Dairy Manure Application Methods: N Credits, Gaseous N Losses, and Corn Yield

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Situation

- Ammonia losses from surface-applied manure can be large, reducing manure N availability/economic value and contributing to environmental problems
- Nitrous oxide (N_2O) is a potent greenhouse gas that can be released from manure
- Injection or quick tillage incorporation reduces NH_3 loss but may (or may not) increase N_2O emissions
- How do manure management variables (timing, method, incorporation time) affect
  - the balance or trade-off between NH_3 and N_2O losses?
  - N availability to corn?
- Can sidedressed manure be a viable N source?

Sidedress Manure?

Quebec

Vermont (Jokela)

Ontario (Ball-Coehlo)

Objective

- Evaluate the effect of liquid dairy manure application method and timing, and time of incorporation on:
  - Corn yield and manure N availability/N credits
  - Ammonia losses
  - Nitrous oxide emissions

Field Site

- Marshfield Ag Research Station
- Withee silt loam
  - Aquic Glossudalf
  - Somewhat poorly drained, 0-2% slope
- Previous crop = corn
  - New site each year

Treatments

- Pre-plant manure (mid- late May)
  - Surface application with disk incorporation
    - Immediate (<1 h)
    - 1-day
    - 3-day (surface)
  - Injection
    - S-tine (Kongsgilde Vibro-flex)
    - 15-inch spacing
    - 2-3-inch diam. band , 4-6 in. deep
  - All plots chisel plowed 3-5 days after manure application

Treatments

- Sidedress manure (5-6 lf stage)
  - Injection
    - S-tine (Kongsgilde Vibro-flex) with shields
    - 30-inch spacing
    - 4-6 inches deep
  - Surface (Yr 2, 3, and 4)
- Fertilizer N
  - 6 pre-plant rates (0 to 200 lb/acre)
  - Not evaluated for NH_3 or N_2O

Injected Manure Placement

Manure Source

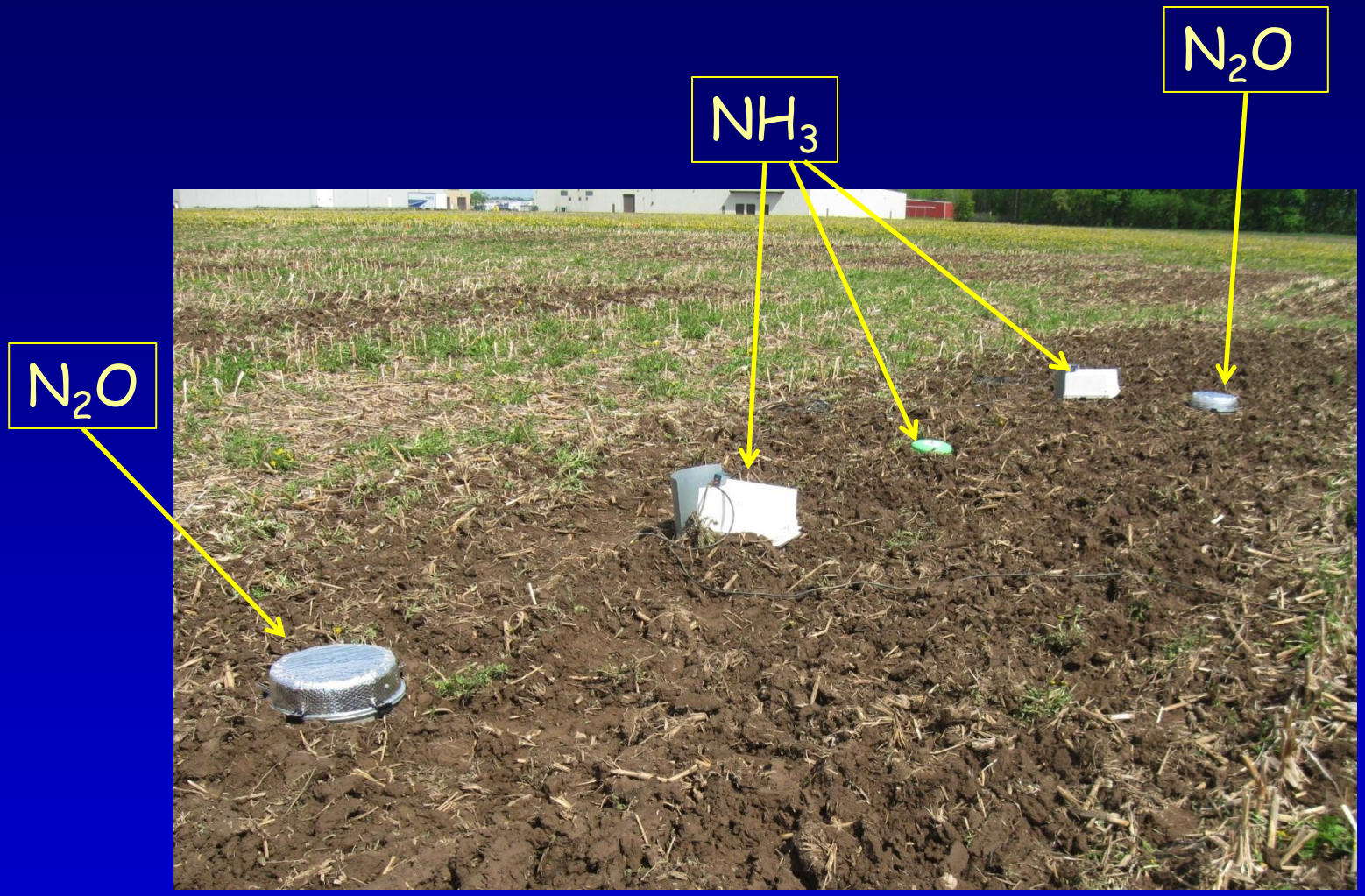
- Liquid dairy manure
  - 6500 gal/acre (target rate)
  - Solids content: 14% (avg.)
  - Sand bedding
  - N application rate (avg.)
    - 2009-2012
      - 146 lb total N/acre
      - 58 lb NH_4-N/acre
    - 2009-2011 (years NH_3 measured)
      - 158 lb total N/acre
      - 62 lb NH_4-N/acre
    - Large variability

