NITROGEN FERTILISER DECISIONS FOR WHEAT ON THE LIVERPOOL PLAINS NSW 1. SHOULD FARMERS CONSIDER PADDOCK HISTORY AND SOIL TESTS?

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Abstract

The APSIM systems model was used to simulate three fertiliser strategies which delivered different levels of precision of nitrogen supply to a continuous wheat-fallow rotation at Gunnedah. The strategies: (i) fixed fertiliser rate; (ii) adjusting fertil iser rate following poor crops; and (iii) using soil N-tests to determine fertiliser rate, were all tested over a range of 5 target yield or risk levels. Results indicate that gross margins are maximised when the nitrogen strategy supplies sufficient n itrogen (N) to grow the 90 percentile yield at 13% protein. However, it was the mean level of N supply rather than the precision (*ie.* variability) of supply that determined return and risk. Applying a fixed annual N rate targeted to supply the average crop requirement was equally as efficient as soil testing and adjusting fertiliser rates each season. The effectiveness of the fixed fertiliser strategy is due to the reasonably low risk of losses of residual fertiliser in this system, thus the fertiliser saved from poor crops is largely available in subsequent good seasons.

Key Words: Nitrogen fertiliser, decision analysis, risk, soil tests, residual fertiliser.

Since the first documentation of nitrogen fertility decline in Northern NSW (1) and Southern Queens-land (5), there has been a considerable amount of research into both the nature of nitrogen (N) decline and how farmers should manage their N fertili ty. Because of the high cost of N fertiliser, the unpredictability of crop responses and possibility of N losses from the soil, N management has been an area where research and extension have seen a need to provide growers with more information. Thus, several decision support tools/approaches have been developed which aim to provide predictions of soil-N supply and demand at a paddock level (*eg.* Operation Quality Wheat, WHEATMAN and Nitrogen in 95' workshops). The most recent tools to be us ed in N management are soil N tests (to provide measures of N supply for each season and each paddock) and soil moisture and climate forecasts (to provide predictions of N demand).

In a review of N research, Henzell and Daniels (3) found that not only were N fertiliser application rates very low, but that growers had little enthusiasm for the more complex fertiliser strategies involving adjusting of fertiliser rates from year to y ear and paddock to paddock.? Another more recent survey of NSW growers attitudes to N management (P.T. Hayman *pers comm*) suggested that within the last 2-5 years fertiliser rates have increased considerably, however they also found a cont inued reluctance to introduce more precision and tact-ical responsiveness into their fertiliser decisions, with 43% of growers using fixed fertiliser rates.

This paper is the first of two papers using simulation modelling to explore the possible benefits to wheat growers at Gunnedah of introducing more precise and tactical approaches into their fertiliser decision making.? In this paper we compare thre e approaches to fertiliser application that result in different levels of precision of N supply. A second paper (2) looks at the value of using soil water and SOI as predictors of N demand and responding tactically to these signals by altering N supply .

There are three causes of uncertainty or imprecision when estimating the soil N supply at planting; first the fluctuations in mineralisation rate due to variability in temperature, soil moisture and organic substrates, secondly the addition of any resid ual fertiliser from the previous crop/s and third, losses of N from the soil via denitrification, leaching or volatilisation. In this paper we have tested three methods of estimating N supply which consider these sources of uncertainty to differing deg rees:

• 1. Ignore all uncertainty and assume N supply at planting will be the long-term average from an unfertilised paddock. This strategy results in a fixed annual fertiliser rate.

• 2. Adjust N-supply estimate for residual fertiliser-N following a poor crop.

• 3. Use a soil test to measure N supply near planting, thus taking into account all sources of gains or losses (except those that occur after the soil sampling).

Strategies 2 and 3 result in fertiliser rates which vary annually.

Methods

This study was conducted using the APSIM systems simulator (6) configured for wheat fallow system at Gunnedah. The wheat model used was I_WHEAT (7) and the water balance and N cycling modules used were SOILWAT2 and SOILN2 both described in Probert (8).? The simulator was run with 90 years of Gunnedah measured weather without resetting the soil water status, but resetting soil N every 10 years to prevent complicat-ions of fertility decline. The simulations provided predictions of wheat yield, pro tein, along with N supply at planting and N losses from the soil.

