Improving manure management to balance nitrogen use efficiency and environmental trade-offs

Emily Duncan[1*], Peter Kleinman[2], Curtis Dell[2], Doug Beegle[1], Heather Karsten[1]

[1]Penn State University, College of Agricultural Sciences, University Park PA, 16802

[2]USDA Agricultural Research Service, 3702 Curtin Rd, University Park, PA 16802

*ewd5089@psu.edu

Introduction

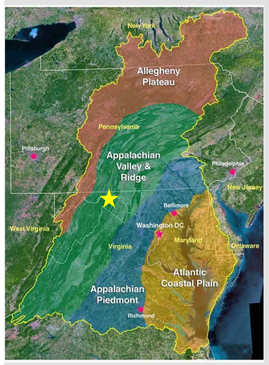
Manure management technologies that conserve nitrogen are ideal in no till systems. Shallow disk injection technology gets the liquid dairy slurry under the soil surface which minimizes ammonia volatilization. One potential trade-off caused by injecting the dairy slurry is an increase in nitrous oxide (N_2O) emissions. This study seeks to assess trade-offs associated with conventional and new manure application methods on a sustainable dairy farm in central Pennsylvania.

Objectives

To measure ammonia volatilization loss and nitrous oxide emissions from two different manure management strategies:

- Conventional broadcast
- Shallow disk injection

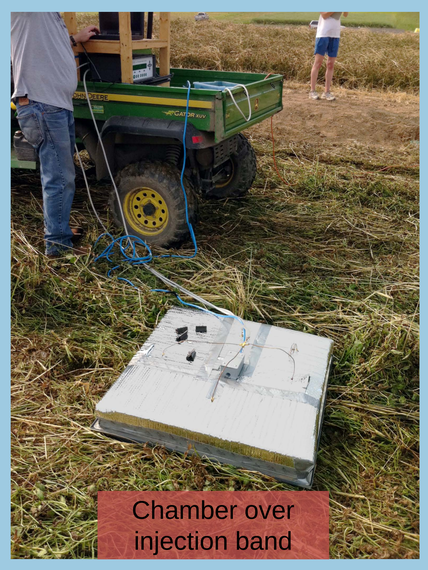
Study site

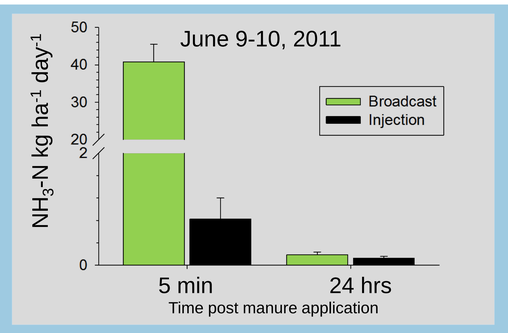


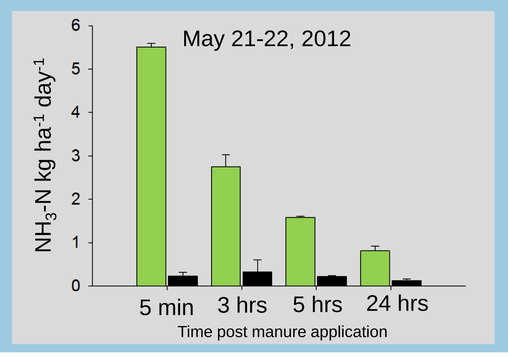
Located in Rock Springs, PA, USA. Within the Ridge and Valley region of the Chesapeake Bay Watershed

NH_3 emissions

differed significantly for both 2011 and 2012 between broadcast and injection application, with greater fluxes corresponding to increased exposure of applied manure to the atmosphere. In 2011 we had two sampling times for each treatment. In 2012 we sampled at 3 different times on the day of application, and once on the day after application (24 hours after).


