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Utilization of Animal Manure for Crop Production
Part III. Worksheet to Calculate Manure Application Rates

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Introduction

Accomplishing good manure nutrient management in crop production is important to ensure that excessive quantities of nutrients are not applied and the risk of water contamination is not increased. The two nutrients of greatest concern are nitrogen (N) in the form of nitrate-N (NO_3-N), potentially getting into groundwater, and phosphorus (P) getting into surface waters via nonpoint source pollution, i.e., being lost from the landscape by erosion/runoff.

This worksheet can be used to manually calculate the manure rate that will provide adequate, but not excessive, nutrients for crop production. A worksheet should be completed for each field. These sheets can be filled in by the livestock producer or a person assisting the producer, such as Michigan State University Extension agents, USDA-Natural Resource Conservation Service conservationists, Soil and Water Conservation District technicians, field crop consultants, etc.

Recommended manure management practices that livestock producers are encourged to follow are discussed in Bulletin MM-2 (Jacobs, 1995). You will need to refer to this bulletin for manure organic N mineralization factors, volatilization factors for manure ammonium-N (NH_4-N) losses, P_2O_5 removal values per unit of yield for MI crops (if soil P test levels are 150-300 lb P/acre), and average nutrient content of different animal manures. (However, it is preferable to use manure analysis information for your manure rather than use these average nutrient values.)

The procedure to follow in making use of this worksheet is provided below.

Step 1. Record the "Year of the growing season" at the top of worksheet which will be useful when referring back to this worksheet at a later time. Write in the Field ID Name, Crop to be grown, Expected crop yield, and the Fertilizer Recommendations. Write in the Average Soil P Test Level (Bray P1) for the field and decide which box should be checked.

Step 2. Write in information about the manure that is to be applied to this field. Manure types and their mineralization factors can be found in Table 1 of Bulletin MM-2. The NH_4-N Retention Factor can be found in Table 3 of Bulletin MM-2 and will depend on how the manure is to be applied.

Average nutrient contents for each manure type are also listed, but the producer is strongly encouraged to have a manure analysis completed, since these average nutrient values can vary by plus or minus 100% or more from your manure. Residual mineralizable N (RMN) values can be obtained from previous years' worksheets for the manure applied in the past three years.

Step 3. Adjust the N fertilizer recommendation, if there were manure applications in any or all of the previous three years. Use the Total RMN value from Step 2.

Step 4. Use Total N and NH_4-N from manure analysis information to estimate the Organic N and then multiply this quantity by the mineralization factor for your manure (you should find this factor listed in Step 2 information) to get the Available Organic N. The Total Available N is calculated by adding the Available Organic N plus the NH_4-N not lost by volatilization of ammonia. The latter is determined by using the appropriate Retention Factor from Table 3 in Bulletin MM-2 times the quantity of NH_4-N in the manure.

The rate of manure that will provide all the N needs of the crop can then be calculated by dividing the Adjusted N Fertilizer Recommendation by the Total Available N to get the total tons or gallons of manure per acre. This N rate can be used, if the soil P test for this field is less than 150 lb P/acre.

The last calculation in this step that can be done (optional) is to determine the amount of residual mineralizable N that is anticipated in the next three growing seasons. As discussed in Bulletin MM-2, these amounts are estimated to be 50%, 25% and 12.5% of the Available Organic N applied by this manure application, i.e., the Available Organic N per ton or per 1000 gal multiplied by the tons or gallons per acre applied, as shown in the RMN equations. *These values can be used for Step 2 RMN values in later years.*

Step 5. If the soil P test is 150-300 lb P/acre, the rate of manure application should be calculated on the basis of replacing the P_2O_5 removed by the harvested crop with manure P_2O_5. This Manure P_2O_5 Rate can also be selected by the producer, if the soil test is less than 150 lb P/acre and he/she wants to balance P inputs with P outputs (i.e., crop removal) for this field (an option when P_2O_5 fert. recomm. is zero).

First, the amount of P_2O_5 removed by the crop is determined by multiplying the expected yield times the amount of P_2O_5 removed by the crop per bushel of grain, per ton of silage or hay, etc. The P_2O_5 removal value can be found in Table 2 of Bulletin MM-2 for various crops grown in MI. The Manure P_2O_5 Rate is then calculated by dividing the lbs P_2O_5/acre remove via crop harvest by the lbs P_2O_5 per ton or per 1000 gal of manure.

If you elect to apply enough manure P_2O_5 for two growing seasons, a TWO YEAR Manure P_2O_5 Rate can be calculated using the equations shown. *If this rate is selected, then no additional manure or fertilizer P_2O_5 should be applied to this field for next year's crop, or growing season. Also, this TWO YEAR rate should be compared to be sure it is not greater than the Manure N Rate (Step 4) and will not exceed the N fertilizer recommendation.*

Step 6. If the producer would like to utilize manure for its potash (K_2O) value, a Manure K_2O Rate can be determined by dividing the K_2O fertilizer recommendation by the lbs K_2O per ton or 1000 gal in the manure. *This manure application rate can be used if it does not exceed the Manure N Rate (Step 4).*

Step 7. Select the manure rate from Step 4, 5 or 6 that will not exceed recommended practices discussed in Bulletin MM-2. Then use the appropriate set of equations for determining the amount of the other two nutrients that will be applied by the manure rate.