We tested the three strategies at different levels of target N supply which equate to different levels of risk, *ie.* a grower decides if they will be conservative and aim at low yields and low risk, or at higher yields with higher risk. In setti ng the N supply targets we used the approach from the Nitrogen in 95' workshops (4) where N demand is determined by choice of a target yield and protein. To provide meaningful yield targets we simulated N unlimited wheat production at Gunnedah for the 90 year weather record and used that yield distribution to determine the 10, 30, 50, 70 and 90 percentile yields. These yields became the very low (10 percentile at 10% protein), low (30 percentile at 11.5%), average (50 percentile at 11.5%), high (70 p ercentile at 11.5%) and very high (90 percentile at 13% protein) target nitrogen demands. These N demands were converted into target soil-N levels using a conversion efficiency for soil to grain N.

The yield, protein and nitrogen rates were taken from the APSIM simulations and converted to economic risk and return in a spreadsheet. The essential assumptions were $70 growing costs, $20 harvesting costs, $/kg of N fertiliser and on farm wheat prices ranging from $100 for ASW wheat (10% protein) to $140 for Prime Hard Wheat (13% protein).

Results and discussion

Fig. 1a shows the frequency distribution of Nitrate-N at planting for the three strategies with the 'average' target (50 percentile yield at 11.5% protein). The target amount of soil nitrate-N was 111 kg N/ha, and the soil testing (strategy 3) has a mea n nitrate-N at planting (117 kg N/ha) very close to the target with only small variation around the mean. In contrast, the fixed N rate (strategy 1) produces a mean of about double the target (235 kg N/ha) and a very broad range of soil N supplies at p lanting. Strategy 2, of adjusting for a previous crop produces a result between the other two in terms of both the mean and variability of N supply.? All other N targets show these same patterns, but they are more exaggerated at the higher targets. These results highlight the import-ance of the residual effects of fertiliser N in this cropping system (despite losses from denitrification and leach-ing).

Strategies 1 and 2 both result in over-supply of nitrogen (*ie.* the average N at planting exceeds the target supply). This cannot solely be due to build-up of unused fertiliser N as strategy 2 accounts for this unused N by reducing fertilise r rates following poor crops. The other mechanism which is contributing to over-supply is the 'feeding' of soil mineralisation by fertilised crop residu-es, *ie.* greater amounts of carbon and N are fed back into the labile N pool through the sto ver and roots of fertiliser on crops.

The three strategies combined by five target yields (or risk levels) has produced 15 different average soil N levels each with its own variability about that mean. In order to compare all 15 combinations of strategy

and risk we have plotted average gros s margins, standard deviation of gross margin and % chance of negative gross margins, against average soil nitrate-N at planting for each (Fig. 1 b ,c ,d). All three measures of perform-ance show that mean soil nitrate-N at planting is a good predictor of performance, with no clear interaction between variability of N-supply (greatest in fixed rate strategies) and average profit, profit variability or chance of negative returns.
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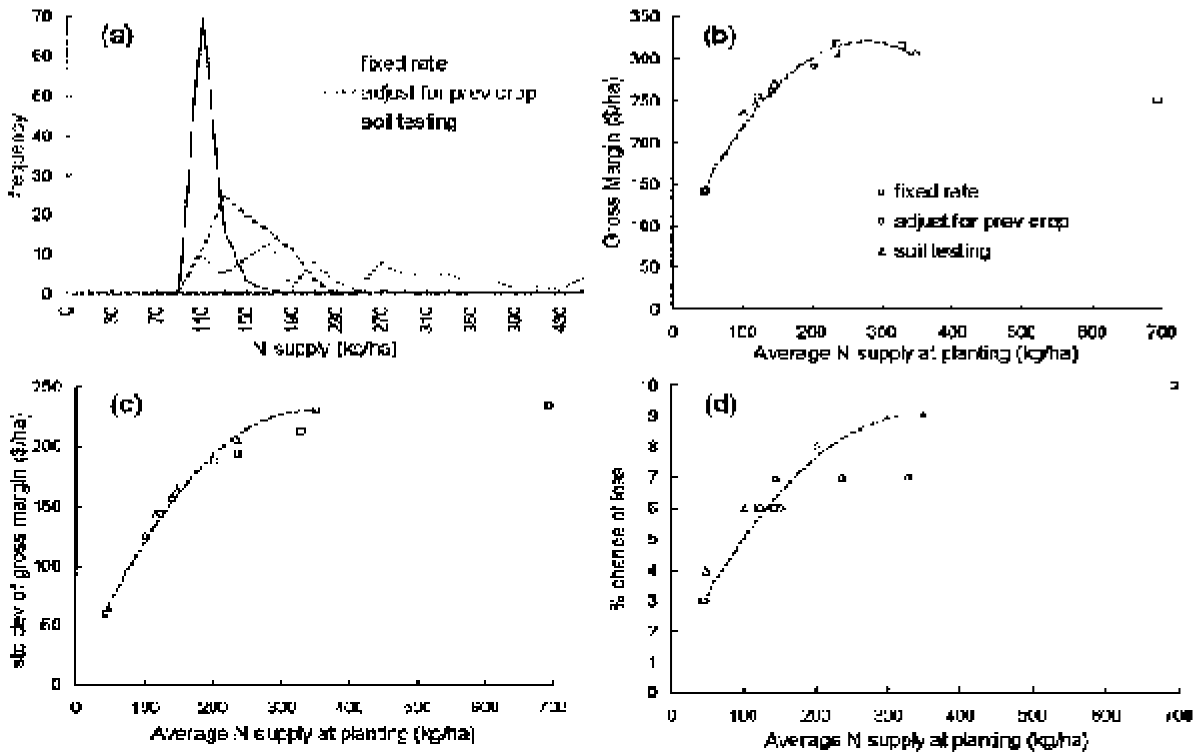

