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Tillage and Vetiver Grass Strips (*Vetiveria nigritana* Stapf) Spacing effects on Aggregate Stability of Soil

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ABSTRACT

The size and aggregation state of soil can be influenced by different soil management processes. The objective of this work was to determine the influence of three tillage practices; Manual clearing (MC), Plough tillage (PT) and Conventional tillage (CT) with vetiver grass strips (VGS) spaced at surface interval of 0 m (control), 5 m and 10 m. Soil samples were collected at (0-0.05 m) depth after each growing seasons in 2004 to 2006. Soil organic carbon was determined in the laboratory. Water stable aggregates (WSA) and mean weight diameter (MWD) were determined by wet sieving in 2004 to 2006. Soil organic carbon was significantly higher by 3.7 and 4.8%, respectively on both PH and CT than MC in 2005. Mean weight diameter was significantly increased on 10 m VGS than the control by 3.5% but similar to 5 m VGS. The result showed that tillage both (MC and PT) significantly increased water stable aggregate only in 2004 growing season by 20 and 16%, respectively. Appreciable but not significant increases in mean of WSA over the three years were 1 and 2.7% on 5 m and 10 m , respectively. The study showed that tillage and vetiver grass strips may have immediate and subsequent effects on soil aggregation.

Introduction

Soil aggregation plays an important role in the maintenance of soil productivity and quality. Soil aggregates physically protect soil organic matter and affect root density and elongation, soil erosion, oxygen diffusion, soil water retention and dynamic, nutrient adsorption and microbial community structure (Amezketa, 1999; Six *et al*., 2004). It is well established that conservation tillage had better aggregate stability than conventional tillage (Hermawan and Cameron, 1993; Munoz *et al*., 2007; Roldan *et al*., 2007). Ashad *et al*. (1999) also found out that mean weight diameter of water stable aggregates were greater under no tillage than conventional tillage. However, other authors reported greater stability under conventional tillage than conservation tillage (Taboada-castrol *et al*., 2004). Karlen *et al*. (1994) suggested that aggregate size distribution and stability are good indicators for evaluating soil quality in tillage experiments. Soil aggregation influenced by large number of factors such as changes in soil organic matter, moisture content, microbial community, crop type, root development and tillage implementation. Over short periods of time the stability of soil aggregates is modified under the influence of different cropping systems probably, being more related to changes in the organic constituents than to the actual total organic matter content (Haynes *et al*., 1991).

Tillage effects on soil aggregate size distribution are directly related to the degree of soil disturbance. Alvaro Fuentes *et al*. (2008) in a semiarid Mediterranean agro-ecosystem, found that the dry mean weight diameter of soil aggregates decreases in relation with tillage intensity in semiarid central Spain. Hernanz *et al*. (2002) observed that water stability of 2-1mm aggregates decreased in the following order: no tillage > reduced tillage > conventional tillage. Cropping systems present a differentiated behaviour on soil aggregation. Grasses due to their exclusive root system are the plants that present the greatest effect on the aggregation and the highest aggregate stability (Tisdall and Ondes, 1979; Carpenedo and Mie Iniczuk 1990; Harris *et al*., 1996). The majority of these studies about tillage and aggregation have been focused on the effects of tillage on aggregate size distribution and aggregate stability.

Little information exists about adopting a conservation measure to ameliorate the effects of tillage on soil aggregation. Historically, the main reason that has been given to justify soil tillage is the achievement of an adequate seed bed preparation in order to facilitate a good seed- soil contact and thus a better crop emergence but mechanized tillage result in breakdown of soil aggregates. Since good soil aggregation is important to soil productivity, there is need to conserve the soil in order to sustain the productivity. Although in many countries, adoption of vetiver grass has been well advocated as a conservative measure, it has not been well recognized and adopted in many areas of Nigeria. Therefore, in areas where mechanization is inevitable so as to meet the need of teeming population, vetiver grass *(Vetiveria nigritana* Stapf) may be planted in strips in order to ameliorate tillage effects on soil aggregation.

The objectives of this work were therefore, to (i) know the effect of tillage on aggregate breakdown and (ii) to assess the effect of vetiver grass in reducing aggregate breakdown.

Materials and Methods

Site

This study was carried out on a 6% slope at the Teaching and Research Farm, Ladoke Akintola University of

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Technology Ogbomoso with latitude 8°l'N and longitude 4°10'E Nigeria, from 2004 to 2006. The soil was classified as an Alfisol under the order Udic Paleustalf according to the USDA classification (Soil Survey Staff, 2006). According to the local classification, the soil belongs to Gambari series (Smyth and Montgomery, 1962). The soil of the site belongs to the USDA classification of Alfisol. It was a moderately drained ferruginous soil with a sandy loamy texture.

