N2 ——— Applied

Performance Report 2020

NEO by N2 Applied

In 2020, N2 Applied conducted field trials in ten different locations across Europe and in South Africa. The trials demonstrated an average yield improvement of 41%. Storage and field application trials displayed a near elimination of both ammonia and methane emissions after treatment. As a result, the N2 technology improves the nitrogen use efficiency of organic fertilisers and substantially reduces the environmental footprint of food production.

Introduction

Nitrogen is essential for global food production. N2 Applied has developed a technology that enables local production of nitrogen fertiliser using only air, electricity and a liquid organic substrate, such as animal slurry or biogas digestate. The N2 unit is a small machine and is situated locally on-farm or at a biogas plant. The N2 treatment enriches the organic substrate with nitrogen from the air, creating Nitrogen Enriched Organic fertiliser (NEO). This novel fertiliser has the potential to greatly benefit agriculture both economically and environmentally.

The N2 treatment redistributes fertiliser production to the end user, the farmer, cutting long value chains and reducing the need for chemical fertiliser production based on fossil gas or coal. The treatment more than doubles the crop available nitrogen content of the slurry or digestate and simultaneously prevents the loss of ammonia from storage and on field application. The treatment also eliminates methane emissions and reduces odour. The resultant NEO fertiliser therefore contains more nitrogen, retains its existing nitrogen for crop uptake and emits less greenhouse gases than the untreated equivalent. The reduction in nitrogen losses leads to a higher nitrogen use efficiency, which limits the amount of nitrogen entering the environment.

N2 Applied conducted a series of field trials with established partners to document the agronomic benefits of NEO. The aim was to demonstrate NEO's agronomic and environmental impact under a variety of conditions, with various input substrates and on different crops.

The completed trials documented an average increase in crop nitrogen uptake of 41 % compared to the untreated substrate, when applied at the same nitrogen rate. The improvement is mainly due to increased crop available nitrogen and reduced ammonia loss, meaning more nitrogen is available for plant uptake. Moreover, storage trials showed that the potent greenhouse gas methane is eliminated in NEO, which substantially reduces greenhouse gas emissions.

Field trials on wheat and canola using cow slurry in Cape Town, South Africa, conducted by University of Stellenbosch.

Field trials – location and partners

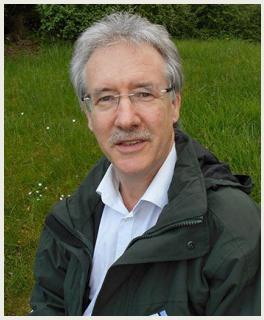
N2 Applied's field trial portfolio now stretches back four years and includes multiple trials in nine countries. All trials are conducted by reputable and established research partners, to ensure that the trial design and analysis meet the highest of standards. The results and insights of our research partners, alongside continued technological development, has led to rapid improvements of the entire N2 process. The results from the 2020 trials have demonstrated that the N2 technology is progressing from both an agronomic and environmental perspective.

"NEO increased wheat yields compared to untreated digestate, similarly the nitrogen offtakes were greater, accounting for much more of the nitrogen compared to the untreated… In this experiment the N2 treatment increased the nitrogen use efficiency, or the fertiliser value, of the digestate significantly, essentially doubling it."

John Williams, Principal Soil Scientist at ADAS.

"Treated digestate performs very well as a fertiliser with similar yields to inorganic nitrogen fertilisers. The treated digestate had significantly higher yields compared to untreated digestate over several cuts, and farmers could potentially make savings on bought-in fertiliser."

Dr. Suzanne Higgins, Soil Scientist at the Agri-Food and Biosciences Institute.



"The N2 treatment is a very interesting concept, certainly in Scotland where we have a lot of Livestock production systems and a lot of renewable energy. This is something which is very interesting for improved grassland management in Scotland."

Dr. David Lawson, Grassland Agronomist at Scottish Rural University College consulting.

