GRID SOIL SAMPLING FOR MANURE APPLICATION
CASE STUDY #8

Dairy Farm #3: Solid Manure

Situation: This dairy farm has 1000 tons of semi-solid pen pack dairy manure, composed of the following analysis ("As Received" basis):

- Moisture = 76%
- Total N = 14 lbs/ton
- P_2O_5 = 5 lbs/ton
- K_2O = 17 lbs/ton

The field size used for this study is 224 acres. The cropping system is a three-year rotation of corn silage, grain corn, and soybeans. Manure is spread with a broadcast spreader for the needed acres with the flexibility of putting down 5 to 25 tons/acre. This study investigates alternative manure application strategies going into the second year of the rotation based on grid soil sampling results at the start of the 3 year rotation. The expected yield for corn grain is 175 bu/acre.

CROP NUTRIENT NEEDS AND MANURE NUTRIENT AVAILABILITY

First, 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 available, since publications are updated as new data become available. 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 of 0.05 for this site, 160 lb N/acre falls above the midpoint in the guideline range for corn after corn. For dairy pen pack manure, broadcast and tilled in less than 12 hours after application, N availability is 55% the first year, so 290 lb/acre manure N would be needed. If broadcast and tilled in more than 12 hours but less than 4 days, N availability is only 40% the first year, so 400 lb manure N would be needed. (See **Manure Management in Minnesota**, UM Extension bulletin 03553, 2007, for manure nutrient availability.)

Phosphorus (P): Crop P needs are determined from soil test values. A composite soil sample for the whole field (field average) is 36 ppm Bray 1-P, falling in the Very High range. The broadcast fertilizer recommendation would be no additional P. However, since we have grid soil sample results mapped for this field (Figure 1), we can see that the P distribution is variable, ranging from low to extremely high (7-110 ppm). A zone in the eastern part of the field (see P map) shows a soil test average of just over 15 ppm, leading to a fertilizer guideline of 45 lbs/acre P_2O_5 for that 40% of the field (89 acres), assuming an expected yield of 175 bu/acre.

Potassium (K): Crop K needs are also determined from soil test values. The whole field average soil test K is 171 ppm, also in the Very High range, so no additional K would be needed for corn. There is variability across the field (Figure 1), ranging from 79 to 511 ppm K, in a pattern similar to that of P. The manure application zone shows a soil test average of 118 ppm K, resulting in 80 lbs/acre K_2O recommended for the 89 acres, assuming 175 bu/acre expected yield.

