



Alternative Management Tool (AMT)

On-Farm Nitrogen Rate Trials

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Alternative Management Tools (AMTs) are specific agricultural practices and solutions, other than nitrogen fertilizer best management practices, to address groundwater nitrate problems. AMTs are described in the Groundwater Protection Rule and approved by the Commissioner of Agriculture.

Introduction

As part of the Groundwater Protection Rule, a list of the applicable nitrogen fertilizer best management practices (BMPs) will be developed for each Level 2 drinking water supply management area (DWSMA). The “BMP list” for each DWSMA will identify an MDA published nitrogen fertilizer rate that aligns with the University of Minnesota nitrogen fertilizer guidelines. If farmers intend to apply a nitrogen rate above the MDA published rate for the DWSMA, data from on-farm nitrogen rate trials can be used to document higher nitrogen needs and therefore justify a higher nitrogen fertilizer rate.

This document provides options for on-farm nitrogen trials as an adaptive nitrogen management strategy to justify rate exceedances above the nitrogen fertilizer rate identified for the DWSMA.

AMT substitution for a Nitrogen Fertilizer Best Management Practice (BMP)

The on-farm nitrogen rate trials AMT can substitute for nitrogen rate in the nitrogen fertilizer best management practice evaluation. See BMP/AMT matrix (www.mda.state.mn.us/nitrogenamts) for more information about how this AMT substitutes for nitrogen fertilizer BMPs.

The Minnesota Department of Agriculture (MDA) will consider multiple strategies that enable farmers to document higher nitrogen needs and justify a nitrogen fertilizer rate above the MDA published rate. These include on-farm nitrogen rate trials as described in this document, and in-season assessments of crop nitrogen needs as described in other AMT documents. Please refer to the Approved AMT webpage (www.mda.state.mn.us/pesticide-fertilizer/approved-amts) to review these other AMT documents. The documents include requirements and recordkeeping.

Water Quality Benefits

The intent of the on-farm nitrogen (N) rate trial AMT is to align N application rate(s) to the needs of the crop while at the same time optimizing the profitability and minimizing N loss to the environment.

It is well-understood that crop production can vary between growers due to differences in soil, climate, rotation, crop management style and strategy, production practices, and response to external factors. Using standardized N fertilizer rates may not adequately reflect these differences or local conditions. These average N rates serve as a starting point, but in some situations may lead to increased N losses due to overapplication or residual soil N remaining in the soil. In other situations, they may be inadequate to meet crop needs.

On-farm N rate trials are tailored to the specific crop management practices and conditions at the grower, farm, and field level. On-farm N rate trials can be used to improve the N use efficiency and therefore decrease the loss of N to the environment, lower production costs, and maximize the realized profit from each field.

Requirements to Qualify for the On-Farm Nitrogen Rate Trials AMT:

1. **Level 1- Basic on-farm trial:** Establish N rate trials to compare two N rates (no higher than the DWSMA specific rate, + 30 lb N/ac) and determine if there is a statistically significant response to additional N fertilizer. A statistically defensible yield difference will be required in two out of three years of on-farm data to be eligible for the additional N fertilizer.
2. **Level 2- Advanced on-farm trial:** Establish N rate trials including a zero N strip to compare multiple N rates and determine field-specific economic return to N. Two or more years of on-farm data is required. The results can be transferable to other nearby fields based on yield and soil similarities.

The experimental design, data analysis, data collection, and documentation criteria required is provided below in the trial guidance. If further assistance is needed with the design of your trial, feel free to contact the MDA for technical assistance.

Trial guidance:

Level 1 Basic On-Farm Trials: The following requirements for a basic on-farm trial may allow for up to 30 lb N/ac exceedance above the MDA published N fertilizer rate for the DWSMA if supported by multiple years of on-farm trial data. The following are general guidance for the basic on-farm trials (See example layout in Figure 1).

- The location of the trial within the field should be on a uniform terrain and straight rows are preferred.
- Field uniformity is desirable. When the field is not uniform with respect to soil type and topography, the impact of this variability on the trial results can be reduced by having the trial strips go parallel to the gradient of the variability.
- Treatments must be repeated in side-by-side strips within the field. Each set of treatments is called a block.
 - Each block should have low N rate (no higher than the maximum rate for the DWSMA) and high N rate treatments up to 30 lb N/ac above the maximum rate for the DWSMA.
 - The two treatments should be randomized within each block.
 - Each trial should have five blocks (a total of 10 strips).
- When possible, avoid areas that have slopes greater than 3%
- Avoid, when possible, areas with variable rate field history (seeding, P, K, lime, etc.) as this may impact the trial response to N fertilizer.
- Field strips preferred dimensions are a minimum of 30 feet wide (or larger to accommodate two-swath width of the combine header) and 400 feet in length.
- The strips should be recorded using GPS or on an appropriate map of the field.
- Account for all N sources including manure, alfalfa and legume credits, starter fertilizer, MAP, DAP, etc.
- If manure is used, a manure lab test result that shows the total N in the manure is required for proper N crediting of first- and second- year plant available N.

- Keep all other factors consistent across the trial area including tillage and planting date, hybrid, seeding density, other nutrient, rates, soils, field history, drainage, topography, etc.
- Use N sources without additional nutrients in the formulation when applying the different rates. Applications of AMS, MAP, DAP, or blends of products should not be used for the N rate difference to avoid the effect of nutrients other than N on the yield response.
- Trials located on a field within the DWSMA boundary are preferred. However, in the second year of the trial, a field outside the DWSMA may substitute for the original field if both fields can be documented to have similar soils, productivity, crop rotation, and management. Soil similarity can be confirmed using soil test lab results including CEC, soil organic matter, and yield maps, or NRCS SSURGO map.
- Yields of each of the ten strips of the on-farm trial can be reported as a GIS layer based on combine yield monitors, weigh wagon or similar method to determine the yield from each strip separately.

