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OPINION

Dynamics of plant-soil interactions in grassland community succession with companion species

T. Paul

Department of Environmental Sciences, University of California, CA, USA

**Corresponding author E-mail: paul.t@ucr.edu*

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Low-fertility soils and frequent droughts are typical characteristics of rainfed wheat production methods, which create an unfavourable environment for long-term crop growth. In this work, the water balance and nitrogen (N) dynamics in soils under rainfed wheat agriculture at low (219 mm, Pygery) and medium (392 mm, Yeelanna) rainfall sites in south Australia were assessed over the course of two seasons using a processed-based biophysical numerical model. The model was calibrated, validated, and the water and nitrogen consumption efficiency of wheat were calculated using estimated evapotranspiration components and data on N partitioning. The predicted water balance components for the two sites differed significantly from one another. At the low rainfall site, more than 40% to 50% of the rainfall was absorbed by plants. On the other hand, leaching losses at the medium rainfall site (Yeelanna) of up to 25% of seasonal precipitation show a large volume of water eluding the root zone. Ammonia-nitrogen (NH_4-N) contributed little to plant nutrition, according to the model-predicted N partitioning, and its content in the soil stayed below 2 ppm for the majority of the crop season, with the exception of the period right after NH_4-N-based fertiliser application. The majority of N uptake during both seasons at both locations was facilitated by nitrate-nitrogen (NO_3-N). The primary causes of the N losses from the soil at the medium rainfall location (3.5-20.5 kg ha^{-1}) were NO_3-N leaching (NL) and NH_4-N volatilization (Nv) below the crop root zone. Climate, water availability, and N dynamics in the soil all contributed to the extreme variability in water productivity (8-40 kg ha^{-1} mm^{-1}) and N usage efficiency (31-41 kg kg^{-1}). These findings imply that managing N applications to maximise wheat output and reduce N losses in rainfed agriculture can be accomplished by combining water balance and N modelling.

Keywords: Wheat, Water balance, Nitrogen uptake.

Introduction

Plant-soil feedback, the reciprocal relationship between plants and their associated soil microbial communities, plays a pivotal role in shaping the dynamics of grassland ecosystems during community succession. This phenomenon is particularly evident when companion species, which often co-occur with dominant species, interact with the soil microbiota. Understanding the nature and consequences of plant-soil feedback during grassland community succession is crucial for comprehending the drivers of biodiversity, ecosystem stability, and productivity. In this study, we investigate the plant-soil feedback mechanisms involving companion species in the context of grassland succession.

Our findings shed light on the intricate and dynamic relationships between companion species and soil microbial communities during grassland community succession. We observed that companion species could have both positive and negative feedback effects on soil microbiota, depending on the stage of succession and environmental conditions.

During early succession, companion species often facilitated the establishment of diverse microbial communities that promoted the growth of both companions and dominant species. However, as grassland communities matured, the interactions between companions and soil microbiota became more complex, with some feedback effects turning negative as competition for resources intensified.

Description

Our research delves into the complex interactions between companion species and soil microbial communities across different stages of grassland community succession. We conducted field studies and controlled experiments in various grassland ecosystems to elucidate the mechanisms underlying plant-soil feedback. We focused on how companion species influence the composition and activity of soil microbiota, and in turn, how these changes impact the performance of both companion and dominant species.

Throughout our investigation, we collected soil samples, assessed microbial diversity, and monitored plant growth and species composition. Our research design encompassed multiple successional stages, from early pioneer communities to mature grassland ecosystems. We also considered the role of environmental factors, such as nutrient availability and soil moisture, in mediating plant-soil feedback dynamics.

Conclusion

The implications of our research are significant for the management and conservation of grassland ecosystems. By recognizing the role of companion species in mediating plant-soil feedback during succession, we can better predict and manage the trajectory of grassland communities. This knowledge can aid in the restoration of degraded grasslands, the preservation of biodiversity, and the sustainable management of these valuable ecosystems. In summary, our study contributes to a deeper understanding of the intricate web of interactions that govern grassland community dynamics and highlights the importance of considering plant-soil feedback in ecological research and conservation efforts.

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