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Assessment of aggregate stability and soil organic carbon sequestration in Alfisols of Guinea Savanna

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Abstract

Soil aggregate stability is a vital indicator for improving soil quality and controlling soil losses. This study aimed to assess the effect of fallow forage legumes and fertilizer application on wet and dry stability aggregate and soil organic carbon on Alfisols of Guinea Savanna, Nigeria. The study was conducted at the Institute for Agricultural Research (IAR) experimental field, Samaru Zaria. Treatment consisted of 3 plots (*Centrosema pascuorum* (Cp planted), *Macrotyloma uniflorum* (Mu planted) and control-natural vegetation regrowth). The soil samples collected were dried at room temperature and then separated into six aggregate fractions. Aggregate stability assessment results showed that dry stable aggregate fraction was significantly influenced by fallow management practice where Cp planted fallow recorded the highest amount in soil aggregate sizes of 2000 μm (0.99 g kg^{-1}). Concerning wet stable aggregate, the proportion of 2000 μm sized aggregate fraction had the highest value (0.22 g kg^{-1}) under treatment Cp. However, 0 kg N ha^{-1} produced the highest quantity in 2000 μm (0.23 g kg^{-1}) sized stable aggregates, and there was no significant difference in Nitrogen and Phosphorus application rates. The wet mean weight diameter (MWD) was significantly affected by forage legume with Mu planted fallow having the highest value (0.40 g kg^{-1}) while the dry MWD aggregates with Cp recorded the best value (1.37 g kg^{-1}). Cp planted fallow sequestered more carbon (0.65 g kg^{-1}) in the 500 μm aggregates fraction. NVR contributed the highest carbon (0.80 g kg^{-1}) under 50 μm sized aggregates. For carbon content in <50 μm sized aggregates, Mu produced the highest carbon (0.72 g kg^{-1}) in the fraction. Conclusively, the type of management practices affects the soil aggregation size fractions, which increased soil organic carbon sequestered.

1.0 Introduction

Soil is the primary stay of existence, and production directly depends on its composition and structural stability. Soil structure is a significant soil property which plays a critical role in maintaining other related processes to soil productive ability, agricultural sustainability and environmental quality (Kay and Munkholm, 2004). Structural stability is expressed by the stability of soil aggregates, directly or indirectly influences other physical and chemical properties of the soil and can be used as an indicator of soil degradation (Cerda, 2000). Structural stability explains the potential of the soil to preserve its aggregation and pore space when exposed to water, wind, or cultivation. Cultivation is one of the main factors that break the protective measure of the soil structural aggregates, so soil structural stability frequently reduced with cultivation (Moreau, 1978; Six *et al*., 2000; Eynard *et al*., 2004). Pagliai (2005) observed that stable macro-aggregate in wet sieving of tilled soil is lower than that of no-tilled soil due to aggregate break down in the tillage process. Furthermore, land use type or cropping pattern has also been found to affect the structural stability of the soil aggregates. Mbagwu and Auerswald (1999) observed that land use influenced structural stability more than inherent soil properties and that percolation stability of soil increased with an increase in organic matter content. Therefore, continuous cultivation leads to easy erosion of poorly structured soils. Perennial crops usually develop soil structure, while annual row cropping often results in structural degradation, primarily as a result of losses in organic matter and ground cover from soil disturbance (Magdoff and van Es, 2000; Karunatilake and Van Es, 2002), is of the view that increased soil disturbance from tillage can promote soil degradation when annual row crops are replaced with perennial crops. Han *et al*. (2007) reported higher content of water-stable aggregates in the orchard than in annual upland crops about land use.

Soil aggregates are the fundamental units of soil structures and supply to soil carbon sequestration function and carbon stabilization (Cerdà, 1996; Mekonnen *et al.*, 2015; Brevik *et al.*, 2015). Suitable soil structures present solid nitty-gritty for the storage and stabilization of organic carbon (Jastrow, 1996; Mao *et al.*, 2007; Gelaw, 2013). The unit sizes of aggregates affect their abilities to store organic carbon as well as the circulations of their stored organic carbon components (Abu-Hamdeh *et al.*, 2005; Liu and He, 2009). The distribution and firmness of soil aggregates are directly related to the wearing away the resistance of soil and, therefore, are helpful signs of erosion sensitivity (Rachman *et al.*, 2003; Valmis et al., 2005; Guo *et al.*, 2007). According to Le Bissonnais (1996, 1997), soil erosion is primarily a result of the destruction of soil aggregates. Young (1980) and Bryan (2000) determined that aggregate stability affects the erodibility and nutrient holding capacity of the soil. The formation and stability of the water-stable aggregates in the soil are dependent on soil organic carbon (SOC), simultaneously vegetation communities affect SOC content through the addition of outer soil organic matter and in turn contribute to the formation of soil aggregates (Gabarrón-Galeote *et al.*, 2013; Mekonnen *et al.*, 2015). Impact of land use changes on aggregate stability and distribution of aggregate-associated SOC has always been a research hotspot (Unger, 1997; Dimoyiannis, 2012; Stanchi *et al.*, 2015).