NH_3 emission measurement

- Dynamic chamber/equilibrium concentration (Svensson, 1994; Misselbrook and Hansen, 2001)
  - 2 chambers, 1 ambient meter/plot
  - 4 passive diffusion samplers (2 types) in each chamber
- Started immediately after manure application; continued through Day 3
- 6 measurement periods
  - Approx. 0-1, 1-2.5, 2.5-6, 6-20, 20-30, and 44-54 h after manure application

N_2O flux measurement

- Static, vented chamber
- GRACEnet protocol
  - Parkin and Venterea, 2010
- 2 chambers/plot
- Sampled approx. weekly May-Oct
  - More frequently after manure or rain
  - Less frequently late in season
- 3 samples/time (0, 30, 60 min.)
- Flux calculated by linear regression


N_2O
NH_3
N_2O

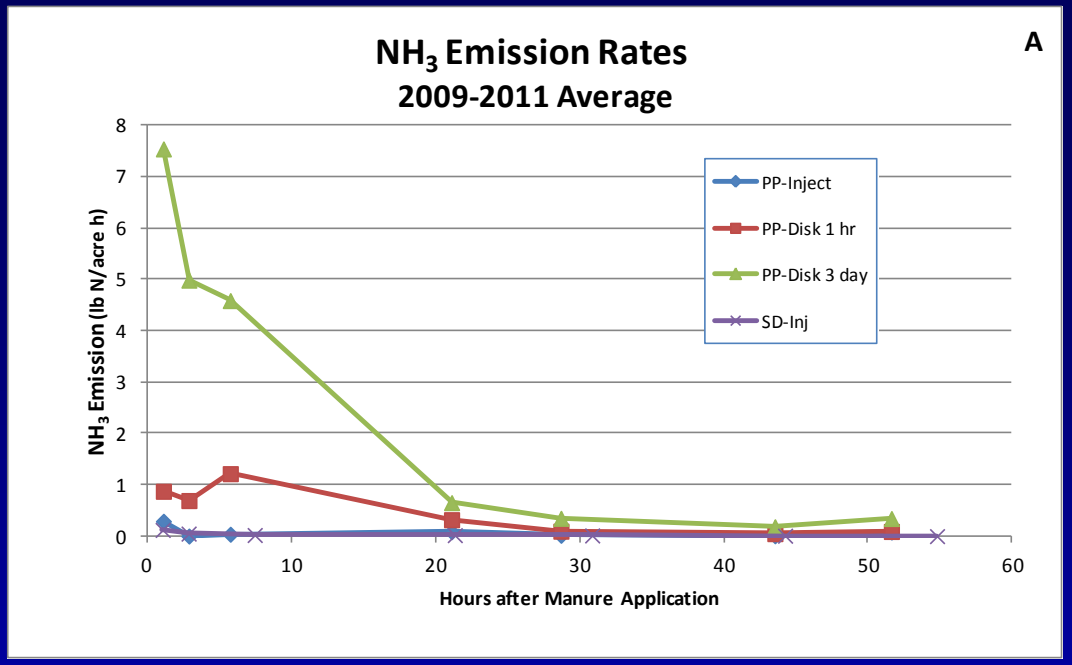
Weather and soil measurements

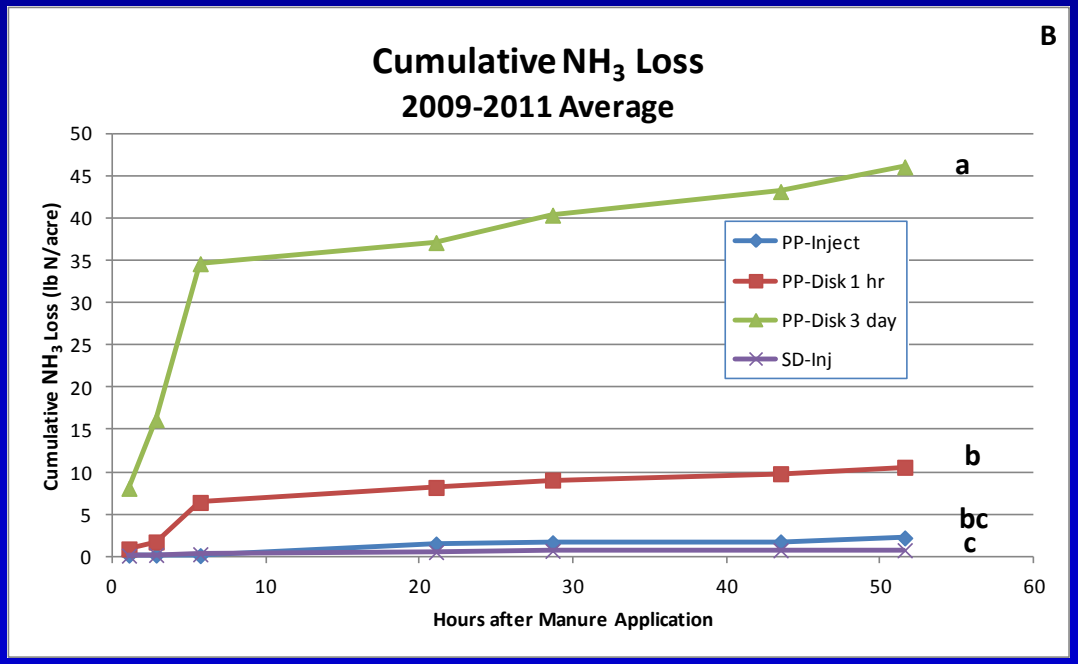
- Throughout season
  - Precipitation, air temperature, wind speed
- At each N_2O sampling
  - Volumetric soil moisture content (Theta probe), 0-2 inch
  - Soil temperature (2-inch depth)
- Periodically (every 1 to 2-month)
  - Bulk density
  - Soil inorganic N (NO_3-N, NH_4-N)

Experimental Design

- Randomized complete design
- 4 replicates (3 for NH_3 and N_2O emission)
- Plot size: 15 x 50-ft
  - 50-75-ft alleys for equipment turning

