STRAW MULCH LEVELS AND SELECTED SOIL PHYSICAL AND CHEMICAL PROPERTIES OF OFOROLA, IMO STATE, NIGERIA

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ABSTRACT
The study was conducted to determine the effect of three levels of straw mulch on selected soil physico-chemical properties of the Research and Demonstration Farm of the Federal College of Land Resources Technology, Owerri. The experiment was laid out in a Randomized Complete Block Design with treatments replicated three times. Soil samples were collected randomly before the application of straw mulch and after two months of application. Soil samples were collected from 0 - 15cm soil depth, using auger. The mulch materials were applied to the plots at 0 t/ha, 6 t/ha, and 12 t/ha. The generated soil data was analyzed statistically using analysis of variance and correlation with GENSTAT Discovery software. The results showed that percent sand dominated other fine particles with mean values of 78.0%, 78.4% and 79.07% for 0 t/ha, 6 t/ha and 12 t/ha respectively. The percent sand however, recorded a non-significant difference among the different levels of straw mulch. The soil porosity, infiltration rate and soil pH increased with increase in the applied levels of straw mulch, as well as bulk density which differed significantly (p=0.05) among the treatment levels. Soil porosity showed significance at 6 t/ha and 12 t/ha (53.21% and 51.32%) when compared to 0 t/ha (46.04%). Infiltration rate was highest at 12 t/ha (0.43 cm/hr) compared to 6 t/ha (0.22 cm/hr) and 0 t/ha (0.14 cm/hr). Soil pH was highest at 0 t/ha (5.49) when compared to 6 t/ha and 12 t/ha (5.01 and 4.96) respectively. Bulk density was highest at 0 t/ha (1.43 g/cm^3) and showed significance (p=0.05) when compared with 6 t/ha and 12 t/ha (1.24 and 1.29 g/cm^3). Soil aggregate stability and soil organic matter (SOM) were not had no significant treatment effect among the different treatment levels. The result of the correlation analysis showed that the treatment correlated positively and significantly (r=0.905, p=0.01; r=0.732, p=0.05) with infiltration rate and porosity. The overall result showed that the straw mulch applied at 12 t/ha had a greater influence relative to the parameters studied. It is therefore recommended that straw much applied at 12 t/ha will be more beneficial compared to 0 t/ha and 6 t/ha.

Keywords: different levels, effects, Oforola, physico-chemical, straw mulch

INTRODUCTION

Straw is an agricultural by-product from stalks of cereals or plants after the grain chaff have been removed. Straw makes up for about half oats, rye, rice, maize and wheat. Straw is rich in organic minerals, so it is increasingly considered to be an important natural fertilizer. The rate of straw use for fuel, mulch and forage have declined significantly and straw is increasingly burned after harvest which leads to high loses of soil organic substances and increased emission of carbon dioxide that pollute the environment.

According to Kar and Kumar (2007) soil infertility, soil erosion and water deficiency are the major factors that limit crop growth. The use of straw mulch can help in the mitigation of these factors. Mulching the soil using straw materials improve soil quality and productivity through their favourable effects on soil properties (Lal and Stewart, 1995; Enyioko *et al.*, 2017). Also, reports have been made on significant effects of straw materials on soil aggregates, bulk density, water retention (Duiker and Lal, 1999), and soil quality (Lal *et al*., 1999). The straw materials can promote the production of a favourable soil environment. Straw mulches reduce water evaporation from soils and help maintain stable soil temperature (Unger, 1990; Kar and Kumar, 2007). Application of straw mulch significantly increased the available phosphorous and potassium in the soil (Sonsteby *et al*, 2004). It also improves plant growth, yield and yield quantity (Singh *et al*, 2007). Ghuman and Sur (2001) found that straw incorporation also improved the aggregate stability and other soil properties compared with farmyard manure. It had positive effect on soil porosity, available water content, bulk density and increased crop yield. The objective of this study therefore, was evaluating the relationships between the various soil physical properties e.g. bulk density, porosity, texture, organic matter and soil water infiltration and the different levels of straw mulch.

