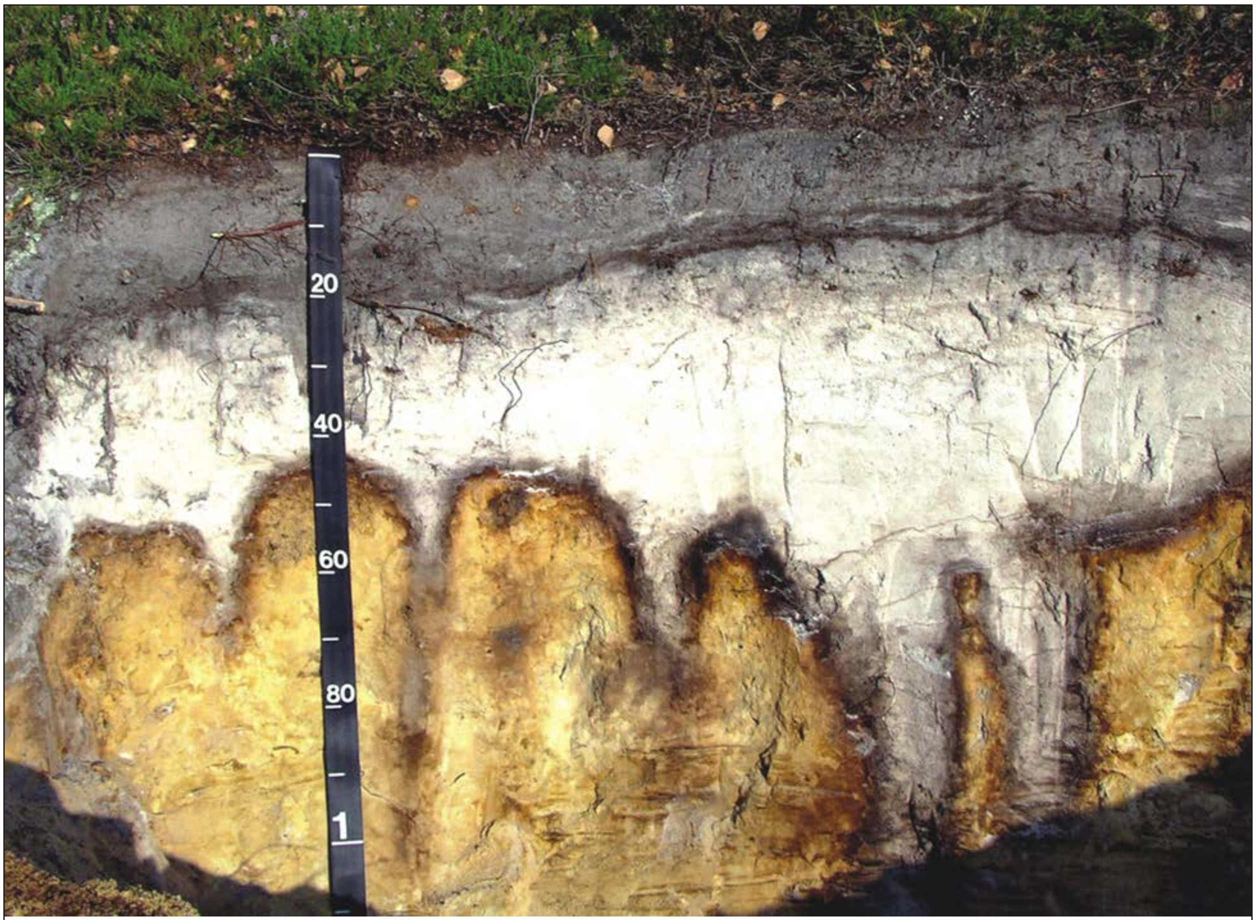

International Journal of
Soil Science

ISSN 1816-4978

Academic
Journals Inc.

www.academicjournals.com

International Journal of Soil Science 2 (4): 258-267, 2007
ISSN 1816-4978

Enhancing the Water Stability of Aggregates of Selected Tropical Soils with Rabbit Waste for Sustainable Crop Production

