



Tas Farming Futures



Nitrogen Use Efficiency Calculator: Users Guide Version 1

Donna Lucas, April 2016



This guide should be referred to when using the Tas Farming Futures, Nitrogen Use Efficiency (NUE%) Calculator: Version 2.

Disclaimer

This guide will help estimating nitrogen use efficiency for a cropping enterprise. RM Consulting Group does not guarantee that this document or the NUE Calculator are without flaw of any kind or wholly appropriate for individual purposes, and therefore disclaims all liability for any error, loss or other consequence, which may arise from relying on any information in this document or the NUE Calculator. This document does not purport to provide legal advice. Data used in this calculator is, to our best knowledge, current or the best available at the time of release of the calculator.

No person should act on the basis of the contents of this guide, whether as to matters of fact or opinion or other content, without seeking additional advice as required, and assuming responsibility for their actions.

Downloading the NUE% calculator

Download the NUE% Calculator from the Tas Farming Futures website (<http://www.tasfarmingfutures.com.au>) and 'Save' it to your computer. Then each time you run a set of calculations, you should save the file ('Save as') with a different name. Alternatively, save the downloaded calculator as a template.



It is a good idea to include the date, property name and/or paddock name (as relevant) in the file name so that you can keep records for different years and then monitor efficiency over time.





Introduction

The NUE% tool was developed by the Tas Farming Futures (TFF) project (the project). The three-year project (June 2013 to April 2016) delivered by RM Consulting Group provided support to Tasmanian farmers to reduce farm emissions and/or participate in the Emissions Reduction Fund. Funding from the Australian Government supported the project.

During the first six months of the project, the project team found that farm planning and review was a useful way to learn more about carbon sequestration (e.g. in soil), the sources and magnitude of farm emissions (such as nitrous oxide from nitrogen fertilisers), and how to reduce emissions and plan for increased efficiency. As a result a Farm Emissions Reduction Planning (ERP) approach was developed together with the NUE% Calculator. (Refer to the Tas Farming Futures website for further information on the Farm ERP approach). The approach used for the TFF NUE calculator is 'partial nutrient balance' (refer to Appendix 1).

The NUE Calculator can be downloaded from: <http://www.tasfarmingfutures.com.au>

Who should use the NUE% calculator

The intended audiences for the NUE% calculator are Tasmanian cropping farmers and their advisors. We suggest using the calculator when undertaking your end of season review with your agronomist and/or field officers. Refer to figure 1 below for a diagram of the nitrogen management and monitoring cycle.



Figure 1: Nitrogen management and monitoring cycle.



The calculator provides a basis for understanding relative utilisation of fertiliser nitrogen applied to a paddock/crop but should not be used as a replacement for soil testing, i.e. monitoring of plant available N in the root zone.



You can use an individual sheet in the calculator to assess one crop, or enter data for all crops on the farm or in the rotation to obtain an overall NUE%.

Data collection needs

Required data

The following data is **required** for each crop being assessed:

Type of nitrogen fertiliser used

Type of biomass removed - for crops with more than one type e.g. crop, residue

Rate of nitrogen fertiliser applications

Crop yield (t/ha)

Other recommended data

The following data is **recommended** but is optional i.e. the NUE% for each crop will still work even if you don't enter this data:

Area of each paddock in hectares. We recommend that you enter this though, so that the overall NUE% for the farm or rotation can be assessed (this overall NUE% is calculated and shown at the bottom on the summary sheet).

Price in \$/t for each type of nitrogen fertiliser used. We recommend that you enter this though, so that the potential \$ value of unused fertiliser can be calculated (this is calculated and shown in column P of the summary sheet).

Optional data

Other optional data that is useful for monitoring and for interpreting the NUE% results is:

Soil type and condition

Planting date

Overview of the NUE% calculator

The calculator contains the following tabs or sheets:

Instructions sheet

This sheet provides instructions.

Summary sheet

You cannot enter **data** into the summary sheet, apart from farm name, total area and date.

