GRID SOIL SAMPLING FOR MANURE APPLICATION
CASE STUDY #6

Beef Farm #2: Solid Manure, Complex Fields

Situation: This Beef Farm has 1200 tons of bedded pack manure composed of the following analysis ("As Received" basis):

- Moisture = 63%
- TOTAL N = 14.6 lbs/ton
  - 0.3 lb/ton NH_4-N
  - 14.3 lbs/ton Organic N
- P_2O_5 = 5.5 lbs/ton
- K_2O = 14.0 lbs/ton

The three fields in this study are 13, 21 and 52 acres = 86 acres total. The cropping system is corn followed by soybeans. Manure is spread with a conventional spreader with the flexibility of putting down 5 to 35 Tons/Acre. This study investigates alternative manure application strategies based on grid soil sampling results for the corn year of the rotation.

Crop Nutrient Needs and Removal Rates:

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, 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 N Price/Crop Value ratio of 0.05 for this site, 130 lb N/acre falls above the midpoint of the guideline range for corn after soybeans. For bedded pack beef manure, broadcast and tilled in <12 hours after application, N availability is 60% the first year, so 217 lb/acre manure N would be needed. If broadcast and tilled in between 12 and 96 hours after application, N availability is 45% the first year, so 289 lb/acre manure N would be needed (See **Manure Management in Minnesota**, UM Extension bulletin 03553, 2007, for manure nutrient availability.)

Phosphorus: Crop P needs are determined from soil test values. Composite soil sample analysis results for Fields 1, 2, and 3 are 24, 17, and 31 ppm P (Bray 1-P). The broadcast recommendation (P need) would be 0 lb/acre P_2O_5 for Fields 1 and 3, and 15 lb/acre for Field 2. Grid soil sample results are mapped for these fields (see below), showing that the P distribution is quite variable on Field 3, ranging from medium to extremely high (11-70 ppm), with a gradient from east to west. The three fields have ravines and streams around them, increasing the need for well-managed manure application to prevent P from reaching the streams.

Potassium (K): Crop K needs are also determined from soil test values. The average soil test K for each of the fields is 196, 100, and 149 ppm respectively, giving a need for 0, 80, and 25 lb/acre available K_2O for the expected yield range 175-199 bu/acre. There is variability across the fields (see map), ranging from 77 to 275 ppm K with a trend similar to that of P only on field 3, where P and K are highest.

