Timing of drought in the growing season and strong legacy effects determine the annual productivity of temperate grasses in a changing climate

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Author(s) Hahn, Claudia; Luscher, Andreas; Ernst-Hasler, Sara; Suter, Matthias; Kahmen, Ansgar
Author(s) at UniBasel Kahmen, Ansgar ; Hasler, Sara ; Hahn, Claudia ;
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The frequency of extreme weather events, such as droughts, is assumed to increase and lead to alterations in ecosystem productivity and thus the terrestrial carbon cycle. Although grasslands typically show reduced productivity in response to drought, the effects of drought on grassland productivity have been shown to vary strongly. Here we tested, in a 2-year field experiment, if the resistance and the recovery of grasses to drought varies throughout a growing season and if the timing of the drought influences drought-induced reductions in annual aboveground net primary production (ANPP) of grasses. For the experiment we grew six temperate and perennial C-3 grass species and cultivars in a field as pure stands. The grasses were cut six times during the growing season and subject to 10 week drought treatments that occurred either in the spring, the summer or the fall. Averaged across all grasses, drought-induced losses in productivity in spring were smaller (-20 % to -51 %) than in summer and fall (-77 % to -87 %). This suggests a higher resistance to drought in spring when plants are in their reproductive stage and their productivity is the highest. After the release from drought, we found no prolonged suppression in growth. In contrast, post-drought growth rates of formerly drought-stressed swards outperformed the growth rates of the control swards. The strong overcompensation in growth after the drought release resulted in relatively small overall drought-induced losses in annual ANPP that ranged from -4 % to -14 % and were not affected by the timing of the drought event. In summary, our results show that (i) the resistance in growth rates of grasses to drought varies across the season and is increased during the reproductive phenological stage when growth rates are highest; (ii) that the positive legacy effects of drought indicate a high recovery potential of temperate grasses to drought; and (iii) that the high recovery can compensate for immediate drought effects on total annual biomass production to a significant extent.
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