The Application of Nitrogen Enriched Organic Fertiliser (NEO)

Introduction

N2 Applied has developed a technology that enables local production of nitrogen (N) fertiliser using only air, electricity and a liquid organic substrate (animal slurry or biogas digestate). The technology enriches the organic substrate with nitrogen from the air, creating Nitrogen Enriched Organic fertiliser (NEO). The enrichment process also makes the fertiliser slightly acidic, which stops the formation and emission of ammonia (NH_3). This gives NEO great potential as an environmental and economic solution for sustainable agriculture.

N2 Applied's scalable process enables fertiliser production to be re-distributed to the end user, the farmer – cutting long value chains and reducing the need for chemical fertiliser production based on fossil gas or coal. As NEO is a new fertiliser product with a high N content, containing a range of different N compounds, other important crop nutrients, and an organic matter fraction, it requires new ways of thinking for its most effective use in crop production. This factsheet explores the optimal methods for managing NEO on-farm and building a nutrient management plan to improve crop yields and soil quality.

Production and storage

NEO is produced in a N2 Unit, which is designed to nitrogen-enrich any liquid organic slurry intended for fertiliser use. Once treated, the resulting NEO can be stored without the risk of losing valuable ammoniacal nitrogen. The treatment also inhibits the formation of methane, which leads to a reduction in greenhouse gas emissions and prevents the loss of organic carbon. In places where a biogas reactor is used to exploit the methane potential in the slurry, the substrate should be treated after the biogas process, not before. It is also important to keep avoid mixing untreated slurries with NEO, because the high buffer capacity of untreated slurry may alter the pH and cause product instabilities.

Application timing

Application timing is important for both crop nutrition and for minimising environmental emissions. As NEO has a stable NH_4 content due to acidification this makes it a more versatile fertiliser than untreated slurry or digestate. With NEO it is not necessary to wait for optimum cool, moist weather conditions to minimise volatilisation, it can be applied on a warm and sunny day and still hold on to its NH_3. This is supported by trials carried out by ADAS (an independent research organisation that specialises on agronomic and environmental consultancy) in 2020 to assess NH_3 loss from NEO compared to an untreated digestate applied to winter wheat, which showed that even in very warm weather conditions NH_3 loss from NEO was extremely low compared to the untreated material (Figure 1). Untreated organic fertilisers may usually be applied prior to cultivation or drilling so they can be incorporated to the soil to minimise NH_3 loss and improve soil infiltration. The versatility of NEO to be applied in a variety of conditions means it can be applied with confidence later in the growing season when crops require the most N to support growth. The nitrate (NO_3) content of NEO also means it is particularly suited to these later applications during the growing season, as the NO_3 is immediately available after application for plant uptake. The NH_4 and organic-N content of NEO means it will also provide release of N for the crop over time, providing nutrition over the growing season or until the next N application is required to drive yields.

ADAS ammonia loss trial 2020 comparing NEO and untreated digestate.

