Table 1. Average fecal matter input by geese and ducks, per treatment field per day, LEISA and Conventional farms, Tallahatchie and Leflore County, Mississippi, November-March 2017-2018.

| Average ($\bar{x}$) Fecal Inputs per Field Type per Day (g/ha) | | | |
|---|---|---|---|
| | ($\bar{x}$) fecal input | Standard Deviation | Standard Error |
| CN | 258.51 | 282.72 | 89.40 |
| CF | 659.07 | 534.09 | 382.07 |
| LN | 677.67 | 98.24 | 49.12 |
| LF | 1924.62 | 1005.12 | 317.85 |

Descriptive statistics of dry fecal matter contributed to field treatment per day over the fallow season. Significantly higher (*p*=0.0012) inputs in LEISA Flooded (LF) fields than other treatment fields were observed.

Table 2. Results of individual based model statistics for influential soil health indicators (fecal matter, anaerobic, gram-neg HPC microbial activity, %TN, %OM, %C) on LEISA and Conventional farms, Mississippi, November-March 2017-2018.

| **Response Var.** | **Test Type** | **Test Statistic** | **$R^2$** | **Model** | **Fall Measurement** | **Fecal Matter Input** | **Treatment Group** |
|---|---|---|---|---|---|---|---|
| | ANCOVA/Rank-Based | F-statistic/Drop in Dispersion Test | Adjusted/Robust | p-value | Covariate p-value | Predictor p-value | Predictor p-value |
| Fecal Matter | Rank-Based | 11.99 | 0.54 | **0.001** | | | **<0.05** |
| Anaerobic Richness | ANCOVA | 7.379 | 0.49 | **0.0001** | 0.12 | 0.36 | **<0.05** |
| Gram - | ANCOVA | 0.28 | -0.12 | 0.91 | 0.58 | 0.49 | >0.05 |
| Microbial Activity | Rank-Based | 2.28 | 0.29 | 0.07* | **0.003** | 0.14 | **<0.05** |
| %TN | Rank-Based | 7.55 | 0.58 | **0.05** | 0.25 | 0.35 | **<0.05** |
| %OM | ANCOVA | 43.113 | 0.25 | **0.02** | 0.13 | 0.20 | **<0.05** |
| %C | ANCOVA | 5.06 | 0.38 | **0.00** | 0.33 | 0.19 | **<0.05** |

Type of test performed on variable (parametric ANCOVA or nonparametric rank-based) and associated statistics: F-value (parametric) or Drop in Dispersion F (non-parametric) and Adjusted $R^2$ (parametric) or Robust $R^2$ (nonparametric listed. Model parameter significance also included (Fall measurement covariate, fecal matter input and treatment predictors). Bold type indicates significance at $p<0.05$. Asterisk represents significance at $p<0.10$ level

Table 3. Pairwise comparisons of treatment fields of influential soil health indicators between field types, Tallahatchie and Leflore County, Mississippi, November-March 2017-2018.

| | **Treatment Comparison** | | | | | |
|---|---|---|---|---|---|---|
| **Soil Parameter** | CN--CF | LF--CF | LN--CF | LF--CN | LN--CN | LN--LF |
| Fecal Input | ns | > | ns | > | ns | < |
| Anaerobic Diversity | < | > | ns | > | > | ns |
| Gram - | ns | ns | ns | ns | ns | ns |
| Activity | ns | > | > | > | > | ns |
| %TN | ns | > | ns | > | ns | ns |
| %OM | ns | ns | <* | ns | ns | ns |
| %C | ns | > * | ns | > | ns | ns |

Tukey contrasts multiple comparisons of means for general linear hypothesis. Asterisk show significant difference at p<0.10 level, >/< show significant difference between comparison at p<0.5 level, ns=no significance in treatment comparison.

