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TILLAGE AND CARBON DYNAMICS IN KWAZULU-NATAL'S SMALL-SCALE FARMING SYSTEMS

Charmaine N. Mchunu and Alan D. Manson

Soil Fertility and Analytical Services, Cedara

E-mail: charmaine.mchunu@kzndae.gov.za

Introduction

Minimal Tillage (No-Till) is promoted as the best land management practice for soil rehabilitation and conservation, as well as aiding soils in cropping systems to act as a sink for atmospheric carbon. With No-Till owing its success to minimal soil disturbance and at least 30% of soil surface coverage, the benefits of this practice were assumed to be hindered in residue scarce small-scale farming systems. However, work done in KwaZulu-Natal, Bergville, showed that No-Till practiced under grazed crop-residue could still yield positive benefits, which were reduced soil erosion; CO_2 emissions and increased C storage. Having observed minimal soil disturbance as the key factor contributing to soil conservation in No-Till, the issue of residue scarcity still remained a challenge in small-scale cropping systems attaining other benefits of the practice. Hence, this study evaluated the effect of tillage and different mulching systems on soil conservation and health, by assessing soil erosion; aggregate stability; C stocks; microbial activity and CO_2 emissions.

Materials and methods

For this study, the site was managed under conventional tillage (CT) and No-Till regimes, with the No-Till portion being under four different mulch management systems.

Thus, treatments evaluated for this study were CT; No-Till with free grazing (NT+Gr); No-Till with mulch (NT+Mulch); No-Till with bare soils (NT+Bare) and No-Till with high density stocking rate (NT+IntGr). To evaluate soil erosion, three 1 m^{-2} (1 × 1 m) runoff plots were installed on each treatment plot and runoff was collected after every erosive rainfall event during the 2011/2012 and 2012/2013 rainy seasons. Soil losses were computed as a product of total runoff volume and sediment concentration for each treatment. Soils were sampled at 0 – 0.05 m to evaluate the effect of treatment on aggregate stability, C stocks and microbial activity. Cumulative CO_2 emissions were evaluated *in-situ* during the 2012/2013 rainy season. All data was run through an Analysis of Variance and Fisher's protected least significant difference test using GenStat.

Results

Table 1. Fisher's protected least significant difference test for various parameters assessed in this study

	Runoff	**SL**	**MWD**	**SOCs**	**FDA**	**CO_2**
	(L)	**(g m^{-2})**	**(mm)**	**(kg m^{-2})**	**(µg g^{-1} h^{-1})**	**(g C CO_2 m^{-2} h^{-1})**
Treatment						
NT+IntGr	53.23 ^{bc}	1.12 ± 0.45 ^{a}	2.09 ± 0.14 ^{b}	14.24 ± 0.83 ^{b}	10.71 ± 0.61 ^{a}	0.97 ± 0.15 ^{a}
NT+Bare	63.97 ^{c}	2.69 ± 0.51 ^{c}	1.52 ± 0.07 ^{a}	10.64 ± 0.50 ^{a}	7.94 ± 1.49 ^{a}	1.86 ± 0.30 ^{b}
NT+Mulch	27.35 ^{ab}	0.46 ± 0.04 ^{a}	2.12 ±0.16 ^{b}	11.32 ± 0.60 ^{a}	10.90 ± 1.31 ^{a}	1.29 ± 0.10 ^{ab}
NT+Gr	11.73 ^{a}	1.04 ± 0.15 ^{ab}	1.55 ± 0.18 ^{a}	11.49 ± 1.24 ^{a}	9.83 ± 0.90 ^{a}	1.69 ± 0.15 ^{ab}
CT	19.05 ^{ab}	1.32 ±0.01 ^{bc}	1.44 ± 0.16 ^{a}	11.94 ± 0.90 ^{a}	16.20 ± 0.59 ^{b}	2.72 ± 0.46 ^{c}

SL = soil losses, MWD = mean weight diameter, SOCs = soil organic carbon stocks, FDA = Fluorescein diacetate hydrolysis assay and CO_2 = cumulative CO_2 emissions from soils during the rainy season. Letters indicate the statistical significance effect of the treatment on the particular parameter, thus, each mean is compared to means on the same column. Significant difference was considered at $p \leq 0.05$. n=9.

Discussion and Conclusions

Overall observations from this study, presented on Table 1, illustrated that No-Till practiced on bare soils results in significantly higher soil losses compared to all considered treatments, due to unprotected soil surfaces. Aggregate stability was highest on treatments with crop residue left on the surface after harvesting. This resulted from the presence of organic matter promoting higher microbial biomass and activity at the soil surface; these are essential in stabilising soil aggregates and structure. CT systems significantly increased microbial activity and CO_2 emissions, since tillage increases aeration in soils and exposes organic matter that can be decomposed for nutrient turnover and increased CO_2 emissions. Thus, conclusions from this study were:

i) NT+Bare systems may result in higher soil losses compared to CT regimes, therefore, minimal soil cover (± 10%) is important in No-Till systems.

ii) For small-scale farming systems, No-Till practised with minimal residue (grazed) may still result in reduced soil losses and CO_2 emissions compared to CT. However, soil structure and nutrient turn-over may not be increased as much as in systems where more than 30% of the soil surface is protected by mulch.