Nitrogen Availability from Compost Dairy Barn Manure

Michael Russelle, Kevin Blanchet, Gyles Randall, and Les Everett

In 2001 a Minnesota producer introduced a new method of housing dairy cows, called "compost dairy barns" (CDB), that has been adopted by some small- and medium-size dairy farms. In the CDB system, a deep bed (eventually 4 feet deep or more) of sawdust or wood shavings is maintained in the loafing area, and the surface layer is stirred (tilled) twice daily when cows are being milked. The combination of deep bedding and mixing of surface materials reportedly helps conserve manure nitrogen (N), improves cow comfort, reduces lameness and mastitis, and increases milk production. It results in a mixture of manure and wood particles that is partially composted and is usually fall-applied for a following corn crop. However, to date, no information on N availability from CDB manure has been available, and thus there is no way to forecast the appropriate rates of manure to apply or the rate of supplemental fertilizer N.

We conducted trials on eight Minnesota farms that included sampling CDB manure for laboratory analysis and measuring corn response to CDB manure with a range of supplemental fertilizer N rates. Our immediate objective was to determine N availability from CDB manure, as measured by crop response in the field and correlated with laboratory analysis of the manure. We also attempted to use laboratory analyses and pack management data to predict the fertilizer N equivalence of CDB manure for use in nutrient management planning. The field trials involved fall-applied manure under two management systems after broadcast application in fall – rapid incorporation or no incorporation until the next spring.

Results

Estimating manure pack density and weight

Bulk density of the compacted manure below the tilled surface layer was similar among barns, averaging 58.2 lb/ft^3. The tilled surface layer density varied, but generally contributed less than 10% of the total mass of manure. Because it is unlikely that new bedding would be added near the time the barn will be emptied, the density of the surface layer likely will be similar to the density of the deeper layers when manure is moved to the field. Therefore:

- ***The total amount of manure available to be applied can be estimated by multiplying the volume of the manure pack (in cubic feet) times 58.2 lb/ft^3.***

Nutrient concentrations

Total N concentration averaged about 1.10% N and did not differ among sampling areas (near outside walls, near the retaining wall, or along the centerline of the pack) in the barns or with depth (surface vs. compact layers). Organic-N was higher in the surface (0.94% N) than the compact zone (0.82% N), but did not vary by area in the barns. Ammonium-N concentration also did not vary with area, but was lower in the surface layer (0.08% N) than the compact layer (0.23% N). Ammonium-N comprised from 1% to 38% of total manure N. Others have reported a pH of 8.6 for CDB manure. Ammonia volatilization losses may be large if CDB manure has both high pH and high ammonium-N concentration. Carbon (C) to N (C:N) ratio for the pack ranged from 11.2 to 20.9. The C:N ratio will increase as ammonia is lost by volatilization. In other materials, C:N ratios above 15 can cause temporary N immobilization by soil microorganisms.

- ***Immediate incorporation of CDB manure after field application is recommended to prevent ammonia volatilization and retain plant-available N.***

Manure applicators also need to know the phosphate (P_2O_5) and potash (K_2O) concentrations of the product. Phosphate concentration in the pack averaged 0.26% and average K_2O concentration was 0.68% in this study. Neither nutrient varied with depth or with sampling location within the barns. On average, these eight CDB manures contained nearly twice the concentration of P_2O_5 and K_2O as typical solid dairy manure.

- ***CDB manure may be sampled at random locations in the barn, but samples must be taken from the entire depth of the pack.***
- ***Manure from each CDB should be analyzed for nutrient content, because composition differs widely among farms.***
- ***We recommend that the final manure sample for analysis be composed of at least 10 samples from different areas of the barn or from the manure as it is being loaded into the spreader.***

Nitrogen availability

Our lab incubation trial showed two general patterns of net nitrate production from the eight manure packs. Three manures maintained a positive amount of nitrate (above that produced by soil alone) throughout the 4-month-long incubation. In contrast, five manures resulted in periods of nitrate immobilization that, in four cases, reduced nitrate-N availability ***below*** that of non-manured soil for 1 to 2 months.

- ***Some CDB manure may produce only small amounts of N and others may reduce N supply for the first several weeks of the growing season***.

It appears that CDB manure behaves more like a mixture of bedding and manure, rather than a well composted mixture. This is substantiated by other recent research, which showed that CDB manure can be further composted in well-managed piles.

Based on our field trials, the actual fertilizer N equivalence ranged from 1.4 to 12.1 lb N/ton for rapidly incorporated CDB manure and from -0.3 to 5.3 lb N/ton for fall-applied CDB manure that was not incorporated until spring, Many of the measured fertilizer N equivalence values were much smaller than the N supply predicted by the MidWest Plan Service or University of Minnesota for solid dairy manure, resulting in *overestimates* of N supply ranging up to 104 lb N/acre. In contrast, these guidelines also *underestimated* N supply for nonincorporated manure by 53 to 64 lb N/acre at one location. It is clear from our research that

- ***Solid dairy manure guidelines should not be used for predicting N availability from CDB manure***.

CDB manure will be of particular value on fields that require P_2O_5 or K_2O to improve crop yield. However, more field response data are needed for this new dairy manure source to generate reliable ways to predict N supply for use by farmers, nutrient management planners, and regulatory agencies. Until such prediction equations are available, we recommend farmers: 1) sample and analyze their CDB manure; 2) apply a moderate rate (for example, 10 tons/acre); 3) incorporate immediately; 4) apply a basal rate of N to corn in spring (for example, 30 to 60 lb N/acre); and 5) be prepared to sidedress if plant or soil analysis indicate the need for more N.

Note: *This is a summary of a paper containing a more thorough presentation of methods and results: "Characteristics and Nitrogen Value of Compost Bedded Pack Dairy Barn Manure."*