EVOLUTION OF NITRATE AND AMMONIUM FROM BANDED UREA AT TWO SOIL TEMPERATURES

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Abstract

Seedling damage can occur where urea is placed in or near a seed-line. To ensure sufficient nitrate-N to meet crop demand after sowing or side-dressing, it is important to understand the interaction of urea rate and soil temperature on formation and persistence of ammonia and availability of nitrate from banded urea application. Soil temperatures of 13 ^{o}C and 25 ^{o}C were adequate for rapid hydrolysis and mineralisation of urea to nitrate. Increasing the urea rate from 0.5 to 8 g/m, lengthened the duration of hydrolysis and mineralisation more than decreasing soil temperature. Urea rates greater than 1 g/m produced soil ammonium concentrations high enough to be toxic to seed germination and rates greater than 2 g/m were likely to inhibit root growth and mineralisation.

Key Words : hydrolysis, mineralisation, ammonia, toxicity, establishment.

Urea is the most widely used nitrogen fertiliser throughout cropping areas of eastern Australia and is applied at various times and using different placement methods to suit cropping and tillage practices .Due to continued growth of reduced tillage and in response to a lack of confidence in rainfall reliability for clay soils of the northern cereal belt, there is a growing trend for use of urea and urea blends at sowing for rain-grown cereal crops and for bed placement close to sowing and side-dressing for irrigated crops.

It has long been recognised that ammonia reduces establishment of crops if placed with or in close proximity to seed and can inhibit root growth if placed in the root zone (1, 2, 3). Ammonia is the primary compound produced by the hydrolysis of urea.

To reduce the incidence of germination and seedling damage where urea is placed in or near a seed-line and to ensure a supply of nitrate-N sufficient to meet early crop demand, or after side-dressing, it is important to understand the interaction of urea rate (in-row concentration) and soil temperature on formation and persistence of ammonia and availability of nitrate from banded urea application.

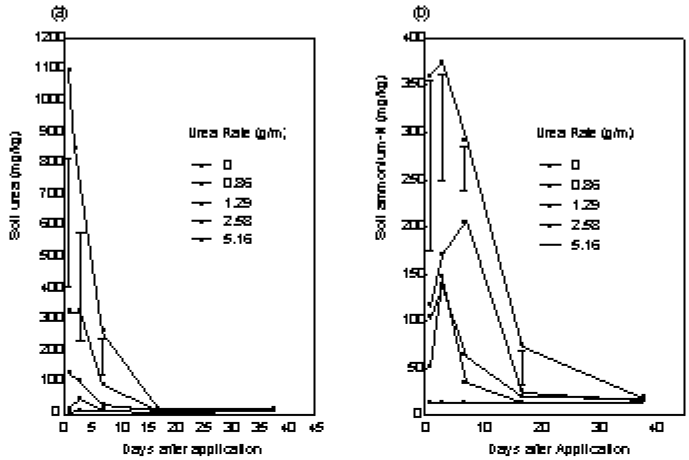
Methods

The experiment was conducted at Formartin, Queensland. Urea was banded into the soil into four 450 mm rows for summer and in seven 250mm rows for winter, 50 - 70 mm deep using 100 mm wide points manufactured by Gyral Implements, Toowoomba . Urea, was applied at 0, 0.43, 0.86, 1.29, 2.58 and 5.16 g/m of row 0, 10, 20, 30, 60, 120 kg/ha applied at 450 mm row spacing. Treatments were laid out in a randomised complete block design, each treatment was replicated four times with plots 2 m wide and 10 m long. Soil moisture and soil temperature at 7.5 cm were measured at each sampling. Soil samples from the application band were collected 1, 3, 7, 17 and 38 DAS from plots designated for destructive soil sampling, and the soil analysed for urea, NH_4-N, NO_3-N and pH within the fertiliser reaction zone.

Results

Complete hydrolysis of urea to ammonium was delayed by high urea rates but was unaffected by soil temperature. Soil temperature at the 7.5 cm depth averaged 13^{o}C for the winter experiment and 25^{o}C for summer. For urea rates less than 2 g/m, hydrolysis was complete 7 days after sowing (DAS), hydrolysis was complete for all urea rates 17 DAS (Fig. 1a and 2a).

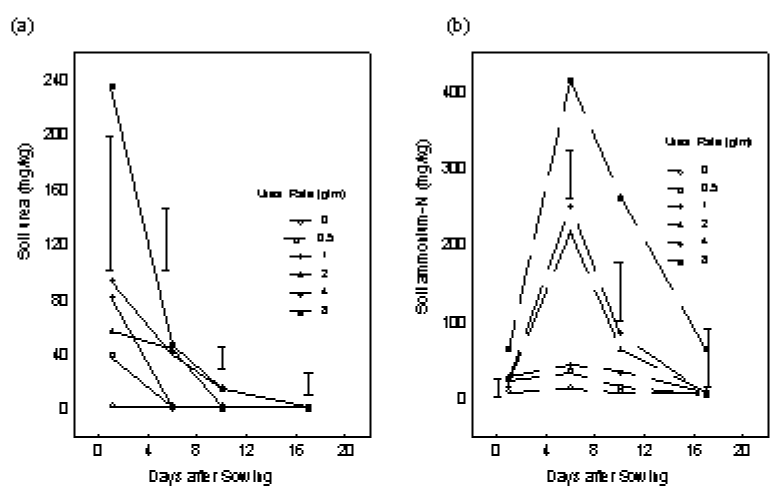
Fig. 1. Mean concentration of urea (a) and ammonium-N (b) within application bands for five rates of urea applied during summer. Error bars represent the lsd 5% values for urea rates at various days after application.