Table 4. Tukey's *post hoc* model effect means and 95% confidence intervals for individual pathogens

| | Treatment | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CF | | | CN | | | LF | | | LN | | |
| | | 95% CI | | | 95% CI | | | 95% CI | | | 95% CI | |
| Pathogen | $\bar{x}$ | Lower | Upper | $\bar{x}$ | Lower | Upper | $\bar{x}$ | Lower | Upper | $\bar{x}$ | Lower | Upper |
| *E.coli* | 2.87 | 0.767 | 10.739 | 4.808 | 1.082 | 21.428 | 1.782 | 0.891 | 10.116 | 2.488 | 0.310 | 19.998 |
| *Enterococci* | 1.667 | 0.087 | 2.792 | 0 | *N/A* | *N/A* | 0 | *N/A* | *N/A* | 0 | *N/A* | *N/A* |
| *C. perfringens* | 645.65 | 242.66 | 1713.95 | **501.18** | 186.21 | 1330.45 | **3162.27** | 1188.50 | 8394.59 | 1883.64 | 401.49 | 8810.48 |

Results reported in CFU/g dry soil. Bold indicates significant difference between groups.

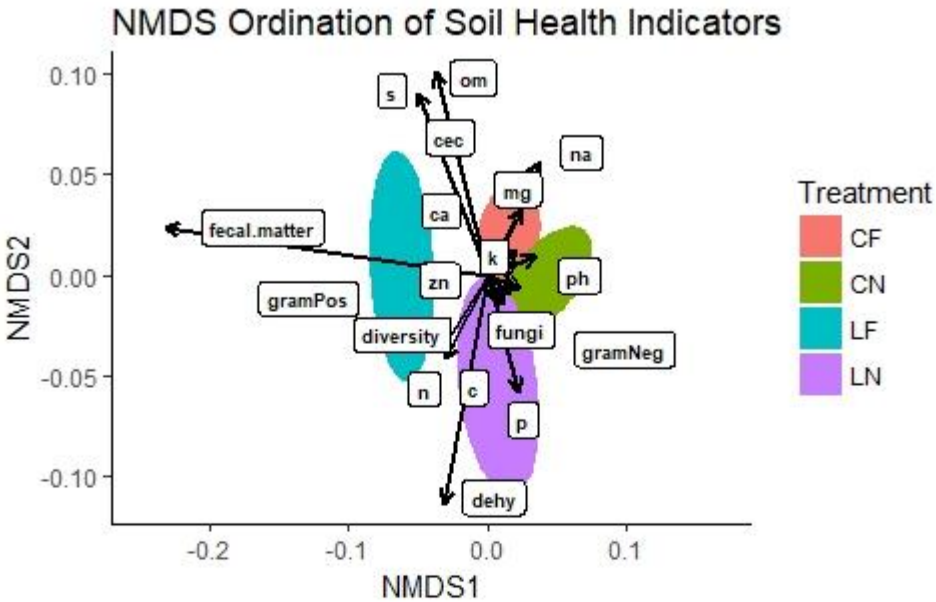


Figure 1. NMDS Ordination of Soil Health Indicators on LEISA and Conventional field treatments. Tallahatchie and Leflore County, Mississippi, November-March 2017-2018.

Nonmetric multidimensional scaling (NMDS) 95% confidence ellipse by field treatment samples. Vectors represent correlation of NMDS axes with soil health indicators ($p<0.1$). Abbreviations: dehy=dehydrogenase assay/microbial activity, p=Phosphorus, c= %Carbon, n=%Total Nitrogen, gramNeg=Gram – bacteria diversity, fungi=Fungal diversity, diversity=anaerobic heterotrophic bacteria diversity, gramPos= Gram+ bacteria diversity, zn=Zinc, ph=pH, fecal.matter= Bird Fecal Matter inputs, k=Potassium, ca=Calcium, mg=Magnesium, na=Sodium, cec=Cation Exchange Capacity, om= % Soil Organic Matter, and s=Sulfur.

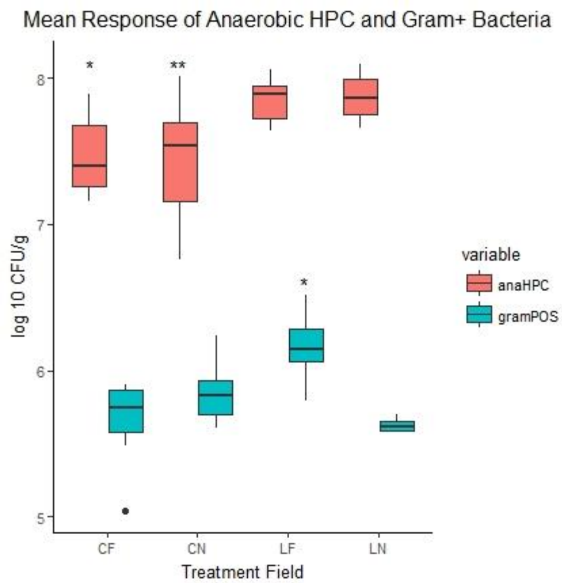


Figure 2. Mean Response of Anerobic HPC and Gram + Bacteria of LEISA and Conventional field treatments. Tallahatchie and Leflore County, Mississippi, November-March 2017-2018.

