Perennial Forage Crops for Improved Soil Nitrogen Cycling in East African Smallholder Dairy Systems

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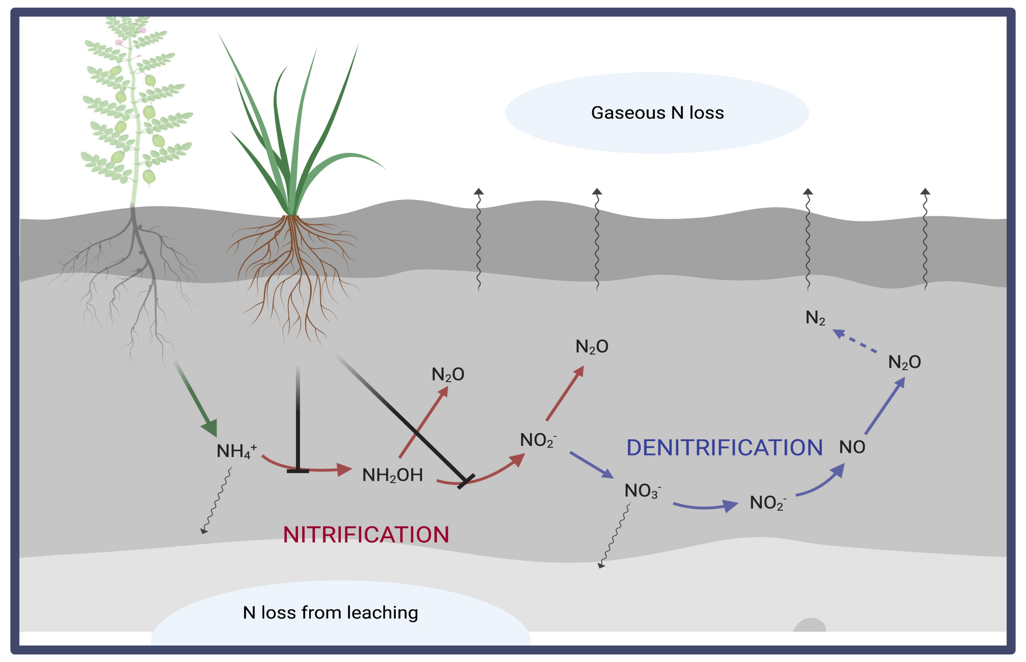
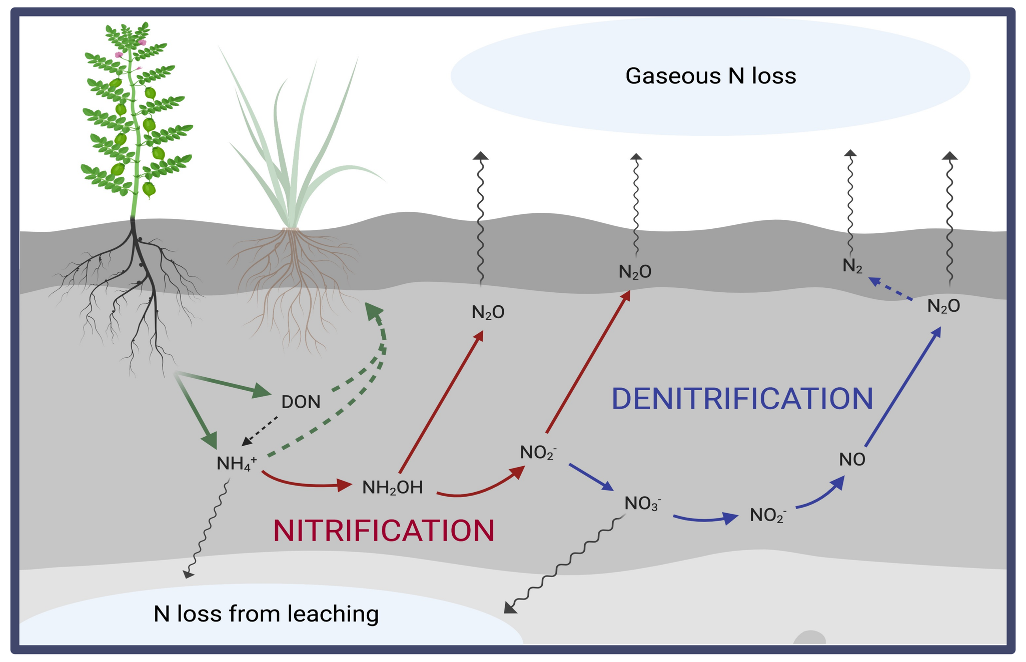
Introduction

