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Natural and forced soil aeration during agricultural managed aquifer recharge (Ag-MAR)

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Agricultural managed aquifer recharge (Ag-MAR) is an emerging method for groundwater replenishment, in which farmland is flooded during the winter using excess surface water to recharge the underlying aquifer. Successful implementation of Ag-MAR projects requires careful estimation of the soil aeration status, as prolonged saturated (waterlogged) conditions in the rhizosphere can damage crops due to O_2 deficiency. We studied the soil aeration status under almond trees and cover crops during Ag-MAR at three sites differing in drainage properties. We used O_2 and redox potential as soil aeration quantifiers to test the impact of forced aeration compared with natural soil aeration. Forced aeration treatments included air-injection through subsurface drip irrigation, or dissolution of calcium peroxide powder (scattered on the soil surface before flooding). Our results suggest that forced soil aeration methods have an average increase of up to 2% O_2 compared to natural soil aeration. Additionally, only a minor impact on crop yield was observed between treatments for one growing season. Results further suggest that natural soil aeration can support crop O_2 demand during Ag-MAR if flooding duration is controlled according to O_2 depletion rates. According to this concept, we developed a simple model based only on soil texture and crop type, for estimating Ag-MAR flood duration with minimal crop damage.