84.25	11.2	5.40	0.55
MO	4.64	103.5	107.8	57.8	96.34	4.30	37.85	8.80	7.20	0.94
RO	5.60	150.	126.3	10.	87.21	2.4	44.5	8.75	8.86	0.76
Mean	4.71	1	118.9	4	91.3	4	55.5	9.58	7.15	0.75
		117.6		25.7		3.04				
FW	25.20	172.6	264.0	46.6	204.1	9.60	120.2	21.1	94.4	2.46
MW	28.01	181.5	205.8	76.4	136.3	16.6	106.8	33.1	109.6	2.00
RW	54.60	217.	404.2	54.	158.7	9.6	178.3	38.0	148.	7.50
Mean	35.94	7	221.1	2	166.4	0	135.1	30.7	0	3.99
		170.6		59.1		11.9			117.3	
FLSD (0.05)										
Tillage(T)	0.81	5.02	19.9	2.0	9.43	0.2	6.9	0.97	2.08	1.02
WA	2.83	18.0	58.0	1	26.9	1	3.50	5.01	29.6	0.52
TXWA	1.00	3	0.78	8.10	3.00	0.44	1.O2	0.99	1	0.13
		0.06		1.01		0.17			0.88	

The highest value of Pb (76.40 and 148.0) were observed in MW and RW plots in the first and second cropping , respectively.. The value 76-40 Mgkg-^{1} was higher than the Pb values in RW,FW,MO,FO and RO by 29,39,24,88 and 86%, respectively, in the first cropping season.

The order of increase in Cu and Zn in the first and second cropping seasons was RW>MW>FW>RO>MO>FO and RW>FW>MW>FO>RO>MO, respectively. The lowest and highest values of Pb were observed in FO and RW plots, respectively in the second cropping season. Soil content of B ranged between 0.55 – 7.50 in the second cropping season. The table showed Fe concentration ranged from 8.75-8.11.2 in tillage practices alone and 21.10-38.0 in tillage practices amended with woodash in the second cropping season. Higher concentration of the heavy metals were observed in the woodash amended tillage practices compared to tillage practices alone in both cropping seasons.

The result of this study showed that heavy metals are naturally present in soils (Table1) and that anthropogenic activities have resulted in high concentration in line with the report of Ojenuga et al .(1996). Nriagu (1979) observed that soils could be polluted from a wide range of heavy metal sources. Ano et al ,(2001) noted that contaminated soils may constitute a health hazard if metals are transferred to other reservoirs or absorbed by plants. In a study in Mano Basin of Oalu Hawai Sutherland and Tolona (2001) observed that Cu, Pb, and Zn are significant anthropogenic enrichment and these potential soil pollutants can be washed into nearby water bodies , where they can form a major source for bioaccumulation. Research results by Brady and Wiel (2002) showed higher concentrations of Pb,Cu and Cd in sewage sludge amended soils relative to the control.

The concentration of Cu according to ICRCL (1981) can only be deleterious when it is above 130 mgkg-^{1} . In another study Ano (1994) reported that the amount of Cu in soils varies but normal agricultural soils is estimated to contain 1-over 50 mgkg-^{1} of Cu. Brown (1977) observed that the normal range of Cu is between 2 and 250 mgkg-^{1} . The result of this study showed that Cu concentration in this soil is within in acceptable limit. Iron (Fe) is the fourth in abundance (about 50%) among the chemical elements in the earths crust or lithosphere after oxygen, silicon and aluminium (Turer and Maynards,2003). The higher Fe levels in tillage practices alone and tillage practices amended with woodash plots in the first cropping season could be partly attributed to high organic wastes from domestic and commercial ventures as the farm is close to mechanic site and partly to the added woodash incase of woodash amended plots only.. The concentration of Fe observed in the tillage practices alone and woodash amended plots in the first cropping season was above tolerable limits of38 mgkg-^{1} (Davies, 1984) in soils.