The experimental design was randomized complete block design in a split plot with four replications on the field. Main plot size was 640 m with lm buffer between plot . Tillage, as main plot included: manual clearing (MC), Plough tillage (PT) and conventional tillage (CT) systems. The MC was where vegetation on the plots was manually cleared with cutlass and hoe. The PT involved the use of disc plough mounted on a tractor to plough the soil once and CT involved first ploughing operation in a similar way as MT but followed after by harrowing once. Hoeing was used to control weeds. Subplot was vetiver grass strips spaced at 0 m (control), 5 m and 10 m surface intervals. The experiment was repeated in 2005 and 2006 in the same manner as described for 2004.

Soil sampling and analyses

Soil samples were collected at 0-5 cm depth from the centre of each plot at 5 m intervals down the slope. Samples were bulked and taken to the laboratory for organic carbon and aggregate size analyses. Organic carbon was determined by the Walkey- Black procedure described by (Nelson and Sommers, 1982). Water stable aggregates (WSA) were determined in a modified Yoder's technique wet sieving method as described by Nimmo and Perkins (2002). Fifty (50) g (oven-dry mass equivalent) of air dry soil was placed on a set of sieves (5.00, 2.00, 0.25 and 0.045 mm) attached to a dipping machine. The set of sieves was cycled through a column of water for 10 min (30 cycles per min, 4.0 cm stroke length). The aggregates were suspended in 5 gL^{-1} sodium hexameta-phosphate solution in a 20 ml dispersion cup, mechanically stirred for 10 minutes to disperse the aggregate. Then, the suspension was poured through a sieve with the same mesh size as the one with which the aggregate were collected. The sand fractions remaining on each sieve were collected and oven dried at 105°C and weighed. To avoid overestimating the mass of the aggregate fraction, aggregate size-sized sand fraction was subtracted from the whole fraction masses (this method is called 'sand correction').The percentage of WSA as fraction of the total sample was calculated as follows:

$$\%\ WSA = \frac{\text{Weight of soil retained} - \text{Weight of sand}}{\text{Total sample weight} - \text{Weight of sand}} \times \frac{100}{1} \quad (1)$$

Mean weight- diameter of the soil aggregates w (MWD) was estimated from the equation:

$$MWD = \sum X_i W_i \quad (2)$$

Where X represents the mean diameter of the soil aggregates on each sieve and w_i is the mass fraction of the aggregates on each sieve

Statistical Analysis

Data were analyzed using the SAS Statistical Package (SAS Institute, 2001). ANOVA was used to test the effects of tillage and vetiver grass strips. The means were separated using least significant differences at 5% level of probability.

Result and Discussion

Tillage effect on soil organic carbon

Soil organic carbon (SOC) was not affected by tillage practices in 2004 and 2006 growing seasons (Table 1). However in 2005, SOC was significantly ($P<0.05$) higher by 3.7 and 8.4%, respectively on plough tillage (PT) and CT (plough plus harrow) than manual clearing (MC). There was a general decrease in SOC over the years. This can be attributed to loss on the field through erosion. The result here is in contrast with the observation of Borie *et al*. (2006) that no tillage and ridge tillage generally favoured SOC than conventional tillage.

Vetiver grass strips effects on soil organic carbon

Soil organic carbon showed no significant ($P>0.05$) differences amongst the effects of VGS spacing for the first two years of the experiment (Table 2). However after the third year, VGS had significant influence on SOC, 5 m VGS spacing had higher SOC than control and 10 m VGS by 3.3%.The reason could be related to the close gap between the strips spaced at 5 m surface interval which led to reduction in loss of SOC by erosion when compared to others VGS spacing. The study corroborates the finding of Hannamthiery (2010) that in the non-vetiver cultivation plot had the lowest organic carbon of 0.19%.

Table 1.Tillage effect on soil organic carbon (gkg^{-1}) after 2004, 2005 and 2006 cropping seasons

Tillage practices/Year	2004	2005	2006	Mean
MC	7.58	7.40	6.98	7.32
PT	7.77	7.67	6.98	7.47
CT	8.05	8.02	7.05	7.70
LSD (p<0.05)	NS	0.05	NS	

MC-Manual clearing; PT- Plough tillage; CT- Conventional tillage; LSD- Least significant difference; ns- not significant

Table 2. Vetiver grass spacing effect on soil organic carbon (gkg^{-1}) after 2004, 2005 and 2006 cropping seasons

Vetiver grass spacing/Year	2004	2005	2006	Mean
5 m VGS	7.93	7.77	7.15	7.62
10 m VGS	7.75	7.67	6.92	7.45
NV	7.92	7.65	6.92	7.49
LSD (p<0.05)	NS	NS	0.09	

NV -No vetiver; VGS- vetiver grass spacing; LSD- Least significant difference; NS- not significant

Tillage effect on mean weight diameter of water stable aggregates

The mean weight diameter (MWD) of water stable aggregates > 0.25 mm had similar values among tillage treatments (Table 3). The similar MWD among MC, PH, and CT can be related with the low differences in carbon inputs among tillage treatments. It is well accepted that soil aggregation is dependent on carbon inputs (Bronick and Lal, 2005).

