

Nitrogen Optimization Pilot Program Trial Protocols

Nitrogen fertilizer timing

Study Overview

Proper timing of nitrogen fertilizer application is key to align nitrogen (N) availability with crop demand, improving crop uptake efficiency and mitigating potential N losses. The goal of this study is to assess the effect of nitrogen fertilizer timing across a standard and reduced commercial nitrogen rate, and the interaction of the two on yield, marginal net return, nitrogen use efficiency, and potentially leachable nitrogen. Investigating N application timing across a standard and reduced nitrogen rate will allow us to better understand how the practice impacts both yield and nitrogen need of the crop. Since the trial only uses two nitrogen rates, it is not designed to determine the optimum nitrogen rate for this system. If that is the goal of a trial, a full nitrogen rate study with 6 or more N rates is recommended (NOPP Option 1).

As you develop specific project details including your research question, treatments, and trial layout, we recommend that you connect with the UW team to develop a project that best meets your interests and goals. If you're applying for a NOPP grant, specific project details can be discussed with UW NOPP Research Director Monica Schauer (monica.schauer@wisc.edu). If interested in implementing this research protocol independently on your own farm, reach out to UW-Extension On-Farm Research Coordinator Abby Augarten (aaugarten@wisc.edu).

Selecting placement treatments

This protocol allows you to choose N application timing most relevant to your operation. Common N timings to compare are fall, pre-plant, at-planting (with planter), early season (ex: corn V3-V5), mid-season (ex: corn V8-V10), and late season (ex: corn V10-VT). Consider what your primary question is for the trial to help inform N timing treatments. Some considerations are listed below.

Projects derived from this protocol are designed to answer producer driven nitrogen fertilizer timing questions. The project requirements described in this protocol align with the research requirements of the DATCP's Nitrogen Optimization Pilot Program (NOPP) grant Option 3 but can be used independently on your own farm to investigate nitrogen fertilizer management. Current funding opportunities for NOPP can be found [here](#).

This protocol was developed by the UW-Madison Department of Soil and Environmental Science and Division of Extension.



- Nitrogen sources should remain consistent between timing treatments (i.e. if comparing V5 & V10 sidedress timings, use 28% UAN for both).
- If making comparison of late season application timing, any other N applications (i.e. pre-plant or starter) should be uniformly applied across all plots.
- If you are interested in fine-tuning split applications for your system, consider these potential approaches:
 - Investigating N sidedress timing with a uniform pre-plant rate across both treatments. For example: uniform pre-plant application of 50 lb-N/ac followed by a standard (150 lb-N/ac) and reduced (120 lb-N/ac) sidedress N rate at V7 or VT
 - Comparing the percentage of total N applied pre or at planting vs in-season. For example: interested in investigating ratio of the split (50% of total N at plant and 50% sidedress, vs 30% at plant, 70% sidedress)
- Increments between chosen application dates should be at least two weeks apart.
- Adaptive management can be utilized to ensure timing treatments align with what would occur given that specific growing season. Adjusting N timing may be necessary due to changing weather conditions.

Selecting nitrogen rate treatments

Identifying a standard synthetic nitrogen rate should be based on the rate you would normally apply and the reduced N rate can be 20-40% less N than your standard rate. For example, if your research question is to compare mid-season and late season sidedress timing and you would normally apply 50 lb-N/ac at plant and 150 lb-N/ac at V7, your rate treatments would be 50 lb-N/ac at plant uniformly across all plots, 120 or 150 lb-N/ac at either V7 or VT. In this example, standard rate is 200 lb-N/ac and the reduced rate is 170 lb-N/ac. Chosen rates are going to vary based on specific project details so please reach out to the UW team to fine tune rates used to match your project goals.

Project design

Given that nitrogen dynamics are variable within a given field, a well-structured project design provides confidence in the results of the project. Replication, or repeating each treatment multiple times in the field, and randomization, or assigning treatments to plots with no particular order, make it possible to account for the natural field variation that occurs. Using a well-structured design and statistical analysis, we can determine if any differences in yield effects were due to the treatments, or random chance and variability. For this study, a minimum of four replications is required. Complete randomization of plots is recommended but not required, since it can be difficult due to limitations in field equipment, but trials can be designed to work around these limitations. See example plot layouts at the end of this protocol.

- Field selection: Select a field that is uniform, relevant to the research question, and accessible for ease of data collection (or outreach). Avoid headlands and any known areas with in-field variability when laying out plots.

- Strip width: Determined based on equipment width. It is important to consider the size and capability of the planter, nitrogen application equipment, and harvester. Strip width should be at least the width of the harvester (preferably two or more combine header widths).
- Strip length: Recommended that strips are the length of the field for ease of implementation. Strips can be shorter if desired but should be >350 ft if using a yield monitor and >150 ft if using a weigh wagon.
- Field management: All other in-season field management outside of nitrogen application timing (i.e. herbicide, other fertilizer, tillage) should occur uniformly across the field and trial area.