MATERIALS AND METHOD

The study was conducted in the research and demonstration farm of the Federal College of Land Resources Technology, Owerri. The study area is located in Oforola community in Owerri West Local Government Area of Imo State. The College covers about 105 hectares of land and lies between Latitude 5º41´N and 6º31´ E and Longitude 7º34´ N and 6º 151´E (Uwakwe, 2012).

The area is within the humid tropics with an annual rainfall range of 1500-2500mm. The average annual atmospheric temperature above 20ºC creates an annual relative humidity of 75mm while during the rainy season, humidity reaches 90mm. The hottest months are between January and March (Uwakwe, 2012).

The original vegetation of the study area has been the tropical rain forest, which has been destroyed through human activities. The greater part of the area is now covered with secondary bush which consist mostly of trees, shrubs, grasses and broad leafed plants. The people are mainly consistence farmers in the study area.

Field layout and operations

The field was laid out in a Randomized Complete Block Design (RCBD) with three replications. The straw used for this study was carpet grass sourced after cutting and air drying in the open for about one (1) week. The mulch was applied by turning them in the soil to a depth of 3cm. The levels of application were 0t/ha (control), 6t/ha and 12t/ha. Soil samples were collected randomly using soil auger at 0 – 15cm before the application of the different levels of mulch for soil texture, soil aggregate stability and soil pH determinations. Another set of soil samples were collected after two months of application from the different treatments and analyzed for Organic Carbon. Organic matter was determined by multiplying the organic carbon with van Bemmelen's factor of 1.724 (Organic matter = % organic carbon x 1.724). Core samples were collected for bulk density and porosity determination.

The infiltration rates were determined using double ring infiltrometer as described by Bertrand (1965). Particle size distribution (PSD) was determined using hydrometer (Gee and Or, 2002). Soil pH was determined using 1:2.5 soil liquid ratio using pH meter (Thomas 1996). Bulk density was determined using core samplers according to Blake and Hartge (1986). Soil aggregate stability was determined as described by Kemper and Rosenau (1986).

The proportion of the total samples that is in each aggregate size class was calculated using

PAWI = [WA – [(Wc/Wo) x WI)]

Where PAWI = Proportion of aggregate weight for each size class

WA = Weight of total material in each size class

Wc = weight of coarse materials in size as measured after wet sieving

Wo = weight of aggregate placed on the sieve prior wet sieving

WI = Total sample weight

Statistical Analysis

Soil data generated were subjected to multiple correlation and analysis of variance (ANOVA) for Randomized Complete Block Design using Genstat discovery edition 4. Mean separation was done using Least Significant Difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

The result of selected properties of soils before land clearing / application of straw mulch are presented in Table 1.From the results the site is dominated with sandy particles with percentages of 76.4%, 78.4% and 80.4% for the proposed treatment levels of 0 t/ha, 6 t/ha and 12 t/ha of straw mulch respectively. The porosity and infiltration rate were relatively high which may be as a result of the sandy nature of the site. This agrees with the findings of Osuji (1984) that sandy soil encourages porosity and infiltration. The soil pH (H_2O) were moderately acidic with values of 5.52, 5.10 and 5.31 for the proposed treatment levels 0 t/ha, 6 t/ha and 12 t/ha of straw mulch, respectively. The soil pH was low when compared with the Singer and Munns (1999) ratings. The organic matter of the soil was low when compared with the ratings of Chude *et al* (2011). The percentage OM were 1.64%, 1.89% and 1.74% for the proposed plot to be applied with 0 t/ha, 6 t/ha and 12 t/ha straw mulch, respectively.

