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Research Article

Physical Fertility of an Ultisol Enhanced by Application of Urine-Decomposed Rice Husk Dust in Abakaliki Southeastern Nigeria

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Abstract

The capability of the soil to produce a crop or sequence of crops under well defined management systems and environmental conditions has dwindled to abysmal level. Triggering researches on application of amendments to ameliorate its condition and precipitate nutrients which will boost productivity. One is the application of urine-decomposed rice husk dusts to accelerate decomposition of lignin-loaded wastes. In this research 4 t ha^{-1} rice husk dusts were decomposed with 5 litres each of human urine, swine slurry, water; with another 4 t ha^{-1} undecomposed rice husk dusts and no application of rice husk dusts as reference. This gave a total of five treatments replicated four times in a Randomized Complete Block Design (RCBD). Results of the study showed that decomposed and undecomposed rice husk dusts significantly (P = 0.05) improved all the physical properties relative to control. The plots amended with undecomposed rice husk dusts improved soil bulk density, total porosity and aggregate stability; while swine slurry decomposed rice husk dusts enhanced moisture, penetration resistance and infiltration rate. There was minimal effect of soil amendment on hydraulic conductivity. The bulk density in control plots were within 1.67 g cm^{-3}, which was higher than amended plots by 3.8 – 11.4%. Total porosity values of up to 50.59% were recorded in undecomposed rice husk dust plot. In amended plots, moisture was within 55% in swine slurry decomposed husks, with increasing order of swine slurry>human urine>water>undecomposed>control. Hydraulic conductivity was highest in plots decomposed with swine slurry (39.88 cm hr^{-1}). Penetrometer resistance and infiltration rate were significantly (P = 0.05) improved in amended plots relative to control; with swine slurry decomposed husks plots recording lowest penetrometer resistance of 1.76, 1.68 and 1.72 kg cm^{-3} for three yrs of study. Highest infiltration rate of 410, 430 and 428 cm hr^{-1} in decomposed plots. Soil aggregate stability was highest in undecomposed husks plots with values of 64.2%, 61.5% and 59% for the three yrs. Physical soil fertility was enhanced by decomposed and undecomposed rice husks. Treating human urine before application was recommended to prevent pathogen transfer and enhance acceptability of innovation amongst peasant farmers.

Keywords: Soil Physical Fertility; Organic Amendment; Rice Husk Dust; Decomposed; Human and Animal Urine

Introduction

Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and human life [1]. It is often used interchangeably with soil quality which is the capacity of soil to continue to provide or support crops with water, nutrients; as well as sustain human life. Soil health and/or quality is an important index for assessing soil productivity and a fundamental asset of any ecosystem. This is because soil is an environment for crop growth and development. Soils that are of poor health or quality cannot maintain and/or sustain productive agriculture [2]. High agricultural productivity is under threat because soils have been damaged, eroded or simply ignored during processes of intensification [1]. For instance, it is projected that nearly 2 billion hectares of land worldwide are degraded due to mismanagement and these soils suffer from physical to chemical degradation arising from acidification, nutrients depletion or pollution from excessive use of fertilizers [2]. Consequently, soil productivity which is the capability of the soil to produce a crop or sequence of crops under well-defined management systems and environmental conditions has dwindled to abysmal level [3]. Since productivity is a function of soil fertility, management and/or interactions of both, it has become imperative to evolve sustainable management strategies that may be enduring for higher productivity. Many approaches according to Cowan [4] are used to measure and manage soil for higher productivity such as application of amendments to ameliorate its condition and precipitate nutrients to increase the productivity.

One of such approaches is the application of organic residues like rice husk dusts. Even though the wastes is limited in its high lignin concentration, researches have centred on methods of decomposition prior to incorporation to the soil. At the Department of Soil Science and Environment Management, Ebonyi State University, Abakaliki, Nigeria, scientists have tried the use of human and animal urine high in nitrogen, nitrates and ammonium in the decomposition and precipitation of nutrients. Hence, this research on use of human urine, swine slurry, water in the decomposition of rice husk dusts prior to soil incorporation.