Background

- Livestock and dairy production are economically important in Rwanda, yet present challenges for conservation agriculture.
- The farmer-preferred forage Napier grass (*Cenchrus purpureus*) is an inefficient feed source.
- Shifting to low-nitrifying cropping systems can reduce nitrous oxide (N_2O) emissions and prevent the loss of leachable mineral nitrogen (N) from low-fertility soils.
- **Little is known about N dynamics resulting from the use of 'climate smart' perennial forages, even while they are promoted as a conservation agriculture practice**



Brachiaria prevents potential **N loss** through **biological nitrification inhibition (BNI).** Intensive harvesting can result in yield declines in unfertilized pastures.



Perennial forage **legumes** (***Desmodium distortum***) can maintain yields and promote soil fertility as an intercrop. However, legumes stimulate nitrification, potentially offsetting benefits from BNI.

Research Questions

1. **Does the climate-smart forage *Brachiaria* reduce potential N loss** compared to preferentially grown non-BNI forage crops such as Napier grass (*Cenchrus purpureus*) or annual maize (*Zea mays*)?
2. **Is nitrification and denitrification stimulated** by the presence of a legume intercrop?

Acknowledgements

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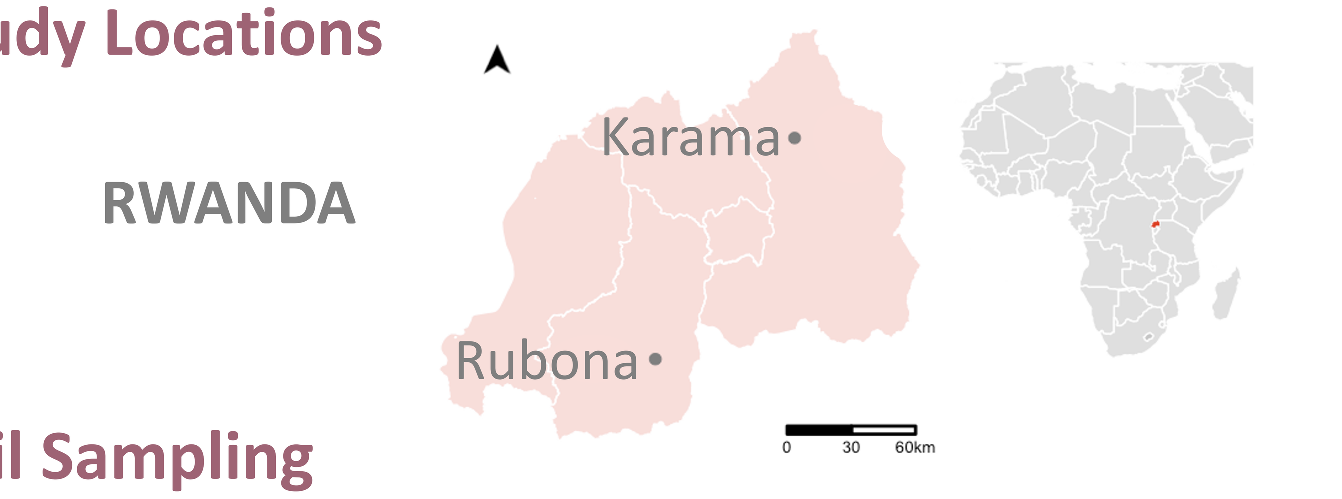
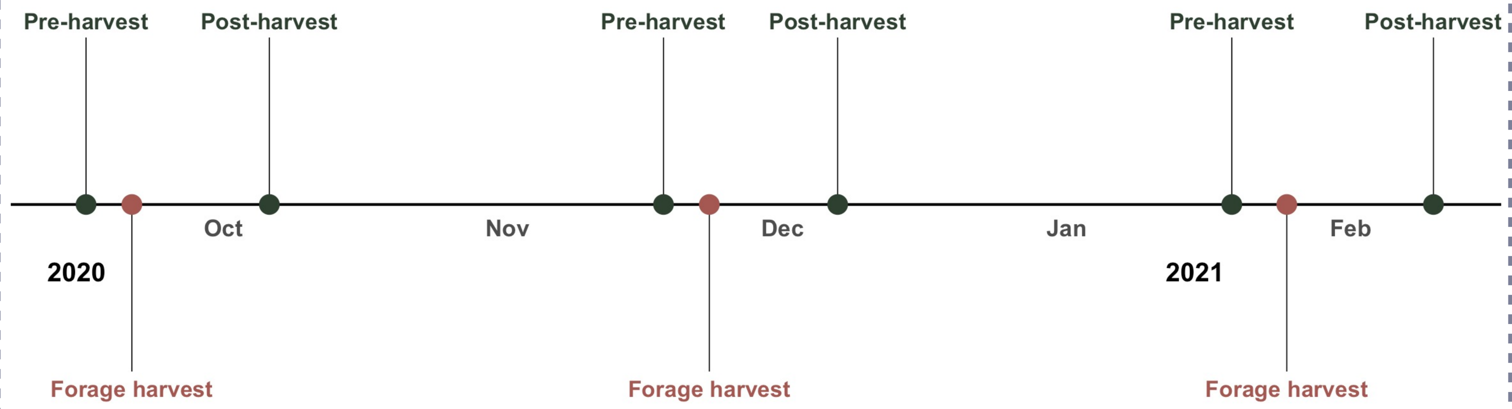
Methods