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Abstract: The study was conducted to investigate effects of different application rates of Rabbit (Oryctolagus cuniculus) Waste (RW) on the water stability of peds (natural aggregates) of three soil types-entisol, inceptisol and ultisol collected from Nsukka, Adani and Ihiagwa (Owerri) respectively in Southeastern Nigeria. Aggregate stability was measured at the macro-level by Mean Weight Diameter (MWD) index and micro-level by Aggregated Silt plus Clay (ASC%) index. From each location, samples were randomly collected from four points or spots and bulked for determining aggregate stability indices and other soil properties. Results obtained revealed that with MWD (mm) index and using LSD (0.05) value of 0.04 for comparing mean values among the soils (A), ultisol was statistically greater in stability than the other soil types. The stability order was ultisol (0.49 mm) >inceptisol (0.42 mm) >entisol (0.213 mm). Similarly, with $LSD_{(0.05)}$ value of 0.02 for the RW rates MWD obtained at 100 g/2 kg soil was significantly higher than MWD of other rates. The magnitude of improvement in structural stability following increased application rates of RW was however dependent on the soil types or vice versa as indicated by the statistically significant ($p \leq 0.05$) soils (A) X RW rate (B) interaction. Using ASC (%) index and $LSD_{(0.05)}$ value of 1.08 to compare mean values of ASC among the soils (A), the stability of inceptisol was statistically greater than other soil types and was in the order: inceptisol (30.39)> entisol (14.23) > ultisol (5.67). Also, with $LSD_{(0.05)}$ values of 0.38 for comparing the mean values of RW rate, the ASC(%) obtained at 100 g 2 kg^{-1} soil was statistically higher than as obtained at other lower rates. The magnitude of improvement in aggregate stability was however a function of the soil types or vice versa as revealed by the statistically significant ($p \leq 0.05$) soil (A) X RW rate (B) interaction.

Key words: Rabbit waste, water stability of aggregates, entisol, ultisol, inceptisol, aggregate stability indices, soil management strategy

INTRODUCTION

Rapid population growth in the humid rain forest zone of southeastern Nigeria has led to increasing pressure on the land through intensive crop cultivation, resulting in soil degradation. The soil degradation has been made manifest through decline in organic matter and high sand and silt relative to clay content, thereby causing low soil structural stability, especially to water. Low structural stability has been found to be one of the most serious soil physical constraints to increased and sustained high level crop production on tropical soils (Mbagwu *et al*., 1993). Its combination with high climatic erosivity is a major cause of water erosion in this region.

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However, since soil texture is a permanent soil physical attribute that cannot be changed and the erosive power of high intensity rainstorm prevalent in this region cannot also be completely checked. There is the need to evolve a stable and better alternative soil management strategy to ensure increase and sustained high level of crop production in this region. This strategy should be low input oriented, ensure ecological balance, feasible, appealing, sustainable and can easily be adopted over a vast expanse of land area, bearing in mind that farmer adoption of any new technology depends on income benefits of that technology while keeping risk with reasonable bounds. One strategy that might appear technically feasible and promising to meet these requirements and offer practical solutions is the incorporation of organic wastes such as farmyard manure, animal wastes and crop residues into the soil. This is part of organic agriculture (farming), which FAO/WHO (1999) regarded as a holistic production management system that promotes a healthy, agro ecosystem. The effectiveness of these organic wastes however, depends on soil attributes; then type and amount of the wastes. For instance, cattle feedlot manure, which linearly increased the water stability of aggregates of a sandy inceptisol, had the opposite effect on a clay soil with vertic properties (Mbagwu, 1989). Schleich (1986) reported improved soil productivity as a result of cow dung application. Mbagwu *et al*. (1991) observed that pig slurries enhanced the water stability of soil aggregates while Mbagwu *et al*. (1994) reported an improved soil structural stability following Dehydrated Swine Waste application. Obi and Ebo (1995) and Boateng *et al*. (2006), reported decreased soil bulk density following poultry manure application. However, since there is still dearth of information on the use of rabbit wastes to stabilize aggregates of major agricultural soils in Southeastern Nigeria, yet large quantities of the materials are produced annually and improperly dumped at disposal sites where their offensive odour constitutes environmental pollution. So, there is the need for more pragmatic means of disposing of the massive quantities of the RW where its potential could be properly tapped or utilized for sustained food and fibre production.

Based on the above therefore, this research was conducted using the Rabbit Waste (RW) which abound in many farmers homes in the region to enhance the water stability of aggregates of selected tropical rainforest soils for sustainable crop production in the humid rainforest zone of Southeastern Nigeria.

