Evaluation of torrefied Napiergrass (*Pennisetum purpureum* Schumach.) biomass as a renewable fertilizer

Heather D. Baldi [1], Russell W. Jessup [2], Dirk B. Hays [2], Sam E. Feagley [2], Fred E. Smeins [3]
(1) Dept. of Soil and Crop Sciences, (2) Dept. of Soil and Crop Sciences, Texas A&M AgriLife Research, (3) Dept. of Ecosystem Science and Management
Texas A&M University, College Station, TX 77843

Abstract

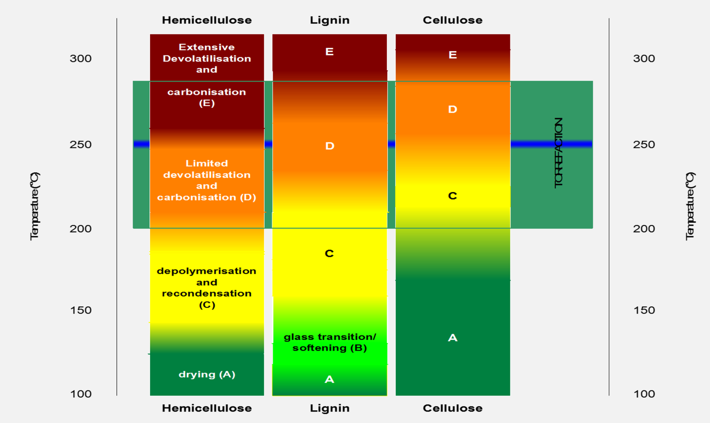
The development of designer, biochar-based fertilizers from perennial, high-biomass feedstocks provides immense opportunity to offset chemical fertilizers. While fertilization is vital for food, feed, fiber, and fuel production, excessive application and loss (volatilization, leaching, run-off, etc.) of inorganic fertilizers have significant, detrimental environmental impacts. This trend has increased dramatically with modern, intensive agricultural practices. Increasing prices for petroleum-based and mined fertilizers further limit opportunities for their utilization in developing nations. As a potential alternative, this study converted a high-nitrogen-feedstock into an organic, pyrolysis-based, biomass-derived, renewable fertilizer. Napiergrass, *Pennisetum purpureum* Schumach., (cv. Merkeron) produces high dry matter yields (20-30 dta/y) and contains high crude protein content (15-20% dwt). It can be harvested multiple times a year and requires little to no supplemental nutrition. Torrefaction of napiergrass biomass was carried out under atmospheric pressure and in the absence of oxygen. The resulting 'Torrified Biomass Fertilizer' (TBF) was ground to a 2mm particle size and compared to inorganic fertilizer for yield response in maize and pearl millet-napiergrass (PMN) hybrids.

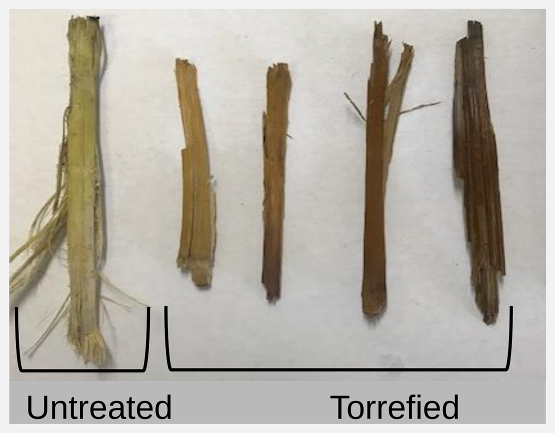
Objectives

- Create a slow-release, renewable, pathogen-free fertilizer utilizing torrefaction.
- Compare nutrient uptake from TBF and urea in perennial PMN and annual maize.

