Strong effect of relative humidity on dryland lichens under climate change

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Manipulative experiments typically show a decrease in dryland biocrust cover and altered species composition under climate change. Biocrust-forming lichens, such as the globally distributed Diploschistes diacapsis, are particularly affected and show a decrease in cover with simulated climate change. However, the underlying mechanisms are not fully understood, and long-term interacting effects of different drivers are largely unknown due to the short-term nature of the experimental studies conducted so far. We addressed this gap and successfully parameterised a process-based model for D. diacapsis to quantify how changing atmospheric CO₂, temperature, rainfall amount and relative humidity affect its photosynthetic activity and cover. We also mimicked a long-term manipulative climate change experiment to understand the mechanisms underlying observed patterns in the field. The model reproduced observed experimental findings: warming reduced lichen cover, whereas less rainfall had no effect on lichen performance. This warming effect was caused by the associated decrease in relative humidity and non-rainfall water inputs, which are major water sources for biocrust-forming lichens. Warming alone, however, increased cover because higher temperatures promoted photosynthesis during early morning hours with high lichen activity. When combined, climate variables showed non-additive effects on lichen cover, and effects of increased CO₂ levelled off with decreasing levels of relative humidity. Our results show that a decrease in relative humidity, rather than an increase in temperature, may be the key factor for the survival of the lichen D. diacapsis under climate change and that effects of increased CO₂ levels might be offset by a reduction in non-rainfall water inputs in the future. Because of a global trend towards warmer and drier air and the widespread global distribution of D. diacapsis, this will affect lichen-dominated dryland biocrust communities and their role in regulating ecosystem functions worldwide.