Microbial Contributions to Rhizosphere Soil Aggregation in a Semi-Arid Agroecosystem

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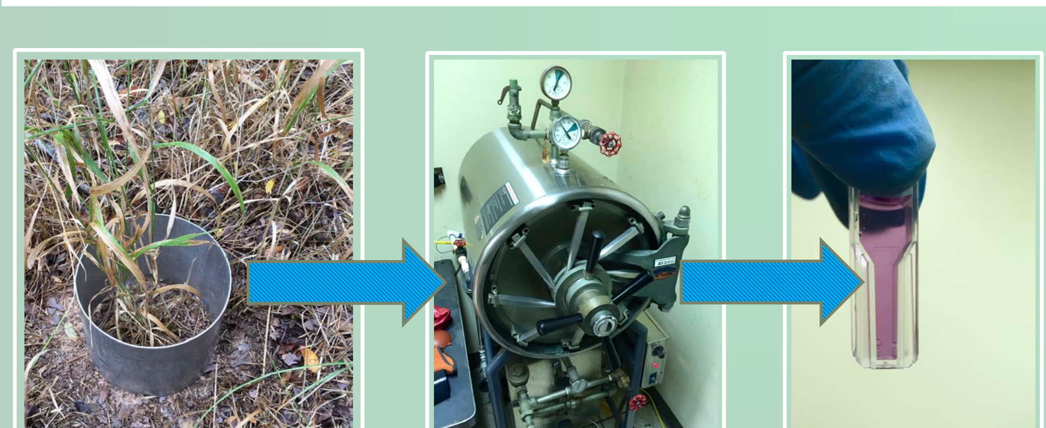
Introduction

- Soil erosion is a major threat to the sustainability of agroecosystems and riparian health (Alldredge *et al.* 2014).
- Microorganisms have been shown to stabilize soil and prevent soil erosion by facilitating soil aggregation (Six *et al.* 2004).
- We asked, How do rhizosphere microorganisms influence the soil aggregation process?
- We separated soil from the rhizosphere of Texas Wintergrass, as well as the surrounding topsoil and subsoil, into four size fractions and analyzed each for organic carbon, nitrogen, carbohydrates, proteins, and other edaphic characteristics.
- We hypothesized that the rhizosphere would have higher concentrations of these substances and a greater degree of soil aggregation.
- We aimed to illuminate the mechanisms by which rhizosphere microorganisms affect soil aggregation.

Methods

- Ten intact rhizospheres were excavated (0-10cm) as a 15cm diameter core. Ten Topsoil (0-10cm) and ten subsoil (10-15cm) samples were taken.
- Soils were slaked and wet sieved. Each fraction was dried, weighed, and kept for further analysis.
- Total organic carbon and nitrogen were measured in a CHNS elemental analyzer at 950^{O}C.
- Total carbohydrates were extracted with 80^{O}C water for 16 h and measured colorimetrically using the phenol-sulfuric acid method described by (Ghani *et al.* 2003).
- Glomalin related soil protein was extracted with sodium citrate for 60 min in an autoclave and determined colorimetrically using the BCA assay (Reyna & Wall 2014).