Materials and Methods

Torrefaction





- A fixed bed torrefaction reactor with a stainless steel reactor chamber, sealed with low oxygen, biomass compacted to bulk density of 200 kg/m³ in an Axner kiln.
- The kiln was heated to 250˚ C at a rate of ~ < 2˚ per minute with an incubation time of 45 minutes.
- The TBF was tested for forage content (Table 1).
- The TBF was then ground to a 2mm particle size.

Table 1	Crude Protein	ADF	TDN	N	P	K
Merkeron	%	%	%	ppm	ppm	ppm
Torrefied	5.9	46.7	47.5	9440	3500	4540

Planting

- Replicated pot trials were initiated on July 19, 2017 and harvested on September 29, 2017.

- All pots were planted by seed (Dyna-Gro Hybrid Seed Corn Var: A1034225 and PMN 10TX15).

Fertilizer Treatments

- Synthetic fertilizer treatment for 166 kg/hectare N was applied as Urea (46-0-0).
- TBF fertilizer treatment for 26.5 kg/hectare N was applied.
- Both amendments were side dressed in the pots.

Forage Assay Results

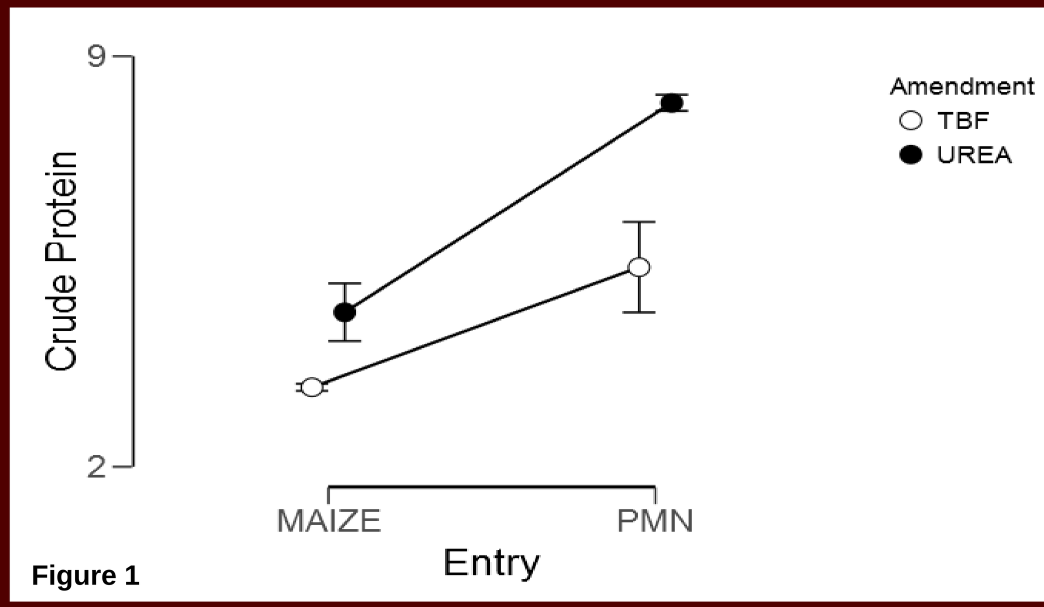


Figure 1. Crude Protein/Nitrogen Content Across Entries and Fertility Treatments
- Shown in %