Results



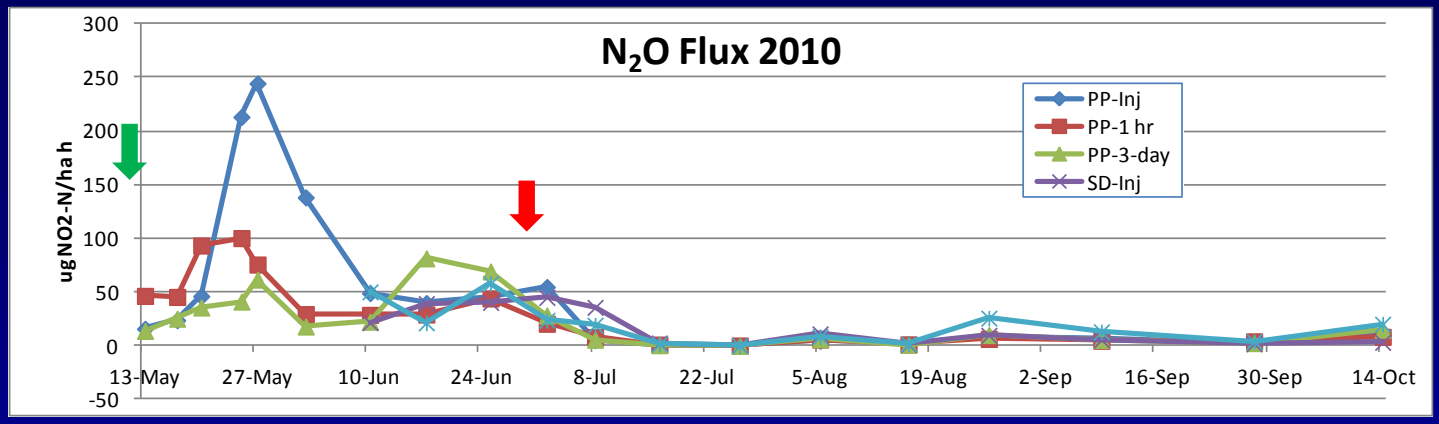


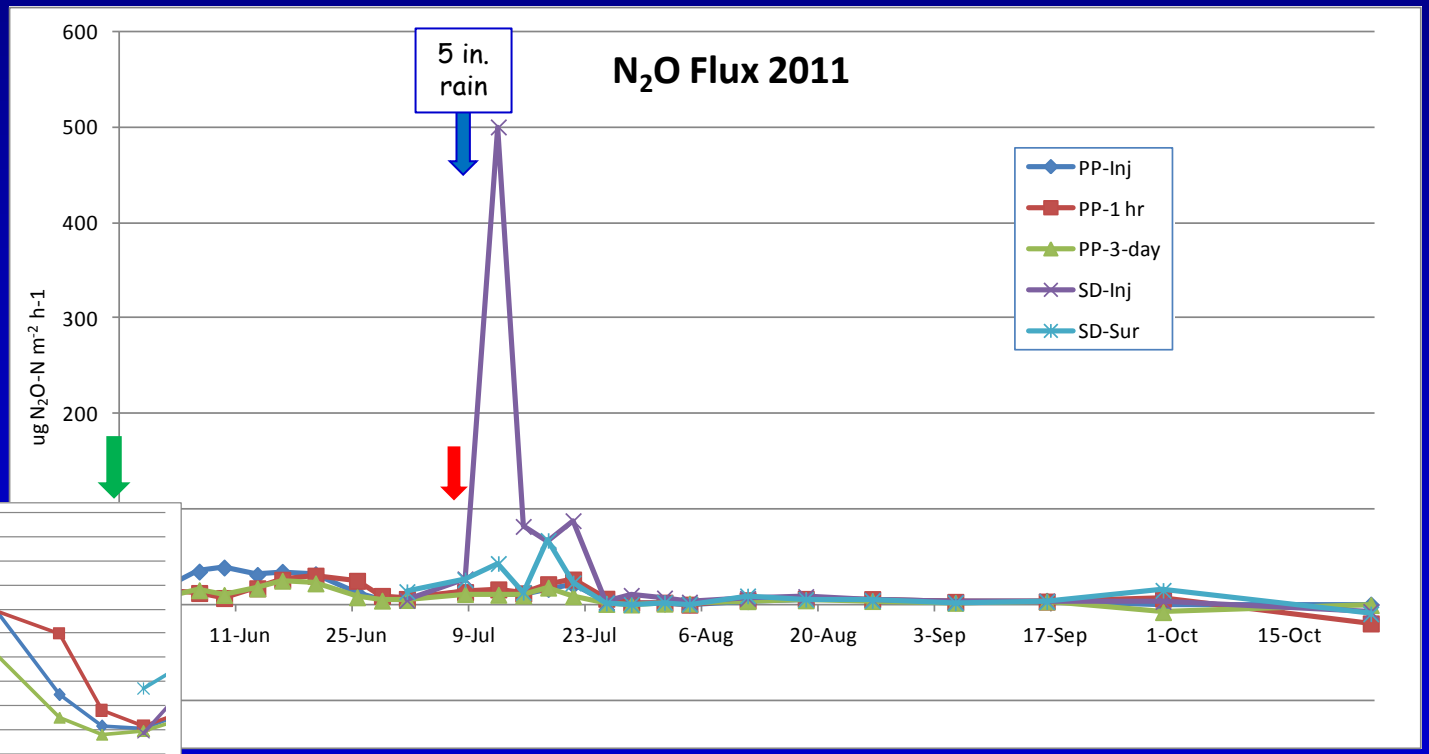
Ammonia Emission 2009-2011 Avg.

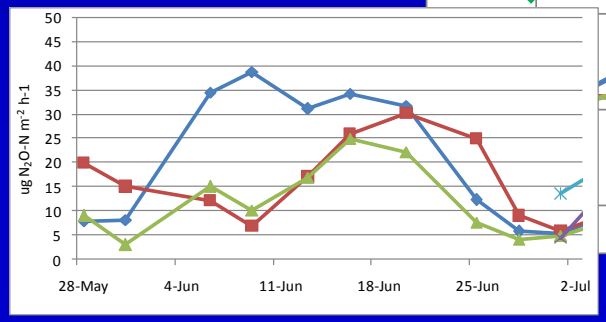
Ammonia Emission

- Most loss in first 6-12 hours after application
- Total 3-day average losses >40 lb/acre for surface application
- NH_3 loss reduced by injection (>90%) or immediate disk incorporation (75%)

