Nutrient Source and Tillage Interactions on Water Quality in Tile Drained Soils

Satish Gupta
Professor
Soil, Water, & Climate
University of Minnesota
St. Paul, MN

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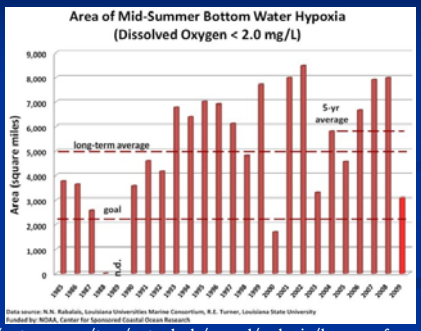
Publications

- Thoma, D.P., S.C. Gupta, J.S. Strock, and J.F. Moncrief. 2005. Tillage and nutrient source effects on water quality and grain yield from a flat landscape. 2005. J. Environ. Quality. 34:1102-1111.
- Randall, G.W., T.K. Iragavarapu, and M.A. Schmitt. 2000. Nutrient losses in subsurface drainage water from dairy manure and urea applied corn. J. Environ. Qual., 29:1244-1252.

Mississippi River Drainage Basin and Aerial Extent of Hypoxia 1999

http://ks.water.usgs.gov/pubs/fact-sheets/fs.135-00.pdf

Temporal Variation in Hypoxic Zone



http://water.epa.gov/type/watersheds/named/msbasin/bar_pop.cfm

Major Rivers in Minnesota

Minnesota River at its Confluence with the Mississippi river

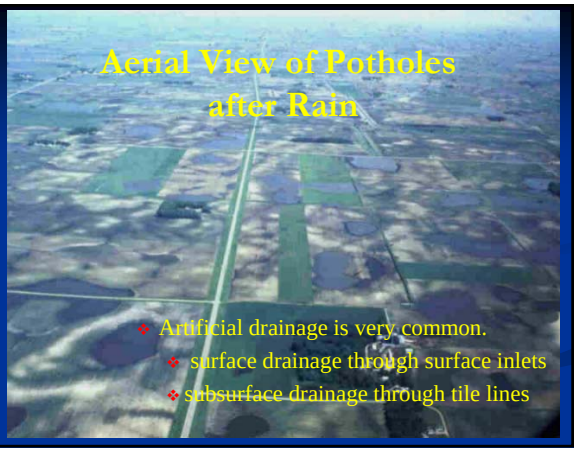
84 Truck Loads of sediment each weighing 20 tons per day

Minnesota River Basin

- 33% of the land in MRB is <2% slope
- 74% of the land in MRB is <6% slope

Webster-Canisteo Clay Loam

Aerial View of Potholes after Rain



- Artificial drainage is very common.
  - surface drainage through surface inlets
  - subsurface drainage through tile lines

Removing excess water

Dominant agriculture in southern Minnesota

Regions Growing:

Corn

Soybeans

Hogs

http://www.extension.umn.edu

Treatments

Primary tillage

Lifting and shattering

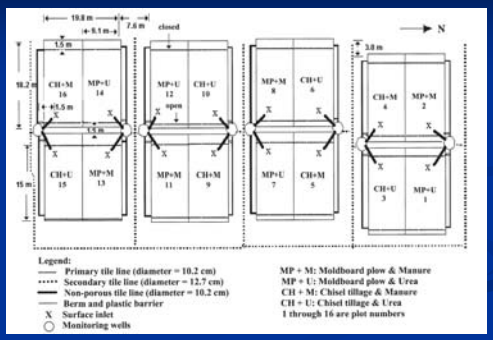
Inversion and incorporation

Nutrient source

Urea

Liquid hog manure

Drainage Plots



Residue cover before planting

Webster-Canisteo Clay Loam

Monitoring well

Equipment shelter

Manure and N Applications

	Crop Year			
	1999	2000	2001	2002
Manure Volume (gal)	8,653	7,664	8,653	12,115
Nutrient Source	Available N (kg ha^{-1})			
Manure	123	41	167	56
Urea	134	146	161	195

Fall applied liquid Hog Manure
Spring applied urea

Available N from manure=mineral N + 30% of organic N year of application +15% and 7.5% of organic N from previous manure applications

P Application (kg ha^{-1})

	Crop Year			
Nutrient Source	1999	2000	2001	2002
Manure	64	11	72	23
Urea	34	25	0	20

Fall applied liquid Hog Manure
Spring applied urea

Runoff and Tile Drainage

Year	Precipitation	Runoff	Tile Drainage	% Loss
	----------cm----------			
1999	37.8	0.2	3.2 (N)	9
2000	67.6	3.0	4.0	10
2001	85.7	7.8	31.5 (T)	46
2002	46.2	4.0	2.7	15
Average	59.3	3.8	10.4	20