Materials and Methods

Site description

The study was carried out in the Research and Teaching Farm of Department of Soil Science and Environmental Management; Ebonyi State University, Abakaliki. It lies by Latitude 06° 04′ N and Longitude 08° 65′ E. The area is referred to as derived savannah belt of South eastern Nigeria. The annual rainfall ranges from 1700 - 2000 mm with a mean of 1800 mm spread from April – November. There is a dry spell in August, popularly known as “August break”. The mean annual temperatures during rainy and dry seasons are 27°C and 31°C; respectively. Relative humidity during rainy and dry seasons are between 80% and 60% respectively [5]. Geologically, the area is underlain by sedimentary rocks derived from successive marine deposits of the cretaceous and tertiary periods. According to the Federal Department of Agricultural and Land Resources [6], Abakaliki agricultural zone lies within “asu River group” and consists of olive brown sandy shales, fine grained sandstones and mudstones. The soil is shallow with unconsolidated parent material (shale residuum) within 1 m of the soil surface. It belongs to the order, ultisol and is classified as Typic Haplustult [6]. The vegetation of the area include shrubs, herbs and grasses with some economic trees.

Materials

The rice husk dust was sourced from Abakaliki rice mill. Swine slurry was collected from the Department of Animal Science, Ebonyi State University, Abakaliki. Human urine was collected by arrangement from students’ hostels. Fresh water was from pipe-borne water at Ebonyi State University, Abakaliki. The test crop (rice), Farrow 55 (Nerrica) was sourced from Ebonyi State Agricultural Development Programme, Abakaliki. Twenty buckets of 6232.94 cm^3 volume was used for the decomposition, while a wire mess of 750 m^2 (30m x 25m) that was used to drive away flies was procured from Abakaliki International Market.

Decomposition of rice husk dusts

To each bucket was measured 4 t ha^{-1} or 64 kg $plot^{-1}$ rice husk dusts, followed by application of 5 litres of human urine, swine slurry and water respectively. The contents were mixed together and confined in an open space with wire-mess for three months before field application.

Experimental design/layout and treatment applications

The site measuring 22 m x 20 m (440 m^2) approximately 0.05 ha was cleared of vegetation and debris removed without burning. The area was then mapped into plots measuring 4 m x 4 m (16 m^2) with 0.5 m spacing between plots and 1 m spaces between blocks. The experiment was laid out in a Randomized Complete Block Design (RCBD). The treatments included: 4 t ha^{-1} each of human urine, swine slurry and water decomposed rice husk dusts, with undecomposed rice husk dust and no application as reference.

The treatments were replicated four times to give a total of 20 treatments in the experiment. These treatments were incorporated into the soil during seedbed preparation (beds). The rice seeds were sown at a spacing of 25 cm x 50 cm at 5 cm depth. Supplying of missing stands was done at 2 weeks after planting. This gave a plant density of 160 stands per plot or 100,000 stands per hectare. Weeds were removed manually at three weekly interval until harvest. The second and third year were residual experiments (no rice husk dust application).

Soil sampling

Composite soil sampling was collected with soil auger randomly at 20 points from the site at a depth of 0 – 20 cm before land clearing and seed bed preparation. Similarly, core and auger samples were collected at 3 points in each plot after planting for post harvest analysis. The auger samples was used for assessment of particle size distribution, moisture, aggregate stability and chemical properties of soil. Core samples were used for determining of total porosity, bulk density, hydraulic conductivity, infiltration rate; while penetration resistance was recorded with pocket penetrometer.

Laboratory Methods

Particle size distribution was determined by sedimentation method of Gee and Bauder [7]. Bulk density was assessed by core method (Stolt 1997). Total porosity was calculated from the bulk density value using assumed particle density (Pp) value of 2.65 g cm^{-3} with the following equation

$$TP = [1 - D_p/P_p] \times 100$$

Where:

TP = Total porosity

D_p = Bulk density (g cm^{-3})

P_p = Particle density (assumed as 2.65 g cm^{-3})

Hydraulic conductivity was by measured by undisturbed core and the constant head method of Klute and Dirksen [8]. Aggregate stability was by Kemper and Rosenau [9] method. Moisture content was determined using Pressure Plate Apparatus as described by Klute [8]. Penetration resistance was recorded with pocket penetrometer with 0.5 cm diameter (Model 06.01 from Ejikeamp) at 0.05m depth and angle of 90° [10]. The infiltration rate was determined using the double ring infiltrometer [11].