Soil aggregate stability and soil organic matter (SOM) are too many properties that are directly related to each other and usually known as critical indicators of soil productivity, which reduce soil erosion as they improve. Aggregate stability is a multifaceted factor and a significant factor affecting soil organic carbon, soil structure, aeration, infiltration, soil compaction, water retention, and hydraulic conductivity. Thus, it is vital to sustain soil aggregate stability to protect soil productivity, effectiveness, and to minimize soil losses (Yu *et al.*, 2015; Onweremadu *et al.*, 2007; Six *et al.*, 2004). Similarly, the presence of soil organic carbon (SOC) in aggregate sizes is necessary for soil quality assessments, which can be easily lost in the erosion process (since large aggregates sizes are more stable). This study aimed to assess soil aggregates and size distribution in three main plots and soil carbon sequestration from fallow of two forage legumes: *Centrosema pascuorum* (Cp) and *Macrotyloma uniflorum* (Mu) on Alfisols of Guinea Savanna, Nigeria.

2.0 Materials and Methods

2.1. Site location and description

The study was conducted in the experimental field of Institute for Agricultural Research (IAR) Samaru Zaria on longitude 7° 38′ E and latitude 11° 11′ N. It is characterized by a tropical continent type of climate with alternating wet and dry seasons, which vary markedly in intensity and period with attendant effects on agricultural productivity. The soils are formed from loess materials overlying basement complex, covering an area of 43,000 km (Klinkenberg & Higgins, 1968). The clay is predominantly Kaolinitic (Ojanuga, 1979) and is typically high in iron (Fe) and aluminium (Al) oxides (Esu & Ojanuga, 1985) and are of paramount agricultural importance (Agbenin & Goladi, 1997). The area has a uni-modal pattern of rainfall annually, beginning in April and ending in October. Rainfall records show that August recorded the highest rainfall amounts. The area is also characterized by high average monthly maximum temperatures and low mini-

mum temperatures within the year with temperatures peak typically attained in March/April. The maximum and minimum temperatures during the rainy season range from 14.12°C – 23.17°C and 29.97°C – 38.43°C respectively (Anosike, 1999). The harmattan periods of December to February are mostly associated with lower temperature. Samaru has an extensive range of mean monthly relative humidity (11-85 %) compared with locations at lower latitudes within Nigeria (Anosike, 1999). The length of the rainy season, however, has been on the decline in recent years. The regular rainy season had been from February with a steady rise through August when it attains its highest peak and begins to decline gradually terminating in October.

2.2. Treatments and experimental design

The main plots for this experiment were *Centrosema pascuorum, Macrotyloma uniflorum* and Natural fallow. The sub-plot treatments were a factorial combination of four nitrogen levels (0, 40, 80 and 120 kg N ha^{-1}) and three levels of P (0, 13.2 and 26.4 kg P ha^{-1}). The field was laid out in split-plot arrangement with three replicates. Gross plot size was (5 m x 3 m) = 15 m^2, while net plot size was (1.5 m x 5 m) = 7.5 m^2. Extra early maize variety (SAMMAZ 11) was used as test crop.

2.3. Soil Analysis

Sampling and Preparation; post-cropping composite soil samples were taken with an auger at depths 0-30 cm. The samples collected were air-dried, grounded and sieved with a 2 mm sieve. The less than 2 mm fraction was analyzed for soil organic carbon.

2.4. Sampling procedure for the determination of aggregate size fractions

To estimate Dry Stable Aggregate (DSA) and Wet Stable Aggregate (WSA), individual soil samples were collected randomly in different locations from the same plot, in triplicate. Samples were sealed in polyethene bags and transported to the laboratory to determine the dry and wet stability of the soil aggregates. Soil samples were air-dried at room temperature for 48 hrs. Plant roots and stones were removed from the samples, and 150 g were measured on the rotary device for sieving (oscillatory sieving analyzer) for the analysis of DSA. This device is enclosed with different sizes of sieves that were 2 mm, 1 mm, 500 µm, 250 µm, 50 µm and >50 µm. Each sample was separately put on the top of the sieve (2 mm), and the fixed sieve analyzer shook for 2 min at 270 rpm. The distributed soil aggregates were collected separately in each sieve and weighed on an electrical balance to calculate the distribution of the 2 mm, 1 mm, 500 µm, 250 µm, 50 µm and >50 µm soil aggregates, while for WSA same gram of soil samples were placed in sieves and dipped into water and the sieves were moved up and down at 30 cycles/min for 2 min. The remaining soil sample in each sieve was recorded to calculate the water aggregate stability, dry aggregate stability and mean weight diameter by using the formulas below.

