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# Drought and heat cause a shift in vegetation composition in an intensive grassland

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**Zusammenfassung**

Der Klimawandel macht es notwendig, dass das landwirtschaftlich genutzte Grünland in Zukunft resistenter gegenüber Trockenheit und Hitze ist und die Wassernutzung durch artspezifische Strategien und Interaktionen zwischen den vorhandenen Arten optimiert. Um die Folgen dieser Veränderungen zu untersuchen, wurde eine kommerzielle Grünlandmischung in Kleinlysimetern angesät und unterschiedlichen Trockenheits- und Hitzebedingungen (Kontrolle: Normalbedingungen; Trocken: zwei trockene und warme Perioden) ausgesetzt. Die Biomasseproduktivität und die Wassernutzungseffizienz (WUE) der Grünlandmischung nahmen bei starker Trockenheit ab. Bereits eine erste Dürreperiode verursachte eine Verschiebung der funktionellen Gruppen von Leguminosen zu Gräsern, die sich bei einer zweiten Periode nochmals verstärkte. Die WUE der Gemeinschaft wurde dadurch verbessert.

Schlagwörter: Lysimeter, Wassernutzungseffizienz, Biomasseproduktivität, Evapotranspiration

**Summary**

Grasslands are expected to adjust to drought and heat, optimising water use through individual strategies and competitive interactions between the present species. A commercial seed mixture used for intensively cultivated hay meadows was cultivated in small-scale lysimeters and subjected to varying drought and heat conditions (control: normal conditions, drought: two dry and warm periods). The biomass productivity and water use efficiency (WUE) of the grassland community decreased when drought was severe. Already a first drought period caused a shift in functional groups from legumes to grasses, which intensified again during a second period. The WUE of the community was thus improved.

Keywords: lysimeter, water use efficiency, biomass productivity, evapotranspiration

## Introduction

Besides the effects of climate change, water balance of grasslands is influenced by plant species composition and competitive interactions between them (Van den Berge et al. 2014). Grassland communities adjust according to individual strategies (Kardol et al. 2010), e.g. legumes and herbs use water acquisitively and resist mild drought (Hofer et al. 2017), and grasses are more conservative and extremely drought-resistant. After a drought period, the community enhances a fast recovery in terms of biomass production, even at cost of biodiversity (Stampfli et al. 2018).

Here, we hypothesize that under drought and heat conditions, water use efficiency (WUE) and biomass productivity of an intensive mountain grassland are affected when drought

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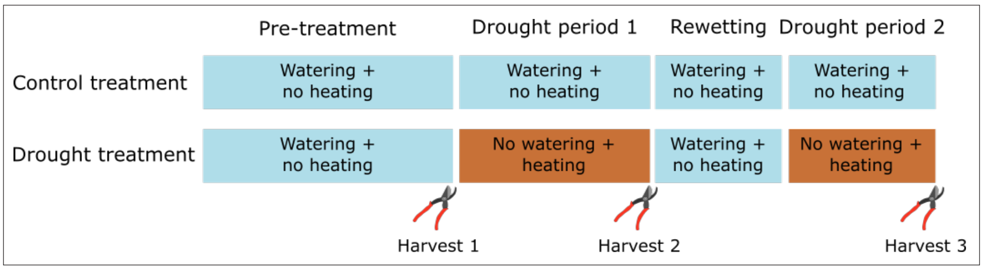


Figure 1. Schedule of the control and drought treatments throughout the experiment. Watering includes irrigation and groundwater supply.

is severe, and, after rewetting, they recover fast by a shift in functional composition, where grasses show a better performance than legumes.

## Material and Methods

Six small-scale lysimeters (Smart-Field-Lysimeter, UMS/Meter Group Munich, Germany) with a depth and diameter of 0.3 m installed in a meadow were sheltered. They were filled with a horticultural standard and sterilised soil, and planted with a commercial seed mixture used for intensively cultivated hay meadows.

The experiment was divided in four phases: pre-treatment, drought period 1, rewetting, and drought period 2; and in two irrigation schemes (*Figure 1*): one providing water on a regular basis by sprinklers (Newesely et al. 2015) and a bidirectional pumping system acting as groundwater supplier (control); and one suffering drought and warm periods (drought). During drought periods, irrigation and groundwater supply were interrupted, and the plant surface temperature increased 2 K by ceramic infrared heat plates.

After each harvest (*Figure 1*), biomass was separated into functional groups (legumes and grasses), dried at 80 °C and weighed. Changes in lysimeter weights were continuously measured to estimate evapotranspiration (ET), with data being processed and smoothed (Peters et al. 2017). The integrated WUE was calculated after each harvest by dividing the total increase of dry biomass by the accumulated ET.

