MANAGING THE NITROGEN NUTRITION OF WHEAT IN NORTHERN NEW SOUTH WALES USING NITROGEN BUDGETS

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Summary. An approach to determining the nitrogen (N) requirements of wheat crops based on crop and soil N budgets is being assessed in northern NSW. The aim of the exercise is to develop a paper-based advisory package to assist farmers understand, and manage the N nutrition of their wheat crops.

It is proposed that targets for grain yield and protein concentration may be set, and used to identify crop demand for N, and in turn how much available soil N must be provided to meet it. An efficiency function (NUE_g) which allows estimation of the N supply required for a given N demand was studied using a number of data sets from cropping systems experiments in northern NSW.

NUE_g varied with grain protein concentration. It was closely related to grain protein in some data sets, but there was considerable variation between sites and seasons. A simple, relationship suitable for global application was therefore not found, and so a more complex model is required to estimate NUE_g for varying grain protein targets.

INTRODUCTION

Although computer-based decision support packages like Wheatman (5), and system simulation models like APSIM (2) are available, a paper-based advisory package is needed to assist farmers understand, and better manage the N nutrition of their wheat crops. Ideally, a suitable package should be based on a simple model, and include a spreadsheet facility for monitoring decisions and outcomes for particular paddocks so that soil-crop N budgets may be developed. A similar procedure has been applied in southern Australia (1).

Both grain yield in wheat and its protein concentration are determined by available soil N (nitrate-N), and other variables such as sowing time, and the amount and distribution of available water during crop growth. The interaction of water and N influences the yield-protein relationship, and must be taken into account in managing the N nutrition of the crop.

The model considered here links the amount of N needed by the crop (N demand) with that available in the soil (N supply) by an efficiency function (ε) as follows:

N Supply → ε → N demand

In the northern grains region, where grain quality is important because premiums are paid for high grain protein concentration ('grain protein'), the most rigorous measure of N demand will be the amount of N harvested in grain (GNY). The amount of soil nitrate-N in the root zone at sowing provides a good estimate of N supply, and needs to be known well in advance to enable farmers to decide upon, purchase and apply N fertiliser.

The model then becomes GNY = f(nitrate-N), where the linking function is the nitrogen use efficiency for grain production (NUE_g). N supply is the amount of nitrate-N available to the crop, and targeted GNY is the N demand. A targeted N demand involves expectation of both grain yield, and a selected grain protein concentration. In order to be useful in practice, NUE_g should be simple, and applicable over a range of sites and seasons. A knowledge of NUE_g allows the N supply required for any selected N demand to be estimated.

In this paper, we assess NUE_g for its suitability for use in a simple decision support package.

MATERIALS AND METHODS

Data sets obtained from cropping systems experiments in northern NSW (3,4) on the properties Windridge (wr) and Glenhoma (gh) at North Star, for the period 1990-93, were used to relate wheat GNY (kg N/ha) to the amount of soil nitrate-N available at sowing (kg N/ha/1.2 m). Treatments in these experiments included variation in fallow management (tillage versus no-tillage), crop rotation (wheat, barley, chickpea), and application of fertiliser N (0 - 200 kg N/ha).

Non-linear equations of best-fit based on least squares, were calculated to quantify the relationships between GNY and nitrate-N, using TableCurve 2D[?]. These were differentiated to provide estimates of NUE_g, which were related to the corresponding observed levels of grain protein concentration.

The principle purpose of this paper is to develop the relationship between NUE_g and grain protein, and assess its suitability for determining the level of N supply needed to meet a selected grain yield and protein target.

RESULTS AND DISCUSSION

Relationships between wheat GNY and nitrate-N

Equations of best fit for four data sets covering a wide range in nitrate-N levels explained 68 - 89% of the variation (Table 1). The data for Glenhoma in 1990 and 1991 (gh9091) were pooled for regression analysis because of their similarity.

Table 1. Equations describing the relationships between GNY and soil nitrate (Y is GNY, X is soil nitrate; a, b, and c are constants; r^2 is the coefficient of determination).

Data	Equation	a	b	c	r^2
wr90	$Y = a + b^{0.5}(cX) - 0.25$	-23.16	102.1	0.1038	0.892
gh9091	$Y = a + b\ (1 - e^{-cX})$	-18.68	89.34	0.0153	0.888
wr93nf	$Y = a + b^{0.5}(cX) - 0.25\ (c^2X^2)$	5.361	88.70	0.08912	0.682
gh93	$Y = a + bX/(c+X)$	14.68	$1.233e^{13}$	3.192	0.749

Nitrogen use efficiency

The relationship between NUE_g and grain protein was close within some data sets, such as wr90, and gh9091 and wr93nf, but the variation between sites and seasons was large (Fig. 1). Indeed, the latter was too great ($r^2 = 0.495$) to justify the global use of a simple relationship.

NUE_g is the outcome of at least three efficiencies (Fig. 2), which describe the accumulation of N in the biomass (Efficiency 1), its partitioning into grain (Efficiency 2), and dry matter accumulation in the grain (Efficiency 3). The first is determined by pre-anthesis conditions and planting date, whereas the others operate post-anthesis. An improved understanding of the relationship between efficient use of soil N and the achievement of given protein goals requires a knowledge of the interaction of all three processes. It is likely therefore, that the relationship between NUE_g and grain protein will be better quantified by a multivariate approach, or simulation modelling, which can take into account the three component efficiencies.

Figure 1. Relationship between nitrogen use efficiency for grain production, NUE_g and grain protein concentration.

Figure 2. Pathway for determination of grain protein concentration in wheat.

CONCLUSIONS

The application of N budgeting to manage the N requirements of a wheat crop involves at least four steps:

1. Selection of the levels of yield expected, and grain protein required to enable N demand (expressed as GNY) to be determined.

2. Assessment of the nitrate-N status of the paddock at planting.

3. Identification of the efficiency with which soil nitrate-N will be used to produce grain N, and therefore the calculation of the N supply required to meet that N demand. How much additional N will be required, as fertiliser can then be calculated.

4. Assessment of the outcome after harvest, and determination of any residual benefit to be carried forward to the following year.

The principal objective of this paper was to assess the variation of NUE_g associated with different levels of grain protein achievement. The relationship was close within some data sets, but variation between sites and seasons was large ($r^2 = 0.495$) making the global use of a simple relationship less useful than required. It may be preferable to use a simpler, alternative measure of NUE_g, based on δGNY\δnitrate, and this is currently being considered.

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