MATERIALS AND METHODS

Soil Samples and Their Locations

The soil types classified in the USDA soil taxonomy (Soil Survey Staff, 1998) as entisol (Lithic usorthent), inceptisol (Typic Paleaquepts) and ultisol (Typic Paleudult) and correlating to Regosol, Cambisol and Haplic acrisols respectively of the FAO-UNESCO soil map of the world legend (FOA-UNESCO, 1994) were used for the study. They were respectively collected from Nsukka (Latitude 6°52^1 N and longitude 7°24^1 E) Adani (Lantitude 6°44^1 N and longitude 7°002^1 E) and Ihiagwa-Owerri (Latitude 5°25^1 N and longitude 7° 00^1 E) (Ofomata, 1975).

Soil Samples and Rabbit Wastes Collection

From each location, soil samples were randomly collected from four spots at 0-20 cm depth in September 2004. Thereafter, they were bulked in plolythene bags, taken to the laboratory for analyses where they were air-dried at about 27°C and gently dry sieved to obtain the 2-1 mm natural aggregates used.

The Rabbit (*Oryctolagus cuniculus*) waste used in this study was collected from School of Agricultural and Agricultural Technology (SAAT) Teaching and Research Farm of Federal University of Technology, Owerri (FUTO). The Rabbit Waste (RW) was air-dried at room temperature of 26°C for 3 weeks; then crushed and sieved through a 2 mm sieve to obtain homogenous materials that would ensure uniformity in application and decomposition rate of the wastes.

Laboratory Methods of Soil Samples Analysis Prior to Experiment

Particle size distribution was determined using Bouyocos (1962) hydrometer. The soil pH was measured in 1:2.5 suspension of soil in 0.1 m potassium chloride (KCl) and soil in distilled water. Organic carbon (%OrgC.) was determined by Walkley and Black (1934) wet oxidation method and percent organic matter (%OM) obtained by multiplying the value of %OrgC by 1.724%, Total nitrogen (%TN) was determined by micro Kjeldahl method (Bremner, 1965). The complexometric titration method described by Chapman (1965) was used for determination of calcium (Ca^{2+}) and magnesium (Mg^{2+}) while sodium (Na^{+}) and potassium (K^{+}) were determined from ammonium acetate (NH_4OAC) leachate using the flame photometer. Exchangeable acidity (Hydrogen (H^{+}) and Aluminium (AI^{3+})) was determined by the titrimetric method using 1 M KCl extract (Mclean, 1965).

Characterization of Rabbit Waste (RW)

Selected properties of RW, thought to influence aggregate stability were determined percent (%) moisture content (%MC), pH, %OrgC, %Total Nitrogen (%TN), Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} were determined using standard procedure as described by AOAC (1980), Mbagwu and Ekwealor (1990) and Tekalign *et al*. (1991).

Experimental Procedures

The experiment was split-plot arranged in Completely Randomized Design (CRD) with the three soil types-entisol, inceptisol and ultisol forming the main plot treatments while the four RW rates of 0, 20, 50 and 100 g/2 kg soil equivalent to 0, 1.0, 2.5 and 5%, respectively constituted the subplot treatments. Each treatment rate was thoroughly mixed with 2 kg soil and the mixture was used in filling a plastic pot. Each rate/soil mixture was replicated three times to give 12 pots for each soil type thereby bringing the total number of pots to 36 for the four soil types. Since the rabbit waste is an organic material, albeit, of animal origin that can only encourage aggregation on releasing some substances or products of microbial synthesis with cementing property example, amino polyuronides, polysaccharides, proteins and lignin like colloidal materials, fats, resins and waxes. For these products to be released, the rabbit waste (organic matter) must first undergo decomposition with the aid of some micro-organisms such as bacteria, fungi and actinomycetes, which use the OM residues as source of energy (Alexander, 1977) while the rate of OM decomposition by these organisms is enhanced when soil/OM mixture is exposed to cycle of drying and wetting or when there is adequate moisture. In the light of this, the soil and RW mixtures were incubated at field capacity for 45 days to give time for microbial buildup, decomposition process, release of products of microbial synthesis, proper incorporation of products of decomposed rabbit manure into the soil and subsequent soil aggregation to take place before determining aggregate stability.