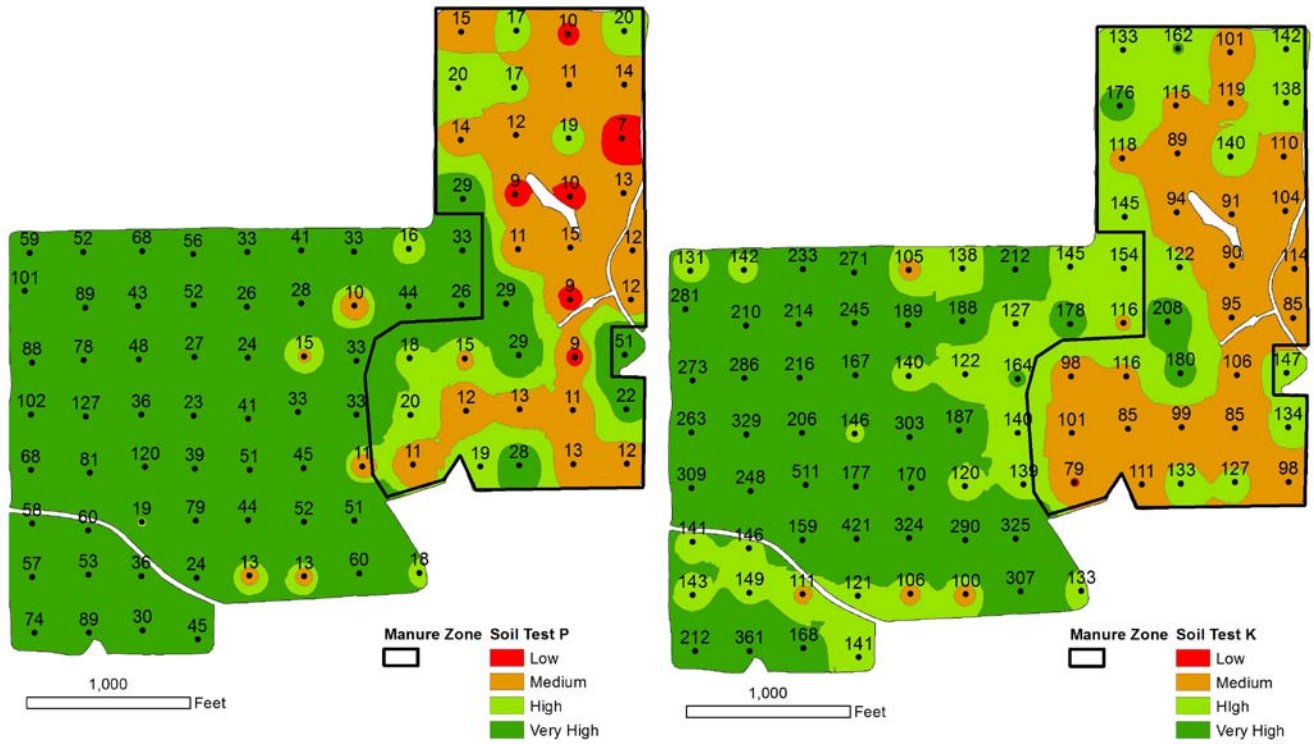


Figure 1. Soil test P and K (ppm) with manure application zone.

COMPARING ALTERNATIVE MANURE APPLICATION OPTIONS

With a grid soil P map the dairy farm manager has the option of excluding 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:

- Whole field manure applications based on nitrogen (N) needs and field-average soil test values
- Zonal manure applications based on N rate requirements, but only in a zone where P is needed as determined by grid soil sampling (see soil test P map)
- Zonal manure application at a rate based on soil test P

Whole field manure application based on an average P rate is not an option with this farm, since no P is needed on a whole-field average basis. For the zonal application rates with grid soil sampling, variable rate fertilizer applications can supplement manure nutrients where needed.

The manure application zone illustrated on the maps above, while contiguous, has an irregular boundary to exclude two high P areas. The producer will determine what final application zone shape is feasible with available equipment. An example alternative zone is shown below which better follows the field configuration.

The economic comparisons are made using the spreadsheet “What’s Manure Worth?” MANURWKST.XLS, available at: http://z.umn.edu/manureworth. Data on the farm’s manure type, amount, analysis, spreading method and spreading costs, manure application rates, and manure nutrient availability, as well as 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 gallon or ton) under the a specific application rate and method. Altering the rate and method will change the value of manure.

Results

A comparison of results for the three rate alternatives is found in Table 1. The highest net value of manure per ton is the P-based zonal application (highlighted in the table) for the 89 acre manure application zone. Since this application area and rate would use almost all of the available manure, there is no need to consider other options that would use the crop nutrients less efficiently. N-based rates with this manure analysis would over-apply P and K, thus reducing the value of the manure calculated on a fertilizer-replacement basis.

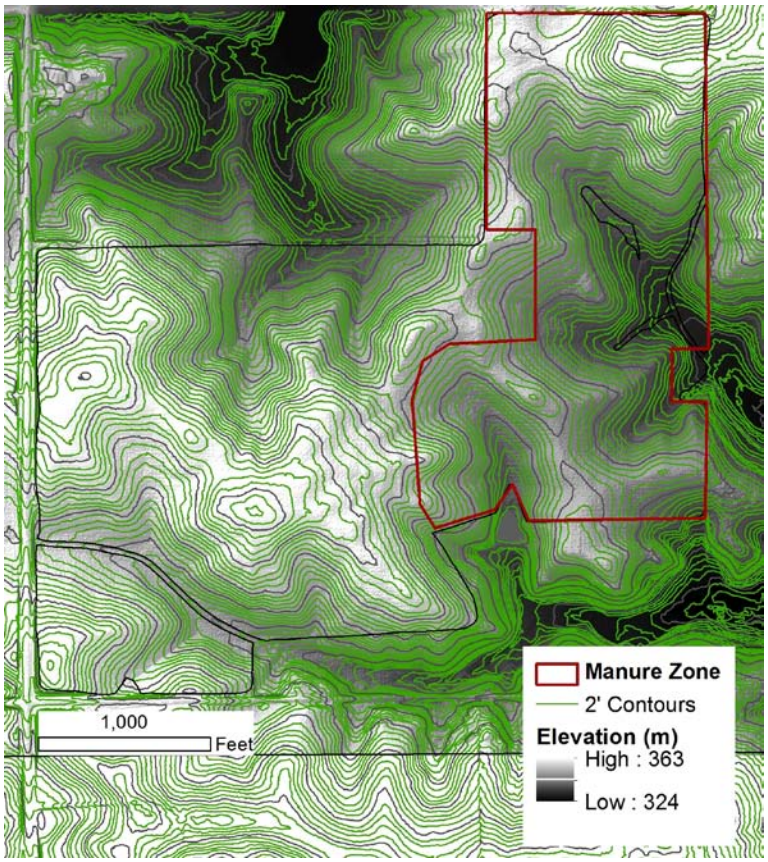
TABLE 1: ECONOMIC COMPARISON OF THREE MANURE APPLICATION STRATEGIES.