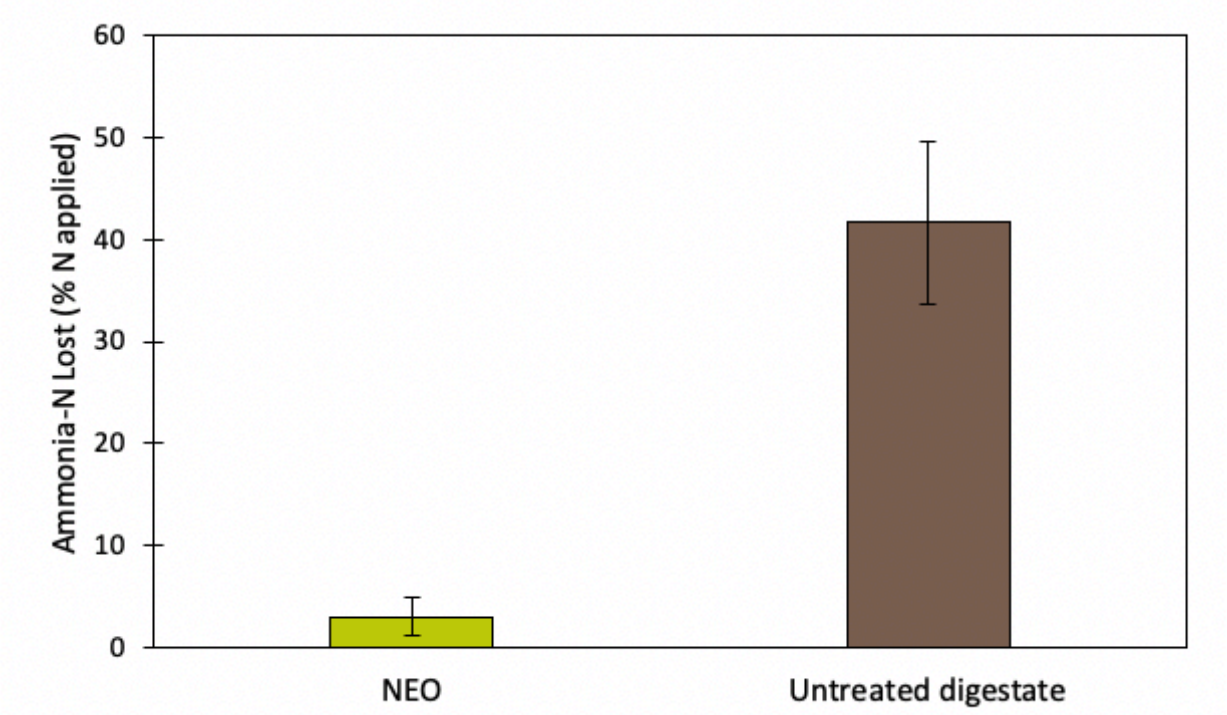

Figure 1. ADAS ammonia loss trials results, spring 2020. Comparison of ammonia loss from a winter wheat field applied with NEO and untreated digestate in warm spring conditions

Application of NEO when crop uptake is high avoids losing NO_3 to leaching, which can be a risk if NO_3 is applied to bare soil or long before crop N uptake is high. It is therefore recommended that NEO be applied to crops at the optimal time for uptake as a first and/or second N application during the growing season in spring when crop uptake is highest, with split applications if it is the main source of N. Applying NEO at a traditional slurry/digestate application timing before cultivation or in the seedbed will not allow for crop uptake of the available N and could lead to leaching losses.

Spring applications at the appropriate growth stage for N uptake will optimise crop yield response, prevent NO_3 leaching loss, and there will be almost no risk of NH_3 volatilisation from NEO, as demonstrated in figure 1. If autumn applications of NEO are required it is recommended this be done on land with vegetation growth where possible, to prevent NO_3 leaching. Applying to cover crops or to winter crops which require some autumn N input, such as oil seed rape, could be a way to improve soil quality, feed the crop and alleviate any storage issues if this is a problem.

Application method

As ammonia emissions from NEO are low, application methods designed to reduce ammonia emissions are not considered necessary when applying NEO on the field – NEO can be used in broadcast spreaders with little risk of ammonia loss. However, the use of band spreading will ensure a more accurate and even spreading of NEO, enabling precision application of the fertiliser. The combination of NEO and band spreading therefore provides an opportunity to use organic fertiliser in precision fertilisation.

Another consideration is whether spreaders use a tanker or umbilical to apply slurry/digestate. Umbilical spreaders minimise soil compaction risk when available, but problems may occur with crop damage if applying later in the season to more mature crops, due to the trailing umbilical. Tankers can cause more soil compaction, but the higher N content of NEO, with lower volumes required to meet crop N requirements, can mean fewer trips to refill and less travel on some land. The improved versatility of NEO, with being able to apply it in warmer, drier weather without fear of volatilisation, could also reduce compaction risk which would usually be higher on wet soils. Some benefit could be offset by the increased travel due to the larger area over which NEO is applied, due to the increased N in the material requiring a larger crop area. Practical considerations therefore need to be made when incorporating NEO into a fertiliser management system and these should be focused towards crop and soil health like in any other circumstance, but NEO can fit in with multiple different management systems.

