Management impacts on water quality in integrated crop-livestock systems

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Integrated crop-livestock systems (ICLS) hold potential to achieve environmentally sustainable production of crop and livestock products as studies have indicated improved soil health. However, there is a lack of information regarding impacts to water quality in ICLS. If ICLS are to be environmentally sustainable, management practices that minimize water quality degradation must be adopted.

Water quality, especially as related to agricultural sources of nutrient and soil runoff, has become increasingly important with the annual occurrence of a hypoxic zone (dead zone) in the Gulf of Mexico and Chesapeake Bay and algal blooms in Lake Erie. Given the lack of information on water quality in ICLS, published research on water quality outcomes from management practices used in ICLS (e.g., cover crops, no-tillage, and livestock grazing) was reviewed and summarized for application to the northern Great Plains.

Nutrient and total suspended solid (TSS) concentrations and loads (i.e., concentration multiplied by runoff volume) were obtained from published research for calculating percent change when a management practice was implemented. A positive number reflects a concentration or load increase, while a negative number is a concentration or load decrease.

Incorporation of cover crops generally decreased nitrate (NO_3^{-}) and TSS in runoff, while results were mixed for soluble (SP) and total phosphorus (TP) (Figure 1). No-tillage management generally reduced losses of nitrogen and TSS, while phosphorus losses (SP and TP) in runoff increased (Figure 2). Losses of phosphorus in many cases were attributed to broadcast application of fertilizer, but sub-surface placement of fertilizer during planting has become a common practice and holds potential for reducing phosphorus losses in runoff in no-tillage systems.

Livestock grazing increased NO_3^{-}, ammonium, SP, TP, and TSS concentrations and loads in surface runoff and aquatic ecosystems (Figure 3). Impacts to water quality from grazing can be reduced by decreasing grazing intensity and preventing livestock from accessing aquatic ecosystems.

Some research studies used multiple management practices that could not be evaluated separately. These studies were more closely related to ICLS in that many practices were used in the same production system. In general, percent changes in concentrations and loads of nitrogen, phosphorus, and TSS were more variable, with more values increased by >200% compared to percent change values of individual management practices (Figure 4). Accordingly, water quality tradeoffs associated with management practices used in ICLS need to be taken into account when deploying practices on working farms.

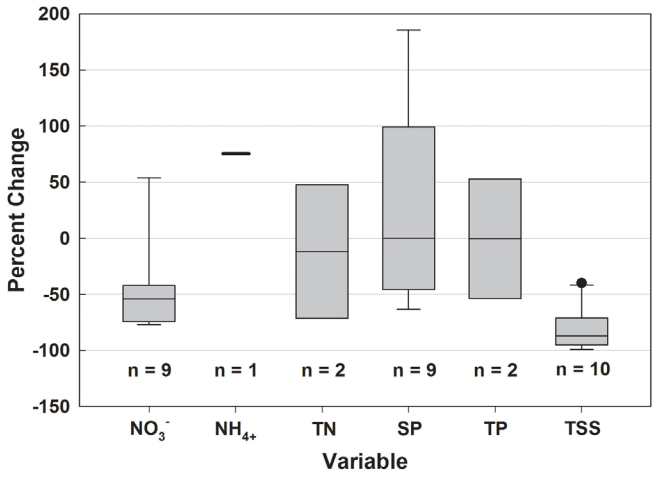

Fig. 1. Percent change of nutrients (NO_3^{-}, NH_4^{+}, TN, SP, TP) and soil (TSS) for surface runoff using cover crops.

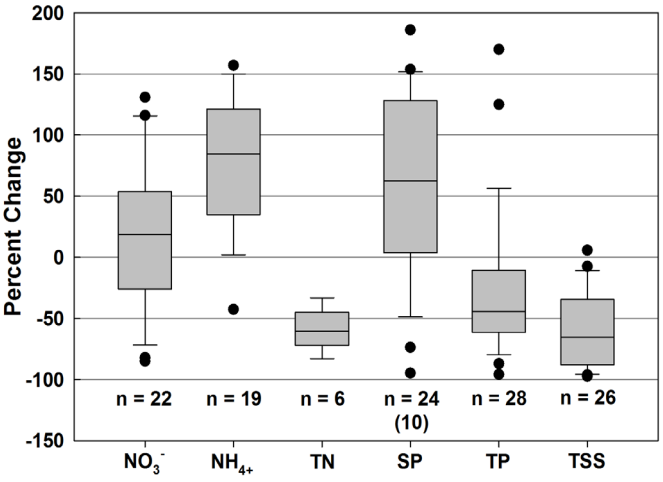

Fig. 2. Percent change of nutrients (NO_3^{-}, NH_4^{+}, TN, SP, TP) and soil (TSS) for surface runoff under no-tillage management.

About the Figures…
Figures contain boxplots in which the line in the box is the median, edges of the box are 25th and 75th percentiles, error bars (whiskers) are 10th and 90th percentiles, and points are values beyond the 10th and 90th percentiles. The n = sample size and numbers in parentheses are the number of percent change values > 200.

