F°I°N°E°

Framework for Improving Nitrogen Efficiency

Background

The Framework for Improving Nitrogen Efficiency (FINE) has been created by the NUE-Profits partners who are a group of industry specialists and some of Britain's most forward-thinking farmers. Led by AgAnalyst and with the University of Lincoln as academic lead, the project is funded by Innovate UK and will benefit the entire farming industry.

At present, scientific expertise in soil science, the growing crop, Internet of Things (IoTs), Earth Observation (EO) - and not to mention the field data from the farm itself - is separated into individual silos that are almost impossible for farmers and agronomists to access, integrate and create insights from.

FINE connects these thus far disconnected silos through the collaboration of the NUE-Profits group who are "best in-class" experts in each of their fields.

FINE will provide farmers and agronomists with a single online service where they can access the combined expertise of the NUE-Profits group along with the field data from their farm so that they can make timely fertiliser interventions bespoke to each of their fields. This will allow farmers to use the right amount of Nitrogen, in the right part of the field, at the right time, optimising NUE, yield and protein in wheat.

Project Partners

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What we need

The project will be carried out on fields of Winter Wheat where you are prepared to treat an area of your choice as a trial, comparing our recommendations against farm practice.

You are welcome to enter as many fields as you are happy to test with the SPAD meter or N-Tester. However, please bear in mind that there will only be one field where we will fund analysis for soil, leaf, grain and straw samples. For any other fields or additional trial plots you wish to include, you must cover the costs of analysis.

Support in data collection will be provided throughout the project. We will need the following from you:

1) Field boundaries for each of the fields you wish to enter which you can provide us access either by:
    a. Sending us your SBI number
    b. Linking DataBaler to another farm software account (John Deere Operations Centre, Claas Telematics, MyCaseIH) where you have field boundaries stored. Instructions can be found here.
    c. Drawing or uploading a shapefile/kml of the fields in DataBaler
2) Soil N cores and regular (weekly) monitoring of plant Nitrogen uptake to be collected using handheld crop spectral sensors (N-Tester or SPAD meter), starting from Growth stage 30, for the trial plot and farm practice plot.
3) Throughout the season we will need your support in collecting soil, tissue, grain and regular N-Tester readings from both plots: the farm practice approach as standard compared to the NUE programme that we are testing.
4) Your commitment! To get the most out of the trials you will need to provide us with information about the field throughout the season. Please keep us updated with any fertiliser plans you have so we can try to align with your operations as closely as possible. With that said, we may ask you to apply to the trial plot on a separate date depending on what the data is telling us.

We will provide in-season support, advising when and how much Nitrogen to apply on the trial area while you apply standard farm practice on the remainder of the field, monitoring both sites throughout the growing season.

You will be supplied with access to the FINE In-season dashboard on DataBaler where you will have access to your soil, crop growth, N-Tester and remote sensing results to support our advice. We will also integrate your yield and grain protein data from your combine to measure your Nitrogen Use Efficiency, providing you with valuable insights into the crop's development.

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What you need

1. A field growing wheat (1st or 2nd Wheats are appropriate)
2. N-Tester or other SPAD meter
3. Digital field boundaries
4. Application timing flexibility
5. Yield mapping from the combine or measured weighbridge weights

Field protocols

There are several factors you should consider when selecting the field and the zones within the field which will be monitored in the project (we are happy to help you if necessary):

1. Select fields which can support replicated trials; ideally having at least six sets of tramlines, to allow comparison of our approach versus existing farm practice.
2. We require at least a tramline for each zone but would preferably have more so that we ensure any variation from the field is reduced. Figure 1 demonstrates an example trial layout. A tramline was left in between as this field was applied with solid fertiliser.

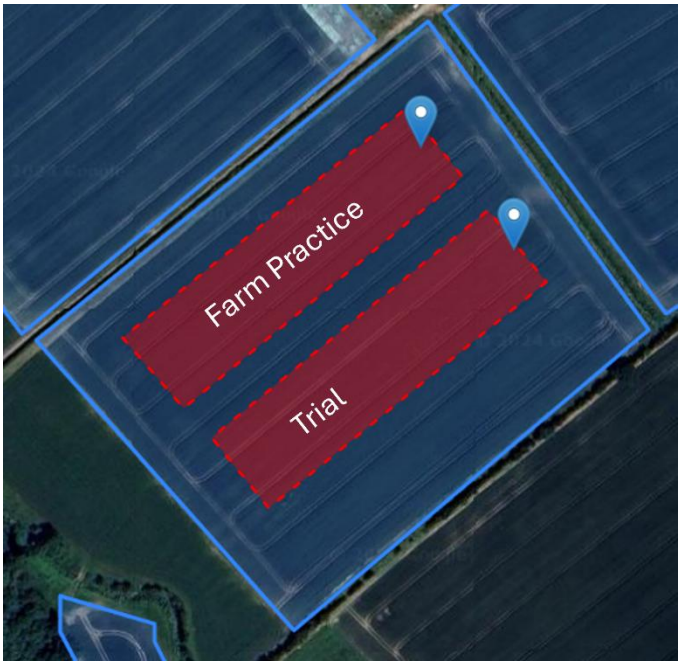

Figure 1 Example trial layout with one red zone being the trial area, and the other being farm practice.