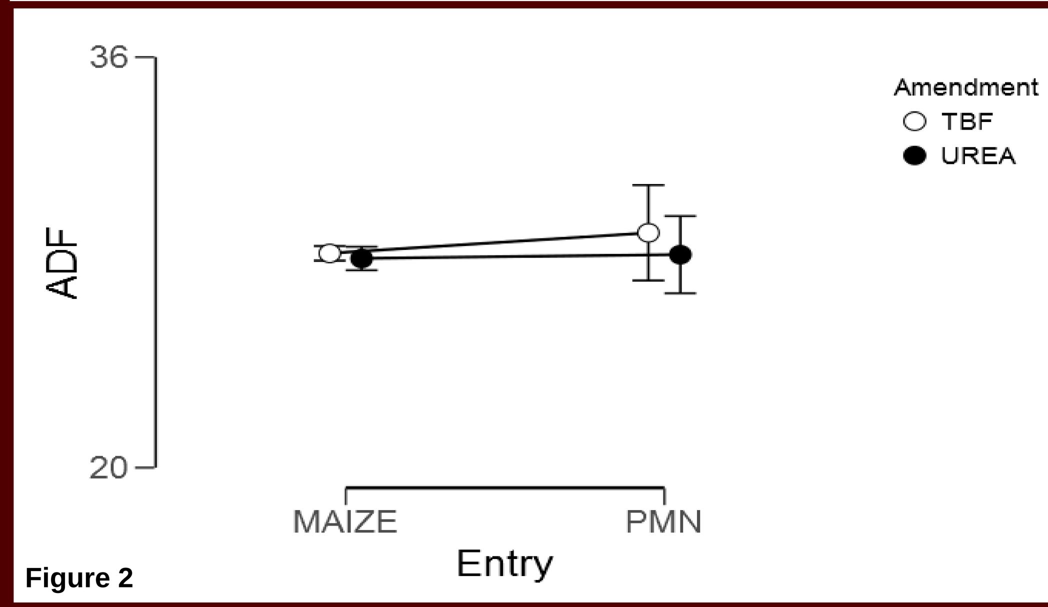


Figure 2. Acid Detergent Fiber Content Across Entries and Fertility Treatments
- Shown in %

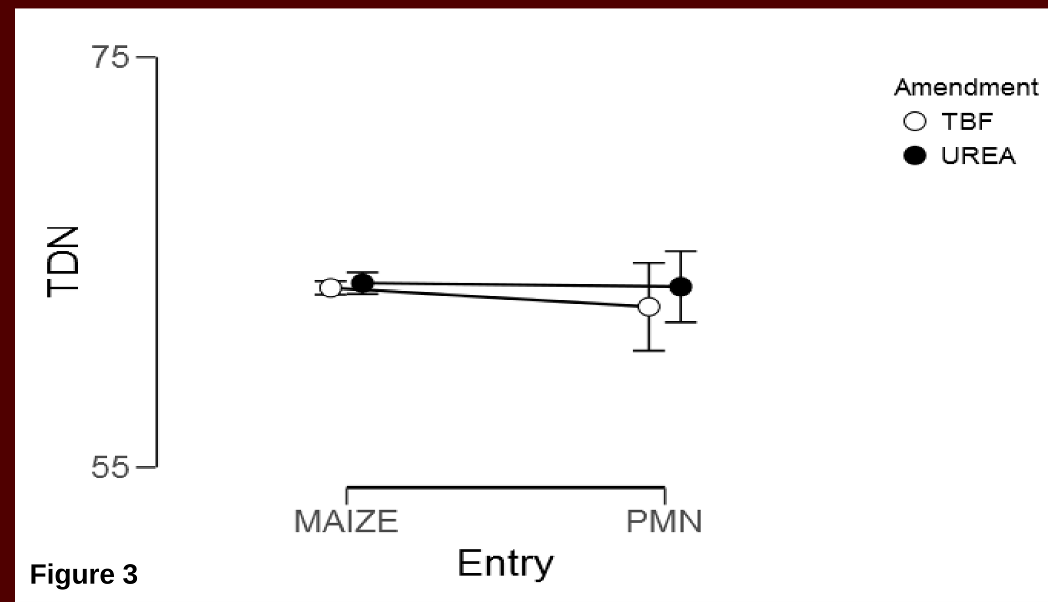


Figure 3. Total Digestible Nutrient Content Across Entries and Fertility Treatments
- Shown in %

