GRID SOIL SAMPLING FOR MANURE APPLICATION
CASE STUDY #7

PURCHASED POULTRY MANURE

Situation: This farm has purchased 200 tons of turkey litter for crop nutrients, composed of the following analysis ("As Received" basis):

- Total N = 50 lbs/ton
  - 10 lbs/ton NH_4-N
  - 40 lbs/ton organic N
- P_2O_5 = 50 lbs/ton
- K_2O = 35 lbs/ton

The three fields used for this study total 50 acres. The cropping systems are corn on corn for 25 acres split between two fields, and corn to alfalfa hay for another 25 acre field. Manure is spread with a conventional spreader with the flexibility of putting down 1 to 5 tons/acre. This study compares alternative manure application strategies based on grid soil sampling results for the continuous corn acres and prior to alfalfa.

CROP NUTRIENT NEEDS, REMOVAL RATES, AND NUTRIENT AVAILABILITY

Crop nutrient needs for the field were determined 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 for corn is determined by the N price/crop value ratio. If we use the N Price/Crop Value ratio of 0.10 for this site, 155 lb N/acre falls above the midpoint of the guideline range for corn after corn. For turkey manure, broadcast and tilled in <12 hours after application, N availability is 70% the first year, so 220 lb manure N would be needed. If broadcast and tilled in between 12 and 96 hours after application, N availability is 55% the first year, so 282 lb manure N would be needed, greatly decreasing it's economic value. (See **Manure Management in Minnesota**, UM Extension bulletin 03553, 2007, for manure nutrient availability.)

Phosphorus: Crop P needs are determined from soil test values. A composite soil sample for the corn/corn acreage is 10 ppm Bray 1-P, in the Low range. The broadcast recommendation (P need) would be 70 lb/acre P_2O_5 for expected yields between 150 and 174 bu/acre. The grid soil sample results mapped for the two corn fields (Figure 1) do not show much variability, so using the average to guide recommendations across the two corn fields is appropriate in this case. In contrast, the average soil test P in the alfalfa field is 46 ppm with a range from 25 to 70, all in the Very High range. The southern portion of

the field averages 58 ppm and the northern part averages 32 ppm. An alfalfa yield of 8 tons/acre removes 96 lbs of P_2O_5/acre and the alfalfa will be in place for 3-4 years. (See **Nutrient Removal by Major Crops** UM Extension: MN Crop eNews, George Rehm, 2001.) That provides an option to apply manure in at least the northern part of the alfalfa field while letting the soil test P values decline in the southern zone (see zone on P map below).

Potassium (K): Crop K needs are also determined from soil test values. The average soil test K for the corn/corn fields is 73 ppm (Low category), without significant variability. That leads to a recommendation for 120 lb/acre available K_2O for the expected yield range 150-174 bu/acre. There is greater variability across the field going into alfalfa (see below), ranging from 109 to 261 ppm K (Medium, High, and Very High categories), and like P, with higher values in the south. The average soil test K in the north half of the alfalfa field is 142 ppm, leading to a recommendation of 20 lbs K_2O/acre.