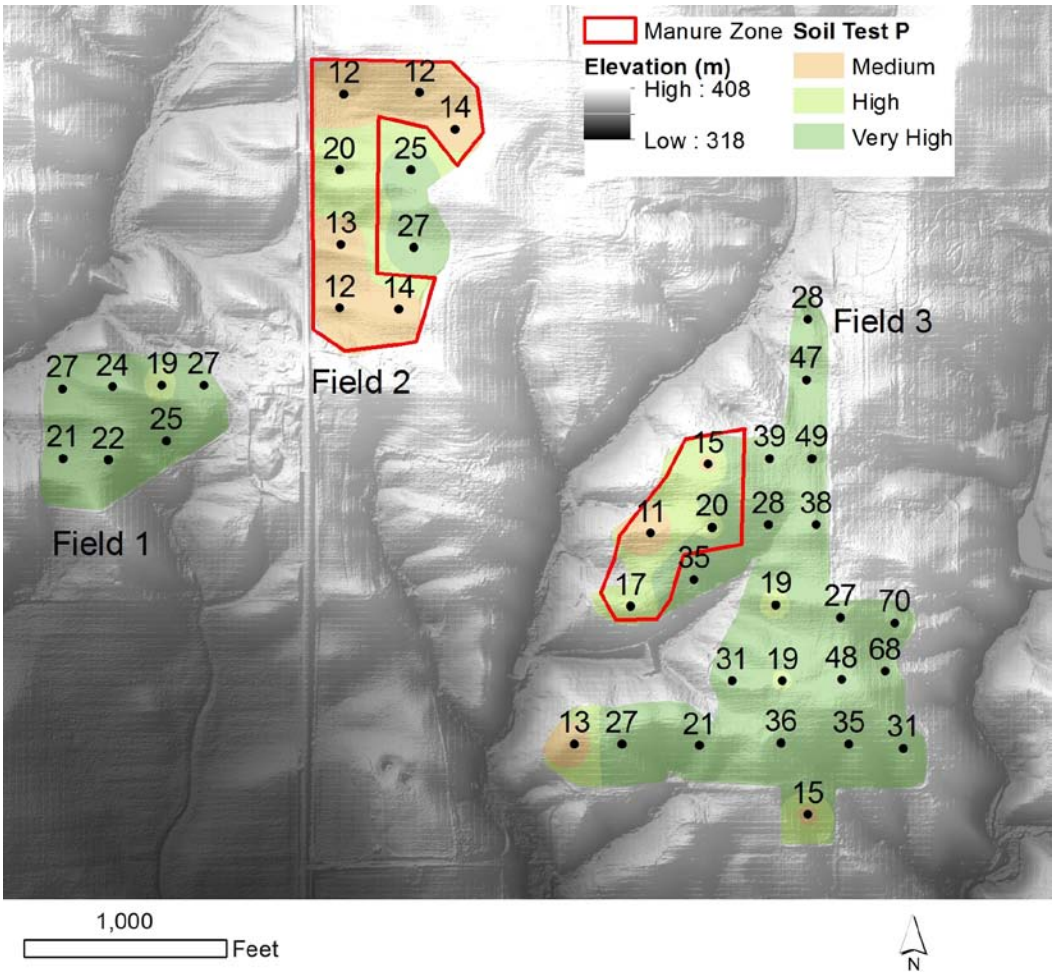


Figure 1: Soil test P (Bray 1-P) in ppm and elevation (m).

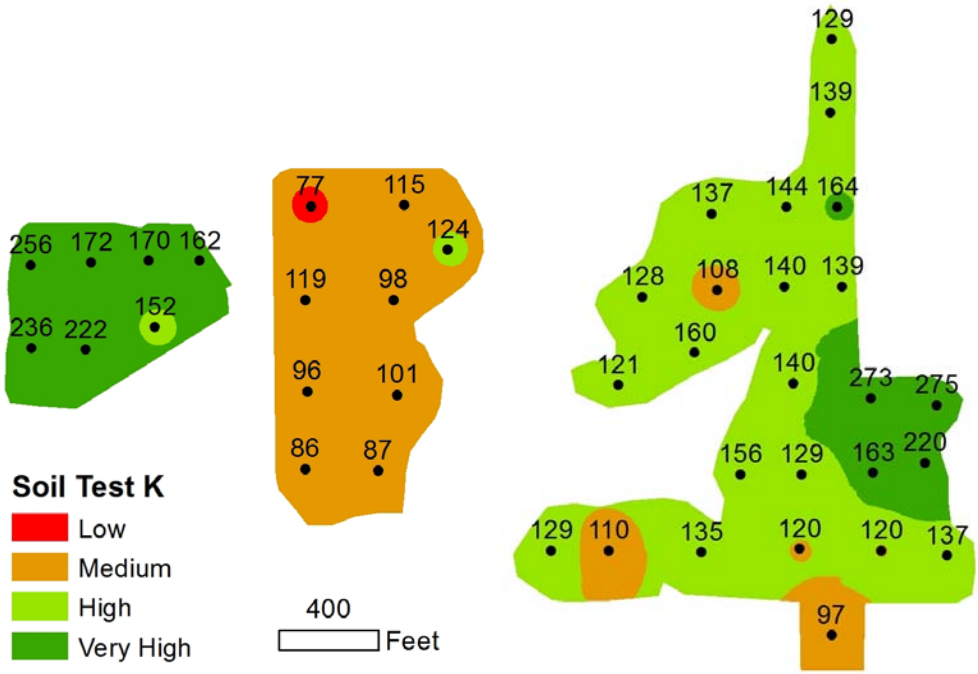


Figure 2: Soil test K in ppm

Comparing alternative manure application options:

With grid soil P and K maps, the producer can target fields and field zones for manure application, avoiding areas already high in nutrients and thus increasing the value of the manure. For zonal manure applications, variable rate fertilizer nutrients can be used to ensure uniform yields in areas of the field where manure is not applied or does not meet the full requirements of the crop. The comparisons below assume that zonal manure application is possible, however the producer may determine that difficult fields such as the irregularly shaped Field 3 may need modified approaches like whole-field manure application at P-removal rates.