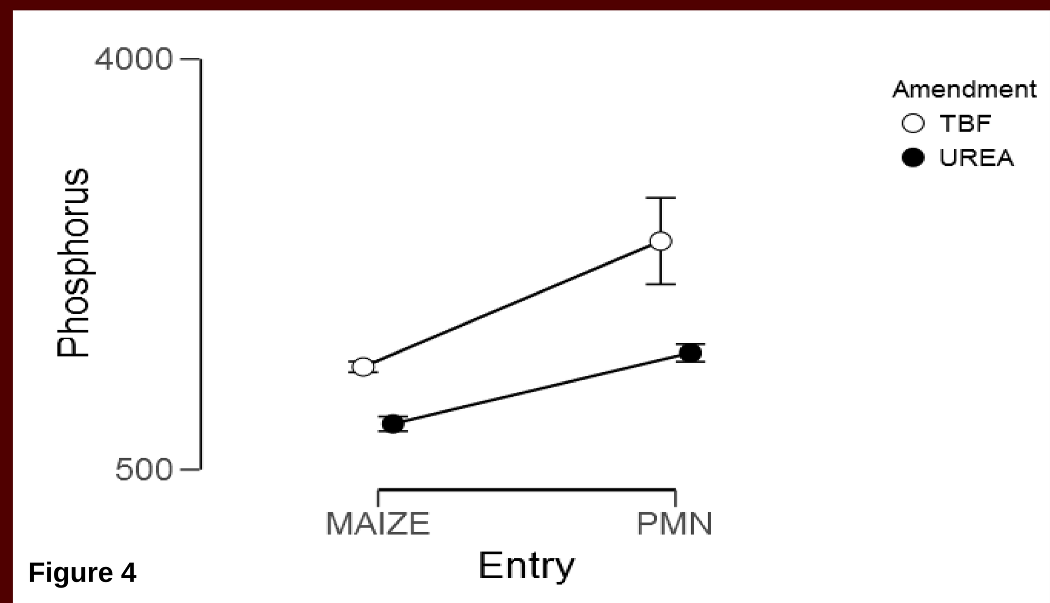


Figure 4. Phosphorus Content Across Entries and Fertility Treatments
- Shown in ppm

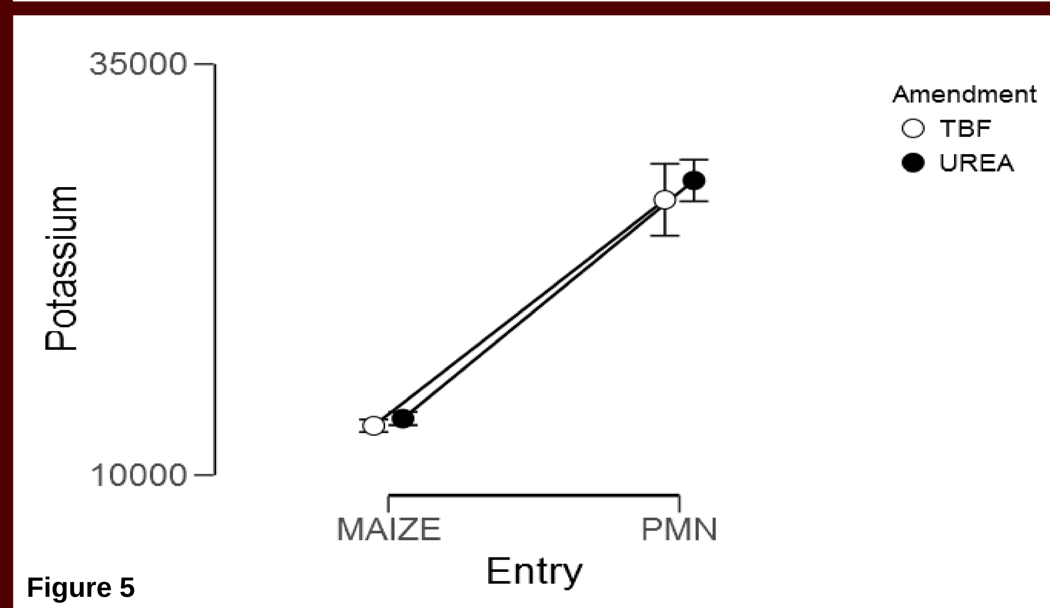


Figure 5. Potassium Content Across Entries and Fertility Treatment
- Shown in ppm

