PHYSICAL PROPERTIES AND YIELD OF MAIZE USING OIL PALM HUSK ON SOILS OF OWERRI AREA, IMO STATE, NIGERIA.

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Abstract
This study was carried out to determine the effect of different levels of oil palm husk on physical properties and yield of maize in an Ultisol of Oforola, Imo State. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. Maize was used as the test crop. Pre-soil composite samples were collected from the field plots at 0-15 cm and 15-30 cm soil depths, using a soil auger. Soil samples were collected 2 and 8 weeks after surface application of oil palm husk (OPH). The generated soil data were subjected to analysis of variance using statistical soft-ware, Genstat discovery. The results showed significant differences amongst the treatments of 0 t/ha, 12 t/ha, 18 t/ha and 24 t/ha respectively. At 2 WAP, oil palm husk significantly ($P < 0.01$) influenced all measured parameters, except moisture content. Highest values of TP were recorded from 0 t/ha (48.16%) and 24 t/ha (45.28%) which did not differ significantly from each other. Significantly, highest amount of percent sand (76.20%) was obtained from 24 t/ha OPH plots, while the least amount (72.20%) was obtained using 12 t/ha OPH mulch. There was significant change in BD following application of 18 t/ha OPH which recorded maximum BD of 1.530 g/cm^3. Maximum values of Ksat (0.0027 cm/s) was obtained using 24 t/ha OPH and did not differ significantly with value obtained (0.0015 cm/s) using 12 t/ha OPH. Lowest value of Ksat (0.0006 cm/s) was obtained using 18 t/ha OPH. Application of OPH mulch improved significantly both macro and micro aggregate stability at 2 WAP. The effect of OPH x sampling depth interaction at 2 WAP showed no significant ($P > 0.05$) effect on moisture content and Ksat. Significant interaction effects ($P< 0.01$) were observed on TP, percent sand, silt and clay, BD and aggregate stability. Highest values of TP were also recorded from 0 t/ha (45.99%) and 24 t/ha (45.38%) which did not differ significantly from each other. At 8 WAP, unmulched plots recorded lowest values of WSA > 0.5 mm (15.0%) and WSA < 0.25 m (6.0%). Optimum values of WSA > 0.5 mm (56.6%) and WSA < 0.25 m (20.5%) occurred at 12 and 18 t/ha OPH mulch, respectively. Significant interaction effects ($P< 0.01$) were observed on TP, percent sand and clay, BD and aggregate stability. The highest grain yield was obtained at 12 t/ha (1270 kg/ha) with an ear height of 48.57 cm, while the lowest yield was at 0t/ha (497 kg/ha) with an ear height of 28.99 cm. Application of 12 t/ha of OPH was therefore, recommended for maize production at Oforola based on yield results and percentage improvement in soil aggregate stability (WSA>0.5 mm (83.5%); WSA<0.25 mm (85.4%) and clay content (79.0%).

Keywords: performance, maize, rates, oil palm husk

Introduction

The southeastern agro-ecological zone of Nigeria is predominantly agrarian, producing annual as well as plantation crops. Due to continuous cultivation of arable land occasioned by alternative uses of land, much of the soils are characterized as low in organic matter and CEC, with little or no mineral reserves. They have low water holding capacity, low pH, highly leached and structurally unstable (Uwah and Iwo, 2011). Under natural vegetative cover, these soils maintain a close system because plant nutrients are brought from the deeper horizons by tree roots and incorporated on the surface through litter falls (Enwezor *et al.*, 1981).

However, with the removal of vegetation and subsequent cropping, fertility maintenance becomes a serious problem. The numerous soil problems are further compounded by the seasonality and erratic distribution of rainfall which results in varying periods of dry spells separated by wet periods (Uwah and Iwo, 2011). There is the need to develop farm management practices that would conserve moisture in the soil to protect crops during periods of dry spells and also protect the soil against erosion during erosive storms.

