



Knowledge grows

The Yara N-Sensor™



Introduction

The improved Yara N-Sensor ALS-2 offers farmers a solution to real-time variable rate nitrogen applications by adjusting rates according to crop growth whilst travelling across a field. As a result the N-Sensor is designed to deliver precise levels of input according to the crop's requirements, helping to both reduce environmental effects whilst maximising potential profit.

A dedicated group of scientists at Yara's R&D base at Hanninghof, Germany, carry out trial work annually to improve calibrations that exist currently and increase the range of options for use. As such the N-Sensor truly is backed by Science.

The result - improved gross margins and greater nitrogen efficiency



Development

The Yara N-Sensor ALS-2 is the culmination of over 20 years of development work at Hanninghof in Germany, through extensive testing and trial work.

Originating from the first generation Passive N-Sensor in 2005 the Active Light Source (ALS) was introduced as a solution to restricted working hours due to low or no ambient light. As the name suggests the ALS contains its own light source to continue operating irrespective of ambient light conditions.

In 2018 the ALS-2 was launched. During research and development, Yara had recognised the issue of damp leaves (dew) that affects all sensors and the reflectance accuracy achieved. Research was targeted to overcome this issue, culminating in the requirement to capture extra waveband data during sensing. This 'dew suppression' is unique amongst sensors and is a feature in the ALS-2 N-Sensor. A new modular design and improved connectivity gives the ALS-2 more flexibility and easier mounting options.

Backed by Science

Trial work continues to be carried out annually at Hanninghof in order to progress the system further. Before a new crop type is introduced to the calibration programme a large number of trials are conducted. These trials look at the nitrogen uptake of the crop in question and the effects of the interactions between different varieties and seed rates on the N-Sensor measurements at different stages of growth and the actual leaf nitrogen contents through laboratory analysis. Only once it is confirmed that there is a good correlation between the two will a new calibration for a crop be released.

Even for calibrations which are long established, work is carried out every year to fine tune them where necessary in order to continually improve accuracy.

How does the N-Sensor Work?

The Yara N-Sensor determines the nitrogen demand by measuring the crop's light reflectance covering a total area of approximately 50m² / sec. Measurements are taken every second with the system designed to operate at normal working speeds and all bout widths. Most sensing technology applied to agriculture is based on the typical light reflectance curve for vegetation (NDVI). The N-Sensor measures light reflectance at specific wavebands related to the crop's chlorophyll content and biomass. It calculates the actual N-uptake of the crop. Optimum application rates are derived from the N-uptake data and sent to the controller of the variable rate spreader or sprayer, which will adjust fertiliser rates accordingly.

The whole process of determining the crop's nitrogen requirement and application of the correct fertiliser rate happens instantaneously, with no time delay. This enables "real-time agronomy and application" to be possible.



N-Sensor: tractor mounted remote sensing

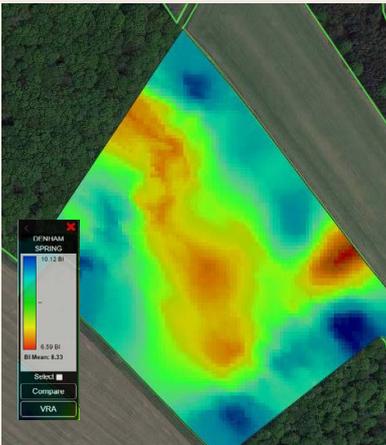
Site-specific fertilisation is one of the main objectives of precision agriculture. Variable-rate nitrogen application requires accurate and efficient tools to determine the actual crops nitrogen status.

Remote sensing techniques offer the opportunity to deliver this information quickly, precisely and cost effectively. The N-Sensor has been developed to determine the crop nitrogen status by measuring the light reflectance properties of crop canopies and to enable variable-rate fertilisation “on-the-go”.

N-Sensor Biomass Map

Showing Biomass as sensed

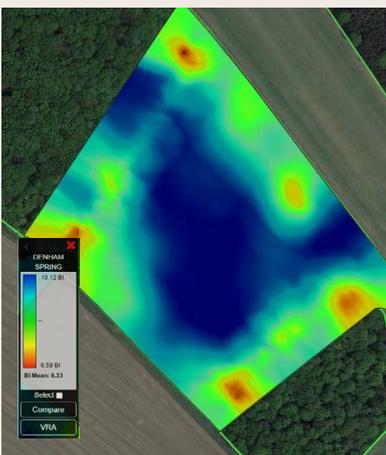
Courtesy of Precision Decisions Ltd MiFarm



N-Sensor Application Map

Showing Nitrogen as applied

Courtesy of Precision Decisions Ltd MiFarm



Why the N-Sensor ALS-2?

