Slurry application techniques to reduce ammonia emissions: field experiments in Basque Country and Navarra

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Abstract

Agriculture is known to produce up to 90% of anthropogenic ammonia (NH_3) emissions to the atmosphere, and techniques to reduce NH_3 emissions following application to land have been identified to be among the most cost-effective measures available to farmers to reduce NH_3 emissions. In this study, two slurry application techniques (trailing hose application and injection) were performed in order to estimate the NH_3 emissions abatement achieved in comparison with conventional surface spreading via a vacuum tanker fitted with a splashplate. Field experiments were conducted on three sites across Basque Country and Navarra, applying pig slurry onto arable lands (cereal stubbles). Cumulative NH_3 emissions during the first day following slurry application were significantly reduced using trailing hose and injection techniques, achieving a reduction of 26% and 93%, respectively, with respect to the conventional surface spreading.

Introduction

Several estimates have shown that agriculture produces up to 90% of anthropogenic ammonia (NH_3) emissions to the atmosphere [1, 2] and the land application of manure represents a major source of NH_3 emissions to the atmosphere in Europe, often accounting for 30–40% of total national emissions [2]. So, abatement of emissions following the application of manures to land is a priority in the development of international approaches to reduce emissions of NH_3 [3]. In this sense, techniques to reduce NH_3 emissions following application to land have been identified to be among the most cost-effective measures available to farmers to reduce NH_3 emissions [4, 5, 6].

Surface placement application techniques for slurry (shallow injection, band spreading and trailing shoe), have resulted in reductions in NH_3 emission of between 70 and 95% compared with surface broadcast application in Netherlands and Germany; however, abatement efficiencies reported under UK conditions are generally lower [7].

In this study, two slurry application techniques (trailing hose application and injection) were performed in order to estimate the NH_3 emissions abatement achieved on representative arable soils in the Basque Country and Navarra, in comparison with conventional surface spreading via a vacuum tanker fitted with a splashplate (surface broadcast).

Material and Methods

Field experiments were conducted on three sites across Navarra and the Basque Country between 2010 and 2011, applying pig slurry onto arable lands (cereal stubbles) and comparing two application techniques with three repetitions in each one: splashplate (P) *vs.* trailing hoses (T) or splashplate *vs.* injection (J). Details of experiments are given in Table 1.

The trailing hose machines had 0.30 m hose spacing and 13 m working width, while the injection machine had seven solid tines to cut the injection slots (10-15 cm deep), spaced 0.35 m from each other (2.5 m working width).

Measurements of NH_3 emissions were made using the dynamic chamber technique, in conjunction with a photoacoustic infrared gas analyser (Brüel and Kjaer, 1302 Multi-Gas Monitor) [8].

Table 1. Experimental details for pig slurry applications on cereal stubble.

Site		1	2	3
Treatments		P *vs.* T	P *vs.* T	P *vs.* J
Rate	Total N (kg N ha^{-1})	123	60	300
	NH4-N (kg N ha^{-1})	109	56	232
Long., lat. (m)		560230E, 4718816N	610167E, 4702028N	521740E, 4748863N
Date		8.9.2010 and 9.9.2010	27.7.2011	4.10.2011
Time of fertilization		11:00 h	12:30 h	10:30 h
Measurement duration		6.5 and 6 hours (1st and 2nd day)	6.5 hours	8 hours
Temperature range		14.7ºC - 22ºC	25ºC - 30ºC	17.5ºC - 30.3ºC
Soil	Texture	Sandy clay loam	Clay loam	Clay loam
	pH	8.4	8.2	8.2
	Organic matter (%)	1.2	2.3	3.6
	Mineral N (kg ha^{-1})	60	67	110
Slurry	Dry matter (%)	0.66	0.74	1.36
	pH	7.5	7.7	6.9
	Organic matter (%)	52.3	45.9	58.0
	Total N (%)	0.2	0.15	0.26

Results and discussion

In Experiment 1, no abatement of cumulative NH_3 emissions was observed using T technique because the entire surface was covered with slurry, due to the low dry matter of the slurry (0.66%) and the high rate applied (60 m^3 ha^{-1} or 123 kg N ha^{-1}). But in Experiment 2, reduction in emissions with T technique (26.3%) was statistically significant at level 0.05 ($p<0.05$).

This is consistent with the fact that the application of slurry in narrow bands (band spreading obtained with trailing hose or trailing shoe), rather than over the entire soil or crop surface, reduces emissions by decreasing the area of slurry exposed to the air [9]. Perhaps a reduction of 26.3% obtained in Experiment 2 may be high, because the effectiveness of band spreading decreases if the slurry is placed on bare soil or below a small plant canopy [9, 10, 11] and there was only stubble in the Experiment 2. However, the trailing hose reduces NH3 emissions by 10–50% [12], there is a considerable variation in the efficiencies reported which varies between 0% and 75% [13] and it is considered that trailing hoses are, in general, more effective on arable than on grassland and when used with dilute than with more viscous slurries [3].

Finally, in Experiment 3, in which comparison was made between P and J techniques, a statistically significant reduction of 93.4% was achieved with the latter ($p<0.05$). Other authors have also observed that NH_3 emissions may be reduced by up to 90%, depending on depth of injection, because injection places slurry below the soil surface so decreasing the surface area exposed to air and increasing contact with the soil and leading to rapid immobilization of NH_3 on clay particles and organic matter [3]. In this experiment the injection depth was greater than 10 cm in Experiment 3, in this sense, Nyord et al. [11] reported that injection depth needs to be at least 5 cm to be effective in reducing emissions of NH_3.

