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Can water management reduce NH_3 emissions from urea application in rice paddies?

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Ammonia (NH_3) is one of the main reactive components of the troposphere and its deposition is a major environmental treat. Rice fields are particular sensitive environment in which NH_3 volatilisation can be mitigated according to water management, increasing the effectiveness of the fertiliser and reducing environmental issues. Urea is the most common N-fertiliser used for rice production and the determination of NH_3 emissions from different water managements is still far from clear.

A two year experiment was designed to quantify NH_3 releases from two urea applications, at tillering and at panicle initiation, and with three different treatment of water managements: (i) “DRY”, with fertilisations on dry soil; (ii) “FLD-D” - water seeding continuous flooding - with fertilisations on temporally dried soil surface; (iii) “FLD-W” - water seeding continuous flooding - with fertilisation into standing water. Measurements were carried out on three contiguous plots, one treatment each, of 2650m^2 (50×53m) in Castello D'Agogna (Italy) during 2015 and 2016; fertilisations provided 70+50 kg N/ha for DRY and 60+40 kg N/ha for FDL-D and FLD-W. NH_3 emissions were quantified by means of concentration-based inverse dispersion modelling, applied to a multi-plot design. This low-cost method allows measuring gas concentrations above the soil surface by using integration-time passive samplers, placed in each plot at 1 m height above soil surface (or crop canopy) and replaced each 6h during the more turbulent daylight hours and kept for 12h during calm night-time. Two additional measurement points assessed background concentration near the plots. Surface to atmosphere exchanges were quantified with the Eulerian short-range dispersion model FIDES-3D (INRA, France) in a multi-plot configuration, in order to tackle with the mutual advection from the three nearby and different sources. Flux were corrected for low turbulence and near-neutrality conditions (u_* <0.05m/s), $|L| < 2$m); 15%of the data.

Water management played a key-role to control NH_3 emissions both at tillering and panicle initiation. When fertilisations occurred directly on soil surface, residual surface humidity was determinant, in fact with soil water contents lower than the field capacity (DRY), the emissions were the lowest, start to emitting when the paddy was re-wetted, and following the circadian trend of air temperatures. Conversely, when the soil surface was not completely dried (i.e. drying time too short; FLD-D) and the soil water content resulting above the field capacity, an unique, intense and rapid NH_3 emission peak was produced in the first 24h from the fertiliser distribution. This effect was probably due to the rapid hydrolysis combined to the urease activity on soil surface. When the fertilisation occurred directly into the water (FLD-W), emissions were prolonged over time and assumed intermediate intensities with no main peaks. Water management after the fertilisation spreading affected secondarily the emissions, outlining discrete emission phenomena only when the paddies were dried out. NH_3 emissions at tillering and at panicle differentiation were, respectively DRY: 3.2 $\pm 0.6\% \ - \ 5.9\%;$FLD-D $: 17.8 \pm 4.1\% \ - \ 21.0 \pm 4.2\%;$FLD-W $: 14.5 \pm 4.9\% \ - \ 17.5 \pm 8.3\%.$