Step 8. Use the equations in this step to determine any additional fertilizer nutrients that may still be needed to meet the fertilizer recommendations. The quantities of manure Available N, P_2O_5 and K_2O applied per acre can be obtained from Step 7 plus Step 4, 5 or 6, depending on which manure rate is selected.

Step 9. This step can be used to estimate the fertilizer nutrient value of the manure nutrients applied. Enter the cost of purchasing urea N (45-0-0), P_2O_5 (0-46-0) and K_2O (0-0-60), or the cost of each nutrient per pound when purchased in blended fertilizers. Multiply these cost values times the amounts of manure Available N, P_2O_5 and K_2O applied per acre (as obtained in Step 8) to estimate the dollar value of the manure nutrients on a per acre basis.

Step 10. This step can be used to estimate the value of manure nutrients per load of manure. Again the cost of buying fertilizer nutrients is multiplied by the Total Available N (Step 4) and P_2O_5 and K_2O (Step 2) in the manure to estimate the manure value per ton or 1000 gal. Then this value is taken times the spreader capacity to estimate dollar value of manure nutrients per load.

The value per load can be used to estimate how far manure can be hauled before an economic benefit is no longer gained. The MANRHAUL computer program, discussed in Bulletin MM-8, can be used to help estimate break-even hauling distances.

Reference

Jacobs, L.W. 1995. Utilization of animal manure for crop production. Part II. Manure application to cropland. Bulletin MM-2, Dept. of Crop and Soil Sciences, Michigan State University, East Lansing, MI.

Worksheet to Calculate Proper Manure Application Rate
for An Individual Field

Year of growing season _____

1. Field ID Name: _____   Crop to be grown: _____   Expected yield per acre: _____

Fertilizer Recommendation (lb/acre):   Average Bray P1 Test Level of Field: _____ lbs P/acre

    N* _____

☐ Check this box if the average Bray P1 test is greater than 300 lb/acre; then no manure rate should be calculated for this field.

    P_2O_5 _____

☐ Check this box if the average Bray P1 test is 150-300 lb/acre; then the manure application rate should be calculated on the basis of anticipated P_2O_5 removal by the harvested crop.

    K_2O _____

    * The N recommendation should be adjusted for a previous legume crop.

☐ Check this box if the Bray P1 test is less than 150 lb/acre; then the manure application rate can be calculated on the basis of providing all of the recom-mended fertilizer N with manure.

2. Information About Manure Applied

Manure Type: _____

Mineralization Factor: _____

NH_4-N Retention Factor: _____

Manure Analysis: Total N _____

Residual mineralizable N (RMN) from previous manure applications available for crops:

1 year ago _____ lbs N/acre

2 years ago _____ lbs N/acre

3 years ago _____ lbs N/acre

Circle correct units:
lbs/ton   lbs/1000 gal

NH_4-N _____

Total P_2O_5 _____

Total K_2O _____

Total RMN _____ lbs N/acre

3. Adjust the above N fertilizer recommendation for previous manure applications.

Adjusted N Fert. Recomm. = N Fert. Recomm. _____ lbs/acre - Resid. Miner. N (RMN) _____ lbs/acre = _____ lbs/acre

4. Manure rate *based on providing all of the fertilizer N recommendation* by the manure application.

"Organic N" = Total N _____ - NH_4-N _____ = _____ lbs/ton   lbs/1000 gal

"Available Organic N" = Organic N _____ x Mineralization Factor (Table 1, Bull. MM-2) _____ = _____ lbs/ton   lbs/1000 gal

"Total Available N" = Avail. Organic N _____ + [NH_4-N _____ x Retention Factor (Table 3, Bull. MM-2) _____]
    = _____ lbs/ton   lbs/1000 gal

Manure N Rate = Adjusted N Fert. Recomm. _____ lbs N/acre ÷ Total Avail. N _____ = _____ ton/acre   1000 gal/acre

    RMN 1 year later = Avail. Organic N _____ x 0.50 x manure rate used = _____ lbs N/acre ---> for _____ growing season

    RMN 2 year later = Avail. Organic N _____ x 0.25 x manure rate used = _____ lbs N/acre ---> for _____ growing season

    RMN 3 year later = Avail. Organic N _____ x 0.125 x manure rate used = _____ lbs N/acre ---> for _____ growing·season

5. Manure rate *based on providing manure P_2O_5 equivalent to P_2O_5 removed by the harvested crop.* (See Table 2, Bull. MM-2, for P_2O_5 removal values per unit of crop yield.)

