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Effects of drought and cutting frequency on agronomic value and functional traits of two pastures of the Jura mountains

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Abstract. In order to determine the impacts of summer drought on the agronomic value and functional characteristics of two semi-natural grasslands, a trial was carried out in 2013 in the Jura mountains. The first grassland (540 m, lowland site) was dominated by *Lolium perenne* and *Poa pratensis*; the second one (1320 m, mountain site) by *Festuca rubra* and *Agrostis capillaris*. Two factors: moisture (drought *vs* control) and intensity of use (high *vs* medium cutting frequency), were tested in a split plot design at each site. The drought was simulated by means of rain shelters. The botanical composition of the meadow and the functional traits of the most abundant species were assessed in spring (initial stage), in summer (after drought treatment) and in autumn (recovery). The drought treatment lowered the yield only during the period of stress (= one growth cycle) and interacted with the cutting frequency. After stress, at the plant community level, important changes were observed in mean trait values (CWMs), whereas the abundance of the main species remained more or less constant. Our results suggest that the ecophysiological plasticity (intraspecific variability) plays a key-role in the response of the meadows in case of a short-time drought.

Keywords. Drought – Functional traits – Permanent meadows – Jura mountains.

Effets de la sécheresse et de l'intensité d'utilisation sur deux pâturages permanents du Jura

Résumé. *Un essai a été mis en place en 2013, dans le but d'évaluer l'effet d'une sécheresse estivale sur les services agronomiques et les caractéristiques fonctionnelles de deux prairies permanentes. La première (540 m) était dominée par des espèces comme* Lolium perenne *et* Poa pratensis*; la seconde (1320 m) était majoritairement composée de graminées comme* Festuca rubra *et* Agrostis capillaris*. Deux facteurs, approvisionnement hydrique (sécheresse* vs *témoin) et intensité d'utilisation (élevée* vs *moyenne), ont été combinés dans un dispositif split-plot. La période de sécheresse a été simulée à l'aide de tunnels maraîchers. La composition botanique ainsi que les valeurs de traits des principales espèces ont été déterminées au printemps (état initial), en été (juste après le stress) et en automne (récupération). La sécheresse n'a impacté que le rendement du cycle ayant subi la sécheresse (interaction « sécheresse × intensité d'utilisation »). Au niveau de la communauté végétale, d'importants changements ont été observés au niveau des valeurs de traits moyens (traits agrégés). La composition botanique est en revanche restée plutôt stable. Ces résultats suggèrent que la plasticité écophysiologique des plantes (variations intra-spécifiques) joue un rôle-clé dans l'adaptation de la végétation lors d'un stress hydrique de courte durée.*

Mots-clés. *Stress hydrique – Traits fonctionnels – Prairies permanentes – Jura.*

I – Introduction

With climate changes, the frequency and the severity of extraordinary events are expected to increase, in an unknown extent. In central and south part of Europe, reduced water availability has become a major concern. For western part of Switzerland, models predict for 2060 a mean decrease up to 40% of the rainfall during the summer period; in addition, periods of hot and dry weather will become more frequent (CH2011). Detailed information about responses of temperate permanent grasslands to summer drought remain incomplete (Gilgen and Buchmann, 2009). In this context, Agroscope has started in 2012 trials which aim at improving grasslands management under water stress (Deléglise *et al.*, 2013). The functional traits approach is an interesting tool that allows a better understanding of plant community responses to changing environmental conditions (Díaz *et al*., 2004). We applied these tools to assess the effect of drought in interaction with cutting frequency on two permanent grasslands situated in the Jura mountains. We made the hypothesis that the short-term responses to drought would mainly be observed on the traits values, rather than on shifts in the botanical composition.

II – Materials and methods

The trial was carried out in 2013 on two permanent meadows of the Jura mountains. The first site (lowland), located at 540 m, was dominated by *Lolium perenne* and *Poa pratensis*. The second one (mountain), at 1320 m, was mainly composed of *Festuca rubra* and *Agrostis capillaris*. Two factors, combined in a split-plot design with three replications, were tested: moisture (Drought [D] *vs* Control [C]; main plot treatments) and cutting frequency (High [H] *vs* Medium [M]; subplot treatments). Post-hoc tests (Tukey's HSD method) were used to determine different means after ANOVAs. The drought stress was simulated with rain shelters for a duration of about 7 weeks (July and August). During the coverage period, 183 mm of water were subtracted at the lowland site, respectively 162 mm at the mountain site. These quantities represented about 55% of the total rain that fell in 2014 from June to August at each site. Number of cuts per year was differentiated, in lowland [M] = 5 and [H] = 7, in mountain [M] = 3 and [H] = 4, in accordance with local turn-out dates for grazing and mowing frequency.