In an attempt to obtain information on the nature of soil structural modification induced by RW applications, aggregate stability was determined at both the macro and micro structural levels. At the macro aggregation level, the Mean Weight Diameter (MWD) index was used and determined as described by Kemper and Chepil (1965), while at the micro-aggregation level, the aggregation silt plus clay (ASC%) was used. The micro-aggregate stability index was computed using the relationship as below.

$$\text{ASC}(\%) = \{(\%\text{clay} + \text{silt})\ (\text{calgon-dispersed})\} - \{(\%\text{clay} + \text{silt}\ (\text{water dispersed})\}$$

It is noteworthy that (a) calgon is also called sodium hexametaphosphate (b) Higher values of MWD and ASC imply greater stability of aggregates while lower values indicate lower stability.

Data obtained for the macro and micro-stability indices were subjected to analysis of variance (ANOVA) procedure for a split plot design and where observed F-values were significant, the means were compared using the Least Significant Difference (LSD) test (Wahua, 1999).

RESULTS AND DISCUSSION

The pH values of the three soil types were very low hence strongly acidic (Brady and Weil, 1999) ranging from 4.4 to 5.4 (Table 1). This is not however, surprising for soils of the tropical region that are highly leached (especially the Ultisols) due to high intensity rainfall prevalent in the region and the porous nature of the soils which is believed to have been inherited from the geology. The Organic Matter (OM) content was low for the ultisol and medium for the entisol and inceptisol (FMAWRRD, 1989). This may be attributed to the exposure of these soils to several high cycles of drying (due to high temperature associated with high solar radiation) and wetting (as a result of high intensity rainfall) prevalent in the region that tend to stimulate microbial activity thereby accelerating the rate of organic matter decomposition or carbon dioxide evolution. The total exchangeable bases were relatively low in all the soil types. These values are expected because of the high intensity rainfall prevalent in the region that tends to promote leaching of these basic cations out of the solum.

Characteristics of Rabbit Waste (RW)

The percent moisture content of the rabbit waste at fresh state was 54.45% thereby giving percent dry matter of 45.55% (Table 2). This agreed with Varenne *et al*. (1963) but different from the ranges of 30-40% moisture content and 24-28% dry matter content of the rabbit manure reported by Lebas *et al*. (1986). This variation is not however unusual since this may be

Table 1: Some chemical properties of the three soil types studied prior to treatment with Rabbit Waste (RW)

	Soil types		
Chemical properties	Entisol	Inceptisol	Ultisol
pH			
H_2O	5.73	5.41	4.82
Kcl	4.62	4.38	3.97
Orgc. (%)	1.73	1.57	1.03
OM (%)	2.98	2.71	1.78
TN (%)	0.16	0.14	0.10
Exchangeable bases (cmol kg^{-1})			
Ca^{2+}	2.85	2.06	0.87
Mg^{2+}	2.25	1.81	0.71
K^+	0.45	0.38	0.25
Na^+	0.26	0.22	0.08
Exchangeable acidity (cmol kg $^{-1}$)			
Al^{3+}	2.98	3.32	2.14
H^+	1.97	2.15	1.17
ECEC (cmol kg^{-1})	10.76	9.94	5.22
ESP (%)	2.42	2.21	1.53
Base sturation (%)	54.00	44.97	36.59

N/B % Orgc. = Percent organic carbon, % OM = Percent Organic Matter, ECEC = Effective Cation Exchange Capacity, ESP = Exchangeable Sodium Percentage

Table 2: Some properties of the experimental rabbit waste used

Properties	Values
Percent (%) moisture content	54.45
pH	8.25
Organic carbon (%)	27.80
Total nitrogen (%)	2.90
Carbon: nitrogen (C:N) ratio	10.10
Total phosphorus (%) magnesium (%)	0.45
Magnesium (%)	1.20
Calcium (%)	2.15
Potassium (%)	1.85
Sodium (%)	1.03

attributed to the type and age of the rabbit and moisture composition of the feed consumed by the rabbit (Brady and Weil, 1999). When comparing rabbit waste with other animal wastes, there exist differences in moisture contents among the various animal manures. This has been attributed to the nutritional quality of the feed consumed by the animal and the conditions under which it has been stored (Brady and Weil, 1999).

