Review of efficacy, agronomic impacts and costs of reduced-NH_3 emission manure application methods

J Webb (AEA), John Morgan and Brian Pain (Creedy Associates), Brigitte Eurich-Menden (KTBL)

Review of NH_3 abatement efficiencies

Focus on studies that:

- **measured ammonia (NH_3) abatement by trailing hose (TH), trailing shoe (TS), open-slot injection (OSInj) or rapid incorporation by cultivation in comparison with NH_3 emissions following broadcast surface application**

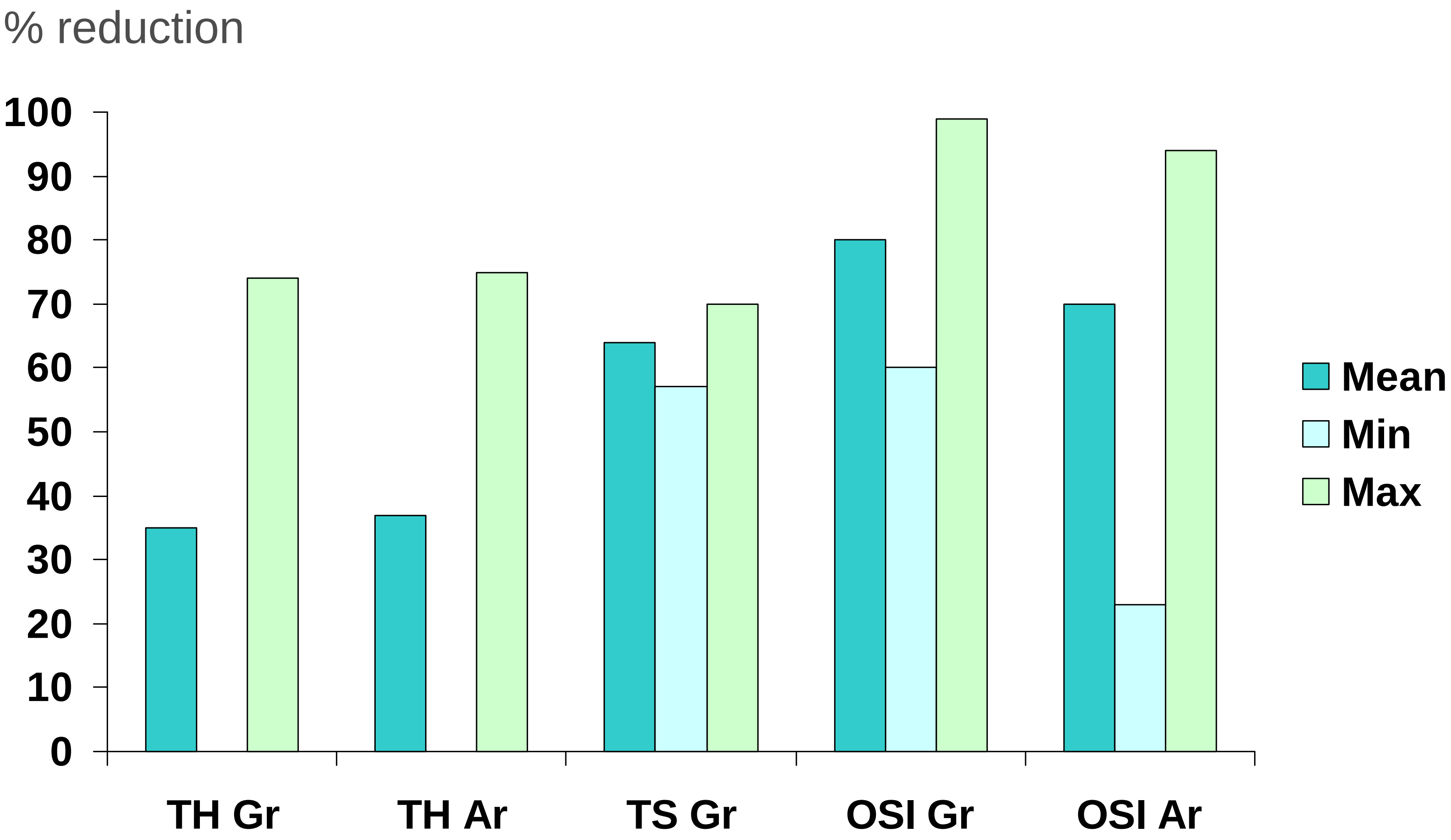
- **measured N recovery by crop**

- **measured emissions of nitrous oxide (N_2O)**

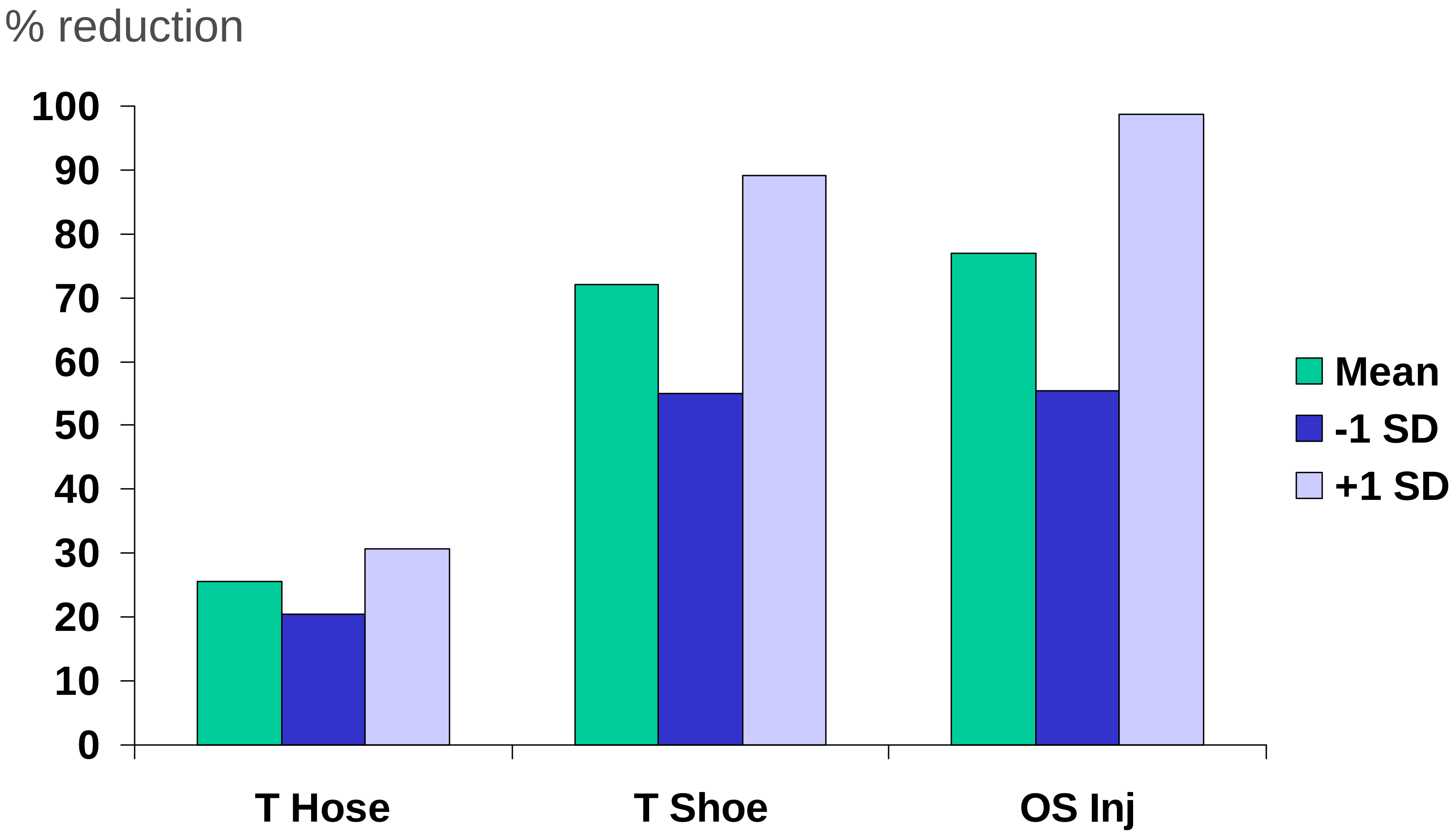
but attempted to review all recent studies of reduced-emission spreading techniques and their NH_3 abatement efficiency

draft report sent to all first authors cited to enable them to point out any incorrect interpretation

Average abatement efficiencies, % reduction compared with broadcast surface application



Anova - of results from studies in which all three machines were tested



Review of agronomic impacts of reduced-emission manure application

Also reviewed studies that measured N recovery by crops, or evaluated other aspects such as silage quality, following manure application by reduced-NH_3 emission spreading techniques (but which did not measure emissions of NH_3)

the draft review of these studies also sent to first authors for comment

Agronomic benefit - season of application

Schils and Kok (2003) positive effect of slot injection was obtained with applications from June onwards.

slurry manure application in March resulted in a similar N utilization for both application techniques

Rodhe and Rammer, (2002) application before the second silage cut in summer was more profitable than spreading before the first cut in spring.