Once all data has been entered in the appropriate cells for each crop, data will appear in the 'Summary' sheet. Information about each crop cannot be altered in this sheet.

Crop 1, Crop 2, Crop 3, Crop 4 and Crop 5 sheets

Enter data into these sheets for crops that have only one type of biomass removed, e.g. harvested potatoes or cabbages.

Crop 6, Crop 7 and Crop 8 sheets

Enter data into these sheets for crops that have more than one type of biomass removed e.g. wheat (grain and straw / grazing).

Fertiliser and crop data sheet

This sheet contains the crop N removal data and the fertiliser %N data that is used for calculating the NUE%.

Note that:

The fertiliser data (products and nitrogen percentage) in columns A & B is used for calculations for all types of crops i.e. Crop 1 through to Crop 8.

The N removal data (crop type and nitrogen removal) in columns C & D is used for calculations in sheets Crop 1 to Crop 5.

- The N removal data (crop type and nitrogen removal) in columns E & F is used for calculations in sheets Crop 6 to Crop 8.



If your fertiliser is not listed or you are using an organic soil amendment, you can add it to the bottom of the list in column A & B. Remember to include the %N in the fertiliser.

If your crop is not listed, you can add it to the bottom of the list in columns C & D for crops 1 to 5 or E & F for crops 6 to 8. Remember to include the N removal as kg/t. If you know your crop has a different removal rate to the rate listed because you have measured it or have new information, you can add it to the bottom of the relevant columns in this sheet.

You can check <https://www.ipni.net/app/calculator/home> for removal rates.

Instructions for using the NUE% calculator

Save your Calculator file regularly while you are working on it to minimise the risk of losing data!

Each cell in the calculator is colour coded based on its function.



Indicates that the information is selected from a drop down list



Indicates that the information needs to be entered by the user



Indicates that the calculation will be made from the information that has been entered in other cells and no action is required by the user - NO ACTION REQUIRED



Indicates that the results that have been calculated from the information entered by the user - NO ACTION REQUIRED



Indicates that the NUE% results that have been calculated from the information entered by the user - NO ACTION REQUIRED

Step 1 Review the instructions

Review the instructions (this guide and the first sheet in the calculator) noting the cell colours based on their function (data is required in green and yellow cells).

Step 2 Go to the 'Summary' sheet

Go to the Summary sheet and enter the farm name, total area and date.

Step 3 Enter data for each crop

For crops with one type of biomass removed, enter data in the first section (Crop 1 etc.).



The calculator includes several different options for cereals based on the protein %. Please note that the 'residue removed' N removal rates for crops with 8% protein and 10% protein are estimates only, and therefore the results should be viewed with care. The N removal rates for other protein levels are more reliable.

Enter the following,

Crops with one type of biomass removed

Data entry cell	What to enter	Is data required or optional?	Example
Crop / pasture (Cell B6)	Select (by clicking) the crop from the drop down list.	Required	Potato
Type of biomass (Cell C6)	Enter (by typing) the type of biomass harvested e.g. grain, seed, tubers.	Optional	Tubers
Total area of crop on farm [ha] (Cell D6)	Enter the area of the crop being assessed (in hectares) i.e. this is usually one paddock. If there are more than one paddock for a crop, enter data for each paddock in separate sheets.	Optional but required for calculating the overall NUE% for the rotation/farm, which is reported at the bottom on the summary sheet.	20
Planting date (Cell E6)	Planting date	Optional (for reference only)	Mar-16
Soil type and condition (Cell F6)	Soil type and condition	Optional (for reference only)	Red Ferro-sol, good condition
Type of fertiliser (Cells G6, G7...etc.)	Select (by clicking) the crop from the drop down list. If more than one type of N fertiliser is used, enter each in a different row.	Required	Urea
\$/tonne fertiliser (Cells I6, I7...etc.)	Required	Required	Required
Fertiliser application [kg/ha] (Cells K6, K7...etc)	Enter fertiliser applied as kg/ha. TIP: this is fertiliser applied not nitrogen applied.	Required	200
Crop yield or plants parts/biomass removed [t/ha] (Cell O6)	Enter the yield for biomass removed in t/ha.	Required	72

