# Practical nutrient management solutions that beef farmers can implement on their farms to increase efficiency, reduce costs and address environmental pressures facing the sector

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## Summary

- Liming mineral soils to achieve a pH in the range 6.2-6.7 will release plant available phosphorus (P) from the soil P pool. This release can often give a one-unit increase in the soil test P index, thus saving money on P fertiliser.
- Prior to clover sward establishment, aim to achieve a soil pH of at least 6.3 for best success, and to reduce nitrogen (N) fertiliser cost and reliance.
- The use of low/no nitrate fertilisers including urea protected with the urease inhibitors NBPT, NBPT+NPPT or 2-NPT in place of nitrate-based fertilisers (e.g. calcium ammonium nitrate, CAN) will maintain grassland production, while reducing greenhouse gas (GHG) emissions on beef farms.
- Including sulphur with N fertilisation increases the grass yield response to applied N, gives potential to reduce N fertiliser application rates, while also reducing nitrate leaching loss to water, particularly in free-draining soils.
- Ribwort plantain inclusion in grass-clover swards reduces nitrate leaching losses across a range of soils, while maintaining sward production.

## Introduction

Beef farmers face challenges to reduce greenhouse gas (GHG) and ammonia emissions along with reducing nutrient losses to water, while maintaining viable farm enterprises. Research in Irish soils and under Irish conditions is providing pathways and tools for Irish farmers to meet these challenges. This paper outlines some of the recent and new practical nutrient management solutions that Irish Beef farmers can consider implementing on their own farms to increase their efficiency, reduce costs and address environmental pressures facing the sector.

## Liming to release soil phosphorus, reduce nitrous oxide emission and increase success with clover

Liming has many benefits in soils managed for production including favouring the retention of more productive grasses and clover. Phosphorus (P) is the most expensive of the macronutrients purchased by farmers; however, under acidic conditions, particularly below pH 6, this purchased phosphorus is readily locked up in non-plant available forms. Liming represents a good investment in these soils with increases in pH freeing up P from the bank of soil P. Liming alone without P application can increase the soil pool of plant available P (Figure 1a), often resulting in an increase in soil P index. In addition, trials at Teagasc, Johnstown Castle have shown that increasing the soil pH prior to seeding clover plays a critical role in the success of clover in that new sward (Figure 1b). Recent work in mineral nitrogen (N) fertilised Irish soil by Žurovec et al. (2021) has also shown that emissions of the GHG nitrous oxide declined linearly with increasing soil pH.

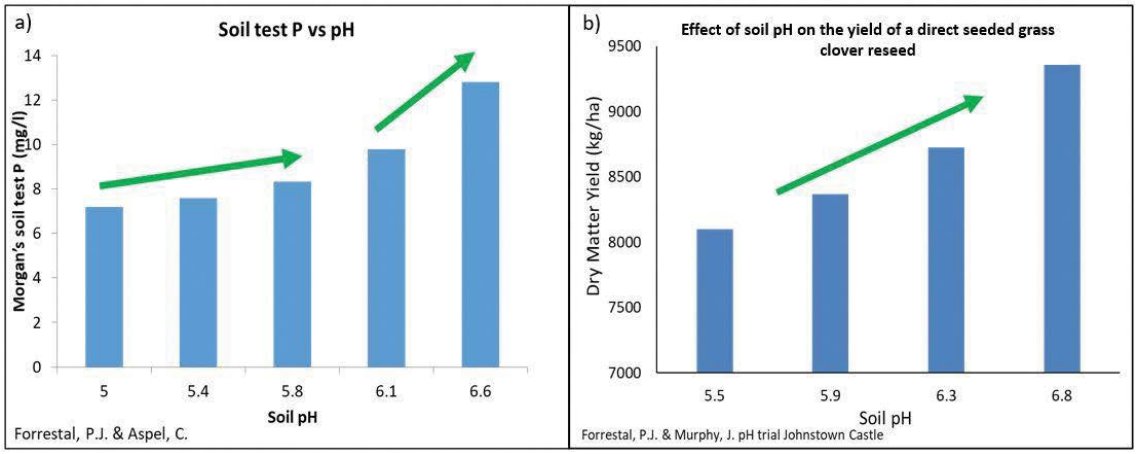


**Figure 1a.** Morgan's soil test Phosphorus levels increase as soil pH increases. **b.** Yield and success with a new grass clover sward increases as soil pH increases.