Weight of aggregate = weight of can + aggregate – the weight of empty can.

Aggregate size distribution was calculated as the proportion of soil retained in each sieve i.e.

Weight of soil retained in the sieve
Total weight of soil taken

The mean weight diameter (MWD) was calculated using the formula

MWD = ∑Pidi

Where Pi = proportion of soil aggregate in the sieve

di = diameter of sieves (Van Bavel, 1949).

2.5. Determination of Organic Carbon (OC)

The organic carbon contents of soil samples were determined using the Walkley-Black wet oxidation method (Nelson & Sommers, 1982).

2.6. Statistical analysis

Data collected were subjected to Analysis of Variance (ANOVA) using a statistical computer package (SAS 2003). The Duncan's New Multiple Range Test (DNMRT) was used to separate means at 5% probability level (P<0.05).

3.0 Results and Discussions

3.1. Effect of forage legumes planted fallow and fertilizer rate on the stability of dry aggregate fractions.

Dry 2000 µm-sized soil aggregates (DA) was significantly (P≤0.05) influenced by fallow management practices where *Centrosema pascuorum* (Cp) planted fallow recorded 3% increase over the control, (Table 1). However, soils under natural vegetative regrowth recorded the lowest values followed by *Macrotyloma uniflorum*, (Mu) probably because of the nature of the plant materials and contributions to soil aggregation. If control Nitrogen (N) fertilizer treatment (0 kg Nha^{-1}) gave the highest value (0.93 g kg^{-1}), this could imply that non-application of N-fertilizer could strongly influence the formation of (2000 µm) sized aggregate fraction. Dry 1000 µm- sized aggregates was significantly (P≤0.05) influenced by forage legume planted fallow. Cp planted fallow produced a higher amount of the aggregate fraction (0.25 g kg^{-1}) than natural vegetative regrowth (NVG) (0.23gkg^{-1}) followed by Mu planted fallow (0.20 g kg^{-1}). This suggests that Cp could improve the soil aggregate fractions 1000 µm better than other treat-

ment. The influence of nitrogen and phosphorus rates on this aggregate fraction was also not significant (Table 1), suggesting that N and P application rates had no effects on 1000 µm sized aggregates fraction. The 500 µm- sized DA were significantly influenced by fallow management practices with the highest values recorded under NVR (0.026 g kg^{-1}) (Table 1). This was followed by Mu (0.025 g kg^{-1}) while Cp planted fallow (0.020 g kg^{-1}) plots significantly recorded the least values. The result implies that the NVR plot produced structurally stable 500 µm soil aggregates relative to other treatments. For DA 250 µm – sized fractions, the natural vegetative regrowth recorded the highest values of aggregate fractions with a 29% increase over Cp planted fallow that recorded the least value (0.007 g kg^{-1}). This was followed by that of Mu (0.013 g kg^{-1}). The result implies that NVR could influence the 250 µm aggregates to be stable against wind erosion (Table 1) better than the other treatments. For soil aggregates of 50 µm sized, Mu planted fallow plots treatment resulted in the highest value, which was 36% higher than control (Table 1). It was observed that Mu planted fallow enhanced the development of 50 µm size aggregates. This may result from increased organic matter that binds soil particles and creates organo-mineral complexes while are important for flocculating aggregates (Tisdall and Oades, 1982). There were no significant differences between nitrogen and phosphorus rates used, suggesting that Nitrogen and phosphorus rates had no direct implication on the 50 µm –sized aggregate fraction. Regarding dry soil aggregates of <50 µm, natural vegetative regrowth treatment recorded the highest values of 50% over the other treatments (Table 1). Cp planted fallow plot recorded the least value that was statistically similar with fallow planted with Mu. This suggests that soils under Cp and Mu planted fallow would resist wind erosion because of low <50 µm aggregation better than natural vegetation regrowth. Wind dislodges and carries away small soil aggregates leading to erosion (Unger, 1997). Treatments with the application of 80 kg N ha^{-1}

