Effect of tillage system and forage type on soil health parameters

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Introduction

Soil health is an assessment of how well soil performs and preserves its functions. A health soil supply the essential nutrients, water, oxygen and root support to crops. Forage managements, particularly tillage and forage species, could change the distribution of **soil aggregate fractions** and **soil microbial community**, which are the two important parameters of soil health. Compared with sole warm-season grass forage system, integration of cool-season grass into forage system expand the growth season, provide greater root activity and plant residue input. Additionally, tillage disturbs soil structure and increases the oxidation of soil organic matters. All these factors would influence the formation of soil aggregates and the growth soil microorganisms. Therefore, to improve soil health and achieve long-term yield goal, systematical evaluation on the effect of forage managements on soil health is essential.

Objective

To quantify the effects of tillage and five forage types on soil aggregate stability and microbial community.

Methods and Material

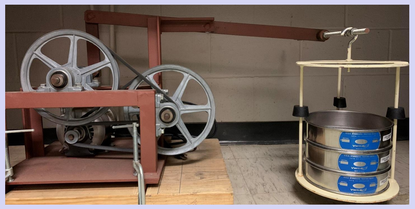
Study Site and Treatments

Forage treatments were initiated at LSU AgCenter Iberia research station, located in New Iberia, LA.

1) **Ryegrass with tillage**: cool-season ryegrass (*Lolium multiflorum*) with conventional tillage
2) **Ryegrass**: cool-season ryegrass
3) **Ryegrass + Clover**: cool-season ryegrass and clover mixture (*Trifolium repens*)
4) **Cocktail mixture**: cool-season cocktail grasses included Alyce clover (*Alysicarpus vaginalis*), pearl millet (*Pennisetum glaucum)* and cowpeas (*Vigna unguiculata*)
5) **Bermudagrass**: warm-season bermudagrass (*Cynodon dactylon L.*).

Soil aggregate fractionation:

The whole soil aggregates were fractionated into four sizes using wet-sieving method (Six et al., 2001):
macroaggregates (>2000µm)
small macroaggregate (250-2000µm)
microaggregates (53-250µm)
silt + clay fraction (<53µm)
Soil organic carbon (OC) were analyzed for the whole soil and each aggregates' fraction.

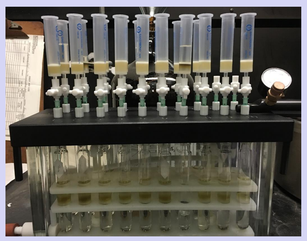


Wet-sieving oscillation equipment

The mean weight diameter (MWD) = $\sum_i (PiDi)$
Pi: the proportion of the whole soil in the given fraction
Di: average diameter (mm) of the particles of the fraction

Soil microbial PLFA analysis:

Soil samples from cool-season forage systems were extracted using a solvent mixture of methanol, chloroform and phosphate buffer (pH 7.4). Then PLFA were purified, methylated and analyzed using a GC equipped with a flame ionization detector (Allison and Miller, 2005).



Silica separation column

Results

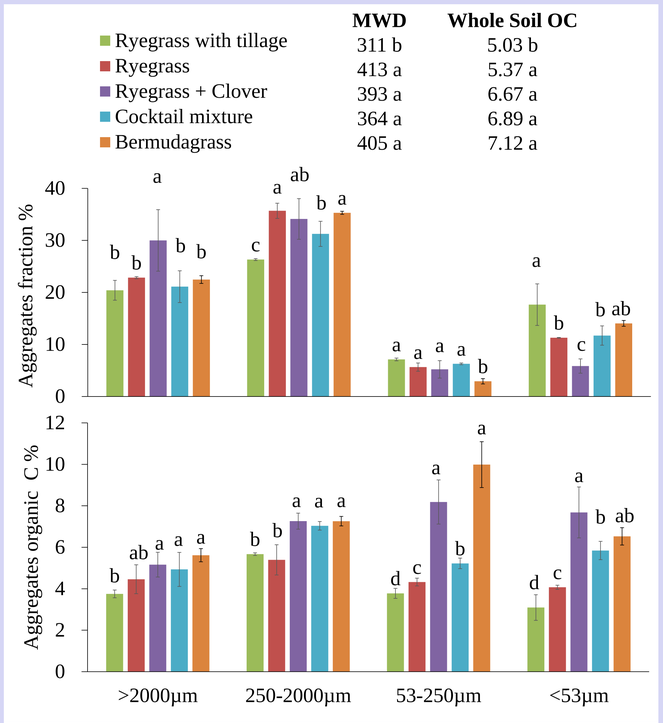


Fig. 1. Fraction and OC content of sand-free water stable aggregates, MWD and whole soil OC showed above the bar chart. Different letters indicate significant differences among treatments (Tukey's LSD comparison, $P < 0.05$)