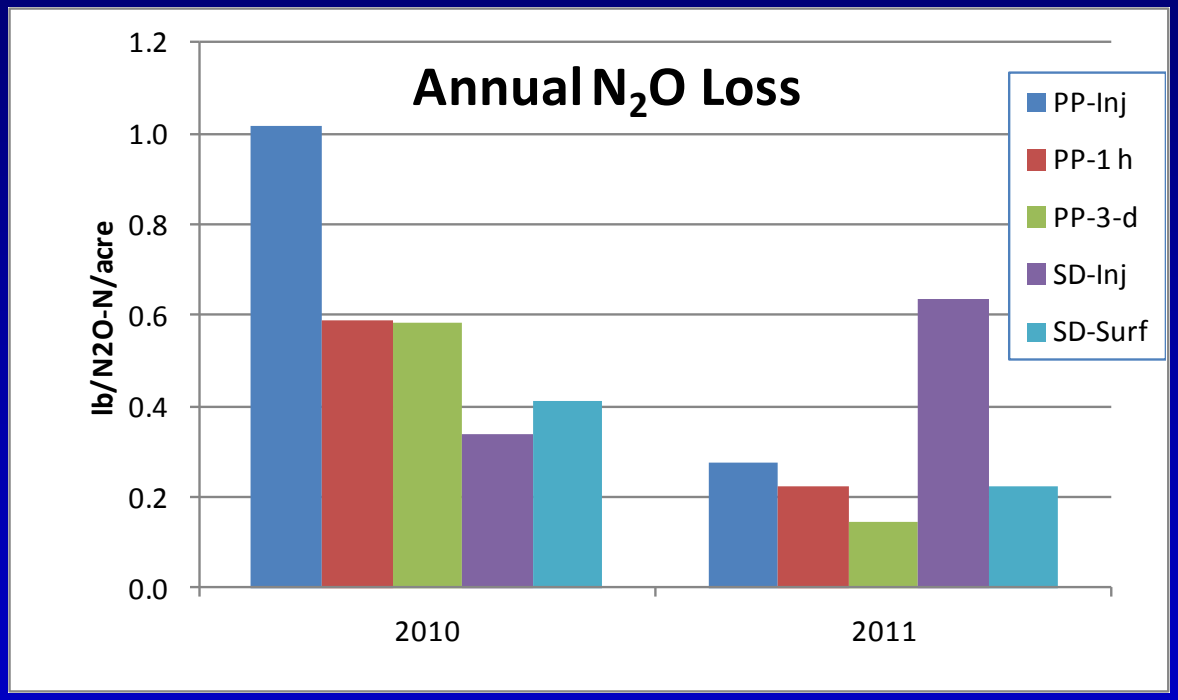
N_2O Flux


N2O Flux 2010
ug NO2-N/ha h
300
250
200
150
100
50
0
-50
13-May
27-May
10-Jun
24-Jun
8-Jul
22-Jul
5-Aug
19-Aug
2-Sep
16-Sep
30-Sep
14-Oct
PP-Inj
PP-1 hr
PP-3-day
SD-Inj


N2O Flux 2011
5 in. rain
ug N2O-N m-2 h-1
600
500
400
300
200
11-Jun
25-Jun
9-Jul
23-Jul
6-Aug
20-Aug
3-Sep
17-Sep
1-Oct
15-Oct
PP-Inj
PP-1 hr
PP-3-day
SD-Inj
SD-Sur


ug N2O-N m-2 h-1
50
45
40
35
30
25
20
15
10
5
0
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul

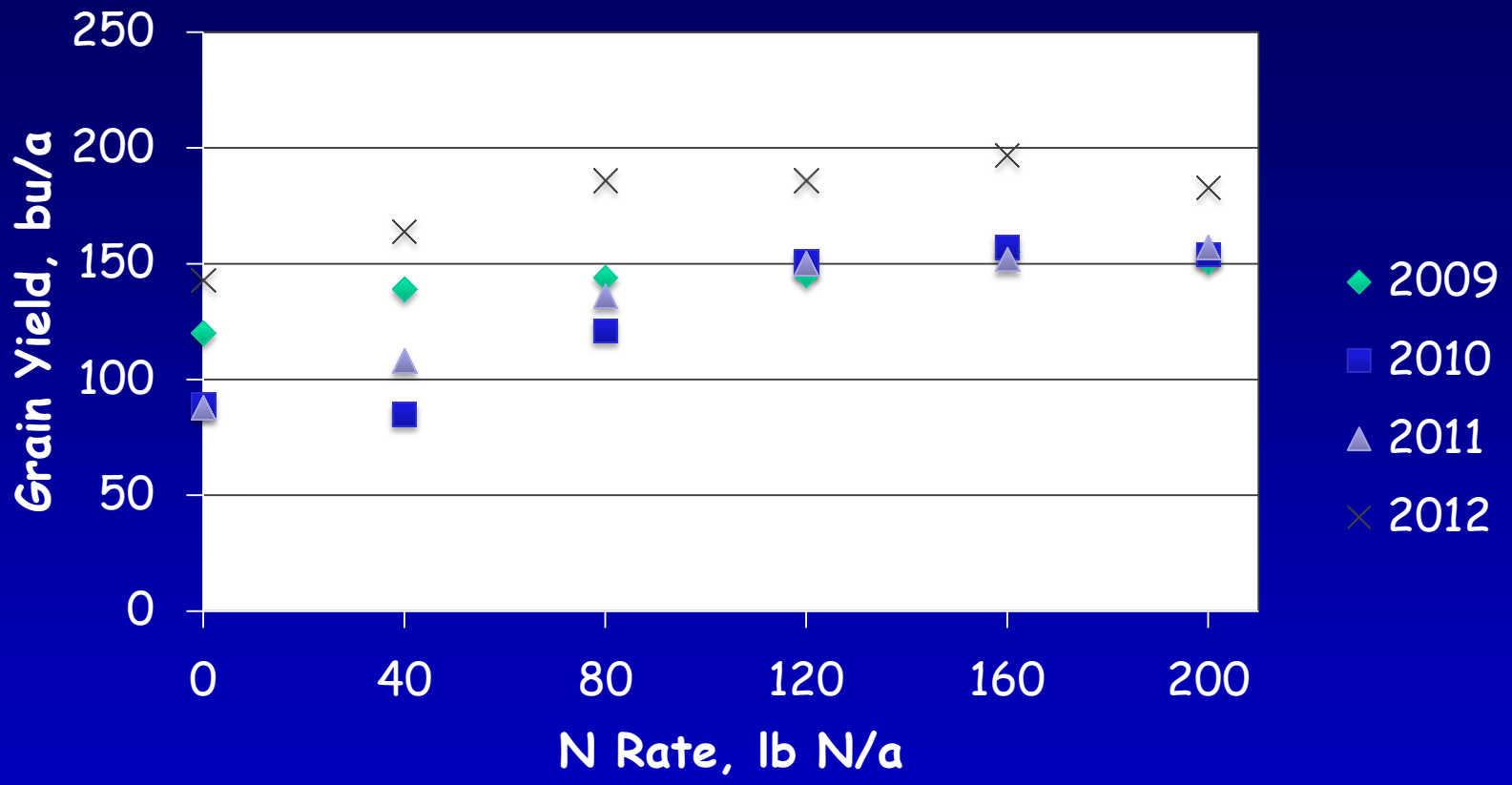
Cumulative N_2O Emission



N_2O Emission

- Peak in N_2O flux after manure application at PP and/or SD
  - Injection most pronounced
  - 6 to 12-day lag time
- Low levels of N_2O late July to Oct.
- Magnitude and timing (PP vs. SD) varied by year
  - May be explained by combination of rain events/soil moisture, soil temperature, and manure characteristics and N content