Asterisk denotes significance difference at p<0.05 level. Points indicate outliers.

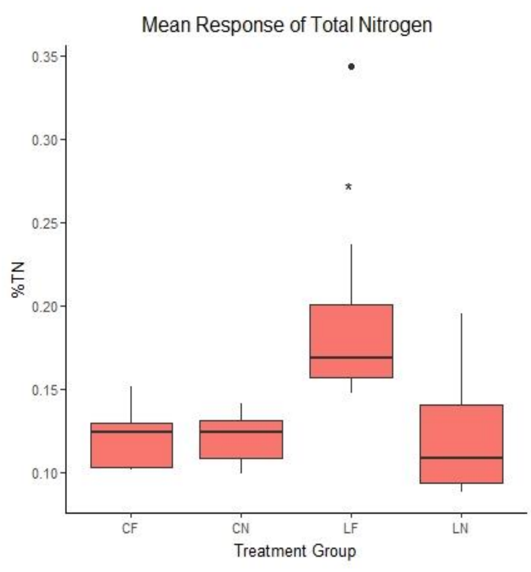


Figure 3. Mean Response of %N in LEISA and Conventional field treatments Tallahatchie and Leflore County, Mississippi, November-March 2017-2018.

Asterisk denotes significance difference at p<0.05 level. Points indicate outliers.

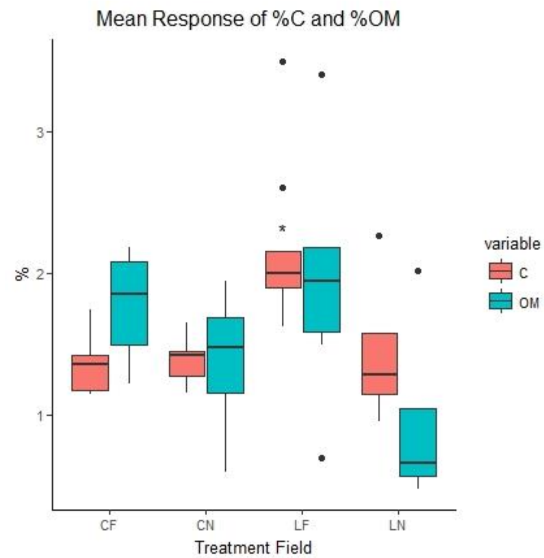

Figure 4. Mean Response of %C and %OM in LEISA and Conventional field treatments. Tallahatchie and Leflore County, Mississippi, November-March 2017-2018.

Asterisk denotes significance difference at $p<0.05$ level. Points indicate outliers.

## References


Brooks, J.P., Adeli, A., Read, J.J., McLaughlin, M.R., 2009. Rainfall simulation in greenhouse microcosms to assess bacterial-associated runoff from land-applied poultry litter. J. Environ. Qual. 38, 218–29. doi:10.2134/jeq2008.0029

Brooks, J.P., McLaughlin, M.R., Scheffler, B., Miles, D.M., 2010. Microbial and antibiotic resistant constituents associated with biological aerosols and poultry litter within a commercial poultry house. Sci. Total Environ. 408, 4770–4777. doi:10.1016/j.scitotenv.2010.06.038

Chu, H., Lin, X., Fujii, T., Morimoto, S., Yagi, K., Hu, J., Zhang, J., 2007. Soil microbial biomass, dehydrogenase activity, bacterial community structure in response to long-term fertilizer management. Soil Biol. Biochem. 39, 2971–2976. doi:10.1016/j.soilbio.2007.05.031

Greenland, D.J., 1984. Organic Matter and Rice.

