NBudget: A simple tool for farmers and advisors for N management in Australia's northern grain cropping

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Abstract

Effective management of plant-available nitrogen (N) by farmers will generally have beneficial productivity, economic and environmental consequences. The reality is that farmers may be unsure of plant-avalable N levels in cropping soils at sowing and by necessity make decisions about how much fertiliser N to apply with limited information about soil N supply. NBudget is an excel-based decision-support (DS) tool developed to assist farmers/advisors in Australia's northern grains region estimate (i) plant-available soil N and water levels pre-sowing, (ii) target yields, (iii) fertiliser N requirements for cereals and oilseed crops and (iv) N_2 fixation by legumes. NBudget does not rely on soil testing either for nitrate-N, organic carbon or water. Rather, the tool relies on rainfall data plus basic descriptions of soil texture and fertility, tillage practice, information about the previous two years paddock use plus rules-of-thumb values and stand-alone or linked algorithms. Winter and summer versions of NBudget cover the major crops of the region. Groundtruthing of NBudget against three independent data sets (n=55) indicated generally close agreement between measured and predicted values for sowing soil nitrate (r^2=0.76). A limitation of the tool is that it does not account for denitrification losses of soil N. The usefulness of NBudget would be enhanced by transforming the current Excel-based tool to a stand-alone app or web-based tool.

Key Words

Nitrogen, NBudget, legume N_2 fixation, management, WUE, N decision

Introduction

Farmers in Australia's northern grains belt produce 20–25% of the nation's grain from ca. 5 Mha cropland. Principal crops are wheat, barley, sorghum, canola, chickpea and fababean. All of the crops, except for the N_2-fixing legumes, chickpea and fababean, require nitrogen (N) to be supplied, through the in situ mineralisation of soil organic matter and crop residues and from fertiliser N inputs. Matching the supply of N to crop demand remains a challenge for farmers as too little supply reduces crop yields and profits, while too much may result in unnecessary costs plus increased gaseous and/or leaching losses. Decision support (DS) tools to help farmers and their advisers manage fertiliser N inputs have been developed and promoted during the past 20 years, from the relatively simple paper-based 'Nitrogen in 95/96' to the more complex computer-based APSIM, WhopperCropper and Yield Prophet® (e.g. Lawrence et al. 2000; Carberry et al. 2009). All rely on a budgeting approach in which the supply of plant-available N is determined prior to sowing together with the N demand, i.e. amount of N required to grow the crop (Marcellos and Felton 1994). The difference between N supply and demand represents the shortfall that is to be met by fertiliser N inputs. A more recent addition to the suite of N management tools for farmers and advisors is the Better Fertiliser Decisions for Crop Nutrition (BFDC) National Database and the associated web-based DS tool, the *BFDC Interrogator* (Bell et al. 2013).

Farmers are encouraged to deep core for soil nitrate late in the pre-crop fallow to determine supply of plant-available N. However, based on information from Government and private agronomists, the majority of the estimated 40–50,000 cropping paddocks in the northern grains region are not deep-cored for testing each year and decisions about fertiliser N inputs are more often based on the relativity of grain and fertiliser prices, paddock knowledge and past practices. The result is that farmers don't always estimate N supply with sufficient accuracy to use the DS tools effectively. Surveys of winter cropping paddocks in northern NSW during the past 20 years consistently showed large variations, i.e. as much as 15-fold, in soil nitrate at the end of the summer fallow and prior to sowing a winter crop (e.g. Elias and Herridge 2014).

NBudget was developed to assist farmers and advisors to make more informed decisions about fertiliser N. It estimates (i) soil nitrate and water levels at sowing, (ii) target yields, (iii) fertiliser N requirements for cereals and oilseeds and (iv) N_2 fixation by legumes. Soil testing either for nitrate-N, organic carbon or water is not required. NBudget was released in 2011 as a simple-to-use Excel-based calculator and transitioned to the

NSW Department of Primary Industries (DPI) CropMate™ website in 2012. The CropMate™ website was closed down in late 2013. NBudget currently exists as an Excel file only. A recent report on crop N management in NSW indicated ongoing use by advisors of NBudget (GD Schwenke, pers. comm. 2016).

