Loss of nitrogen by ammonia volatilization and NO_x emission after application of urea to a maize crop in Shanxi Province, China

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Introduction

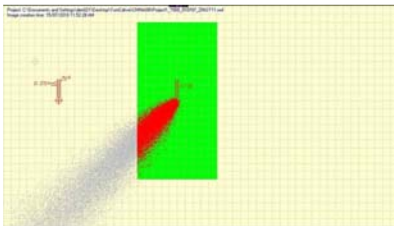
- Maize yields in northern China have increased from 1180 to 5000 kg/ha in last 50 years
- Increase due mainly to irrigation and use of nitrogen (N) fertilizer
- Over fertilising (> 200 kgN/ha) common; low N efficiency
- Much of N lost by ammonia (NH_3) volatilization and emission of N oxides (NO_x)
- Quoted magnitudes of NH_3 and NO_x losses uncertain
- Best management practices for fertilizer application, involving deep placement, have been developed (described in Study site below)
- Previous experiments with deep placement in North China Plain indicate N losses by volatilization of NH_3 of around 12% (Cai et al., 2002)
- Experiments around the world indicate NO_x losses from fertilizers of 0.5 – 0.7% (Veldkamp and Keller, 1997, Yan et al., 2005)
- Present paper reports determinations of these losses from a maize crop in China with micrometeorological techniques

Study site

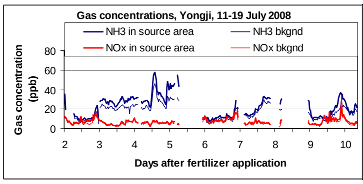
- Farmer's field at Yongji, Shanxi Province, China in 2008
- Cultivated horizon 0-20cm
  - 17% sand, 46% silt, 37% clay
  - pH 8.5
  - 9.6 g/kg organic C, 1.1 g/kg total N, 6.3 µg N/g as NH_4^+, 5.1 µg N/g as NO_3^-
  - Bulk density 1.23 g/cm^3
- 60 kg N/ha applied as prilled urea 33 days after maize seeded
- Used recommended best planting practice of point deep placement of fertilizer (picture below)
  - Remove a small amount of soil to the required depth with a hoe
  - Add a calculated amount of urea to the hole by hand
  - Cover urea with soil

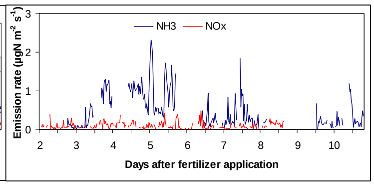
Micrometeorological

- Gas fluxes determined with a backward Lagrangian stochastic (bLs) dispersion technique
- Fertilizer applied to a rectangular area, approximately 100 x 50 m, (shaded green in the map shown at below left)
- Gas concentrations measured continuously at 2 m height at the centre of area with a chemiluminescence NH_3/NO_x analyser (below right)
- Wind speed & direction & other turbulence data measured at 10 Hz (on left mast on map)
- The bLs technique
  - uses turbulence data to trace particles backwards from the sensor in 50,000 simulations of particle trajectories
  - calculates the surface flux from the numbers of particle touchdowns in the source area (red dots on the map), their vertical velocities & sensor gas concentrations



Gas concentrations and fluxes





Above left: Source area and background concentrations of NH_3 and NO_x

- The high backgrounds result from extensive use of nitrogen fertilizers in the region
- Difficult in these studies since accuracy of the calculated flux depends on the small difference between source and background

Above right: Fluxes of NH_3 and NO_x

- Some power failures, but 158 hours of available data
- Urea was hydrolysed immediately after application and emissions increased rapidly
- Emissions remained high and then decreased around day 10
- Most of urea hydrolysed by day 13
- NO_x emissions relatively small, but measurable
- Estimated losses of NH3-N and NOx-N were 3.9 and 0.7 kg N/ha
- Equivalent to 6.5 and 1.2% of N applied

Conclusions

- The bLs micrometeorological technique proved to be a very useful tool for measuring gas fluxes from small, well-defined areas
- NH_3 volatilization was much less than in other experiments in China
- In this soil, deep placement of the urea to limit NH_3 volatilization proved to be a very effective method of fertilizer application
- NO_x loss was not insignificant, amounting to ca. 20% of that of NH_3

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