Soil ammonium-N concentration peaked 3 DAS for the summer experiment and 7 DAS for winter (Fig.1b and 2b) . Highest soil ammonium-N concentrations were found in the treatments with the highest urea rates, maximum soil ammonium-N concentration were 375 mg/kg for 5.16 g/m urea rate (Fig. 1b) and 430 mg/kg for 8 g/m (Fig. 2b). Soil ammonium-N concentrations for low urea rate treatments declined to zero fertiliser control concentrations 7 DAS in summer and 17 DAS in winter. Ammonium-N for all treatments was at background levels 38 DAS in summer and only in the 8 g/m urea treatment was soil ammonium-N above background levels 17 DAS in winter.

In summer, soil nitrate-N increased within application bands 1 DAS fin 5.16 g/m urea treatment (Fig. 3a), whereas for lower rates significant increase occurred 3 DAS. Nitrate-N did not increase above the zero fertiliser control until 6 DAS in winter (Fig. 3b). Maximum concentrations of nitrate-N were measured 6 DAS in summer and 10 DAS in winter. Soil nitrate-N decreased in both experiments 17 DAS. Twenty five millimetres of rainfall of was received 9 DAS in summer and 37 mm 12 DAS in winter, and was thought to have promoted movement of nitrate out of the application zone.

Fig. 2. Mean concentration of urea (a) and ammonium-N (b) within application bands for five rates of urea applied during winter. Error bars represent the lsd 5% values for urea rates at various days after application.



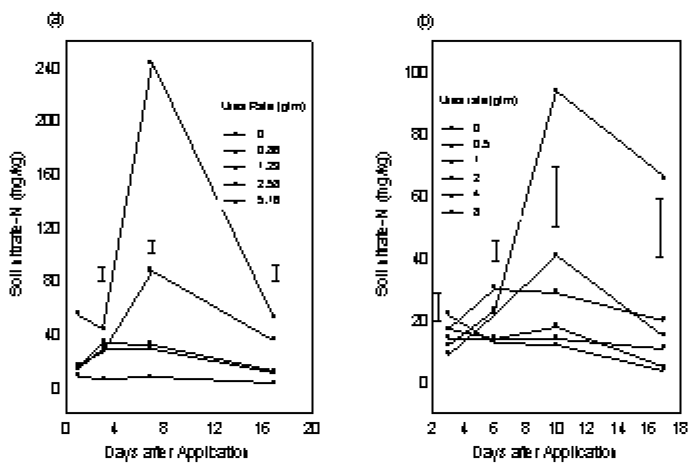
Discussion

The safety of banded urea fertiliser on germinating seeds and plant roots depends on soil ammonium-N concentration and the pH of fertiliser bands, which regulate ammonia toxicity. The rate at which ammonium-N is generated from urea by urease enzyme and mineralisation rate of ammonium to nitrate, determine the maximum soil concentration of ammonium and persistence of ammonia toxicity.

At the maximum urea rate recommended for placement with seed at sowing for winter and summer cereals, 1 g/m (25 kg/ha N), hydrolysis was rapid at both 13 ^{o}C and 25 ^{o}C and the peak ammonium-N concentration was below 200 mg/kg, a level at which significant wheat establishment damage has been measured in this soil. For urea rates greater than 2 g/m, ammonium-N concentrations were in the range 210 to 420 mg/kg, enough to inhibit root growth and mineralisation. Application bands containing greater than 2 g/m of urea should therefore be placed away from the root zone during seedling establishment or applied at least 14 days prior to sowing.

Significant nitrate-N mineralisation was measured 1 DAS for 5.16 g/m applied during summer and for all urea rates by 3 DAS in summer and 6 DAS in winter. Urea hydrolysis and ammonium mineralisation was sufficiently rapid at both 13 ^{o}C and 25 ^{o}C to provide nitrate-N for an establishing seedling or a side-dressed crop.

Fig. 3. Mean nitrate-N concentration within application bands for five rates urea applied during summer (a) and winter (b). Error bars represent the lsd 5% values for urea rates at various days after application.



Conclusion

Soil temperatures of 13 ^{o}C and 25 ^{o}C were adequate for rapid hydrolysis and mineralisation of urea to nitrate. Increasing the urea rate lengthened the duration of hydrolysis and mineralisation more than decreasing soil temperature. Urea rates greater than 1 g/m produced soil ammonium concentrations high enough to be toxic to seed germination and rates greater than 2 g/m were likely to inhibit root growth and mineralisation.

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