

Livestock Manure Utilization in No-till Cropping Systems

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Concern for the environment, water conservation and economic savings through reduced fuel use have been the driving forces for adopting no-till crop production in North Dakota. Concern for the environment, economic savings through reduced commercial fertilizer dependence and, more recently, federal government incentives have driven enhanced manure management in the state.

North Dakota livestock producers have increased their reliance on manure nutrient credits to supply their crops with needed plant nutrients. They have done this voluntarily because they realize the value of the nutrients in the manure or they want to take advantage of government incentive programs.

No-till crop producers with livestock are concerned with surface, nonincorporated manure application for several reasons: availability of nutrients to the crop, increased weed competition and nutrient stratification in the soil surface. Environmentally, a major concern is surface water contamination when surface-applied, nonincorporated manure leaves the field in runoff.

Environmental Issues

The transport of manure nutrients off-site in runoff is a major source of surface water contamination. Phosphorus and nitrogen in surface runoff are the major contributors to the impairment of lakes and ponds through the process of eutrophication. Eutrophication is the result of excessive bacteria and algae growth in surface waters due to nutrient enrichment, usually of nitrogen and phosphates. When this growth dies, other bacteria decompose the material, depleting the waters of oxygen, resulting in fish kills. Eutrophic waters contain high levels of bacteria and algae that cause taste and odor problems. In addition, certain types of algae in eutrophic waters are toxic to livestock and humans.

A recent study in Wisconsin (Bundy, et al., 2001) assessed the amount of phosphorus (P) in runoff from no-till plots with nonincorporated manure applications versus chisel-plowed plots with incorporated manure applications. The researchers found higher concentrations of dissolved P in the runoff from the no-till plots versus the chisel-plowed plots, but the total amount of P lost was lower for the no-till versus the chisel plow. They stated that the increased infiltration of water in the no-till plots lowered the sediment loss and reduced the total P load in runoff.

These results showed opposite effects on total P loss than what was expected from surface-applied nonincorporated manure. The researchers suggested examining all aspects of a cropping system when designing nutrient management recommendations to minimize losses of P that cause surface water pollution.

No-till crop production increases the amount of soil macropores and allows for greater water infiltration, which could lead to nitrate (N) contamination in groundwater. A study published in 1995 (Izaurralde, et al.) showed increased nitrogen leaching in the soil profile under no-till compared with conventional tillage. More recent studies (Halverson, et al., 2001; Zhu, et al., 2003; and Gupta, et al., 2004) showed no difference in nitrogen leaching between tillage types. These studies emphasize that no-till has an increased risk of macropore flow that may impact N leaching. Soil type, rainfall, crop rotation and other external factors will influence the amount and rate of the macropore flow. Therefore, proper nitrogen fertilization management is important to prevent producers from applying too much crop-usable nitrogen and increasing the risk of nitrogen leaching in macropore flow.

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Nutrient Stratification

Lack of tillage to mix the topsoil and surface application of nutrients in no-till crop production systems can lead to nutrient stratification in the upper several inches of the soil. Several long-term studies (Holanda ,et al., 1998, and Robbins, et al., 1991) have shown nutrient accumulations in the upper 2 to 5 inches of the soil after nine to 13 years of no-till row crop production with surface application of nutrients.

They also report stimulated root growth in the upper portions of the soil and higher nutrient uptake by the plants grown under no-till vs. tillage. They attribute these results to nutrient stratification at the soil surface and more consistent soil moisture conditions under no-till. Yield-limiting problems due to the positional unavailability of nutrients caused by stratification in the upper 2 to 5 inches of the soil are a concern. To address this, banding nutrients at 6 to 8 inches deep may be advisable. However, under dryland conditions, any rainfall will tend to wet the surface more than the subsurface when crops are growing. Therefore, the benefits of deep banding vs. surface application of nutrients are minimized under dryland conditions.

Nutrient Availability

Research has shown that 40 percent of the total nitrogen (N) in beef feedlot manure and 15 percent in composted beef feedlot manure is plant available in the first year it is applied and incorporated (Eghball, et al., 1999a). When beef feedlot manure is applied and not incorporated in a no-till system, research has shown first-year availability of 38 percent of total N for manure and 20 percent for compost (Eghball, et al., 1999b). In this study, surface application of manure or composted manure did not show significant N loss because the N in both manure and compost were in very stable forms. The study also indicates no difference in corn yield between no-till and tillage or manure, compost or fertilizer treatments. Soil-test P levels increased when manure or compost was applied at rates higher than crop uptake, regardless of tillage.