The need for various mulch materials in soil conservation systems has risen due to waste generation with the potential to replace straw, wood shavings and saw dust. The oil palm husk, which is a product of oil palm, has proven suitable for mulching, although, its use as organic material in agriculture is under-exploited (Okoli *et al*., 2010). With the dawn of the oil palm revolution, its cultivation and processing is expanding rapidly every year due to a high demand for palm oil in the market, hence, unlimited generation of oil palm husk. Though, much impact has been made in the area of cultivation of oil palm trees, much of other vegetation have been destroyed leading to little or no canopy cover causing large losses to soil, nutrients and organic matter on fragile lands (Ghulam *et al.*, 2007). Furthermore, without proper conservation methods to retain topsoil which is susceptible to soil erosion, reduction on soil productivity will occur (Morgan 2005).

Cereal crops especially, maize is one of the highest yielding cereal crop in the world, it is of considerable substance for countries like Nigeria, where rapidly increasing population has already ran short of existing food supplies. Maize accounts for 4.8 % of the total cropped area and 3.5 % of the value of agricultural output (Akinci *et al*, 2004). Its importance is apparent in daily life food stuff as it is used as edible food and high valued food for human beings, feed for livestock and poultry and a raw material for various agro-based industries (Chaudhry, 2003). Corn starch, corn oil, alcohol and tanning materials for leather industry are commercially produced from the maize. About two third of the total world production of maize is used for livestock feed or for commercially starch and oil.

Developing countries like Nigeria are facing great challenges to meet input resources for Maize production which include fertilizer, irrigation, good quality seed and energy crisis in order to sustain their production. There is need to adopt such organic practices that decrease the cost of production. Such practices include mulching practices. The interest in oil palm husk is predicated on the availability, low cost and management.

A study was therefore, carried out to assess the effects of different levels of oil palm husk on selected soil physical properties; ascertain the soil physical parameters that will affect the soil productivity under the different treatments; and provide recommendations on the best level(s) of treatment that will enhance soil productivity of the study soil.

Materials and Methods

Description of the study area

The research was carried out in the Research and Demonstration Farm of the Federal College of Land Resources Technology (FECOLART), Owerri Area, Imo State. It lies between latitude 5^0 14 and 6^0 31^I North, and longitude 7^o 34^I and 6^o 15^1 East (Uwakwe, 2012).

The annual rainfall in Oforola ranges from 1500-2000 mm with an annual temperature of 31^oC (Uwakwe 2012). The soils of Oforola are porous, weakly structured, well drained in such a way that run-off water disappear 30 minutes after a typical rain storm (Ufot, 2012).

Climate

The climate of the area is mainly tropical in nature. The weather condition in the study area during the rainy season is cold while hot and warm during the dry season. The area witnesses a rainy season from the month of April to October, usually interrupted by a short dry weather in the month of August, while the dry season or harmattan starts from November to January of the following year.

Experimental layout and soil sampling method

The experiment was laid out in randomized complete block design (RCBD) with four replications. Pre-soil composite samples were collected from the field plots at 0-15 cm and 15-30 cm soil depths, using a soil auger. The soil samples were bagged, into different polythene bags, labeled and carried to laboratory for standard routine analysis. Soil samples were collected 2 and 8 weeks after surface application of oil palm husk. Core samples were collected using core samplers.

Laboratory analyses

Undisturbed soil core samples were taken from all the treated plots at 2 depths (0-15 cm and 15-30 cm). The samples were used to determine bulk density (BD) according to Blake and Hartge (1986).

Total porosity (P_T) was obtained from bulk density (d_B) values, with assumed particle density (d_P) of 2.65 g cm^{-3}, as follows:

$P_T = 100\ (1 - d_B/d_P)$ ---------------------------(1)

Saturated hydraulic conductivity (K_{sat}) was determined by the constant head method as described by Klute (1986) using the equation:

$K_{sat} = \theta\ /\ At \times L\ /\ \Delta H$ ----------------------- (2)

Where θ = volume of water per unit time; A = area of core sampler; t = unit time in minutes / hours; L = length of core; and ΔH = hydraulic head difference

Particle size distribution was measured by the hydrometer method (Day, 1965).