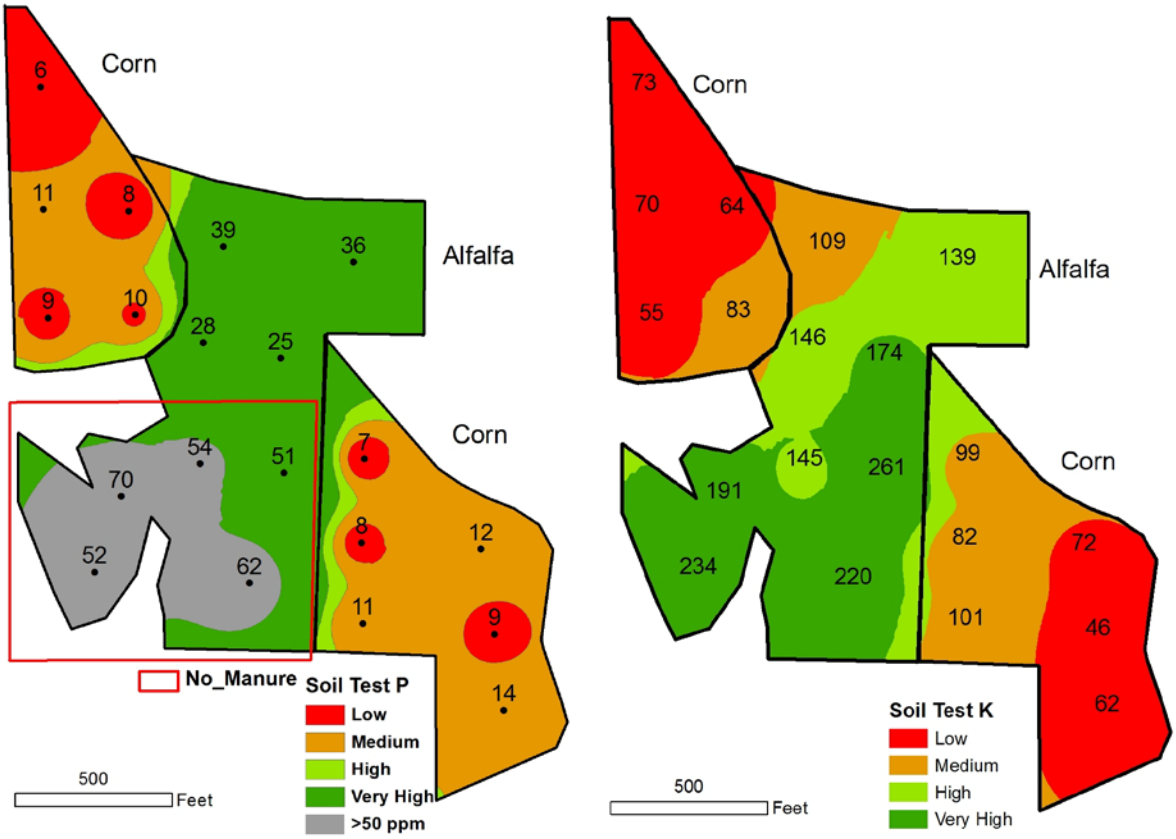


Figure 1. Soil Test P- Bray 1-P (left) and Soil Test K (right), with the no-manure zone indicated in red box outline.

COMPARING ALTERNATIVE MANURE APPLICATION OPTIONS

Using the soil test maps, we can demonstrate the effects on economic returns of the following four strategies for applying the manure:

- Manure application to continuous corn acres, based on fertilizer N requirement, incorporate <12 hours after application
- Manure application to continuous corn acres, based on fertilizer N requirement, incorporate 12-96 hours after application
- Manure application to continuous corn acres, based on soil test P, incorporate <12 hours
- Zonal manure application, based on P removal rates, incorporate <12 hours after application, northern alfalfa acres prior to seeding alfalfa.

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, application rates, and 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. Results are shown in Table 1. Additional data to complete the spreadsheet calculations are shown in Appendix 1.

Results

Use of this manure can be profitable, however adjustments must be made because the N-P-K ratios in the manure do not match the nutrient need ratios for either corn or alfalfa on these fields. For corn there will be either over-application of P to meet N and K needs (N-based application), or under-application of N and K to match P needs (P-based application), requiring supplementation with fertilizer N and K. The highest value of the manure per ton (Table 1) is obtained with the P-based strategy on corn and would be the choice if the manure is scarce or expensive. That would allow more of the manure to be conserved for fields with a greater need for P. The alternative is to apply manure at N-based rates in year one, then rely on fertilizer N and K the following year to avoid further build-up of soil test P. Both of these strategies are highlighted in the table. Note that the per ton value of manure decreases because delayed incorporation causes higher volatile N loss and inflates the imbalance between N and P (second strategy in Table 1).

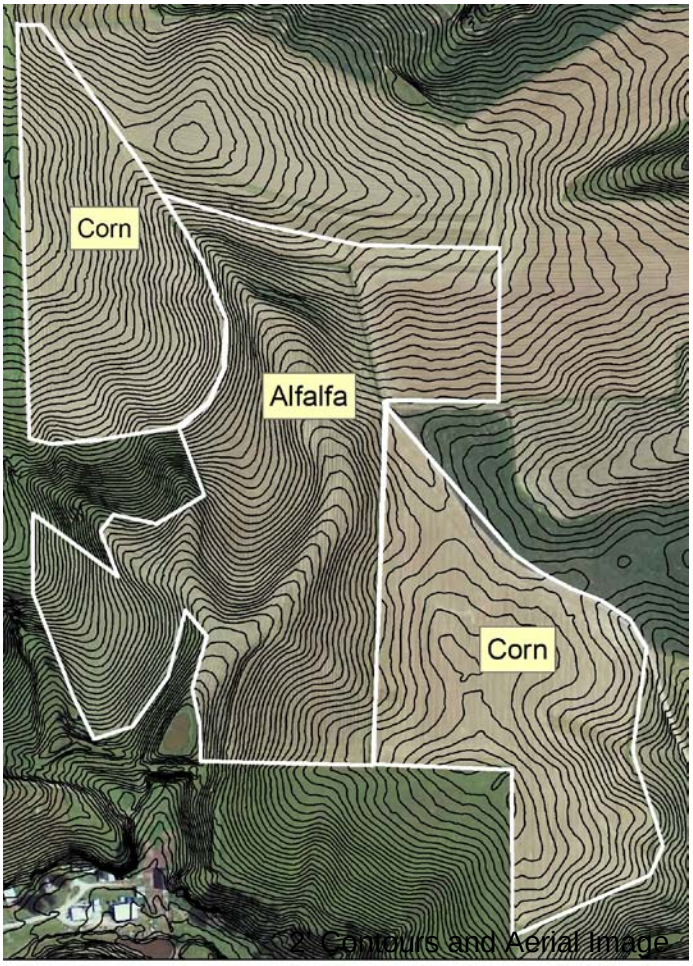
Applying the manure to the alfalfa produces the lowest value of manure of the four scenarios because the alfalfa does not need the N, and removes much more K than P. With the P-removal rate analyzed for the alfalfa field, the value of the manure is based on replacement value of fertilizer that would be needed in future years, rather than the current year fertilizer replacement value as used for the calculations for the corn fields. The main benefit would be the additional P and K applied prior to alfalfa, since levels will drop over a 3-4 year stand when manure cannot be incorporated.