Ebosiem (2004) reported that air transfer Pb very far away through air borne to the point of release. Run- off water along the expressway gutter after rainfall events could also contribute to heavy metal of Pb offsite. Brown (1977) observed that Pb range in soil is between 2 to 300 mgkg-^{1} . The result of this study showed Pb values in tillage practices and woodash amended tillage practices were within normal range in soils in the seasons studied. Studies carried out by Purves and Mckenzie (1974) and Purves (1973) demonstrated significant increase in the amount ot Zn,B and Cu extracted from soils after waste application. Similariy, Gallardo-lara and Nogales (1987) in a study showed that waste application increased Zn and fe soil content relative to the control in line with the results of this study. Alloway (1990) reported soil concentration range of 70-400 mgkg-^{1} total Zn as critical above which toxicity is likely. On the otherhand Brown (1977) reported that the normal range of Zn in soil is between 1-900 mgkg-^{1}. The result showed that Zn values in both woodash amended tillage practices and tillage practices alone does not constitute toxicity problems in soils.

Effect of tillage practices and wood ash on shoot (Fe,Zn,Cu,B,Pb) concentration mgkg-^{1}

Results of the study in Table 8 showed significant (p-0.05) differences in heavy metal content of the castor seed in both cropping seasons.

Table 8
Effect of tillage practices on tillage practices and wood-ash on shoot heavy metals (Cu, Zn, Fe, Pb and B) (mgkg^{-1}).

Treatment		2016				2017				
	Cu	Zn	Fe	Pb	B	Cu	Zn	Fe	Pb	B
FO	1.03	105.7	59.62	1.10	21.80	0.08	2.19	49.50	0.20	1.75
MO	0.65	94.5	60.75	1.03	12.65	0.06	2.20	52.20	0.08	1.18
RO	0.9	121.0	30.90	1.2	21.90	0.0	2.30	27.90	0.93	0.95
Mean	8	107.1	50.40	8	18.78	3	2.23	43.2	0.40	1.29
	0.89			1.14		0.06				
FW	1.10	425.95	66.60	1.67	16.01	0.15	1.80	56.95	0.12	1.25
MW	1.06	447.95	67.35	1.83	32.05	0.11	2.30	57.35	0.88	1.68
RW	1.37	707.25	68.03	2.11	34.00	0.42	2.36	54.15	1.16	1.51
Mean	1.18	527.05	67.33	1.87	27.35	0.23	2.15	56.15	0.72	1.48
FLSD(0.05)										
Tillage (T)	1.01	12.9	3.02	1.00	0.21	0.48	0.11	2.99	0.15	0.51
WA	0.98	23.2	1.01	0.22	2.03	0.08	0.13	1.10	0.83	0.72
							0			
TXWA	0.98	8.54	3.05	0.22	0.43	0.04	0.01	3.33	0.12	0.37

In the first cropping season shoot Cu content of castor ranged from 0.65-1.37 Mgkg-^{1} with highest value of Cu observed in RW plots.

The table also showed highest Pb value of 2.11 mgkg-^{1} in RW plots. This value (2.11 mgkg-^{1}) was higher than Pb values observed in FO,MO, RO,FW and MW by 48,58, 59,13 and 21%, respectively in the first cropping season.

Similarly, significant variations in shoot concentrations of heavy metals were observed in the second cropping season. However, observed heavy metal contents of the shoot in the first cropping season were higher than the values in the second cropping season irrespective of the heavy metal.

For instance Pb content of the shoot in FW plots in the first cropping season was 1.10 mgkg-^{1} while the value was 0.12 mgkg-^{1} in the second cropping season. The value 1.10 mgkg-^{1} in FW in the first cropping was 93% higher than the Pb content of the shoot in the second cropping season.

Effect of tillage practices and woodash on seed contents of heavy metals (Cu, Zn, Fe, Pb and B)

Results of the study in Table 9 showed significant (p=0.05) increase in seed contents of Cu, Fe, B, Pb in both tillage practices and tillage pactices amended with woodash in the first cropping season.

Table 9
Effect of tillage practices on tillage practices and wood-ash on seed heavy metals (Cu, Zn, Fe, Pb and B) ($mgkg^{-1}$).