The 5 m^2 plots were cut by means of a motor mower and weighted. Samples were collected and oven-dried for determining dry matter (DM) content. The vegetation surveys were conducted at (i) the beginning of the growth season (spring), (ii) just after the drought (summer) and (iii) during the recovery period (autumn). On each plot, botanical composition was determined along two transects of 4 m with records every 20 cm (Daget and Poissonet, 1971). Traits values (specific leaf area, SLA and leaf dry matter content, LDMC) were assessed according to standard protocols of Cornelissen *et al*. (2003). The community weighted means (CWMs) were then calculated at subplot scale, by weighting the measured values of the main species by their specific contribution (Garnier *et al*., 2004).

III – Results and discussion

1. Dry mass production

The drought did not impact the total annual yield (Table 1). Nevertheless, the drought treatment lowered the yield of the cut harvested just after the stress event. At the lowland site, both MD and HD plots suffered from the stress. At the mountain site, only the HD-plots showed a significant decrease (table 1). In both locations there was an interaction between drought and intensity of use (p<0.001 for both sites).

2. Botanical composition

In spring (data not shown), no differences were observed in the botanical composition of the subplots, neither in the lowland site nor in the mountain site.

Table 1. Yield (dt DM/ha; n = 3 ± SD) in the two experimental sites. Significant differences are indicated by different letters (Tukey post-hoc tests)

Lowland site, 540 m	Medium cutting frequency (M)		High cutting frequency (H)	
	Control (C)	Drought (D)	Control (C)	Drought (D)
Total (annual) yield	101 ± 8.2 [a]	95 ± 7.0 [ab]	81 ± 7.9 [ab]	71 ± 1.8 [b]
Yield after the drought	24.7 ± 0.6 [a]	17.3 ± 3.1 [b]	14.8 ± 2.3 [b]	03.7 ± 0.6 [c]
Mountain site, 1320 m	**Medium cutting frequency (M)**		**High cutting frequency (H)**	
	Control (C)	**Drought (D)**	**Control (C)**	**Drought (D)**
Total (annual) yield	44 ± 7.1	44 ± 1.6	42 ± 3.1	35 ± 4.6
Yield after the drought	19.1 ± 3.4 [a]	14.3 ± 2.7 [a]	12.4 ± 0.9 [a]	03.8 ± 0.4 [b]

In summer, a strong effect of drought on plant senescence was observed at the lowland site, dead parts accounted up to 40% (HD treatment, Table 2). Consequently, the abundance of many plant species tends to diminish. With regard to the mowing frequency, *Poa pratensis* diminished in extensively used subplots ($p<0.01$), whereas *Lolium perenne* and *Dactylis glomerata* showed an increase ($p<0.05$ and $p<0.01$, respectively). At the mountain site, the proportion of litter increased significantly, but not to the same extent than in the lowland site. No significant changes in the abundance of the main species were observed.

Table 2. Abundance (specific contribution; n = 3; ± SD) of the main species in the lowland and the mountain site, just after the drought treatment. Significant differences are indicated by different letters (Tukey post-hoc tests)

Lowland site, 540 m	Medium cutting frequency (M; 5 cuts)		High cutting frequency (H; 7 cuts)	
	Control (C)	Drought (D)	Control (C)	Drought (D)
Lolium perenne	22.6 ± 0.9 [a]	20.7 ± 2.6 [ab]	21.0 ± 1.0 [a]	15.4 ± 1.7 [b]
Poa pratensis	20.8 ± 3.6 [b]	12.6 ± 1.0 [c]	27.8 ± 1.1 [a]	21.7 ± 1.0 [ab]
Taraxacum officinale	16.4 ± 6.5	07.8 ± 4.4	22.0 ± 8.0	08.9 ± 2.1
Dactylis glomerata	12.4 ± 6.7 [a]	08.8 ± 3.2 [a]	06.8 ± 5.4 [ab]	02.7 ± 1.5 [b]
Plantago major	06.2 ± 4.2	03.0 ± 2.0	06.9 ± 1.8	03.1 ± 1.3
Trifolium repens	03.3 ± 2.9	05.4 ± 4.9	04.8 ± 2.6	02.3 ± 2.4
Senescent plants	02.6 ± 2.3 [a]	25.4 ± 7.9 [b]	00.7 ± 0.7 [a]	38.9 ± 3.5 [b]
Mountain site, 1320 m	**Medium cutting frequency (M; 3 cuts)**		**High cutting frequency (H; 4 cuts)**	
	Control (C)	**Drought (D)**	**Control (C)**	**Drought (D)**
Festuca rubra	27.6 ± 3.7	21.6 ± 3.7	27.8 ± 4.5	24.6 ± 1.6
Agrostis capillaris	23.0 ± 3.2	16.5 ± 7.8	21.0 ± 1.8	22.6 ± 2.8
Alchemilla vulgaris	14.0 ± 4.8	13.4 ± 3.8	12.4 ± 1.0	06.6 ± 4.6
Trifolium repens	05.1 ± 5.1	04.1 ± 1.7	02.9 ± 2.2	02.7 ± 1.9
Ranunculus ac. fries.	05.0 ± 1.5	04.4 ± 2.1	05.2 ± 2.7	02.2 ± 2.2
Poa pratensis	04.3 ± 2.1	01.6 ± 1.6	06.6 ± 5.4	00.1 ± 0.2
Senescent plants	01.4 ± 1.3 [a]	13.6 ± 2.7 [b]	05.1 ± 2.3 [a]	22.8 ± 4.6 [c]