For crops with more than one type of biomass removed, enter data in the second section (Crop 6 etc.). Enter the following:

Crops with more than one type of biomass removed

Data entry cell	What to enter	Is data required or optional?	Example
Crop / pasture (Cell B6)	Select (by clicking) the crop from the drop down list.	Required	Barley 10.5% protein
Type of biomass (Cell C6, C7 & C8)	Select (by clicking) the crop from the drop down list.	Required	Barley 10.5% protein Barley 10.5% protein BALED
Total area of crop on farm [ha] (Cell D9)	Enter the area of the crop being assessed (in hectares) i.e. this is usually one paddock. If there are more than one paddock for a crop, enter data for each paddock in separate sheets.	Optional but required for calculating the overall NUE% for the rotation/farm, which is reported at the bottom on the summary sheet.	30
Planting date (Cell E9)	Planting date	Optional (for reference only)	Mar-16
Soil type and condition (Cell F9)	Soil type and condition	Optional (for reference only)	Red Ferro-sol, good condition
Type of fertiliser (Cells G9, G10...etc.)	Select (by clicking) the crop from the drop down list. If more than one type of N fertiliser is used, enter each in a different row.	Required	MAP Sulphate of Ammonia
\$/tonne fertiliser (Cells I9, I10...etc.)	Enter price per tonne of fertiliser. Enter price per tonne for each type of N fertiliser used	Optional but required for calculation of potential value of unused fertiliser. We recommend you enter this but it can be left blank.	800 540
Fertiliser application [kg/ha] (Cells K9, K10...etc)	Enter fertiliser applied as kg/ha. TIP: this is fertiliser applied not nitrogen applied.	Required	125 100
Crop yield or plants parts/biomass removed [t/ha] (Cell O6, O7 & O8)	Enter the yield for biomass removed in t/ha.	Required	8 4

Step 4 Review the results

Review the results on the summary sheet and check that they make sense. Consult an advisor if you need further advice or help with interpretation. Refer to the 'Nitrogen use efficiency' section in the Appendix of this document for guidance on what the NUE percentages may mean.

Step 5 Consider action plans

Consider if you need to make any adjustments to your nitrogen management. Consider:

Are there opportunities to increase harvestable yield / efficiency? e.g. crop nutrition other than N, improving soil health, irrigation management, managing disease pressure or other stresses that affect the crops ability to utilise the applied nitrogen efficiently.

Soil and sap testing to fine-tune nitrogen management.

Using the 4 R's (right source, right rate, right time, right place) (<http://www.nutrientstewardship.com/what-are-4rs>)

Step 6 Save a copy

Save a copy of the excel file for future reference.

Tip: Copy the results into a word document and/or add any comments in the word document e.g. about the rotation, different soil condition in each paddock etc. This can be useful for monitoring NUE% over time.

Example

Last year you grew potatoes, onions and wheat as well as pasture (for beef cattle). Potatoes were grown in two different paddocks: 'house' and 'long' paddock - each paddock had the same N fertiliser but different yields. The wheat was harvested and then stubble baled.

We can only use the calculator to assess the crops but not the pasture because the calculator is not designed for pasture-based enterprises (although it does allow for grazing of crop residues).

Enter data for potatoes (house paddock) in sheet 'Crop 1'

Enter data for potatoes (long paddock) in sheet 'Crop 2'

Enter data for wheat in sheet 'Crop 6' - because there were two types of biomass removal.

Tip: You could also assess the NUE% of a rotation in a given paddock e.g. the last five years for the 'house' paddock. Enter each of the crops into a separate sheet i.e. 'Crop 1', 'Crop 2'...etc. Then the overall NUE% in the summary sheet provides the NUE% for the rotation. This can be useful in addition to assessing each individual crop.



Frequently asked questions

How can I add a crop that is not currently listed in the calculator?

