Reduce Ammonia Emissions from Manure Land Application with Banded Subsurface Deposition

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This article was written for publication in the November / December 2006 Biosystems and Agricultural Engineering Newsletter, Michigan State University, East Lansing, MI

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Dairy and livestock farmers face increasing economic and environmental challenges as they look to the future. Many crop and livestock farmers have adopted low-disturbance tillage and soil conservation practices to improve profitability and protect the environment. Cropping systems that reduce tillage intensity, conserve crop residue and increase the use of cover crops improve soil quality and protect the environment in many ways. Although a modified no-till cropping system using aeration tillage on dairy and livestock farms reduced machinery costs 25%; fuel costs, 45%; and labor costs, 50% compared to conventional tillage and planting (Harrigan et al., 1996; fig.1), environmentally sensitive manure land application continues to be a challenge in no-till cropping systems.

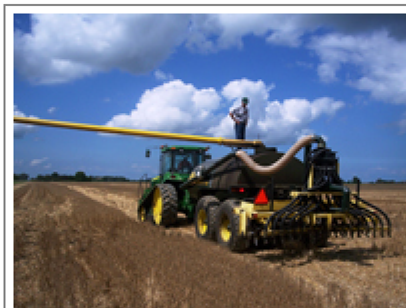

Fig. 1 . Volatile ammonia losses following aeration tillage with sub-surface slurry deposition were compared with losses from surface spreading and surface spreading with rapid incorporation.

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The best way to recover costs associated with manure storage and handling is to apply the manure at an agronomic rate, account for the nutrients, and reduce subsequent commercial fertilizer purchases. Non-mobile nutrients such as potassium (K) and phosphorus (P) are easy to account for, but calculating nitrogen (N) credits is a challenge. Manure contains nitrogen in inorganic and organic forms. Organic N is not available for crop growth until it is mineralized to ammonium (NH_4^+). Ammonium N is fairly stable and available for plant uptake, but a portion is immobilized by microbial biomass and nitrifying bacteria convert NH_4^+ to nitrate (NO_3^-) which is subject to loss by leaching or denitrification and subsequent loss to the atmosphere. Volatile ammonia (NH_3) is transformed from NH_4^+ and can be lost to the atmosphere after land application.

Nitrogen lost to the atmosphere is not available for crop production. Injecting the slurry into the soil or incorporating it with tillage are the most effective ways to reduce NH_3 losses, but most tillage and injection tools are not compatible with no-till cropping. Ammonia emissions increase with an increase in temperature and wind speed, and decrease with an increase in relative humidity. Emission is generally greater with an increase in slurry dry matter and viscosity because these delay infiltration. Rapid infiltration reduces volatile N losses because sorption of NH_4^+ on to soil colloids reduces the concentration of total ammoniacal nitrogen (TAN) in the soil solution.

Little is known about the effects of aeration tillage and subsurface slurry deposition on NH_3 losses. Measurements of NH_3 emission from liquid manure land application were made in multiple locations in 2006. Ten thousand gallons per acre of liquid manure was applied with three levels of tillage: 1) no-tillage, surface applied through drop tubes, 2) aeration tillage, banded, sub-surface deposition through drop tubes behind each set of aeration tines, and 3) surface application, immediate incorporation with tillage. This article reports on the results of ammonia emissions gathered from two locations.

Methods and Materials

Aeration tillage was provided with a rolling-tine aerator (12 ft; AerWay) [1] mounted behind a 3,000 gal. slurry tanker. The rolling-tine aerator was ground-driven with sets of four, 8-inch tines mounted on a rotating shaft with 7.5 inches between each set of tines. The tines were angled slightly on the shaft to provide lateral movement and loosening of the soil. The angle of the rotating shaft was adjustable in 2.5° increments from 0° to 10° relative to the direction of travel. The angle was set at the 10° for maximum soil loosening.

Ammonia gas flux was measured hourly during daylight hours for 24 hours by collecting NH_3 emissions within a non-flow through, non-steady state, vented, plexi-glass enclosure with a basal area of 800 cm^2 and a volume: basal area ratio of 10 cm. The enclosure restricted the volume of air available for exchange across the covered surface and the net emission was measured as a concentration change with a NH_3 –specific detector tube (Dräger). The detector tube provided a direct colorimetric indication of the ammonia concentration. The duration of the collection time was ten minutes. Concentrations (vol.-ppm NH_3) were reported as averages of two simultaneous measurements.