Although, crop, climate and soil conditions (e. g. temperature, wind speed or pH) influence NH_3 emissions, these results obtained in the Basque Country and Navarra were of a similar order to that reported by other authors, in particular from UK and Europe.

NH_3 emission peaked within the first 3 hours after slurry surface spreading in the three experiments (Figure 1), as reported in other trials; e.g. Sanz *et al.* [14] found NH_3 emission peak within the first 5 hours after pig slurry application to a bare soil in central Spain. The NH_3 emissions were less fluctuant in the other two treatments, except when T technique was used in Experiment 1 because the soil surface was covered completely with slurry.

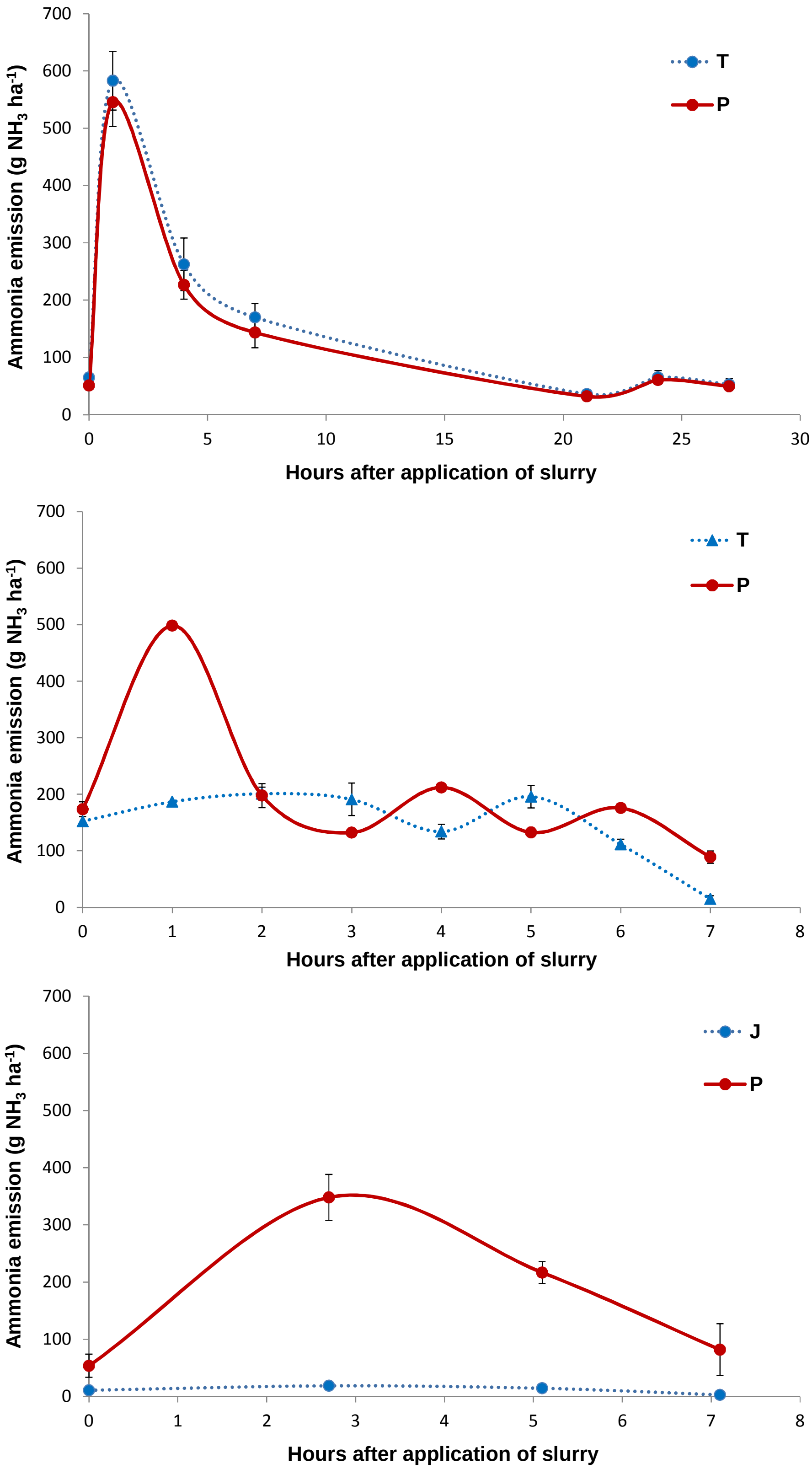

Figure 1. NH_3 emissions from slurry applied to soil using different application techniques in Experiment 1, 2 and 3. Each value is the mean of three replicates and the vertical bars indicate the standard error for each sampling time.

Conclusion and perspectives

Cumulative NH_3 emissions during the first day following pig slurry application were significantly reduced using trailing hose and injection techniques, achieving a reduction of 26% and 93%, respectively, with respect to the conventional surface spreading. Nevertheless, there may be no reduction if the technique of trailing hose is not used properly and the entire surface is covered with slurry.

These reduced-NH_3 emission application techniques will also increase crop uptake of slurry-N, increasing the value of slurries. But there may be circumstances under which reduced-NH_3 application techniques increase emissions of N_2O [11], so field studies reporting both NH_3 emissions and N_2O emissions are needed.

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