Table 1: Effects of forage legumes planted fallow and fertilizer rates on the stability of dry sieved aggregate fractions

Aggregate fraction→ Treatment↓	2000 µm	1000 µm	500 µm	250 µm	50 µm	<50 µm
Legumes (L)						
Natural	0.91b	0.23b	0.026a	0.018a	0.081b	0.006a
Centrosema	0.99a	0.25a	0.020c	0.007c	0.101a	0.003b
Macrotyloma	0.77c	0.20c	0.025b	0.013b	0.103a	0.003b
SE±	0.02	0.006	0.0015	0.001	0.002	0.0007
Nitrogen(N) kg ha^{-1}						
0	0.93	0.23	0.025a	0.012	0.094	0.0038b
40	0.90	0.23	0.023b	0.013	0.095	0.0044ab
80	0.85	0.22	0.024ab	0.013	0.095	0.0048a
120	0.89	0.22	0.024ab	0.015	0.094	0.0044ab
SE±	0.03	0.007	0.0017	0.001	0.002	0.0008
Phosphorus (P) kg ha^{-1}						
0	0.90	0.22	0.02	0.01	0.093	0.0045
13.2	0.89	0.23	0.02	0.01	0.097	0.0043
26.4	0.89	0.23	0.02	0.02	0.094	0.0044
SE±	0.02	0.006	0.0015	0.001	0.002	0.0007
Interaction						
L X N	NS	NS	*	NS	*	*
L X P	NS	NS	NS	NS	NS	*
N X P	NS	NS	NS	NS	NS	NS
LXNXP	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by unlike letters are significantly different at P ≤0.05 using DMRT.
*- Significant   NS- Not Significant

recorded the highest dry aggregates of <50 µm - sized (0048 g kg^{-1}) and suggests that application of 80 kg N ha^{-1} in the soil might have NVR plant root biomass that enhanced soil <50 µm aggregation.

3.2. Effect of forage legumes planted fallow and fertilizer rates on wet aggregates fractions.

The proportion of 2000 µm sized aggregate fraction was significantly (P≤0.05) affected by treatments Cp recorded the highest value (0.22 g kg^{-1}) and was followed by fallow planted with Mu (Table 2). The value for the NVR treatments was significantly lower than for the other treatment. Treatments with non-application of nitrogen (0 kg N ha^{-1}), recorded the highest wet 2000 µm aggregates fraction (0.23 g kg^{-1}) though it was statistically similar to 40 and 80 kg N ha^{-1} treatment. This implies that Cp, Mu and N fertilizer rates application enhanced the development of 2000 µm aggregates better than the NVR treatment. The proportion of 1000 µm - sized wet aggregates fraction was not significantly (P≤0.05) affected by forage legumes planted fallow. Similarly, N and P application rates did not significantly (P≤0.05) affect 1000 µm- sized wet aggregates (Table 2). The WA stability of 500 µm - sized fractions was significantly (P≤0.05) influenced by the fallow management practices; with highest values recorded under NVR (0.020 g kg^{-1}) and 1.41% increase over Mu

Planted fallow. The lower value was recorded under Cp fallow treatments (Table 2). This implies that NVR could stabilize the soil aggregates against erosion by water better than the planted legume fallows. However, 0 kg N ha^{-1} produced the highest quantity of 500 µm – sized stable aggregates (0.025 g kg^{-1}). P application rates did not significantly (P≤0.05) affect the development of the aggregate fraction. The 250 µm – sized WA fractions, were significantly (P≤0.05) influenced by the fallow management practices. The highest value was recorded under natural vegetative regrowth (0.018 g kg^{-1}) with 13.89% increase over fallow planted with Mu. Cp fallow treatment recorded the least value. This suggests that NVR regrowth increased the 250 µm size aggregates, consequently producing more structurally stable 250 µm size aggregates that would resist erosion by water. N and P application rates did not significantly (P≤0.05) affect the fraction of the aggregate. Among the forage legume planted fallow, Mu treatment recorded the highest 50 µm – sized aggregates (0.103 g kg^{-1}) followed by Cp planted fallow and then the (0.101 g kg^{-1}) control. It was observed that Mu planted fallow enhanced the formation of 50 µm size aggregates better than the others. There were no significant (P≤0.05) differences between nitrogen and phosphorus rates used (Table 2). For <50 µm – sized WA, there were no significant differences between forage legume planted

Table 2: Effects of forage legumes planted fallow and fertilizer rates on the stability of wet aggregate fractions of a savannah Alfisol.