Agronomic benefits - greater N uptake

Papers report increased N uptake from e.g. injection

e.g. Schröder et al. (2007) +18 to +41 kg N/ha

- although only 1 year in 4 significant
- out of a total application of 307 kg N/ha

measured N uptake consistent with estimates of NH_3-N conserved

greater consistency of N uptake when applied by reduced-emission techniques

concluded that lack of significant increases due to additional N uptake being small in comparison with the sensitivity of agronomic experiments

Agronomic benefits - greater N uptake

Hence as a working hypothesis reduced-emission slurry spreading techniques will lead to increases in N_{off} of the size we expect from the amount of manure-TAN applied and the efficiency of the technique employed

estimates of the financial savings could then be made on the basis of the expected increase in N_{off}

decided other potential benefits could not be reliably quantified

Agronomic benefits - silage quality and grazing palatability

TS caused little damage to tall swards and the slurry was deposited below the grass canopy with minimal contamination of herbage

no significant differences were reported in Expt 1 but in Expt 2 application of slurry by Injection and TS appeared to leave the sward more palatable to the cattle

Additional costs of reduced-NH_3 emission spreading techniques

Estimated to be £0.52 m^{-3}, £0.54 for immediate incorp, by plough

Much less than previous estimates - £1.44 - 2.84 m^{-3}, £0.79

- UK contractors appear to charge 20-30% more for application with reduced-emission machines than for SP
- costs for the SP varied between less than £1 to over £2 m^{-3} applied
- a reasonable average considered to be £1.40 m^{-3}
- the additional contractor's charge for these machines over SP was estimated to be between £0.28 and £0.42 m^{-3}

Estimates from other European countries, £ m^{-3}

	T Hose	T Shoe	OS Inj	Imm Inc Pl, slurry
KTBL, D		2.59	3.50	0.73
KTBL, I			1.79	0.00
KTBL, Es		1.05	1.09	0.48
KTBL, Dk			0.68	1.30
Sv	1.05		2.71	

