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Using the Cycles Model to Analyze the Effects of Dairy Manure and Anaerobic Digestate Fertilizers on the Nitrogen Cycle

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Introduction:

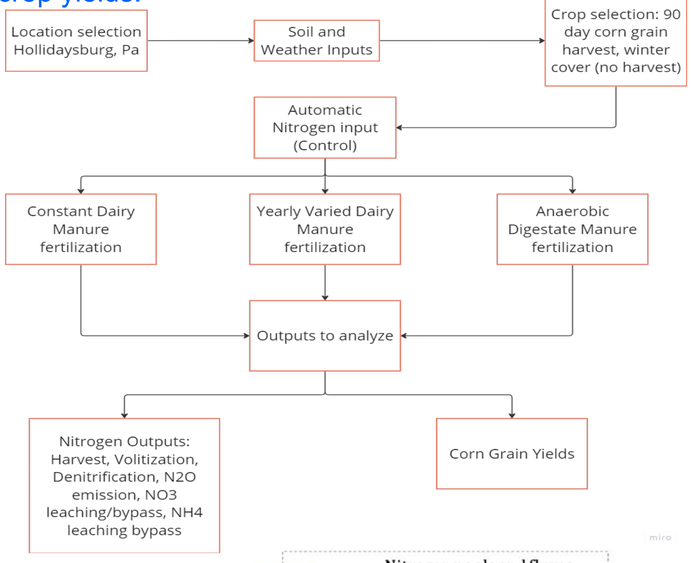
The type and amount of fertilizer are known to have impacts on soil chemistry and crop yields. There is some question as to how variation in manure composition from year to year and whether the manure is digested or raw will affect the nitrogen cycle and crop yields.

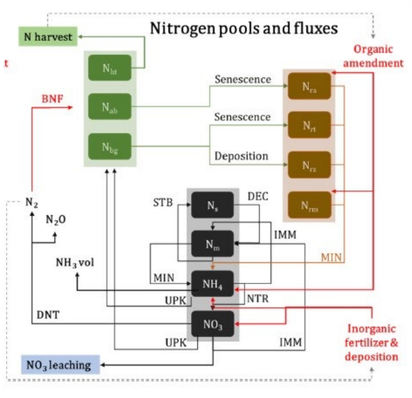
Overarching Question:

Can we test a field management plan that optimizes crop yield while maintaining a Nitrogen Cycle balance with dairy manure (constant and varied yearly) and digested fertilizer?

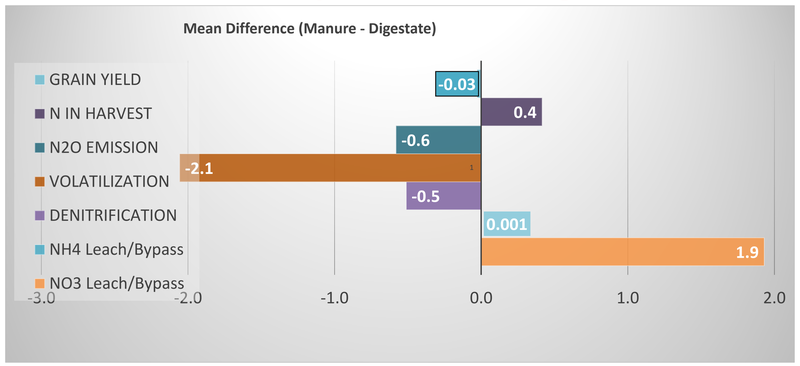
Methods: Using Cycles (Kemanian)

The Cycles Model allows one to vary many inputs (fertilizer, crop selection, weather, etc.) and runs multiple years of modeling that produces outputs pertaining to nutrient cycling and crop yields.





Data 1: Dairy Manure vs Digestate



	Dairy Manure	Dairy Manure	Dairy Manure	Dairy Manure	Dairy Manure	Dairy Manure	Dairy Manure
	NO3 Leach/Bypass	NH4 Leach/Bypass	DENITRIFICATION	VOLATILIZATION	N2O EMISSION	N IN HARVEST	GRAIN YIELD
	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	Mg/ha
Average	12.3	0.018	18.0	33.0	1.9	170.1	11.8
Max	35.9	0.043	27.8	39.2	3.2	222.7	14.9
Min	1.8	0.004	4.4	27.7	0.9	94.4	6.5
StdDev	8.7	0.011	6.2	2.7	0.4	21.7	2.0
	Digestate	Digestate	Digestate	Digestate	Digestate	Digestate	Digestate
	NO3 Leach/Bypass	NH4 Leach/Bypass	DENITRIFICATION	VOLATILIZATION	N2O EMISSION	N IN HARVEST	GRAIN YIELD
	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	Mg/ha
Average	10.3	0.018	18.5	35.1	2.4	169.7	11.8
Max	31.2	0.043	29.9	40.5	3.7	225.1	14.9
Min	1.6	0.004	4.4	29.8	1.1	96.4	6.9
StdDev	7.3	0.010	6.5	2.7	0.6	20.8	1.9
	NO3 Leach/Bypass	NH4 Leach/Bypass	DENITRIFICATION	VOLATILIZATION	N2O EMISSION	N IN HARVEST	GRAIN YIELD
diff Bau-Dige	1.9	0.001	-0.5	-2.1	-0.6	0.4	-0.03