Chamber over injection band

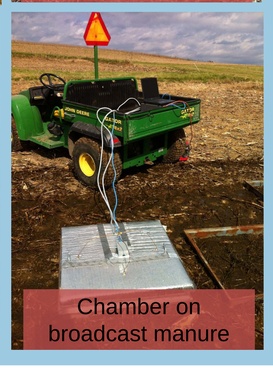


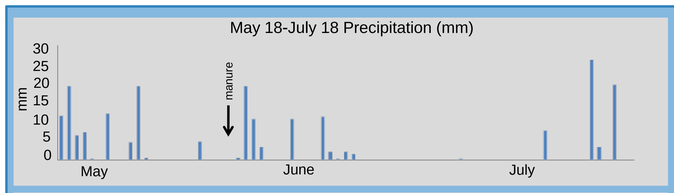


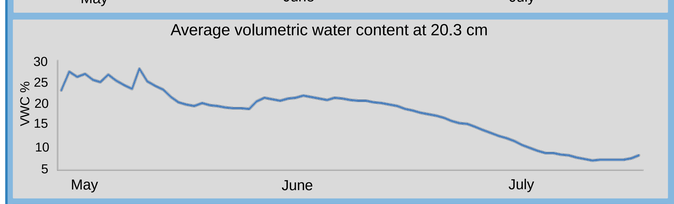

Shallow disk injection application

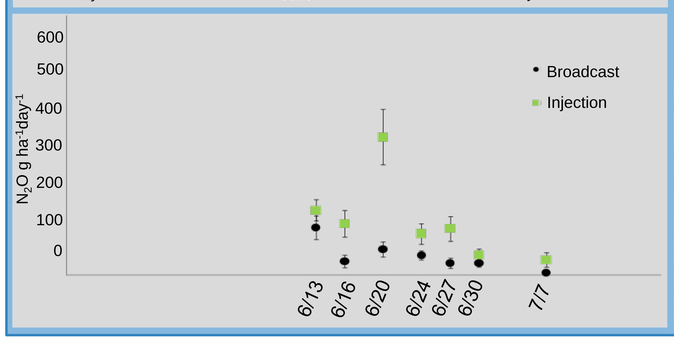

Broadcast manure application


Frames and INNOVA set up


Chamber on broadcast manure



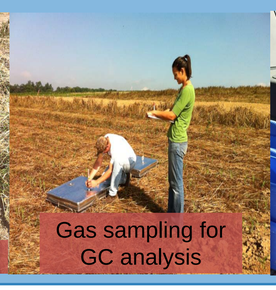




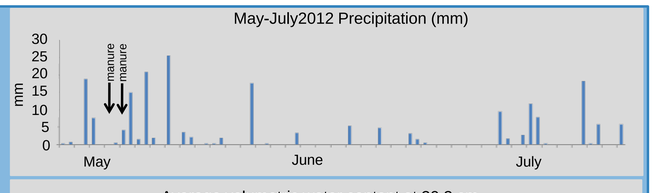
N_2O fluxes declined after manure application, reflecting drying of the manure.

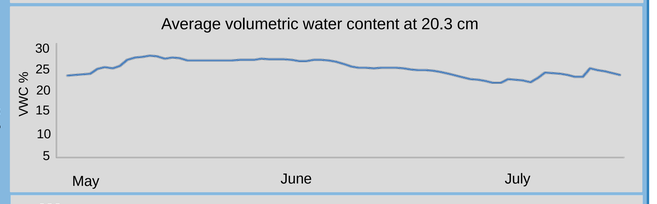
A notable spike in N_2O from injected manure indicates delayed activity of the denitrifying microbial community. Plots spread in 2012 show similar trends to 2011, but plots spread on the second date in 2012 show fewer differences between broadcast and injection.

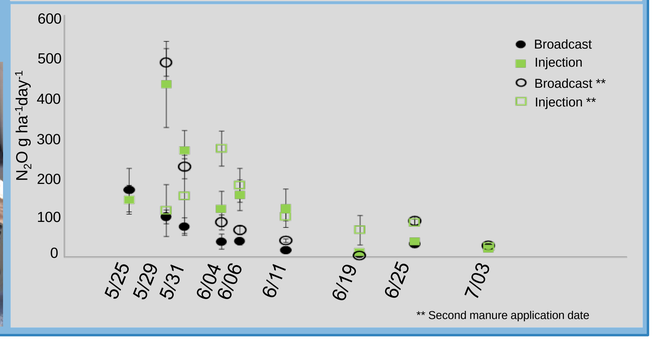

Injection bands


Gas sampling for GC analysis


Transferring N_2O samples







Experimental Design

Two manure application treatments were imposed on 15 x 27 m field lysimeters established on a Hagerstown soil (fine, mixed, semi-active mesic Hapludalf).

Broadcast application

Shallow disk injection


INNOVA and laptop


Collecting INNOVA data

All ammonia measurements were taken using an in-field photoacoustic gas analyzer (INNOVA). The machine is then connected to a 76.2 x 76.2 cm chambers for measurements over time.

Nitrous oxide measurements were taken using the same size chambers used for ammonia measurements. N_2O sampling began 3 days after manure application. Samples were collected at 3 times over 20 min intervals. Each sample was taken back to the lab for analysis on the gas chromatograph.


Pulling N_2O samples


N_2O sampling

Conclusions

Incorporation of manure using shallow disk injection significantly decreases ammonia volatilization losses.

Injection bands cause some brief peaks in nitrous oxide, but how do we make these results environmentally relevant?

Overall, shallow disk injection offers an alternative to broadcast manure that can improve nitrogen efficiency.

Future Research

- Continue to collect N_2O and NH_3 samples
- Collect water quality samples for nitrate and ammonium
- Quantify a water budget
- Create a nitrogen budget
- Apply data to a model