Fungal and bacterial community responses to fallow period in the Bolivian highlands

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Introduction

In the Bolivian highlands (Altiplano; approx. 4000 masl), traditional fallow periods are being shortened in an effort to increase short-term crop yields, which may be at the expense of soil quality. Using 454-pyrosequencing, we characterized the response of the microbial community to (1) the length of fallow period and (2) the presence of plants in the genera *Parasthrephia* and *Baccharis* (both locally known as 'Thola'), considered beneficial to the maintenance of soil quality in this region. Our results suggest increasing fallow years were associated with a decrease in diversity in both fungal and bacterial communities.

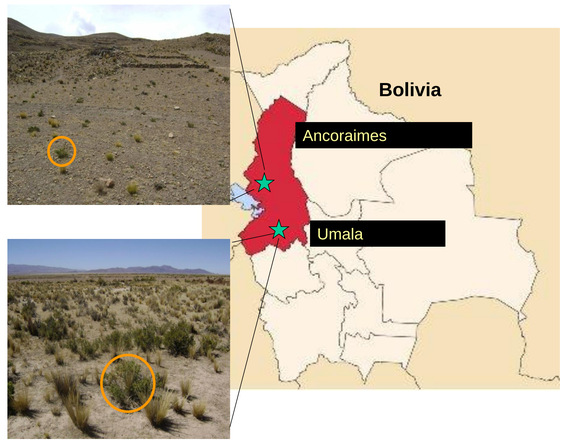

Figure 1.

Top: location of the 29 study fields in Ancoraimes and Umala, Bolivia. Photos illustrate fields after two years of fallow during the winter season with Thola plants indicated.

Bottom: Thola.

Objectives

1. Compare soil characteristics in the study regions Umala and Ancoraimes.
2. Characterize soil microbial communities in fields with a range of fallow periods.
3. Determine the effect of being under Thola versus away from Thola on soil microbial communities.

Methods

- Twelve and 17 fields were sampled in Ancoraimes and Umala (Figure 1).
- DNA was extracted using Soil DNA Isolation kits, and a list of sequences was obtained using 454 pyrosequencing.
- Diversity estimators such as 1 - Simpson's dominance were used to estimate taxon diversity based on 97% similarity. The effects of fallow period and Thola on diversity estimators were evaluated in regression analyses.
- The effects of fallow period and Thola (under and away) on the frequency of specific taxa were evaluated using generalized linear models and Q-value comparisons.

Results

➢ Organic matter and pH

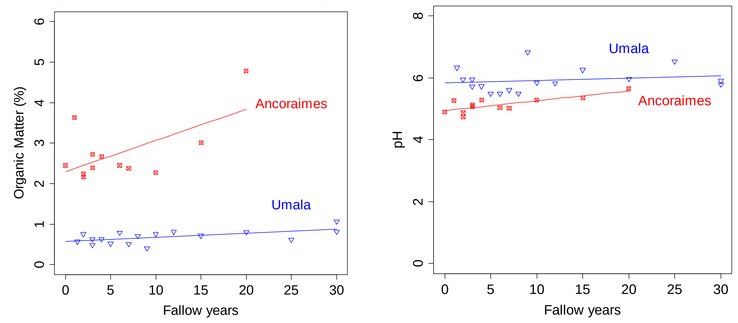

Figure 2. Organic matter (OM) and pH in sampled fields in Umala and Ancoraimes. OM: the regression line for Umala (slope P<0.05, R^2=0.3); for Ancoraimes, (slope P<0.05 R^2=0.3); t-test comparing Umala and Ancoraimes: P<0.001. pH: the regression line for Umala (slope P=0.4, R^2=-0.02); for Ancoraimes, (slope P<0.01 R^2=0.5); t-test comparing Umala and Ancoraimes: P<0.001.

