Unveiling Carbon Allocation Dynamics in Mountain Grasslands Under Drought Stress Using Position-Specific Isotope Analysis

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Mountain grasslands are currently experiencing significant changes in land use and climate, with an increased frequency of extreme droughts anticipated in the near future. Understanding the drought responses of carbon (C) allocation—a critical process in the C cycle—remains limited. In this study, we conducted an experimental summer drought on traditionally managed hay meadows and traced the fate of recent assimilates into leaf and root sucrose. We applied $^{13}CO_2$ pulses at peak drought and tracked the labeled carbon into individual positions of glucose using liquid chromatography coupled with ultrahigh-resolution mass spectrometry.

Our findings revealed that drought conditions decreased total C uptake and led to a reduction in above-ground carbohydrate storage pools. The turnover of the leaf sugar pool, determined through position-specific carbon enrichment, was significantly reduced compared to the control treatment. Interestingly, below-ground C allocation to root sucrose was enhanced by drought, but the position-specific carbon enrichment was less affected, suggesting the involvement of other carbon sources.

These results demonstrate that position-specific isotope distribution provides a novel understanding of plant carbon allocation, offering new insights into the resilience and adaptation of mountain grasslands to drought stress.