The chemical characteristics of the rabbit manure as presented in Table 2 revealed a pH of 8.25 and this agreed with the pH ranges of 7.2-9.7 and 8.1-8.8 as reported by Franchet (1979) for the rabbit manure used in his studies. The variation in pH values may be attributed to factors such as moisture content of the waste, type and nutritional composition of the feed consumed and the degree of decomposition of the manure and the age of the rabbit. The rabbit waste's pH of 8.25 was observed to exceed the values obtained from the respective soil types used in conducting this study, thereby confirming the fact that it is an excellent source of soil amendment. The relative improvement on the soils may be estimated at 43.98, 52.50 and 71.16% for entisol, inceptisol and ultisol, respectively.

The pH has been reported to correlate positively with the availability of some basic cations such as Ca^{2+}, Mg^{2+}, K^+ and Na^+ (Donahue *et al*., 1990; Brady and Weil, 1999). Apart from the utilization of some of these cations (Ca^{2+}, Mg^4, K^+) as plant nutrients and lime materials (Ca and Mg), it has been reported that they also have influence on aggregate stability of the soil (Ahmad *et al*., 1969).

The percent organic carbon (% OrgC) of 27.80 and percent total nitrogen (%TN) of 2.90 were obtained. These values gave rise to a carbon: Nitrogen ratio of 10:1 as against +6:1 reported for bone meal, fish waste, chicken manure, pig manure, seed meal, meat scraps and rabbit manure (http//www.agricnsw.gov.au/reader//;http//ecosyn.us/ecocity//link;http//www.ces.uga.edu/Agriculture/horticulture). The %OrgC and %TN content of the rabbit waste may vary from the values obtained for manures from other animals. This is because the composition of any animal waste depends on the type of animal. With high %OrgC content of the rabbit waste as observed in this study, it may therefore be asserted that rabbit waste has high and/or excellent potential to compete favourably with and supplement other sources of organic manure in promoting soil aggregate stability. Furthermore, that the %OrgC ($\geq$3%) and %TN ($\geq$0.25%) rated as high when present in these soil types (FMAWRRD, 1989; Tekalign *et al*., 1991) are lower than values of the same variable obtained from RW has further confirmed the high potentials of the RW to act as excellent soil amendment and improve the aggregate stability of these soils.

As indicated in Table 2, the values of Ca (2.15%), Mg (1.2%), K(1.85%) and Na (1.03%) obtained in this study were higher than that obtained by Franchet (1979), Lebas (1986) and Donahue *et al*. (1990). The values of Ca, Mg, K obtained in this study were also observed to be higher than values reported for sheep, horse, poultry and swine by Donahue *et al*. (1990) and Brady and Weil (1999). All these therefore, are further confirmation of high potentials of RW as a good soil amendment.

Assessment of the Various Aggregate Stability Indices Used in Measuring Vulnerability of the Different Soil Types to Disintegration When in Contact with Water

Results in Table 3 and 4, showed that the two aggregate stability indices used, ranked the soil types differently in order of their vulnerability to disintegration when in contact with water, for instance, whereas MWD (mm) index ranked the soil types in the order of Entisol>Inceptisol>Ultisol; at macro level; ASC (%) index (micro-level), ranked the soil types as ultisol>entisol>inceptisol. The ASC (%) index reversed the position which the MWD indices placed the ultisol. This is not surprising because the various methods used in quantifying aggregate stability and their results have been reported to be technique-dependent. Moreover, there are different levels of organization with aggregates and the major binding agents can differ among these levels; (Edward and Bremner, 1967). Micro-aggregates are

Table 3: Effect of Rabbit Waste (RW) on MWD (mm) of the three soil types

	Rabbit Waste (RW) rates of application (g/2 kg soil)				
	B1	B2	B3	B4	
Soils (A)	0	20	50	100	Means (g/2 kg soil)
Entisol (A1)	0.14	0.18	0.24	0.29	0.213
Inceptisol (A2)	0.32	0.37	0.40	0.59	0.420
Ultisol (A3)	0.43	0.47	0.48	0.58	0.490
Means (g/2 kg soil)	0.30	0.34	0.37	0.49	

LSD$_{(0.05)}$, Soils (A) = 0.04, RW rates (B) 0.02

Table 4: Effect of Rabbit Waste (RW) on ASC (%) of the three soil types

	Rabbit Waste (RW) rates of application B (g/2 kg soil)				
	B1	B2	B3	B4	
Soils	0	20	50	100	Means (g/2 kg soil)
Entisol (A1)	6.90	12.97	16.90	20.13	14.230
Inceptisol (A2)	25.78	27.78	32.70	35.10	30.393
Ultisol (A3)	4.73	4.73	6.23	7.90	5.670
Means (g kg^{-1} soil)	15.16	15.16	18.61	21.04	

LSD$_{(0.05)}$, Soils (A) = 1.08, RW rates (B) 0.38

bound by persistent, degraded, aromatic humic materials and transient to persistent polysaccharides. Temporary blinding agents, such as roots and fungal hyphae, bind micro-aggregates (<250 µm) together into macro-aggregates (>250 µm) (Tisdall and Oades, 1982). However Tisdall and Oades reported that aggregation process depends on soil type. Therefore, different methods for measuring aggregate stability may assess aggregation at different levels in different soil types.

