Exploring Forage Mixtures to Improve Traditional Fallows and Build Soil Health in Crop Rotations of the Andean Highlands

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Introduction

- Traditional fallows play an important role in forage provision and the restoration of soil health during non-crop phases of traditional smallholder rotations in the Andes.
- Agricultural intensification throughout the region is leading to the shortened fallows with implications for the long-term productivity of these lands.
- Recent work has explored the use of more productive, forage-based fallows to enhance biomass production and the recovery of these soils, but little information is available on the optimal plant species and mixtures to be used in this context.

Objective: To explore the potential of introduced forage mixtures vs. monocultures to enhance biomass (forage) production and belowground root allocation.

Figure 1. Traditional fallow covered by the weed, *Rumex acetosella,* alongside an improved fallow (with *Lupinus mutabilis,* oats, rye grass) in the community of Quilcas, Peru, 2016.

Methodology

- Four species of legumes and five grasses selected together with participating farmers (Table 1).
- Soils from two locations (Quilcas and Huancavelica)
- Plants/mixtures grown in pots (10 cm dia., 40 cm deep) in monoculture and all possible legume-grass combinations (Figs. 2 & 3)
- Grown under field conditions (Elevation: 3506 m; Avg temp: 14-15° C; Precip: 727 mm yr^{-1})
- Destructive harvest at 150 days for evaluation of above- and belowground biomass and total N uptake/fixation.

Grasses	Code	Type*
Avena sativa	OAT	A
Lolium multiflorum	RG	P
Festulolium hybrid	FELU	P
Bromus catharticus	BROM	P
Dactylis glomerate	DAG	P
Legumes		
Vicia dasycarpa	VETCH	A
Trifolium pratense	RC	P
Medicago lupulina	MELU	P
Medicago sativa	ALRA	P

Table 1. List of forage species tested with code. *A= Annual species; P= Perennial species

Figure 2. Mixtures and monoculture treatments growing in the field, near Quilcas, Peru, in 2015.

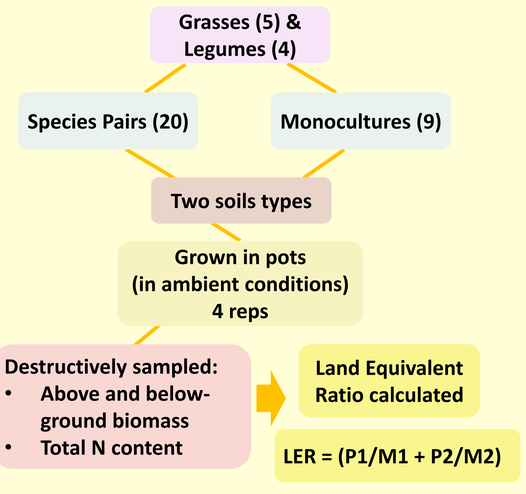

Figure 3. Experimental design + sampling scheme

Results

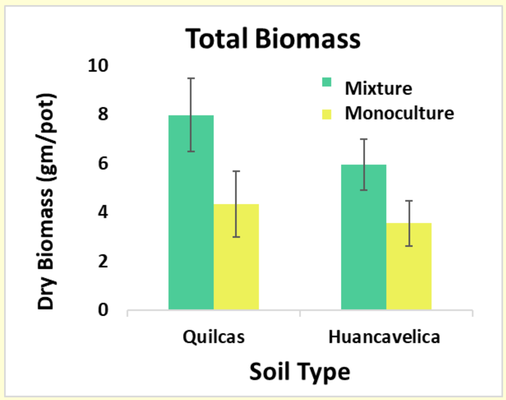

Figure 4. Biomass in mixtures is significantly higher than monoculture for both soils ($p<0.05$). Error bars represent the standard error of the means.

