GRID SOIL SAMPLING FOR MANURE APPLICATION
CASE STUDY #5

Beef Farm #1: Solid Manure, High Soil Test P

**Situation:** This beef operation has 5000 tons of manure nutrients available annually, composed of the following analysis ("As Received" basis):

- TOTAL N = 8.8 lbs/ton
  - 1.0 lb/ton NH₄-N
  - 7.8 lbs/ton Organic N
- P₂O₅ = 4.9 lbs/ton
- K₂O = 7.1 lbs/ton

The field size used for this study is 189 acres. The cropping system is one year of no-till soybeans followed by two years of grain corn. Manure is spread with a slinger-type spreader for the corn crops with the flexibility of putting down 6 to 35 tons/acre. This study investigates alternative manure application strategies based on grid soil sampling results for the first year of corn production.

**Crop Nutrient Needs and Removal Rates:**

We can determine the crop nutrient needs for the field using University of Minnesota guidelines found in UM Extension bulletin 3790, *Fertilizing Corn in Minnesota*, 2006 or UM Extension bulletin 06240, *Fertilizer Guidelines for Agronomic Crops in Minnesota*, 2011. Use the most recent guidelines, since publications are updated with new research. Publications are available at: [http://www.extension.umn.edu/nutrient-management](http://www.extension.umn.edu/nutrient-management).

**Nitrogen:** The nitrogen (N) rate range is determined by the N price/crop value ratio. If we use the lowest N Price/Crop Value ratio (0.05), 140 lb N/acre falls near the maximum of the guideline range for corn after soybeans. For beef manure, broadcast and tilled in <12 hours after application, N availability is 60% the first year, so 230 lb manure N would be needed. If broadcast and tilled in between 12 – 96 hours, N availability is 45% the first year, so 310 lb manure N would be needed (See *Manure Management in Minnesota*, UM Extension bulletin 03553, 2007, for manure nutrient availability.) For comparisons of application options in this case study, we assume incorporation in <12 hours after application. Delayed or no incorporation would lead to economically significant loss of nitrogen by volatilization and a less favorable ratio of N, P, and K for crops.
Phosphorus: Crop P needs are determined from soil test values. A composite soil sample for this whole field (field average) is 50 ppm Bray 1-P. The broadcast fertilizer P recommendation (P need) would thus be 0 lb/acre P₂O₅ for corn. The grid soil sample results mapped for this field (see map below, left) show that the P distribution is variable, ranging from high to extremely high (18-282 ppm P). The eastern and central field areas tend to be below 50ppm while the western part is primarily above 50ppm. Although the soil test data show no large acreage where a yield response to P would be expected (< 21 ppm P), the crop rotation and P distribution offer an opportunity to use manure nutrients by applying manure at crop P removal rates in the lower soil test areas. This would maintain soil P levels on 58% of the field while allowing the very high levels on the western side and southeast corner to decline and thus reduce risk of P in runoff on these sloping fields. For crop nutrient removal rates see Nutrient Removal by Major Crops, UM Extension: Minnesota Crop News, George Rehm, 2001.

Potassium (K): Crop K needs are also determined from soil test values. The whole field average soil test K is 227 ppm, indicating that there would be no response to fertilizer K. There is variability across the field (see map below, right), ranging from 70 to 951 ppm K. In contrast to the P distribution, K is higher in the eastern portion of the field.

Soil Test P (Bray 1-P), left, and Soil Test K, right, in ppm. University of Minnesota soil test classes for K are shown. The whole field is in the Very High class for P, so an additional class was added for values >50 ppm.

Comparing alternative manure application options:

Using a grid soil P map, we can exclude one or more field areas from manure application because of excessive P levels. Excluding 79 acres of extremely high P on the western side and southeast corner (see map), the average P test drops from 50 ppm to 37 ppm. For the zone where manure could be applied, the P need is based on a crop removal rate of 0.60 lbs/bu for the expected crop yield.
We can compare several manure application options, both zonal and whole-field, and assume supplementation with variable rate fertilizer application where needed.

The manure application rate and area alternative economic comparisons are:
1. N-based manure rate, whole field
2. N-based manure rate, manure zone only, supplemental fertilizer where needed
3. P-removal rate, whole field, supplemental fertilizer where needed
4. P-removal rate, manure zone only, supplemental fertilizer where needed

The economic comparisons are made using the spreadsheet “What’s Manure Worth?” MANURWKST.XLS, available at: [http://z.umn.edu/manureworth](http://z.umn.edu/manureworth). Data on the farm’s manure type, amount, analysis, spreading method and spreading costs, manure application rates, manure nutrient availability, fertilizer costs, crop nutrient needs, acres for spreading, expected yield boost from use of manure instead of fertilizer, and second year nutrient credits are entered to determine the value of manure (total, per acre, and per ton) under the a specific application rate and method. Altering the rate and method will change the value of manure. See Appendix 1 for data needed for the spreadsheet that is not in Table 1.