Data analysis

The data generated were subjected to Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD). Means that were significant were separated with Fishers' Least Significant Difference (FLSD) – [12], and significance accepted at 5% probability level.

Results

Physical properties of the soil

Texture

There was no significant change in soil particle sizes for the three years of study. The sand particle in control were 691, 672 and 668 g kg^{-1} for the respective years. In human urine decomposed rice husk dust the sand fractions were 591, 639 and 638 g kg^{-1}. In swine slurry decomposed rice husk plot it was 608, 647 and 647 g kg^{-1} for the three years. The water decomposed rice husk dust plot recorded 575, 649 and 649 g kg^{-1} for the respective years, while the undecomposed rice husk dust gave 641, 652 and 659 g kg^{-1} for the three years (Table 1).

Particle size	Sand			Silt			Clay		
Treatments	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
Control	691	672	668	196	160	193	113	168	139
Human urine *	591	639	638	220	227	244	189	134	118
Swine slurry*	608	647	647	213	225	241	179	128	112
Water*	575	649	649	203	217	240	222	134	111
Undecomposed*	641	652	659	202	197	254	159	151	101
FLSD (0.05)	Ns	Ns	ns	Ns	Ns	ns	ns	Ns	ns

Table 1: Particle sizes of the soil for the three years of study.

*Human urine, swine slurry, and water decomposed rice husk dust in addition to undecomposed rice husk dust. Y_1 = year one; Y_2 = year two; Y_3 = year three

In terms of silt the values were 196, 160 and 193 g kg^{-1} for control; 220, 227 and 244 g kg^{-1} for human urine decomposed rice husk plot. Others include 213, 225 and 241 g kg^{-1} for swine slurry decomposed rice husk plot and 203, 217 and 240 g kg^{-1} for the water decomposed rice husk plot, while undecomposed rice husk plot gave 202, 197 and 254 g kg^{-1} silt (Table 1).

The clay proportion in control were 113, 168 and 139 g kg^{-1}, while that in human urine decomposed rice husk plot were 189, 134 and 118 g kg^{-1}. Others include swine slurry decomposed rice husk plot that gave 179, 128 and 112 g kg^{-1} and 222, 134 and 111 g kg^{-1} in water decomposed rice husk plot; while in undecomposed rice husk plot it was 159, 151 and 101 g kg^{-1} for the respective years (Table 1). From the above separates the soil texture was sandy loam.

Bulk density

There was statistical (P < 0.05) significant relationship amongst treatments (Table 2). During the first y of cropping the least bulk density was in undecomposed rice husk dust plot (1.35 g cm^{-3}) and the highest (1.62 g cm^{-3}) was in control. The order of decrease in soil bulk density was control > human urine decomposed rice husk dust > swine slurry decomposed rice husk dust > water decomposed rice husk dust > undecomposed rice husk dust. This represent an increase of 2.47, 8.02, 12.35 and 16.67% of control relative to human urine decomposed rice husk dust (RHD), swine slurry decomposed rice husk dust (RHD), water decomposed rice husk dust (RHD) and undecomposed rice husk dust (RHD) – Table 2.

Properties	Bulk density (g cm^{-3})			Total porosity (%)			Gravimetric moisture content (%)		
Treatment	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
Control	1.62	1.64	1.67	38.9	38.13	36.98	37	39	36
Human urine*	1.58	1.47	1.55	40.4	44.6	41.73	43.5	52	48
Swine slurry*	1.49	1.37	1.44	43.8	48.3	45.65	45.6	55	50
Water*	1.42	1.33	1.38	46.4	49.83	47.9	42	50	45
Undecomposed*	1.35	1.30	1.33	47.2	50.95	49.83	44	49	46
FLSD(0.05)	0.17	0.11	0.14	2.41	3.06	2.72	1.14	1.92	1.68

Table 2: Bulk density, total porosity and moisture content of the soil.

*Human urine, swine slurry, and water decomposed rice husk dust in addition to undecomposed rice husk dust. Y_1 = year one; Y_2 = year two; Y_3 = year three

During the second y residual trial, the least bulk density (1.30 g cm^{-3}) was also recorded in undecomposed rice husk dust and the highest (1.64 g cm^{-3}) in control. The same order of decrease observed during the first y but an increase of 10.37, 16.46, 18.90 and 20.7% of control relative to human urine decomposed RHD, swine slurry decomposed RHD, water decomposed RHD and undecomposed RHD – Table 2.