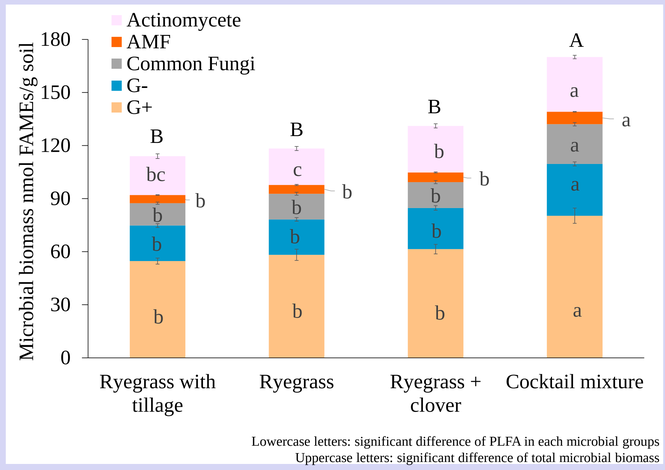


Fig. 2. Abundance of soil microbial biomass (nmol PLFA g^{-1}) in each microbial groups among different cool-season forage types and tillage. G+, Gram positive bacteria; G-, Gram negative bacteria; AMF, arbuscular mycorrhiza fungi

Table 1. Relative abundance (%), and ratios of PLFA biomarkers among different cool-season forage types and tillage

	Ryegrass with tillage	Ryegrass	Ryegrass + Clover	Cocktail mixture
Relative abundance				
Bacteria %	64.5a	64.9a	63.7a	63.1a
Fungi %	10.8b	12.0a	10.9b	12.9a
FBR	0.17b	0.19a	0.17b	0.21a
G+/G-	2.74b	2.91b	2.66b	2.77b
Nutrients stress factor*	0.29a	0.28a	0.31a	0.29a

*Nutrient stress indicator (cy/pre): (cy17:0 ω7c + cy19:0 ω7c) / (16:1 ω7c + 18:1 ω7c)
FBR, Fungi to bacteria ratio; G+/G-, Gram positive to Gram negative ratio.

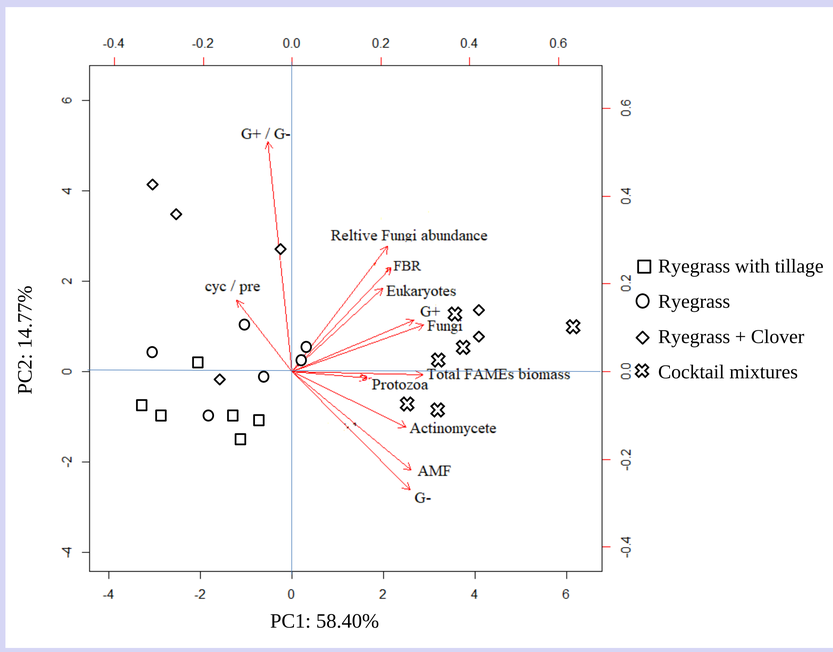


Fig. 3. Biplot of principal component analysis for soil microbial PLFA profile and PLFA ratios

Results and Discussion

The effects of tillage:

- Ryegrass with tillage had lower proportion of macroaggregates and higher proportion of silt + clay than ryegrass without tillage, indicating the prohibition effect of tillage on the formation of macroaggregates (Fig. 1).
- Tillage reduced MWD, and OC in whole soil and microaggregates (Fig. 1).
- Tillage decreased the relative abundance of fungi and FBR, suggesting a microbial community shift (Table 1).

The effects of forage types:

- Compared to Ryegrass, Ryegrass + Clover shifted the aggregate proportion from silt + clay to macroaggregates, while potentially raised microbial biomass content, indicating the positive effect of clover on soil health (Fig. 1&2).
- As a long term warm-season forage, bermudagrass had the smallest fraction in microaggregates, from which the highest OC content was found (Fig. 1).
- Cocktail mixture promoted the highest microbial biomass in total and in each category, indicating a microbial growing benefit under multi-species forage systems (Fig. 2&3).
- There is no significant difference of microbial nutrient stress factor among all cool-season grass forage systems (Table 1).

Conclusions

Tillage caused deterioration in soil aggregate stability, reduced organic content of soil and macroaggregates, and suppressed fungal abundance. The addition of clover in ryegrass systems showed positive effect on soil health. Cocktail mixture presented the highest growth in soil microbial biomass. Overall, the two cool-season multi-species forage systems both demonstrated improvement on soil health.

Reference

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