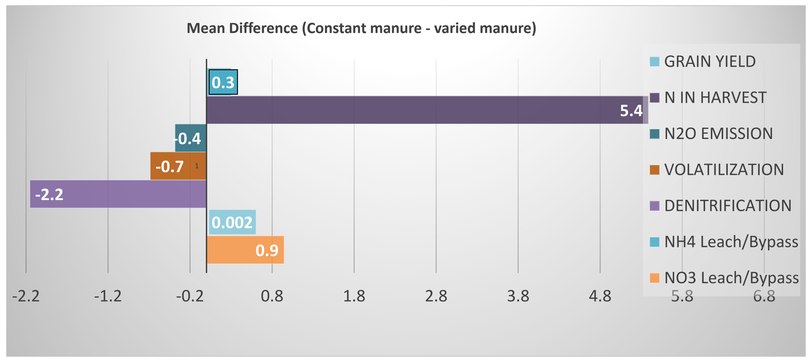
Discussion 1:

There were two areas with noticeable differences in the nitrogen cycle. The first was in nitrate leaching/bypass, where dairy manure showed higher amounts. The digestate showed a higher value in volatilization. The nitrate leaching/bypass is of more note seeing that it is a higher percentage difference. This is of note that the two fertilizers are essentially trading off nitrogen losses.

Conclusions 1:

The model shows that producing an equivalent grain yield while using digestate in place of undigested dairy manure is attainable. There may be benefits in the amount of nitrate leaching and bypass when using digestate as well.

Data 2: Constant vs Varied (Yearly) Dairy Manure



	Manure Constant	Manure Constant	Manure Constant	Manure Constant	Manure Constant	Manure Constant	Manure Constant
	NO3 Leach/Bypass	NH4 Leach/Bypass	DENITRIFICATION	VOLATILIZATION	N2O EMISSION	N IN HARVEST	GRAIN YIELD
	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	Mg/ha
Average	21.4	0.05	17.9	33.3	1.9	161.6	11.0
Max	52.6	0.12	25.7	39.4	2.8	215.8	14.9
Min	3.5	0.01	4.5	28.0	1.0	86.0	5.6
StdDev	12.0	0.03	5.4	2.8	0.4	22.4	2.3
	Manure Varied	Manure Varied	Manure Varied	Manure Varied	Manure Varied	Manure Varied	Manure Varied
	NO3 Leach/Bypass	NH4 Leach/Bypass	DENITRIFICATION	VOLATILIZATION	N2O EMISSION	N IN HARVEST	GRAIN YIELD
	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	kg N/ha	Mg/ha
Average	20.4	0.05	20.0	34.0	2.3	156.2	10.7
Max	50.7	0.11	40.0	48.1	4.0	212.4	14.7
Min	3.0	0.01	8.2	23.3	0.8	93.2	6.0
StdDev	11.0	0.03	8.2	5.5	0.8	31.6	2.3
	NO3 Leach/Bypass	NH4 Leach/Bypass	DENITRIFICATION	VOLATILIZATION	N2O EMISSION	N IN HARVEST	GRAIN YIELD
diff Const - varied	0.9	0.002	-2.2	-0.7	-0.4	5.4	0.3

Discussion 2:

The constant manure showed a higher nitrogen in harvest while the varied manure showed a higher denitrification. The denitrification number would have a higher percent difference but seeing that the grain yield is essentially the same, the higher nitrogen in harvest for the constant manure may be more of interest.

Conclusions 2:

The model shows an equivalent grain yield, but a disparity in the nitrogen in the harvest. This indicates that the constant composition manure may provide an excess of nitrogen, but that may not be increasing grain yields.

Further Questions:

1) Digestate Variability
2) Broadcast / till vs Injection / no till
3) Carbon / Phosphorous impacts

The RET for Teachers is funded by the USDA-NIFA Award No. 2020-68012-31824, Consortium for Cultivating Human and Naturally regenerative Enterprises.