Aggregate fraction→ Treatment↓	2000 µm	1000 µm	500 µm	250 µm	50 µm	<50 µm
Legumes (L)						
Control	0.16b	0.03	0.026a	0.018a	0.081b	0.006
Centrosema	0.22a	0.03	0.020c	0.007c	0.101a	0.003
Macrotyloma	0.20ab	0.02	0.025b	0.013b	0.103a	0.026
SE±	0.015	0.006	0.0015	0.001	0.002	0.014
Nitrogen(N) kg ha^{-1}						
0	0.23a	0.03	0.025a	0.012	0.094	0.0038
40	0.21a	0.02	0.023b	0.013	0.095	0.0044
80	0.15b	0.02	0.024ab	0.013	0.095	0.0048
120	0.20a	0.03	0.024ab	0.014	0.094	0.0357
SE±	0.017	0.006	0.0017	0.001	0.003	0.016
Phosphorus (P) kg ha^{-1}						
0	0.21	0.03	0.02	0.01	0.093	0.004
13.2	0.18	0.02	0.02	0.01	0.097	0.004
26.4	0.20	0.03	0.02	0.02	0.094	0.027
SE±	0.015	0.006	0.0015	0.001	0.002	0.014
Interaction						
L X N	*	NS	*	NS	*	NS
L X P	NS	NS	NS	NS	NS	NS
N X P	NS	NS	NS	NS	NS	NS
LXNXP	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatments followed by unlike letters are significantly different at P ≤0.05 using DMRT. *- Significant   NS- Not Significant.

fallow treatment, although Mu produced the highest value (0.026 g kg^{-1}). This was followed by Cp fallow and control (Table 2). This implies that Mu can stabilize soil aggregate fractions of <50 µm in diameter. Nitrogen and phosphorus application rates did not significantly (P≤0.05) affect <50 µm WA.

3.3. Effect of forage legumes planted fallow and fertilizer rates on the wet and dry mean weight diameter of soils.

The wet mean weight diameter (MWD) was significantly

(P≤0.05) affected by forage legume planted fallow management practices, with Mu fallow planted having the highest value (0.40 g kg^{-1}), followed by that of Cp (0.37 g kg^{-1}) and then control (0.33 g kg^{-1}) (Table 3). This suggests that the planted forage legumes enhanced soil aggregation better than the control. The high wet MWD value recorded under Mu planted fallow could be attributed to the nature of Mu to contribute high carbon materials to support more stable aggregates than the other treatments. Treatments with non – application of nitrogen 0 kg N ha^{-1}

had significantly (P≤0.05) higher values of wet MWD. This could be attributed to an increase in microbial-derived agent produced by micro soil organism as a result of using N-fertilizer as a source of energy.

The dry MWD was also significantly (P≤0.05) affected by forage legume planted fallow management practices, with Cp planted fallow having the highest value (1.37 g kg⁻¹), and followed by NVR (1.26 g kg⁻¹) treatment (Table 3). Mu planted fallow had the lowest value (1.12 g kg⁻¹). This

Table 3: Effects of forage legumes planted fallow and rates of fertilizers on mean weight diameter of wet and dry Savannah Alfisol.

Treatment	Wet sieve (g)	Dry sieve (g)
Legumes (L)		
Control	0.33b	1.26b
Centrosema	0.37ab	1.37a
Macrotyloma	0.40a	1.12c
SE±	0.02	0.03
Nitrogen(N) kg ha⁻¹		
0	0.40a	1.30
40	0.37ab	1.25
80	0.31b	1.20
120	0.39a	1.24
SE±	0.02	0.03
Phosphorus (P) kg ha⁻¹		
0	0.36	1.26
13.2	0.34	1.25
26.4	0.40	1.24
SE±	0.02	0.03
Interaction		
L X N	NS	NS
L X P	NS	NS
N X P	*	NS
LXNXP	NS	NS

Means in a column of any set of treatments followed by unlike letters are significantly different at P ≤ 0.05 using DMRT. *- Significant NS- Not Significant

implies that fallow was grown to Cp stabilize macro aggregate than the other treatments probably through increased organic carbon content. High MWD values indicate the resistance of soil to erosion because of high soil aggregate stability that allows for greater water storage and infiltration thereby protecting the soil from being dislodged by wind and water (Unger,1997). Nitrogen and phosphorus rates did not significantly affect dry MWD, although 0 kg N ha⁻¹ and 0 Kg P ha⁻¹ treatments gave the highest values.