A comparison of results for the four rate alternatives is found in Table 1. The highest net value of manure per ton comes from the P-removal based zonal and whole-field strategies. That is because the value for the P-removal options is based on anticipated future P and K fertilizer replacement value rather than present fertilizer replacement value, which is zero for P in these high P testing soils. Zonal compared to whole-field approaches do not differ in value of manure per ton or per acre in this case, however, the zonal approaches leave more manure available for application on other fields where nutrients may be needed more and would create less environmental risk. Or, it could be sold as a crop nutrient source to other producers within an economic radius.

The “Economics of Manure” spreadsheet analysis does not account for the increased cost of grid soil sampling. At $10.25 per acre for approx. 2 acre grids, the field-total cost is $1938. The value of the grid soil sampling is in:

- Potential yield response to precision applied supplemental K in the central part of the field if following P-removal manure application rates or below.
- Reducing P in runoff and reducing soil test P in the extremely high testing parts of the field by avoiding application in those areas.
- Conserving manure for use on fields where P and K are needed.

One grid soil sampling every 3 to 5 years can serve multiple manure applications, reducing the cost substantially on a per-application basis.
TABLE 1. ECONOMIC ANALYSIS OF ALTERNATIVE MANURE APPLICATION STRATEGIES.

<table>
<thead>
<tr>
<th>Manure Application Strategy</th>
<th>N-Based, Whole-Field</th>
<th>N-Based, Zonal</th>
<th>P-Removal Rate, Whole-Field</th>
<th>P-Removal Rate, Zonal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure Application (acres)</td>
<td>189</td>
<td>110</td>
<td>189</td>
<td>110</td>
</tr>
<tr>
<td>Crop Nutrient Need N - P₂O₅ - K₂O (lbs/acre)</td>
<td>140-0-0</td>
<td>140-0-0</td>
<td>140-63-45</td>
<td>140-63-45</td>
</tr>
<tr>
<td>Manure Application Required/Acre (tons/acre)</td>
<td>27</td>
<td>27</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Manure to be Applied (tons/acre)</td>
<td>27</td>
<td>27</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Manure-Available Nutrients Applied (lbs/acre)</td>
<td>143-106-173</td>
<td>143-106-173</td>
<td>84-63-102</td>
<td>84-63-102</td>
</tr>
<tr>
<td>Net Value of Manure ($/acre)</td>
<td>12</td>
<td>12</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>Net Value of Manure ($/ton)</td>
<td>0.43</td>
<td>0.43</td>
<td>4.30</td>
<td>4.30</td>
</tr>
<tr>
<td>Manure Remaining After Spreading (tons)</td>
<td>0</td>
<td>2030</td>
<td>1976</td>
<td>3240</td>
</tr>
</tbody>
</table>

Additional Environmental Considerations:
Approximately half of this field is on slopes of 6 to 12%, with a stream near the center. Surface application of manure without incorporation would risk surface runoff of soluble P and loss of some inorganic N through volatilization. Tillage incorporation of manure, while reducing surface runoff of soluble P and loss of N, can also reduce protective crop residue and increase erosion. To minimize loss of both nutrients and soil on this field with a soybean-corn-corn rotation (including a manure application prior to each corn year), would require no-till for soybeans, light tillage to incorporate fall applied manure, and no additional tillage prior to the first year of corn. Waterways, terraces and buffers are essential management strategies on this landscape. Estimates of soil and P loss for any combination of slope, tillage, and manure application method can be calculated from the Minnesota Phosphorus Index, run by the local NRCS/SWCD office and some crop consultants. It can be obtained at: http://www.mnpi.umn.edu/
Conclusions:

1. Periodic Grid Soil Sampling allows livestock operations to identify field areas of excess P and K, which may have developed with a history of non-uniform manure applications.

2. Excluding zones of excessive soil test P from manure applications will:
   a. Allow more efficient use of manure on other fields and field areas, increasing the total value of the manure supply if other acres of need have been identified or the manure is marketable.
   b. Reduce P pollution in runoff, since soluble P in runoff is proportional to soil test P.

3. On fields where manure must be applied even though P is not currently needed, applying at P removal rates will prevent additional soil test P buildup.

4. The manure application method and timing of incorporation has a strong influence on conservation of nutrients and potential loss of P to water.

5. The choice of crop rotation and tillage practices, including manure incorporation, has direct impact on soil erosion and conservation.

Appendix 1: Additional information used to calculate the value of manure with the spreadsheet “What’s Manure Worth?”:

- Fertilizer nutrient prices/lb.: N = $0.59, P₂O₅ = $0.54, K₂O = $0.54
- Cost of purchased micronutrients/acre: $2.50
- N fertilizer application cost avoided for N-based strategies: $10.00/acre
- Dry P₂O₅ and K₂O fertilizer application cost avoided/acre: $0 for all strategies.
- Additional value of micro-nutrients in manure: $0.00 assumed.
- Second year nutrient credits/acre for valuation:
  - N-based, whole field = 59-0-0
  - N-based, zonal = 59-0-0
  - P-Removal based, whole field = 35-0-0
  - P-Removal based, zonal = 35-0-0
- Manure yield boost value/acre over fertilizer alone: $20.00
- Tillage effect of manure application: $0.00
- Manure application cost/ton: $5.00