To understand the site, we will need the field boundary and current history for any applications to the crop to date. A form will be sent to you in late December/early January which you will need to fill in informing us of:

- Previous 4 years crop rotation
- Variety
- Intended market.
- Drilling date
- Seed rate (plants per square metre)
- History of applications of mineral and organic fertiliser

Other information we would like to collect:

- Soil sample data (most recent)
- Weather station, particularly rainfall
- Any variable application plans or as applied data
- Current and historic yield map data for the trial site
- Grain protein data

All data collected from your fields will be processed by AgAnalyst and will be available for you to analyse on the farm data integration platform DataBaler. This will also be combined with remote sensing data to compare the results and calibrate our model.

We will work with you to design the trial layout that is representative across the field as a whole and following the ADAS Yen best practice for setting up field trials. We will then decide with your input on where high-resolution monitoring will take place for the treatments. We will mark these points with canes, so they are easy to find as well as recording their GPS / What Three words location for collecting follow up samples if necessary.

Data Collection

DataBaler – AgAnalyst's farm data integration platform,

The AgAnalyst team will provide in-field mapping and visualisations of field variability, yield and protein to support NUE modelling. This will require providing us with field names and boundaries, as well as underlying map data, to ensure all data is captured accurately.

Field Boundaries

Field boundaries can be submitted for the whole farm and should include any other field information related to trees, woodland or other features which may be present that could interfere with satellite data. AgAnalyst will share this data with the relevant partners.

Satellite Imagery

This will be provided by Assimila for all fields included in the project. This data can also support remote assessment and evaluation of variability within the fields to monitor crop growth, while also providing a tool to generate variable application maps.

Soil Sampling

Localised soil nutrient, carbon and N samples will be collected for the target sample point. This will provide us with a detailed insight to the freely available soil supply of nutrients that may restrict or support plant growth and therefore fertiliser use efficiency. For soil mineral Nitrogen (SMN), please sample down to 60cm and split the sample into a 0-30cm (topsoil) and 30-60cm samples or, if the soil is shallow, to the depth of the topsoil. For broad-spectrum analysis and organic matter, please add a separate sample down to 15 cm.

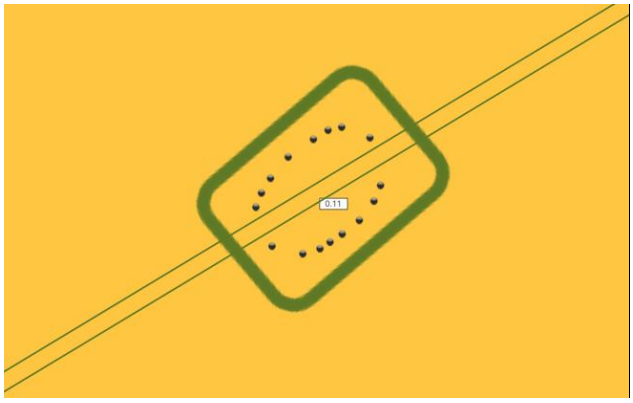

Figure 2 Soil sample cores within a sample area

Canopy weekly field measurements.

N-Tester/SPAD meter sampling should start from when your crop starts growing in spring after the first application of Nitrogen. This generally occurs during March depending on the season from around GS30. Once at this growth stage, we recommend taking weekly readings until mid to late June from both Farm Practice and Trial plots.

N-Tester / SPAD Protocol

- Within the trial area, take the **last** fully developed mature leaf
- Insert leaf into device and nip head together
- Repeat randomly 30 times (15 each side of the tramline) through sample area to ensure you get a representative sample
- Use the DataBaler Scout app to record the reading (how to download DataBaler Scout and logging N-Tester measurements guide)

Nitrogen Applications

The N-Tester readings measure the plant N content, and these inform the N sufficiency status which is variety dependent. We recommend that the first application of Nitrogen is done as farm standard practice but does not exceed 60 Kg N/ha, which should provide a sufficient boost to get the crops moving.