3.4. Effect of forage legumes on the sequestration of organic carbon in aggregate size fractions.

Cp planted fallow sequestered more (0.65 g kg⁻¹) carbon than Mu (0.55g kg⁻¹) in 500 µm soil fraction followed by NVR (0.47 g kg⁻¹) (Figure 1). This implies that 500 µm sized aggregates were more stable under CPF that could resist wind erosion than the other aggregates due to their stabilized state by higher carbon content. Mu and NVR sequestered similar (0.59 g kg⁻¹) carbon content which was statistically the same with Cp (0.57 g kg⁻¹) in 250 µm sized
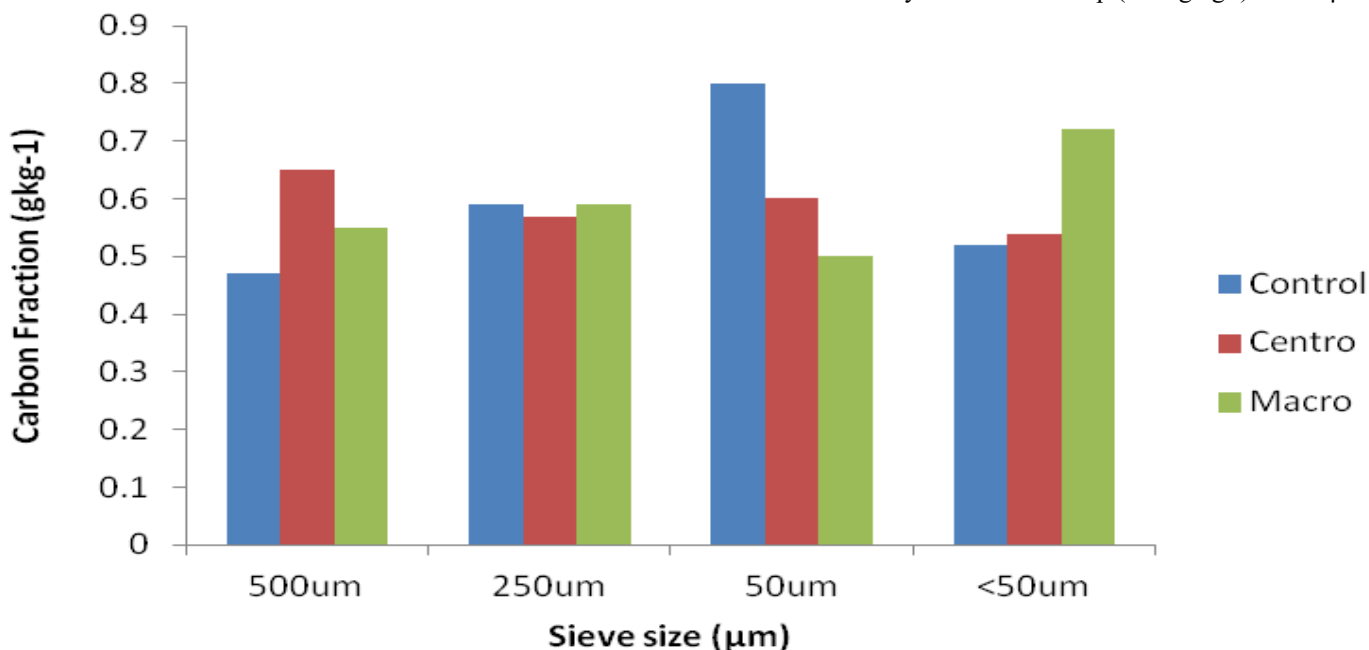

Figure 1 Effect of forage legumes planted fallow on the sequestration of organic carbon in aggregate size fraction.

aggregates. These suggest that soil aggregates of 250 µm size were not differently affected by either of the treatment. Considering 50 µm sized aggregates, NVR contributed the highest carbon (0.80 g kg⁻¹) in the aggregate sized class than the other treatment. This implies that 50 µm stable aggregates were bound by organic carbon better under NVR. Regarding the content of OC in <50 µm sized aggregates, the forage legumes were not significantly different, but Mu produced the highest carbon (0.72 g kg⁻¹) in the fraction (Figure 1).

