Cropping and livestock systems: Manure and soil quality
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Agriculture across the Midwest was founded on the integration of crop and livestock systems. This integration was based on the utilization of crop production for animal feed and utilization of the manure as the nutrient sources for the crops. This same integration of components of the agricultural system exists today but we no longer view these components as an integrated puzzle and tend to consider crop and livestock production as separate systems. The Midwest is one of the most intensive agricultural systems leading in corn and soybean production, dairy, hog and poultry production and can serve as an example of the value of returning to viewing agriculture as an integrated system.

Agriculture faces a number of challenges which will affect our ability to feed the world and provide food security. These challenges can be simply stated as the intersection of climate change and soil degradation. Variation in crop production across years is due to a combination of variation in climate, mainly rainfall, as typified in Figure 1. In the past four years there has a decline in corn and soybean production because of the variability in weather during the growing season. At the field scale, there is variability in crop yields due to a combination of weather and soil. One of the critical soil parameters affecting crop production is the soil organic matter content and the linear relationship to soil water holding capacity. This can be seen in Figure 2. As organic matter increases the greater the available soil water for different soils.

![Figure 1. Corn and soybean yield.](image)

![Figure 2. Soil organic matter and available water for 3 different soils.](image)

This aspect becomes critical because crop production is dependent upon the amount of water transpired by the crop. Simply stated, the more water transpired by the crop, the higher the crop yield. Field scale research has demonstrated that soils with low water holding capacity show a decreased yield because of the lack of soil water during the grain-filling period. This effect is evident during years with below normal rainfall during the late July through early September period. An aspect of climate change across the Midwest is that our rainfall patterns are beginning to show a trend toward decreasing amounts in the summer and increased amounts during the spring period. As we begin to experience more variation in the weather during the growing season the greater the impact of soil quality on variation in crop production. Observations of crop production across the Midwest has shown that the higher the soil quality the higher the yield and less chance of yield loss during adverse weather conditions.
The Midwest has an advantage compared to other regions of the United States with the good soils and intensive animal production systems with the capacity to produce large amounts of manure. Utilization of manure as part of the agronomic system offers two distinct benefits for agronomic systems which include nutrient supply for the crop and improvement of soil quality. Manure is a valuable source of nitrogen, phosphorus, potassium, and micronutrients. Organic sources of nutrients offer the potential of being more available in sequence with crop demand during the growing season.

The most overlooked value of manure is the role in improving soil quality. Soil properties which exhibit a positive response to the utilization of manure include bulk density, aggregation, soil organic matter, and soil biological activity. Soil quality is an interaction of a number of factors; however, improvement of soil quality is initiated with providing a stable food source for microbial activity. Manure provides a balanced carbon and nitrogen source which supports microbial activity and when coupled with soil management practices which don’t disturb the root systems of the previous crop there is a positive response to bulk density, organic matter, and aggregation. Bulk density is improved because the soil aggregates become more stable and allow for a more efficient exchange of carbon dioxide and oxygen between the soil and the atmosphere. This is a critical component in improving soil quality because a stable soil microenvironment is necessary to allow the soil biological activity to increase. The increase in soil microbial activity provides the foundation for the increase in organic matter in the soil. Organic matter increases are necessary for any improvement in soil quality and continual soil biological activity is needed as the sustaining factor in providing the mechanism for incorporating manure into a valuable soil resource.

On-farm evaluations of manure management has demonstrated that the combination of reducing tillage by utilizing strip tillage systems as a method of incorporating liquid manure greatly improved soil quality within a five year period. The strip tillage system prepared the soil for the planting of the next crop and limited the soil disturbance. One of the attributes of this system has been the placement of the tillage strip to avoid disturbing the previous root system and allowing these roots to be utilized as food source for the soil biological systems. The increased aggregate stability increases the infiltration rate of rainfall into the soil and also decreases the potential for soil erosion.

Incorporation of manure into a fertilizer source by reducing the water content and balancing the nutrient content offers the potential to be a valuable soil nutrient source because of the stimulation of the soil biological activity. The increased soil biological activity increases the nutrient cycling and availability to the growing crop and there has been an increase in corn production as a result of a combination of enhanced nutrient availability during grain-filling and improved soil quality leading to improved soil water supply. The value of manure can not be overlooked and Midwestern agricultural systems have the potential to become more efficient in the utilization of the natural resources, e.g., water, nutrients, and light, with the incorporation of manure as part of the management system. Improvement of soil quality provides the foundation for enhanced crop production and resilience to climate variability. The linkage between water, nutrients, and soil management must be understood to be able to continue to increase crop production.