For the third y residual trial the lowest bulk density of 1.33 g cm^{-3} was in undecomposed RHD plot and highest (1.67 g cm^{-3}) in control. The order of decrease in soil bulk density was control>human urine decomposed RHD>swine slurry decomposed RHD>water decomposed RHD>undecomposed RHD. This represent an increase of 7.19, 13.77, 17.37 and 20.36% respectively of control relative to human urine decomposed RHD, swine slurry decomposed RHD, water decomposed RHD, and undecomposed RHD (Table 2).

Total porosity

Statistical (P < 0.05) significant difference was established among treatments (Table 2). The total porosity in first y of cropping was highest in undecomposed RHD (47.2%) and least (38.9%) in control. The order of increase was undecomposed RHD>swine slurry decomposed RHD>human urine decomposed RHD>control. This represents an increase of 1.69, 7.20, 14.41 and 17.58% respectively of undecomposed RHD relative to water decomposed RHD, swine slurry decomposed RHD, human urine decomposed RHD and control – Table 2.

During the second and third y of residual cropping same trend was observed. The highest soil total porosity of 50.95% was in undecomposed RHD during the second y and lowest (38.13%) in control. The level of increase was undecomposed RHD>water decomposed RHD>swine slurry decomposed>human urine decomposed RHD>control. This represents an increase of 2.20, 8.20, 16.25 and 25.79% of undecomposed RHD relative to water decomposed RHD, human urine decomposed RHD and control.

During the third y, the highest total porosity of 49.83% was in undecomposed RHD and the least (36.98%) in control. The trend of increase was undecomposed RHD>water decomposed RHD>swine slurry decomposed RHD>human urine decomposed RHD>control. This is an increase of 3.87, 8.39, 16.26, and 25.79% respectively of undecomposed RHD relative to water decomposed RHD, swine slurry decomposed RHD, human urine decomposed RHD and control (Table 2).

Moisture

There was statistical ($P < 0.05$) significant difference among treatments (Table 2). During the first y of cropping the highest soil moisture (45.6%) was in swine slurry decomposed RHD, while the least (37%) was in control. The order of increase was swine slurry decomposed RHD>undecomposed RHD>human urine decomposed RHD>water decomposed RHD>control. This represent an increase of 3.51, 4.61, 7.89 and 18.86% respectively of swine slurry decomposed RHD relative to undercompsed RHD, human urine decomposed RHD, water decomposed RHD and control – Table 2.

During the second y residual trial, the highest moisture of 55% was also in swine slurry decomposed RHD and the lowest (39%) in control. The order of increase was swine slurry decomposed RHD>human urine decomposed RHD>water decomposed RHD>undecomposed RHD>control. This represents an increase of 5.45, 9.09, 10.91 and 29.09% respectively of swine slurry decomposed RHD relative to human urine decomposed RHD, water decomposed RHD, undecomposed RHD and control – Table 2.

In the 2nd y residual studies, the highest total porosity of 50% was in swine slurry decomposed RHD and least (36%) in control plot. The order of increase was swine slurry decomposed RHD>human urine decomposed RHD>water decomposed RHD>undecomposed RHD>control. This is an increment of 4, 8, 10 and 28% respectively of swine slurry decomposed RHD relative to human urine decomposed RHD, undecomposed RHD, water decomposed RHD and control (Table 2).

Hydraulic conductivity

There was statistical ($P < 0.05$) significant difference among treatments (Table 2). The highest hydraulic conductivity of 31.56 cm h^{-1} was in human urine decomposed RHD and least (20.06 cm h^{-1}) in control. The order of increase was human urine decomposed RHD>swine slurry decomposed RHD>undecomposed RHD>water decomposed RHD>control. The rate of increase was 9.82, 2.34, 4.24, and 36.43% respectively of human urine decomposed RHD relative to swine slurry decomposed RHD, undecomposed RHD, water decomposed RHD and control – Table 2.