N effect: More water losses from Urea than manure treatment
T effect: moldboard draining more snow melt than chisel plow

Flow Weighted Concentrations Through Surface Inlet

Year	NH_4-N	NO_3-N	TP	SP	TS
	----------mg L^{-1}----------				
1999	0.2	13.6	2.7	0.2	2521
2000	0.2	2.5	3.1	0.8	2999
2001	0.5	1.5	3.6	0.2	4829
2002	0.3	1.4	2.7	0.1	5995

Drinking Water Standard=10 mg L^{-1} (NH_4+NO_3)-N

Flow Weighted Concentrations Through Tile Drainage

Date	NH_4-N	NO_3-N	NH_4+NO_3-N
	----------mg L^{-1}----------		
1999	2.7	2.1	4.7
2000	0.3	18.6	18.8
2001	0.5	10.7	10.8
2002	0.1	11.2	11.5

Drinking Water Standard=10 mg L^{-1} (NH_4+NO_3)-N

Annual N, P, and Sediment Losses Through Surface Inlet

Date	Flow	NH_4-N	NO_3-N	TP	SP	TS
	cm	----------kg ha^{-1}----------				
1999	0.2	0	0.1	0.1	0.0	73
2000	3.0	0	0.7	0.9	0.1	753
2001	7.8	1.1	3.0	4.1	0.3	2845
2002	4.0	0.1	0.6 (N)	1.0	0.1	1813
Average	3.8	0.3	1.1	1.5	0.1	1371

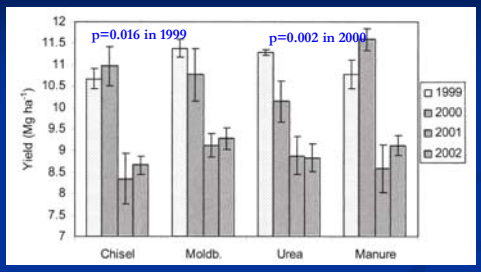
N effect: Less losses from manure treatment due to slow release

Annual N Losses Through Tile Drainage

Date	PPT	Flow	NH_4-N	NO_3-N	(NH_4+NO_3)-N
	cm	cm	----------kg ha^{-1}---------		
1999	38	3.2 (N)	0.8	0.6 (N)	1.3 (N)
2000	68	4.0	0.1	6.9	7.0
2001	86	31.5 (T)	0.7	29.5	30.2
2002	46	2.7	0.0	2.5	2.5
Average	59	10.4	0.4	9.9	10.3

N Effect: More N losses from urea treatment due to more tile drainage and due to readily available inorganic form. Less losses from manure treatment due to slow release.

Corn Yield



Ave. over 4 yr, moldboard grain yield were significantly higher than the yield from chisel plow plots

9 Mg/ha=134 Bushel/acre
10 Mg/ha= 149 Bushels/acre
11 Mg/ha=164 Bushel/acre

Olsen P (0-15 cm depth)

	Spring 1999	Fall 1999	Fall 2000	Fall 2001	Fall 2002	4 Yr-Average
	----------mg kg^{-1}----------					
	Moldboard Plow					
Manure	17.3	26.0	29.0	21.0	18.3	22.3
Urea	7.1	8.4	18.4	9.1	20.0	12.6
	Chisel Plow					
Manure	20.5	26.3	36.5	22.0	22.0	25.5
Urea	5.8	10.8	20.3	7.5	13.3	11.5

Tile Drain Losses from Urea and Dairy Manure (Randall et al.)

Year	N Source	Total Flow	FW NO_3-N Concentration	NO_3-N Loss
		mm	mg L^{-1}	kg ha^{-1}
1994	Urea	229	9.5	19.3
	Manure	226	9.7	19.6
1995	Urea	187	8.1	13.5
	Manure	201	9.0	16.1
1996	Urea	116	10.4	10.7
	Manure	134	10.5	12.6
1997	Urea	198	8.3	14.3
	Manure	192	5.8	9.9
4 Yr. Ave	Urea	183		14.5
	Manure	188		14.6

Conclusions

- There were few significant differences ($p<0.10$) in water quality between tillage or nutrient source treatments.
- There was a slight reduction in mineral N losses both through surface inlets and tile drainage from manure treatment.
- There was a slight decrease ($p=0.025$) in corn grain yield from chisel plow plots compared to moldboard plots.

Conclusions

- One of the constraints in manure application is the built up of soil P test levels and the possibility of particulate P losses via soil erosion.