Treatment		2016				2017				
	Cu	Zn	Fe	Pb	B	Cu	Zn	Fe	Pb	B
FO	1.04	1.40	34.10	1.01	13.25	0.07	1.25	25.00	0.06	0.10
MO	0.84	1.30	45.00	0.99	11.15	0.08	1.10	35.80	0.04	0.25
RO	0.9	1.20	35.00	1.1	17.15	0.1	1.14	32.60	0.0	0.27
Mean	9	1.30	38.00	8	13.85	0	1.16	31.1	4	0.21
	0.96			1.06		0.08			0.11	
FW	1.08	1.52	67.90	1.50	40.75	0.06	1.40	40.80	0.20	0.02
MW	1.04	2.32	67.00	1.21	46.99	0.09	1.70	59.80	0.26	0.35
RW	1.4	2.30	68.80	1.5	49.75	0.0	1.50	44.20	0.5	0.83.
Mean	4	2.04	67.9	11.41	45.83	6	1.53	42.27	6	0.40
	1.87					0.07			0.34	
FLSD (0.05)										
Tillage	0.2	NS	0.91	0.0	2.33	NS	0.05	3.23	NS	0.18
WA	2	0.03	0.90	2	2.90	NS	0.12	3.88	0.0	
TXWA	0.06	0.07	0.82	6.30	6.76	NS	0.01	12.5	8	0.21
	0.11			0.13					0.12	0.04

Lead (Pb) values ranged from 0.99 -1,18 $mgkg^{-1}$ in tillage practices alone and 1.06 -1.50 $mgkg^{-1}$ in woodash amended tillage practices. The order of increase in B was RW>MW>FW>RO>FO>MO. Similarly, the order of increase in Zn was FW>RW>FW>FO>MO>RO in the first cropping season. The lowest and highest values of B was observed in MO and RW respectively, in the first cropping season. In the second cropping season Cu content of the seed did not vary significantly.

The table showed that Zn concentration of the seed increased in the order FW>RW>MW>RO>FO>MO in the second cropping season. Highest Pb (0.56$mgkg^{-1}$) content of the seed was observed in RW plots in the second cropping season. This value 0.56 $mgkg^{-1}$ was 89, 93,93 , 54 and 64 % higher than Pb values observed in MO,FO,RO,MW and FW respectively.

The order of increase in B content of the seed was RW>MW>FW>RO>FO>MO. Results from the study showed large variation in Cu, Zn, B, Pb and Fe in the first and second cropping seasons. This result corroborates the findings of Vousta et al.(1996) that heavy metal concentration in harvested crops often show large variations from year to year even in the same field. The authors attributed the variations to variable emission rates, atmospheric transport deposition process and plant uptake.

According to the US National Institutes of Health (2018), therecommended average daily iron intake from foods and supplements is 19.3–20.5 mg/day in men. Iron shoot and seed content in both seasons are within tolerable limit in both seasons. Iron toxicity is uncommon in human beings as it is required in large amount. Similarly, Zn concentrations of the castor shoot and seed were within normal range for human requirement the recommended dietary allowance (RDA) for zinc is 8 milligrams (mg) a day for women and 11 mg a day for men (Nordqvist, 2018).The total Pb burden of a man ranged 90-400 mg (Bersenyi, 2003). Pb can interact with DNA (Tchounwou 2012). In a study carried out with 150 accident students in US, Shroeder and Tipton (1968) found their mean Pb body content to be 121 mg. The authors noted that about 90% of the body Pb was present in the skeleton. Based on this report the Pb content of castor shoot and seed in this study does not constitute potential danger. Similarly, the recommended daily allowance (RDA) for Cu is about 900 micrograms (mcg) a day for adolescents and adults (Ware, 2017). The value of Cu in the shoot and seed of castor in this study was within the normal range for human beings.

Conclusion

The results of this study showed that tillage practices improved soil hydraulic conductivity and total porosity relative to tillage practices amended with woodash. Results also showed increased soil base saturation, effective cation exchange capacity, organic carbon available, total nitrogen, Avaialble P and decrease exchangeable acidity in woodash amended tillage practices compared to tillage practices alone. Application of woodash to tillage practices at the rate of 4 t ha^{-1} increased soil, shoot and seed heavy metals (Cu,B,Fe,Zn,Pb) concentration of castor but to non-toxic levels. On the average the highest improvements in the studied properties were observed in RW plots.

References

Adeleye,B., Ayeni,L.S and Ojeniyi,S.O (2010)Effect of poultry manure on soil physicochemica6 properties ,leaf nutrient contents and yield of yam(*Discorea rotundata*) on Alfisol in southwest Nigeria. Journ African Sci,61(10) 509-518.