Crop nutrient considerations

NEO can have more than double the crop available N content of an untreated slurry or digestate, which needs to be considered appropriately in nutrient management planning. The increased N content is added mainly as NO_3 with some nitrite (NO_2) also present (Figure 2). Organic N and NH_4 tend to remain unchanged while the NO_3 and NO_2 are absorbed to the fertiliser to increase available N. All the NH_4, NO_3 and NO_2 needs to be considered in a nutrient management plan as available N. The total N, which also includes organic-N, needs to be considered for maximum total N application limits in nitrate vulnerable zones (NVZs).

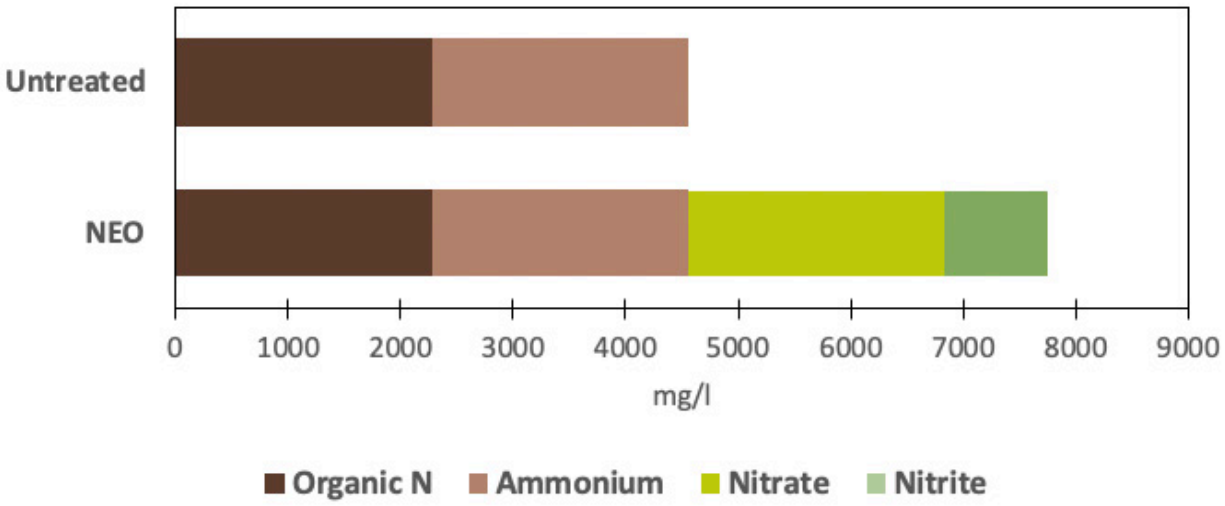

Figure 2. Comparison of average contents of nitrogen compounds in untreated slurry/digestate and NEO.

Figure 2 shows that the mineral nitrogen content is more than doubled. However, the untreated fertiliser is expected to lose around 30 % of its ammonium to volatilisation, while the ammonia loss from NEO will be close to zero. The mineral nitrogen available for crop uptake is therefore more than three times higher in NEO than in the untreated fertiliser, given the values in figure 2. Combined with the benefit of a share of immediately available nitrate and the ability for precision application, this makes NEO a versatile and valuable fertiliser product.

Results from agronomic trials

Agronomic trials have been conducted to assess the effect of the treatment. To best demonstrate the impact of the treatment, the compared fertilisers are applied at the same nitrogen level. This entails that NEO is dosed at approximately half the volume untreated slurry. Even in such a scenario, NEO is expected to outperform untreated slurry, as a result of reduced ammonia emissions.

