NT26 Research Programme

Executive Summary

Background

- The main objective of the NT26 Research Programme was to assess the impacts of possible changes in the use of fertiliser-N products on UK agriculture and the consequential impacts on the environment. The work (Sept 2002 to Dec 2005) was led by ADAS UK Ltd who collaborated with seven other leading UK research organisations.
- Ammonium nitrate (AN) is the most common source of fertiliser-N used by farmers in Britain (approx. 85% of total N use); the correct use of N is very cost-effective for farm businesses
- Urea is the most common source of fertiliser-N used world-wide and is the only realistic alternative to AN for the UK mass market. In the UK, approximately 15% of total fertiliser-N use is as urea, in either solid form or as liquid urea ammonium nitrate (UAN). All urea-based fertilisers are imported and current supplies to the UK market can be erratic. Nitrogen as granular urea is commonly 10% cheaper than nitrogen as AN.
- The NT26 research investigated the behaviour and impacts of urea-based fertilisers compared to AN-based nitrogen fertilisers, including:
  - Ammonia emissions to the atmosphere and their mitigation
  - Nitrous oxide emissions to the atmosphere
  - Nitrogen losses to water
  - Crop responses
  - In-field spreading of fertilisers
  - Scenario testing

Ammonia emissions

- The most important impact from an increased use of urea-based fertilisers (solid or liquid) would be to increase ammonia emissions to the atmosphere. Twenty eight field experiments using purpose built wind tunnels quantified ammonia emissions from granular urea at on average 27% (grassland) and 22% (arable) of the total N applied, compared with c.2% from N applied as AN. For liquid UAN (arable), the average emission was 14%. A positive relationship was found between the ammonia emission differences from urea and AN, and the extra amount of urea fertiliser required to match the crop N offtake from use of AN. This indicates that higher rates of fertiliser-N application are justified when urea-based fertilisers are used.
- Ammonia emissions from urea were, however, very variable ranging from 2 to 58% of the total N applied, largely due to unpredictable weather factors (rainfall reduces emission). Urea is thus considered to be a less reliable source of fertiliser-N for crop production purposes than AN.
- Any significant increase in the use of urea fertilisers is likely to prevent the UK Government from meeting it's commitment under the EU National Emission Ceilings Directive and UNECE Gothenburg Protocol to reduce annual total ammonia emissions to 297kt ammonia (NH_3) by 2010, against total emissions of 320kt in 2002. If current AN use were to be totally replaced with urea, this target would <u>not</u> be achievable.
- Mitigation of ammonia emissions from urea is possible by treatment with the urease inhibitor nBTPT (trade name Agrotain).

Comment [LS1]: Wording implies Agrotain is only urease inhibitor?

- The field and laboratory based studies both showed conclusively that the nBTPT urease inhibitor does work, reducing ammonia emissions from untreated granular urea by 70% on average when used at a concentration in the range of 250 to 1000mg/kg nBTPT. The laboratory studies showed that there was little loss of efficacy between concentrations of 100 and 500mg/kg nBTPT.

- Addition of the urease inhibitor to liquid UAN reduced ammonia emissions by 44% on average in the field studies – it was less effective probably due to the more rapid loss of ammonia from liquid UAN than granular urea.
- The stability of the nBTPT urease inhibitor in stored fertilisers varied depending on the formulation and storage temperature. However, its stability was good when added to the hot urea melt.

Nitrous oxide emissions

- Nitrous oxide (N_2O) is an important greenhouse gas and contributes about 6% of the global warming potential of all UK greenhouse gas emissions. Agriculture contributes an estimated 67% of UK N_2Oemissions, of which fertiliser-N directly contributes about 25%. Use of fertiliser-N in UK agriculture therefore contributes about 2% of all UK greenhouse gas emissions.
- There was some indication from the field measurements that direct N_2O emissions are likely to be slightly lower from urea based fertilisers than AN based fertilisers. However, if expected indirect emissions of N_2O following volatilisation and re-deposition of ammonia are taken into account, the total N_2O emissions from AN and urea are likely to be similar.

Nitrogen losses to water

- Agriculture is estimated to be responsible for 5-10% of the Freshwater Fish Directive NH_4-N non-compliance cases (NH_4-N concentrations >0.78 mg/l), with *c.*50% of these cases from point sources and *c.*50% from diffuse sources. Furthermore, the majority (80-90%) of agricultural non-compliance appears to be from poor manure management.
- Field based experiments showed that N losses following the application of N fertilisers to 'wet' soils in spring were dependent on the timing and amount of rainfall following application, and water movement pathways through the soil.
- The peak ammonium-N concentration in drainflow from the drained clay experimental sites exceeded levels in the range 2 to 40mg/l, and in surface runoff/subsurface flow from the undrained clay sites exceeded levels in the range of 8 to 80mg/l.
- A switch from AN to urea would change the balance of N loss forms from drained/undrained clay soils to surface waters. Typically, the combined ammonium-N and urea-N loads were 2-3 fold higher from urea than AN, and nitrate-N loads 3-6 fold higher from AN than urea. The balance between N loss forms depended upon the degree of urea hydrolysis to ammonium-N, and nitrification of ammonium-N to nitrate-N, in relation to timing of water flows.

Crop responses

- Field-based nitrogen response experiments on winter cereals showed that use of granular urea often resulted in higher economic optimum application rates of N (around 20% higher on average), compared with the use of AN. Optimum N rates tended to be higher for liquid UAN than granular urea. Use of the nBTPT urease inhibitor tended to reduce the optimum N rate. The assumed cause of these effects is differential losses of N due to ammonia volatilisation. Experiments on 1st cut silage showed no difference in optimum N rates, probably due to the earlier timing of the N applications which was not conducive to ammonia losses.
- For some crops, the results would justify the introduction of higher recommended economic optimum N rates where urea-based fertilisers are used. Provided higher rates of urea-N were applied, the same crop yield and protein contents were obtained.

- Experiments with some arable and potentially sensitive high value horticultural crops showed that the use of urea-based fertilisers can cause:
  - crop damage (e.g. leaf scorch in lettuce and temporary N deficiency symptoms in spring brassica transplants)
  - delays in the rate of maturation of vegetable brassicas (cauliflower and calabrese)
  - reductions in the yields of some crops (e.g. sugar beet, salad onions, calabrese and cauliflower)
  - changes in the size distribution of some root crops (red beet and potatoes)

  However, the results were highly variable in both incidence and severity between sites and seasons.

In-field spreading of fertilisers

- Solid urea is available as imported prills or granules, both of which have a lower density than AN (prills are smaller particles than granules). Studies showed that farm fertiliser spreaders can spread commercial granular urea to a similar accuracy as AN. However, prills cannot be spread to a satisfactory accuracy with commonly used farm spreading equipment.

Scenario testing

- A component of the NT26 work investigated and quantified the impacts of changes in the balance of the use of AN- and urea-based fertiliser-N products on UK agriculture, and its effects on the environment.