Figure 1: (a) Frequency distribution for nitrate-N at planting with the three strategies for a target supply of 111 kg N/ha. Average nitrate-N at planting versus (b) average gross margin, (c) standard deviation of gross margin, and (d) % chance of negative returns, for each of the three strategies at five risk levels.

If we define the optimum N strategy as that which achieves maximum profit while minimising risk, the three solutions closest to this are the fixed fertiliser rate for average target yield, the adjusted rate for the high target yield and soil testing for the very high target yield.? All these three produce similar average soil nitrate-N supplies, similar gross margins and similar risks of negative returns despite the fact that the standard deviation of N supply is much greater with the more strate gic approaches (Table 1). Not surprisingly, the average fertiliser application rates are also similar although the more tactical approaches produce a much greater variability around the mean.

These results indicate that if your goal is to maximise gross margins (and this may not be the case) a grower should supply enough N to a wheat crop to grow the 90 percentile yield at 13% protein. This can be done by either using soil tests near sowing and topping up N requirements or using the more strategic approaches but lower the target nitrogen supply to account for residual effects of fertilisation. The fact that these more strategic methods give comparable results to soil testing suggests that fallow losses are not causing significant problems in this system. This is because the simulations predictions of leaching and denitrification losses are generally of the order of 10 to 30 kg N/ha over a fallow, similar to the amounts gained by in-crop mineralisation.

Table 1: Summary of fertiliser rates, gross margins, and risk for the three strategies

	V low	low	medium	high	v high
Rate of Nitrogen Fertiliser					
1. Fixed rate- mean N rate kg/ha	13	65	81	106	200
2. Adjust for last crop - mean and std dev kg/ha	13 (0)	57 (17)	68 (23)	83 (34)	121 (72)
3. Soil tests - mean and std dev kg/ha	15 (3)	47 (20)	54 (24)	64 (31)	91 (56)
Nitrogen at planting					
1. Fixed rate - mean and std dev kg/ha	44 (8)	142 (42)	235 (98)	328 (145)	694 (336)
2. Adjust for last crop - mean and std dev kg/ha	44 (8)	123 (25)	152 (32)	201 (50)	349 (90)
3. Soil tests - mean and std dev kg/ha	47 (5)	101 (9)	117 (10)	143 (11)	236 (14)
Return - Gross Margin					
1. Fixed - GM $/ha	142	263	317	313	251
2. Adjust for last crop - GM $/ha	140	255	272	291	306
3. Soil tests - GM $/ha	144	236	249	271	306
Risk					
1. Fixed - % chance of -ve GM	3	6	7	7	10
2. Adjust for last crop - % chance of -ve GM	3	6	6	8	9
3. Soil tests - % chance of -ve GM	4	6	6	7	7

Conclusions

Results of simulation experimentation indicates that residual value of fertiliser is very high in the Gunnedah climate and soils. Because of this high value of residual N, the use of average target yields for N demand is close to the optimum N managemen t strategy for continuous cereal. This indicates that the use of pre-planting soil tests to determine levels of N supply may not be necess-ary in stable cropping rotations for the management of fertiliser N. This result does not however negate the need or soil tests or bioassays to estimate the soils mineralisation potential at strategic intervals.

It is important to acknowledge that these results are for a continuous winter cereal system and rely on the stability of N mineralisation in this system. How far you can extrapolate these results to mixed and opportunistic systems is uncertain, and they certainly would not hold for a system using legumes.

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