Soil Health in Warm-Season Perennial Pastures Over-seeded with Cool-Season Annuals

Kathleen Bridges[1], Lisa M. Fultz[1], Josh Lofton[2], Beatrix J. Haggard[2] and Wink Alison[3]
(1)Louisiana State University AgCenter, Baton Rouge, LA
(2)Oklahoma State University, Stillwater, OK
(3)Louisiana State University AgCenter – Macon Ridge Research Station, Winnsboro, LA

Background

Fertilizing forage land is becoming less economically and environmentally sustainable, requiring the implementation of alternative production methods. One potential alternative is over-seeding pastures of warm-season perennials with cool-season annuals especially leguminous species which provide a source of nitrogen. This practice also extends the grazing season reducing the financial burden of supplemental feeding and reduces nutrient loss.

Objectives

- To determine the impact that long term over-seeding of warm-season perennial pasture with cool-season species may have on soil health in Southeastern U. S.
- To determine a relationship between cool-season species distribution and soil properties

Methods and Materials

Site Description

The site for this project is a privately owned commercial grazing operation located in south central Mississippi. The soils are primarily a cultivated Loring silt loam. The site is a bahiagrass (*Paspalum notatum*) pasture that has been over-seeded with oats (*Avena sativa,* 17.0 kg/ha), triticale (*Triticum secale,* 11.3 kg ha^{-1}), annual ryegrass (*Lolium multiflorum,* 14.5 kg ha^{-1}), hairy vetch (*Vicia villosa,* 5.7 kg ha^{-1}), radish (*Raphanus* sp., 0.6 kg ha^{-1}), turnips (*Brassica* sp., 0.6 kg ha^{-1}), AU Red Ace red clover (*Trifolium pretense,* 1.1 kg ha^{-1}), Ball clover (*Trifolium nigrescens,* 0.6 kg ha^{-1}), and Dixie crimson clover (*Trifolium incarnatum,* 5.7 kg ha^{-1}) for the past nine years. Soil samples were collected and analyzed for a suite of biological, chemical, and physical properties.

Soil Analysis

- Three samples per location were collected across a topographic sequence immediately prior to planting with samples collected on the ridge, backslope and footslope at multiple locations (Fig. 1)
- At each location three samples were collected randomly at depths of 0-7.5 cm, 7.5-15 cm, 15-22.5 cm and 22.5-30 cm
- Biological analysis at 0-15 cm depths
  - Fatty Acid Methyl Ester analysis was conducted to determine microbial community structure and total microbial biomass (Schutter and Dick 2000)
  - Enzyme activity assays were conducted following Tabatabai (1994) methods
- Chemical analysis at 0-30 cm depths
  - Soil chemical assessments included macronutrients, pH, soil organic carbon (SOC), and total nitrogen (TN)
  - Soil organic matter (SOM) was determined by loss on ignition
  - Inorganic nitrogen was determined colorimetrically

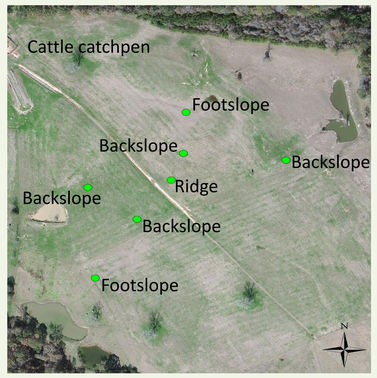

Fig. 1: Site map of the sampling area.

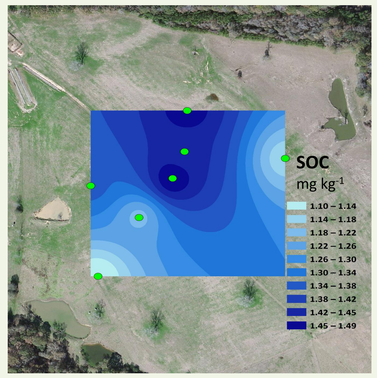

Fig. 2: Soil organic carbon (SOC) distribution along the sampling points.