Agegnehu,G., Bassb,A.M.,Newlsona,P.M.,Muirheads,B.,Wrightd,G and Bird,M.R (2015) .Biochar and biochar compost as soil amendment: Effect on peanut yield, soil properties and green house gas emission in tropical North Queensland, Australia. Agric.Ecosyt.Environ. 213:72-85.

Alloway,B.J(1998) Heavy metal in soils. Published by Blackie Academic and Professional on imprint of Chapman.

Alvarez,Z,R.,Diaz,R.A., Barbero,N.,Santanat.,Ogcu,O.J and Blothel, C (1995) Soil organic carbon , microbial biomass. CO_2-C production from three tillage systems. Soil Tillage Res. 33:17-28.

Anikwe,M.A.N(2000) Amelioration of a heavy clay loam soil with rice husk dust and its effect on soil physical properties and maize yield. Biores Technol 74(167-173.

Ano, A.O., OdoemeE,Lam,S.A and Ekwueme, P.O(2007). Lead and Cadnium levels in soils and cassava (manihot Esculenta Crantz) along Enugu-Portharcourt expressway in Nigeria. Electronic Journ of Environ Agric and Food Chemistry 6(5) 2024-2031**.**

Ano,A.O (1994). Trace metal studies on soil of the Nigeria coastal plain sands.1. Status Cu,Zn, Mn,Pb and Fe. Journ of Soil Crop 4:1-5.

Asadu,C.L.A and Akamigbo,F.O.R (1990). Relative contributions of organic matter and clay fraction location in exchange capacity of soil in southern Nigeria. Banen.Journ of Agric Res.7:17-23.

Awodun.M.A., Otani.M.S andOjeniyi,S.O.(2007). Effects of saw dust ash plus urea on maize performance and nutrient status. Asain Journ. Agric Res, 12: 27-30.

Ayeni, L.S Adetunji, N.T and Ojeniyi,S.O (2008) Comparative nutrient release from cocoa pod ash, poultry manure and NPK 20:10:10 fertilizer and their nutrient combinations-incubation study. Nig.Journ.Soil. Sci. 18:114-123.

Bersenyi' A (2003). Study of toxic metals (Cd, Pb, Hg and Ni) in rabbits and broiler chickens. Budapest. pp. 1-89.

Brady,N.C and Weil,R.R(2002). The nature and properties of soils. 12th ed. Prince Hall Inc New York. p860.

Bray,R.H and Kurtz,L.T (1945) Determination of total organic and available forms of phosphorus in soils. Soil Sci. 59:39-45.

Bremner, J.M and Mulvancy, J.W (1982) Total Nitrogen. In Page A.L.,Miller, R.H and Keeny,D.R eds Methods od soil analysis .Part 1: ASA,No9 Madison.

Brown,H.J.M(1977) Environmental Chemistry of the elements. Academic Press. London.

Danielson,R.E and Sunderland, P.L.C (1986) Soil porosity . In A.Klute (ed) . Methods of soil analysis . Part 1: Agron.N0 9. 2nd ed.ASA W.I.pp 443-461.

Davies,.B.E (1983)A graphical estimation of normal lead content of some British soils. Geordema,69:67-75.

Ebosiem, G.L(2002) Trace metals of soil and crop around Ishiagu mining site. Status of Pb, Fe Cu,Cd and As. MSc Thesis. Micheal Okpara Univ. of Agric, Umudike-Nigeria.

Eusufzai, M.K. and Fujii, K. (2012) 'Effect of Organic Matter Amendment on Hydraulic and Pore Characteristics of a Clay Loam Soil' Open Journal of Soil Science, 2, 372-381

Ezeaku,P and Anikwe,M.A.N(2006)A model for description of water and solute movement in soil water restrictive horizons across two land scape in SE-Nigeria. Soil Sci.171(10 493-500-

Farrell,M.,Macdonald,C.M.,Butler,G Chirino-Valli.I and Cendron, L.M(2014) Biocha and fertilizer application influence on phosphorus fractionalization and wheat yield. Biology and Fertility of soils.50:169-178.

Federal Ministry of Agriculture and Land Resources (FDALR,1985). Reconaisance soil survey of Anambra state of Nigeria. Soil Report 1985, Federal Department of Agric. and Land Resources, Lagos..

Haynes P.J and Naidu, R(1998). Influence of lime fertilizer and manure content and soil physical condition. A review . Cycling Agroecosystem 51:123-137.