N2 Applied's first agronomic field trials were initiated in 2018. Figure 3 (next page) shows the result from a field trial conducted by the Agri-Food and Biosciences Institute in Northern Ireland (AFBI), comparing an untreated biogas digestate to the treated digestate (NEO) and chemical fertiliser. Over the course of two cuts, NEO resulted in a 14 % higher yield compared to untreated slurry. No significant difference was found between chemical fertiliser and NEO in this trial.

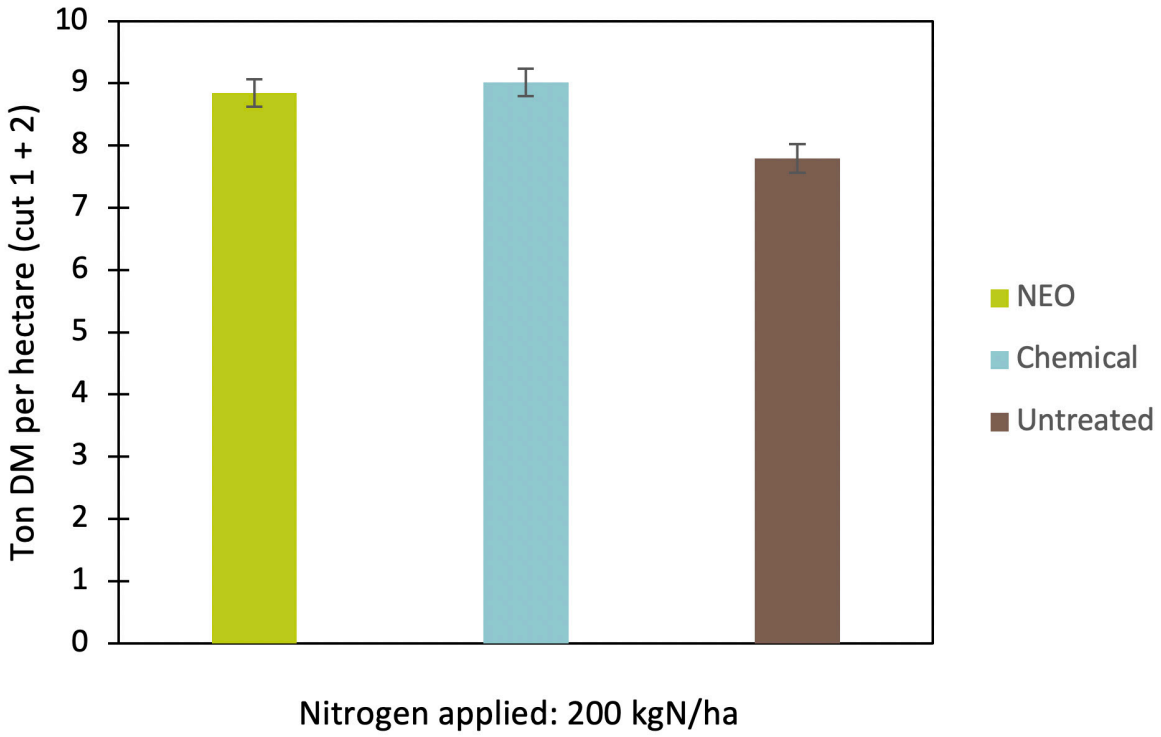

Figure 3. The first trial with NEO on grassland. Mineral fertiliser and NEO resulted in higher yields overall than untreated biogas digestate.

In 2019, Scotland's Rural University-College (SRUC) carried out trials on grassland swards on behalf of N2 applied. These trials demonstrated that NEO outperforms untreated cattle slurry even when dosed at the same nitrogen level (Figure 4), which can be explained by the high volatilisation from untreated slurry. Trials are underway with SRUC in 2020 to investigate the yield response of grassland with matched application rates of available N in NEO, untreated organic fertiliser and chemical N fertiliser.