During the second y of residual trial the highest hydraulic conductivity of 37.97 cm h^{-1} was in undecomposed RHD and least (19.54 cm h^{-1}) in control. The order of increase was undecomposed RHD>human urine decomposed RHD>swine slurry decomposed RHD>water decomposed RHD>control. The level of increase was 16.43, 14.75, 7.08 and 48.54% respectively of undecomposed RHD, relative to human urine decomposed RHD, swine slurry decomposed RHD, water decomposed RHD and control (Table 2).

In the third y residual cropping the highest hydraulic conductivity of 39.88 cm h^{-1} was in swine slurry decomposed RHD and least (19.98 cm h^{-1}) in control. The order of increase was swine slurry decomposed RHD>undecomposed RHD>water decomposed RHD>human urine decomposed RHD>control. This represents an increase of 5.01, 5.6, 19.4 and 49.89% respectively of swine slurry decomposed RHD relative to undecomposed RHD, water decomposed RHD, human urine decomposed RHD and control – Table 2.

Penetrometer resistance

There was statistical ($P < 0.05$) significant difference among treatments (Table 3). The highest penetrometer resistance of 3.19 Kg cm^{-2} was observed in control, while the least (1.84 Kg cm^{-2}) was in undecomposed RHD during the first y of cropping. The order of increase was control>human urine decomposed RHD>swine slurry decomposed RHD. This is an increase of 34.8, 39.82, 41.69 and 46.08% respectively of control relative to human urine decomposed RHD, water decomposed RHD, undecomposed RHD and swine slurry decomposed RHD – Table 3.

Infiltration rate

There was statistical ($P < 0.05$) significant difference among treatments (Table 3). The highest infiltration rate of 410 cm h^{-1} was observed in swine slurry decomposed RHD and the least (110 cm h^{-1}) in control. The order of increase was swine slurry decomposed RHD>water decomposed RHD>undecomposed RHD>human urine decomposed RHD>control. This represent an increase of 36.59, 4.87, 24.14 and 73.17% respectively of swine slurry decomposed RHD relative to water decomposed RHD, undecomposed RHD, human urine decomposed RHD and control – Table 3.

During the 2nd y of residual trial, the highest infiltration rate of 430 cm h^{-1} was in swine slurry decomposed RHD and least (118 cm h^{-1}) was in control. The order of increase was swine slurry decomposed RHD>undecomposed RHD>water decomposed RHD>human urine decomposed RHD>control. This represent an increase of 3.48, 7.44, 7.44 and 72.56% respectively of swine slurry decomposed RHD relative to undecomposed RHD, water decomposed RHD=human urine decomposed RHD and control – Table 3.

During the third y of residual cropping the highest infiltration rate of 428 cm h^{-1} was in swine decomposed RHD and the least (118 cm h^{-1}) was in control. The order of increase was swine slur-

Properties	Penetrometer resistance (kg cm^{-2})			Infiltration rate (cm hr^{-1})			Aggregate stability (%)		
Treatment	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
Control	3.19	3.08	3.19	110	118	118	46	40	36
Human urine	2.26	2.15	2.08	311	398	385	49	48	48
Swine slurry	1.76	1.68	1.72	410	430	428	49	49	46
Water	2.06	1.97	1.92	395	398	398	49	54	50
Undecomposed	1.84	1.77	1.86	390	415	410	56	61	59
FLSD(0.05)	1.67	1.55	1.81	79.99	ns	62.8	1.87	1.61	1.48

Table 3: Human urine, swine slurry, and water decomposed rice husk dust in addition to undecomposed rice husk dust. Y_1 = year one; Y_2 = year two; Y_3 = year three

ry decomposed RHD>undecomposed RHD>water decomposed RHD>human urine decomposed RHD>control. This represents an increase of 4.21, 7.01, 10.4 and 72.4% of swine slurry decomposed RHD relative to undecomposed RHD, water decomposed RHD, human urine decomposed RHD and control (Table 3).

Aggregate stability

There was significant ($P < 0.05$) difference among treatments (Table 3). The highest aggregate stability of 56% was in undecomposed RHD plot during the first yr of cropping; while the least (46%) was in control. The order of increase was undecomposed RHD>water decomposed RHD=swine slurry decomposed RHD= human urine decomposed RHD>control. This represent an increase of 12.5=12.5=12.5, 17.86% respectively of undecomposed RHD relative to water decomposed RHD=swine slurry decomposed RHD=human urine decomposed RHD and control – Table 3.

