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Regional simulation of soil nitrogen dynamics and balance in Swiss cropping systems

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We evaluated the regional-scale potential of various crop and soil management practices to reduce the dependency of crop N demand on external N inputs and N losses to the environment. The estimates of soil N balance were simulated and compared under alternative and conventional crop production across all Swiss cropland. Alternative practices were all combinations of organic fertilization, reduced tillage and winter cover cropping. Using the DayCent model, we simulated changes in crop N yields as well as the contribution of inputs and outputs to soil N balance by alternative practices, which was complemented with corresponding measurements from available long-term field experiments and site-level simulations. In addition, the effects of reducing (between 0% and 80% of recommended application rates) or increasing chemical fertilizer input rates (between 120% and 300% of recommended application rates) on system-level N dynamics were also simulated. Modeled yields at recommended N rates were only 37–87% of the maximum yield potential across common Swiss crops, and crop productivity were sensitive to the level of external N inputs, except for grass-clover mixture, soybean and peas. Overall, differences in soil N input and output decreased or increased proportionally with changing the amount of N input only from the recommended rate. As a result, there was no additional difference in soil N balance in response to N application rates. Nitrate leaching accounted for 40-81% of total N output differences, while up to 47% of total N output occurred through harvest and straw removal. Regardless of crops, yield potential became insensitive to high N rates. Differences in N2O and N2 emissions slightly increased with increasing N inputs, in which each gas was only responsible for about 1% of changes in total N output. Overall, there was a positive soil N balance under alternative practices. Particularly, considerable improvement in soil N balance was expected when slowly decomposed organic fertilizer was used in combination with cover cropping and/or reduced tillage. However, the increase in soil N balance was due to the decreases in harvested yield and nitrate leaching under these organic cropping based practices. Instead, the use of fast decomposed organic matter with cover cropping could be considered to avoid any yield penalty while decreasing nitrate leaching, hence reducing total N output. In order to effectively reduce N losses from soils, approaches to utilize multiple alternative options should be taken into account at the regional scale.