## Urea protected with NBPT, NBPT+NPPT or 2-NPT maintain grassland production while reducing emissions of the greenhouse gas nitrous oxide in Irish soils compared to calcium ammonium nitrate (CAN)

In a multi-site experiment conducted over 2 years in Ireland, Forrestal et al. (2017) reported that urea protected with NBPT and calcium ammonium nitrate (CAN) fertilised grass consistently produced the same dry matter (DM) yield, and had the same level of N recovery as urea+NBPT.

Research carried out at Teagasc, Johnstown Castle during the relatively poor grass growing conditions of 2024, compared CAN with urea and urea protected by NBPT, NBPT+NPPT and 2-NPT, and found no statistically significant difference in grass DM production between the different N fertilisers (Figure 2). Although grass DM yield is similar between fertiliser N types in Irish grassland, important differences in emissions of the GHG nitrous oxide have been reported between N fertilisers. Emission factor reductions of approximately 70% with urea-based N compared to CAN (Harty et al., 2016), and of 66% for ammonium only compared to nitrate only fertiliser (Rahman and Forrestal, 2021) (Figure 3a and b, respectively).

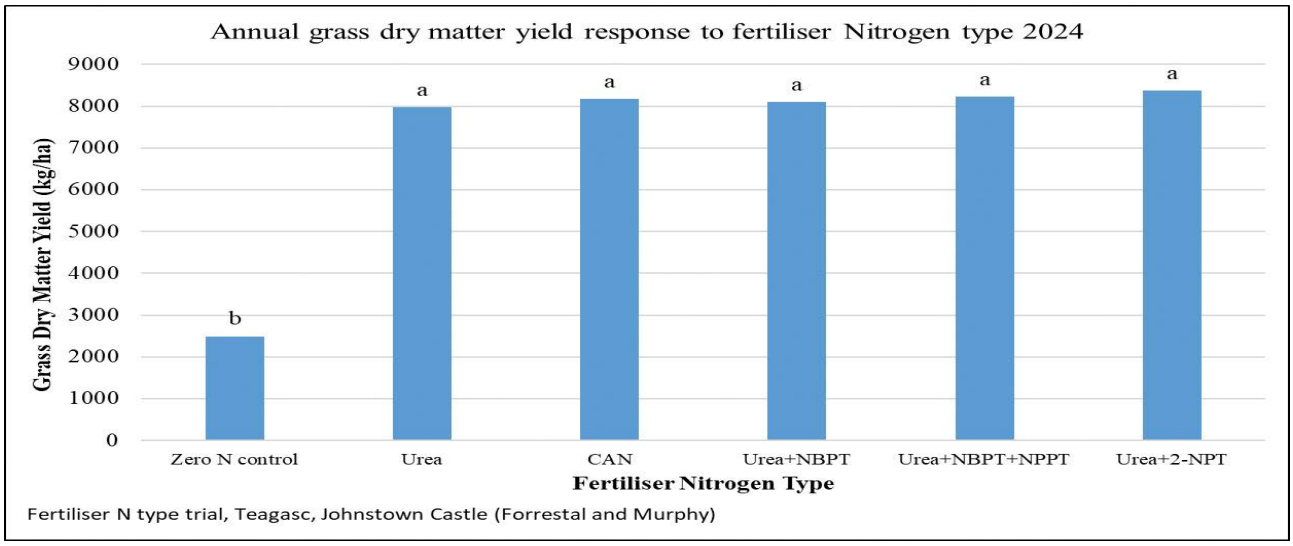


**Figure 2.** Effect of fertiliser nitrogen source on grass dry matter yield in 2024. Treatments with differing lettering are significantly different (P≤0.05).

