Adding Urease Inhibitors

METHODOLOGY AND RATIONALE

This document sets out the proposed methodology to implement urease inhibitors into Overseer including supporting research. It is a discussion document to inform engagement with interested parties to confirm the approach for implementing Urease Inhibitors.

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Background

Various urease inhibitors (UIs) have been used over the last 30 years to reduce ammonia (NH_3) losses via volatilisation. Among these, N-(n-butyl) thiophosphoric triamide (nBTPT), sold under the trade name Agrotain®, is currently used in New Zealand.

The effect of urease inhibitors in reducing NH_3 losses is included in the agricultural inventory method for greenhouse gas emissions based on a critical analysis of the published and non-published data on the effectiveness of nBTPT in reducing NH_3 emission for New Zealand pastures (Saggar *et al*., 2013) and 2 MAF Technical papers (see Wear and Stevens, 2013). In the agricultural inventory method, emission factor for volatilisation from N fertiliser treated with a urease inhibitor is 0.55 (FracGASFnFert(UI)), and 0.1 otherwise (FracGASFnFert(non-UI)).

Overseer Limited has sought advice on how to incorporate the effect of urease inhibitor use in Overseer, based as closely as possible on the agricultural inventory methods, but taking into account that Overseer uses farm-specific parameters wherever possible. In this context, farm-specific parameters mean that an emission factor may vary according to farm site or management characteristics where applicable.

This report provides a summary of the implementation method, followed by a summary of the research that this was based on.

Implementation

Volatilisation for each N fertiliser application (Volat, kg N/ha) is estimated as:

Volat = fertN * Fvolat   Equation 1

where fertN is the rate of fertiliser (kg N/ha) and Volat is estimated volatilisation of ammonia (NH_3) from urea fertiliser (kg N/ha), and Fvolat is the site specific volatilisation rate that varies with N type, rate, temperature, soil moisture, cover and soil properties (Wheeler, 2018).

The use of urease inhibitors will be incorporated by extending the equation 1 for urea fertilisers treated with nBTPT to:

Volat = fertN * Fvolat * (1 – FUIeffectiveness)   Equation 2

where FUIeffectiveness is the effectiveness of nBTPT urea fertiliser in reducing volatilisation, and has a value of 0.45.

This implementation assumes that:

- The urease inhibitor is nBTPT and is applied with urea fertiliser at the minimum rate of 0.025% w/w of nBTPT per unit of N (250 ppm).
- The estimation of Fvolat is not affected by urease inhibitors.
- The effectiveness of urease inhibitors is constant throughout the year.
- The effectiveness of urease inhibitor is not dependent on the rate of N applied.
- There are no direct effects on any other processes such as denitrification, nitrous oxide emissions or leaching.
- The effectiveness of urease inhibitors when urea is surface-applied to crops is the same as for pasture. The effectiveness for incorporated product is zero.

The use of urease inhibitors will be linked to a specific fertiliser product by incorporating its use as part of the fertiliser input fields, similar to N type or P type. Thus, the inclusion of the use of a urease inhibitor will follow the same rules for adding fertiliser products, which is currently that they must be a Fertmark registered product. Urease inhibitors would not be included when fertiliser data is entered using the soluble fertiliser or fertiliser nutrients by forms approach.

In effect, this means that equation 2 is applied to urea N fertiliser products that are treated with nBTPT which are surface applied.

We need to understand if this approach is going to meet customer needs.

Summary of information

This section contains a summary of research reports that the implemented model was based on.

Please inform us of any errors in this summary, or additional information that would materially change the implementation plan.

Average effectiveness

This section outlines the basis for the factor FUIeffectiveness used in the implementation.

Saggar *et al*. (2013) reported that the mean effectiveness of urease inhibitors (nBTPT) on reducing NH_3 emissions from urea fertiliser was 45%, whereas Wear and Stevens (2013) recommend that an 'efficacy scalar value of 0.55 to the fraction of nitrogen in fertiliser that volatilises' is applied. These indicate the same degree of effectiveness of urease inhibitors at reducing NH_3 emissions. Saggar *et al*. (2013) reports the estimate of the effect of urease inhibitor as +/-5.5 per cent at a 95 per cent confidence.

Saggar *et al*. (2013) identified that 0.025% w/w of nBTPT per unit of N (250 ppm) is optimum for reducing NH_3 emissions from temperate grasslands and cited evidence that that there was no any additional benefit above that rate. No method of application was identified, but all experiments were conducted using nBTPT treated urea granules. Wear and Stevens (2013) did not identify optimum rates or methods of application of nBTPT associated with the recommend efficacy scalar.

Other fertiliser types generally have lower modelled volatilisation rates than urea as described by Wheeler (2018). Some ammonium-based fertilisers (e.g. diammonium phosphate, or DAP) also have some ammonia volatilisation but it is very unlikely urease inhibitors would be used with these, given the absence of urea in the product.