Net costs of reduced-NH_3 manure application - 2003

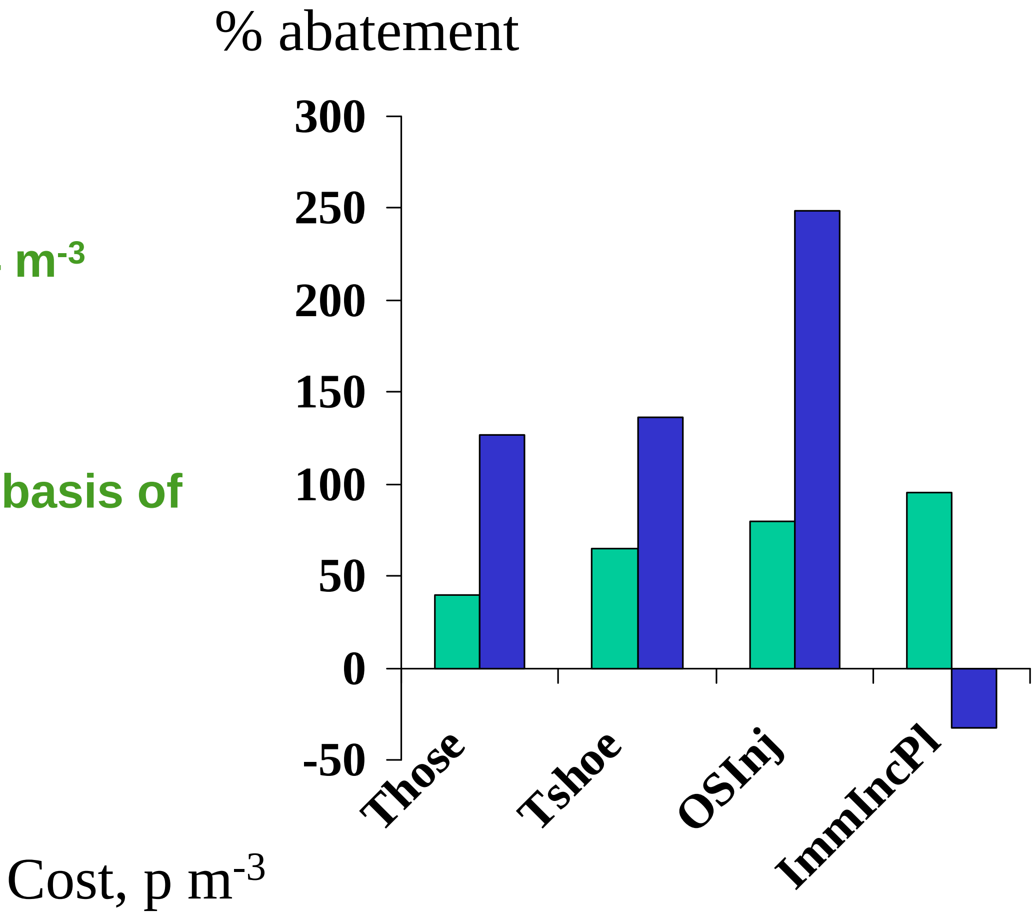
30 m^3 slurry

NH_3 emission, 50% of TAN

Additional cost, £0.79-2.84 m^{-3}

£100/t AN

(savings estimated on the basis of N only)



Net costs of reduced ammonia manure application -1

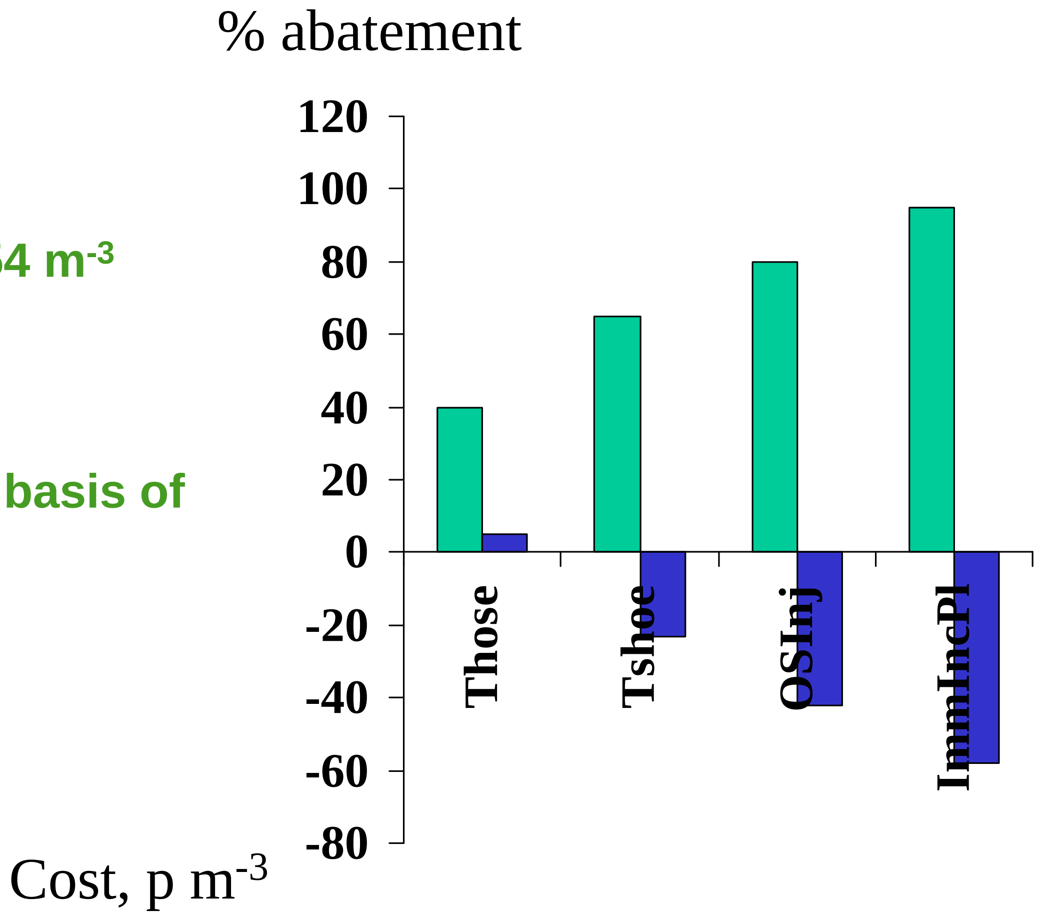
30 m^3 slurry

NH_3 emission, 50% of TAN

Additional cost, £0.52-£0.54 m^{-3}

£325/t AN, Feb 2009

(savings estimated on the basis of N only)