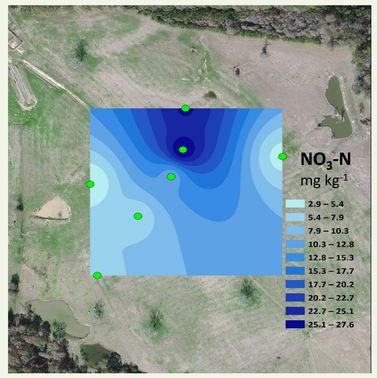

Fig. 3: Nitrate (NO_3^--N) distribution along the sampling points.

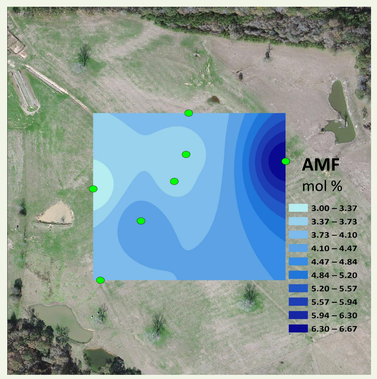

Fig. 4: Relative abundance of arbuscular mycorrhizal fungi (AMF) distribution along the sampling points.

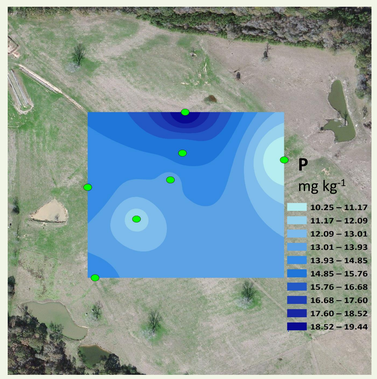

Fig. 5: Extractable phosphorus (P) distribution along the sampling points.

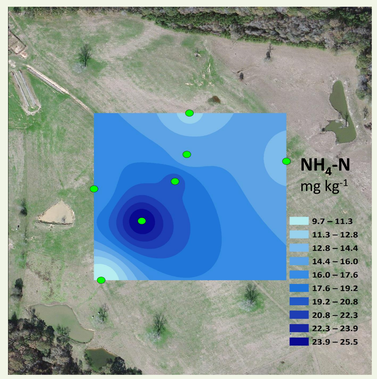

Fig. 6: Ammonia (NH_4^+-N) distribution along the sampling points.

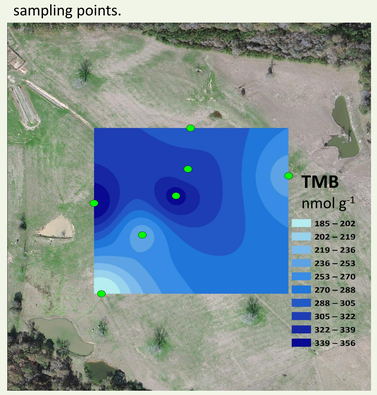

Fig. 7: Total microbial biomass (TMB) distribution along the sampling points.

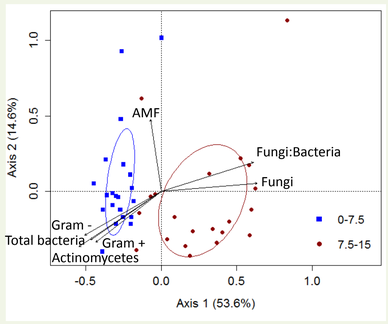

Fig. 8: The microbial community structure at 0-7.5 (blue squares) and 7.5-15 (red circles) cm. Microbial groups are represented by vectors. (AMF= Arbuscular mycorrhizal fungi)

