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Nitrate leaching in intensive dryland agriculture under monsoon climate: a suction lysimeter study

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Intensive agriculture in Central Korea is characterized by excessive N fertilization against the background of a strong summer monsoon season. Heavy monsoon rains together with predominantly sandy soils and upland farming is predestined not only for high erosion but also for extensive losses of nitrogen through leaching during the cropping season.
Our aim was not only to measure the contribution of agricultural fields to the nitrogen export but also to define the exact pathways of nitrogen losses in dryland cropping systems with concentrated summer rains. Precise information on plant uptake of nitrogen, release of nitrogen in seepage water, and long-term retention of inorganic nitrogen in soils at farm level was obtained by applying 15N labeled KNO3 as a tracer. Recovery rate, retention rate and loss rate of 15N will be shown. In order to determine optimal gains in ecosystem services, namely production of agricultural crops versus limited impacts on water quality, nitrogen balances were examined within a range of fertilization levels ranging from 50 to 350 kg N ha-1. Fertilizer addition within this range is also commonly employed in the research area of Haean Catchment. New elements of this experiment were 1) the dicotyledonous root crop species, 2) the adaption of local farming method of row systems covered with plastic foil, and 3) the measurement of N2O release and its consideration in the N budget. To account all nitrogen fluxes, we additionally measured the atmospheric N deposition with an approach that combined exchange resins with the isotope dilution method. Furthermore, to investigate soil water dynamics and to model nitrogen loss in seepage over the course of a season, the monitoring equipment included standard tensiometer and ECH2O logger as well as suction lysimeter for the collection of seepage. Seepage water was collected continuously once a week and analyzed for total nitrate and ammonium and for its 15N abundance.
To cover the aspect of cultivation in row systems and to gain insights on their impact, we analyzed the seepage water for rows and interrows separately. Nitrate values reveal only small differences regarding dimensions as well as patterns of nitrate leaching in deeper soil layers. In a depth of 45cm, interrows and rows show their peak a few weeks after fertilization with values clearly below and marginally below 200 mg N l-1, respectively. However, the upper layer in the row system shows a different behavior. Starting with values distinctly above 200 mg N l-1, they decrease continuously with time. Yet, the end of the strongest N leaching seems to be completely independent from factors like location, depth or fertilization rate. After day 40 of the experiment, with values leaning towards zero, strong leaching could no longer be recorded for most of the replicates. It will be shown, that plant growth and thus, their N uptake seems to play the major role in nitrogen leaching magnitudes and patterns.
To observe potential shifts in the nitrogen cycling depending on slope, we also compared upland dryland farming with dryland farming on flat areas. The nitrogen losses with surface run off are marginal, as the 15N abundances of the sediment are within the range of the natural abundance of the soils (below 10‰. Hence, independently from slope, leaching can be seen as the main nitrogen loss pathway.