Trial locations:

Yield

Blæstad, Norway - HINN/NLR

Kvithamar, Norway - HINN/NLR

Hvam, Norway - HINN/NLR

Åmot, Norway - HINN/NLR

Jokioinen, Finland – LUKE

Aarhus, Denmark - DTI

Aberdeen, Scotland - SRUC

Belfast, Northern Irland - AFBI

Mansfield, England – ADAS

Cape Town, South Africa - Uni. of Stellenbosch

Figure 1: Overview of N2 Applieds 2020 trials using organic inputs from cattle, pig and biogas production to test agronomic and environmental performance.

Ammonia and Methane Emissions

Aarhus, Denmark - DTI

Uppsala, Sweden – RISE

Mansfield, England – ADAS

Cape Town, South Africa - Uni. of Stellenbosch

Yield trials – on average improved by 41%

N2 Applied's 2020 field trials were highly successful in demonstrating NEO's agronomic benefits. One parameter used is protein yield, which is a derivative of 'crop dry matter yield' multiplied by 'nitrogen content'. Protein yield is a useful representation of the value of the crop.

NEO had an average increase in protein yield of 41%, when compared to untreated organic fertiliser. The results ranged between trials, with increases as high as 90% recorded. In most cases, NEO significantly outperforms the untreated organic fertilisers, leading to a much higher nitrogen uptake in the grass or grain. A summary of the protein yield differences between NEO and untreated substrate is displayed in Figure 2.

Most trials are conducted at the same available-nitrogen rate for all treatments. Since NEO has a higher nitrogen content than untreated fertiliser, less than half the volume of fertiliser was needed to apply the same amount of nitrogen. The exceptions are trial 5, 7 and 8 (see Figure 2) which compared applications to the field of equal volumes of NEO and untreated substrate.