From the results obtained in this study, it was assumed that the stability of these soils as indicated by the two indices-MWD and ASC considered were due to the intrinsic properties of the soils and the applied rabbit waste (RW), since the characteristics of the shear stresses produced by the water molecules were kept constant. Therefore, differences in the water stability of the soil aggregate is due to the intrinsic property of the soil, especially pressure build-up due to compression of the air within the intra-aggregate pores which is caused by water movement into an initially dry soil aggregates. If this pressure exceeds the resisting forces within the aggregates, the aggregate would eventually disintegrate (Torri *et al*., 1987).

Effect of Rabbit Waste (RW) on the Aggregate Stability Indices Used in Measuring Vulnerability of Soil Types to Disintegrate When in Contact with Water

Analysis of the results in Table 4 revealed that at macro-structural level, the use of MWD index gave an order in intrinsic stability of the soils as ultisol (0.43 mm) > inceptisol (0.32 mm) > entisol (0.14 mm). This order is expected since inceptisol and entisol are weakly developed young soils and still undergoing horizon differentiation, hence would witness low structural stability (Brady and Weil, 1999). Albeit, the position which MWD index placed inceptisol and entisol in this order was reversed by another macro-structural index which is water stable aggregates > 0.5 mm) used by Mbagwu *et al*. (1991). With this index, Mbagwu *et al*. (1991) obtained an order of ultisol>alfisol>entisol> inceptisol. Interestingly both indices ranked the more, strongly aggregated and weathered ultisol first as one with the highest intrinsic stability than the weakly aggregated and young entisol and inceptisol. They however, attributed this to presence of higher free iron oxides in the more strongly aggregated ultisol and alfisol than in the more weakly aggregated entisol and inceptisol. They also attributed this to presence of substantial expanding clays minerals (vermiculite and sinectite) in the weakly aggregated soils, which are conspicuously absent in ultisol and alfisol, since according to Stern *et al*. (1991) soils containing vermiculites and sinectites are unstable in water.

It was observed that increasing rates of Rabbit Waste (RW) conferred on the soil aggregates more resistance in water but at varying degrees. The highest MWD (mm) was obtained at the 100 g/2 kg soil rate on all the soils. The relative improvement in MWD over the control at the 20 g/2 kg, 50 g/2 kg and 100 g/2 kg soils application rates were 28.57, 71.43 and 107.143% on entisol; 15.63, 25 and 84.38% on inceptisol and 9.30, 11.63 and 34.88% on ultisol. Based on these values the implication is that, on poorly structured soils, more than 80% improvement in structural stability was recorded while on strongly aggregated soil (ultisol), less than 35% was obtained following RW applications at macro level. This indicates that poorly structured soils tend to benefit more from RW applications than soil with high aggregate stability. This is in line with Mbagwu *et al*. (1993). The improved soil aggregates stability following RW application resulted from the binding process between clay particles and organic materials provided by RW. This fits into the clay-polyvalent cation-organic matter linkages (that is C-P-OM). This is the well-known clay-poly cation-organic matter model of aggregation proposed by Harris *et al*. (1966). This type of binding would depend on organic matter and water status forming strong complexes with the clay particles and the polyvalent cations (Ca, Mg, Fe, AI) in the intercrystalline domains. Therefore, organic matter increase resulting from RW application is capable of conferring on the aggregates enhanced stability when in contact with water. The F-values of analysis of variance (ANOVA) for the main effects, that is soils (A) and RW application rates (B) and their interaction (AB) were highly significant ($p \leq 0.01$) for the MWD (Table 5). Consequently, all possible pairs of mean were compared using least significant difference (LSD) method.Using $LSD_{(0.05)}$ value of 0.04 to compare the mean values of MWD among the soils, it is evident that the ultisol was statistically greater than the other soils as was in the order of ultisol (0.49) > inceptisol (0.42) > entisol (0.213). Similarly, with $LSD_{(0.05)}$ value of 0.02 for the RW application rates (B), MWD obtained at 100 g/2 kg soil rate was significantly higher than the other rates. The statistically significant ($p \leq 0.05$) soils (A) × RW rates (B) interaction, indicates that the magnitude of improvement in structural stability following RW application rates was dependent on the soil types or vice-versa.