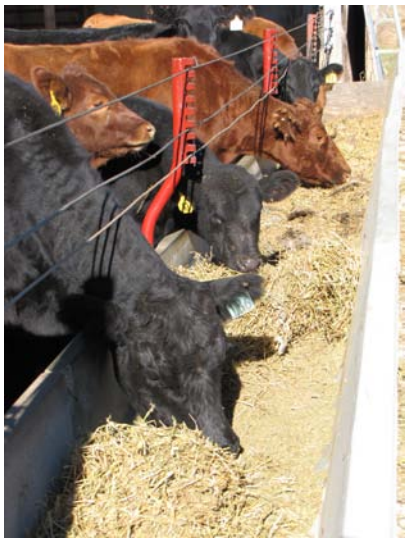
This case study compares the following application options:

- All fields receiving manure applications based on N needs.
- Manure applications at rates based on crop N needs but only in zones where P is also required. (See soil test P map for manure application zones.)
- Manure applications at rates based on soil test P and only in zones where P is required
- All fields, manure applications at rates determined by crop P removal

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, spreading costs, application rates, 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 under a specific application rate and method. Altering the rate and method will change the value of manure.

A comparison of results for the four rate alternatives is found in Table 1. Among the three fields of this farm, only the western edge of Field 3 as well as most of Field 2 would show a yield response to applied P. Applying manure at the P-based rate to one contiguous zone in each of those two fields (Figure 1), a total of 24 acres, would use 240 of the 1200 tons of available manure. Applying manure at the N-based rate to those same acres would use 360 tons, but the value of the manure would drop from $10.58/ton to $8.91/ton net after application costs because of the excess P and K applied relative to need by the corn crop. The only way to maintain the per-ton value of the remaining manure is to find alternative fields on this farm with a need for P and K, or sell it to another farm.

If there are no alternative application locations, the manure could be applied to the full extent of these three fields at either an N-based rate or a crop P-removal rate. (See **Nutrient Removal by Major Crops**, UM Extension: Minnesota Crop News, George Rehm, 2001.) Neither method would reduce the in-field variability or reduce P in the highest testing areas, but at the P removal rate they would not rise further. The N-based, whole-farm rate would slightly exceed the 1200 tons available, while the crop P-removal rate would use 1118 tons and require only a small amount of starter N. The value of the manure drops to $3.97 per ton for the whole-field N-based application rate because there is no immediate fertilizer replacement value for the P and K in the manure when applied to areas testing high in those nutrients. The per ton value for the whole-field P-removal rate is $5.43, however that is not based on current fertilizer replacement value, but rather on expected future fertilizer replacement value. The highest P-testing area is on the southeast corner of Field 3, near a ravine. If applying manure at the whole-field N rate or P-removal rate, the producer should consider avoiding application at that location, about 6 acres, and apply only N fertilizer there.