Using NBudget

There are two versions of NBudget – one for winter cropping (bread wheat, durum, barley, canola, chickpea and fababean) and one for summer cropping (sorghum, sunflower, soybean and mung bean) – with 16 localities (12 in NSW and 4 in Qld) from Roma and St George in Qld to Dubbo in the central-west of NSW. The tool contains rules-of-thumb values and algorithms for estimating the net release or immobilisation of nitrate-N in the soil following a range of crops, N_2 fixation by legume crops and nitrate-N and fertiliser-N requirements for cereal and oilseed crops. Input data to generate the rules-of-thumb values and algorithms were derived from published and unpublished experiments conducted principally by the farming systems and plant (N) nutrition programs of the NSW and Qld agricultural agencies during the past 35 years. Details of data sources are in Herridge (2013). The logic and assumptions underlying NBudget are presented in detail in Herridge (2013).

Site details

The location is selected from a drop-down list of 16 and property and paddock names inserted (Figure 1). Also selected from drop-down lists are the fertility status of the paddock (high, medium, low-medium or very low, according to the short description of each), soil texture (clay soil (>35% clay), red-brown earth (20–35% clay) and sand/sandy loam (<20% clay)) and tillage practice (no-tillage/minimum tillage or cultivated). Other specific nutrient constraints are not considered.

Two seasons ago

The user selects from a drop-down list the crop grown in the paddock two seasons ago. A rule-of-thumb estimate of soil nitrate-N at the start of the previous season, drawn from a hidden look-up table containing values based on 460 observations from 11 years of N experiments across 5 sites in northern NSW, is then shown (Herridge 2013). Note that all estimates for soil nitrate and water are to 1.2 m depth.

Last season and estimating current levels of soil nitrate-N and plant-available water

The user selects from another drop-down list the crop that was last grown in the paddock and inserts the yield, protein (in the case of bread wheat, durum, barley and sorghum) and amount of fertiliser N applied. The program then provides an estimate of the end of fallow, i.e. May for winter crops and October for summer crops, soil nitrate level. Values for fallow and in-crop N mineralisation of soil organic matter, including old crop residues, are taken from look-up tables, determined initially from APSIM-generated values for clay soils that had been cropped for varying lengths of time and modified to account for differences in soil texture and fertility, tillage, and for periods of low soil water (see Herridge 2013 for details). With fresh crop residues, it is assumed that 65–70% of residue carbon (C) is respired during the post crop (summer) fallow with the remaining 30–35% locked into stable soil organic matter with a C:N ratio of 11:1 (Ladd 1987). Depending on the C:N ratio of the fresh residues, mineral N will either be released during the fallow (C:N <27:1), or immobilised (C:N >27:1) (Jensen 1997).

The program also provides an estimate of end-of-fallow plant-available soil water, determined using either fallow rainfall records and fallow-efficiency values, depth of wet soil and conversion factors or by other means, e.g Howwet?

Assessment of crown rot risk

The expected level of crown rot is selected from the list. The yield loss for bread wheat, durum and barley is then calculated using default data from the NSW DPI Grain Pathology research program, Tamworth (S.Simpfendorfer 2010, pers. comm.).

Estimating grain yields and proteins, fertiliser N

Expected grain yields for the coming season are calculated automatically using default transpiration efficiency values (12.5 kg grain/mm available water for bread wheat after subtracting 100 mm for evaporation etc.). The user inserts the target grain proteins for the average season for bread wheat, durum, barley and sorghum. The remaining crops are set at default levels. NBudget estimates sowing soil nitrate-N and fertiliser N requirements for the cereals, canola and sunflower using N-use efficiency (NUE) values, adjusted for grain protein in the case of the cereals. For example, NUE values for wheat vary from 0.58 kg grain N/kg sowing nitrate-N at 10% grain protein to 0.39 at 13% protein (all grain proteins at 12% mouisture) . Amounts of N fixed by the legumes are also calculated together with residual (post-fallow) nitrate levels for all crops. Fertiliser N is assumed to be converted to soil plant-available N with an efficiency of 0.8 (Pilbeam 1995).