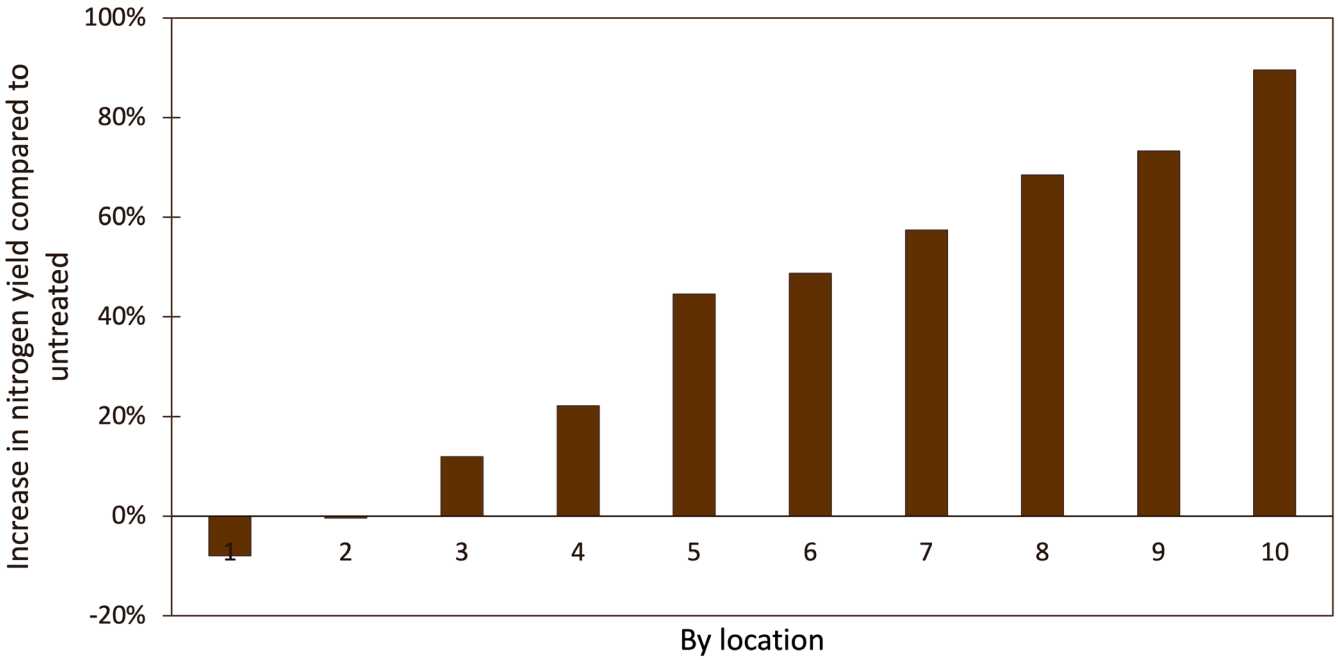


Figure 2: Average protein yield difference between NEO and untreated organic fertilisers from the top application rate of each trial conducted by N2 in 2020.

The performance of NEO and chemical fertiliser

NEO demonstrates a similar nitrogen use efficiency (NUE) when compared to the chemical fertilisers ammonium nitrate (AN) and calcium ammonium nitrate (CAN). A trial designed to evaluate NUE and ammonia loss on wheat was conducted by ADAS (Mansfield, UK). This trial demonstrated that NEO had a NUE of 61%, AN 63%, and 27% in untreated digestate. Similarly, in the grass trial with SRUC (Aberdeenshire, UK), NEO displayed a NUE of 45%, with CAN having 47% and untreated slurry being 18%. NEO displays a NUE very similar to chemical N fertilisers while substantially outperforming untreated slurries and digestates in most cases.

HINN: Field trial with five different fertiliser options, CAN, untreated organic fertiliser, acidified organic fertiliser and NEO at Blæstad, Norway, conducted by HINN.

NEO's Environmental Impact

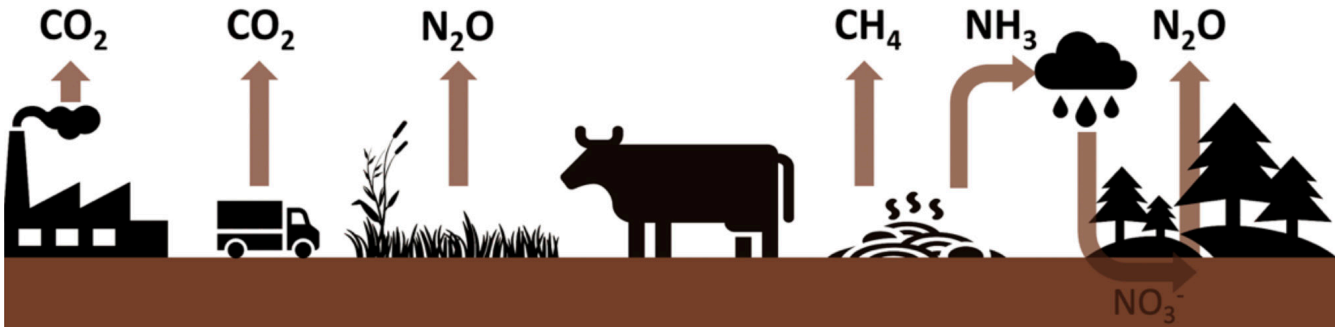


Figure 3: Illustration of the environmental impact from todays fertiliser practice.

NEO impacts environmental emissions in five important ways:

1. Nitrogen fertiliser production is shifted from a process based on fossil gas or coal to one that runs on electricity.
2. Increased nitrogen use efficiency due to lower ammonia volatilisation (nitrogen loss) from the slurry or digestate reduces the need for chemical fertiliser and prevents over-fertilisation.
3. The reduced ammonia emissions will improve local air quality, as ammonia is a hazardous gas and contributes to the formation of harmful particulate matter (PM2.5).
4. Preventing ammonia emissions leads to an indirect reduction in the formation of the potent greenhouse gas nitrous oxide.
5. The treatment eliminates the methane emissions from slurry storage, reducing emissions of a potent greenhouse gas.

Emissions from storage of organic substrates

Storage of slurry and digestate is a large emission source for ammonia and methane. N2 Applied commissioned a storage trial, led by Research Institutes of Sweden (RISE) in Uppsala to demonstrate the effect of emissions from storage.