During the second yr of residual cropping the highest aggregate stability of 61% was observed in undecomposed RHD plot and least (36%) in control. The order of increase was undecomposed RHD>water decomposed RHD>swine slurry decomposed RHD>human urine decomposed RHD>control. This is an increase of 11.48, 19.67, 21.31 and 34.43% of undecomposed RHD relative to water decomposed RHD, swine slurry decomposed RHD, human urine decomposed RHD and control – Table 3.

During the third yr of residual cropping the highest aggregate stability of 59% was in undecomposed RHD, and the least (36%) in control. The order of increase was undecomposed RHD>water slurry decomposed RHD>swine slurry decomposed RHD>human urine decomposed RHD>control. This represent an increase an increase of 15.25, 22.03, 18.64 and 38.98% of undecomposed RHD relative to water decomposed RHD, swine slurry decomposed RHD, human urine decomposed RHD and control – Table 3.

Discussion

Texture

Texture is a soil property that do not change over a farming season. It takes many years (over 10 years) before significant management practices on soil texture is noticed. This explains the outcome of the results in this research. Texture is a very important physical fertility index. The texture of a soil determines its potential to sustain nutrients including water holding capacity of the soil. Clayey and loamy soil is able to hold more nutrients and water for crop growth and productivity. On the other hand, sandy soil do not hold enough water and nutrients for sustainable period of time.

Many authors have supported the fact that soil texture influence soil chemical and biological fertility [13]. Finer separates of clay determines most of the chemical properties of soils. Particles with diameter smaller than 0.002 mm are colloids. There is an indirect relationship between particle size and surface area of the particles. Texture influences chemical, physical and biological properties of soil. Larger particles or larger pores have more rapid infiltration and drainage of water. Finer particles have finer capillary pores that hold water in the soil [13]. This improves the soil's water holding capacity. Coarse textured soils is quickly drained of rainfall. They are not able to hold much water for plant growth. Droughty soils lack available water for crops. It has also much lower heat capacity. Coarse-textured soils heat up much more rapidly, while fine textured soils like clay have greater water holding capacities and fewer symptoms of drought.

Waterlogging is not good for plant roots that need oxygen for respiration. Similarly, soil waterlogging is serious limitation to crop production. Soil texture is very important for water movement, soil temperature and aeration [13]. The sandy-loam used in this project was conditioned by the soil amendment. Hence, its capability to support upland rice production.

According to Anikwe and Nwobodo [14], sandy-loam soil permits permeability and allows larger quantities of leachates to pass through it. Nevertheless, the authors infers that such sandy-loam soils are poor in plant nutrients content and requires organic amendments for good productivity and crop performance.

Bulk density and total porosity

The soil bulk density and total porosity were significantly improved by the soil amendments. All the treatments except control positively influenced soil bulk density and total porosity. This result is similar to that of Okonkwo., *et al*. [15] of a similar ultisol amended with burnt rice husk. The authors observed a reduction in bulk density to significant proportion. The authors reported the positive effects of the amendment on soil structure, total porosity and water infiltration, all of which improve crop growth and yield. Also, many researches on soil responses to organic amendment include that of Nnabude and Mbagwu [16]; Mbagwu [17], Piccolo and Mbagwu [18] who reported decreased bulk density due to the application of different organic wastes. Similarly, Okonkwo., *et al.* [19] also observed application of different organic forms of cassava peels decreased soil bulk density and increased soil total porosity. Bulluck., *et al*. [20]; Fares., *et al*. [21] recorded decrease in bulk density which was attributed to direct and indirect effect of soil properties prompted by the particulate organic nature of the constituents of dairy liquid manure applied to the soil. Others like Anikwe and Nwobodo [14] observed that application of high rate of organic wastes under repeated application in a given area, resulted to decrease in soil compaction, that led to reduced soil bulk density and increased soil total porosity. Again, Atiyeh., *et al.* [22] reported high bulk density. Again, Mbagwu [23] linked soil bulk density to a combination of soil organic matter and natural processes that occurred on the surface of the soil; while Zhang., *et al.* [24] observed that the application of dairy manure to the soil improved soil structural stability with subsequent impact on soil total porosity.