Results

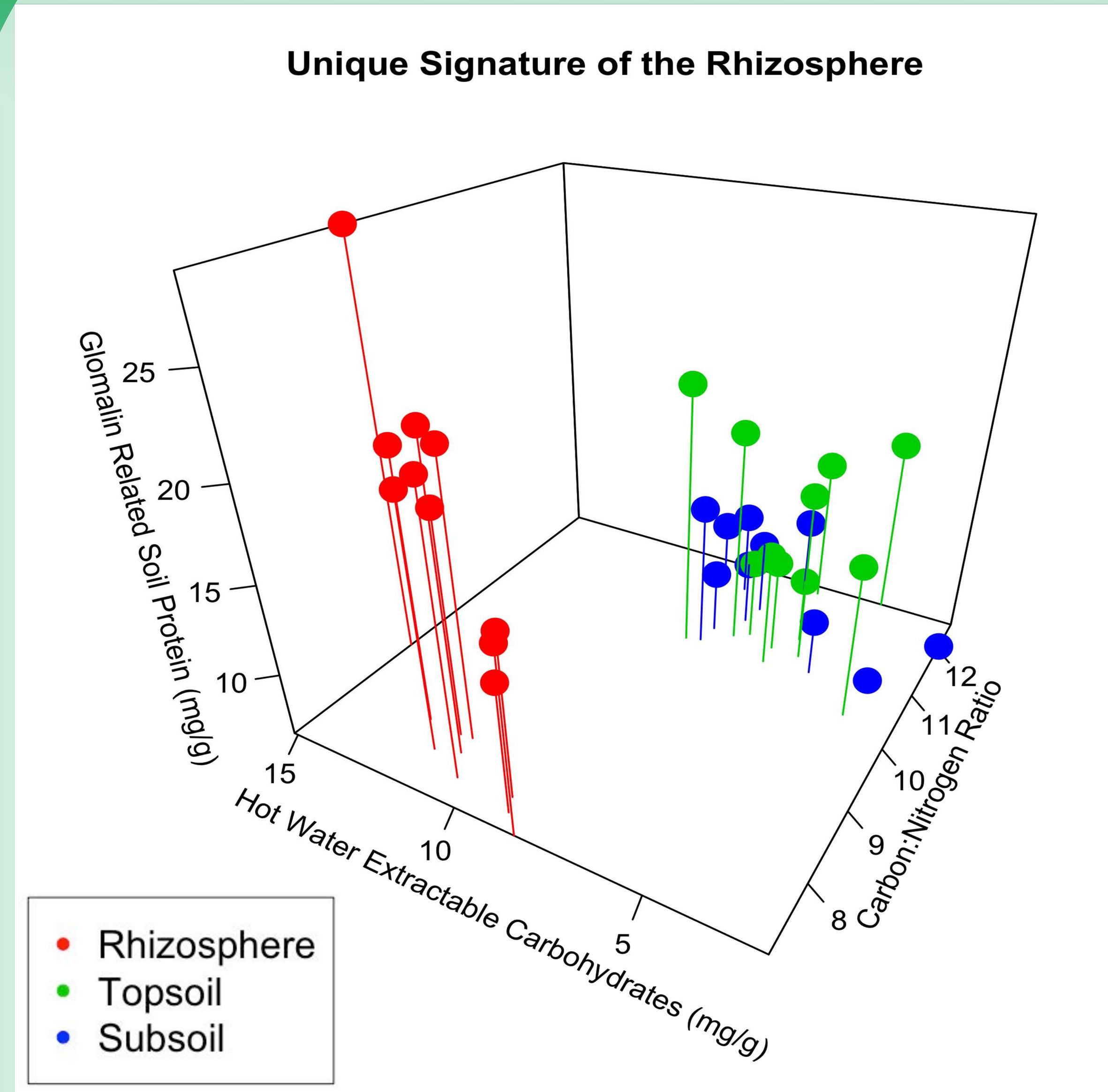


Figure 1. The rhizosphere displays significantly (**p<0.05**) greater concentrations of hot water extractable carbohydrates and glomalin related soil protein and a significantly (**p<0.05**) lower carbon to nitrogen ratio.

