INTEGRATED MANAGEMENT PRACTICES TO MINIMISE LOSSES AND MAXIMISE CROP NITROGEN VALUE OF BROILER LITTER

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ABSTRACT

This study quantified the effects of contrasting storage methods on ammonia emissions from broiler litter heaps and the effects of ammonia abatement strategies during storage and land spreading on nitrate leaching losses and crop nitrogen (N) availability. There were 5 storage treatments: conventional, sheeted, turned, 'A-shaped' and roofed. Ammonia volatilisation losses were highest (P<0.001) from the roofed heaps (19 % of N into store) and lowest from the sheeted heap (1 % of N into store), with intermediate emissions from the other heap treatments (13-16 % of N into store). Storage and soil incorporation methods both had significant effects on ammonia emissions at land spreading (P<0.001). Emissions from the surface spread sheeted broiler litter were equivalent to 26 % of N into store and were higher (P<0.05) than from the surface spread conventionally stored broiler litter at 11 % of N into store. To conserve the N retained during sheeted storage rapid soil incorporation was required; this reduced emissions by 15–87 % compared with surface spreading. Ploughing the broiler litter into the soil within 4 hours of land application increased (P<0.05) nitrate leaching losses from the sheeted broiler litter (14 % of N into store) compared with 4 % of N into store from the surface spread broiler litter. The soil incorporation method had a significant effect on grass N offtake, with ploughing within 4 and 24 hours of application increasing (P<0.05) grass N offtake compared with surface spread broiler litter.

INTRODUCTION

Agriculture is the principal source of atmospheric ammonia in the UK, accounting for 265 kt NH_3 per year or *c*.80 % of total emissions (Anon., 2002). Ammonia emissions not only represent a large loss of potential crop available nitrogen, but are also a serious threat to the environment. When deposited on natural ecosystems, ammonia can cause acidification of soils and water, and can contribute to changes in the biodiversity of semi-natural habitats. In order to protect sensitive habitats, the UK has signed a number of international agreements to reduce ammonia emissions, including the UNECE Gothenburg Protocol, the EC National Emission Ceilings Directive (NECD) and the EC Integrated Pollution Prevention and Control (IPPC) Directive.

The storage and land spreading of manures is responsible for *c*.6 % and 36 % of UK total ammonia emissions, respectively (Anon., 2002). Most of the research to date in the UK on ammonia abatement from manure storage has focussed on liquid manures, hence, there was a need to quantify the effects of contrasting solid manure storage regimes on ammonia emissions. In addition to investigating the effect of contrasting manure storage methods on ammonia losses during storage, there was also a need to consider the 'down stream' impacts of the different storage methods on ammonia losses following land application, as management practices that retain ammonia during storage will only be beneficial if they do not subsequently exacerbate losses following land spreading. Conversely, there would only be justification for implementing land spreading abatement measures if manures at the end of the storage period contained 'high' concentrations of ammonium-N, that could result in substantial ammonia losses following land application.

MATERIALS AND METHODS

In 2001, broiler litter was stored for 6 months (April to November) at ADAS Gleadthorpe, UK. The broiler litter was stored in heaps containing approximately 15 m^3 of manure on concrete pads. There were 5 storage treatments: conventional, sheeted, turned, 'A-shaped' and roofed, each replicated 3 times. The turned treatment was turned on 2 occasions by a tractor loader; after 14 days and after 2 months. Ammonia emissions from the heaps were measured using specially adapted polytunnel enclosures, based on the windtunnel design developed by Lockyer (1984) and leachate was collected and analysed for total N.