Study Locations

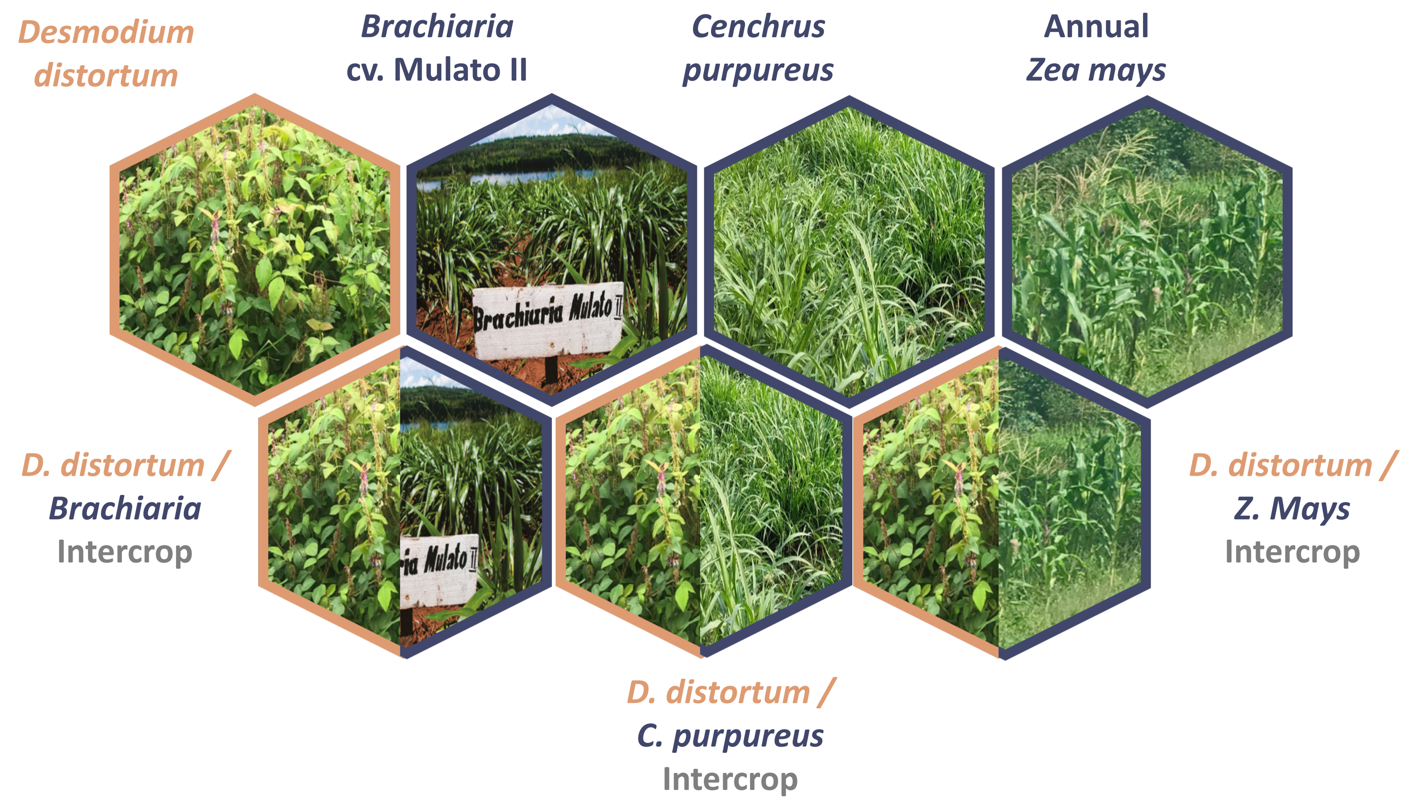


Soil Sampling



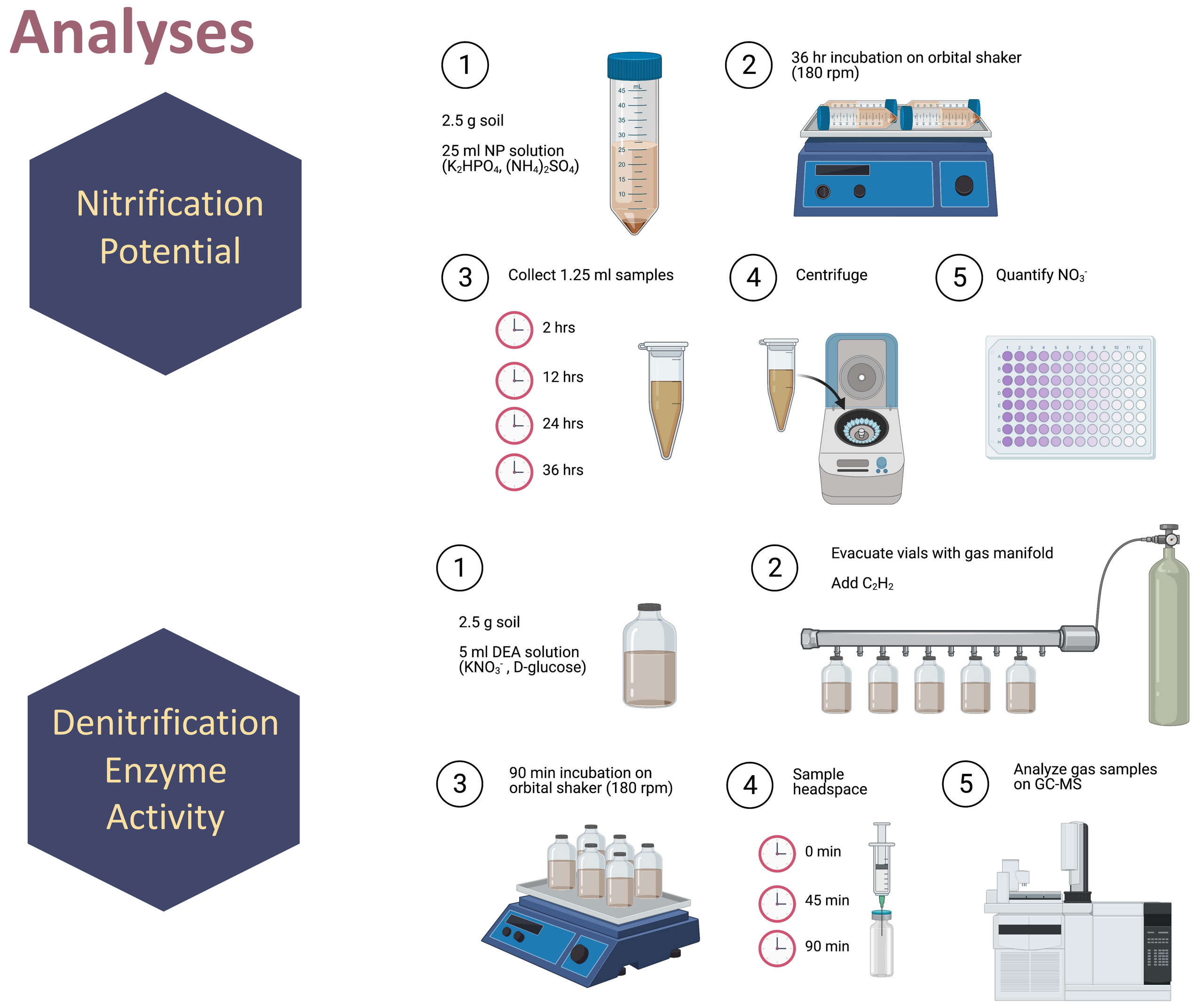
Bulk soil was collected to a depth of 12cm after removing the top layer of leaf litter. Soil was collected six times at each location between September 2020 and March 2021. These sampling events spanned both dry and rainy seasons, occurring immediately before and two weeks following forage harvest to account for contrasting periods of crop N demand.