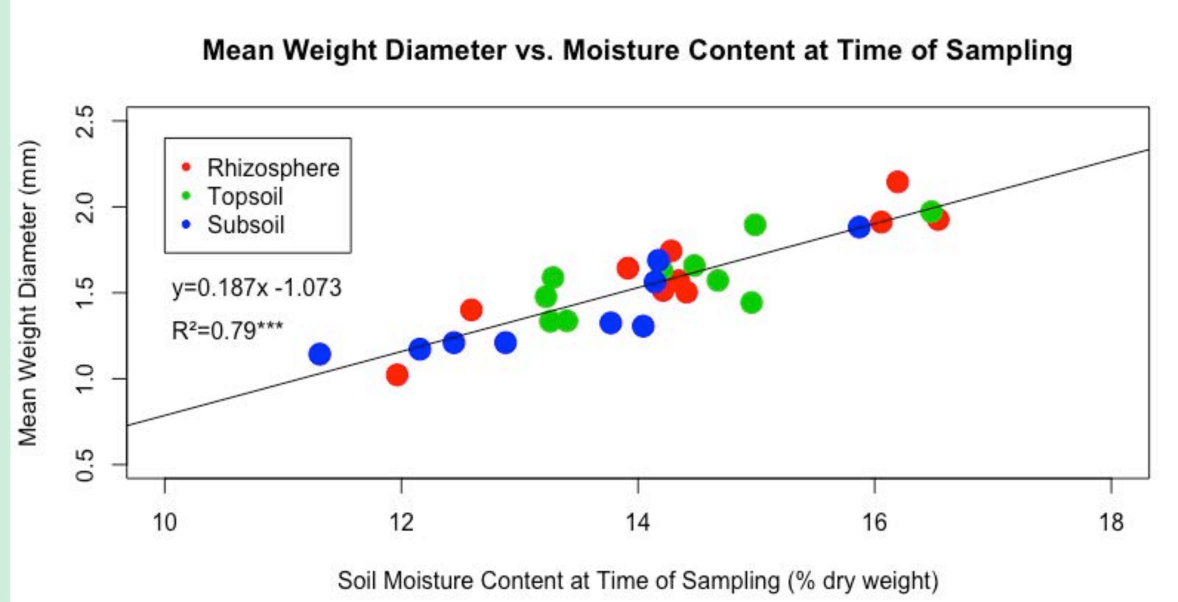
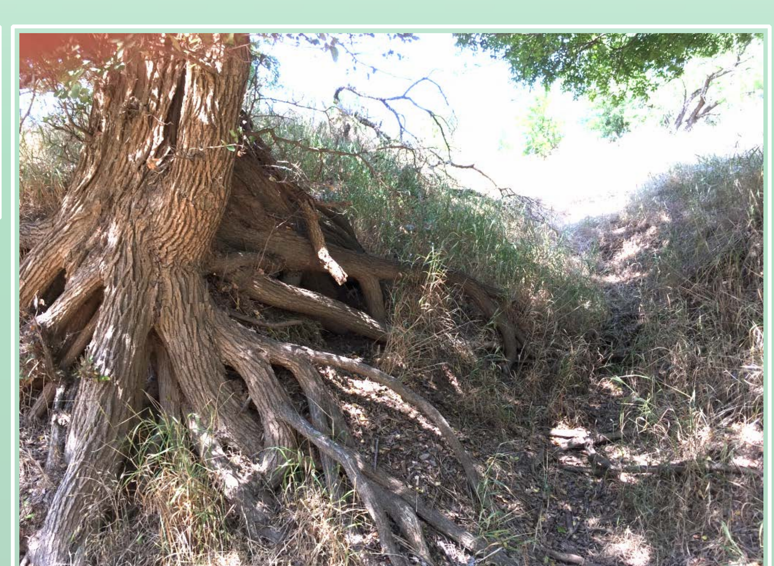


Figure 2. The best (**R^2 =0.79*****) predictor of mean weight diameter was the antecedent moisture content of the soil at the time of sampling.

Figure 3. A tree holding on to the soil next to a newly forming gully at the study site (Right).



