Vertical Tillage to Reduce Ammonia Volatilization and Conserve Residue after Dairy Manure Application

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INTRODUCTION

The loss of nitrogen (N) in surface-applied dairy manure through volatilization as ammonia (NH_3) is a primary concern both economically and environmentally. Manure incorporation by conventional tillage has been shown to greatly reduce NH_3 losses, but the associated reduction in surface residue may lead to increased erosion. Vertical tillage, as a form of conservation tillage, has become popular in recent years, and a number of implements with varied functionality are being marketed for this purpose. Their effectiveness for incorporating manure is not well researched however.

MATERIALS & METHODS

Field Site and Experimental Design

Univ. of Wisconsin/USDA-ARS Research Station, Stratford/Marshfield, in central WI.

- Withee silt loam (Aquic Glossudalfs); somewhat poorly drained, 1-3% slope.
- Six trials conducted Sept 2013 – May 2016 in fields of harvested silage (Trials 1, 6), grain corn (Trials 4, 5), or oats (Trials 2, 3).
- Plots 9 x 24 m or 15 x 15 m arranged in randomized complete block design with 3 replicates.
- Statistical analysis by ANOVA using SAS-GLM. Multiple means comparison using Fisher's LSD (alpha=0.10).

Treatments

Liquid or solid manure was applied and incorporated within 5 min. where applicable.

- No manure control
- Surface Broadcast application
- Chisel Plow (CP) incorporated broadcast manure (15 cm tillage depth)
- Vertical Tillage (VT) incorporated broadcast manure (Case IH 330 – 8 cm tillage depth (Trials 1-4) or Great Plains Turbo Max 1800 – 5 cm tillage depth (Trials 5-6))

Surface Broadcast

Chisel Plow

Vertical Tillage (Case IH 330)

Vertical Tillage (Great Plains Turbo Max 1800)

Case IH 330

Great Plains Turbo Max 1800

Field Measurements:

- Ammonia was measured using Ogawa passive samplers (Ogawa USA Co.), 3 per plot positioned 30 cm above the ground, upwind samplers were also used to determine background levels.
- Samplers were collected after 24 h and a new set was deployed for a second 24 h. Fick's law was used to determine concentrations (Roadman et al., 2003).
- Manure was analyzed for DM, TN, and NH_4-N.
- Surface residue cover measured using photographs (2 per plot) and digital imagery analysis (SamplePoint software; Booth et al., 2006).
- Soil moisture was measured and soil samples (for pH, NH_4-N, and OM) were collected 6 per plot (20 cm depth).
- Weather conditions were measured at edge of field.

RESULTS

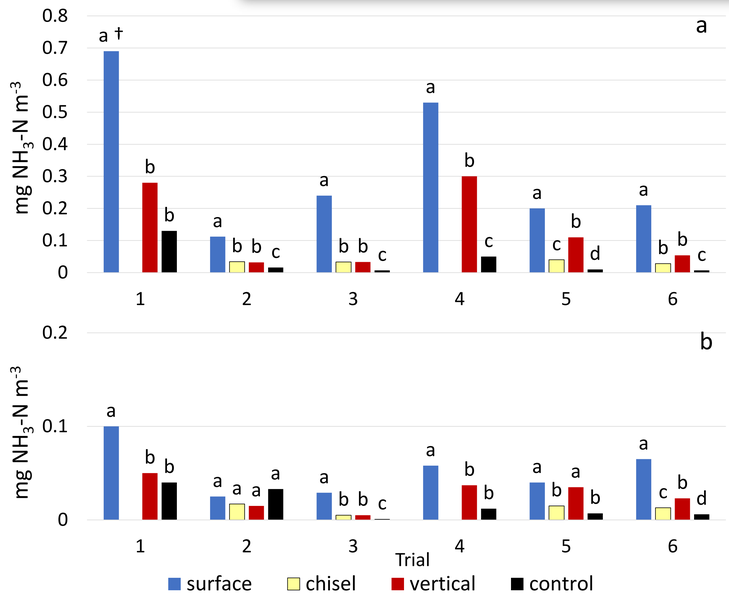

Figure 1. Average NH_3-N concentration for each treatment and trial during the first 24 h (a) and second 24 h (b) after application. Note the scale difference.