At the end of the storage period in November 2001, the broiler litter from the conventional and sheeted treatments was applied to cereal stubble at a target rate of 250 kg total N/ ha and the land sown with grass. The broiler litter was surface spread or incorporated into the soil by ploughing or discing, either within 4 or 24 hours of spreading. There were 3 replicates of each treatment arranged in a randomised block design. Ammonia emissions following land spreading were measured using the dynamic chamber technique in combination with passive diffusion samplers, as described by Svensson (1994). Nitrate leaching losses were measured using porous ceramic cups from an untreated control and from the surface spread and ploughed within 4 hours treatments, for both the conventional and sheeted broiler litter storage treatments. Nitrate concentrations in the porous cup samples were combined with drainage volume estimates obtained using IRRIGUIDE (Bailey and Spackman, 1996) to calculate nitrate leaching losses. Grass dry matter (DM) yields and N offtakes were measured at harvest in July 2002. The fertiliser N replacement values of the broiler litter treatments were determined by comparing grass yields and N offtakes from the different treatments, with those from plots receiving spring inorganic fertiliser N applications at 6 incremental rates (0-200 kg N/ ha).

RESULTS AND DISCUSSION

Storage losses

Nitrogen losses in leachate from the stored heaps accounted for between 0 and 3 % of N into store, and ammonia volatilisation losses accounted for between 1 and 19 % of N into store (Figure 1). There was a statistically significant effect of storage method on ammonia losses ($P<0.001$). Sheeting the heap reduced ($P<0.05$) ammonia losses by *c*.90 % compared with con-

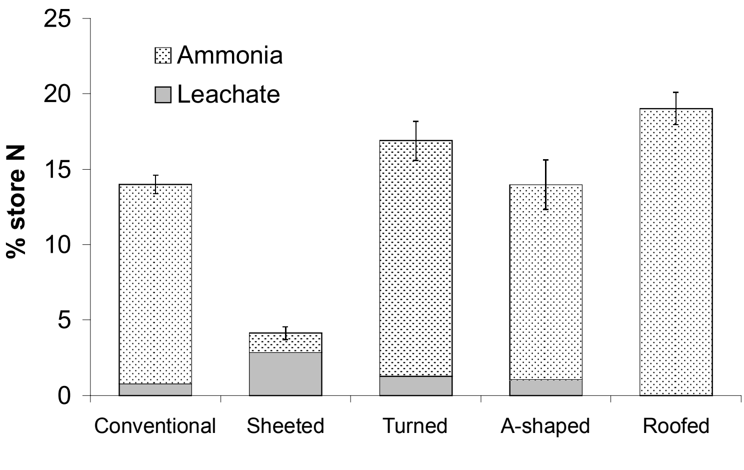
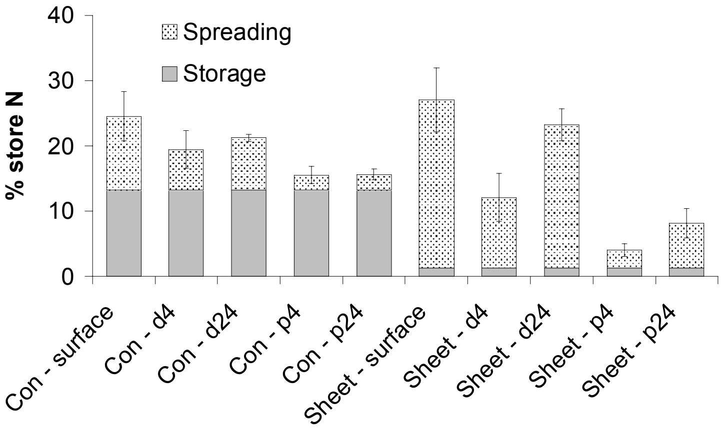


***Figure 1**. Nitrogen lost from broiler litter heaps during storage*

ventional storage (loss from sheeted heap 1.3 % of N into store; loss from conventional heap 13.2 % of N into store). Storage of the manure under a roof (loss 19.0 % of N into store) increased (*P*<0.05) ammonia losses by *c*.40 % compared with conventional storage, which was most probably due to the surface of the roofed heaps remaining 'open and porous' compared with the 'crusted' surface of the conventional heaps that provided a barrier to ammonia losses. There were no differences (*P*>0.05) in emissions between the conventional, A-shaped and turned heaps.