Moisture content was determined by the gravimetric method using undistorted soil core (Blake and Hartge, 1986), using the formula:

$$\%\ moisture = \frac{^{M}initial - {^{M}dried} \times 100}{^{M}initial}$$

Where : ^{M}initial and dried are the masses of the samples before and after drying, respectively.

Water-stable aggregates (WSA) of the 2-mm air-dry samples were determined using a nest of sieves 2, 1, 0.5, and 0.25 mm in diameter as described by Kemper and Chepil (1986). The WSA > 0.5 mm were used to assess aggregate stability, whereas the percentage aggregates < 0.25 mm measured the unstable aggregates.

Statistical analysis

Data generated were subjected were subjected to analysis of variance for a randomized complete block design using Genstat Discovery (Edition4, 2011). Significant treatment means were separated using Fischer's least significant different (F-LSD) as described by Obi (1986) at 5% probability level.

Results and Discussion

Initial soil status before application of OPH

Table 1 shows the means of selected soil properties before land clearing and application from two soil depths (0-15 cm and 15-30 cm). The total porosity was very high with the values of 69.86%, and 78.18% for 0-15 cm, 15-30 cm depths, respectively. Bulk density was high and ranged from 1.63 g/cm^3 to 1.75 g/cm^3, while saturated hydraulic conductivity was also low, ranging from 0.0016 to 0.0066 cm/s. Water stable aggregates ranged from 15 – 17.2% cm across the two studied depths. Percent sand and silt decreased with increase in soil depth. Higher values of 73.2 and 6.0%, respectively, were recorded at 0-15 cm soil depth.

Table 1: Physico-chemical status of the studied soil before OPH application at two sampling depths.

	Sampling depth	
Soil physical parameter	**0 – 15 cm**	**15 – 30 cm**
Sand (%)	73.20	69.20
Silt (%)	6.00	4.00
Clay (%)	20.80	26.80
Textural class	SCL	SCL
Ksat (cm/s)	0.0016	0.0066
Bulk density (g/cm^3)	1.75	1.63
Moisture content (%)	19.30	19.53
Total porosity (%)	35.43	34.90
WSA > 0.5 mm (%)	36	15
WSA < 0.25 (%)	17	17.2

Ksat = Saturated hydraulic conductivity; WSA = Water Stable Aggregates

Effect of OPH mulch and sampling depth on selected soil physical properties 2 WAP.

The effect of different levels of oil palm husk and sampling depth and oil palm husk x sampling depth interaction on selected physical parameters at 2 WAP are as shown in Table 2. Oil palm husk significantly ($P < 0.01$) influenced all measured parameters, except moisture content. Highest values of TP were recorded from 0 t/ha (48.16%) and 24 t/ha (45.28%) which did not differ significantly from each other. Significantly highest amount of percent sand (76.20%) was obtained from 24 t/ha OPH plots, while the least amount (72.20%) was obtained using 12 t/ha OPH mulch. Highest percentage silt (7 and 6%) was obtained from 24 and 0 t/ha OPH mulch, respectively. These values differed significantly with values (4%) obtained using other OPH mulch rates. Application of 12 t/ha OPH which recorded the least percent sand (72.20%), recorded the highest amount of percent clay (23.80%) and did not differ significantly with the percent clay (22.80%) obtained with 18 t/ha OPH. There was significant change in BD following application of 18 t/ha OPH which recorded maximum BD of 1.530 g/cm^3. The bulk density due to other mulch rates did not differ significantly with that due to the control (1.370 g/cm^3). Maximum values of Ksat (0.0027 cm/s) was obtained using 24 t/ha OPH and did not differ significantly with value obtained (0.0015 cm/s) using 12 t/ha OPH. Lowest value of Ksat (0.0006 cm/s) was obtained using 18 t/ha OPH. This may be implicated by the highest BD (1.53 g/cm3) recorded by 18 t/ha OPH. Mehuys and Dekimpe (1976) had associated hydraulic conductivity decrease largely with increase in BD. Application of OPH mulch improved significantly both macro and micro aggregate stability at 2 WAP. Maximum percent improvement in WSA > 0.5 mm (38.3%) and WSA < 0.25 mm (41.8%) over the control occurred in plots treated with 18 t/ha OPH. This agrees with early reports of Russell (1961), where he reported that mulching improves soil aggregate stability. Mbagwu (2003) also that decreased aggregate stability was observed in unmulched plots.