In autumn (data not shown), the mowing frequency influenced the abundance of *P. pratensis, L. perenne* and *D. glomerata* in the lowland site. The first species was favoured by an intensive cutting (p<0.001), whereas the two other species benefited from the medium cutting frequency (p<0.05 and p<0.01, respectively). On the mountain site, the botanical composition remained comparable for all treatments.

3. Functional traits

After the stress, the drought treatment induced an increase of the community LDMC and a lowering of the community SLA, especially in the lowland site (Fig. 1). These responses clearly reflect a slowdown in the metabolism of the plants, as well as a shift from a strategy of resource acquisition towards a strategy of resource conservation (Díaz *et al.*, 2004). These responses seemed to be less pronounced in the mountain site where the important presence of so-called conservative species (e.g. *Festuca rubra*) could explain the weaker response. No more differences between treatments were observed in autumn.

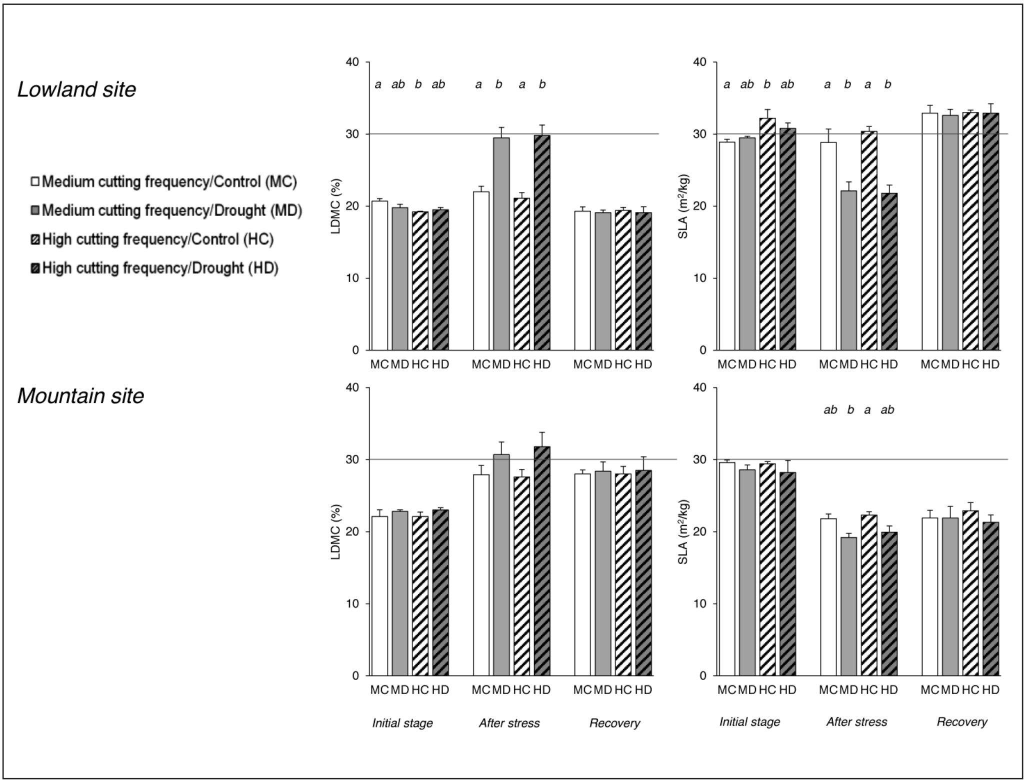

Fig. 1. Community weighted mean traits in the two sites: LDMC (Leaf dry matter content, %) and SLA (Specific leaf area, $m^2 \cdot kg^{-1}$), for the different treatments (see legend on the figure). Mean values (n = 3; ± SD) are given for the three periods: initial stage, after stress and recovery.

IV – Conclusions

The drought had more impact on the community trait values than on the botanical composition, which remained rather stable. The effect of drought on the productivity was exacerbated by a more frequent use during the period of stress (interaction "drought × cutting frequency"). Even in absence of a statistical comparison, it seems that the responses at the mountain site were less marked than those observed at the lowland site. Further researches will be undertaken to gain insight into the potential buffering role of altitude in grassland response to drought.

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