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Effect of severe drought on carbon uptake by plants and carbon translocation towards soil in a model grassland and heathland

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Extreme weather events such as severe drought likely become more frequent in the future. This influences carbon (C) cycling in the plant-soil system, which is poorly understood so far. Our objective was to study the potential impact of increasing drought intensity on C uptake by plants and C translocation into soil. This was studied in a model grassland ecosystem and a model heathland ecosystem that have been subjected to 14 weeks of severe drought in 2011 in the Event I experiment in Bayreuth, Germany. The conceptual approach included multiple$^{13}CO_2$ pulse labeling (in the first, the fifth and the ninth week of drought simulation period) of plants exposed to drought conditions in order to trace above- and belowground C uptake and allocation. Plant and soil samples were analysed for their C content and stable carbon isotope composition ($\delta^{13}C$). During the whole experiment, the $\delta^{13}C$ values were 0.5‰ higher in heathland soil compared to corresponding grassland soil due to plant input that also revealed higher $\delta^{13}C$ values. During the first four weeks of the severe drought $\delta^{13}C$ values increased by 1‰ in both model ecosystems and remained almost constant until the end of the experiment. After the first $^{13}CO_2$ pulse labeling the $\delta^{13}C$ value increased by 2‰ after two weeks in the grassland and 1‰ in the heathland soil. Six weeks after labeling, $\delta^{13}C$ values were 2‰ higher in grassland and heathland soils compared to the corresponding non-labeled soils. The larger time-lag of the highest ^{13}C enrichment in heathland compared to grassland soil indicates the slower uptake of C by plants and C translocation into soil, whereas the total C allocation was identical for both model ecosystems exposed to drought after 6 weeks. After the second $^{13}CO_2$ pulse labeling (i.e. after five weeks of drought) the $\delta^{13}C$ values increased by less than 0.5‰ in both soils of the different model ecosystems within 2 weeks. This increase was not observable any more after four weeks of labeling in the grassland and six weeks after labeling in heathland soil. This confirms the slower C cycling in heathland vs. grassland plant-soil systems. The soil $\delta^{13}C$ values did not reveal any labeling of the soil after the third labeling in the ninth week any more, clearly demonstrating the lack of any further C uptake and translocation at this severeness of the drought. This study concludes that the manipulated drought scenario led to reduced plant C uptake and C allocation in soil after ten to twelve weeks of drought for grassland and heathland ecosystems, respectively. As the largest effects of drought were observed within the first six weeks of the drought, one can conclude that the typical 100 year extremes at the experimental site (42 days = 6 weeks) lead to changes in C cycling, but the model ecosystems can resist and cycle C even longer.