Sampling depth did not show any significant effect ($P > 0.05$) on TP, percent silt, BD, moisture content and Ksat. Percent sand decreased (72.70%) with increase in sampling depth, while percent clay increased (21.80%) with increase in sampling depth. Similarly, WSA > 0.5 mm increased (17.6%) with increase in sampling depth.

The effect of OPH x sampling depth interaction at 2 WAP showed no significant ($P > 0.05$) effect on moisture content and Ksat. Significant interaction effects ($P< 0.01$) were observed on TP, percent sand, silt and clay, BD and aggregate stability. All treatment combinations improved TP, except, 12 t/ha OPH x 15 – 30 cm depth and 18 t/ha OPH x 0 – 15 cm depth. Interaction effect of 12 t/ha OPH x 15 – 30 cm depth resulted in significantly lowest percent sand (71.20%). Silt clay ratio which is a measure of erosion and flood incidence was highest in plot that received 24 t/ha OPH x 0 – 15 cm depth (0.47). This may suggest that high percent sand (81.20%) recorded in these plots may be due to erosion/flood and deposition of sand as the velocity of flow is reduced by the mulch material. The effect of interaction on aggregate stability showed that sampling depth influenced aggregation more than OPH mulch application. As sampling depth increased for every OPH mulch treatment, aggregate stability (both macro and micro aggregate stability) increased. Exception was only at 4 t/ha OPH x 15 – 30 cm depth, where lower values were obtained as the sampling depth increased.

Table 2: Effects of OPH, sampling depth and OPH x sampling depth interaction on selected soil physical properties of Oforola soil at 2 Weeks After Planting (WAP).

Treatment	Total porosity (%)	Sand (%)	Silt (%)	Clay (%)	BD (g/cm^3)	Moisture content (%)	K sat (cm/s)	WSA > 0.5 mm	WSA < 0.25mm
OPH (t/ha)									
0 t/ha	48.16	75.20	6.00	18.80	1.370	9.84	0.001	18.2	4.1
12 t/ha	43.92	72.20	4.00	23.80	1.480	9.33	0.0015	21.8	4.8
18 t/ha	42.45	73.20	4.00	22.80	1.530	9.37	0.0006	47.5	9.4
24 t/ha	45.28	76.20	7.00	16.80	1.450	9.64	0.0027	20.9	8.9
LSD(0.05)	3.45**	0.88**	1.11*	1.62**	0.092*	NS	0.0013*	3.0**	0.6**
Sampling depth (SD) (cm)									
0 – 15 cm	45.28	75.70	5.00	19.30	1.450	9.52	0.0015	15.1	22.1
15 – 30 cm	44.62	72.70	5.50	21.80	1.468	9.57	0.0014	17.6	9.8
LSD(0.05)	NS	0.62**	NS	1.15**	NS	NS	NS	1.0**	4.4**
OPH x Sampling depth interaction									
0 x 0-15 cm	47.92	75.20	8.00	18.80	1.380	47.92	0.0005	8.0	4.0
0 x 15-30 cm	48.40	75.20	4.00	20.80	1.368	20.80	0.0006	22.1	9.2
12 x 0-15 cm	47.08	73.20	2.00	22.80	1.402	24.80	0.0025	21.5	8.0
12 x 15-30 cm	40.75	71.20	6.00	24.80	1.570	22.80	0.0005	22.0	10.7
18 x 0-15 cm	39.25	73.20	4.00	22.05	1.610	22.80	0.0013	9.4	6.9
18 x 15-30 cm	45.66	73.20	4.00	24.80	1.440	22.80	0.0013	9.4	12.0
24 x 0-15 cm	46.89	81.20	6.00	12.80	1.407	12.80	0.602	24.8	10.4
24 x 15-30 cm	43.68	71.20	8.00	22.80	1.492	20.80	0.003	17.0	7.4
LSD(0.05)	4.88*	1.24**	1.57**	2.29**	0.129**	NS	NS	8.8**	0.9**