Saggar *et al*. (2013) reported no effect of rate of N applied on the effectiveness of a urease inhibitor for the given range of experimental data. This didn't include very low (e.g. hill country) or very high (e.g. some crops) rates.

The effectiveness was based on research using nBTPT. It is unclear whether there the same results can be applied to other urease inhibitors.

In summary, the effectiveness of urea treated with nBTPT at a rate of 250 ppm or more is assumed to be 0.45.

Site Specific

Overseer uses farm-specific parameters wherever possible. This section describes information related to the effectiveness, and whether a site-specific estimate of effectiveness can be determined.

Saggar *et al*. (2013) noted that 'High soil organic matter content could account for most of the observed differences in nBTPT effectiveness' and noted several studies in support. Saggar *et al*. (2013) did not provide any further analysis on the effect of organic matter on urease inhibitor effectiveness. Overseer includes estimates of organic matter based on soil sibling or soil order selected by the user, and hence this could be factored in.

The possible relationship between urease inhibitors and soil organic matter indicates that although urease inhibitor effectiveness may differ between farms, particularly between those with very high (organic soils) or low organic matter levels, there is insufficient evidence to ascribe the differences due to organic matter levels.

Additional work would be needed to determine if there is a relationship between soil organic matter, other soil properties (e.g. cation exchange capacity (CEC), soil pH) and urease inhibitor effectiveness.

Saggar *et al*. (2013) also referred to a report by Kelliher *et al*. (2012) where volcanic soils had lower effectiveness. However, the number of soils involved was limited and hence any possible effects can be ignored. Additional work would be needed to determine whether the effectiveness on volcanic soils is different.

Saggar *et al*. (2013) looked at other factors affecting urease inhibitors, and quote:

> *Laboratory studies by Watson et al. (1994a) using 16 different soil types showed that soil CEC, pH, urease activity, moisture content and titratable acidity contributed significantly to the variation in effectiveness of nBTPT. Overall the effect of increasing nBTPT concentrations was pronounced in soil with low organic matter content, high pH and low buffering capacity; these soil conditions also led to high NH_3 emissions from urea. The majority of New Zealand pastoral soils have a high organic C content, low pH, and high buffering capacity, making them less vulnerable to emitting NH_3. New Zealand soils would therefore be expected to be relatively insensitive to nBTPT treatment.*

Saggar *et al*. (2013) also mentioned relationships between effectiveness and soil clay and sand contents. In Overseer, soil clay and sand contents inputs are included in Smap sibling data, and soil CEC might be able to be estimated from other soil properties or directly obtained by expanding the Smap sibling data downloaded through the Overseer webservice, but the other properties (soil pH, urease activity, moisture content and titratable acidity) are not likely to be readily obtainable.

Saggar *et al*., (2013) did not report any differences in effectiveness during the year. The lack of a relationship with temperature (Saggar *et al*., 2013) would suggest that the effectiveness of urease inhibitors is constant over the year, although the possible relationship with soil moisture implies that a seasonal response is possible. Note that volatilisation rates will vary (Wheeler, 2018).

In summary, there is not currently enough evidence to provide site-specific estimates of the effectiveness of urease inhibitors. This would only be possible with additional research evidence that allows spatial or temporal disaggregate of FUIeffectiveness.

Modelling

This section outlines possible implications on other sections of the model.

Saggar *et al*. (2013) noted that 'it seems probable that nBTPT has a minimal effect on either N immobilisation or other N transformations'. Within Overseer, if all other inputs remain the same, then reducing volatilisation will leave more N in the soil, and potentially lead to higher N denitrification or N leaching.

Saggar *et al*. (2013) didn't report about any effects on pasture yield. This may be important for scenario-based analysis. Martin et al (2008) reported that when nBTPT treated urea was applied at different rates (0, 25, 50, 75, 100 kg N/ha per dressing), significant but small yield responses were measured at the two highest rates. Any increase in pasture production from the actual use of an urease inhibitors is captured by production data. When undertaken scenario analysis, any increase in pasture yield should be factored into production data entered. When implementing scenario modelling, the expectation is that yield responses to urease inhibitors would behave similarly to DCD. Thus, for example, if there is a 10 kg N reduction in volatilisation (10 kg N saved), either 10 kg less fertiliser N can be applied and production remains constant, or if the same amount of N is applied, the production will increase as there is more available N for crop growth.

In summary, it is assumed that there are no direct effects on any other processes such as denitrification, nitrous oxide emissions or leaching. The effect of N saved due to decreases in volatilisation on increasing pasture yield, and hence animal productions will need to be considered as part of implementing scenario modelling when this occurs.

Other factors

This section describes other factors considered when developing an implementation plan.