TABLE 1. ECONOMIC ANALYSIS OF ALTERNATIVE MANURE APPLICATION STRATEGIES

Manure Application Strategy	N-Based, corn acres, incorporation <12 hr	N-Based, corn acres, incorporation 12-96 hr	P- Based, corn acres, incorporation <12 hr	P-Removal, alfalfa zone, incorporation <12 hr
Manure Application (Acres)	25	25	25	12
Crop Nutrient Need N - P_2O_5 - K_2O (lbs/acre)	155-70-120	155-70-120	155-70-120	0-96-400
Manure Application Required/Acre (tons/acre)	4.4	5.6	1.8	2.4
Manure to be Applied (tons /acre)	4.5	5.6	2.0	2.5
Manure-Available Nutrients Applied (lbs/acre)	158-180-142	154-224-176	70-80-63	88-100-79
Net Value of Manure ($/acre)	254	264	126	105
Net Value of Manure ($/ton)	56	47	63	42
Manure Remaining After Spreading (tons)	88	60	150	170

Value of Grid Soil Sampling

The “What’s Manure Worth?” spreadsheet analysis does not account for the increased cost of grid soil sampling. At $10.25 per acre for approximately two-acre grids, the total cost for the 50 acres is $513. The grid sampling results indicate that the corn acres are relatively uniform in fertility and applications can be applied uniformly. For the alfalfa acres, the grid sampling suggests delineation of a zone of excess P levels in the south and suggests that our manure would be more profitably used in fields and field areas where soil test P and K are lower. One grid soil sampling every 3 to 5 years can serve multiple manure applications, reducing the cost substantially on a per-application basis.



2. Contours and Aerial Image

Additional Environmental Considerations

Most of the alfalfa field and part of the northern corn field are on soils classified with slopes of 12-17%. Only the southern corn field has a significant area with less than 6% slope. Incorporation of manure while minimizing the potential for soil erosion will be a challenge.

Half of the north corn field is on slopes of 12-17%. If a traditional fall disk-chisel and spring disk or field cultivate system were followed in a continuous corn situation and assuming less than 20% residue cover, average in-field erosion would be predicted to be up to 10 tons/acre (RUSLE2). Several practices could reduce the potential erosion, including rotation with alfalfa, terraces, waterways, and reduced tillage.

The biggest challenge on the field going from corn into alfalfa is incorporating manure and establishing the alfalfa on these steep slopes (12-17%), without causing excessive soil erosion. If there is significant tillage, a companion ("nurse") crop like oats with the first year alfalfa will be essential to anchoring soil until the alfalfa is established. Terraces and permanent grassed waterways would be recommended practices on this field as well.

Estimates of soil erosion under a range of tillage and rotation alternatives can be compared by using the soil loss estimator RUSLE2. It can be run by the local NRCS or SWCD personnel, and by some crop consultants. It is also available as part of the Minnesota Phosphorus Index, available at: http://www.mnpi.umn.edu/

CONCLUSIONS

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

2. Targeting manure and supplemental fertilizer P and K applications to lower soil test P fields and field areas will likely result in more uniform fields and yields.

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 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.

4. P-Removal Rate of the crop can used as the basis for manure application strategies, where soil test P is high but not excessive and when lower P testing fields are not available.

5. Incorporation of manure will conserve nitrogen and preserve economic value.

6. Tillage practices, both type and intensity over the duration of a crop rotation, must be considered in relation to incorporation of manure, crop establishment, soil loss potential, and complementary soil conservation practices.

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 for N-based strategies: $10.00/acre
Dry P_2O_5 and K_2O fertilizer application cost avoided/acre: $7.50 for N-based corn strategies.
Additional value of micro-nutrients in manure: $0.00 assumed.
Second year nutrient credits/acre for valuation:

- **N-based corn = 56-60-12**
- **N-based corn, late incorporation = 70-70-30**
- **P-based corn = 25-0-0**
- **P-Removal based alfalfa, zonal = 30-0-0 (P and K given full credit first year)**

Manure yield boost value/acre over fertilizer alone: $20.00
Tillage effect of manure application: $0.00
Manure application cost/ton: $11.00