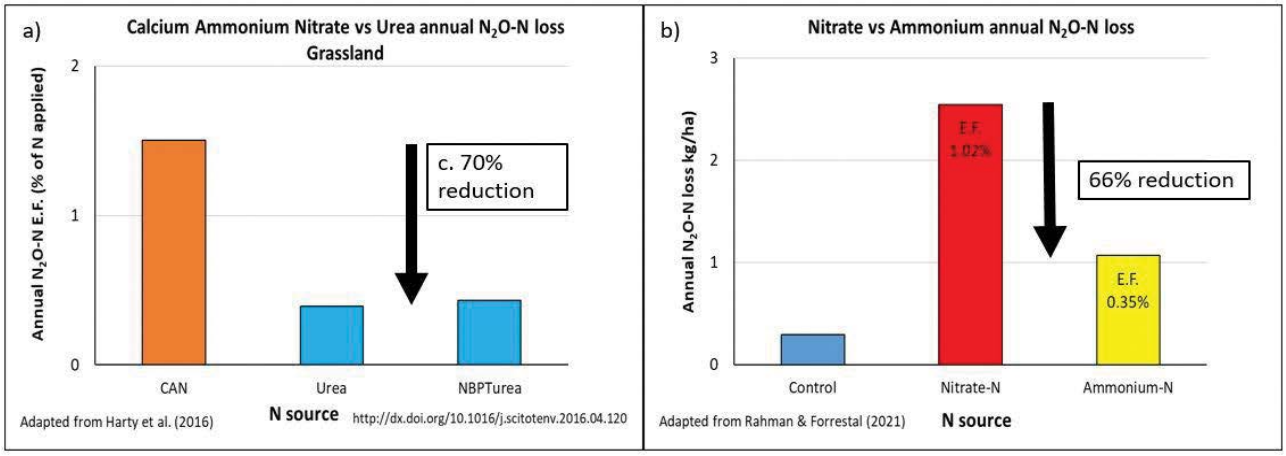


**Figure 3a.** The effect of calcium ammonium nitrate (CAN) compared to urea and urea protected with NBPT on the nitrous oxide ($N_2O$) emission factor in Irish soils. **b.** the effect of zero N, nitrate only and ammonium only fertiliser N on $N_2O$ emissions and emission factors.

## Optimising sulphur applications has potential to increase grass yield, nitrogen use efficiency and reduce nitrate leaching losses

Suboptimal plant sulphur (S) availability can reduce plant N efficiency and yield thereby increasing N loss potential. An experiment was conducted at Teagasc, Johnstown Castle using a free-draining sandy loam soil to determine if alleviating S deficiency in a grass sward affects nitrate leaching. The study also examined a number of strategies for applying N and S, including the use of cattle slurry (Aspel et al., 2022).

Application of mineral S fertiliser increased grass yields by up to 2,907 kg DM/ha and increased apparent fertiliser N recovery from 39% to 47–49%. Addressing the grass S deficiency on the tested soil by the addition of mineral S to N decreased nitrate leaching losses by 46% compared to N only. The maximum allowable nitrate-N level for drinking water was not breached for treatments that included S (6.6–11 mg nitrate-N per L), whereas this limit was breached for treatments without S (23–40 mg nitrate-N per L) (Figure 4). The S applied in the slurry treatment (9 kg S/ha) was not adequate to meet plant S requirements in this soil.

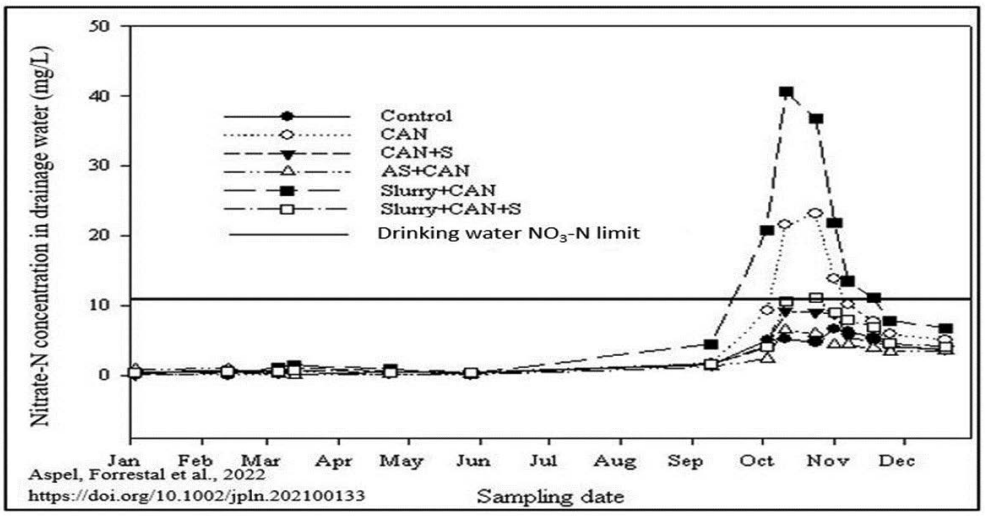


**Figure 4.** Inclusion of sulphur (S) with nitrogen fertilisation reduces nitrate-N concentrations in leachate in a free-draining soil. The horizontal straight line indicates the maximum allowable concentration of nitrate-N in drinking water.