Hadas, A., Rosenberg, R., 1992. Guano as a nitrogen source for fertigation in organic farming. Fertil. Res. 31, 209–214. doi:10.1007/BF01063294

Haque, M.M., Biswas, J.C., Kim, S.Y., Kim, P.J., 2017. Intermittent drainage in paddy soil: ecosystem carbon budget and global warming potential. Paddy Water Environ. 15, 403–411. doi:10.1007/s10333-016-0558-7

Hubálek, Z., Hubá, Z., 2004. An Annotated Checklist of Pathogenic Microorganims Associated with Migratory Birds. Source J. Wildl. Dis. Wildl. Dis. Assoc. J. Wildl. Dis. Wildl. Dis. Assoc. 40, 639–659. doi:10.7589/0090-3558-40.4.639

Kross, J.P., Kaminski, R.M., Reinecke, K.J., Pearse, A.T., 2008. Conserving waste rice for wintering waterfowl in the Mississippi Alluvial Valley. J. Wildl. Manage. 72, 1383–1387.

Maier, R.M., Pepper, I.L., Gerba, C.P., 2009. Environmental microbiology. Academic Press.

Manley, S.W., 1999. Ecological and agricultural values of winter-flooded ricefields in Mississippi. Mississippi State University Library.

Manny, B.A., Wetzel, R.G., Johnson, W.C., 1975. Annual contribution of carbon, nitrogen, and phosphorus by migrant Canada geese to a hardwater lake. Int. Assoc. Theor. Appl. Limnol. 19, 665–672.

Mattis, P., Kimball, S., 2018. GNU Image Manipulation Program.

McKean, J.W., Kloke, J.D., 2014. Efficient and adaptive rank-based fits for linear models with skew-normal errors. J. Stat. Distrib. Appl. 1, 18. doi:10.1186/s40488-014-0018-0

Patil, G.P., Patil, G.P., 2013. Composite Sampling, in: Encyclopedia of Environmetrics. John Wiley & Sons, Ltd, Chichester, UK. doi:10.1002/9780470057339.vac039.pub2

Post, D.M., Taylor, J.P., Kitchell, J.F., Olson, M.H., Schindler, D.E., Herwig, B.R., 2008. The Role of Migratory Waterfowl as Nutrient Vectors in a Managed Wetland. Conserv. Biol. doi:10.1111/j.1523-1739.1998.97112.x

United States Department of Agriculture NRCS (2012, November). Farming in the 21$^{st}$ Century: A practical approach to improve soil health.

Sanderson, G.C., Anderson, W.., 1978. Waterfowl studies at Lake Sangchris. Illinois Nat. Hist. Surv. Bull. 32, 656–690.

Sass, S. B. (2012, December 03). View of Environmental Impacts of Agriculture: Conventional and Organic Farming Systems. http://journals.iupui.edu/index.php/spea/article/view/3819/3760

Sylvia Jeffry J Fuhrmann Peter G Hartel David A Zuberer, D.M., n.d. Principles and Applications of Soil Microbiology.

Terres, J.K., National Audubon Society., 1980. The Audubon Society Encyclopedia of North American Birds. Distributed by Random House.

Waldenström, J., Broman, T., Carlsson, I., Hasselquist, D., Achterberg, R.P., Wagenaar, J.A., Olsen, B., 2002. Prevalence of Campylobacter jejuni, Campylobacter lari, and Campylobacter coli in different ecological guilds and taxa of migrating birds. Appl. Environ. Microbiol. 68, 5911–7. doi:10.1128/AEM.68.12.5911-5917.2002

Zerzghi, H., Gerba, C.P., Brooks USDA-ARS Ian L Pepper, J.P., n.d. Long-Term Eff ects of Land Application of Class B Biosolids on the Soil Microbial Populations, Pathogens, and Activity. doi:10.2134/jeq2009.0307

# Investigation of soil management practice impacts on water quality

Candace McKnight[1], Beth Baker[1], Alexandra Firth[1], Kelsie Hall[1], Keaton Hamid[1]

[1]Department of Wildlife, Fisheries, and Aquaculture

## Introduction

Rice is a staple food for more than half of the world's population and has the ability to support more people per unit of land area than wheat or corn. However, there are concerns about the sustainability of rice production practices pertaining to soil and water quality. Conventional farming practices (relying on external inputs) can effect nutrient cycling and availability in soils and subsequently the water quality. Using an alternative farming approach, Low-external-input sustainable agriculture (LEISA), which is a production approach that optimizes the use of locally available resources, while minimizing the use of fertilizers or pesticides, has the potential to improve soil health and prevent soil degradation while improving water quality. This study, using soils from four different fields, under four different management regimens in the Mississippi Alluvial Valley (MAV) measures these effects, via a soil column experiment. Soils were kept at set temperatures to mimic winter-weather, and ecologically relevant concentrations of phosphorus and nitrogen were added to each column. Water was tested for changes in nutrient concentration to assess soil-water interactions at specified intervals. It is hypothesized that LEISA soils will facilitate nutrient reduction in overlying water concentrations than those from conventional rice production systems.

a. b. c.