Forage Treatments



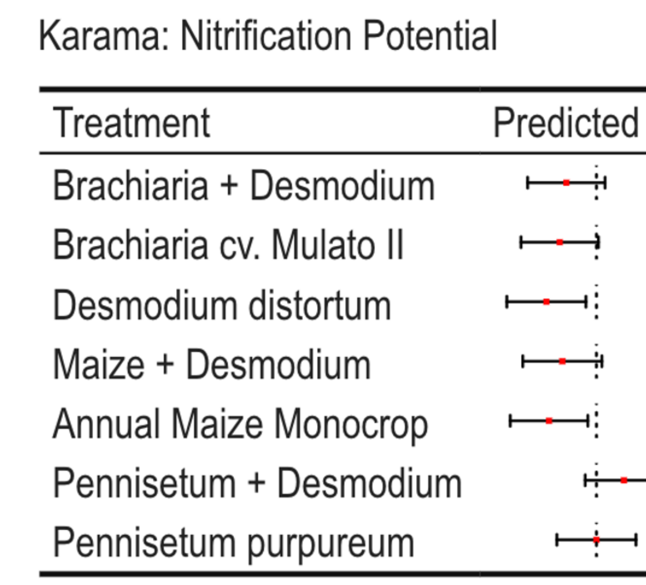
Forage trials were planted in October 2019 and harvested every ~8 weeks since establishment. Maize was not harvested during the course of data collection.

