Field studies on the fate of urea applied to flooded rice

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There is great potential for increasing rice yields if problems concerning the supply of nitrogen in flooded soils can be overcome. Applications of fertilizer nitrogen to flooded rice are often inefficient, and therefore very costly. Recoveries of applied nitrogen by rice can be as low as 10% and rarely exceed 60%. The effectiveness of nitrogen fertilizers also varies greatly from site to site, but the reasons for poor efficiency and variable effectiveness are not clear (1). It is known that recovery is greatly affected by management practices such as time and method of application and form of fertilizer, and that the processes of immobilization, ammonium fixation, ammonia volatilization, denitrification, leaching and run-off can all affect the recovery of nitrogen by the plant. While ammonia volatization has been suggested as an important mechanism for nitrogen loss from flooded soils very little evidence is available to support this suggestion.

This paper describes an investigation of the above problem.

Methods

Frilled urea fertilizer was applied at 80 kg N ha^{-1} into the flood water of a rice crop when the plants were 6 weeks old. ^{15}N-labelled urea was applied in a similar way to separate microplots within the bays. Changes in soil- and water-nitrogen were monitored, and ammonia loss was determined by a chemical/micro-meteorological technique. Total recovery of urea-N was obtained by analysis of soil and crop samples from the microplots.

Results and Discussion

The application produced a uniform concentration of c 40 mg urea-N 1 L in the (15 cm deep) floodwater, and this urea was gradually hydrolysed over 8 days to produce a high concentration of ammonium at the surface of the underlaying soil. Concentrations of ammoniacal (NH_4 + NH_3) nitrogen in the floodwater reached. maximum of 3.2 mg N L^{-1}. Ammonia volatilized at rates up to 200 g N ha^{-1} hr^{-1} during each day, but with a strong diurnal effect and low rates, e.g. 10-20 g N ha^{-1} hr^{-1} , between evening and mid-morning. The cumulative loss of ammonia-N was ~14% of the applied urea-N.

Total recovery of ^{15}N in the plants, soil and water at final harvest was 55%, of which 17% was found in the plant tops. All significant losses occurred at an early stage.

It appears that the hydrolysis of urea created a source of adsorbed ammonium at the soil surface which maintained low concentrations of ammoniacal-N in the floodwater and thus produced a secondary ammonia source. Changes in water temperature and pH then produced higher vapour pressures of ammonia at the water surface during the day so increasing the potential for gaseous ammonia loss. Finally, varying wind velocities affected the sink strength for removal of ammonia into the atmosphere and determined the actual rates of loss over short periods (e.g. < 1 hr) during each day.

1. Prasad, R. and DeDatta, S.K. 1979. In: Nitrogen and Rice.465-484. IRRI, Los Banos, Philippines.