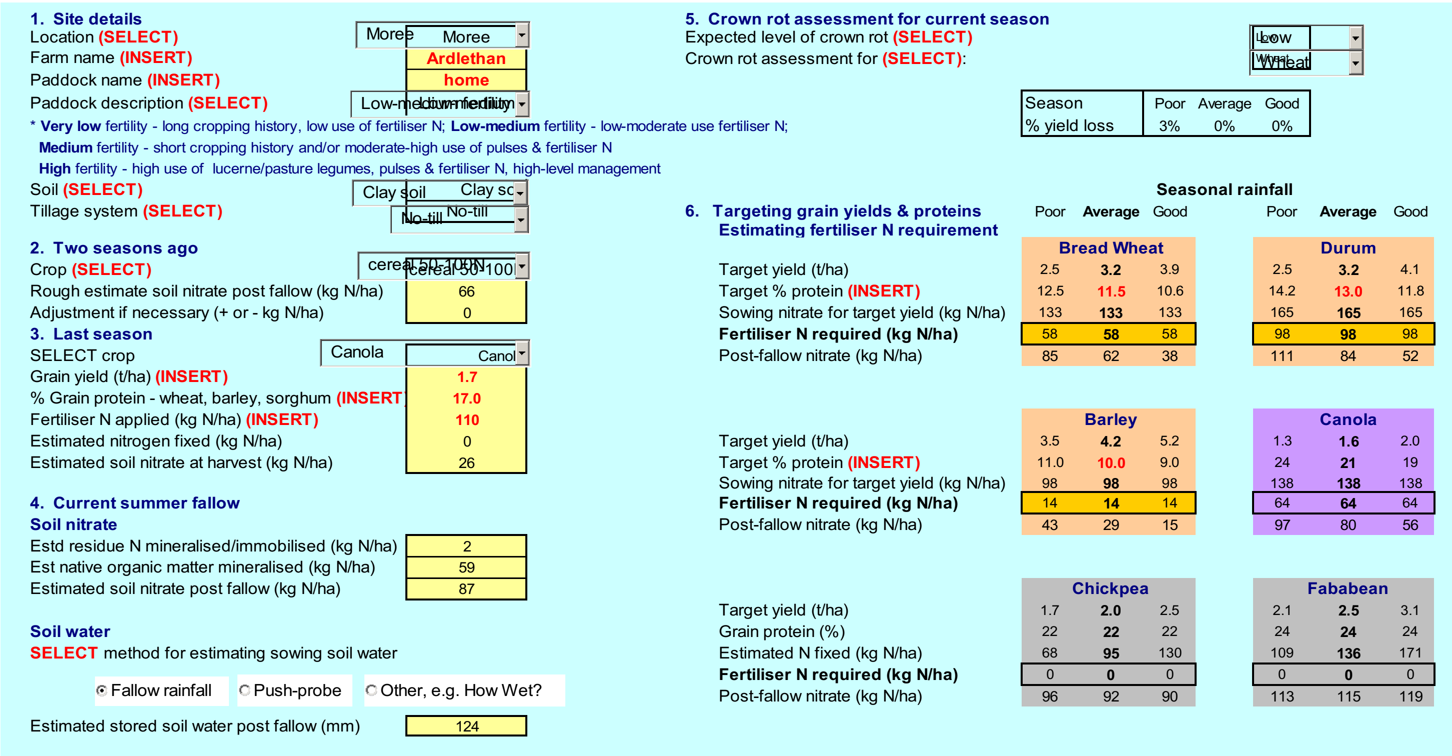

Figure 1. Output worksheet of the winter crop NBudget showing estimated levels of sowing soil nitrate (87 kg N/ha) and water (124 mm) and predicted yields, sowing nitrate-N and fertiliser N requirements for bread wheat, durum, barley, canola. Predicted yields and N_2 fixation inputs are shown for chickpea and fababean.