This study provides evidence that optimization of S nutrition has the potential to deliver both grass yield benefits and environmental impact reduction to Beef and other farm as a nitrate leaching migration strategy on S-deficient soils.

## Ribwort plantain inclusion in grass-clover swards maintains yield, while reducing nitrate leaching losses to water

A two-year study was conducted at Teagasc Johnstown Castle to evaluate the potential of ribwort plantain (*Plantago lanceolate L.*) inclusion in grass-clover (*Lolium perenne L.* and *Trifolium repens L.*) swards across five contrasting soils (Egan et al. *In review*).

At a target inclusion of 30% plantain, nitrate-N leaching losses were reduced by 32-74% (mean 56%) in year one, and by 93-99% (mean 96%) in year two. In poorly-drained soils the loss reduction was 3-10% (mean 6%) in year one and 97-98% (mean 97%) in year two. Increasing the plantain target inclusion to 50% further reduced N losses; however, much of the benefit of plantain was achieved at the 30% inclusion level (Figure 5).

Exceedances of the maximum allowable nitrate-N level for drinking water in leachate samples were reduced from 28 in the grass-clover treatment to seven in the 30% plantain inclusion treatment, and to four in the 50% plantain inclusion treatment. Overall, across a broad range of soils, the inclusion of plantain in grass-clover swards was shown to be an effective tool for reducing nitrate-leaching losses in pasture systems.

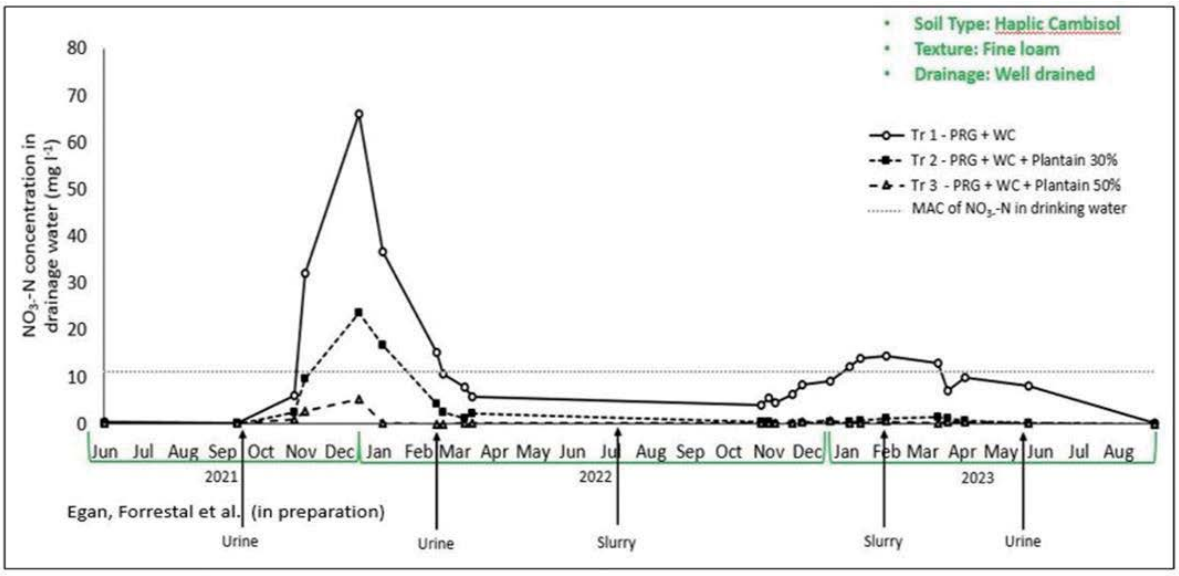


**Figure 5.** The inclusion of ribwort plantain in perennial ryegrass - white clover (PRG+WC) swards reduces nitrate-N concentrations in leachate over two years on a well-drained fine loamy soil. The horizontal straight line indicates the maximum allowable concentration of nitrate-N in drinking water

## Summary

The use of liming, low/no nitrate fertilisers such as urea protected with NBPT, NBPT+NPPT or 2-NPT, the use of sulphur and the integration of ribwort plantain into grass clover swards all represent practical and cost effective options that farmers can implement on their farms to increase efficiency of herbage production, reduce costs and address environmental pressures facing the sector.

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