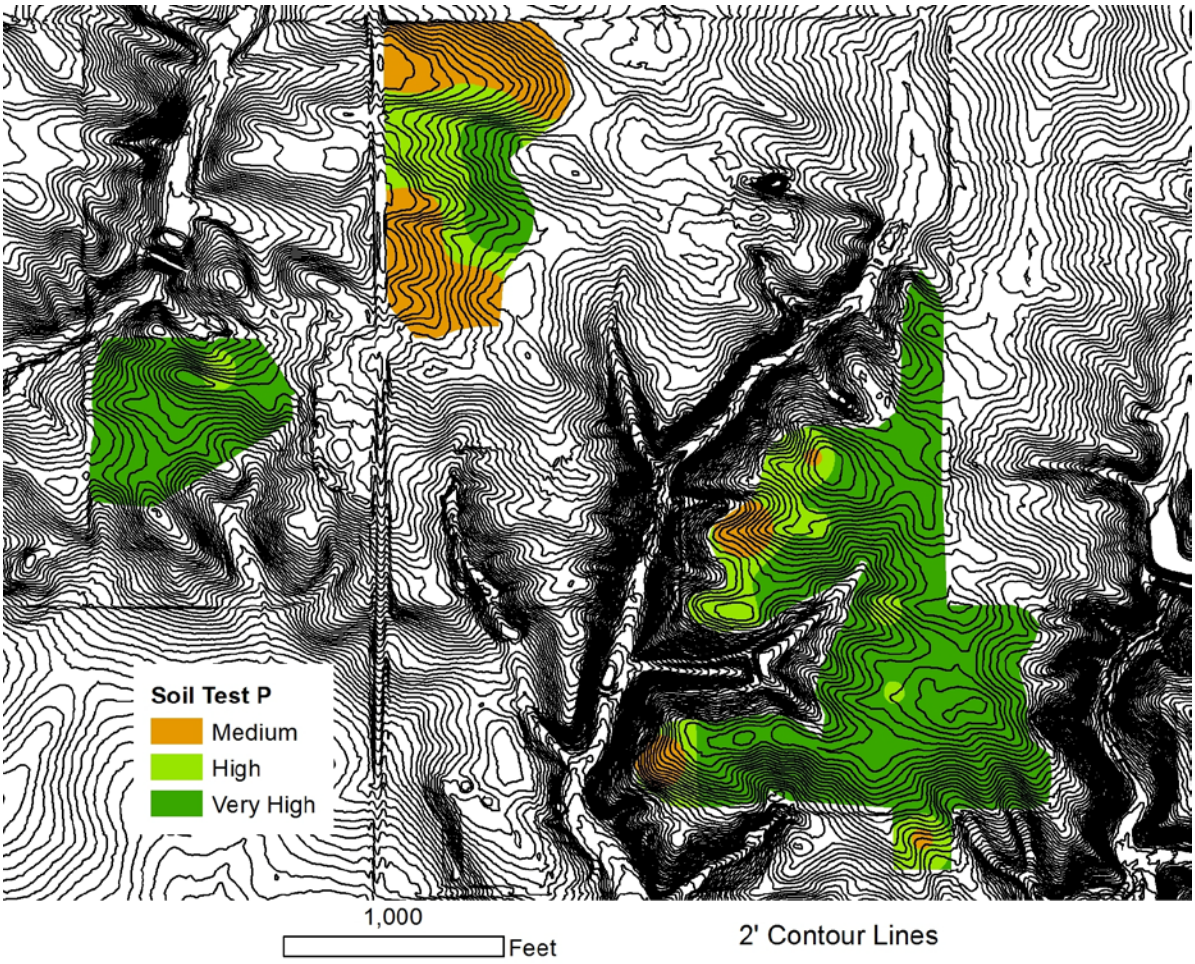
Note: The “Economics of Manure” spreadsheet analysis does not account for the increased cost of grid soil sampling vs whole field composite sampling. At $10.25 per acre for grid soil sampling, the 3-field total cost is $882. The information provided by the grid sampling shows us that if the producer has other fields requiring P and K at a rate similar to that of the lower testing areas of Fields 2 and 3, shifting the excess manure to those fields would increase the value of the manure by $4.94/ton (zonal N-based rate compared to whole-field N-based rate). For 1200 tons of manure, that is an increase in value of $5928. In addition, targeting manure applications and using precision fertilizer applications to fill in where necessary can increase yields in areas of the field where soil test values are lower. One grid soil sampling can serve several years, reducing cost on a per-year basis.

Table 1. Economic analysis of alternative manure application strategies.

