GRID SOIL SAMPLING FOR MANURE APPLICATION
CASE STUDY #4

HOG FARM #2: LIQUID MANURE

Situation: This hog operation in southeast Minnesota has 1.0 million gallons of Swine Finishing Liquid Manure available annually, with an analysis of:

- Total N = 46 lbs/1000 gal
  - 36 lbs/1000 gal NH_4-N
  - 10 lbs/1000 gal organic N
- P_2O_5 = 14 lbs/1000 gal
- K_2O = 25 lbs/1000 gal

Photo: USDA-ARS

The field for this case study is 157 acres with 1-6% slopes. The cropping system is one year of soybeans followed by two years of grain corn. Manure is knife injected the first and second years of corn after soybeans. The value of manure spreadsheet is used to analyze the **first** year of corn.

CROP NUTRIENT NEEDS AND MANURE NUTRIENT AVAILAILABILITY

The crop nutrient needs for this field were from University of Minnesota guidelines 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*

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 hog manure, knife injected, N availability is 70% the first year, so 200 lb manure N would be needed. For manure nutrient availability see **Manure Management in Minnesota**, UM Extension bulletin 03553 from 2007, and **Nitrogen Availability from Liquid Swine and Dairy Manure: Results of On-Farm Trials in Minnesota**, UM Bulletin 08583 from 2008.

Phosphorus (P): Crop P needs are determined from soil test values. A composite soil sample for the whole field (field average) is 33 ppm Bray 1-P, which is in the "Very High" range. In that range, no P applications are needed. However, since we have grid soil sample results mapped for this field (Figure 1), we can see that the P distribution is highly variable, ranging from Low to Very High (7-98 ppm Bray 1-P). For the acres falling in the Medium to Low P category a P application would be recommended.

Potassium (K): Crop K needs are also determined from soil test values. The whole field average soil test K is 194 ppm, also in the Very High range, indicating no need for additional K. There is variability across the field, ranging from 121 to 360 ppm K following the trends of P, but with no areas below the High category.

COMPARING MANURE APPLICATION OPTIONS

Zonal Application

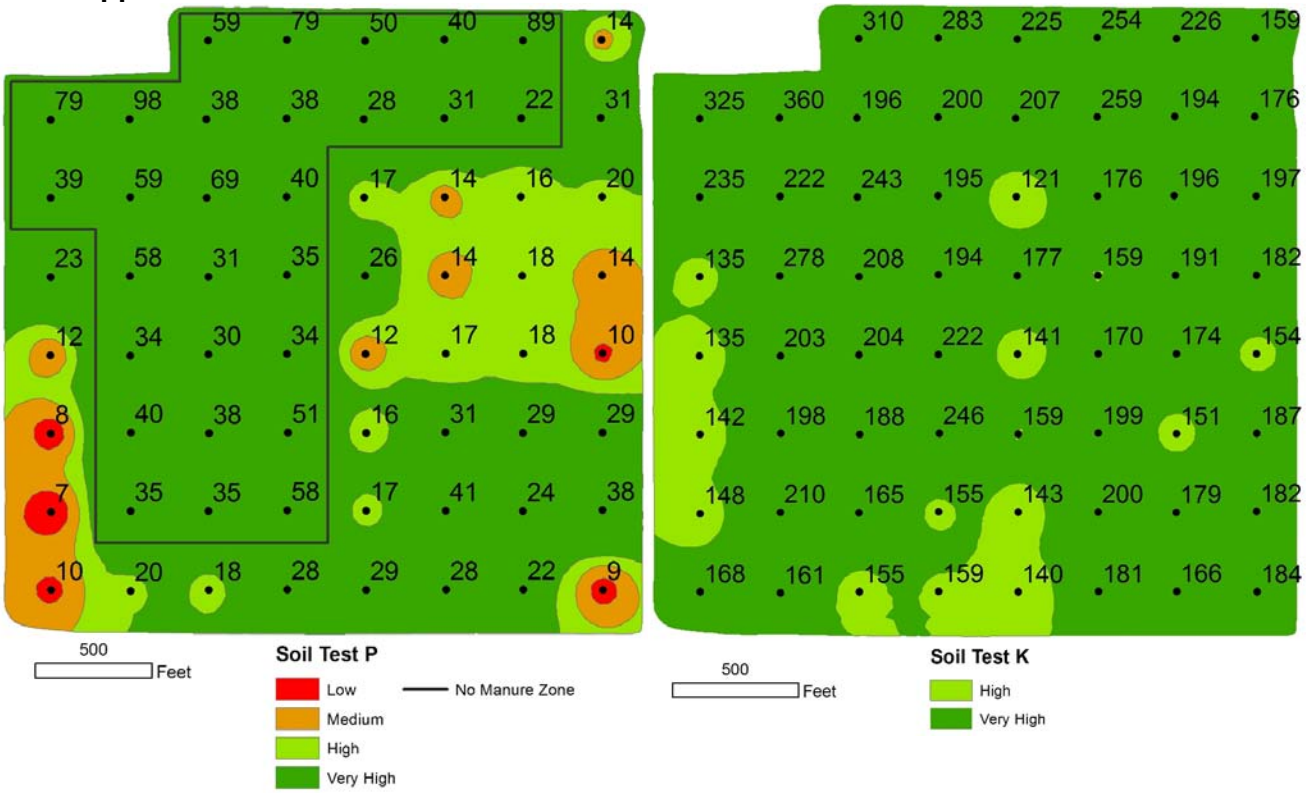


Figure 1. Soil Test P (Bray 1-P) and Soil Test K in ppm with University of Minnesota soil test classes.