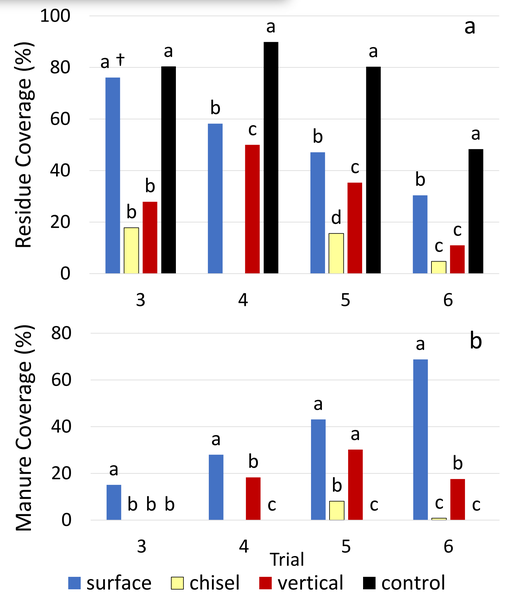

Figure 2. Residue cover (a) and manure cover (b) for selected trials.

Figure notes: † bars with the same letter within a trial date are not significantly different at alpha=0.1

Table 1. Manure composition, nutrients applied, and average weather data for each trial

Trial	Date	DM †	TN	NH_4-N	Appl Rate	N	NH_4-N	Temp	Total Rain	Wind Speed
			%		Mg ha^{-1}	kg ha^{-1}		°C	mm	m s^{-1}
1	25 Sept. 2013	28.6	1.80	0.35	95.3	484	94.1	13.9	0.0	2.55
2	2 July 2014	1.47	6.83	4.5	53.6	81.9	53.9	16.4	0.0	1.31
3	11 Aug. 2015	5.13	3.27	1.3	83.9	137	54.7	20.0	0.0	0.93
4	4 Nov. 2015	21.8	1.55	0.70	110	412	185	14.1	8.4	2.80
5	3 May 2016	8.70	3.05	1.5	69.6	181	89.2	9.40	7.1	2.03
6	17 May 2016	6.50	3.10	1.3	90.9	180	73.7	11.1	1.3	0.43

† DM = dry matter, TN = total nitrogen

- Vertical tillage (VT) with Case IH 330 and chisel plow (CP) showed similar NH_3 concentration reductions (70-86% less than surface broadcast treatments (Trials 2 and 3)) in both first and second 24 h periods. Case IH consistently showed reductions compared to surface broadcast (44-86%) in both time periods (Trials 1-4) (Fig. 1).
- Less aggressive Great Plains VT implement (trials 5-6) while reducing NH_3 concentrations 46-75% in the first 24 h compared to surface broadcast, showed higher NH_3 concentrations than CP in the first (93-175% greater; NS in Trial 6) and second (77-133% greater) 24 h periods.
- The higher NH_3 loss in surface broadcast and VT treatments in Trials 1 and 4, particularly in the first 24 h, is likely due to minimal infiltration with high DM content manure (Fig. 1, Table 1).
- Residue cover with VT was statistically similar to CP in Trials 3 and 6, but was twice that of CP with Great Plains VT (Trials 5 and 6, though NS in 6; Fig. 2).
- Less aggressive Great Plains implement left more manure on soil surface than Case IH 330.

CONCLUSIONS

- Incorporation reduced losses of NH_3 in both time periods in most cases and more aggressive VT can reduce NH_3 concentrations, but also residue cover, to near conventional tillage levels.
- The type of VT implement used can affect manure incorporation, residue coverage and amount of NH_3-N conserved.

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