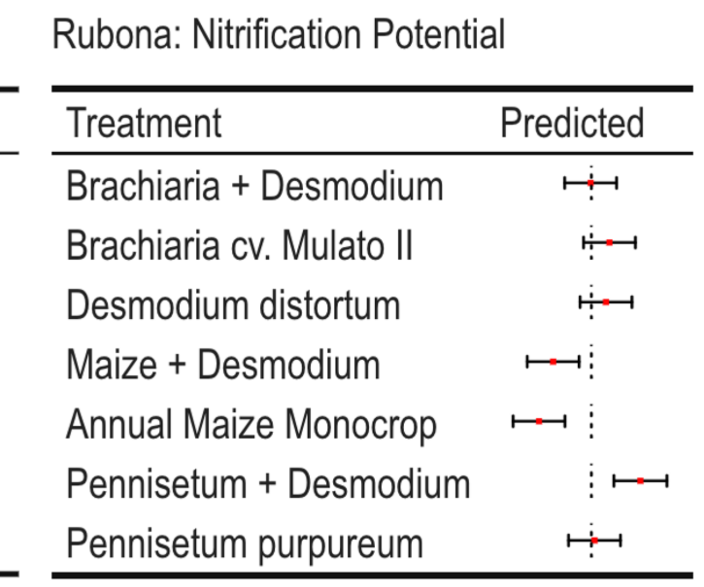
Soil Analyses



Results & Discussion

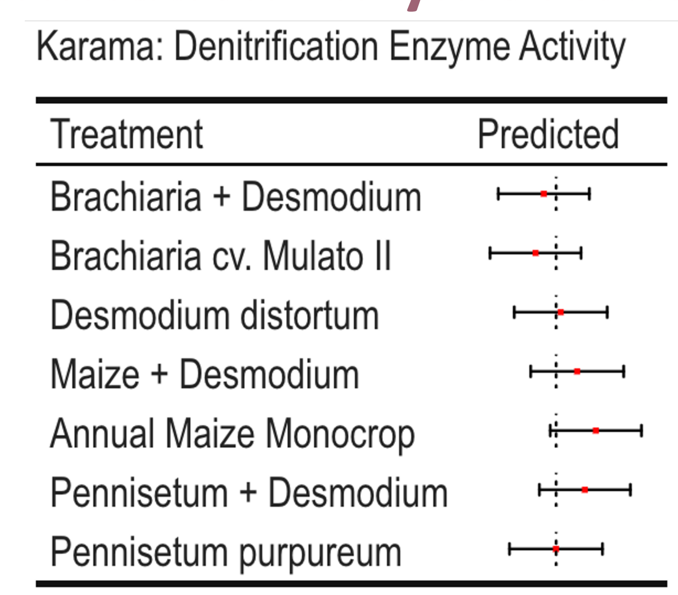
Nitrification Potential

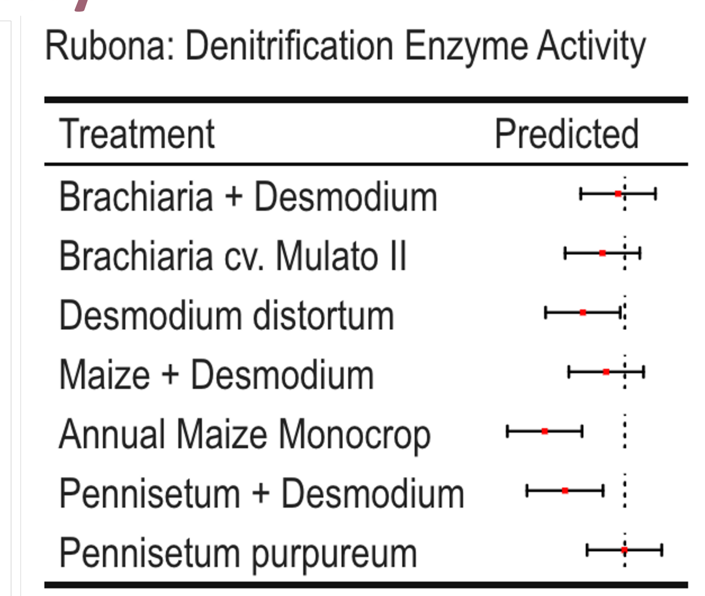




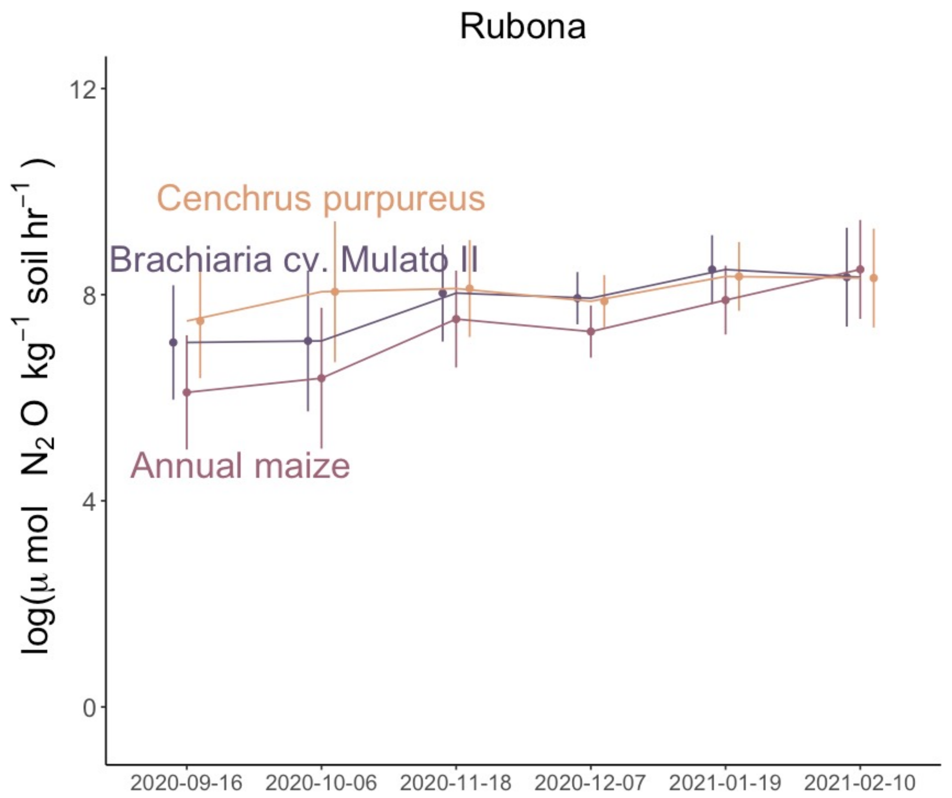
Estimated marginal means of treatment effects from a mixed effects linear model. Treatment and collection timepoint were both treated as fixed effects, with block and timepoint as random effects. NP is expressed as mg NO_3^- kg^{-1} soil hr^{-1}. **Dashed vertical line: marginal mean effect of the *C. purpureus* monocrop treatment.**