Agronomic

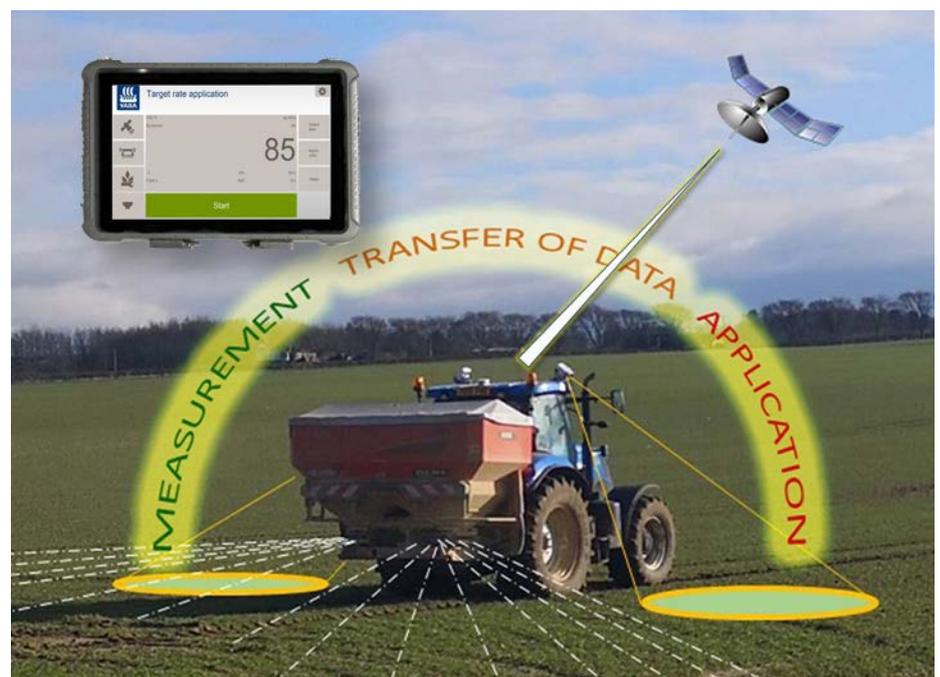
- Unique, agronomically based crop specific algorithms. For wheat, oilseed, barley, maize, grass
- Unique spectral indices to accurately ‘sense’ variable nitrogen supply throughout the main growing season
- Clean, accurate ‘sensing’ with NO clouds, trees, landscape features to corrupt the data
- Unlimited scanning, day or night, NO waiting for satellites
- Large ‘scanning footprint’ - up to 4.2m width each side of the sensor
- 4 wavelengths measured giving enhanced accuracy, suppressing the effects of damp leaves (e.g. dew)
- Ensures application of the optimal nitrogen fertiliser rate to every part of the field
- Maximising the crop’s potential across the whole field
- Gives increased yields and improved grain quality from more homogeneous crops
- Enables improved combine performance, reducing harvesting time and cost through more uniform crops

Environmental

- Increases nitrogen use efficiency, reducing the risk of nitrogen losses to the environment
- Decrease nitrogen residues in soils post-harvest
- Reduces carbon footprints

Practical

- Includes variable nitrogen applications from simple ‘switch on and go’, to more complex precision mapping and data management
- Lightweight for easier, safer fitting
- Modular design for more flexibility in fitting
- LAN connections enable greater distances between sensor heads when mounting
- Allows comparison between standard farm practice and Absolute-N





Modes of Operation

N Application

This calibration is the original which requires a reference scan to be conducted from an average area of the field, and entered before beginning the fertilizer application.

Target Rate

Target rate was introduced to speed up the calibration process and allows a rolling calibration during operation, whereby the reference value is calculated from the moment the sensor starts taking measurements on the field.

Both operation modes allow reference or target N rates to be assigned as well as fixing MAX & MIN to control the range of adjustments possible. The reference or target rate is essentially the average rate to be applied to the field and should be calculated before entering the field. The N-Sensor will then vary around this average depending on measurements from the crop.

Absolute N on OSR & WW

The Absolute N calibration was introduced in 2010 for OSR and then developed for WW in 2018. In this mode, rather than calculating the amount of N to apply before getting to the field, the N-Sensor makes the recommendation at the point of application. The N-Sensor measures the N picked up in the crop for the given growth stage and knows the expected amount of N

required by the crop at that timing and then applies or cuts back the difference.

Other parameters are required during the setup to help calculate the appropriate rate of N to apply, including dead biomass and mineralisation potential.

Grassland Application

Based on experiences with N-Sensor measurements in Nordic grass fields, the N-demand in grassland can vary by 80kg N/ha, from the lowest to the highest point. With the Yara N-Sensor, nitrogen is optimized for DM yield and the profit is estimated to 40-68 £ per hectare.

The Yara N-Sensor grassland calibration is developed for cut systems for forage production (pure ryegrass or mixed swards, typically meadow fescue and timothy). High clover content affects the measurements and should not exceed 20% content. The oblique angle of Yara N-Sensor is especially beneficial to avoid the effect of clover or weeds.

Potato Haulm Killing

An under license module from Plant Research International in the Netherlands for site specific dosing of potato desiccants. By measuring the reflectance of the potato canopy it is possible to pick up differences in colour significantly in advance of the human eye, therefore applying higher dose rates to the 'greener' canopies to improve the uniformity of action and help reduce overall herbicide use.