Results

August 8-9, Tuscola Co.

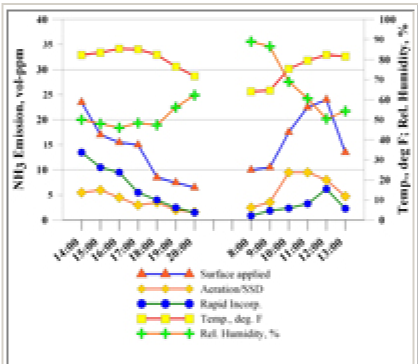

Fig. 2 . Ammonia emissions from three slurry application

Dairy slurry was applied at mid-day to untilled wheat stubble on a sandy clay-loam soil in Tuscola Co. Incorporation of the surface applied slurry occurred within five minutes of spreading with a single pass of a combination disk/deep-chisel tillage tool. Initial losses for each application method were greatest immediately after spreading, but the rate of loss decreased at a nearly constant rate until sundown (Fig. 2). On the day of spreading the greatest NH_3 loss followed the surface application; the least NH_3 loss followed aeration tillage; and intermediate losses were measured following rapid incorporation. Initial losses with aeration tillage were 23% and rapid incorporation losses were 57% of surface spreading alone.

methods in Tuscola Co.

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The greatest NH_3 losses on the day after application were from surface spreading. Losses with aeration tillage were greater than with rapid incorporation. By noon of the second day, NH_3 emissions from the surface application were as great as the initial losses on the day of spreading.

October 9-10, Ingham Co.

Liquid dairy manure was applied to corn silage stubble on a sandy loam soil in East Lansing on 9 October 2006. The slurry was incorporated with a conventional disk harrow within a few minutes of application. Ammonia emissions from the tilled plots were very low throughout the collection period indicating thorough soil coverage of the slurry. The greatest initial losses were from the surface applied slurry (37.5 vol.-ppm) and the aerated plots (26.5 vol.-ppm; Fig.3). The NH_3loss from the surface application with rapid incorporation was less than 10% of the other treatments. The initial loss from aeration was about 70% of the surface application. Ammonia emission from aeration tillage decreased at a faster rate than with surface spreading; one hour after spreading NH_3 losses were only 34% of surface spreading. On the day after spreading emissions remained low for all application methods as ambient temperatures were low, ranging from the upper 40's to low 60's.

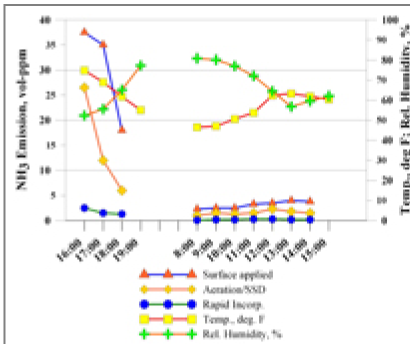

Fig. 3. Ammonia emission from three slurry application methods in Ingham Co.

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Conclusions

• Aeration tillage with sub-surface deposition decreased NH_3 losses largely by improving infiltration. Aeration tillage was most effective when combined with wheat stubble to reduce air movement at the soil/air interface. In wheat stubble, initial NH_3 emissions with aeration tillage and sub-surface deposition were 23% of surface spreading alone.

- Reducing NH_3 losses with rapid incorporation requires effective soil coverage of exposed slurry. In practice, there is often a one- or two-hour delay between surface spreading and incorporation to allow infiltration and drying of the slurry. This delay occurs when the NH_3 losses are greatest, and this reduces some of the N recovery advantage of rapid incorporation compared to other land application methods.

- The initial rate of NH_3 loss was high for each application method because of the initially high concentration of total ammoniacal N (TAN). The volatilization rate decreased rapidly as the TAN in the slurry surface layer decreased due to volatilization and infiltration.

- Losses declined as the ambient temperature decreased and relative humidity increased.

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[1]Mention of trade names, proprietary products, or specific equipment is intended for reader information only and constitutes neither a guarantee nor warranty by Michigan State University , nor does it imply approval of the product named to the exclusion of other products.