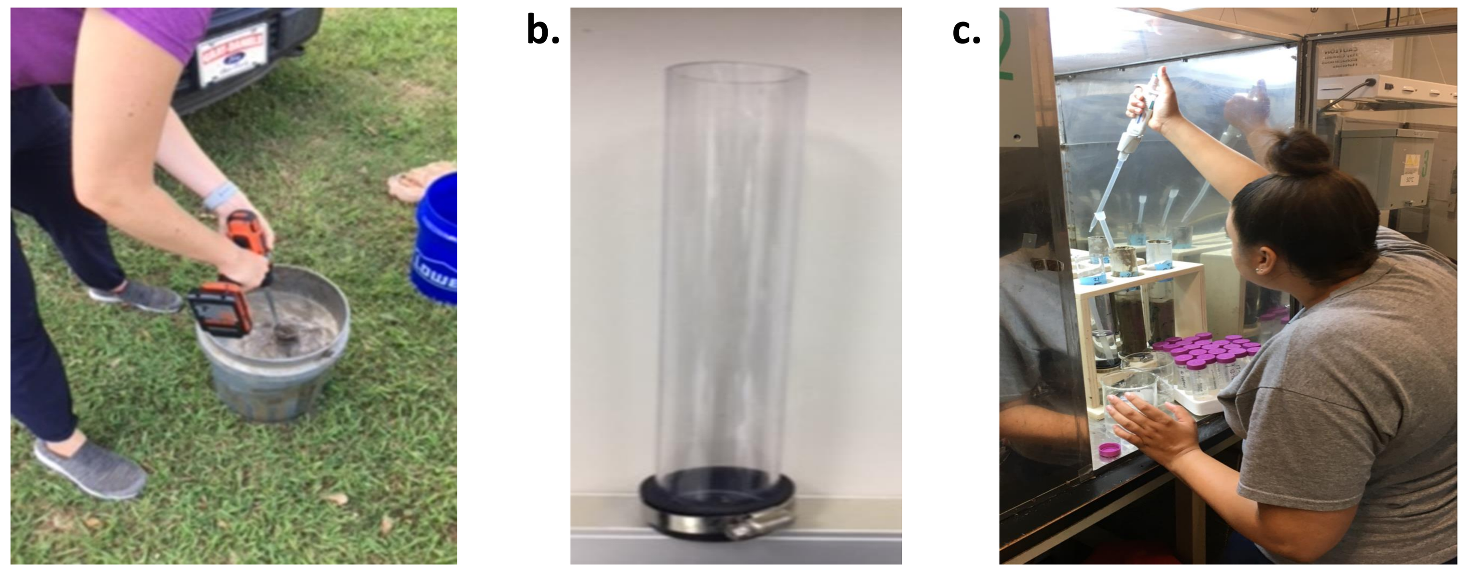

*Figure 1. a) Soils being mixed into a pourable slurry using an electric drill; b) depicts cylindrical microcosm columns measuring 30.48 cm X 5.08 cm capped off with 3.81 cm (Econo) test caps, fastened with stainless steel clamps; c) shows water sampling from temperature controlled chambers.*

## Methods

- Forty liters of topsoil (approximately 1 liter from each field) were collected from four study fields, LN, LF, CN, CF. Initial soil moisture content of each soil was determined by weighing 10 grams of moist soil, then placing it in a drying oven for 24 hours. Soils were weighed again, and percent moisture was calculated from the differences.
- Groundwater was added to each soil type until soil was homogenized into a pourable slurry state (Figure 1). The slurry soils were distributed by treatment into cylindrical microcosm containers (Figure 2), filled to approximately half of the containers volume. Microcosms were dried back to their original moisture content.
- Microcosm were then set up in a randomized block design, four liters of groundwater experimentally reformulated into moderately hard reconstituted water, containing concentrations of N and P (5.67 mg/L and 6.37 mg/L, respectively) added to all experimental columns. The microcosms were then placed in environmental chambers with temperatures set to approximately 15°C high and a 4°C low.
- At pre-determined intervals (24, 48 and 168 hours), 30 mL of water from each microcosm was tested for changes in nutrient concentrations. Samples were analyzed for TN in liquid samples, using HACH TNT 880 s-TKN™ kits. Total Inorganic phosphorus (TIP) was also analyzed using HACH TNT 843 and 845 Phosphorus™ kits.
- Percent change in nutrient concentrations between time periods was calculated. Preliminary descriptive statistics indicated non-normality of data, which was confirmed with both Kolmogorov-Smirnov and Shapiro-Wilk tests. Because of that, non- parametric Analysis of Variances (ANOVAs) were used to asses nutrient reduction differences between farm treatments at each specified time interval. Post-hoc analysis significant alpha value was set at 0.05.