Expected crop yield per acre _____ x lb P_2O_5 per unit of yield _____ = _____ lbs P_2O_5 removed per acre

Manure P_2O_5 Rate = lbs P_2O_5 removed/acre _____ ÷ lbs P_2O_5 per ton *or* 1000 gal _____ = _____ ton/acre   1000 gal/acre

TWO YEAR Manure P₂O₅ Rate

Crop to be grown (1st growing season): _____   Expected yield per acre: _____

Crop to be grown (2nd growing season): _____   Expected yield per acre: _____

Expected crop yield per acre (1st yr.) _____ x lb P_2O_5 per unit of yield _____ = _____ lbs P_2O_5 removed per acre

Expected crop yield per acre (2nd yr.) _____ x lb P_2O_5 per unit of yield _____ = _____ lbs P_2O_5 removed per acre

= _____ lbs P_2O_5 removed per acre (2 yr. total)

TWO YEAR Manure P_2O_5 Rate = lbs P_2O_5 removed/acre _____ ÷ lbs P_2O_5 per ton *or* 1000 gal _____ = _____ ton/acre   1000 gal/acre

6. **Manure rate** *based on providing manure K_2O equivalent to K_2O Fertilizer Recommendation.*

   Manure K_2O Rate = K_2O Fert. Recomm. _____ ÷ lbs K_2O per ton *or* 1000 gal _____ = _____ ton/acre   1000 gal/acre

7. Quantities of N, P_2O_5, and K_2O added by the manure *using the selected manure application rate.*

   If use Manure N Rate: _____ ton/acre *or* 1000 gal/acre x _____ lbs P_2O_5 per ton *or* per 1000 gal = _____ lbs P_2O_5/acre

       x _____ lbs K_2O per ton *or* per 1000 gal = _____ lbs K_2O/acre

   If use Manure P_2O_5 Rate:** _____ ton/acre *or* 1000 gal/acre x _____ lbs Avail. N per ton *or* per 1000 gal = _____ lbs Avail. N/acre

       x _____ lbs K_2O per ton *or* per 1000 gal = _____ lbs K_2O/acre

   If use Manure K_2O Rate:** _____ ton/acre *or* 1000 gal/acre x _____ lbs Avail. N per ton *or* per 1000 gal = _____ lbs Avail. N/acre

       x _____ lbs P_2O_5 per ton *or* per 1000 gal = _____ lbs K_2O/acre

   ** *The lbs Available N applied per acre should not exceed the Adjusted N Fertilizer Recommendation.*

8. Fertilizer N, P_2O_5 and K_2O Needed in Addition to Manure Nutrients Applied by Selected Rate.

   Adjusted N Fertilizer Recomm. _____ - Manure Avail. N Applied _____ = _____ lbs fertilizer N/acre still needed

   P_2O_5 Fertilizer Recommendation _____ - Manure P_2O_5 Applied _____ = _____ lbs fertilizer P_2O_5/acre still needed

   K_2O Fertilizer Recommendation _____ - Manure K_2O Applied _____ = _____ lbs fertilizer K_2O/acre still needed

9. Value of N, P_2O_5 and K_2O Applied as Manure Nutrients by Selected Rate.

   Cost of Fertilizer N ($/lb) _____ x Manure Avail. N Applied _____ lbs/acre = _____ $/acre (value of manure N applied)

   Cost of Fertilizer P_2O_5 ($/lb) _____ x Manure P_2O_5 Applied _____ lbs/acre = _____ $/acre (value of manure P_2O_5 applied)

   Cost of Fertilizer K_2O ($/lb) _____ x Manure K_2O Applied _____ lbs/acre = _____ $/acre (value of manure K_2O applied)

   _____ $/acre (TOTAL value of nutrients applied)

10. Manure Hauling Cost Calculations. (See Bull. MM-8 about the MANRHAUL computer program that can assist you in determining how far you can haul manure based on the dollar value of manure nutrients.)

    Cost of Fert. N ($/lb) _____ x Total Avail. N in Manure _____ lbs/ton *or* lbs/1000 gal = _____ $/ton *or* $/1000 gal (N value)

    Cost of Fert. P_2O_5 ($/lb) _____ x Total P_2O_5 in Manure _____ lbs/ton *or* lbs/1000 gal = _____ $/ton *or* $/1000 gal ($P_2O_5$ value)

    Cost of Fert. K_2O ($/lb) _____ x Total K_2O in Manure _____ lbs/ton *or* lbs/1000 gal = _____ $/ton *or* $/1000 gal ($K_2O$ value)

    _____ $/ton *or* $/1000 gal (TOTAL value)

    TOTAL $ value of manure/ton or 1000 gals _____ x Spreader Capacity (Tons or 1000 gals/load) = _____ $/load (Fertilizer nutrient value)