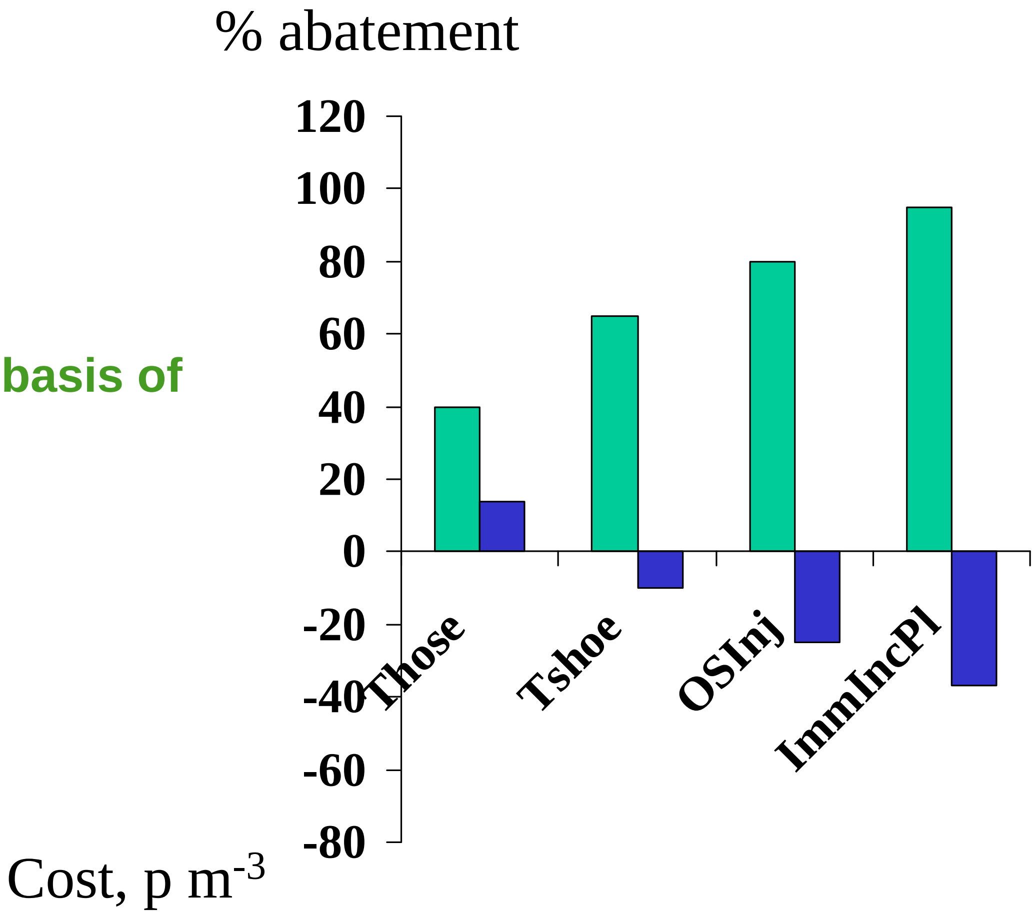
Net costs of reduced ammonia manure application -2

30 m^3 slurry

NH_3 emission, 50% of TAN

£266/t AN, Mar 2009

(savings estimated on the basis of N only)



N Fertilizer break-even price

	T Hose	T Shoe	OSInj	Imm Inc
N conserved kg m^{-3}	0.5	0.8	1.0	1.2
Break even £/kg N	1.04	0.65	0.52	0.45
AN price £/t	359	224	180	157

Farmer experience provided by Creedy Associates

Information gathered from telephone interviews with farmers, contractors and machinery suppliers

- **included some who participated in MAFF project WA0710 Ammonia Pilot Farms**

historical feedback from farmers during manure management workshops

and on extensive day-to-day advisory contact with farmers

most information relates to use of reduced-NH_3 emission machines

many farmers incorporate manures, but little evidence they do this soon enough after spreading to have a significant impact on NH_3 emissions

'soft' measures do not appear to be often used to reduce NH_3 emissions.