From this point we will monitor the plant uptake of N weekly both through your weekly SPAD/N-Tester measurements and satellite Leaf Area Index (LAI) estimates, which you will be able to view in the FINE In-Season dashboard on DataBaler. Our application approach will vary season to season and may potentially involve more N application passes with lower amounts of Nitrogen than farm practice. We do recognise that this approach is more time-consuming in collecting readings, but with your input this will reduce in the future as we

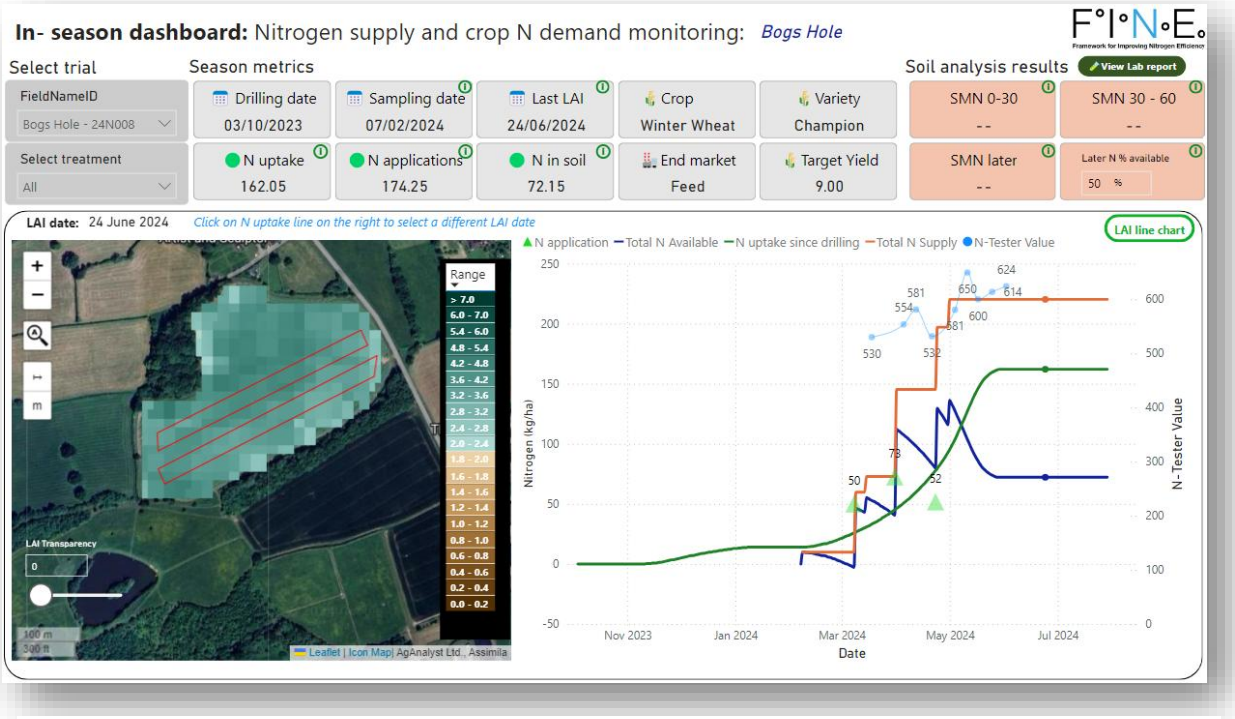

Figure 3 FINE In-season dashboard

calibrate our remote sensing model. As the model becomes more accurate, we will be able to more accurately predict N testing windows, removing the need for weekly N testing.

Our recommendations for further Nitrogen applications will be individual to each field and site. As such, we cannot give any indication to the timing without regular monitoring. It is particularly important to stress that time invested in collecting the spectral readings to inform N uptake is vital. This will ensure we get most profit from our Nitrogen investments and that longer term this need will reduce as we calibrate remote sensing models. Please ask for support if you wish to use variable rate applications. Let us know when you have applied the fertiliser along with the final rate and product used to support the following recommendations.

Rainfall and climate data

Climate and rainfall data is important in assessing the available water to the crop and its ability to take up Nitrogen. A simple farm rain gauge will suffice, but we suggest farm partners budget to purchase a weather station if they do not already have one. You can connect your Sencrop weather station to the FINE network here, or please see the appendix

for details if you are looking for a weather station. We will also include prototype sensors in the 2023-24 seasons measuring soil temperature, moisture and nitrate.

Leaf Tissue

We are proposing to take tissue samples within the season to confirm nutrient levels and status within the plants. These leaf tissue samples should collect approximately 200g of plant tissue and be collected at GS32 and at flag leaf emergence at GS37. Samples can be collected at the same time as one of the weekly measurements. When the GS37 leaf samples are collected, we will also require 5 -10 whole plants to be pulled out (including the crown roots) and send with the leaves. The roots will give a precise indication of the N status of the crop at the time of sampling.