An untreated biogas digestate was trialled alongside the treated biogas digestate (NEO), and the cumulative ammonia and methane emissions were measured over 108 summer days. NEO saw <0.01kg/m³ of ammonia loss compared to the untreated 0.25kg/m³ loss (Figure 3). Negligible methane emissions were detected from NEO compared to 0.48kg/ton in the untreated digestate (Figure 4 – next page).

Storage emissions trial in Uppsala, Sweden conducted by Research Institutes of Sweden (RISE).

This trial demonstrated the effectiveness of the N2 treatment for reducing both methane and ammonia emissions in storage. Given this was a biogas digestate, most of the methane potential of untreated digestate is exhausted before the trial. However, an equivalent of 16kg CO_2 per ton of digestate was still emitted. The trial followed an initial small-scale trial from 2019, and the elimination of methane in storage of organic fertiliser makes an important contribution to the climate footprint of a farm.

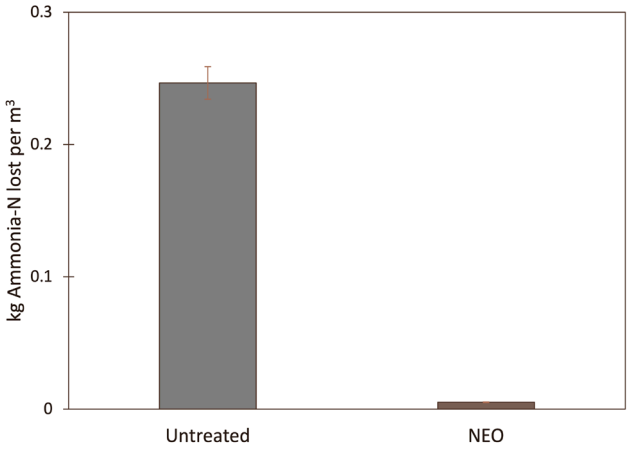


Figure 4: Ammonia emissions differences in storage between NEO and untreated biogas digestate, RISE.

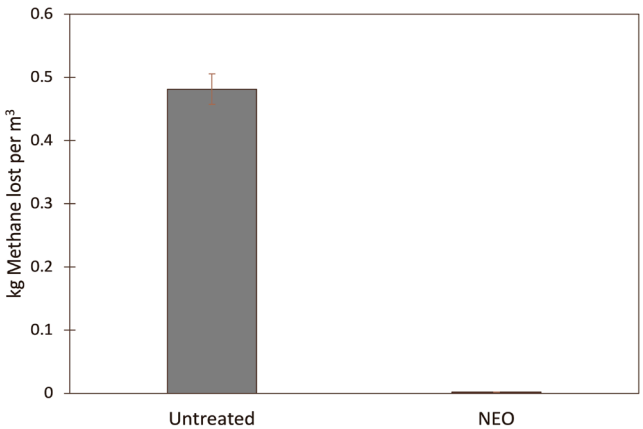


Figure 5: Methane emission differences in storage between NEO and untreated biogas digestate, RISE.

Emissions from fields related to fertilisation

It is important to address emissions both from storage and when the organic fertilisers are applied to fields. Field plot trials were conducted by ADAS in the UK (Mansfield, UK) using wind tunnels to measure ammonia loss differences from biogas digestate and NEO. Over three days, more than 40% of the plant available nitrogen was lost as ammonia from the untreated digestate. NEO, in contrast, lost just 3% (Figure 6), which equates to a 93% reduction in ammonia loss.

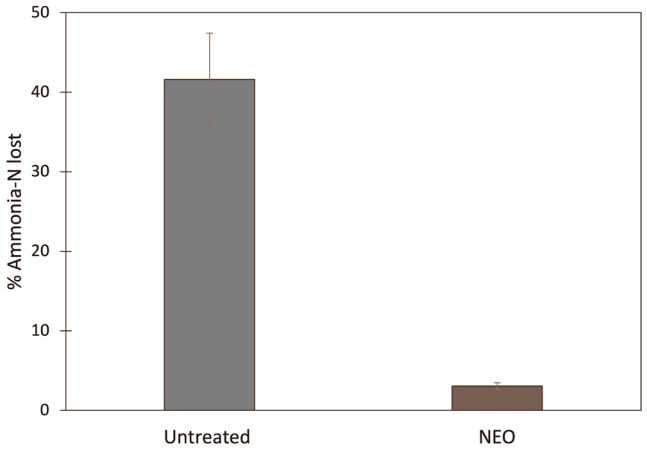


Figure 6: Ammonia emission differences between NEO and untreated biogas digestate applied to field plots, ADAS, UK.