ICRCL (1981) Interdepartmental committee for thr redevelopment on contaminated land. Guidance on the assessment and redelopment of contaminated land . Paper 59/83 2nd ed. Dept of the Enviroment London.

Kayode,.G.O and Agboola, A.A (1993). Investigation on the use of macro and micro nutrient to improve maize yield in southeast Nigeria. Liming Research. 4;201-211.

Kirchof, G and Salako, F.K (2000) Residual tillage and bush fallow effects on soil properties and maize intercropped with legumes on a tropical Alfisol. Soil Use Mgt. 16: 183-188.

Lee, A. (2016) 'Nitrogen and Phosphorus Availability From Various Composted Wastes For Use In Irish Agriculture And Horticulture' Doctoral thesis, Dublin Institute of Technology https://arrow.dit.ie/cgi/viewcontent.cgi?article=1171&context=sciendoc

Lemming, C., Oberson, A., Magid, J., Braunn, S., Scheutz, C., Frossard, E., Jensen, L.S. (2019) 'Residual phosphorus availability after long-term soil application of organic waste' Agriculture Ecosystems & Environment 270:65-75

Mbah,C.N and Onweremadu,E.C(2009). Effect of organic wastes and mineral fertilizer inout soil and grain yield in an ultisol in Abakaliki, southeastern Nigeria. American-Eurasian Journ. Agric 2(1) 07-12.

Mbah,C.N., Dada,.O.A., Okoro,T.N and Ifejmalu,A.(2018) Use of poultry droppings and woodash as soil amendment aand its effects on soil properties and yield of maize.Int.Journ of Advances in Scientific Res.and Engineering 4(7) 74-78.

Mbah,C.N., Mbagwu,J.S.C., Onyia,V.N and Anikwe,M.A.N(2014) Effect of application of biofertilizer on soil densification, total porosity, aggregate stability and maize grain yield in an Ultisol at Abakaliki-Nigeria. Nig.Journ.Sci.Tech.10:74-84.L) African Journ of Agric. Res. Vol 12(2) 1781-1792.

Mbah,C.N., Njoku,C., Okolo,C.C., Attoe,E.E and Osakwe,U.C (2017) Amelioration of a degraded ultisol with hardwood biochar: Effects on soil physicochemical properties and yield of cucumber(Cucumis sativus)

Mbah,C.N., Nwite,J.N., Njoku,C and Nweke,A.I(2010) Response of maize (Zea Mays L) to different rates of woodash in an ultisol in southeast Nigeria. African Journ of Agric. Research 5:580-583.

Mbah,C.N.,Nwite,J.N and Nweke,A.I (2009). Amelioration of spent oil contaminated ultisol with organic wastes and its effect on soil properties and maize (Zea mays L) yield. New World Journ Agric Sci. 5(2) 163-168.

National Institutes of Health (2018) 'Iron Deficiencies' Fact Sheet for Health Professionals U.S. Department of Health & Human Services https://ods.od.nih.gov/factsheets/Iron-HealthProfessional/#en5

Nnabude, P.C and Mbagwu,J.S.C(1998). Soil water relations of a Nigerian Typic-Haplustult amended with freh and burnt rice husk wastes. Soil Tillage Re. 50;207-214..

Nordqvist, O. (2018) 'What are the health benefits of zinc?' MedicalNewsToday https://www.medicalnewstoday.com/articles/263176.php

Nriagu,J.O(1979) Copper in the environment . Part A .Health effects . John Wiley. New Jersey, Nwite, J.N. and Okolo, C.C. (2016) 'Soil Water Relations of an Ultisol Amended withAgro-Wastes and its Effect on Grain Yield of Maize(Zea Mays L.) in Abakaliki, Southeastern Nigeria' European Journal of Scientific Research Vol. 141 No 2, 126-140

Nwite, J.N.,Mbah,C.N .,Okonkwo,C.I and Obi,M.E(2011) Analysis of the physical conditions of a cultivated Typic-Haplustult amended with wastes. Int.Journ.Agric.Sci.1(2) 58-63.

Odedina, S.A., Odedina, J.N.,Ayeni,S.O.,Arowogolu,S.A.Adeyeye,S.O and Ojeniyi,S.O (2003) Effect of types of ash on soil fertility, nutrient availability and yield of tomato and pepper . Nig Journ of Soil Sci. 13:66-67.