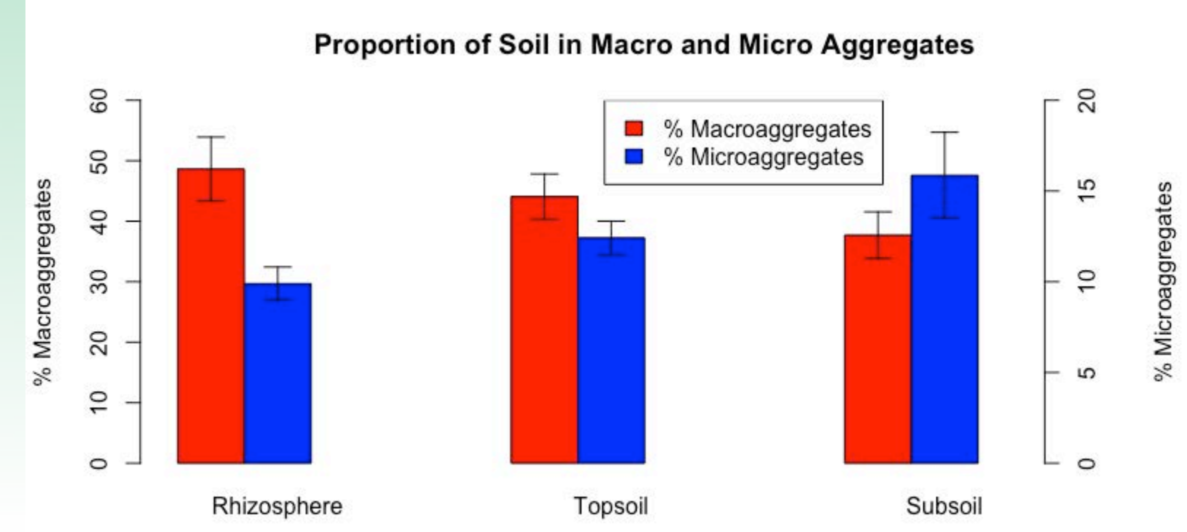


Figure 4. Macroaggregation (left axis) trends from highest in the rhizosphere to lowest in the subsoil. Microaggregation (right axis) shows the opposite trend. The rhizosphere had a significantly (**p<0.05**) greater proportion of its soil in the macroaggregate size fraction than the subsoil. All groups had significantly (**p<0.05**) different proportions of their soil in microaggregates.

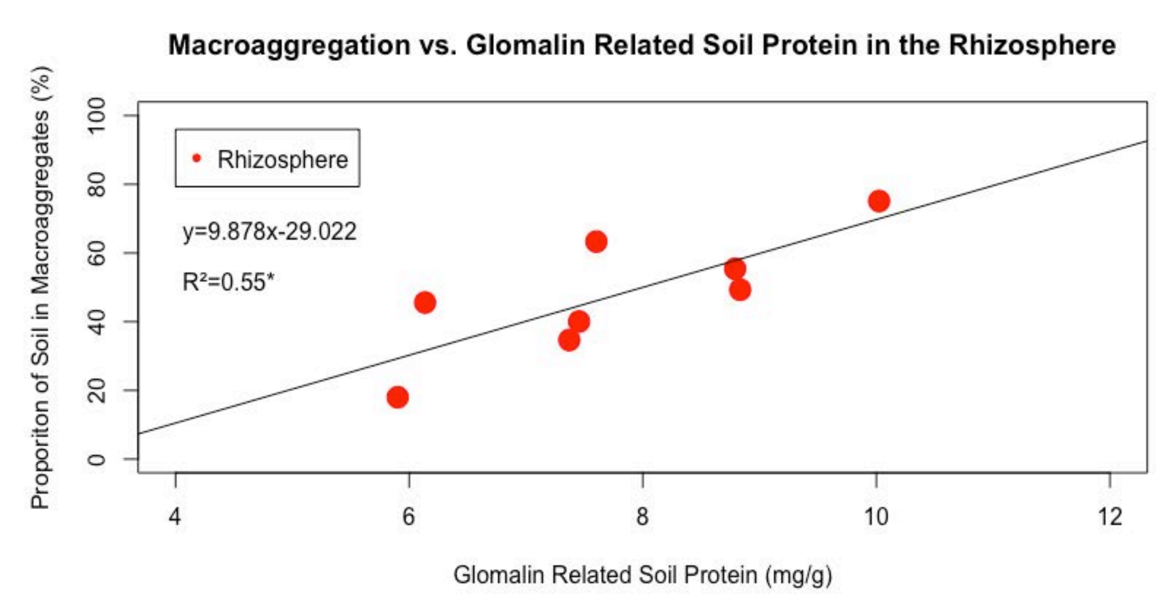


Figure 5. The degree of macroaggregation in the rhizosphere (the niche of glomalin producing arbuscular mycorrhizal fungi) displays a distinct (**p<0.05**) and strong (**R^2 =0.55**) relationship to the concentration of glomalin.