There appears to be no New Zealand information on the effectiveness of urease inhibitors to reduce volatilisation from urea fertiliser treated with urease inhibitors are applied to crops, or volatilisation from crop residues. Saggar *et al*. (2013) referred to international literature (more than 800 trials) that indicated that inhibitors are useful on crops, but they concluded that the research 'mainly deals with the agricultural production systems of the USA and Canada under tropical and continental climate conditions. Although the data are valuable, in principle, they are of little practical relevance to New Zealand's temperate climate and grazed pastoral systems. Saggar *et al*. (2013) noted that fertiliser N is sometimes applied to crops when temperatures are high and soil moisture low, potentially resulting in high volatilisation losses. This effect of N volatilisation should be captured in the volatilisation model, but the model would need to include urease inhibitors on crops to enable it as a mitigation option. Saggar *et al*. (2013) also noted that the mode of application (surface v incorporated) could affect the effectiveness. Surface application is likely to have better effectiveness, as urease activity is only very active in the surface soil.

The underlying principles for Overseer are that potential benefits from using a mitigation options such as applying a urea fertiliser treated with urease inhibitors to crops should be recognised. It is probable that urease inhibitors have similar effectiveness as for pasture systems when urea fertilisers containing urease inhibitors are surface applied. When urea fertilisers containing urease inhibitors are incorporated, the effectiveness of the inhibitor is reduced, but the size of that reduction is unknown. There may be sufficient information in the international literature to provide a reliable indication of the size of the reduction due to incorporation. This would require a literature review

Saggar *et al.* (2013) reported the effect of urease inhibitors on volatilisation from urine is highly variable (11-93%) from limited studies, and hence did not recommend its inclusion in the national inventory. Currently there are no publically available technologies to apply urease inhibitors with urine, although experimental trials have been undertaken. Applying urease inhibitor coated urea to grazed pasture at around the time of grazing may decrease volatilisation from urine, and is feasible to include in the model, but no information has been found to support this.

Despite high ammonia volatilisation rates from composts of feed pad bunkers, there appears to be no information on the use of urease inhibitors to reduce volatilisation.

In summary, it is effectiveness of urease inhibitors when urea is surface-applied to crops is the same as for pasture. The effectiveness for incorporated product is zero.

Urease Inhibitor Products and Data entry approach

So far 3 urease inhibitor products are known to be used in New Zealand as shown in **Error! Reference source not found.**, and these all use nBPT. There may also be a number of derivative products, for example, Ballance has derivative products pHasedN and PastureMag range which have SustaiN in them. Other urease inhibitors are being researched but details of the product(s) or their effectiveness are not known.

Table 1. Urease inhibitor products and rate of inhibitor

COMPANY	PRODUCT	RATE OF nBTPT
		PPM BASED ON UNIT OF UREA N
Ravensdown	N-Protect	300
Ballance	SustaiN	250
TerraCare	exteNd	242

Additional urease inhibitors may be available over time. Other urease inhibitors are noted by Saggar *et al.* (2013). If these are added, the effectiveness and minimum product requirements may differ from that of nBTPT. Hence data entry approaches considered allowed flexibility in the software to enable additional inhibitors to be added in the future.

The options for recording the use of urease inhibitors include:

- Added as a separate input field (urease inhibitor) similar to DCD (nitrification inhibitor), either generically similar to DCD (e.g., 'urease inhibitor'), or as a specific inhibitor (nBTPT or Agrotain®).
- As part of the fertiliser product fields, similar to N type or P type, either generic or specific

Farmers may not use urease inhibitors with all the urea they apply and hence the first option may not always be applicable. The latter 2 options would link the use of urease inhibitors to general policies for adding fertiliser products to the model and would allow different urease inhibitors to be included. The use of urease inhibitors would need to be included as an addition input field when fertiliser data is entered using the soluble fertiliser or fertiliser nutrients by forms approach is used.

In summary, the use of urease inhibitors will be linked to a specific fertiliser product by incorporating its use as part of the fertiliser input fields, similar to N type or P type.

References

Martin R J, van der Weerden T J, Riddle M U and Butler R C (2008). Comparison of Agrotain-treated and standard urea on an irrigated dairy pasture. Proceedings of the New Zealand Grassland Association 70: 91–94.

Saggar S, Singh J, Giltrap D L, Zaman M, Luo J, Rollo M, Kim D-G, Rys G, and van der Weerden T J (2013). Use of urease inhibitors in reducing ammonia emissions from fertiliser urea and animal urine in grazed pastures: an approach to quantifying emission reductions for the New Zealand agriculture inventory. Science of the Total Environment 465: 136-146.

Wear S, and Stevens N (2103). Urease Inhibitors. Agricultural Inventory Advisory Panel Meeting. MPI, Wellington, New Zealand.

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