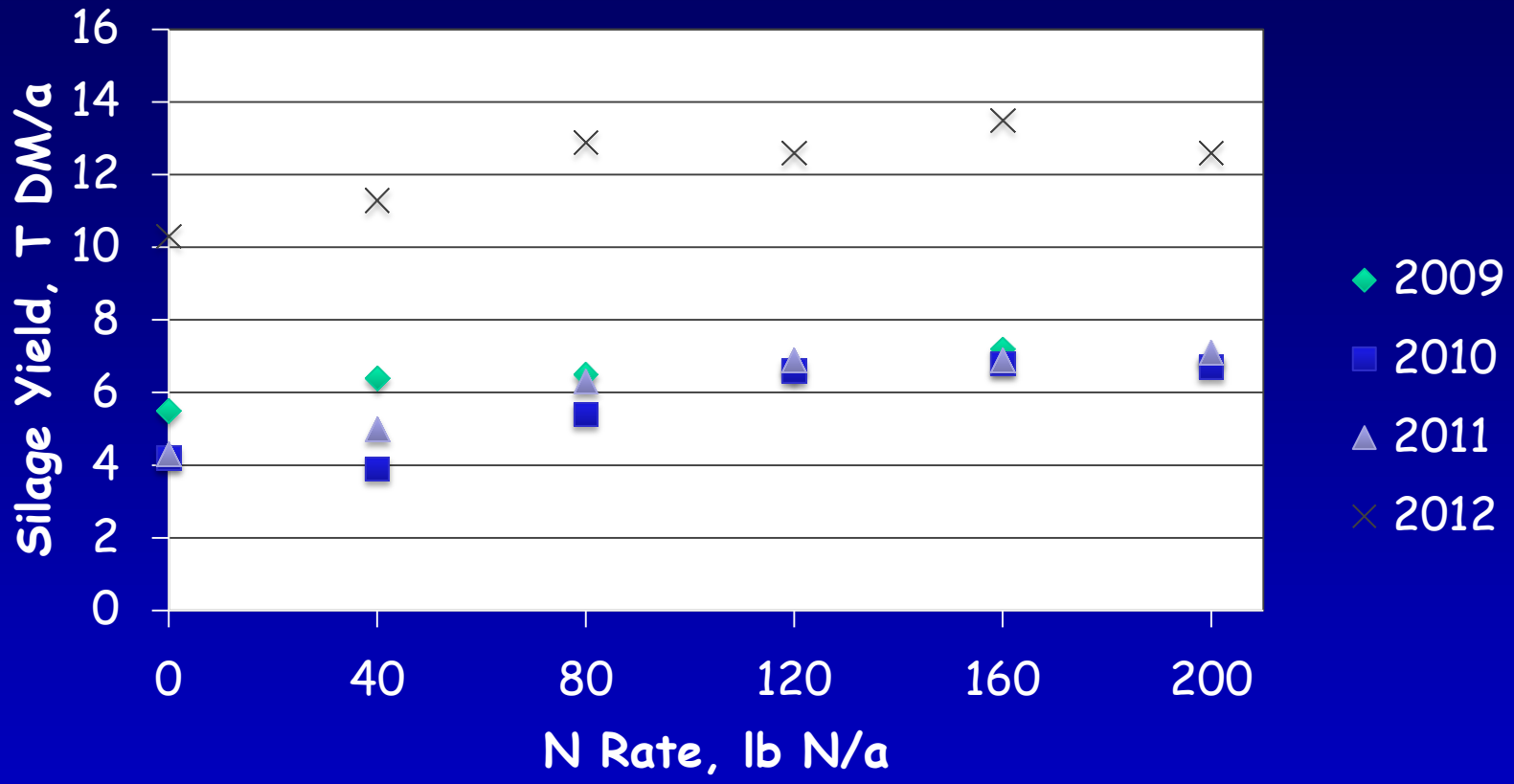
Grain response to preplant incorporated urea



Includes 9 lb N/a in starter

	N rate	2009	2010	2011	2012	Mean
AONR	N rate, lb/a	182	149	133	94	140
	Yield, bu/a	151	156	155	189	
$EONR_{0.10}$	N rate, lb/a	126	149	133	94	126
	Yield, bu/a	149	156	155	189	

Silage response to preplant incorporated urea



	N rate	2009	2010	2011	2012	Mean
AONR	N rate, lb/a	195	149	118	92	139
	Yield, T DM/a	7.0	6.8	7.0	12.9	
$EONR_{0.10}$	N rate, lb/a	124	149	118	92	121
	Yield, T DM/a	6.8	6.8	7.0	12.9	