## Results

- Results of ANOVA for time period 0-24 hours showed no significant differences for TN ($P > 0.05$). Results for TIP showed significant differences between farms ($P=.001$). Post-hoc pairwise comparison results for TIP showed LF to be significantly different from E ($p=0.004$) and LN to also be significantly different from E ($p=.012$).
- Kruskall-Wallis test showed significant differences between both TN ($p=.001$) and TIP (.004) for time period 24-48 hours. Post-hoc pairwise comparison results for TN showed LF to be significantly different from CF ($p=0.036$) and E ($p=0.001$). Pairwise comparisons of TIP also showed LF to be significantly different from E ($p=.002$).
- No significant differences between farm treatments were found for time period 48-168 hours for TN or TIP ($P > 0.05$).

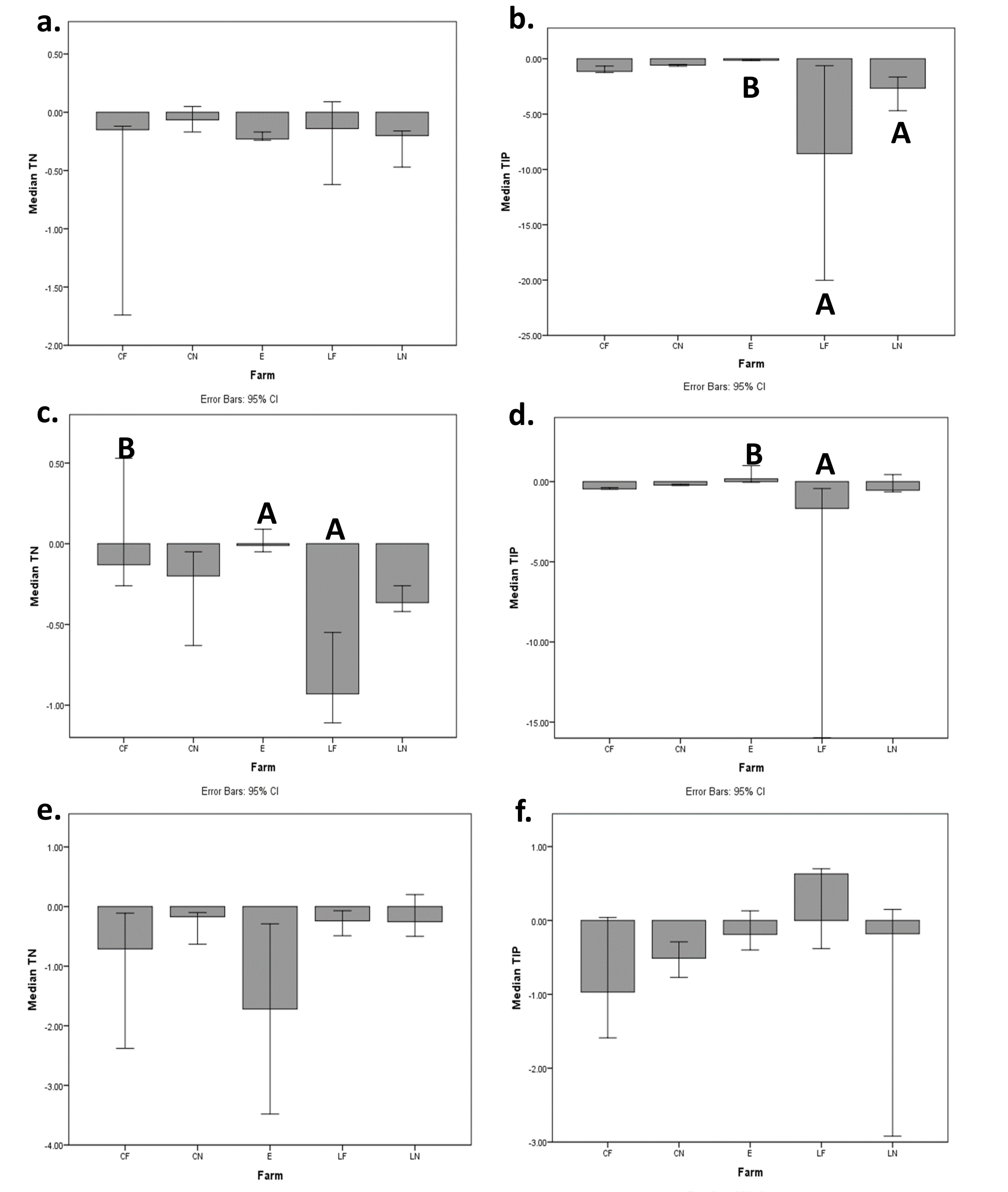


*Figure 2. Nutrient concentration percent change are reflected on the y-axis. Figure a) 0-24 hour Median TN; b) 0-24 hour median TIP; c) 24-48 hour median TN; d) 24-48 hour TIP; e) 48-168 hour median TN; f) 48-168 hour median.*Units are indications of percent change, however they are not in percentage form.*