Manure Application Strategy		N-Based, Whole-Field	N-Based, Zonal	P- Based, Zonal	P-Removal-Whole-Field
Fields 1-3 Summary	Manure Application (acres)	86	24	24	86
	Net Value of Manure $/ton (acreage-weighted average)	$3.97	$8.91	$10.58	$5.43
	Tons needed	1287*	360	240	1118
Field 1	Manure Application (acres)	13	0	0	13
	Rate (tons/acre)	14	0	0	13
	Crop Nutrient Need N - P_2O_5 - K_2O (lbs/acre)	130-0-0	130-0-0	130-0-0	130-61-44
	Manure-Available Nutrients Applied (lbs/acre)	126-67-176	0	0	117-62-164
	Net Value of Manure ($/ton)	$1.64	0	0	$5.43
	Tons needed	182	0	0	169
Field 2	Manure Application (acres)	21	16	16	21
	Rate (tons/acre)	15	15	10	13
	Crop Nutrient Need N - P_2O_5 - K_2O (lbs/acre)	130-15-80	130-45-80	130-45-80	130-61-44
	Manure-Available Nutrients Applied (lbs/acre)	135-72-189	135-72-189	90-48-126	117-62-164
	Net Value of Manure ($/ton)	$7.61	$9.02	$10.75	$5.43
	Tons needed	315	240	160	273
Field 3	Manure Application (acres)	52	8	8	52
	Rate (tons/acre)	15	15	10	13
	Crop Nutrient Need N - P_2O_5 - K_2O (lbs/acre)	130-0-25	130-45-80	130-45-80	130-61-44
	Manure-Available Nutrients Applied (lbs/acre)	135-72-189	135-72-189	90-48-126	117-62-164
	Net Value of Manure ($/ton)	$3.09	$8.69	$10.25	$5.43
	Tons needed	780	120	80	676

*Exceeds supply by 87 tons

Additional Environmental Considerations



Rapid incorporation of manure preserves its N value by reducing N volatilization, and prevents loss of P in surface runoff. However, soils on these fields are classified primarily in the 7-11% slope category with some steeper areas especially near ravines leading to streams (see 2' contour map above). This presents the challenge of incorporating manure without exposing the soil to high rates of erosion. In a corn-soybean rotation, the manure will be applied to the soybean residue. A light disking, field cultivation, or chisel with non-aggressive points for manure incorporation would preserve as much residue as possible and yet put the manure in contact with soil. With only a light disking to incorporate the manure and no additional tillage in either the corn or soybean year, the rotation average expected soil erosion (RUSLE2) would be 5.2 tons/acre (200' slope length) and the Minnesota Phosphorus Index score would be in the Low range. With a chisel for manure incorporation followed by a field cultivator in the spring prior to corn, and no-till for soybeans, the expected soil erosion increases to 7.8 tons/acre rotation average and the Phosphorus Index is in the Medium range. If we add tillage prior to soybeans (fall chisel and spring field cultivate) the expected soil erosion moves up to 9 tons/acre rotation average and the Phosphorus Index remains in the Medium category. Local NRCS/SWCD offices and some crop consultants can calculate the expected soil loss using RUSLE2 for any combination of manure application, cropping system and tillage for a specific field. The Minnesota Phosphorus Index also includes RUSLE2 and is available for download and use from http://www.mnpi.umn.edu/

Conclusions:

1. Grid soil sampling allows livestock operations to identify areas 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 average and more uniform yields compared to blanketed rate applications based on the average soil test values for the entire field and:
   a. Allows 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. Reduces P pollution in runoff, since P in runoff is proportional to soil test P.

3. If alternative application sites are not available, limiting manure application to P-removal rates can reduce P build-up in already high testing areas.

4. Manure application method and timing of incorporation have a strong influence on the preservation of manure N value.

5. Tillage practices over the full crop rotation, including type of manure incorporation, have direct impact on soil erosion and loss of P in runoff.

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: \$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 where applicable.
Additional value of micro-nutrients in manure: \$0.00 assumed.
Manure yield boost value/acre over fertilizer alone: \$20.00
Tillage effect of manure application: \$0.00
Manure application cost/ton: \$6.00

Second year nutrient credits/acre for valuation

	Field 1	Field 2	Field 3
N-based whole field	0-0-0	0-15-55	0-0-25
N-based zonal	0-0-0	0-15-55	0-15-55
P-based zonal	0-0-0	0-0-25	0-0-25
P-Removal based*	0-0-0	0-0-0	0-0-0

*** P and K given full credit first year**

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