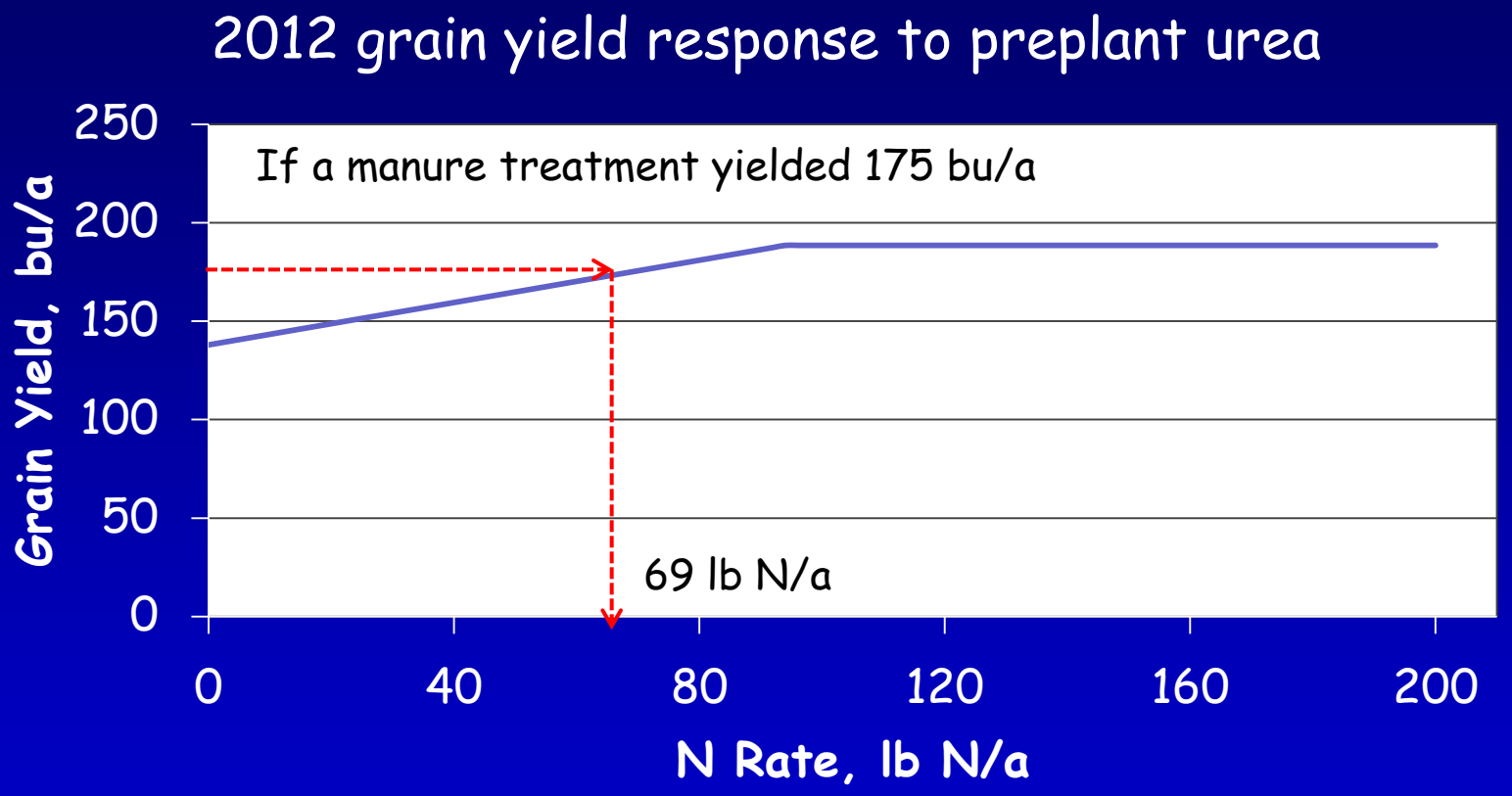
Includes 9 lb N/a in starter

Effect of manure application timing and method on grain yield

Timing	Method & days to incorp.	Grain yield 2009	2010	2011	2012
		---------- bu/a ----------			
Preplant	Injected	144 ab	123 a	107	179 a
	Surface broadcast (< 1 hour)	134 bc	124 a	110	158 bc
	Surface broadcast (1 day)	133 c	122 a	112	159 bc
	Surface broadcast (3 days)	137 bc	105 ab	103	166 ab
Sidedress	Injected	147 a	98 b	114	175 a
	Surface band (no incorporation)	-	89 b	108	150 c
	p	0.09	0.07	0.75	0.02
	LSD(0.10)	10	23	NS	14

NS, not significant at the 0.10 probability level

N Fertilizer Equivalence Value (NFEV) of Manure



% N availability = NFEV ÷ total N applied

Manure N availability

Timing	Method & days to incorp.	Manure N Availability †				
		2009	2010	2011	2012	Mean
		NFEV as a % of total N applied				
Preplant	Injected	48	53	38	63	51
	Surface broadcast (< 1 hour)	22	50	42	31	36
	Surface broadcast (1 day)	19	51	46	32	37
	Surface broadcast (3 days)	30	33	31	43	34
Sidedress	Injected	39	42	60	72	53
	Surface band (no incorporation)	-	26	48	23	32

† Manure N availability = (NFEV / total N rate applied in manure and starter) x 100

Conclusions

- Injection of manure most effective at reducing NH_3 losses… but also increased N_2O emissions
  - N_2O-N << NH_3, so not economically important; but environmentally important as a greenhouse gas
  - But a portion of NH_3 emitted eventually converted to N_2O (1 %; IPCC, 2006), so trade-off may be minimized

- Alternatives
  - Tillage incorporation, but consider residue management and erosion/water quality concerns
  - Different injection techniques (injector type, depth, etc.)

Conclusions

- Injection resulted in less NH_3 volatilization and greater N availability (50% of total N)
- For broadcast applications,
  - NH_3 volatilization for <1 hr incorporation was 75% less than incorporation at 3 days
    - But N availability did not always match this trend in individual years
  - Averaged over all years, general trend for lower availability with greater time to incorporation
    - ~30% of total N for no incorporation
- Weather conditions and actual manure N rate affected results in individual years

Conclusions

- Sidedress application of manure is a viable N source for corn
  - Another window of time for manure application
  - May be lower N loss
  - Can use PSNT
  - Practical limitations
    - Equipment: Injection or direct incorporation preferred
      - Capture more N, reduce burning
    - Field issues: equipment turning, plant damage
- Data support recent changes to UWEX manure N availability
  - 50% injected or broadcast incorporated <1 hr
  - 40% broadcast incorporated 1 to 72 hr
  - 30% broadcast incorporated >72 hr or not incorporated

Thank You

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  - USDA-ARS
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- Thanks to all the staff & students that helped with field and lab work