Pre-Harvest

It's important to collect a final grain and straw sample from the trial points as close to harvest as possible. This will conclude the sampling and inform on the grain protein, removal of other nutrients and the nutrient status of crop residues. We will also provide a full nutrient measurement for these samples, and this will be used to measure the grain protein levels with laboratory analysis. We aim to gain insight to the sample point and field average protein in order to calculate our use efficiency.

Harvest

If combine yield mapping is available, then we would propose to utilise this data for analysis of final yield to calculate the yield at the sample point. If mapping is not available, it will be important to collect the average yield of each of the treatments. A harvest protocol will be provided to support accurate measurement of the trials to calculate yield accurately, ideally measured over a weighbridge. It is recommended that if yield mapping is not enabled, then this should be considered along with grain protein monitors to be included in the proposal budgets. AgAnalyst will be able to provide advice on different machines' yield mapping costs and capabilities.

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Summary of Sampling Calendar and Protocols:

Date	Soil/Crop	Test	Essential/Optional
Autumn	Soil	Identify measurement plot	Essential
Autumn	Sensor	Install soil sensor	Optional
Feb* – pre N application	Soil	SMN Plus	Essential
Feb – pre N application	Soil	Broad spectrum, OM	Optional
Feb – Mar Frist N app	Application	Farm Practice rates	Essential
Mar – GS30	Sensor	Start weekly N Testing	Essential
March - GS 32	Crop	Total N Leaf & Roots	Optional
March – May N app	Application	Further N applications	Essential
April – GS 37	Crop	Total N Leaf & Roots	Optional
June -	Sensor	Stop weekly testing	Optional
Aug - Preharvest	**Crop**	**Broad spectrum Grain and Straw**	**Essential**

***note Soil N testing should not occur within 4-6 weeks of organic manure application**

All Sampling Protocols and Forms can be found by clicking on the link below:

https://hillcourtresearch.co.uk/nue-profits-sample-forms-and-instructions/

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	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Crop Drilled												
Field boundary upload												
DataBaler on-boarding												
Satellite monitoring												
Weather data												
Soil Sensor												
Soil N Core												
First N												
Canopy monitoring												
First leaf sample												
Second N												
Third N												
Second Leaf Sample												
Grain / Straw sample												
Harvest Field												
Post Harvest soil sample												
Submit Yield data												
NUE calculation												

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Requirements for reliable N-Tester measurements on trial plots

- At least 30 measurements must be carried out on 30 different plants per field.
- In order to obtain a representative average reading, the measurements must be carried out randomly distributed across the trial areas.
- Measuring point: The measurement must be carried out in the middle of the leaf blade of the youngest fully developed leaf. Measurements on not fully developed leaves may lead to increased recommendations.
- Variety: Differences in the varieties need to be considered, e.g. by correction factors.
- Sulphur deficiency: S deficiency such as N deficiency leads to the leaves being brighter. Therefore, a sufficient S supply has to be ensured when using the N-Tester. Other nutrients do not have any significant influence. Issue: 03.2013 (EN) 11
- Weather: The N-Tester is not able to display future N soil supplies, e.g. from applied N that plants have not yet absorbed due to drought.
- Drought: avoid measuring plants that suffer from visible drought stress (e.g. leaves rolled together).
- The following factors do not have an effect on the N-Tester reading:
    - Time of the day when measuring
    - Pesticides
    - Moisture on the leaf
    - The use of strobilurins
    - Yield level
- Further instructions can be found here

Each measurement is comprised of the following steps:

- Calibrate internally (after the device has been switched off) by following instructions.
- Measure 30 x leaves on different plants.
- Read off result and record it providing the result with the plot reference, growth stage and any other comment.

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Trial equipment and sampling costs

Equipment

N-Tester currently free with Yara Atfarm subscription – follow this link to get yours. To buy your own at £1250 + VAT, contact Clive Blacker.

Weather Station – join the FINE Sencrop network

Sencrop have offered to support the use of their systems for farmers wanting to participate and use Sencrop technology. Over the course of the project, we are developing yield prediction models that we use to help us recommend the right amount of fertiliser at the right time. To improve these models, accurate weather data is key. We have therefore created a FINE weather network on Sencrop which you can join here if you have a Sencrop weather station. By providing us with access to your weather station data you are helping us improve the accuracy of how we will provide recommendations bespoke to your farm. If you have a different weather station producing data please contact us and we can discuss integrating it.

Yield Mapping

Price to specific combine. Please enquire directly to Clive Blacker as there are several options available and it's not always as expensive as you think.

Cereal Growth stages

A guide to cereals growth stages can be found at this site from the AHDB

https://ahdb.org.uk/knowledge-library/the-growth-stages-of-cereals