Go to the 'Fertiliser and crop data' sheet. You can add a crop in the bordered cells to the bottom of the list in columns C & D for crops 1 to 5 or E & F for crops 6 to 8. Remember to include the N removal as kg/t.

How can I add a fertiliser or organic amendment that is not listed in the calculator?

Go to the 'Fertiliser and crop data' sheet. You can add a fertiliser or organic amendment in the bordered cells to the bottom of the list in column A & B. Remember to include the %N in the product.

If I add an organic amendment to the list, what % N should I enter?

If you are entering an organic amendment, you need to consider how much of the N will be available for the crop this year and how much will be available for the next crop / next year. Adjust the %N accordingly.

Example 1: You applied an organic amendment to the 'house' paddock in 2015 and then grew canola. It was first time you had applied it on this paddock and it had 3% N (see tip below re dry versus wet %N basis). You know from your advisor that 2/3rds of the N will be available for the canola crop, but the rest will become available over the following 2 years (i.e. although most of the N will be available for the first crop, the N will become available over a period of three years)

To calculate the NUE% of the canola crop planted in 2015:

Add the product in the 'Fertiliser and crop data' sheet and enter "2" for %N ($3\% \times 2/3\text{rds} = 2\%$)

Example 2: As per example 1 above, but you applied the organic amendment each year for three years, up to and including 2015.

To calculate the NUE% of the canola crop planted in 2015:

Add the product in the "Fertiliser and crop data' sheet and enter "3" for %N. The 3% is calculated as follows:

- 2015 application: $3\%N \times 67\% = 2\%$ (i.e. 67% is available in year 1)
- 2014 application: $3\%N \times 25\% = 0.75\%$ (i.e. 0.75% is available in year 2, so this is available from the 2014 application)
- 2013 application: $3\%N \times 8\% = 0.25\%$ (i.e. 0.25% is available in year 3, so this is available from the 2013 application)
- Add the above ($2\% + 0.75\% + 0.25\% = 3\%$)



If the % N entered for the product in the 'Fertiliser and crop data' sheet is % N on a dry basis, remember to enter the application rate (kg/ha) also on a dry basis. E.g. if a product is % 3 N on a dry basis, and you applied 15 wet tonnes/ha which was 50% water; then enter 7,500 kg/ha for the application rate i.e. $15,000 \text{ kg} \times (100\% - 50\%) = 7,500\text{kg}$.

How do I calculate nitrogen use efficiency for my pasture?

The calculator has been designed primarily for cropping. While the calculator does allow for N removal through grazing e.g. grazing crop stubble/residues, it is not designed for calculating pasture NUE.

For dairy pasture refer to DairyTas and the 'Predictive N fertiliser response calculator'.

How can I compare my NUE% results with the industry average?

It is best to discuss this with your advisor or agronomist. Average data is available for some crops (i.e. poppies, potatoes, cereals) from Tas Farming Futures project 2013-2016.

Trouble-shooting

The NUE% results don't look quite right,

- Check that the crop yield entered is in tonnes/ha
- Check that the fertilisers have been entered as tonnes of fertiliser not tonnes/units of nitrogen
- Consider the harvest index of the crop (refer to Appendix 1)
- Consult an advisor if you need assistance, or contact us if you have any feedback.

The drop-down menus are not working properly

- If the item you are looking for does not appear but you know it is in the list, scroll down and then back up again.
- If your computer is using an older version of Excel, try saving the file in an older version of excel e.g. .xls versus .xlsx

For more information or to provide feedback

If you would like further information or would like to provide feedback contact RM Consulting Group, Tasmania (03) 6437 2264 or visit the following websites:

- Tas Farming Futures: <http://www.tasfarmingfutures.com.au>
- RMCG: <http://www.rmCG.com.au>



Appendix 1: Nitrogen use efficiency

Nitrogen (N) can be lost as nitrous oxide (N₂O) gas from cropping, coming at a cost to the farmer and to the environment. N₂O is a powerful greenhouse gas. Other potential losses include volatilisation, leaching and run-off. Refer to the Fertcare best management guides for further information (Fertiliser Australia, 2016) (<http://www.fertilizer.org.au/Fertcare/Nutrients-And-Fertilizer-Information/Nitrogen-Use-Efficiency-And-Nitrous-Oxide>).

