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Nitrogen fertilization raises CO_2 efflux from inorganic carbon: a Global assessment

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Nitrogen (N) fertilization is a worldwide indispensable agricultural practice serving the survival of half of global population. Nitrogen transformation in soil as well as plant N uptake leads to release of protons and enhances soil acidification. Neutralization of this acidity in carbonate-containing soils (7.94 109 ha; ca. 54% of global land surface area) results in CO_2 release corresponding to 0.21 kg C per kg applied N. Based on the global N fertilization map and the distribution of soils containing $CaCO_3$, we calculated the annual amount of CO_2 released from carbonates as 7.48 1012 g C y-1. These baseline levels of continuous CO_2 release will remain until N fertilization occurs. In the second half of the study, we estimated that about 273 1012 g C are released annually in the same process of $CaCO_3$ neutralization by liming of acidic soils, a common agricultural practice to revitalize over-fertilized fields. These two CO_2 sources correspond to 3% of global CO_2 emissions by fossil fuel combustion or 30% of CO_2 by land use changes. However, the duration of CO_2 release after land use changes usually takes only 1-3 decades before a new C equilibrium is reached in soil. In contrast, the CO_2 released by $CaCO_3$ acidification cannot reach equilibrium until it is completely neutralized, which will take centuries or even millennia. This promotes limiting soil acidification as an effective strategy for inhibiting millennial CO_2 efflux to the atmosphere. Hence, N fertilization should be plant demand-specific to prevent over fertilization, not only because of its role in local eutrophication, but also this newfound role of continuous CO_2 release by global acidification.

Key words: CO_2 efflux, global acidification assessment, global warming, mitigation policy, nitrogen fertilization, soil acidification mechanisms, soil inorganic carbon