Similarly, Nnabude and Mbagwu [25] showed that low bulk density and high total porosity were beneficial to water transmission, root penetration and cumulative feeding area of the crops that affect yield to desirable proportion. Zhang., *et al.* [24] showed that organic wastes contain high organic matter which can reduce soil stress and control any negative changes towards soil physical properties. Obi [26] asserted that bulk density decreases soil total porosity. All these literature help to explain reaction of different soils to organic matter amendment in the tropics.

Soil moisture content and hydraulic conductivity

Soil moisture content and hydraulic conductivity increased with the application of decomposed and undecomposed rice husk dust. The increase in moisture remained consistent in plots amended with rice husk dusts. This is good for crop growth and productivity. Mbagwu and Ekwealor [27], Mbagwu [23], Nnabude and Mbagwu [25] all reported improved soil moisture due to surface area of the soil available to organic matter.

Similarly, Okonkwo [28] asserted that soil water retention is due to absorption, rather than capillary action, which in turn is less influenced by the structure and textural composition of soil and organic materials. Obi [26] observed an inverse relation of soil bulk density to moisture content and total porosity. Low moisture content and hydraulic conductivity were generally observed in the control plots. According to Okonkwo., *et al.* [15], low moisture could be caused by soil compaction which can increase soil bulk density and reduce soil total porosity, moisture content and hydraulic conductivity. These, they attributed to external loading that lead to deterioration of some physical and agronomic properties. Then, Bullock., *et al.* [20] and Fares., *et al.* [21] observed total porosity, moisture content and hydraulic conductivity resulting from application of dairy liquid manure to the soil. Bellakki., *et al.* [29] showed that application of organic waste improved soil effective pore volume. Flowers and Lal [30] showed that soil permeability was a function of effective pore volume. They also established relations between pore volume and hydraulic conductivity of the soil.

Penetrometer resistance, infiltration and aggregate stability

Across the years of cropping, amended plots improved soil penetrometer resistance, infiltration and aggregate stability. Lowest values of penetrometer resistance were observed in amended plots, while values for infiltration rate were highest in amended plots. For aggregate stability, the highest values were in amended plots and lowest in control. Coskun and Candemir [31] observed that most soil properties were significantly correlated with penetration resistance. Organic amendments have also been reported to reduce soil vulnerability to erosion and compaction, decrease soil bulk density, penetration resistance and increased soil water storage [32].

Soil compaction and mechanical impendence are some of the physical problems affecting some physical properties like penetration resistance and water infiltration rate. As soil compaction increases, penetration resistance increases. The rate of water infiltration is reduced and vice versa (Mosaddeghi., *et al*. 2008). Increase in hydraulic conductivity, infiltration rate and low penetration resistance according to Bellakki., *et al.* [20] was attributed to improved soil structural stability, increase in organic matter content of the soil and biological activity at the surface of the soil. Flowers and Lal [30] also observed similar results, that addition of farm yard manure to the soil caused better aggregation which later resulted to an increase in effective pore volume of the soil that gave a direct positive influence on decreased soil penetration resistance and increased infiltration rate. Zhang., *et al.* [24] also observed a significant decline in soil strength with application of organic matter that resulted to decreased penetration resistance and increased water infiltration. Similar findings were observed by Hati., *et al.* [33] that the application of farm yard manure to the soil improved soil aeration, lowered bulk density and penetration resistance, thereby promoting better root proliferation. Okonkwo., *et al*. [19] reported values obtained in amended plots to be due to improvement in soil water retention at 10Kpa over the control plots by 20%. Nnabude and Mbagwu [25] studied the influence of organic wastes on physical properties of heavy clay-soil and observed that aeration porosity and infiltration rate were significantly correlated in amended rice husk dust, while soil surface penetration resistance also appreciated.

Conclusion

Soil physical fertility is very important in soil fertility studies. The results has shown that rice husk dust can be used as organic amendment to improve soil physical properties (especially when properly decomposed). For instance, with decomposition with human urine, swine slurry significantly improved soil physical properties relative to control. From the results, application of rice husk dust up to the rate of 4 t ha^{-1}, in addition to 5 litres of either human urine, swine slurry were recommended. The work is relevant to sustainable use of natural resources. The human urine and swine slurry are by so doing converted to harmless forms, while the rice husk dust are optimally utilized for agricultural fertilization. Further work on other natural resources as alternative to chemical fertilizers is hereby recommended.

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