Groundtruthing NBudget output against independent data sets

Three sets of data, from the 1988–96 Warra (Dalal et al. 1998) and 1996–2001 Nindigully experiments in southern Qld (Thomas et al. 2007) and the 1996–99 Cryon experiments in northern NSW (Edwards 2000) were used to test the accuracy of NBudget in predicting soil nitrate levels at sowing as described above. For the Warra simulations, the clay soil was classed as very low fertility (0.65% C) after 50 years cropping. The Nindigully clay soil was similarly classed very low fertility (0.65% C) after 40 years cropping. The Cryon clay soil was classed medium fertility (20 years cropping and 0.76% C).

Measured and NBudget simulated values for sowing soil nitrate following wheat and chickpea (Warra), wheat and barley (Nindigully) and wheat, chickpea and canola (Cryon) are shown in Figure 2. Predicted and measured soil nitrate levels were similar for all three data sets with slopes reasonably close to unity and regression coefficients of 0.86 (Warra; n=16), 0.61 (Cryon; n = 18) and 0.62 (Nindigully; n=21).

Limitations of NBudget

The NBudget tool does not account for denitrification losses of N from flooded and severely waterlogged soils. The assumption in the program's logic is that 15% of applied fertiliser N is lost to the atmosphere, plus 5% immobilised in the soil, but there are no denitrification-associated losses of nitrate N. Nbudget was also used to simulate sowing soil nitrates for a group of 2012 N nutrition trials across seven sites in northern NSW (Herridge and Gardner 2013). There was reasonable agreement between measured (43–116 kg N/ha) and predicted values (58–119 kg N/ha) at four of the sites but, at the other three wetter/flooded sites, predicted soil nitrates were substantially higher (116–148 kg N/ha than measured (51–56 kg N/ha).

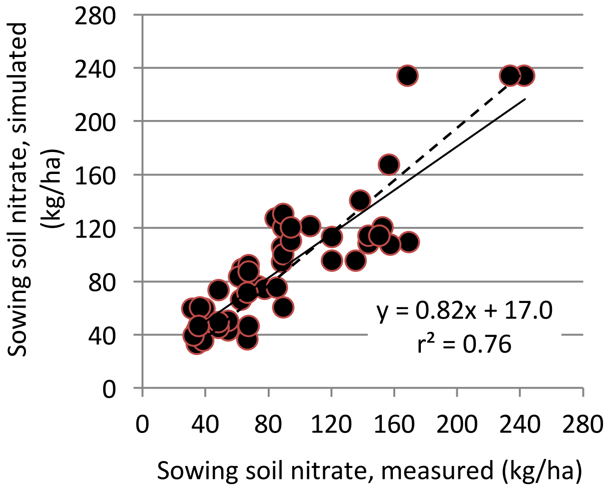

Figure 2. Observed and NBudget predicted post-fallow soil nitrate levels from the Warra and Cryon farming systems and Nindigully agronomy experiments. The dashed line is the 1:1 line.

Conclusion

The motivation for developing NBudget was to assist northern grains farmers make more informed decisions about fertiliser N rates for cereal and oilseed crops. The fact that most paddocks are not deep cored for nitrate testing prior to sowing means that farmers need to estimate soil nitrate levels at sowing as well as the likely shortfall for target grain yields and proteins. Published and unpublished data from more than 30 years of research trials in the region was utilised in the development of NBudget and considerable effort went into structuring the calculator in a logical way and making it simple to use. Comparing NBudget-derived estimates of sowing soil nitrate levels with measured values indicated generally good agreement, although NBudget does not account for denitrification losses from waterlogged/flooded soils. It should be noted also that essentially all of the groundtruthing has been done with soils classified as very low to medium fertility. NBudget would be more useful as a stand-alone app or web-based tool.

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