At micro-structural level, the use of ASC(%) index (Table 4) revealed an order in intrinsic stability of the soils as inceptisol (25.99%)<Entisol (6.90%)> ultisol (3.81%). The ASC (%) index reversed the position which MWD index placed the ultisol. This may be due to differences in binding mechanisms existing between micro-and macro-aggregates or differences in soil types, in that, the textural class of soils used are sandy loam for inceptisol and entisol and loamy sand for ultisol. The higher silt, clay, organic matter, Ca and Mg contents of the inceptisol and entisol than the ultisol might have also contributed to this ranking or order, despite the weakly aggregated and youthful state of inceptisol and entisol. The aggregating property of silt fraction is due to its composition because silt contains some primary minerals, like mica and feldspar (Foth, 1984). Whereas mica contains biotitie (black mica), which has a brucite sheet with ferrous iron proxying for the Mg^{2+} ion feldspar contains aluminum (AI^{3+}), Ca^{2+} and Na^{+}, which on structural disintegration would give, rise to kaolinite. Therefore, the presence of Ca^{2+} Mg^{2+} and kaolinitic clay might have contributed in conferring high aggregating property on the silt.

Table 5: The F-values of the analysis of variance (ANOVA) of treatment effects on MWD (mm) and ASC (%)

		F-values	
Sources of variation	df	MWD (mm)	ASC (%)
Soils (Factor A)	2	183.900**	1028.39**
RW rate of application (Factor B)	3	116.670**	611.69**
AB (Interaction)	6	7.056**	59.32**

N/B:** = Highly significant at probability level of ≤1% or MWD (mm) = Mean Weight Diameter (mm), ASC (%) = Aggregated Silt plus clay (%), df = Degree of freedom

Results in Table 4, showed an increase in ASC (%) of all the soils following increased RW application rates. Consequently, the various soil aggregates were conferred with more resistance in water. The highest ASC (%) was obtained at the 100 g/2 kg soil rate on all the soils. The relative improvement in ASC over the control at the 20, 50 and 100 g/2 kg soils application rates were 87.97, 144.93 and 191.74% on entisol; 6.89, 25.82 and 35.05% on inceptisol and 24.15, 63.52 and 107.35% on ultisol. The implication of this is that on poorly structural entisol which, is the youngest of all the soil types used, more than 120% improvement in structural stability was recorded while more than 100% was obtained under ultisol following RW applications at micro-level. This indicates that both the entisol and ultisol were more favoured by RW applications than the inceptisol. This may be attributed to high sand content relative to clay.

The result of the main effects, showed that soils (A) and RW application rates (B); and their interaction (AB) were also highly significant ($p \leq 0.01$) for the ASC (Table 5). Consequently, all possible pairs of means were compared using Least Significant Difference (LSD) method. Using the $LSD_{(0.05)}$ value of 1.08 to compare the mean values of ASC (%) among the soils, it was observed that the inceptisol was statistically greater than other soils and was in the order of inceptisol (30.39%)> entisol (14.23%) > ultisol (5.67%) (Table 5). Similarly, with $LSD_{(0.05)}$ value of 0.38 for the RW application rates (B), ASC (%) obtained at 100 g/2 kg soil rate was significantly higher than the other rates (Table 4).

CONCLUSIONS

The result of this study has revealed that rabbit waste or manure can be used to improve aggregate stability of the major agricultural soil types in Southeastern Nigeria especially if they are structurally degraded. Its ability to confer on the aggregates, resistance to disintegration and dispersion (especially in the case of fine fraction), when in contact with water varied under different application rates and from one soil type to another. The improvement in the structural stability of the soils could be attributed to enhanced organic matter content following application of rabbit waste and subsequent increase in soil pH that created favourable soil condition for availability of cations with aggregating property. So it is an excellent supplement or substitute to other organic wastes. It is however, recommended that further studies be conducted especially under field conditions to elucidate more facts and effect its use for sustainable crop production.

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