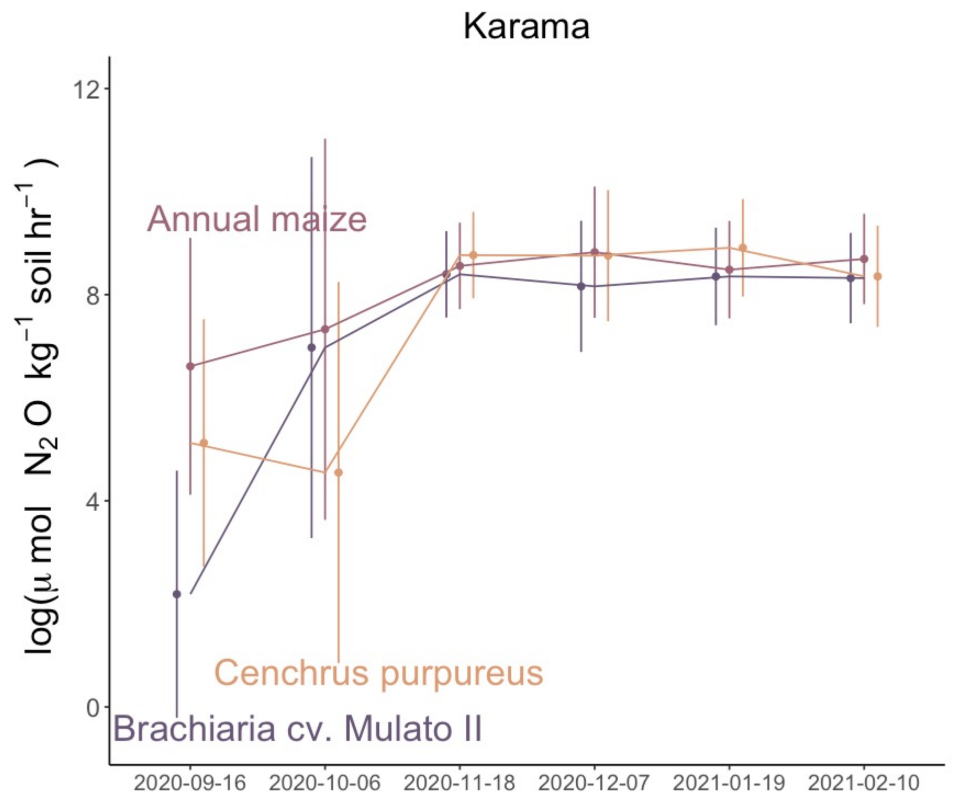
Denitrification Enzyme Activity





Estimated marginal means of treatment effects from a mixed effects linear model. Treatment and collection timepoint were both treated as fixed effects, with block and timepoint as random effects. DEA was log-transformed and expressed as umol N_2O kg^{-1} soil hr^{-1}. **Dashed vertical line: marginal mean effect of the *C. purpureus* monocrop treatment.**





Discussion

- ***Brachiaria* plots tended to exhibit lower nitrification and denitrification potential** than Napier (*P. purpureum)* plots in the dry season. Increasing soil moisture resulted in non-significant treatment differences in the rainy season.
- The legume ***D. distortum* did not stimulate nitrification or denitrification** compared to non-intercropped treatments, except for *P. purpureum*.
- Maize plots had low nitrification and denitrification activity; this may be due to 'priming' effects on microbial activity from intensive forage harvesting.
- **Intercropping perennial legumes with a climate-smart forage such as *Brachiaria* is a promising smallholder strategy to improve soil fertility while preserving soil N cycling benefits from BNI.**