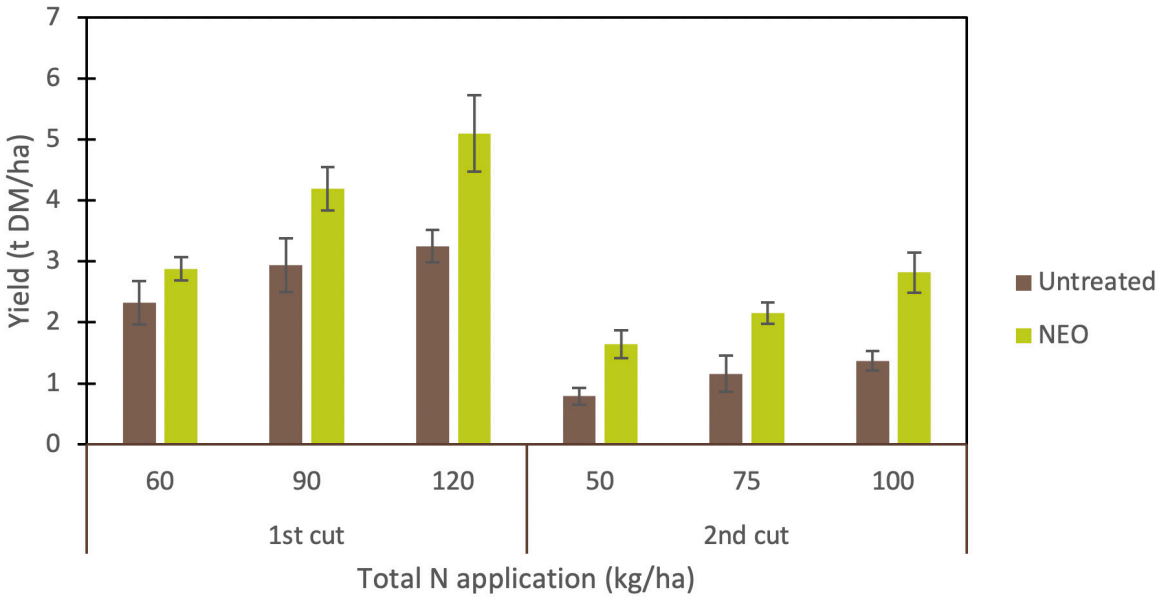

Figure 4. SRUC 2019 grassland dry matter yield results. Untreated = cattle slurry.

Scorch risk

The application rates of NEO discussed in this section contain high levels of N, and concern has previously been raised about scorch risk to crops with these application rates. To address this, N2 Applied carried out trials with Inland Norway University of Applied Sciences (HINN). NEO was applied at a rate of 30m³/ha, an equivalent 127kg/ha available N, to a spring barley crop at tillering on a sunny day with a temperature of 24°C to investigate scorch risk. No scorching effect was observed several days after the application (see image below).

Though the N content of NEO is high, the NEO solution itself is not highly concentrated and is still similar to untreated slurry/digestate which is mainly water. This means evaporation from the leaf is unlikely to leave a solution which is concentrated or saline enough to damage the leaf cell structure. Furthermore, as N is present mainly in ammonium and nitrate forms there is no risk of scorching from excess urea uptake and build-up in plants. Further trials will be carried out with research partners in the future to reinforce these claims.

Wheat field a few days after application of 30 tonnes NEO per hectare. NEO was applied on a sunny day, temperature of about 24°C. Photo by Thomas Cottis from HINN.

Summary

N2 Applied's technology allows for the enrichment of slurry or digestate to form NEO, a high N liquid organic fertiliser. The treatment process acidifies NEO, which means there is almost no loss of NH_3 in storage or on field application, allowing more N to be available to the crop. This lack of NH_3 volatilisation also means that NEO can be applied confidently later in the growing season when crop uptake is at its highest and yield response will be greatest. The high N content of NEO means that it can be spread over a larger area of land than untreated organic fertiliser to feed the same crop N requirements but provide a larger area of soil health benefits associated with organic fertiliser.

However, this high available N should be considered in any nutrient management planning, and NEO may be most appropriate for application to high N requirement crops and split applications to ensure optimal use. Overall, NEO is a highly versatile and valuable organic N fertiliser which can be utilised effectively in many management systems to improve crop yields and soil quality and reduce emissions.