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Microbial control of biogeochemistry during drying-rewetting: the legacy of drought

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Drought and drying-rewetting cycles are frequent stressors for soil microbial communities; a stress that is predicted to grow increasingly severe with future climate change. Understanding how the microbial community controls biogeochemical cycles under these dynamic events is instrumental to enable predictive power for C and nutrient cycling in soils. First, we investigated the microbial growth dynamics underlying the dramatic soil C pulse induced by rewetting a dry soil at high time-resolution in a series of week-long studies in a range of soils. Second, we investigated how the duration of drought modulated the microbial responses to rewetting. Third, we investigated how the legacy of experimental field-drought modulated the microbial responses to rewetting dry soil. Fourth, we extended our analysis by investigating how the legacy of drought affected the actively growing microbial community and their biogeochemistry by assessing a cross-continental set of long term (>10 y) drought experiments including soils from ecosystems across Europe.

We found two principal types of respiration responses induced by rewetting a dry soil: (i) an immediate maximal peak followed by an exponential decline or (ii) an immediate peak maintained for 20 h, followed by an intermittent period of exponential increase reaching a maximal peak rate only after > 24 h, followed by an exponential decline. Microbial growth contrasted sharply with the respiration dynamics of both types of rewetting responses. In the type (i) response a linear increase starting immediately after rewetting from zero growth and gradually converging to similar rates as in a moist control soil occurred. In the type (ii) response microbial growth remained at zero for about 20 h, followed by an exponential increase, reaching a peak value many-fold times higher than that of the moist control soils >24 h after rewetting. An extended period of drought prior to rewetting could change the microbial responses from type (i) to type (ii). A legacy of field drought prior to a drying-rewetting cycle was found to reduce the respiration while the microbial growth was unchanged, suggesting an economized microbial C-use efficiency. The cross-continental comparison on drought effects showed that despite pronounced direct effects of drought on microbial growth and function, and despite an affected functioning during perturbation (drying rewetting) cycles, a decade of experimentally reduced precipitation (drought) did not modulate contemporary microbial process rates when assayed under the same stable moisture conditions.