Data collection

Required data and sampling

- Field history & management records (survey to collect this information will be provided)
- Manure sample (if manure applied during this crop year), one sample per application.
- Routine soil (pH, OM, P, K, etc.) sampled across trial area as one composite.
- Cover crop sample if field has cover (see UW sampling resources linked in the NOPP protocol library). Sample at time of termination in each replicate.
- Soil nitrate and ammonium sampled prior to nitrogen rate treatment applications at 0-1' & 1-2'. Soil nitrate and ammonium sampled prior to nitrogen applications at 0-1' & 1-2'. For example, if all synthetic N is going out pre-plant, sample by each replicate before planting.
- Yield data from calibrated yield monitor or weigh wagon.

Additional sampling is encouraged as your budget allows. Examples include:

- In-season soil nitrate and ammonium (0-1' & 1-2')
- Post-harvest soil nitrate and ammonium (0-1' & 1-2')
- Soil health analysis
- Plant tissue nutrient analysis
- Forage quality analysis
- Corn ear leaf
- Stalk nitrate
- Grain %N

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Plot plan examples

Plot plan A

Complete randomization and replication of N timing and N rates. This is the preferred plot plan if achievable by equipment and field size.

Plot ID

101	170 lb-N/ac	Rep 1
102	200 lb-N/ac	
103	170 lb-N/ac	
104	200 lb-N/ac	
201	170 lb-N/ac	Rep 2
202	170 lb-N/ac	
203	200 lb-N/ac	
204	200 lb-N/ac	
301	200 lb-N/ac	Rep 3
302	170 lb-N/ac	
303	200 lb-N/ac	
304	170 lb-N/ac	
401	170 lb-N/ac	Rep 4
402	170 lb-N/ac	
403	200 lb-N/ac	
404	200 lb-N/ac	

Timing

	At plant (AP)
	Early sidedress (ES)

Nitrogen rate treatments

N1	170 lb/ac synthetic N
N2	200 lb/ac synthetic N

Treatment code

AP-N1	At plant, 170 lb/ac synthetic N
AP-N2	At plant, 200 lb/ac synthetic N
ES-N1	Early sidedress, 170 lb/ac synthetic N
ES-N2	Early sidedress, 200 lb/ac synthetic N

Plot plan B

Complete replication of N timing and N rates with N timing plots grouped and not fully randomized. This allows for wider passes.

Plot ID

101	170 lb-N/ac	Rep 1
102	200 lb-N/ac	
103	170 lb-N/ac	
104	200 lb-N/ac	
201	200 lb-N/ac	Rep 2
202	170 lb-N/ac	
203	170 lb-N/ac	
204	200 lb-N/ac	
301	200 lb-N/ac	Rep 3
302	170 lb-N/ac	
303	200 lb-N/ac	
304	170 lb-N/ac	
401	170 lb-N/ac	Rep 4
402	200 lb-N/ac	
403	200 lb-N/ac	
404	170 lb-N/ac	

Timing

	At plant (AP)
	Early sidedress (ES)

Nitrogen rate treatments

N1	170 lb/ac synthetic N
N2	200 lb/ac synthetic N

Treatment code

AP-N1	At plant, 170 lb/ac synthetic N
AP-N2	At plant, 200 lb/ac synthetic N
ES-N1	Early sidedress, 170 lb/ac synthetic N
ES-N2	Early sidedress, 200 lb/ac synthetic N

Plot plan C

Complete replication of N timing and N rates with N timing plots grouped and not fully randomized. This allows for a wider passes.

Plot ID

101	170 lb-N/ac	Rep 1
102	200 lb-N/ac	
103	170 lb-N/ac	
104	200 lb-N/ac	
201	200 lb-N/ac	Rep 2
202	170 lb-N/ac	
203	170 lb-N/ac	
204	200 lb-N/ac	
301	200 lb-N/ac	Rep 3
302	170 lb-N/ac	
303	200 lb-N/ac	
304	170 lb-N/ac	
401	170 lb-N/ac	Rep 4
402	200 lb-N/ac	
403	200 lb-N/ac	
404	170 lb-N/ac	

Timing

	At plant (AP)
	Early sidedress (ES)

Nitrogen rate treatments

N1	170 lb/ac synthetic N
N2	200 lb/ac synthetic N

Treatment code

AP-N1	At plant, 170 lb/ac synthetic N
AP-N2	At plant, 200 lb/ac synthetic N
ES-N1	Early sidedress, 170 lb/ac synthetic N
ES-N2	Early sidedress, 200 lb/ac synthetic N