Odum, M.A (2007) Effect of saw dust on soil chemical properties and cowpea performance in south eastern Nigeria. Nig.Journ.Sci.2(1) 78-81.

Ogboghodo,J.A., Azehabor,U.F and Osemnota,I.A (2003) Amelioration of crude oil polluted soil with poultry manure and the effects on the growth and soil properties.Global Journ on Environ Sc. 2:60-67.

Ojeniyi,S.O (1991) Soil tillage method an soil properties. Effect on okra at Akure southwest Nigeria. Journ of Agric Sci and Tech.1:70-71.

Ojeniyi,S.O., Oso,O.P and Arowotolu, A.A (2002) Response of vegetable to woodash . Proceeding 30th annual conf. Agric. Society of Nigeria. Pp39-43.

Ojenuga, A.G., Lekwa,G and Okensami, T.A(1996) Distribution, classification and potentials of wetland soils of Nigeria. Monograph N0 2. Soil Sci. Soc of Nigeria.1-24.

Okenmuo, F. C., Odii, O. U. and Okolo, C. C. (2018) 'Short-term amelioration of soil properties and maize yield enhancement using animal wastes in degraded hydromorphic soils of Southeastern Nigeria' Journal of Soil Science and Environmental Management Vol. 9(6), pp. 91-97

Purves, D (1977) Trace elements contamination of the environment . Elsevier Pub. Co. Amsterdam p216.

Purves,D and Mckenzie, E.J (1974).Phytotoxicity due to boron in municipal compost. Plant and Soil.40:231-235

Rawls, W.T.,Brakensick,D. and Saxton.K.E (1982). Estimation of soil water properties. Trans AISAE, 1716-1328.

Reynoids, N.D (1993) Saturated hydraulic conductivity laboratory measurement . In soil sampling and method of analysis. Carter, M.R(eds) Lewis Publ. Boca Raton,pp509.

Sainjh,UM and Singh,B.P (2001) Tillage, cover crops and kill-planting date effect on corn yield and soil. Agronomy Journ 93:878-886.

Shroedr, H.A and Tipton,.I.H (1986) Trace elements in human and animal nutririon. E underwood (eds) Academic Press.NY. Francisco London pp410-421.

Singh,C.,Singh,P and Singh R (2003) Modern techniques of raisng field crops . 2nd Oxford and IBH Co Ltd. New Delhi. Pp325-336.

Strudley, M.W.,Green.T.R and Ascough,J.C.(2008) Tillage effects on soil .Soil Tillage Res. 99:94-98.

Suntherland, R.A and Tolason,C.A(2001) Variations in total and extractable elements with distance in an urban watershed. Hoululu,Hawai Water , Air and Soil Pollution.127:315-338.

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy metal toxicity and the environment. Experientia supplementum (2012), 101, 133–164.

Uguru B.N.,Njoku, C and Mbah,C.N (2010). Influence of rice husk dust on exchangeable bases and acidity of an ultisol and maize growth in Abakaliki, southestern, Nigeria. Scientia Agriculturae 13(3) 156-162.

Vousta, D., Grimanis, A and Samara, L (1996) Trace elements in vegetable grown in an industrial area in relation to soil and in particulate matter. Envron. Pollution. 94: 325-335.

Ware, M. (2017) 'Health benefits and risks of copper' MedicalNewsToday https://www.medicalnewstoday.com/articles/288165.php

Table 1: Initial properties of the soil

Parameter	Value
Sand	561 g kg-1
Silt	369 g kg-1
Clay	70g kg-1
Texture	Sandy loam
Exchangeable bases	
Ca	2.8 cmolkg-1
Mg	1.58 cmolkg-1
Na	0.12 cmolkg-1
K	0.07 cmolkg-1
Available P	17.6 mgkg-1
Base saturation	87%
Organic C	1.06%
Total N	0.07
pH (H2O)	5.5
Heavy metals	
Zn	134.5 mgkg-^{1}
Cu	25.61 mgkg-^{1}
Fe	240.0 mgkg-^{1}
B	5.50 mgkg-^{1}
Pb	46.8 mgkg- ^{1}