Biomass Cut-Off

For all modes a biomass cut-off value is required during the setup which will vary according to the growth stage of the crop. This instructs the N-Sensor to cut back to the minimum application rate when the biomass measurements falls below the entered value.

This ensures N is not wasted on areas of the field which are unlikely to yield due to pest damage, waterlogging etc.

An Agronomy Tool & Scanning

The N-Sensor operates with GPS mapping to enable users to create biomass and N application maps for each field scanned. These maps are a useful agronomy tool. Highlighting areas of low biomass they enable the user to go back and gather more information as to the cause of the problems. They can also be matched with yield maps to help identify reasons for high or low yielding areas and can also be useful for traceability records for Crop Assurance Schemes.

Additionally through the MiFarm platform it is a simple process to produce your own VRA maps for other products or seed application. These maps can then be transferred to the relevant controller.

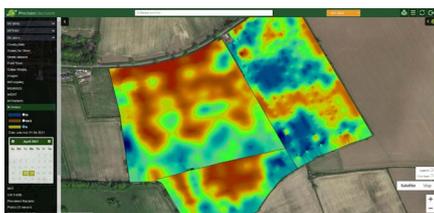
It is recommended to scan crops with the N-Sensor even when not applying N, especially at crucial growth stages.

Benefits of the Yara N-Sensor™



N-Sensor Tablet & MiFarm

All new N-Sensor installations come with a tablet PC which runs the software and links to the rate controller. This tablet records Biomass and N applied maps (in most cases). It connects automatically via WiFi to your MiFarm account and uploads these maps for interrogation. The MiFarm software is part of your N-Sensor package and is supplied by Precision Decisions Ltd.



Improved Yield - Improved Gross Margin

The single biggest benefit from using the N-Sensor is also the hardest to measure. Yara have conducted a large number of trials across the UK and Europe, looking at the yields of uniformly applied to crops compared with those which received variably applied N.

Yield increase of up to 12% on trials using the N-Sensor

Comparing the use of the N-Sensor to uniform application, 82% of the trials showed an advantage. The average yield increase compared to uniform application was 3.2% with a maximum of 12% on some trials.

Analysis has shown that where fields contain higher levels of variability due to changing soil types, manure application or topography, the benefit obtained from variable N application using the N-Sensor was at its greatest.

Reduced Lodging

One of the most common benefits seen by customers is the reduction in lodging from using the N-Sensor. Over application of N can result in crop lodging, which can have dramatic effects on profitability through reduced yield, through reduced yield and quality and increased harvest time and drying costs. Lodging in OSR in particular as a result of too dense a canopy, can have a severe impact on yield with losses of up to 30% possible.



Improved Combine Performance

Greater crop evenness achieved by using the N-Sensor also results in more even ripening, enabling faster harvesting and reduced drying times. Trials over the last 20 years consistently show improvements in combine output with an increase of between 10% to 26% across trials with an average of 18.5%, reducing the number of harvest days required.

Combine output with an average of 18.5% reducing the number of harvest days

Even Grain Quality

By applying the crop's optimum N requirement in all areas of the field, the N-Sensor has the effect of helping to reduce variability in yield and grain quality over the field. One trial carried out in 2002 looking into the application of late N in winter wheat showed that the variability in protein was reduced by over 60% where the N-Sensor was used, compared to uniform application.

Variability in protein was reduced by over 60% where N-Sensor used

Summary

- Nitrogen savings of up to 14% have been recorded where N-Sensor was used
- The first nitrogen sensor to have 'dew suppression' to further improve sensing accuracy
- Cereal yields increased by 3.5% where the same intensity of fertiliser was used
- Oilseed yields increased by 3.9% through the Absolute-N calibration
- An 80% reduction in lodging rates (compared with crops where nitrogen was applied under conventional practices)
- Combine performance was increased by 12-20% due to reduced lodging, lower losses and faster intake speeds
- Protein levels in cereal crops showed greater consistency averaging 0.2-0.5% above target
- Increases in nitrogen use efficiency have reduced the carbon footprint by 10-30%
- The N-Sensor ALS was awarded the RASE Gold Medal



About Yara

Yara grows knowledge to responsibly feed the world and protect the planet. Supporting our vision of a world without hunger and a planet respected, we pursue a strategy of sustainable value growth, promoting climate-friendly crop nutrition and zero-emission energy solutions. Yara's ambition is focused on growing a climate positive food future that creates value for our customers, shareholders and society at large and delivers a more sustainable food value chain.

To achieve our ambition, we have taken the lead in developing digital farming tools for precision farming, and work closely with partners throughout the food value chain to improve the efficiency and sustainability of food production. Through our focus on clean ammonia production, we aim to enable the hydrogen economy, driving a green transition of shipping, fertilizer production and other energy intensive industries.

Founded in 1905 to solve the emerging famine in Europe, Yara has established a unique position as the industry's only global crop nutrition company. We operate an integrated business model with around 17,000 employees and operations in over 60 countries, with a proven track record of strong returns.

Yara UK Limited,
Harvest House
Europarc,
Grimsby
N. E. Lincolnshire
DN37 9TZ

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