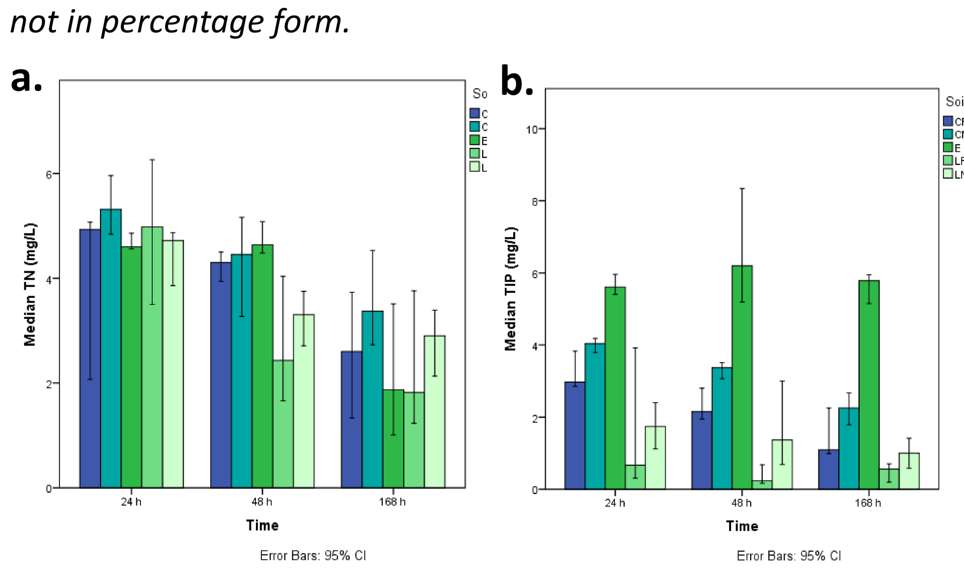


*Figure 3. a) Median TN values (mg/L) for each soil and time period. B) Median TIP values (mg/L) for each soil and time period.*

This project is supported by the FY16 USDA NIFA AFRI ELI REEU Fellowships Program of the NIFA, USDA, Grant #2017-67033-26015.

Table 1. Summary statistics of percent change in water nutrient concentrations for each treatment for time period 0-24 hours.

| | Total Nitrogen (TN) | | | | Total Inorganic Phosphorus (TIP) | | | |
|---|---|---|---|---|---|---|---|---|
| ***Farm*** | Mean | Median | Min. | Max. | Mean | Median | Min. | Max. |
| CF | -48% | -15% | -174% | -12% | -105% | -114% | -124% | -66% |
| CN | -6% | -7% | -17% | 5% | -59% | -58% | -68% | -52% |
| E | -22% | -23% | -24% | -17% | -13% | -14% | -18% | -7% |
| LF | -24% | -14% | -62% | 9% | -919% | -858% | -2002% | -63% |
| LN | -27% | -20% | -47% | -16% | -272% | -266% | -469% | -165% |