Table 2: Nutrient composition of the woodash

Parameter	Value
Organic C	0.68 %
Total N	0.04%
Available P	260.5 $mgkg^{-1}$
pH(H20)	11.57
Ca	47.8 $cmolkg^{-1}$
Mg	9.8 $cmolkg^{-1}$
K	0.28 $cmolkg^{-1}$
Na	0.39 $cmolkg^{-1}$
Fe	246.10 $mgkg^{-1}$
Zn	225.6 $cmolkg^{-1}$
B	50.0 $cmolkg^{-1}$
Pb	52.5 $cmolkg^{-1}$
Cu	147.6 $cmolkg^{-1}$

Table 3: Effect of tillage practices and wood-ash on Hydraulic conductivity (HC)

Treatment	Hydraulic conductivity ($cmhr^{-1}$)	
	2016	2017
FO	4.11	3.35
MO	4.76	3.70
RO	5.35	4.30
Mean	4.74	3.78

FW	16.32	15.32
MW	16.32	15.31
RW	16.45	15.41
Mean	16.36	15.35
FLSD (0.05)		
Tillage	0.86	1.11
WA	NS	NS
WXA	NS	NS

Table 4: Effect of tillage practices on tillage practices and woodash on soil total porosity (%) in days after planting (DAP)

Treatment	2016			2017		
	30 (DAP)	60 (DAP)	90 (DAP)	30 (DAP)	60 (DAP)	90 (DAP)
FO	42	50	42	49	49	42
MO	47	49	44	53	48	43
RO	49	52	43	50	49	42
Mean	54	50.3	43	52.7	48.7	43.3
FW	57	53	49	55	52	45
MW	58	53	51	55	52	44

RW	58	52	50	54	49	45
Mean	57.7	52.7	51.3	54.7	51	45
FLSD (0.05)						
Tillage	1.08	1.02	NS	4.01	0.86	NS
WA	NS	NS	NS	NS	NS	NS
TXWA	NS	NS	NS	NS	NS	NS

Table 5: Effect of tillage practices on tillage practices and wood-ash on total N, organic carbon, available P and pH

Treatment	2016				2017			
	Total N (%)	Available P (mgkg^{-1})	Organic C (%)	pH	Total N (%)	Available P (mgkg^{-1})	Organic C (%)	pH
FO	0.06	14.80	0.57	5.80	0.06	8.60	0.52	5.00
MO	0.07	16.40	0.67	5.60	0.06	7.80	0.50	5.10
RO	0.05	14.00	0.60	5.70	0.06	6.20	0.45	5.00
Mean	0.06	15.1	0.61	5.70	0.06	7.53	0.49	5.03
FW	0.12	15.50	1.90	7.00	0.08	10.30	0.83	6.50
MW	0.13	20.90	1.21	6.80	0.11	18.70	0.95	7.20
RW	0.10	24.90	1.29	6.80	0.12	13.20	0.97	7.30
Mean	0.12	20.43	1.47	6.87	0.10	14.1	0.92	7.00
FLSD (0.05)								
Tillage(T)	NS	NS	NS	NS	NS	NS	NS	NS
WA	0.23	1.22	0.45	0.25	0.02	1.56	0.10	0.70.

TXWA	NS	NS	NS	NS	NS	NS	NS	NS

Table 6: **Effect of tillage practices and woodash on Base saturation(BS), Exchangeable acidity(EA) and Effective cation exchange capacity (ECEC).**

Treatment	2016			2017		
	Base saturation	Ex.Acidity	ECE Capacity	Base saturation	Ex.Acidity	ECEC
FO	76	0.80	4.92	72	0.24	3.20
MO	68	0.40	5.58	75	0.20	4.38
RO	66	0.20	4.08	73	0.32	3.50
Mean	70	0.37	4.86	73.3	0.25	3.69
FW	97	0.08	6.91	80	0.28	5.42
MW	94	0.06	11.94	86	0.18	10.11
RW	95	0.08	15.00	90	0.08	10.80
Mean	95.3	0.073	11.28	85.3	0.018	8.78
FLSD (0.05)						
Tillage(T)	NS	NS	NS	NS	NS	NS
WA	1.02	0.38	3.77	6.00	0.86	0.80.
TXWA	NS	NS	NS	NS	NS	NS

Table 7: Effect of tillage practices on tillage practices and wood-ash on soil heavy metals (Cu, Zn, Fe, Pb and B) (mgkg^{-1})