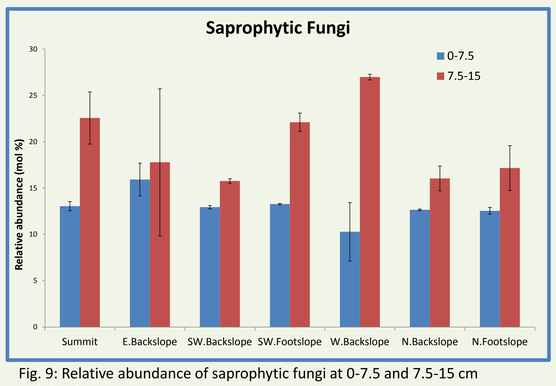

Fig. 9: Relative abundance of saprophytic fungi at 0-7.5 and 7.5-15 cm soil depths.

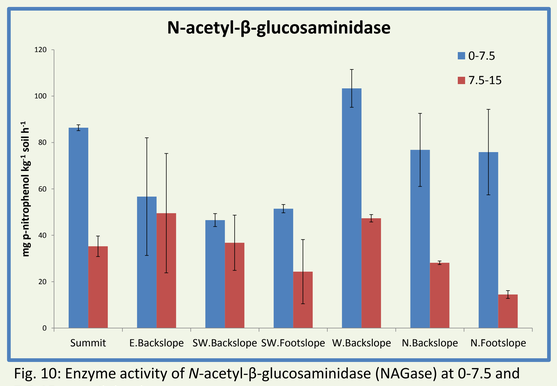

Fig. 10: Enzyme activity of *N*-acetyl-β-glucosaminidase (NAGase) at 0-7.5 and 7.5-15 cm soil depths.

Results

- Topography had a significant influence on SOC (Fig.2), total microbial biomass (Fig. 7), TN, and K (data not shown) with greatest concentrations at the ridge.
- NO_3^- -N was found in greatest concentration in the 0-7.5 cm layer of the north facing slope (Fig. 3).
- Soil depth had no significant effect on relative abundance of arbuscular mycorrhizal fungi which were highest on the east facing backslope (Fig. 4).
- The highest measurements for SOM and P (Fig. 5) were at 0-7.5 cm depth of the north facing footslope and for NH_4^+-N, the 0-7.5 cm depth of the west facing backslope (Fig. 6).
- Saprophytic fungi were found in greater relative abundance at 7.5-15 cm depth (Fig. 9).
- Depth was most influential for total microbial biomass (Fig.8), *N*-acetyl-β-glucosaminidase (NAGase) (Fig. 10), SOC, and TN, which were highest at 0-7.5cm.
- Forage yield was uniform throughout the site. However, species of cool-season annual forages were observed to be unevenly distributed over the area.

Summary

- The north facing slope where NO_3^- -N was found in greatest concentration is down hill from a cattle catchpen. This is also an area of high NAGase activity. Nitrification of NH_4^+ -N deposited in this area may be resulting in high NO_3^- -N concentration.
- The location of the catchpen may also explain the high amounts of SOC and P in the north facing footslope.
- Arbuscular mycorrhizal fungi were concentrated in areas of low nutrient availability.
- Saprophytic fungi were found at lower depths which was unexpected as these fungi normally consume organic carbon typically found in the top layer of soil. It may be that there is an unidentified carbon source at the 7.5-15 cm depth.
- Future sampling and data analysis is expected to provide more information and may reveal connections between forage species and soil properties.

Acknowledgments

Cooper and Katie Hurst Hunt Hill Cattle Co.
LSU AgCenter Soil Testing and Plant Analysis Lab
Thanks to students Ina Sanchez and Jonathan Angers

References

Schutter, M. E., & Dick, R. P. (2000). Comparison of fatty acid methyl ester (FAME) methods for characterizing microbial communities. Soil Science Society of America Journal, 64(5), 1659-1668.

Tabatabai MA (1994) Soil enzymes. Weaver RW, Angle JS, Bottomley PS (eds) Methods of soil analysis, part 2. Microbiological and Biochemical Properties. SSSA Book Series No. 5. Soil Sci. Soc. Am., Madison, Wis., pp 775–833