Using a grid soil P map the operator can exclude one or more field zones from manure application because of already high P levels. In this case we demonstrate the effects on economic returns of excluding a contiguous zone composed of 71 acres of soil test values ranging from 22-98 ppm Bray 1-P (see Figure 1). The average P test for the remaining grids is less than 21 ppm, putting it in the High category. For these acres where manure would be applied, the average P need is 15 lb/acre P_2O_5 for broadcast application, or 19 lb/acre manure P_2O_5 equivalent with 80% availability. The lowest P testing areas in that zone would benefit from a yet higher P application rate. The partial field average soil test K for the same grids is 166 ppm, still in the Very High category and calling for no added K.

N-based vs. P-based Application

We have the option of basing manure application rates on either N or P needs of the crop if we do not exceed the crop N needs and do not over-apply P in sensitive areas. (See the bulletin "Applying Manure in Sensitive Areas", available on-line at *http://www.pca.state.mn.us/index.php/view-document.html?gid=3530*.)

We can compare the expected economic outcomes of the following three manure application rate and area alternatives. P-based whole field application is not an option because the field-average P test results in a guideline of no P needed.

Whole-Field Application (no grid sampling)	Zonal Application (with grid sampling)
N-based manure rate	N-based manure and precision P&K fertilizer in manure application zone. N fertilizer in manure exclusion zone.
	P-based manure rate plus supplemental N in manure application zone. N fertilizer in manure exclusion zone.

The economic comparisons are made using the spreadsheet "What's Manure Worth?" MANURWKST.XLS, available at: http://z.umn.edu/manureworth. A comparison of results for the three rate alternatives is found in Table 1. For the remaining data needed to complete the spreadsheet, see Appendix 1.

The liquid swine manure on this farm is high in available N relative to P and can meet the N needs of the crop at less than 5,000 gallons per acre.

Our three options are:

1. N-Based Whole Field for a maximum amount of manure to be applied. It produces the lowest net value of manure per acre because manure P & K is being applied in large areas where it is not needed.

2. N-Based Zonal where we have a crop nutrient need for P. There are smaller areas within the application zone where the N-based application level of P exceeds the recommended rate. However, crop removal (63 lb/acre P_2O_5 for 175 bu./acre corn) will exceed the N-Based manure application rate of P with this high N analysis manure and the soil test P values will decline gradually over years. If there is an increased application cost with lower manure application rates, the producer might choose this N-Based Zonal rate.

3. P-Based Zonal where less manure is applied per acre compared to N-Based applications. The Net Value of manure per 1000 gallons is highest for this alternative, and the recommended amount of P is applied for the average of the manure application zone. This alternative would leave the most amount of manure for application to other fields where it would have more value if placed in lower soil nutrient testing areas. Equipment capabilities will have to be considered since 1400 gallons per acre may be too low for older application equipment to reliably apply. If this alternative is chosen, the producer should consider variable rate P fertilizer supplement for the Medium and Low testing areas of the field, as well as the necessary N supplemental fertilizer.

TABLE 1. ECONOMIC ANALYSIS OF ALTERNATIVE MANURE APPLICATION STRATEGIES.

Manure Application Strategy	N-Based, Whole-Field	N-Based, Zonal	P-Based, Zonal
Manure Application (Acres)	157	86	86
Crop Nutrient Need N - P_2O_5 - K_2O (lbs/acre)	140-0-0	140-15-0	140-15-0
Manure Application Required/Acre (gal/acre)	4350	4350	1350
Manure to be Applied (gal/acre)	4400	4400	1400
Manure-Available Nutrients Applied (lbs/acre)	142-49-99	142-49-99	45-16-32
Net Value of Manure ($/acre)	77	91	40
Net Value of Manure ($/1000 gal)	18	21	28
Manure Remaining After Spreading (gal)	309,000	622,000	880,000