- **Some farmers are reluctant to spread in the evening because of a greater likelihood of complaints about odour when neighbours are home**

Farmer experience

Experiences and views varied widely from having no interest or intention of employing the machines, to having tried and dismissed a machine to being very enthusiastic and using on a regular basis.

however, overall the responses were much more positive than expected. The main conclusions are:

there has been a large increase in the uptake of the machines over the past year or two. This seems to have arisen from pressure from farmers rather than hard sell by suppliers

the main reason for use is savings in fertilizer - but clearly sensitive to N fertilizer price as illustrated earlier

Farmer experience

In general, capital cost of ownership is too great for individual farmers and most use contractors

- pig farmers appear more likely to own a machine than cattle farmers. This may be due to the greater need of pig farmers to control odour

it needs to be remembered that machine purchase in the Pilot farm study was subsidized

and if reduced-NH_3 emission spreading becomes mandatory contractors could put their prices up

the machines are generally reliable and most problems/breakdowns can be fixed fairly readily

Farmer experience

Shallow injectors are popular for use on grassland unless conditions are such that there is poor soil penetration (esp. very heavy or stony soils) or soils are too wet resulting in damage to the sward.

TS overcomes some of these problems, and may be increasing in popularity for grass, although new injectors are adjustable to allow slurry to be placed on the surface

TH/dribble bars are more common on arable land for growing crops and can be used on crops up to 15 cm high but extra storage is needed to apply from March to May

Pilot farms subsequent feedback

Dairy farmer on a gritty loam over clay soil (Somerset), high rainfall gave up on his 10 m^3 tanker-mounted disc injector mainly due to problems of soil compaction, damage to gateways and headlands and damage to grass swards

- **there were also difficulties with soil penetration in dry weather and problems with blockages. He now applies mechanically-separated slurry, that infiltrates into the soil very quickly, with a TS (contractor operated) to grassland and TH to growing cereals**

another dairy farmer on heavy clay soil (Gloucestershire) has successfully used his 7 m^3 disc injector for the past 11 years

- **much improved utilisation of slurry and lack of contamination of grazed grass have encouraged him to convert to organic**

a pig farmer on a heavy clay soil in the Midlands gave up on both an umbilical disc injector and a TS due to soil compaction and high operating costs. Soil penetration was also a problem with the injector. He now successfully uses a TH machine to apply to growing crops and considers this to be the only option on his soils.

Pilot farms - overall conclusions

All the farmers are still using reduced-NH_3 emission machines after 10 – 11 years, and most still have their original machine.

albeit one has stopped using an injector in favour of a TH

most claim a positive impact on their business, especially in terms of saving on fertilizer costs, flexibility in when and where to apply slurry

It is not always clear whether or not savings in fertilizer are entirely due to the machine or could have been achieved by more considered use of splashplate spreading. It appears that the machine encourages, and makes it easier, for farmers to use slurry more effectively

most could not afford to replace the machine nor could have afforded to initially purchase without subsidy from the project.

Pilot farms - overall conclusions

All claim maintenance costs to be relatively high but, in general, resolved mechanical problems.

most did not think running costs were significantly more than tanker and splashplate because time for filling tanker and transport to field, that accounted for large proportion of total time, were the same. Unfolding the boom added some time to TH machines.

many farmers were not able to use the machine to apply all the slurry produced on their farm and often used SP for a proportion. This was due to difficult soil conditions (too wet or too dry at times of the year, stony or steeply sloping land, some slurry too thick or containing stones etc, inaccessibility of some fields

Impact of reduced-NH_3 emission on emissions of N_2O

There are not enough field studies reporting both NH_3-N emissions and N_2O emissions measured over 12 months to draw firm conclusions. The available data suggest a different pattern of results for slurry and FYM:

- **following application of slurry by reduced-NH_3 emissions spreading techniques N_2O emissions were usually greater than when manures were surface-applied, although differences were not always significant.**

- **when solid manures are rapidly incorporated N_2O emissions have often been less than from surface application, in some cases significantly less**

in an incubation N_2O study emissions were greatest when pig manure was placed at 5 cm (P <0,05), least when placed at 10 cm ($P < 0.05$) and intermediate for surface application, thorough mixing and placement at 5 cm.

These results suggest that while injection to 5 cm might increase emissions of N_2O, deeper injection might reduce them

Conclusions

TS and Osinj both give greater reductions in NH_3 emissions than TH

At recent prices for fertilizer-N, TS and OSinj and immediate incorporation by plough appear cost-effective due to greater uptake of manure-N

Farmers who use them generally seem to derive benefits

But capital costs suggests the use of reduced-NH_3 emission machinery will be largely via contractors

This has a further potential advantage of enabling farmers to choose among the machines for the most suitable option for different circumstances

While it is likely that the use of these methods will reduce direct emissions of N_2O, indirect emissions will be reduced.

Concerns over increasing emissions of N_2O should not be a barrier to the adoption of reduced- NH_3 emission spreading techniques