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Liming effects on microbial carbon use efficiency and its potential consequences for soil organic carbon stocks

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The allocation of metabolised carbon (C) between soil microbial growth and respiration, i.e. C use efficiency (CUE) is crucial for SOC dynamics. The pH was shown to be a major driver of microbial CUE in agricultural soils and therefore, management practices to control soil pH, such as liming, could serve as a tool to modify microbial physiology. We hypothesised that raising soil pH would alleviate CUE-limiting conditions and that liming could thus increase CUE, thereby supporting SOC accrual. This study investigated whether CUE can be manipulated by liming and how this might contribute to SOC stock changes. The effects of liming on CUE, microbial biomass C, abundance of microbial domains, SOC stocks and OC inputs were assessed for soils from three European long-term field experiments. Field control soils were additionally limed in the laboratory to assess immediate effects, accounting for lime-derived CO_2 emissions (δ13C signature). The shift in soil pH_{H2O} from 4.5 to 7.3 with long-term liming reduced CUE by 40%, whereas the shift from 5.5 to 8.6 and from 6.5 to 7.8 was associated with increases in CUE by 16% and 24%, respectively. The overall relationship between CUE and soil pH followed a U-shaped (i.e. quadratic) curve, implying that in agricultural soils CUE may be lowest at pH_{H2O} = 6.4. The immediate CUE response to liming followed the same trends. Interestingly, liming increased microbial biomass C in all cases. Changes in CUE with long-term liming contributed to the net effect of liming on SOC stocks. Our study confirms the value of liming as a management practice for climate-smart agriculture, but demonstrates that it remains difficult to predict the impact on SOC stocks due its complex effects on the C cycle.