Table 1: Result of selected properties of the soil before land clearing and application of straw mulch

Soil Properties	Proposed sites for treatment		
	0 t/ha	6 t/ha	12 t/ha
Sand (%)	76.4	78.4	80.4
Silt (%)	6	4	6
Clay (%)	17.6	17.6	13.6
Porosity (%)	46.79	47.93	46.42
Infiltration (cm/hr)	0.13	0.16	0.11
SAS (mm)	1.88	1.56	1.62
pH(H_2O)	5.52	5.10	5.31
OM	1.64	1.89	1.74
BD (g/cm^3)	1.41	1.38	1.42

SAS =Soil Aggregate Stability, OM = Organic Matter, BD =Bulk Density

Comparison of Selected Properties of Soils Applied with Different Levels of Straw Mulch

The effect of different levels of straw mulch on selected soil properties are presented in Table 2. Sand dominated the other fractions in the particle size analysis. The result showed that sand had means of 78.0%, 78.4 % and 79.07% among the different levels of straw mulch (0 t/ha, 6 and 12 t/ha respectively). However, percent sand did not differ significantly (p =0.05) among the treatments. Enwezor *et al.* (1990) and Onweremadu *et al.* (2011) noted that the sandy nature was a reflection of the coastal plain sand parent materials from which the soils were formed. The silt was generally low, which could be as a result of high weatherability. This agrees with the findings of Ahn (1993), that the silt content of the soil is dependent on weatherability rate. The silt had percent mean values of 4.6%, 4.00% and 6.6% for 0 t/ha, 6 t/ha and 12 t/ha straw mulched plots respectively. There was no significant difference (p =0.05) in silt content among the different levels of straw mulch applied.

Clay particles recorded means of 17.13, 17.16 and 14.23% for 0 t/ha, 6 t/ha plot and 12 t/ha respectively. Clay content showed no significant difference (p =0.05) among the treatments of 0 t/ha, 6 t/ha and 12 t/ha of straw mulch. This implied that the treatments applied at different levels had no effect on clay percent of the soil under study.

Porosity values were high and significant at p=0.05 for all treatments (46.04, 53.31 and 51.32% for 0 t/ha, 6 t/ha and 12 t/ha respectively). High porosity could be as a result of low bulk density values, hence, agreeing with the relationship between bulk density and porosity according to Jarvis and Messing (1995).

The infiltration rate recorded means of 0.14cm/hr, 0.22cm/hr and 0.43cm/hr at 0 t/ha, 6 t/ha and 12 t/ha. The result showed that the infiltration rate increased in an increasing order of 0.14cm/hr < 0.22cm/hr < 0.43cm/hr for applied levels of 0 t/ha, 6 t/ha and 12 t/ha of straw mulch respectively. Straw mulch had a significant influence on the soil infiltration rate as applied straw mulch level increased. The variation in infiltration rate could be dependent on bulk density. Saxton *et al* (1986) stated that the influence of bulk density on infiltration rates predominate other factors.

Soil aggregate stability values were 1.77mm, 1.81mm and 2.08mm at 0 t/ha, 6 t/ha and 12 t/ha respectively. The result showed that straw levels had no significant effect on soil aggregate stability (p=0.05).

The soil pH values (in water) in plots of 0 t/ha, 6 t/ha and 12 t/ha were 5.49, 5.01 and 5.49 respectively. According to Singer and Munns (1999) ratings, the soils were generally acidic. The acidic nature of the soil could be attributed to organic release by straw mulch during decomposition (Brady and Weil, 1997; Jandel *et.al*; 2004).

The organic matter values of the treated soils increased in the order of 2.16%> 2.13%> 1.78% for applied levels of 12 t/ha, 6 t/ha and 0 t/ha of straw mulch respectively. However, organic matter showed no significant treatment effect (p=0.05) at the levels of 0 t/ha, 6 t/ha of straw mulch. This insignificant difference may be dependent on rate/level of decomposition. The bulk density of the soil as affected by different levels of straw mulch was $1.43g/cm^3$, $1.24g/cm^3$ and $1.29g/cm^3$ for 0 t/ha, 6 t/ha and12 t/ha respectively. The control plot had higher bulk density when compared with values from 6 t/ha and 12 t/ha. The bulk density differed significantly (p=0.05) among the different levels (0 t/ha, 6 t/ha, 12 t/ha) of applied straw mulch. Results on bulk density were lower than the critical limits for root restriction ($1.75\text{-}1.85g/cm^3$) (Soil Survey Staff, 1996).