Field emissions trial in Aarhus, Denmark, conducted by Danish Technological Institute (DTI).

A quick summary

In the 2020 trials NEO has demonstrated greatly increased yields and an almost elimination of ammonia and methane emissions, both in storage and on-field. This supports that NEO is a fertiliser which enables precise application, leads to an increased NUE and reduces environmental impact at several stages of agricultural production.

Greenhouse Applications of Nitrogen Fixation with the N2 Unit

The application of N2 technology is not limited to NEO. Any process that requires plant available nitrogen could benefit from a technology that synthesises this with only electricity and air.

One such application is greenhouse cultivation, where nitrogen fixed by the N2 technology can replace fossil-based nitrogen fertilisers. The remaining essential nutrients can be extracted from other organic sources with the use reactive nitrogen produced in the N2 process. This enables the local production of an environmentally friendly greenhouse fertiliser that serves as a full-fledged alternative to chemical fertiliser solutions.

To demonstrate the potential of N2 technology in the greenhouse sector, N2 Applied is conducting a series of trials with Norway's largest herb growers, Snarum Gartneri, supported by Grofondet. The results obtained to date show that equivalent yields are achieved with the environmentally friendly fertiliser solution when compared to the fossil-based control.

By obtaining the other nutrients from organic sources, a renewable, hydroponic fertiliser tailored for individual greenhouses is achievable. During the colder months of the year, the heat produced by the N2 technology is recoverable, and utilised to provide the heating needed to keep the greenhouses running, further increasing thecefficiency of the production process.

Herbs produced with chemical and recycled fertilisers show no difference in yield or quality.

A word from N2 Applied's CEO, Carl Hansson

2020 was a special year for everyone. We started the year with our most ambitious field trials plan ever for testing the NEO performance. Conducting field trials in many different locations, in several countries and with different raw material always represents a challenge when it comes to logistics. The COVID-19 outbreak certainly did not make it any easier. I am really proud to say that we managed to execute the trials according to plan. This is thanks to extraordinary efforts and flexibility from our team and excellent partners, all the way from Svene to South Africa. Thank you.

It is important for us to demonstrate on the field that NEO makes better use of nutrients and gives significantly more yield. I have been asked why we are still carrying out field trials when we have already shown that NEO works in principle. As each trial requires resources, this is a valid question. But agronomy is subject to the environment, with many influencing factors; climate, weather, soil and crop type to name a few. Continuous field trials over multiple years and several locations improves the assurance that NEO is beneficial to crops and soils. It also gives us new insight when it comes to fertiliser management, which we can use to further benefit farmers.

Through the pandemic, more and more people have learned to appreciate the importance of sustainable food production and local supply chains. During 2020 our partners have done extensive testing of emissions related to NEO, and the environmental performance exceeded expectations. Ammonia and methane emissions from storage and application were shown to be practically eliminated, and the need for chemical fertiliser significantly reduced. This shows that the N2 technology is a holistic abatement solution, effectively reducing both climate-changing greenhouse gases and harmful ammonia emissions.

The N2 Applied technology allows for a new and revolutionary farming practice where nutrients are recycled on the farm, reducing the need for external input factors. This will allow farmers to achieve higher outcomes with a better environmental footprint. With the help from our research partners, we are on the path towards a better future for livestock farming. We look forward to further cooperation in 2021 – thank you all so much!

Carl Hansson
CEO of N2 Applied

Crop growth is monitored during the growing period and each cut is analysed to account for the full growing season.

A special thanks to:

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