From another study, corn, soybean and wheat yields were not different among chisel plow, moldboard plow or no-till when composted swine manure was the fertilizer source (Singer, et al., 2004). The study also showed soil-test P and potassium (K) levels can be elevated when those nutrients are applied with compost at rates higher than crop uptake.

Barley and oilseed crop yields were similar between manure incorporated in conventional tilled plots vs. surface applied nonincorporated manure in no-till plots (Stevenson, et al., 1998).

In all these studies, nutrient availability is not an issue when manure or composted manure is surface applied and not incorporated under no-till cropping systems. Nitrogen typically is the limiting nutrient in crop production, and nitrogen mineralization from beef feedlot manure or composted manure is the same whether it is incorporated with conventional tillage or left on the surface in no-till systems (Eghball, 2000).

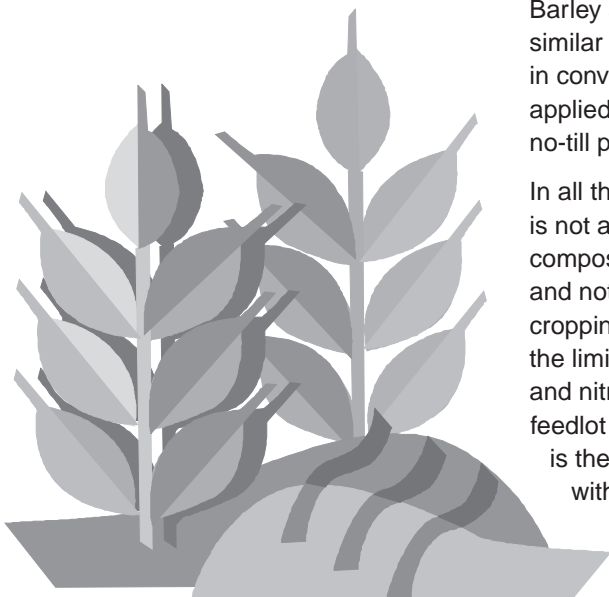
Manure vs. Composted Manure

Composting manure is becoming more popular. In comparison with manure, compost is a more stable product since almost all of the nutrient fractions are in an organic form and the material is semidecomposed. Plants take up the majority of nutrients in an inorganic form. Therefore, the nutrients in composted manure need to undergo biological breakdown (mineralization) in the soil before they are available to the plants. In essence, composted manure is a slow-release fertilizer, so consider the timing of the application.

Studies have shown that the slow mineralization of nutrients in compost increases soybean yields at a higher rate than commercial N fertilizers applied in-season (Singer, et al., 2004). Composting also is a good method of producing a more nutrient-stable soil amendment with a lower moisture content and less volume, compared with raw manures. The composted material can be hauled longer distances at less cost, it has less odor when applied, and pathogens and weed seeds are killed during the composting process if temperatures generated during the process were high enough.

Both manure and compost can improve the soil's physical, chemical and biological properties, which helps increase crops' nutrient uptake efficiencies and lead to higher yields. Research has shown that soils with compost applications had a 13 percent higher organic matter concentration than those without compost (Singer, et al., 2004).

Many crop producers have noted weed problems following manure applications. Of the research conducted to investigate this issue, one study showed that weed production was more highly correlated to the nutrient availability of applied manure than to the weed seeds in the manure (Eghball, et al., 1999a). If weed seeds



Manure Nutrient Values

are a concern, one sure method of reducing the viability of weed seeds is to compost the manure properly. The temperatures in properly composted manure reach a high enough level to kill weed seeds.

Some disadvantages of using compost would be the loss of some nutrients, particularly nitrogen, during the composting process; additional labor needed to manage the process; and the possible investment in specialized equipment. Standard farm equipment can be utilized to compost successfully; however, some producers choose to purchase compost turners to gain efficiency during the process.

The rate of manure or compost applied to fields depends on the crop being grown, soil test levels and nutrient composition of the manure or compost. NDSU Extension Service bulletin SF-882, "North Dakota Fertilizer Recommendation Tables and Equations Based on Soil Test Levels and Yield Goals," is a good resource to help determine crop nutrient needs in conjunction with soil test levels.

