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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 CO_2 , 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 CO_2 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 CO_2 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.