Höhere Bundeslehr- und Forschungsanstalt für Landwirtschaft
Raumberg-Gumpenstein

18. Gumpensteiner Lysimetertagung 2019, 157 – 158
ISBN: 978-3-902849-64-9

Reactions of Alpine grassland species in agricultural ecosystems to predicted climate changes

Georg Leitinger[1*], Erich Tasser[2], Ulrike Tappeiner[1,2], Francesca Scandellari[3], Michael Thoma[3] and Massimo Tagliavini[3]

Zusammenfassung

Landnutzungs- und Klimawandel beeinflussen Berggebiete und deren Vegetation stärker als der globale Durchschnitt. Da Gebirge für einen Großteil der Wasserressourcen der Welt verantwortlich sind, ist ihre Vegetation ein Schlüsselfaktor für die Speicherung großer Wassermengen. Um die Auswirkungen des Klimawandels auf die alpinen Graslandökosysteme zu bestimmen, können Lysimetermessungen und stabile Isotopentechniken verwendet werden. Das internationale Forschungsprojekt ‚ClimAgro' hat zum Ziel, in einer vergleichenden Studie zu analysieren, wie der Wasserhaushalt (Niederschlag, Verdunstung, Infiltration, Bodenfeuchtigkeit) in alpinen Graslandökosystemen durch eine Reihe von Faktoren beeinflusst wird, wie beispielsweise landwirtschaftliche Bewirtschaftung, Bodentypen, unterschiedliche klimatische Bedingungen (Nördliches mitteleuropäisches Klima vs. trockenes inneralpines Klima) und extreme klimatische Ereignisse (Dürren). Dazu wurden alpine Graslandgesellschaften in einem Gartenexperiment am sozio-ökologischen Langzeit-Forschungsstandort (LTSER) „Stubaital", Tirol, Österreich, mit Präzisionslysimeters (Smart Field Lysimeter®, SFL, METER Group AG, München) untersucht. Veränderungen im Pflanzenmetabolismus wurden durch verschiedene isotopische Reaktionsmuster der Arten analysiert. Aus den Ergebnissen wurde ein besseres Verständnis der Reaktionen von Grünlandarten auf vorhergesagte Klimaveränderungen gewonnen.

Schlagwörter: Grünlandmanagement, Klimawandel, Smart-Field-Lysimeter, Wassernutzungsstrategie

Summary

The impact of land use and climate change in mountain areas is stronger than the global average. Since mountains are responsible for much of the world's water resources, their vegetation is a key factor in buffering large volumes of water. To determine the effects of climate change on Alpine grassland ecosystems, lysimeter measurements and stable isotope techniques can be used. The international research project ‚ClimAgro' aims to analyze in a comparative study how the water balance (precipitation, evaporation, infiltration, soil moisture) in Alpine grasslands is influenced by a number of factors, such as agricultural management, soil types, different climatic conditions (Northern central european climate vs. dry Inneralpine Climate) and extreme climatic events (droughts). Alpine grasslands were investigated in a garden experiment at the long term socio-ecological research (LTSER) site 'Stubai Valley', Tyrol, Austria, with high precision lysimeters (smart field lysimeters®, SFL, METER Group AG, Munich). Changes in plant metabolism were reported by various isotopic response patterns of species. From the results, a better understanding of the reactions of grassland species to predicted climatic changes was obtained.

Keywords: grassland management, climate change, smart-field-lysimeter, plant water-use strategy

Introduction

Impacts of climate change on mountain areas and their vegetation are larger than the global average and pose a challenge for the agricultural management of mountain grassland to maintain forage production and other ecosystem services (Leitinger et al. 2015 and references therein). In a joint study between the Department of Ecology (University of Innsbruck), the Institute for Alpine Environment at Eurac Research (Bolzano/Bozen) and the Free University of Bolzano, the effects of changing precipitation patterns and air temperatures on water supply and grassland productivity were examined. The research project 'ClimAgro - *Valorization of grassland management for the water supply in context with climate change*' addressed gradients of agricultural intensity and environmental characteristics by analysing different types of grassland ecosystems in a garden experiment at the long-term socio-ecological research (LTSER) site 'Stubai Valley', Tyrol, Austria (Tappeiner et al. 2013).

