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Increasing aridity reduces carbon sequestration in drylands by markedly lowering production but maintaining high rates of decomposition

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Ecosystems in many regions worldwide are projected to experience increasingly dry conditions caused by warming, often associated with lower rain amounts. These trends are expected to result in a reduction in carbon stocks, as carbon sequestration declines with increasing aridity. However, it is unclear how some of the main processes controlling carbon sequestration add up to the decrease in carbon sequestration. Here, we investigated aboveground net primary production (ANPP) and litter decomposition in ephemeral herbaceous Mediterranean plant communities as affected by various degrees of aridity. The experimental design included four sites along a steep aridity gradient between dry-subhumid and hyperarid regions, and rainfall manipulations of -30% and +30% of ambient rain amounts.

Results showed a progressively steeper decline in the carbon-related fluxes with increasing aridity. However, this decline was more pronounced for ANPP than for decomposition, a result supported by lower values for plant growth traits and higher values for litter decay traits at the drier compared with the wetter sites. Litter decomposition rate was more affected by litter quality and than by climate, as supported by a long-term transplantation study. Furthermore, litter quality increased with aridity and consequently litter from the most arid site decomposed faster than litter from the other sites.

The combined outcome of reduced carbon input by less production and relatively quick decay of newly acquired biomass carbon was reflected by a steep decline in soil organic carbon (SOC) stock over most of the precipitation gradient. However, SOC at the most arid site was higher than expected from the combination of production and decomposition, potentially indicating efficient soil organic matter formation and stabilization.