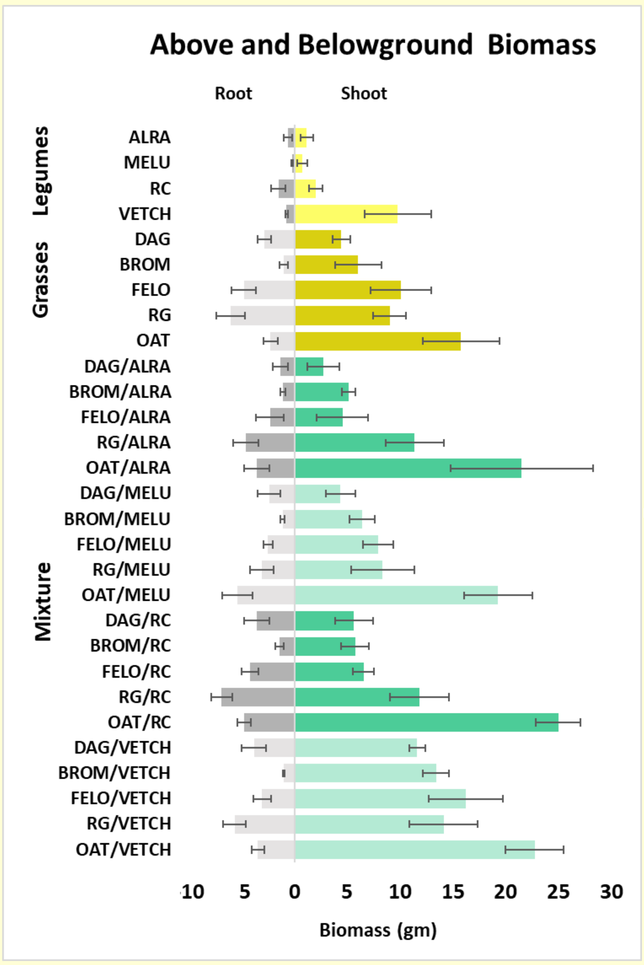

Figure 6. Biomass production in soil from **Quilcas**. Treatments with the annual forages (VETCH and OAT) show higher aboveground biomass production. However, combinations with RC (rye grass) and ALRA (alfalfa) show greater belowground allocation.

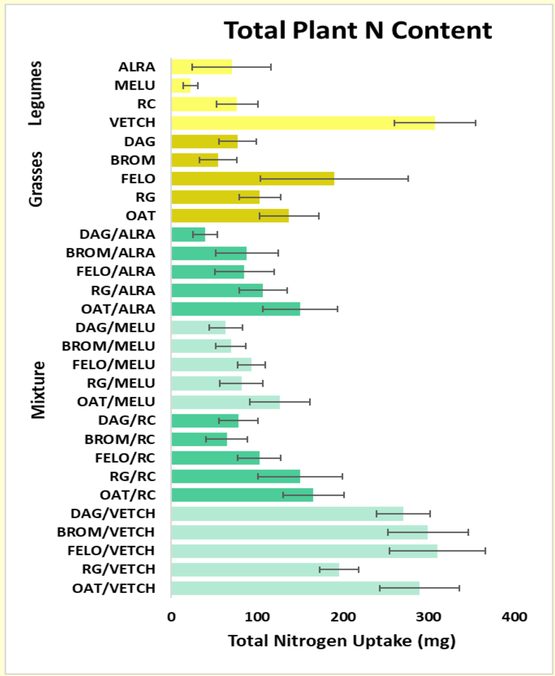

Figure 5. Quilcas and Huancavelica Soil. On average mixtures accumulated 21% more total N than monocultures. Combinations with annual species tended to accumulate more N in plant biomass ($p<0.05$).

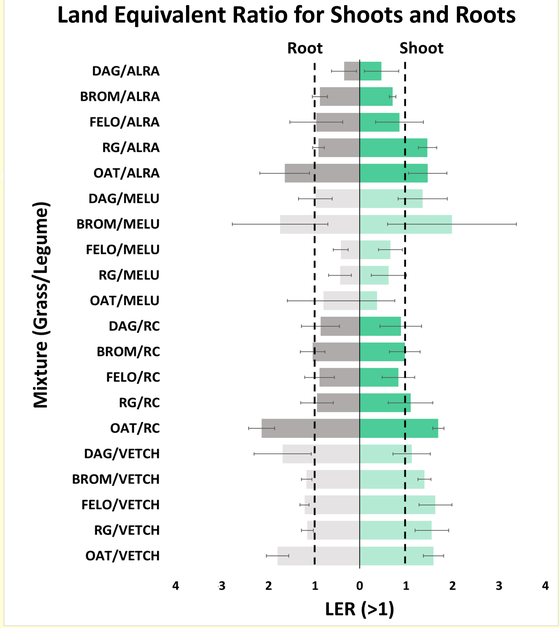

Figure 7. Land Equivalent Ratio (LER) for mixtures growing in soil from **Quilcas**. 55% of mixtures display LER > 1 for aboveground biomass production. Mixtures with VETCH, as well as OAT+RG are particularly promising.

Discussion and Conclusions

1. The most promising mixtures for forage production across both soil types are based on combinations between the annual legume (vetch) with any grass (annual or perennial).
2. Inclusion of perennial species (grasses and legumes) seems promising for increasing belowground C allocation and offers potential to build soil organic matter and overall soil health in fallows, while also providing forage beyond the first year of fallow.
3. Given the relatively short-term duration of this study, these results need to be taken with caution. We have begun implementing participatory field trials with local farmers to test some of the most promising species mixtures for longer time periods and across multiple environmental contexts

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