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Crop trait diversity and redundancy drive soil cover by crops and weeds in successional agroforestry

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INTRODUCTION

Literature has pointed to benefits of applying trait-based ecological approach in agricultural research. This approach can be used to assess different aspects of biodiversity, i.e. functional diversity (FD) and functional redundancy (FR), related with ecosystem properties. The hypothesis surrounding this work is that high diversified agroecosystems are more able to delivery multiple agroecosystem functions (Figure 1). One priority process linked to function such as crop productivity is weed suppression.

AIM

To investigate how FD and FR drive soil cover processes (as a surrogate of weed suppression) in an early stage experimental Agroforestry System (Figure 2).

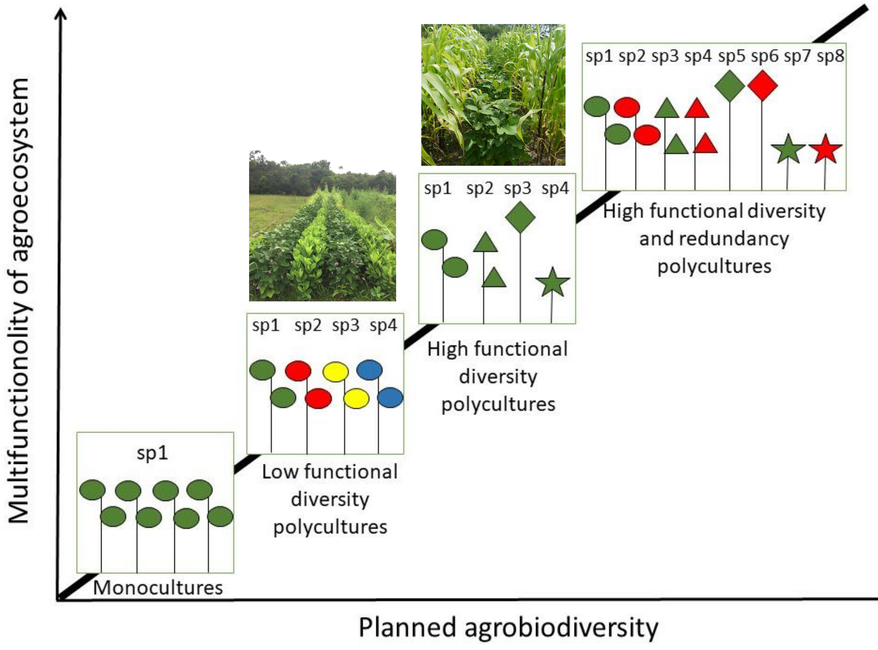


Fig. 1 - Conceptual hypothetical model to explain multifunctionality in agroecosystems due to the increase of the planned agrobiodiversity. Inside boxes, different objects (shapes and/or colors) represent different species of plants. The different shapes represent species that differ in their functional traits.

Fig. 2 - Early stage Agroforestry System, Florianópolis, Santa Catarina, Brazil, 2017.

METHODS

Experiment
Planted in Nov. 2016 in humid subtropical Southern Brazil. Three treatments: contrasting functional compositions of agroforestry systems.

Crop and weed composition and soil cover assessment
Visual estimation of % cover in 144 0.5 x 0.5m quadrats (100 days after planting).

Determination of seven plant traits: maximum plant height, leaf area, leaf nitrogen concentration, specific leaf area, stem specific density, clonality and N_2 fixing status.

Index calculated for crop and weed communities:
Functional Diversity: Rao's quadratic entropy (RAO, 1982)
Functional Redundancy: difference between species diversity (Gini-Simpson index) and functional diversity (PILLAR et al., 2013).

Structural Equation Modeling (SEM):
D-separation based on GLMM (SHIPLEY 2013) using packages "nlme" (PINHEIRO et al., 2018) and "piecewiseSEM" (LEFCHECK, 2016) in R (R Core Team, 2018).

RESULTS

Both components of crop diversity (FR and FD) have affected weed suppression process. However, weed functional diversity was not significant in the model, therefore, weeds functional redundancy was the only component of weed diversity remained in the final model (Figure 3).

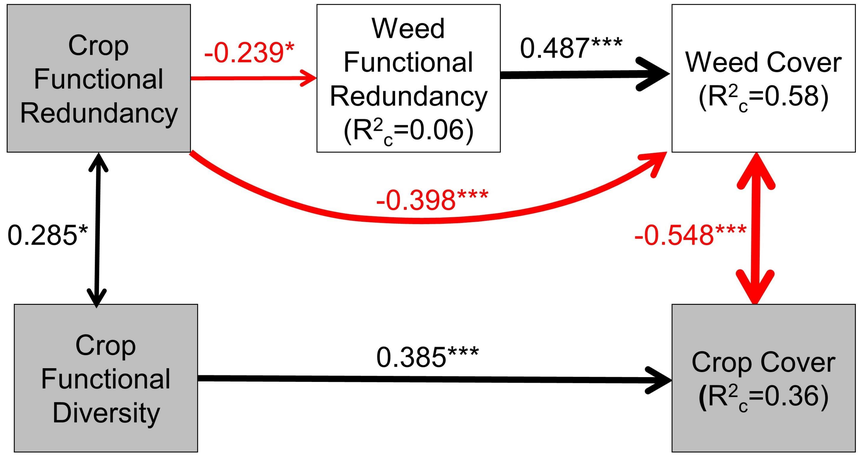
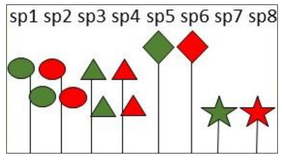


Fig. 3 - Structural equation model (SEM) exploring the effects of crop diversity on weed diversity and soil cover on an agroforestry system. Boxes represent measured variables. Arrows represent unidirectional relationships among variables and double-headed arrows represent relationships not presumed causal. Black arrows denote positive relationships, and red arrows negatives ones. The thickness of the significant paths (***P < 0.001, **P < 0.01, *P < 0.05) has been scaled based on the magnitude of the standardized regression coefficient or correlation coefficient, given next to the arrows. The conditional R^2 (based on the variance of both the fixed and random effects) for component models are given in the boxes of response variables. N=72.

CONCLUSION



- It is possible to manage weeds in early Agroforestry System by enhancing both components of planned agrobiodiversity, i.e. functional diversity and functional redundancy.
- In order to increase diversity using crop mixtures, it may be worth considering to mix species with different traits values but also considering species with similar trait values.

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