Land spreading losses

The conventional and sheeted broiler litter storage treatments were land spread and subsequently soil incorporated in November 2001. The readily available-N (ammonium-N plus uric acid-N) expressed as a percentage of the total N in the broiler litter was 37 % for the conventionally stored broiler litter and 49 % for the sheeted broiler litter, confirming the greater retention of readily available N during sheeted storage. There was a statistically significant effect of both method of storage and soil incorporation on ammonia losses at land spreading (*P*<0.001). Ammonia losses from the sheeted broiler litter were overall greater than from the conventionally stored broiler litter (Figure 2). Ploughing within 4 or 24 hours of application was the most effective incorporation method for reducing ammonia losses, reducing emissions by > 70 % compared with surface spreading. Discing within 4 hours reduced ammonia losses compared with surface spreading by 30 and 58 % for the conventional and sheeted broiler litters, respectively. Discing within 24 hours reduced ammonia losses compared with surface spreading by 30 and 15 % for the conventional and sheeted broiler litters, respectively.



Con = Conventional; Sheet = Sheeted; d4 = Disced within 4 hours; d24 = Disced within 24 hours; p4 = Ploughed within 4 hours; p24 = Ploughed within 24 hours.

Figure 2*. Ammonia volatilisation losses during storage and following the land spreading of broiler litter.*

Ammonia losses from the surface spread sheeted broiler litter at 27 % of N into store were similar to those from the conventionally stored surface spread broiler litter (25 % of N into store), indicating that the ammonia conserved at storage by sheeting the manure was subsequently lost at land spreading if the manure was not soil incorporated.

Nitrate losses

Nitrate leaching losses were measured following land application of the conventional and sheeted broiler litter storage treatments, where these had been surface spread or ploughed in within 4 hours of application. Compared with surface spreading, incorporating the broiler litter increased (P<0.05) leaching losses from 4.2 % to 13.7 % of N into store for the sheeted treatment, with no differences between the conventional storage treatment (surface applied and ploughed in losses 5.9 % and 6.9 % of N into store, respectively).

Crop yields and N offtake

Ploughing in both the conventional and sheeted broiler litters doubled grass yields from *c*.3 t DM/ ha to > 6 t DM/ ha, and increased crop N offtakes from 55 kg N/ ha to 70-90 kg N/ ha. The percentage of N recovered in the grass ranged from 7.6 % of the N into store for the conventional surface spread broiler litter to *c*.20 % for the sheeted broiler litter that was ploughed in within 4 or 24 hours. Based on grass N offtakes the broiler litter treatments had fertiliser N replacement values of between 35 kg N/ ha (conventional surface spread broiler litter) and *c*.100 kg N/ ha (sheeted broiler litter ploughed in within 4 or 24 hours).

CONCLUSIONS

Sheeting broiler litter during storage was shown to reduce ammonia volatilisation losses and storage under a roof to increase losses compared with conventional storage. To realise the benefits of sheeting, the broiler litter had to be rapidly soil incorporated following land spreading, otherwise the ammonia conserved during storage was subsequently lost at land spreading. Compared with surface spreading of the conventionally stored broiler litter, sheeting the heap and ploughing within 4 hours reduced ammonia emissions from 24.6 to 4.0 % of N into store. However, nitrate leaching losses were increased from 5.9 % (conventional, surface spread) to 13.7 % of N into store (sheeted, ploughed within 4 hours). Overall, crop N recovery was highest where the broiler litter had been ploughed into the soil. These measurements provide a good example of 'nitrogen pollution swapping' (i.e. an ammonia reduction strategy increasing nitrate leaching losses) and highlight the need to develop integrated manure management systems that consider all N loss routes and forms.

REFERENCES

Anon. 2002. Ammonia in the UK. Department for Environment, Food and Rural Affairs. DEFRA Publications, London, PB6865.

Bailey, R.J., Spackman, L. 1996. A model for estimating soil moisture changes as an aid to irrigation scheduling and crop water-use studies: I Operational details and description. Soil Use Manag., 12: 122-129

Lockyer, D.R. 1984. A system for the measurement in the field of losses of ammonia through volatilisation. Jour. Sci. Food Agr., 35: 837-848

Svensson, L. 1994. A new dynamic chamber technique for measuring ammonia emissions from land-spread manure and fertilizers. Acta Agric. Scand., Sec. B. Soil Plant Sci., 44: 35-46