Treatment	2016					2017				
	Cu	Zn	Fe	Pb	B	Cu	Zn	Fe	Pb	B
FO	3.90	99.5	152.6	8.80	140.3	2.37	84.25	11.2	5.40	0.55
MO	4.64	103.5	107.8	57.8	96.34	4.30	37.85	8.80	7.20	0.94
RO	5.60	150.1	126.3	10.4	87.21	2.44	44.5	8.75	8.86	0.76
Mean	4.71	117.6	118.9	25.7	91.3	3.04	55.5	9.58	7.15	0.75
FW	25.20	172.6	264.0	46.6	204.1	9.60	120.2	21.1	94.4	2.46
MW	28.01	181.5	205.8	76.4	136.3	16.6	106.8	33.1	109.6	2.00
RW	54.60	217.7	404.2	54.2	158.7	9.60	178.3	38.0	148.0	7.50
Mean	35.94	170.6	221.1	59.1	166.4	11.9	135.1	30.7	117.3	3.99
FLSD (0.05)										
Tillage(T)	0.81	5.02	19.9	2.01	9.43	0.21	6.9	0.97	2.08	1.02
WA	2.83	18.03	58.0	8.10	26.9	0.44	3.50	5.01	29.61	0.52
TXWA	1.00	0.06	0.78	1.01	3.00	0.17	1.O2	0.99	0.88	0.13

Table 8: Effect of tillage practices on tillage practices and wood-ash on shoot heavy metals (Cu, Zn, Fe, Pb and B) (mgkg^{-1})

Treatment	2016					2017				
	Cu	Zn	Fe	Pb	B	Cu	Zn	Fe	Pb	B
FO	1.03	105.7	59.62	1.10	21.80	0.08	2.19	49.50	0.20	1.75
MO	0.65	94.5	60.75	1.03	12.65	0.06	2.20	52.20	0.08	1.18

RO	0.98	121.0	30.90	1.28	21.90	0.03	2.30	27.90	0.93	0.95
Mean	0.89	107.1	50.40	1.14	18.78	0.06	2.23	43.2	0.40	1.29
FW	1.10	425.95	66.60	1.67	16.01	0.15	1.80	56.95	0.12	1.25
MW	1.06	447.95	67.35	1.83	32.05	0.11	2.30	57.35	0.88	1.68
RW	1.37	707.25	68.03	2.11	34.00	0.42	2.36	54.15	1.16	1.51
Mean	1.18	527.05	67.33	1.87	27.35	0.23	2.15	56.15	0.72	1.48
FLSD(0.05)										
Tillage (T)	1.01	12.9	3.02	1.00	0.21	0.48	0.11	2.99	0.15	0.51
WA	0.98	23.2	1.01	0.22	2.03	0.08	0.130	1.10	0.83	0.72
TXWA	0.98	8.54	3.05	0.22	0.43	0.04	0.01	3.33	0.12	0.37

Table 9: Effect of tillage practices on tillage practices and wood-ash on seed heavy metals (Cu, Zn, Fe, Pb and B) ($mgkg^{-1}$)

Treatment	2016					2017				
	Cu	Zn	Fe	Pb	B	Cu	Zn	Fe	Pb	B
FO	1.04	1.40	34.10	1.01	13.25	0.07	1.25	25.00	0.06	0.10
MO	0.84	1.30	45.00	0.99	11.15	0.08	1.10	35.80	0.04	0.25
RO	0.99	1.20	35.00	1.18	17.15	0.10	1.14	32.60	0.04	0.27
Mean	0.96	1.30	38.00	1.06	13.85	0.08	1.16	31.1	0.11	0.21
FW	1.08	1.52	67.90	1.50	40.75	0.06	1.40	40.80	0.20	0.02
MW	1.04	2.32	67.00	1.21	46.99	0.09	1.70	59.80	0.26	0.35
RW	1.44	2.30	68.80	1.51	49.75	0.06	1.50	44.20	0.56	0.83.
Mean	1.87	2.04	67.9	1.41	45.83	0.07	1.53	42.27	0.34	0.40
FLSD										

(0.05)										
Tillage	0.22	NS	0.91	0.02	2.33	NS	0.05	3.23	NS	0.18
WA	0.06	0.03	0.90	6.30	2.90	NS	0.12	3.88	0.08	0.21
TXWA	0.11	0.07	0.82	0.13	6.76	NS	0.01	12.5	0.12	0.04