➢ Diversity measured as 1 - Simpson's dominance

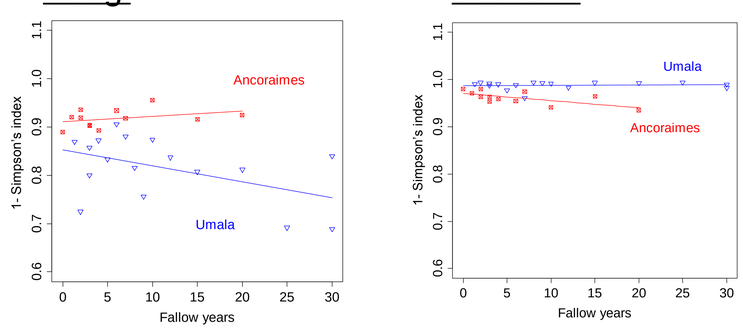

Figure 3. 1 - Simpson's dominance for fungal and bacterial communities in Umala and Ancoraimes across fallow periods (years), sampled away from Thola. Fungi: Umala (slope P<0.05, R^2=0.2); Ancoraimes (slope P=0.2, R^2=0.03); t-test comparing Umala and Ancoraimes: P<0.001. Bacteria: Umala (slope P=0.7, R^2 =-0.05); Ancoraimes (slope P=0.01, R^2 =0.4); t-test comparing Umala and Ancoraimes: P<0.001.

➢ Fungi and Bacteria: taxa significantly increasing in frequency with fallow period

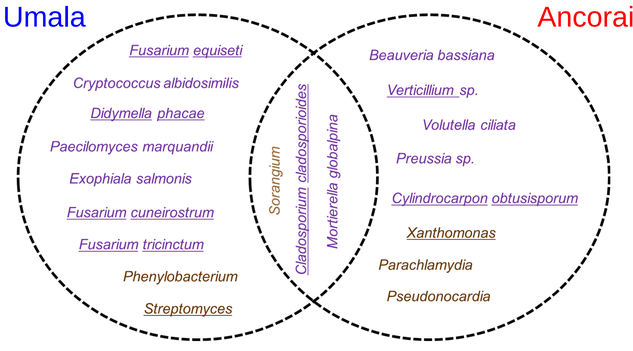

Figure 4. Taxa with similarity above 94% that increase significantly with fallow period in Umala and Ancoraimes. GLM: Q<0.05. Purple font indicates fungi. Brown font indicates bacteria. Underlined genera are plant-associated.

➢ Fungi: selected taxa that are significantly more frequent…

Under Thola

Genus -Species
Alternaria alternata
Bionectria sp.
Cladosporium cladosporioides
Fusarium equiseti
Stagonospora sp.

Away from Thola

Genus -Species
Cercophora sp.
Chaetomium globosum
Cryptococcus aerius
Fusarium cuneirostrum
Paecilomyces marquandii

➢ Bacteria: selected taxa that are significantly more frequent…

Under Thola

Genus
Bradyrhizobium
Gemmata
Methylobacterium
Sphingobium

Away from Thola

Genus
Belnapia
Hymenobacter
Nitrospira
Pseudonocardia
Streptomyces

Table 1. Fungal and bacterial genera (>94% similarity) more frequent in soil under Thola versus away from Thola with Q (from GLM) < 0.05. Green font indicates a plant-associated genus, while pink font indicates a genus important for plant health through nutrient cycling.

Discussion

- Umala had lower fungal species diversity (higher dominance) than Ancoraimes, and Ancoraimes had lower bacterial species diversity (higher dominance) than Umala (Figure 3). Another set of taxa significantly decreased in frequency with fallow period (data not shown). Much of the shift in diversity was a result in changes the frequency of the dominant genera, *Fusarium* and *Didymella*. Bacteria in soil responded more to OM than did fungi (data not shown).
- Many of the fungal taxa are recognized plant pathogens (names colored in green in Table 1, underlined in purple in Figure 4) while others may have little direct effect on plants.
- A wide range of bacterial taxa were recovered. The genus *Phenylobacterium* is usually isolated when chloridazol (an herbicide) is present in cultivated soils (Figure 4), while *Bradyrhizobium* is a symbiotic nitrogen fixer associated with plant roots (Table 1).

Conclusions

- Diversity decreased with fallow period for fungi in Umala and for bacteria in Ancoraimes and several taxa changed in abundance.
- The presence of Thola changed fungal and bacterial community composition.
- This pyrosequencing approach allowed us to identify taxa important to plant health that changed in frequency with fallow period.

Acknowledgments

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