Table 2: Mean Comparison of Selected Properties of Soils Applied with Different Levels of Straw Mulch

Treatment Plot	Sand	Silt	Clay	Porosity	IR (cm/hr)	SAS (mm)	pH (H_2O)	OM (%)	BD (g/cm^3)
0 t/ha	78.00	4.67	17.13	46.04	0.14	1.77	5.49	1.78	1.43
6 t/ha	78.40	4.00	17.16	53.21	0.22	1.81	5.01	2.13	1.24
12 t/ha	79.07	6.67	14.27	51.32	0.43	2.08	4.96	2.16	1.29
LSD (0.05)	NS	NS	NS	1.110	0.1167	NS	0.3041	NS	0.0512

IR = Infiltration Rate, SAS = Soil Aggregate Stability, OM = Organic Matter, BD = Bulk Density.

Correlation matrix of selected physiochemical properties of soil applied with three different levels of straw mulch.

The results of correlation matrix of selected physico-chemical properties of soils applied with the three different levels of straw mulch are presented in Table 3. The treatment correlated positively and significantly (r=0.905, p=0.01; r=0.732, p=0.05) with infiltration rate and porosity, respectively. It also correlated negatively and significantly with soil pH (in water) (r=0.747, p=0.05). The Infiltration Rate (IR) correlated positively (r=0.495, r=0.228, r=0.322) with Organic Matter (OM), Soil Aggregate Stability (SAS), and percent sand, respectively, while it had a positive and significant correlation (r=0.695, p=0.05) with porosity. OM had a negative correlation (r=-0.14, r=-0.266, r=-0.622) with SAS, soil pH and BD respectively. SAS correlated positively (r=0.116, r=0.072) with clay content and bulk density respectively while it has a negative correlation (r=-0.031, r=-0.018) with porosity and sand content.

CONCLUSION

The study was conducted to determine the effect of different levels of straw mulch on soil physico-chemical properties of soils of Oforola. The result of the analysis showed that the study site was predominantly sandy with mean values of 78%, 78.4% and 79.07% for 0 t/ha, 6 t/ha and 12 t/ha respectively. The percent sand recorded a non-significant difference among the different levels of straw mulch. The soil porosity, infiltration rate and soil pH increased with an increase in the applied levels of straw mulch, as well as bulk density which differed significantly among the treatment levels. Soil aggregate stability and soil organic matter (SOM) had no significant effect among the different treatment levels. The result of the correlation reveals that the treatments had positive and significant correlation (r=0.905, p=0.01; r=0.732, p=0.05) with infiltration rate and porosity respectively. It also correlated positively (though non-significant) (r=0.517, r=0.098; p=0.05) with organic matter and soil aggregate stability. The result revealed that the physical and chemical properties of the soil were generally influenced by the different levels of the straw applied.

Table 3: Correlation matrix of selected physiochemical properties of soils applied with three different level of straw mulch.

	Treatment (t/ha)	IR (cm/hr)	OM (%)	SAS (mm)	Soil pH	Porosity	Sand	Clay	Silt	BD (g/cm^3)
Treatment	1									
IR	0.905**	1								
OM	0.517	0.495	1							
SAS	0.098	0.228	-0.141	1						
Soil	-0.747*	-0.452	-0.266	-0.021	1					
Porosity	0.732*	0.698*	0.432	-0.031	-0.495	1				
Sand	0.194	0.322	0.458	-0.018	0.078	0.593	1			
Clay	-0.465	-0.567	-0.522	0.116	-0.071	-0.691*	-0.772	1		
Silt	0.491	0.453	0.158	-0.170	-0.060	0.233	-0.217	-0.450	1	
BD	-0.652	-0.462	-0.622	0.072	0.774*	-0.343	-0.065	0.032	-0.009	1

**= correlation is significant at the 0.01 level, *= correlation is significant at the 0.05 level,
IR = infiltration rate, OM = organic matter, SAS = soil aggregate stability, BD = bulk density.

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