## Results

After the first drought period (harvest 2, H2), biomass was lower in drought than in control lysimeters, contrastingly, at the end of the experiment (harvest 3, H3), it was similar. The functional groups showed differences in productivity (*Figure 2*). Legumes biomass decreased over time and a difference between control and drought treatments

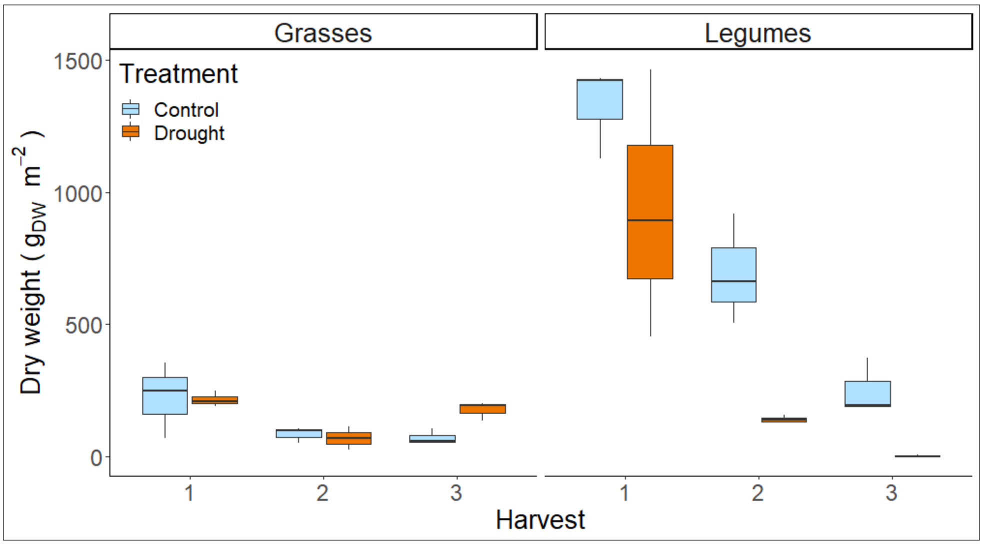


Figure 2. Dry weight biomass of legumes and grasses after each harvest for vegetation subjected to control and drought treatments.

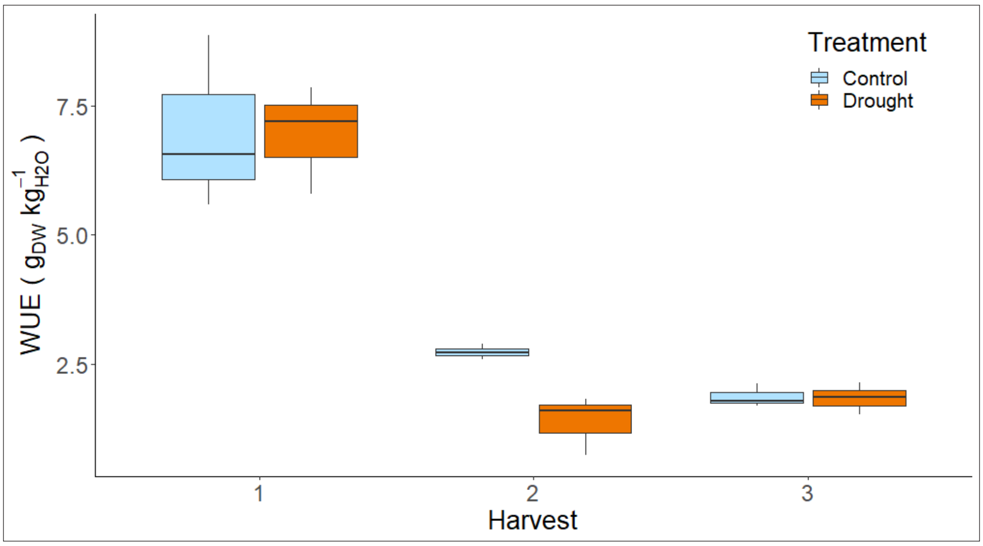


Figure 3. Water use efficiency (WUE) at each harvest period for lysimeters subjected to drought and control treatments.

started after the first drought (H2). Nevertheless, grasses biomass was similar until H3, where it was higher in drought lysimeters.

Control and drought lysimeters had similar WUE at the pre-treatment (harvest 1), and differed in H2, when it was lower in drought lysimeters (*Figure 3*). After the rewetting and the second drought (H3), WUE was again similar between control and drought.

## Discussion

The WUE of the grassland was lower in lysimeters affected by the first drought. More water was needed to produce biomass, although the amount of it was lower. The community was not optimised to save water and may be more strongly and earlier affected by drought than communities with conservative strategies (Frenck et al. 2018). Afterwards, they showed a recovery on WUE and biomass productivity.

Behind these processes, we found that grasses were slightly affected by drought and heat, while legumes decreased drastically. The higher resistance of grasses may be explained by their physiological strategies and the canopy structure of the community. Legumes have long stems and horizontal big sun-exposed leaves on the highest levels of the community, whereas grasses are below protected from the sun-light (Tappeiner and Cernusca 1996). Grasses may not respond directly to drought, but to a change on competitive interactions (Kardol et al. 2010) by a decrease of legumes, combined with an increase of nutrients availability in the soil after drought (Borken and Matzner 2009).

## Conclusions

Drought and heat induced a re-assemblage of the grassland community, which was beneficial because WUE and biomass productivity increased. However, it is unclear if the new composition will be resistant and resilient in the future. Besides, the decrease of legumes affects the soil nutrient availability and the forage quality.

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