There are several ways of calculating nitrogen use efficiency including for example:

- Use of labeled 15N (used in research trials)
- Difference Method or Agronomic Efficiency (measure of the response of N fertiliser and requires a nil fertiliser strip in the paddock)
- Partial Factor Productivity (measure of production against different nutrient rates)
- N Balance (gives difference between inputs and outputs from all sources but not efficiency). N balance is useful though for N management, especially environmental management.
- Partial Nutrient Balance (ratio of N applied to N removed).

The approach used for the TFF NUE Calculator is 'partial nutrient balance'.

Partial nutrient balance method:

The NUE partial nutrient balance (also known as output-input ratio or removal to use ratio) calculates NUE% as follows:

$$\text{NUE\%} = \text{N removed} / \text{N applied} \times 100$$

This method does not take into account N from sources other than applied N (e.g. N fixed by legumes, mineralisation of organic matter are not taken into account) or N losses (e.g. N₂O gas, NH₄ volatilisation, leaching, runoff).

NUE% can be calculated for a country, region, farm, paddock or individual crop.

A high NUE% of >100%, indicates that more N is being removed than is being applied and the plants access N from the 'organic pool' or residual N from fertiliser applications to a preceding crop. Depleting the 'organic pool' can result in nitrogen deficiencies at a later stage, if not replenished.

A low NUE% e.g. <70-60% (depending on crop) indicates that less N is being removed than has been applied; applied N is left in the soil and may be lost. As a 'rule of thumb', residual available nitrogen in the soil after harvest should not exceed 50 kg/ha for vegetables and 30 kg/ha for grains or poppies. If NUE% is low it could indicate excessive use of fertilisers or issues with crop health i.e. the crop has not grown to potential due to lack of water or pests or diseases, so that a standard fertiliser program provided too much N.

Rotation or farming system:

If the NUE% of a rotation or farming system is $>100\%$ there is a risk of mining soil N and reducing the soil N status, unless the crop in question is grown after legumes. If the NUE% is low, this indicates that N is not being used by the crop and likely to be lost to the environment (e.g. N_2O gas, leaching, runoff) especially if the soil is kept fallow for some time after harvest i.e. a following crop or cover crop does not make use of residual N. All N losses represent an environmental risk (waterway health, greenhouse gas emissions), as well as a cost to producers i.e. cost of fertiliser N that is not used by the crop. N inputs into water can be an issue if used as stock and domestic water. A partial nutrient balance NUE% of 80-100% - for a whole rotation/system – is considered sustainable.

Individual crops:

When considering individual crops e.g. a wheat crop grown in a particular year, the NUE% should be viewed with consideration of the harvest index as well as the previous crop. For example some crops may have a low NUE% because of a low harvest index (ratio of biomass removed via harvest to biomass left behind). In this situation a relatively large amount of residue is left on the paddock after crop harvest/removal. This residue provides organic matter for the soil which will in turn provide N (and other nutrients) for the next crop, as it is broken down by soil microbes. The next crop should then have a relatively high NUE, so long as N fertiliser is not over-applied, because the crop can access mineralised N from the crop residues in the soil. This applies if the carbon to nitrogen ratio (C/N) fosters mineralisation of organic matter i.e. is below 25. For low harvest index crops, e.g. poppies, grain crops, pyrethrum or some brassica crops with high amounts of residues, you should aim for a NUE% of 50% or greater.

The sustainable NUE% for a specific crop will depend on the type of crop, harvest index, the previous crop and how they fit into the rotation. The % figures we give here provide rough guidance only.

Nitrogen use efficiency (NUE) provides an insight into potential N losses via calculating the percentage of applied N removed from the system by the harvested part of a crop.