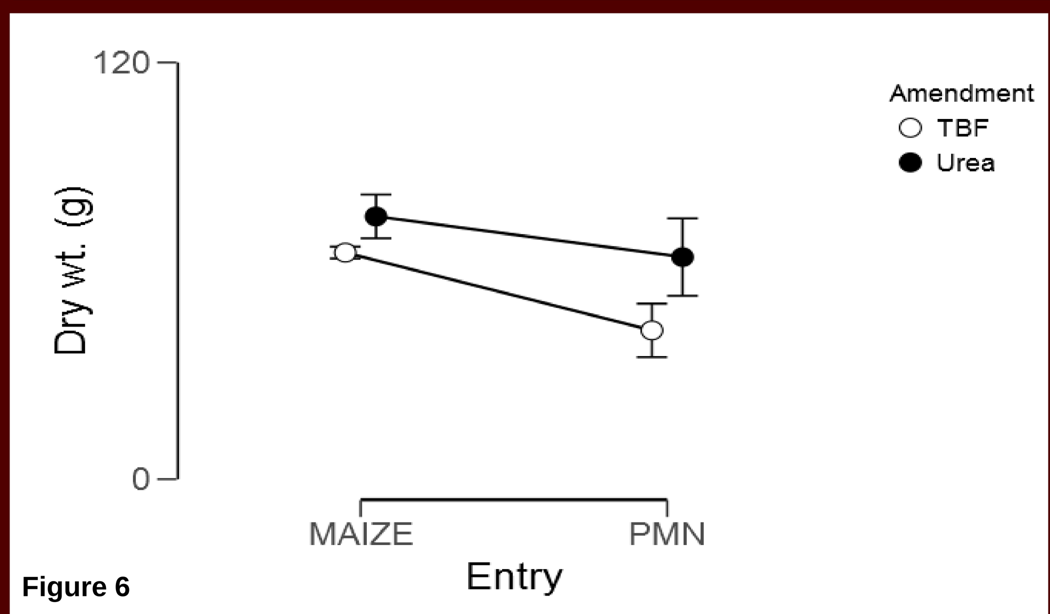


Figure 6. Dry Weight Yield Across Entries and Fertility Treatment
- Shown in g

Results

- The crude protein/nitrogen (Figure 1) results illustrate a significant difference between the TBF and urea. Since the TBF is a slow-release fertilizer and the urea a fast-release fertilizer, the urea had higher crude protein/nitrogen than the TBF. Overall, PMN had higher crude protein/nitrogen across both fertilizer treatments.
- ADF (Figure 2) and TDN (Figure 3) did not have a significant difference between the entries of amendments.
- Phosphorus (Figure 4) showed elevated levels in TBF across both entries, while the urea was significantly lower.
- Potassium (Figure 5) does not have a significant difference between amendments. However, the entries show that PMN had higher amounts of K with both amendments.
- The overall dry weight (Figure 6) was higher in the urea amendment across both amendments. There was a significant difference in the weight of PMN across both amendments.

Figure 7. Merekeron Napiergrass used for TBF

Conclusions

- The results of the torrefaction did not reduce crude protein.
- The TBF provided a higher percentage of phosphorus to the plants in this study. Phosphorus is a limiting nutrient in fertilizer and is not currently mined with sustainable practices.
- PMN demonstrated potential with TBF in this study, and a parallel field trial should produce additional findings.
- TBF would be most appropriate if used as a slow-release fertilizer and should produce results with feedstocks and crops that have a longer growing season.

Acknowledgements

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