Materials and Methods

Analyses were performed using 24 high precision lysimeters (Smart Field lysimeters®, SFL, METER Group AG) with

[1] Department of Ecology, University of Innsbruck, Sternwartestraße 15, A-6020 INNSBRUCK
[2] Institute for Alpine Environment, Eurac Research, Viale Druso 1, I-39100 BOZEN
[3] Faculty of Science and Technology, Free University of Bolzano, Universitätsplatz 5, I-39100 BOZEN
[*] Ansprechpartner: Dr. Georg Leitinger, georg.leitinger@uibk.ac.at

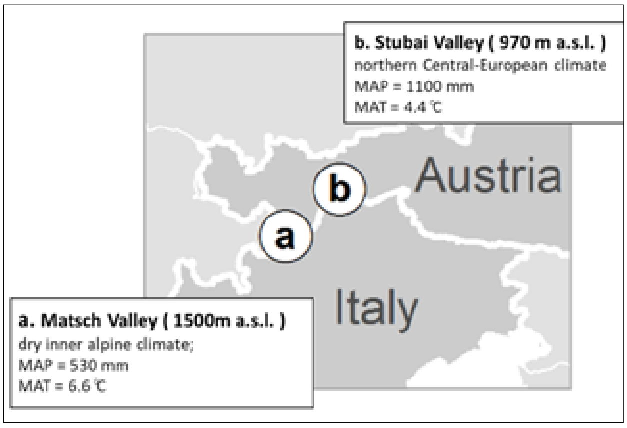

Figure 1. **Location of the grassland ecosystems at the two climatically different study sites Matsch Valley and Stubai Valley.**

0.3m in diameter and depth, containing soil-vegetation monoliths from two climatically different study sites (*Figure 1*).

Isotope analysis of carbon ($^{13}C/^{12}C$) and oxygen ($^{18}O/^{16}O$) of plant biomass to quantify intrinsic water use efficiency (WUE_i), photosynthetic activity and stomatal conductance of species were performed. The conceptual model of Scheidegger et al. (2000) was used to determine changes in photosynthetic activity (A_{max}) and stomatal conductance (g_s).

Results and conclusion

At species level, four patterns of isotopic reactions linked to different drought strategies identified: no reaction, sudden shutdown, water spending strategy and controlled stomatal regulation. In the drought treatment, A_{max} dropped significantly. Stubai and Matsch Vegetation behaved very similar, with Matsch showing in general a stronger increase of WUE_i at species level with drought (***Tr1***) (*Figure 2*) compared to Stubai vegetation. For the control (***Ctrl***), Stubai mixed grass species revealed lower WUE_i and a more pronounced water-spending strategy than other species (i.e. *Achillea sp.* and *Trifolium sp.* as representatives for forbs and legumes, respectively).

At canopy level (lysimetry), the drought-adapted vegetation type (Matsch) showed a high potential to utilize even scarce water resources. The non-drought-adapted type (Stubai), in contrast, showed high water conductance potential. With high rates even at dry conditions, this community appears not to be optimized to save water and might experience drought effects earlier and probably more strongly.

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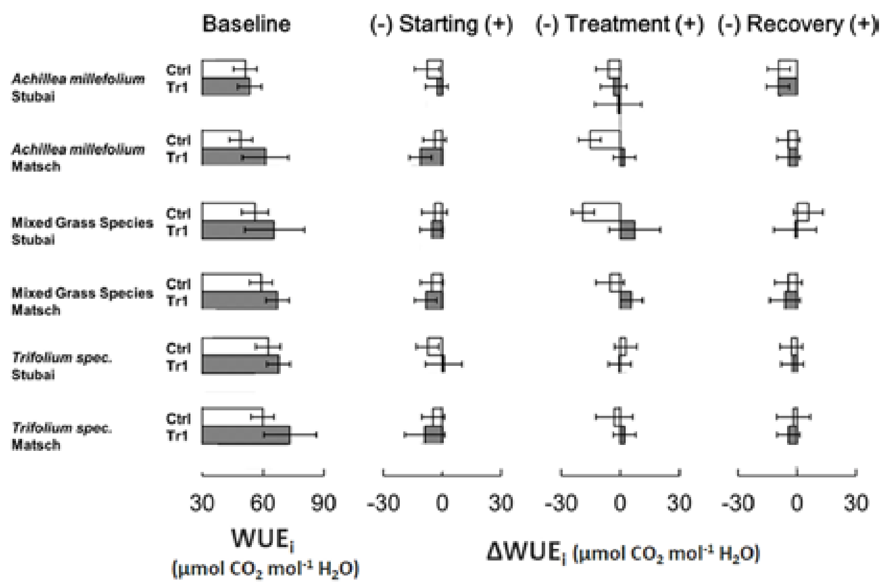

Figure 2. **Intrinsic water use efficiency (WUE_i) for different species at the *Starting-, Treatment-,* and *Recovery-phase* of the drought experiment. *Baseline* represents WUE_i for the pre-treatment that was used to define the mean WUE_i serving as baseline for ΔWUE_i assessment for the different drought experiment phases (*Starting, Treatment, Recovery*).**