3.5. Effect of Nitrogen Rates on Sequestration of organic carbon in aggregate size Fractions

The 0 kg N ha⁻¹ contributed a higher (0.90 g kg⁻¹) carbon in the soils than the other rates in 500, 250 and 50 µm sized aggregates, except in <50 µm sized aggregates, (Figure 2). Application of 40 kg N ha⁻¹ resulted in sequestration of higher carbon in <50 µm sized aggregates followed by 50 µm, 500 µm and the least in 250 µm sized aggregates. Treatment with an application of 80 kg N ha⁻¹
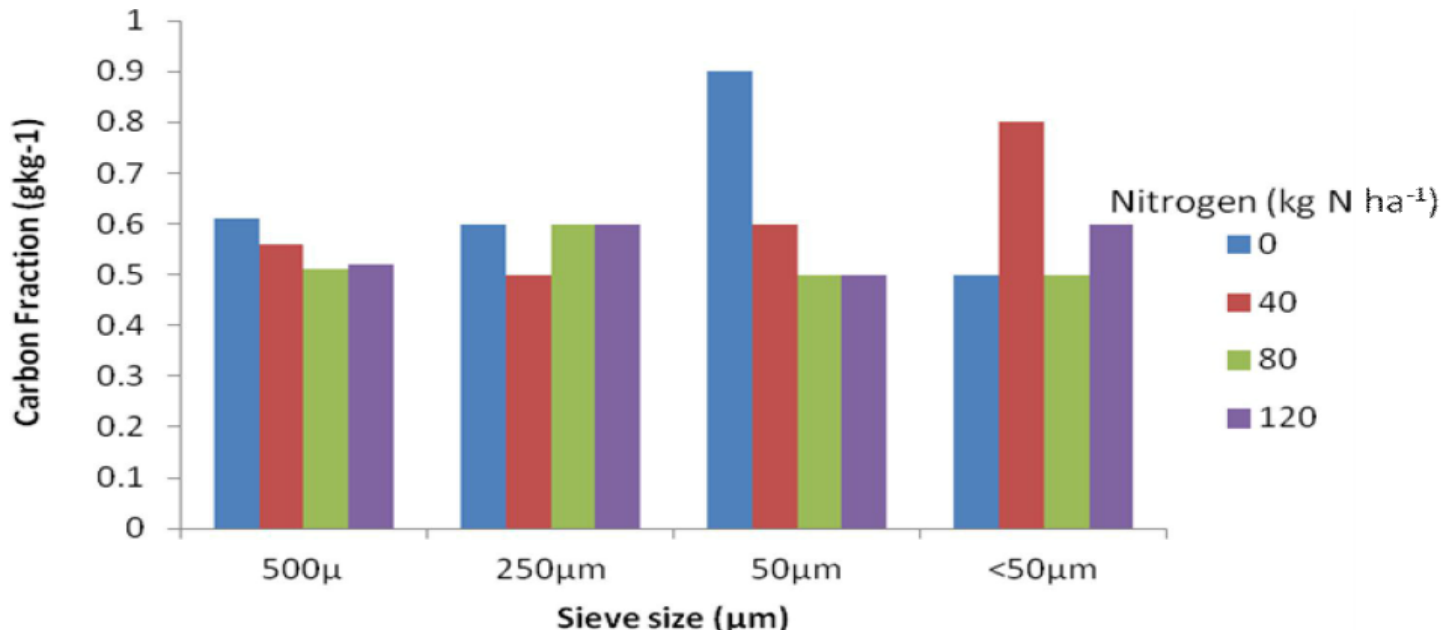

Figure 2: Effect of Nitrogen Rates on sequestration of organic carbon in aggregate fractions

sequestered more carbon in 250 µm sized aggregates followed by 500 µm, and the least carbon were both in 50 and <50 µm sized aggregates which were statistically equivalent in organic carbon (0.60 g kg⁻¹) as seen in Figure 2. Treatments with an application of 120 Kg N ha⁻¹ sequestered the same carbon in 250 and <50 µm followed by 500 and 50 µm which had the least. The effect of nitro-

gen rates on sequestration of organic carbon suggests that increase in N application rates reduced carbon content in aggregate sized fractions.