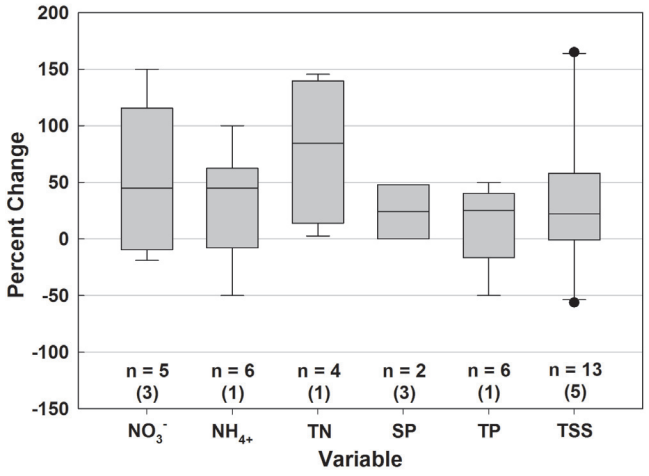

Fig. 3. Percent change of nutrients (NO_3^-, NH_4^+, TN, SP, TP) and soil (TSS) for surface runoff with livestock grazing.

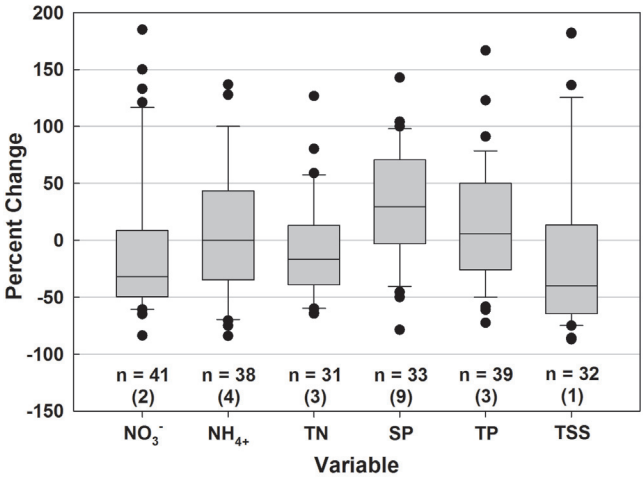

Fig. 4. Percent change of nutrients (NO_3^-, NH_4^+, TN, SP, TP) and soil (TSS) for surface runoff with combinations of management practices implemented.

This research review identified four major research needs associated with water quality in ICLS in the northern Great Plains: 1) quantify surface runoff water quality associated with crop rotation and intercropping, 2) quantify soil leachate water quality associated with cover crops, no-till, and grazing, 3) increase emphasis on collection of water quality data in ICLS (Figure 5), especially in the face of projected increases in rainfall amount and intensity due to climate change, and 4) maintain long-term (7-10 year) data collection efforts.

Some pertinent research questions include: How does the use of multiple management practices in the same production system affect water quality? Does cropland grazing increase water quality impacts? What are the tradeoffs between water quality outcomes and ecosystem services provided by ICLS?

These questions can be answered by conducting studies at multiple study scales: plot, whole field/farm, and watershed. Surface runoff and soil leachate samples can also be collected during rainfall simulations in ICLS (Figure 5). Data from existing studies of individual management practices and future plot, field, watershed, and rainfall simulation studies can also be used to build simulation models to predict water quality outcomes under different management and climate scenarios. Results from region-specific studies can then be used to inform adaptive management decisions and improve management practices used by producers to increase water quality and improve environmental sustainability of ICLS throughout the region.

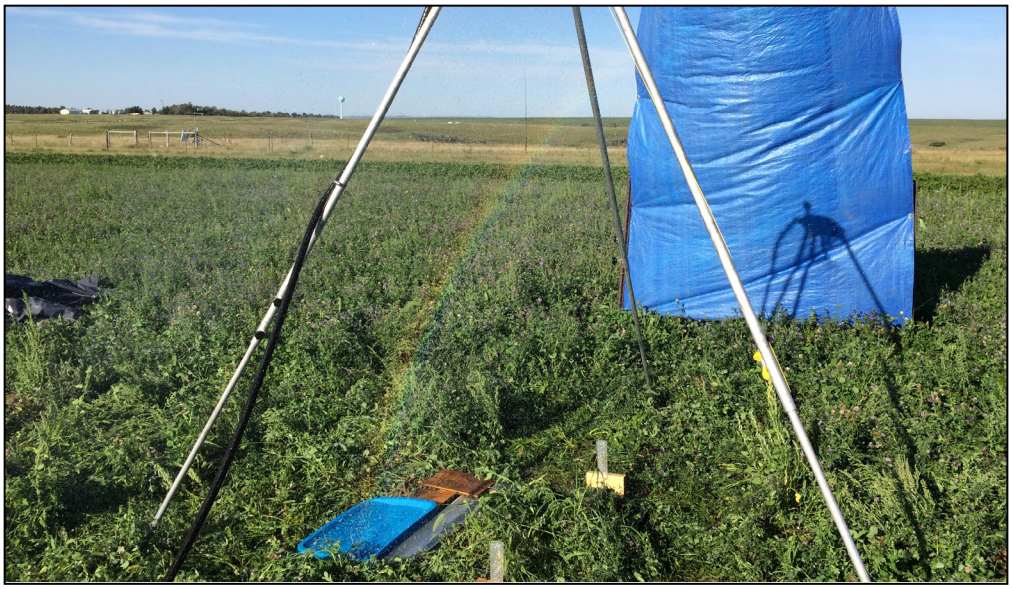

Fig. 5. Surface runoff and soil leachate samples were collected during rainfall simulations in cover crops of an integrated crop-livestock study at NGPRL, August 2017.

Adapted from Faust, D.R., S. Kumar, D.W. Archer, J.R. Hendrickson, S.L. Kronberg, and M.A. Liebig. 2018. Integrated crop-livestock systems and water quality in the northern Great Plains: Review of current practices and future research needs. Journal of Environmental Quality. 47(1):1-15

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