**=Significant at 1% probability level, NS=Not significant at 5% probability level.

Effect of OPH mulch and sampling depth on selected soil physical properties 8 WAP.

The effect of different levels of oil palm husk and sampling depth and oil palm husk x sampling depth interaction on selected physical parameters at 8 WAP are as shown in Table 3. Oil palm husk significantly (P < 0.01) influenced all measured parameters, except moisture content and Ksat. Results of TP followed the same trend as at 2 WAP. Highest values of TP were also recorded from 0 t/ha (45.99%) and 24 t/ha (45.38%) which did not differ significantly from each other. This implies that application of < 24 t/ha OPH reduced total porosity of the soil, relative to the control at both 2 and 8 WAP. The results of particle size distribution at 8 WAP did not differ from the results obtained at 2 WAP. At 8 WAP, application of 18 t/ha OPH also gave the highest BD of 1.580 g/cm^3 followed by 12 t/ha with a BD of 1.516 g/cm^3. Lowest values of BD (1.437 and 1.447 g/cm^3) were obtained using the control and 24 t/ha OPH, respectively. Mulching improved soil aggregate stability at 8 WAP. Unmulched plots recorded lowest values of WSA > 0.5 mm (15.0%) and WSA < 0.25 m (6.0%). Optimum values of WSA > 0.5 mm (56.6%) and WSA < 0.25 m (20.5%) occurred at 12 and 18 t/ha OPH mulch, respectively.

Sampling depth did not show any significant effect (P > 0.05) on percent silt and moisture content at 8 WAP. Percent sand (72.20%), TP (42.71%) and Ksat (0.0011 cm/s) reduced with increase in sampling depth, while percent clay (23.30%), BD (1.518 g/cm3) WSA > 0.05 mm (52.1%) and WSA < 0.25 mm (22.2%) increased with increase in sampling depth.

The effect of OPH x sampling depth interaction at 8 WAP showed no significant (P > 0.05) effect on percent silt, moisture content and Ksat. Significant interaction effects (P< 0.01) were observed on TP, percent sand and clay, BD and aggregate stability (Table 3). Application of 24 t/ha OPH and sampling at 0 – 15 cm depth improved the total porosity (47.45%), percent sand (81.20%) and lowered the percent clay (12.80%) and BD (1.392 g/cm^3). Highest TP recorded by this treatment combination may be due to its low clay content (12.80%) and BD (1.392 g/cm^3).

Table 3: Effects of OPH, sampling depth and OPH x sampling depth interaction on selected soil physical properties of Oforola soil at 8weeks after planting (WAP).