3.7. Effect of phosphorus rates on sequestration of organic carbon in aggregate fractions.
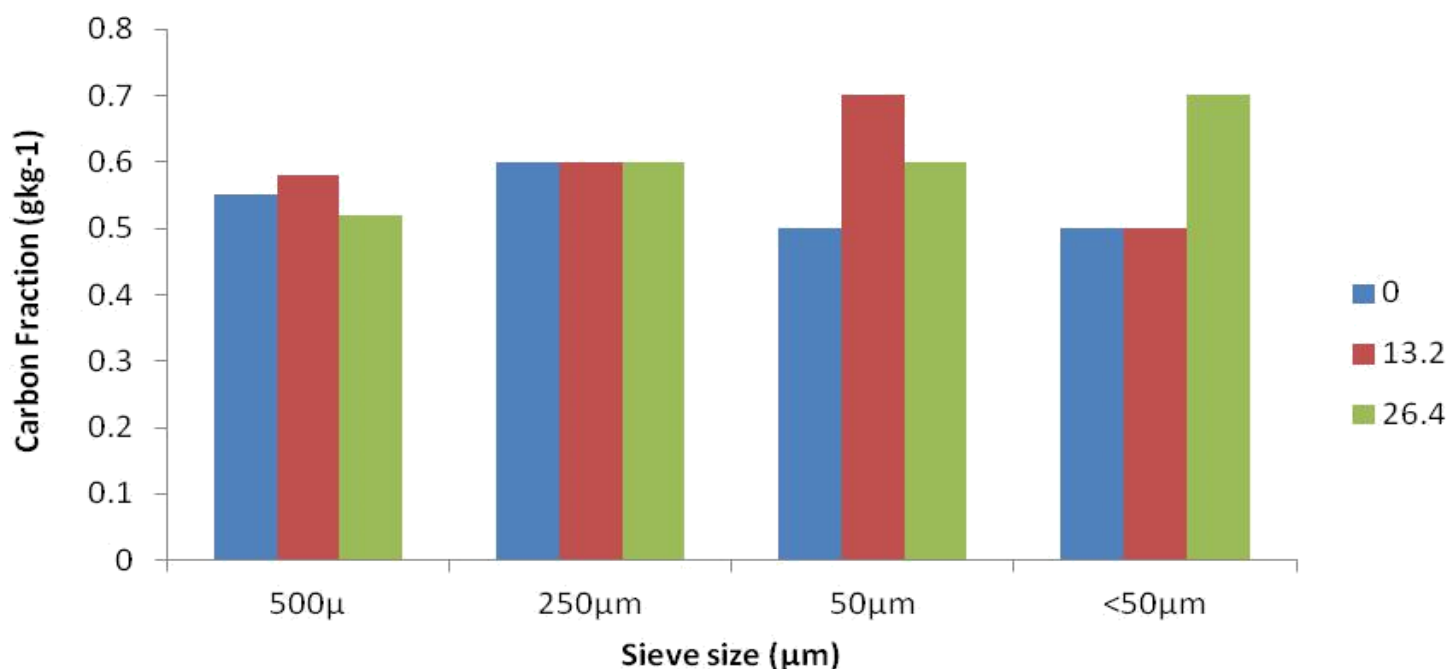

Figure 3: Effect of phosphorus rates on sequestrations of organic carbon in an aggregate fraction

The application of 0 Kg P ha^{-1} had the highest organic carbon in 250 μm sized aggregates followed by 500 μm while 50 μm and <50 μm sized aggregates both had the same organic carbon. The application of 13.2 Kg P ha^{-1} supported the highest C (0.70 g kg^{-1}) in 50 μm sized aggregates followed by 250 μm than 500 μm and 50 μm sized aggregates that had the least carbon. 26.4 Kg P ha^{-1}, had the highest organic carbon in <50 μm sized aggregates than other rates. All the P rates applied gave statistically similar carbon credit in 250 μm sized aggregates. It is inferred that the increase in the rate of P application increases the carbon content in < 50 μm sized aggregates fraction. (Figure 3).

4.0 Conclusions

Aggregate stability assessment results showed that dry stable aggregate fraction was significantly influenced by fallow management practice where Cp planted fallow recorded the highest amount in soil aggregate sizes of 2000 μm (0.99 g kg^{-1}). For wet stable aggregate, the proportion of 2000 μm sized aggregate fraction had the highest value (0.22 g kg^{-1}) under treatment Cp. However, 0 kg N ha^{-1} produced the highest quantity in 2000 μm (0.23 g kg^{-1}) sized stable aggregates, and there was no significant difference in Nitrogen and Phosphorus application rates. The wet mean weight diameter (MWD) was significantly affected by forage legume with Mu planted fallow having the highest value (0.40 g kg^{-1}) while the dry MWD aggregates with Cp recorded the best value (1.37 g kg^{-1}). Cp planted fallow sequestered more carbon (0.65 g kg^{-1}) in the 500 μm aggregates fraction. NVR contributed the highest carbon (0.80 g kg^{-1}) under 50 μm sized aggregates. With respect to the carbon content in <50 μm sized aggregates, Mu produced the highest carbon (0.72 g kg^{-1}) in the fraction. Conclusively, the type of management practices affects the soil aggregation size fractions, which increased soil organic carbon sequestered. The short fallow period of one year might not have been adequate for significant aggregate stabilization over the forage legume soils. Secondly, acceptable soil management practices under cultivated condition could reduce the rate of aggregate break down and maintain stable aggregation.

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