Table 1 gives some estimates of nutrients that livestock produce. These numbers are just estimates. Manure or compost should be tested to determine the actual nutrient levels. For information on proper manure sampling procedures, consult NDSU Extension

Service bulletin AE1259, "Manure Sampling for Nutrient Management Planning." Manure samples can be sent to the NDSU Soil Testing Lab at 103 Waldron Hall, Fargo, ND 58105. Please call the lab at (701) 231-9589 for sample handling information before submitting samples.

Knowing soil-test levels can help producers plan their manure application rates based on N or P needs. If soil test levels for P are in the low range, then manure application rates can be based on N needs of the crop to be grown. If soil test levels for P are high, then manure application rates are based on P needs of the crop to be grown.

Manure Nutrient Value Examples

1. A producer has 200 head of beef cows that are contained in a feedlot for three months (one-quarter of a year) every spring and the manure is hauled every fall. The soil test shows P levels in the low range and K levels in the medium range. How many acres of no-till corn with an estimated yield of 100 bushels/acre can be fertilized with the manure?

$$(200 \text{ cows} \times 79 \text{ pounds of N/year}) / 4 = 3,950 \text{ pounds of available N}$$

$$(200 \text{ cows} \times 105 \text{ pounds of P/year}) / 4 = 5,250 \text{ pounds of available P}$$

$$(200 \text{ cows} \times 85 \text{ pounds of K/year}) / 4 = 4,250 \text{ pounds of available K}$$

Since soil test levels are low for P, manure application rates can be based on the corn's N needs. The 100 bushels/acre corn requires 120 pounds of N/acre, 46 pounds of P/acre and 44 pounds of K/acre.

$$(3,950 \text{ pounds of N}) / (120 \text{ pounds of N/acre}) = 33 \text{ acres of corn N needs}$$

$$(5,250 \text{ pounds of P}) / (46 \text{ pounds of P/acre}) = 114 \text{ acres of corn P needs}$$

$$(4,250 \text{ pounds of K}) / (44 \text{ pounds of K/acre}) = 97 \text{ acres of corn K needs}$$

Therefore, 33 acres of corn can be fertilized with the manure to meet all of the nutrient requirements. The soil test levels of P and K will increase. The level of increase will depend on soil type and field history.

2. Use the same example as above except soil test levels for P are high and K the same. In this case, manure application rates should be based on crop P needs. For this scenario, 100 bushels/acre corn requires 120 pounds of N/acre, 11 pounds of P/acre and 44 pounds of K/acre.

$$(5,250 \text{ pounds of P}) / (11 \text{ pounds of P/acre}) = 477 \text{ acres of corn P needs}$$

In this situation, manure application would not meet the N and K needs and would have to be supplemented with commercial fertilizers. To develop specific manure application rates, please consult NDSU Bulletin 1187, "Manure Application Planning Workbook."

Table 1. Estimated Available Nutrients Produced Per Animal Per Year*

	Nitrogen	Phosphorous	Potassium
Dairy – Solid (lbs/yr for 1,400-lb cow in bedded pack)	176	122	140
Dairy – Liquid (lbs/yr for 1,400-lb cow in liquid slurry)	214	122	140
Beef – Solid (lbs/yr for 1,100-lb cow in open lot)	79	105	85
Swine – Solid (lbs/yr for 200-lb finished hog in bedded pack)	21	26	20
Swine – Liquid (lbs/yr for 200-lb finished hog in liquid slurry)	26	26	20

*From Nebraska's CNMP Manure Application Workbook

Summary

The concerns that producers have about utilizing manure nutrients for no-till crop production are valid. Research has been conducted to address those concerns and the results are encouraging.

Crop yields are not depressed when manure is applied at the correct rates and in the long term, manure applications have shown positive effects on soil quality. Long-term studies have shown increased carbon sequestration, higher cation exchange capacity, lower bulk density and increased levels of organic matter in soils where manure was applied consistently (Eghball, 2002). These side benefits of manure application have a beneficial impact on water and air movement in soils, which helps enhance crop growth.

Crop producers can help reduce yield differences between conventional and no-till production with manure and compost surface applications. Producers can make a manure or compost application that provides several years' worth of nutrients without depressing yields (Stevenson, et al., 1998). This can result in less frequent applications to fields where annual transportation costs may be prohibitive.

When designing a manure application plan, producers have to make sure they are getting the nutrients they are crediting. The size and species of the animal, housing, feeding ration, manure storage and climate all have impacts on the manure nutrient content. The rate of manure applied depends on the manure analysis, soil-test levels, crop rotation and environmental conditions. If producers implement a sound nutrient management plan, they should feel confident in fully utilizing manure nutrients in no-till crop production.

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