Manure Application Strategy	N-Based, Whole-Field	N- Based, Zonal	P-Based, Zonal
Manure Acres Available	224	89	89
Acres Covered at this Rate	50	50	89
Crop Nutrient Need N - P_2O_5 - K_2O (lbs/acre)	160-0-0	160-45-80	160-45-80
Manure Application Required/Acre (tons/acre)	20.8	20.8	11.3
Manure to be Applied (tons/acre)	20	20	11
Manure-Available Nutrients Applied (lbs/acre)	154-80-306	154-80-306	85-44-168
Net Value of Manure ($/acre)	4	90	101
Net Value of Manure ($/ton)	0.2	4.5	9.2
Manure Remaining After Spreading (tons)	0	0	21

Note: The spreadsheet analysis does not account for the increased cost of grid soil sampling. At $10.25 per acre for approximately 2 acre grids, the field-total cost is $2296. The total value of the manure above application costs is $210 if we know only the field-average soil test value and apply at the N-based rate until the manure is all applied (50 untargeted acres). If we have grid soil sampling and can target the manure application to areas where P and K are needed, then the value increases to $4520 at the N-based zonal rate, and $9230 at the P-based zonal rate. This does not account for the higher value of the increased yield expected from more precise application of P and K. The return on investment for the grid soil sampling is therefore quite high for this farm. 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

According to the soil survey, there are 6-12% slopes on more than 43% of this field (see contour elevation map), creating an erosion risk. The dominant source of total P reaching water on these slopes with corn harvested for silage, tillage for manure incorporation, and light residue from soybeans would be P attached to eroded soil particles. In addition to avoiding build-up of soil test P to excessive levels, crop rotations and tillage practices that minimize soil erosion are essential to reducing P pollution of water. Several strategies should be considered:



1. Minimize tillage intensity as much as possible. No-till soybeans into corn residue, and no-till corn into soybean residue are good options on well-drained soils of southeast Minnesota. No-till corn into previous silage corn ground is also an option where manure wasn't applied and incorporated by tillage.
2. No-till drill a cover crop immediately after silage harvest.
3. Consider structural controls such as terraces, sediment control basins, filter strips and waterways.

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. The Minnesota Phosphorus Index, available at http://www.mnpi.umn.edu/ , provides an evaluation of P pollution risk and includes a simplified version of RUSLE2 for erosion loss estimates. If the producer uses no-till throughout the corn silage, corn grain, and soybean rotation, then the P risk rating is Low, and expected average soil loss below 3 tons/acre over the rotation. In the manure zone, where tillage is required after silage to incorporate the manure, then the P risk rating is Medium and rotation average erosion is above 6 tons/acre. Predicted erosion is almost double that in the tillage year. Consequently, additional measures will be needed to intercept water (cover crop, terraces and/or filter strips). The erosion estimates are based on 8% slope and 250' slope length.

CONCLUSIONS

1. Periodic Grid Soil Sampling (3-5 years) allows farm operations to identify zones of excess P and K, which may have developed with a history of non-uniform manure applications.

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

3. Excluding zones of highest 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 when alternative application areas are available or there is a market for the manure.
    b. Reduce P pollution in runoff, since P in runoff is proportional to soil test P.

4. The choice of crop rotation by the farm operation, the manure application method, and type and timing of incorporation all have a strong influence on the potential loss of N and P.

5. The choice of tillage practices, both type and intensity over the duration of the crop rotation, strongly influence expected soil losses from erosion as well as P attached to eroded soil particles.

Appendix 1: Additional information used to calculate the value of manure with the spreadsheet "What's Manure Worth?":

Fertilizer nutrient prices/lb.: N = \$0.48, P_2O_5 = \$0.57, K_2O = \$0.55
Cost of purchased micronutrients/acre: \$5.00
N fertilizer application cost avoided for N-based strategies: \$10.00/acre
Dry P_2O_5 and K_2O fertilizer application cost avoided/acre: \$5.50
Additional value of micro-nutrients in manure: \$0.00 assumed.
Second year nutrient credits/acre for valuation (soybean next crop):

- **N-based whole field =0-0-0**
- **N-based zonal = 0-0-20**
- **P-based zonal = 0-0-20**

Manure yield boost value/acre over fertilizer alone: \$20.00
Tillage effect of manure application: \$0.00
Manure application cost/ton: \$5.00

© 2012 Regents of the University of Minnesota. All rights reserved. University of Minnesota Extension is an equal opportunity educator and employer. In accordance with the Americans with Disabilities Act, this material is available in alternative formats upon request. Direct requests to the Extension Store at 800-876-8636. Printed on recycled and recyclable paper with at least 10 percent postconsumer waste material.