Results: To be eligible for the additional 30 lb N/ac, the yield for the higher N rate must be statistically higher than yields for the DWSMA N Rate in at least 2 out of 3 consecutive growing seasons (See Appendix for guidance on the statistical analysis).



Figure 1. Example of a basic on-farm N rate trial comparing two N rates each repeated five times.

Level 2 Advanced On-Farm Trials: The N rate allowance will be based on results from advanced multiple-rate trials and may be greater than 30 lb N/ac. See example layout in Figure 2.

1. Follow the guidelines from the advanced Nutrient Management Initiative program (link below) for laying out an advanced trial and accounting for field variability. These guidelines are:
 - a. Preferred layout is field strips. *If variable rate application is not possible and a small plot approach is required, please contact the MDA for instructions.*
2. The field trial must contain the following:
 - a. At least five N application rates including a zero rate where no N is applied or is applied in starter fertilizer at rates not to exceed 20 lb N/ac.

- i. The rates compared should include the target N rate (which is the maximum N fertilizer rate identified for the DWSMA or the normal N application rate, whichever is lower), a zero N rate, and at least one rate below the target rate. The rates should maintain a 30-50 lb N /ac rate separation.
 - ii. The total amount of N applied (starter + preplant + sidedress + late season + fertigation) from fertilizer, and all other N sources should be included in the N rate computation. Appropriate N credits from manure and legumes must be taken. Manure N credits should be based on actual N content of the manure and not be based on generalized book values. If manure is used, a current manure lab test result that shows the total manure N is required for proper N crediting of first- and second-year plant available N.
- b. Each treatment, containing five rates, must be replicated at least three times in the same field.
- c. Each set of treatments is called a block. Treatments should be placed randomly within each block, and blocks should be selected in the field to minimize within-block variability
- d. The study should be completed on at least one field each year.
 - i. The study should be conducted for a minimum of two consecutive years.
 - ii. Trials may move between fields to capture the same crop in the rotation if the fields have similar soils and management. For example, a corn N rate trial for corn after soybeans can move between fields to capture the corn phase of the rotation each year.
 - iii. Field conditions should be similar for comparison purposes. This includes at a minimum the tillage, fertilizer history, soils, productivity, crop rotation, and management
- g. Avoid areas that have slopes >3%, when possible.
- h. Avoid areas, when possible, with variable rate history (P, K, lime, etc.) to ensure that any yield difference is due solely to N treatments.
- Keep all other factors consistent across the trial area including tillage, planting date, hybrid, seeding density, other nutrient rates, drainage, topography, etc.
- Use N sources without additional nutrients in the formulation when applying the different rates. Applications of AMS, MAP, DAP, or blends of products should not be used for the N rate difference to avoid the effect of nutrients other than N on the yield response.

N Rate #1	N Rate #2	N Rate #3	N Rate #4	0 lb N/ac

Figure 2. Example of an advanced on-farm N rate trial comparing five N rates each repeated three times.

Data analysis and expected outcome:

Data must be statistically analyzed before conclusion can be drawn (see Appendix A). If participating in the Nutrient Management Initiative (NMI) program, data analysis will be completed by the University of Minnesota. All information will be shared and discussed with the participating farmers and crop advisers.

Farmers that conduct on-farm N trials outside of the NMI program must follow “trial guidance” as stated above (e.g., randomized and replicated strips/plots), use proper statistical analysis, and provide results to qualify for this AMT (See Appendix for more details on statistical analysis). The outcome of the trial should be a field specific Economically Optimum Nitrogen Rate (EONR).

Recordkeeping: Participants in the on-farm trials must maintain the following records:

- Current soil test lab result (including nitrate).
- A map showing the trial design and location of the strips or plots.
- As-applied map showing the N rates applied in each strip or plot (shapefile format).
- Yield map that clearly shows the yield for strips or experimental plots when possible (shapefile format).
- Results from data analysis of field trial data.

Technical Resources

Nutrient Management Initiative: www.mda.state.mn.us/nmi

Guidelines for Adaptive Nutrient Management: NRCS 2015 http://socwisconsin.org/wp-content/uploads/2015/07/TechNoteAppendix3_BroadReview.pdf

MDA Contact information

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Appendix A

Statistical Analysis

Basic Rate Trials

Results from the basic rate comparison (Level 1) will be compared using statistical test for two-mean comparison and a significance level of 0.10.

Advanced Rate Trials

Data must be statistically analyzed before conclusions regarding N rate can be drawn. When evaluating nutrient application rates, the grower has several options:

- Submit the trial data (N rates, yield, Trial layout) to the MDA for analysis.
- Use the Crop Nutrient Response Tool (<http://phosphorus.ipni.net/article/NANE-3068>) developed by the International Plant Nutrition Institute (IPNI) to calculate the economic optimum nutrient rate. For a comparison of practices, analysis on variance (ANOVA) with Fisher's least significant difference (LSD) is an appropriate statistical analysis. Excel can compute an ANOVA, but not a LSD. Alternatively, AgStats (<http://pnwsteep.wsu.edu/agstatsweb/>) is an online tool that can be used.
- Use other recognized statistical tools and a significance level of 0.10.