Treatment	Total porosity (%)	Sand (%)	Silt (%)	Clay (%)	BD (g/cm^3)	Moisture content (%)	Ksat (cm/s)	WSA > 0.5 mm	WSA < 0.25 mm
OPH (t/ha)									
0 t/ha	45.99	75.20	5.0	19.80	1.431	10.01	0.0056	15.0	6.0
12 t/ha	42.78	72.20	4.0	23.80	1.516	9.95	0.0016	56.6	16.6
18 t/ha	40.38	72.20	4.36	23.42	1.580	9.96	0.0024	48.5	20.5
24 t/ha	45.38	76.20	6.0	17.80	1.447	9.92	0.0030	63.7	29.9
LSD(0.05)	2.38**	0.16**	1.03**	0.96**	0.063**	NS	NS	8.8**	9.3**
Sampling depth (SD) (cm)									
0 – 15 cm	44.55	75.70	5.19	19.11	1.469	10.04	0.0027	39.8	14.3
15 – 30 cm	42.71	72.20	4.50	23.30	1.518	9.88	0.0011	52.1	22.2
LSD(0.05)	1.68*	0.111**	NS	0.68**	0.045*	NS	0.0002*	5.4**	6.6**
OPH x Sampling depth interaction									
0 x 0-15 cm	46.79	75.20	6.00	18.80	1.410	10.27	0.0025	15.3	10.1
0 x 15-30 cm	45.19	75.20	4.00	20.80	1.452	9.75	0.0026	14.7	19.0
12 x 0-15 cm	46.13	7320	4.00	22.80	1.427	10.25	0.0025	38.9	12.0
12 x 15-30 cm	39.43	71.20	4.00	24.80	1.605	9.64	0.0026	54.2	21.2
18 x 0-15 cm	37.83	73.20	4.75	22.05	1.647	9.83	0.0034	24.9	7.0
18 x 15-30 cm	42.92	71.20	4.00	25.80	1.512	10.10	0.0014	52.0	34.0
24 x 0-15 cm	47.45	81.20	6.00	12.80	1.392	9.79	0.0045	44.6	23.3
24 x 15-30 cm	43.30	11.20	6.00	22.80	1.502	10.05	0.0015	62.0	36.4
LSD(0.05)	3.36**	0.22**	NS	1.35**	0.089**	NS	NS	10.6**	13.2**

****=Significant at 1% probability level, NS=Not significant at 5% probability level.**

Effect of OPH on grain yield and some yield parameters of maize

Table 4 shows the grain yield obtained from different treatments. The highest yield was obtained at 12 t/ha (1270 kg/ha) with an ear height of 48.57 cm, while the lowest yield was at 0 t/ha (497 kg/ha) with an ear height of 28.99 cm. The result of this table shows that, oil palm.

Table 4: Grain yield result of oil palm husk after 8 weeks of planting

Treatment	1000 grain weight (g)	Ear height (cm)	Grain yield (kg/ha)
0t/ha	106.47	28.99	497.0
12t/ha	102.75	48.57	1270.0
18t/ha	105.19	35.72	763.0
24t/ha	104.49	39.37	907.0
LSD (0.05)	1.02**	5.40**	212.8**

** = Significant at 1% probability level.

Conclusion

The study ascertained the effect of four levels of oil palm husk on soil physical properties of FECOLART Demonstration Farm Southeastern Nigeria. The results indicated differences among applied treatment levels of 0 t/ha, 12 t/ha, 18 t/ha and 24 t/ha. Oil palm husk mulch has a significant effect by ways of reduction on the soil bulk density. The reduction in BD by of 24 t/ha oil palm husk mulch was higher when compared with that due to 12 t/ha of OPH mulch at both 2 and 8 WAP. Also the hydraulic saturated conductivity of the soil under study at 2 WAP was affected significantly by way of increase by the different level of 12 t/ha, 18 ton/ha and 24 t/ha of OPH mulch when compared with that of 0 ton/ha of OPH. At 8 WAP, OPH treatments had no significant effect on Ksat. Similarly OPH X sampling depth interaction did not significantly ($P > 0.05$) influence Ksat at 2 and 8 WAP. Saturated hydraulic conductivity due to sampling depth did not vary at 2 WAP. However at 8 WAP higher Ksat value (0.0027) was obtained from the top soil. It was observed that oil palm husk on different level of treatment, improved the soil bulk density, total porosity and Ksat, while there was reduction in the moisture content of the soil due to mulch application.

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