Table 2. Summary statistics of percent change in water nutrient concentrations for each treatment for time period 24-48 hours.

| | Total Nitrogen (TN) | | | | Total Inorganic Phosphorus (TIP) | | | |
|---|---|---|---|---|---|---|---|---|
| ***Farm*** | Mean | Median | Min. | Max. | Mean | Median | Min. | Max. |
| CF | -2% | -13% | -26% | 53% | -43% | -45% | -48% | -37% |
| CN | -27% | -20% | -63% | -5% | -21% | -22% | -24% | -16% |
| E | 2% | -1% | -5% | 9% | 28% | 18% | -4% | 100% |
| LF | -86% | -93% | -111% | -55% | -413% | -167% | -1597% | -43% |
| LN | -35% | -37% | -42% | -26% | -32% | -54% | -64% | 44% |

Table 3. Summary statistics of percent change in water nutrient concentrations for each treatment for time period 48-168 hours

| | Total Nitrogen (TN) | | | | Total Inorganic Phosphorus (TIP) | | | |
|---|---|---|---|---|---|---|---|---|
| ***Farm*** | Mean | Median | Min. | Max. | Mean | Median | Min. | Max. |
| CF | -85% | -71% | -238% | -11% | -83% | -97% | -159% | 4% |
| CN | -27% | -17% | -63% | -10% | -52% | -51% | -77% | -29% |
| E | -154% | -172% | -348% | -29% | -12% | -19% | -40% | 13% |
| LF | -26% | -24% | -49% | -7% | 26% | 63% | -38% | 70% |
| LN | -21% | -26% | -50% | 20% | -78% | -18% | -292% | 15% |

## Discussion

Results moderately supported hypotheses that LEISA soils (LF and LN) would improve nutrient removal from overlying water, as significant differences between LF and the control (E) were observed after 24 hours for TIP, and significant differences were observed after 48 hours between LF and E and CF for TN and between LF and E for TIP. Summary statistics also indicate greater mean and median nutrient reductions after 48 hours for LF and LN. Results indicate that, in LEISA soils, most nutrient removal occurred between 0 and 48 hours, whereas nutrient reduction in conventional soils increased during the 48-168 time interval. We would expect the LEISA soils (LF and LN) to impact nutrient concentrations differently due to the minimal tillage practices and addition of organic wastes via avian defecation that have been applied to these soils, in addition to inorganic fertilizers, during their life history. The conventional soils (CF and CN) on the other hand did receive inputs of fertilizer. The use of fertilizers may be fundamental to maintain yields, however it's the risk of over-fertilization that can cause imbalance of nutrients in soil (Sass, 2012). Unlike LEISA soils, the conventional soils (CF and CN) have a life history of regular tillage. Intensive tillage practices fractures the soil, disturbs soil structure, and can accelerate surface runoff and soil erosion (Al-Kaisi, Hanna, Tidman). According to the United States department of Agriculture Natural Resource Conservation Services, "Tilling the soil is the equivalent of an earthquake, hurricane, tornado, and forest fire occurring simultaneously to the world of soil organisms". Nutrient cycling is facilitated by soil organisms, which require adequate environmental conditions to thrive. Increases in TIP in certain samples are likely a result of anaerobic conditions causing dissolution of P from soil back into the overlying water. In general the results moderately support the hypotheses, however there were soils came from two farms and replication was limited to 5 replicates of each treatment. Potential future researchers may consider utilizing intact soil cores, considering different time intervals, and investigating more complex modelling of the data.

**References**

-Al-Kaisi, M., Hanna, M., & Tidman, M. (n.d.). Frequent tillage and its impact on soil quality. Retrieved from https://crops.extension.iastate.edu/frequent-tillage-and-its-impact-soil-quality

-Sass, S. B. (2012, December 03). View of Environmental Impacts of Agriculture: Conventional and Organic Farming Systems. http://journals.iupui.edu/index.php/spea/article/view/3819/3760

-United States Department of Agriculture NRCS (2012, November). Farming in the 21st Century: A practical approach to improve soil health.

mcknigc4017@uapb.edu

MISSISSIPPI STATE UNIVERSITY™ RESEARCH & EDUCATION TO ADVANCE CONSERVATION & HABITAT

beth.baker@msstate.edu