Impact of experimentally induced summer drought on biomass production in alpine grassland

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Introduction

The future summer climate in the Swiss Alps is predicted to be drier and warmer, with an increased probability of extreme weather events such as severe droughts. How alpine grassland will respond to changing precipitation regimes is unclear. Biomass production is an essential ecosystem process in grassland and could be affected by prolonged summer drought.

Objectives

- to study the impact of experimentally induced summer drought on biomass production in alpine grassland at community, functional group and species level
- to contribute to predictions of the consequences of the most likely climate change scenario for the Swiss Alps

Conclusions

- Two years of summer drought considerably reduced alpine grassland biomass production.
- Different species seem to respond differently to drought.
- We assume that a drier climate will strongly affect community composition of alpine grassland.

Results and discussion

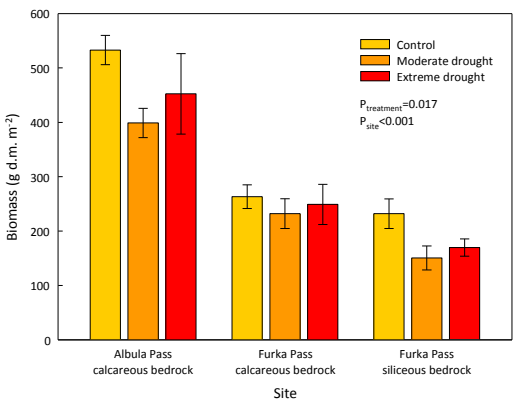

Fig. 1 Effect of experimentally induced summer drought on community standing aboveground biomass (mean±standard error, n=4) of alpine swards at Albula Pass (calcareous bedrock) and Furka Pass (calcareous and siliceous bedrock) in 2009.

Table 1 Standing aboveground biomass (g d.m. m^{-2}, mean±standard error, n=4) of the functional groups graminoids, forbs, legumes and dwarf shrubs of alpine swards at Albula Pass (calcareous bedrock) and Furka Pass (calcareous and siliceous bedrock) under experimentally induced summer drought in 2009. Treatments: ct=control, md=moderate drought, ed=extreme drought.

	Albula Pass calc. bedrock			Furka Pass calc. bedrock			Furka Pass silic. bedrock				
	ct	md	ed	ct	md	ed	ct	md	ed	P_{treatm}	P_{site}
Graminoids	342±47	250±51	289±52	159±18	137±14	112±30	109±20	76±14	78±5	0.096	**<0.001**
Forbs	143±21	111±18	106±23	83±32	65±17	69±8	97±15	61±10	63±9	n.s.	**0.005**
Legumes	15±10	5±1	24±17	19±17	10±2	40±24	26±9	14±3	28±9	n.s.	n.s.
Dwarf shrubs	33±13	32±16	34±11	2±2	20±16	27±22	0±0	0±0	0±0	n.s.	**<0.001**

Table 2 Standing aboveground biomass responses of individual plant species to summer drought in 2009. ↗=increase, ↘=decrease and →=no change in biomass under dry compared to control conditions.

Species calcareous bedrock	Response	Species siliceous bedrock	Response
Sesleria caerulea	↘	*Carex curvula*	↘
Carex sempervirens	↘	*Helictotrichon versicolor*	→
Anthyllis vulneraria	↗	*Trifolium alpinum*	↗
Helianthemum spp.	↘	*Leontodon helveticus*	↘
Aster alpinus	↘	*Homogyne alpina*	↘
Dryas octopetala	↗	*Geum montanum*	↘
Saxifraga paniculata	↘	*Gentiana punctata*	↘

Responses at community level (Fig. 1)

- significant reduction of standing aboveground biomass under summer drought
- more pronounced decrease under moderate drought (12 to 35%) as under extreme drought (5 to 27%)
- no differences between the two drought treatments
- substantial differences between sites

Responses at functional group level (Table 1)

- graminoids and forbs show negative response to drought (trend)
- legumes and dwarf shrubs show positive response, especially under extreme drought (trend)

Responses at species level (Table 2)

- most of the species respond negatively (trend), seem to be drought-susceptible
- some species respond positively (trend), seem to profit from a drier climate

Possible explanations for negative responses

- drought stress-induced reduction in biomass production
- intensified biomass allocation to root system

Possible explanations for positive responses

- competitive advantage in nitrogen acquisition, enhanced symbiotic nitrogen fixation due to higher soil temperature (legumes)

Methods

- three grassland sites in the Swiss Central Alps on steep slopes at 2500 m a.s.l. with contrasting macroclimate and geology
  - Albula Pass, continental-dry, calcareous bedrock
  - Furka Pass, temperate-moist, calcareous bedrock
  - Furka Pass, temperate-moist, siliceous bedrock
- *Sesleria caerulea* sward on calcareous bedrock, *Carex curvula* sward on siliceous bedrock
- drought simulation with rainout-shelters during summer 2008 and 2009
- treatments:
  ct=control (ambient rainfall)
  md=moderate drought (6 weeks rainfall exclusion)
  ed=extreme drought (12 weeks rainfall exclusion)
- harvesting, separating, drying and weighing the standing aboveground biomass in 2009
- two-way analysis of variance (ANOVA), factors treatment and site

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