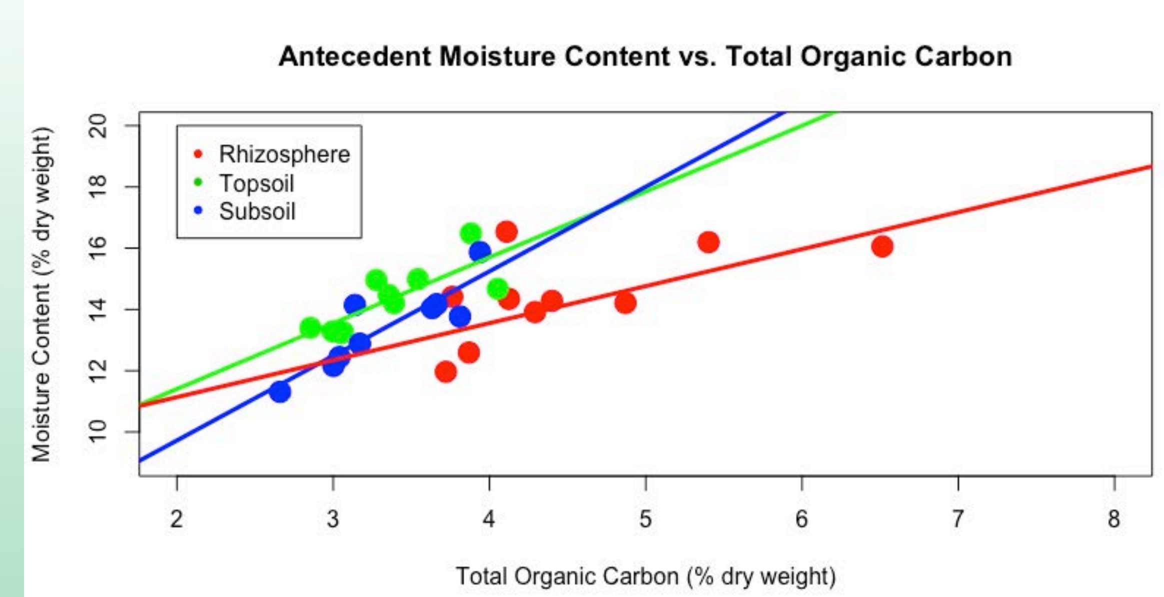


Figure 6. Regressions of total organic carbon on antecedent moisture content by sample type show the distinctly different relationship in the rhizosphere. R^2 values for the rhizosphere, topsoil, and sub soil are **0.60****,**0.59****,and **0.74****, respectively. However, the rhizosphere regression slope value was roughly ***half*** that of the top and sub soil regressions (** indicates p<0.01).

Figure 7. One of many large debris filled gullies at the study site. For scale, several large cars could fit in this gully which is just meters from the Texas Colorado River.

Discussion

- Lower carbon to nitrogen ratios and higher concentrations of organic carbon, carbohydrates, and glomalin found in the rhizosphere provide evidence that root exudates are feeding the production of microbial aggregation agents.
- Higher degrees of aggregation in the rhizosphere indicate that Texas Wintergrass cooperates with its microbial symbionts to augment the suitability and stability of its niche.

Conclusions

- Microbial metabolites play a significant role in the process of soil aggregation and erosion prevention by providing the necessary "glue".
- The rhizosphere of Texas Wintergrass facilitates additional and accelerated soil aggregation by stimulating the growth of "ecosystem engineer" microorganisms.
- Slaking is a key process controlling erosion in seasonally dry soils. Future studies should examine how microbial aggregation agents affect moisture content over time.

References

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