LITTER QUALITY EFFECTS ON SOIL STABILITY AND ERODIBILITY IN THE NTABELANGA AREA, EASTERN CAPE, SOUTH AFRICA

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DECLARATION

I, Cosmas Parwada, declare that the thesis hereby submitted for the degree of Doctor of Philosophy (PhD) at the University of Fort Hare is entirely my work with the exception of such quotations or references which have been attributed to their sources or authors. This thesis has not been previously submitted to this or any other University for a degree.

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GENERAL ABSTRACT

Soil organic matter (SOM) plays a primary role in aggregation and stabilization of soils, hence reducing their susceptibility to erosion. In South Africa (SA), most soils have low (< 4%) soil organic matte (SOM) contents, making them susceptible to soil erosion. Little is known about SOM quality effects in soil stabilization in the SA context, it is therefore difficult to advocate specific organic matter sources in order to stabilize a particular soil. This study evaluated effects of different litter quality sources (*Vachellia karoo* (sweet thorn) leaf litter and *Zea mays* (maize) stover) on soil aggregate stabilization at a soil micro-level (soil aggregate), guided by the following specific objectives; (i) to characterize soil properties that influence the erodibility of soils in the Ntabelanga area, Eastern Cape (EC) Province, SA (ii) to assess fractionation of organic carbon during decomposition of different litter sources (iii) to determine rate of soil macroaggregate re-formation under different litter amendments (iv) to determine the influence of different litter quality on splash soil erosion and (v) to delineate the Ntabelanga area into different soil erosion sensitivity zones.

Soil samples collected from a proposed Ntabelanga dam site, EC Province, SA, were characterized for factors influencing erodibility. Soil physical and chemical properties were analyzed, soil erodibility (K-factor) estimated using SOC content and surface properties and soil loss rates by splashing determined under rainfall simulations at 360 mm h^{-1} rainfall intensity. Soil loss was then correlated with the chemical and physical soil properties. SOC showed significant ($P< 0.05$) inverse relationship with soil loss. Soils samples were bulked to seven composite samples according to major soil horizons (orthic A, melanic A, pedocutanic B, red apedal B, saprolite, G horizon and prismacutanic B) in the areas of soil associations, macroaggregate (> 0.250 mm) were removed by passing through a 0.250 mm sieve. The remaining soil microaggregates (< 0.250 mm) were then mixed with high quality *Vachellia karoo* leaf litter (C/N = 23.8) and low quality *Zea mays* stover (C/N = 37.4) and incubated at 23^{o}C for 30 weeks. Jars were arranged as a 7 × 3 factorial laid in completely randomized design (CRD) with three replicates. Data was repeatedly measured at 1, 3, 8, 14, 23 and 30 weeks after incubation: to determine the stabilization of SOM by fractionating the soil particulate organic matter (POM), rate of soil macroaggregate re-formation and influence of litter quality on splash soil erosion along a decomposition continuum. Free light fractions (Free LF), coarse particulate organic matter (CoPOM) and fine particulate organic matter (FiPOM) within macroaggregates (> 250 μm) decreased exponentially from week 1 to 30 and were significantly ($p < 0.05$) influenced by litter quality × soil horizon × time interactions. A similar trend for FiPOM fractions in macroaggregates was observed in the 53-250 μm microaggregates ($p < 0.05$). The greatest influence on changes in POM fractions occurred within the first 3 weeks of incorporation. Both *V. karroo* leaf litter and *Z. mays* stover significantly stabilized the macroaggregates within the first 3 weeks after incubation.

Cumulative macroaggregates yields, mean weight diameter (MWD), percentage water stable aggregates (%WSA) and whole soil stability index (WSSI) in litter amended soils increased up to week 8 of incubation and thereafter gradually declined in all soils. An increase in macroaggregation resulted in increased MWD, WSSI values and large and small aggregates distribution. Aggregation was significantly higher in soils with higher clay content than sand content, suggesting that soil texture was highly influential in litter decomposition. Rate of litter

decomposition was influenced by soil type × time interactions which determined extent and macroaggregation dynamics along a decomposition continuum. The amount of splashed sediments was determined from each soil horizon at 360 mm h^{-1} simulated rainfall intensity applied as either single 8minute rainstorm (SR) or 4 × 2minute intermittent rainstorms (IR) separated by a 72 h drying period. Results showed a reduction in splashed sediments under IR and SR storms in litter-amended soils during the first 8 weeks of incubation with gradual increase thereafter. More sediments were splashed under IR than SR and litter quality had no influence on splashed sediments per soil horizon. Soil horizons profile with more clay than sand particles enhanced the litter effects on the soil resistance against detachment. The amount of SOC loss was influenced by primary particle size distribution and initial SOC content of the soil. Rainfall pattern and the initial SOC content were the main factors by which different soils influenced SOC loss. More rainstorm patterns should be investigated on these soils.

Digital mapping of the Ntabelanga area into erosion sensitivity zones showed the largest proportions (40%) of total area be covered by shallow soil associations. The largest proportions (40%) of total area had K-factor of 0.0693 t.ha.h.ha^{-1}.MJ^{-1}.mm^{-1}. Most (60.2%) soil associations in the Ntabelanga area had a structural stability index of 0.8 and the largest area (42.7%) had a dispersion ratio of 0.79. Addition of OM reduced the extent of area with high-to-extreme erosion rates (> 15 t/ha/yr) in the first 8 weeks with a gradual increasethereafter under both IR and SR.

The study confirmed that SOM can effectively stabilize soils but only up to 8 weeks of incorporation, thereafter fresh litter has to be reapplied. Litter quality effect (*Vachellia karoo* (C/N = 23.8) and *Zea mays* stover (C/N = 37.4)) was insignificantly different per soil horizon but significantly different across horizons suggesting that not all litter is equally suitable in soil structural stability. Slow decomposing litter had prolonged stabilizing effects on SOC, hence soil structural stability. However, the experiments may need to be repeated at a macro-level and determine the carbon saturation point of the soils. It is also recommended to develop mathematical models for quantitative operational monitoring of different factors contributing to soil erosion in the Ntabelanga area.