Value of Grid Soil Sampling

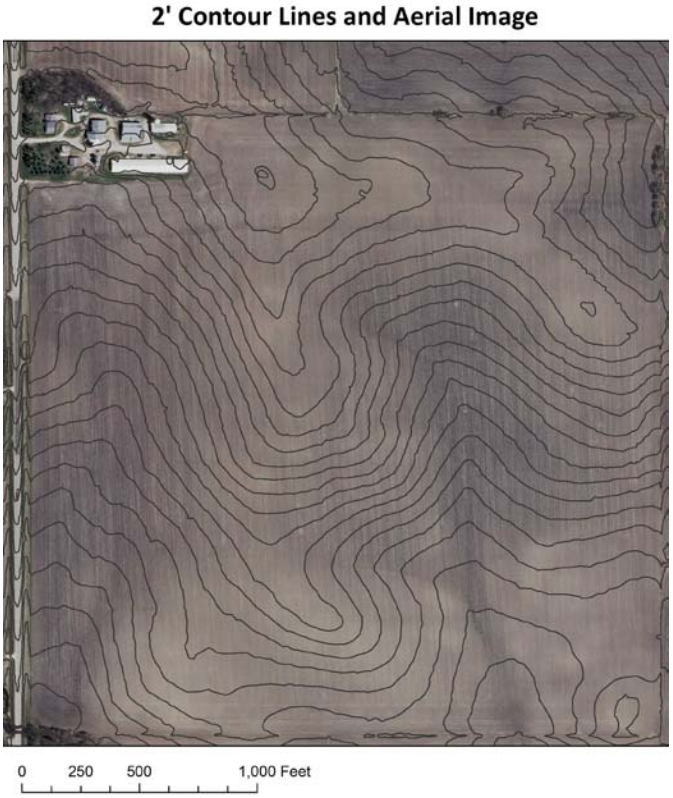
The spreadsheet analysis does not account for the increased cost of grid soil sampling. At $10.25 per acre for approximately two- acre grids, the field-total cost is $1609. Comparing the N-based whole-field with the N-Based Zonal application shows an increase in the value of the manure by $3 per 1000 gal or $1134 for the 86 acres where manure is to be applied with the zonal application. This appears to be a loss until we consider:

- It does not account for the higher value of the increased yield expected from precision application rates of manure and fertilizer P that would occur with the zonal strategies in the Low and Medium P testing areas.
- The value of the manure conserved in using the zonal strategies and available for other fields with greater P and K need is not calculated.
- One grid soil sampling every 3 to 5 years can serve multiple manure applications, reducing the cost substantially on a per-application basis.

ADDITIONAL ENVIRONMENTAL CONSIDERATIONS:

Preventing loss of P and N to surface water requires management of the sources of P and N, as well as transport to a water body. Management to reduce sources on this farm would include:

- Zonal manure management to gradually reduce excessively high P in soil.
- Subsurface injection to avoid manure on the soil surface susceptible to runoff (existing practice on this farm).
- Timing of application to reduce loss of N. If fall application is delayed until the soil temperature is below 50 degrees F, the ammonium in the injected manure will not be converted to nitrate and will not be leached to tile or groundwater.



Erosion and transport of soil particles with attached P is the remaining risk. There are two primary ranges of slopes in this field based on soil types, specifically, 2 to 6% and 1 to 4% slopes. See the 2' contour map (left). There is a stream touching the southwest corner of the field and running 400-700 feet from the south field edge. The aerial image and contours indicate possible runoff in two areas of concentrated flow from the field to the stream. To minimize soil and P loss several strategies should be considered:

- Minimize tillage intensity as much as possible.
- Consider structural controls such as terraces, sediment control basins, filter strips and waterways where appropriate.

The local NRCS/SWCD office and some crop consultants can provide a predicted erosion rate for any combination of slope, crop rotation, and tillage practices using the RUSLE2 model. It is also part of the Minnesota Phosphorus Index available at http://www.mnpi.umn.edu/

As an example, if tillage on this field was fall chisel and spring field cultivate all three years of the corn-corn-soybean rotation, the predicted erosion rates would average 1.8 tons per acre per year assuming 4% slope and 300 foot slope length. Converting to no-till soybeans, spring field cultivate before first year corn, and fall chisel/spring field cultivate before second year corn would reduce rotation average erosion to 1.3 tons per acre per year while maintaining yields. The predicted erosion reduction in the first corn year would be 1.0 ton per acre because of the soybean residue conserved with the reduced tillage.

CONCLUSIONS:

1. Grid soil sampling allows the livestock producer to identify and treat zones of excess and deficiencies for P and K, which may have developed with a history of non-uniform manure applications.

2. Targeting manure and perhaps supplemental fertilizer P and K applications to lower soil test P and K areas of the field will likely result in higher average and more uniform yields compared to blanketed rate applications based on the average soil test value for the entire field.

3. Excluding zones of excess soil test P from manure application 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 P in runoff is proportional to soil test P.

4. The crop rotation and the manure application method have a strong influence on the potential loss of P to water.

5. Tillage practices, both type and intensity over the duration of a crop rotation, have direct impact on trends related to soil erosion-conservation goals, thus an additional key management decision that can reduce the loss of P from productive soils.

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, P_2O_5 = $0.54, K_2O = $0.54
Cost of purchased micronutrients/acre: $2.50
N fertilizer application cost avoided: $10.00 for the N-based application strategies.
Dry P_2O_5 and K_2O fertilizer application cost avoided/acre: $0.00 for all strategies where manure applied.
Additional value of micro-nutrients in manure: $0.00 assumed.
Second year nutrient credits/acre for valuation:

- **N-based, whole field = 30-25-0**
- **N-based, zonal = 30-17-0**
- **P-based, zonal = 10-0-0**

Manure yield boost value/acre over fertilizer alone: $20.00
Tillage effect of manure application: $0.00
Manure application cost/gallon: $0.015