Vetiver grass strips effects on mean weight diameter of water stable aggregates

Vetiver grass strips (VGS) had no significant effect on mean weight diameter (MDW) > 0.25 mm of water stable aggregate in 2004 and 2005 growing seasons (Table 4). However in 2006, 10 m VGS significantly increased MDW compared to 5m VGS but not significantly different from no-vetiver (NV) [Table 2].The result revealed that VGS produced greater MDW of water stable aggregates than NV.

Table 3. Effect of tillage on mean weight diameter of water stable aggregates >0.25 mm at 0-15 cm soil depth

Tillage practices/Year	2004	2005	2006	Mean
MC	0.29	0.26	0.27	0.27
PT	0.26	0.30	0.30	0.28
CT	0.29	0.26	0.28	0.27
LSD (p<0.05)	NS	NS	NS	

MC-Manual clearing; MT- PT- plough tillage; CT- Conventional tillage; LSD- Least Significant Difference; NS- not significant

Table 4. Effect of Vetiver grass strips spacing (VGS) on mean weight diameter of water stable aggregates >0.25 mm at 0-15cm soil depth

Vetiver grass spacing/Year	2004	2005	2006	Mean
5 m VGS	0.28	0.26	0.26	0.27
10 m VGS	0.27	0.29	0.30	0.29
NV (control)	0.28	0.29	0.29	0.29
LSD (p<0.05)	NS	NS	0.03	

NV -No vetiver; VGS- vetiver grass spacing; LSD- Least significant difference; NS- not significant

Tillage effect on water stable aggregates

Tillage had no significant effect on water stable aggregates (WSA) > 0.25 mm (Table 5). However in 2004, WSA was significantly greater on MC and PT by 16.8 and 13.5%, respectively when compared with CT. It is well established that conservation tillage had better aggregate stability than conventional tillage (Munoz *et al.,* 2007; Roldan *et al.,* 2007). Although higher organic carbon was observed on CT throughout the study period, MC and PT had higher water stable aggregates than CT. This could be as a result of pulverization of the soil to form microaggregates which made it easy to be carried away by runoff water. Simanky (2011) had similar report that microaggregates are faster and more easily taken away by erosion processes than larger macroaggregates.

Table 5. Effect of tillage on water stable aggregates (%) at 0-15 cm depth

Tillage practices/Year	2004	2005	2006	Mean
MC	55.60	51.91	51.09	52.87
PT	53.50	51.39	52.99	52.63
CT	46.28	52.06	51.09	49..81
LSD (p<0.05)	5.74	NS	NS	

MC = manual clearing, PT = Plough tillage; CT = conventional tillage; LSD- Least significant difference; NS- not significant

Vetiver grass strips effects on water stable aggregate

Water stable aggregates (WSA) >0.25 mm was not influenced by VGS spacing (Table 6). However, WSA under 5 m VGS and 10 m VGS spacing were 5.8 and 5.3%, respectively greater than NV at the end of three years. Wilkinson (1975) observed that the benefits of grasses on subsequent crops in the savanna zone were apparently due to improvements in nutritional status rather than to any significant and durable improvement of the physical properties of the surface soils.

Table 6. Effect of Vetiver grass strip spacing (VGS) on water stable aggregates (%) at 0-15 cm depth

Vetiver grass spacing/Year	2004	2005	2006	Mean
5 m VGS	53.29	50.58	50.72	51.53
10 m VGS	50.26	53.54	54.29	52.69
NV (control)	51.74	51.24	50.54	51.17
LSD (p<0.05)	NS	NS	NS	

NV = No vetiver; VGS- vetiver grass strips spacing; LSD- Least significant difference ; NS- not significant

Interaction between tillage practices and VGS spacing

There were no significant interaction between tillage and VGS spacing on water stable aggregates in 2004 and 2006 growing seasons (Data not shown). However, there was significant ($P < 0.05$) tillage x VGS spacing in 2005 growing season.

Conclusion

The results of the study showed that tillage implementation led to the breakdown of soil aggregates. However, this effect was different depending on both type of tillage implement used. Also, vetiver grass trips resulted in improved aggregate stability. Although the findings presented in this study resulted from a three years experiment and therefore, further research is necessary for better understanding of the influence of vetiver grass on aggregate stability over years and its implication on southern guinea savanna agro systems productivity.

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