NITROGEN FERTILISER DECISIONS FOR WHEAT ON THE LIVERPOOL PLAINS, NSW. II. SHOULD FARMERS CONSIDER STORED SOIL WATER AND CLIMATE FORECASTS ?

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Abstract

We used the cropping systems model APSIM to compare different approaches a farmer deciding on nitrogen rates might use to determine target yields. The three approaches were; 1) a strategic or fixed target yield based on the long term average 2) tactically adjusting the target yield based on stored soil water and 3) tactically adjusting the target yield based on stored soil water and the May trend in the southern oscillation index. Although the more tactical approaches performed better than the fixed strategy, the benefits were less than we expected. We suggest that this is due first, to a short fallow at Gunnedah being able to usually provide enough stored water to make fertiliser decisions relatively simple and, second, to the flat shape of the economic response of wheat to nitrogen.

Key words: Nitrogen fertiliser, wheat, climate variability.

The essence of managing the nitrogen (N) nutrition of wheat is to balance crop demand with the supply from the soil and fertilisers. The first paper in this two part series examined the value of information on soil N supply, this paper focuses on the crop demand. Although crop demand is unknown when N fertiliser is applied, there are a number of ways of estimating demand and hence reducing the uncertainty. Should farmers ignore the uncertainty and stick to a fixed strategy, or should they tactically adjust their fertiliser rates?

Atactical or flexible approach to inputs is more likely to be useful when outcomes are variable and there are states of the system which influence the outcome and can be measured at the time of the decision. The NE wheat belt has a higher variability of yield and income from wheat production than the rest of Australia (6). This is due to the variable climate which is not only considered as a factor making N decisions on wheat difficult (2), but also as a major reason for sub-optimal rates of N fertiliser (5). Although the climate is variable, there are states of the system which can be measured. For example, it is common for up to half the supply of water for the crop to be stored in the heavy clay soils from the previous summer fallow. Farmers have long been encouraged to determine a potential yield range by measuring stored soil water at sowing (1). More recently, the value of a seasonal climate forecast to wheat farming in southern Queensland has been shown (2, 5). Not only can farmers respond tactically to the state of the stored soil water, they can also respond to the state of the atmosphere.

Asurvey of the N decisions of 400 wheat farmers in northern NSW at the beginning of the 1997 wheat season showed that 43% of the group used fixed rates (P. Hayman and J Kneipp, unpublished data). Of the other 57% which took a more tactical approach and adjusted their N rates, many of these only used paddock history or fallow length as measures of soil N supply. About 25% of the respondents used stored soil water and less than 10% used seasonal climate forecasts.

Methods

We ran the simulation model APSIM with 90 years of daily climate data at Gunnedah to compare the risk and returns of strategic and tactical approaches to N fertiliser decisions. The major difference from the companion paper was the resetting of soil N and crop residue levels at planting. This removed the uncertainty in N supply making the fixed treatment in this paper similar to soil testing in the previous paper. The soil water module ran from season to season to simulate recharge of the fallow between a winter crop (harvested in December) and a wheat crop sown the following June. We compared three methods to determine N rates:

• a strategic or fixed rate based on long term yields;

• tactically adjusting the rate based on the yield as determined by stored soil water; and,

• tactically adjusting the rate based on the yield as determined by stored soil water and the May trend in the southern oscillation index (SOI).

Table 1 shows the range of yields generated by APSIM run with Gunnedah climate information and a high supply of N, this was then converted into a range of N requirements as per the companion paper. Table 2 shows the median yield for 5 different levels of stored soil water and the 5 phases of the SOI in May and the corresponding N requirements. We found no correlation between the May SOI phase and the level of stored soil water in June. This lack of correlation ensures that the SOI is offering additional information beyond what is already known by measuring stored soil water.

Considering median target yields, the fixed approach was simulated by applying 101 units of N each year (Table 1). To simulate the response to stored soil water we set the manager module in APSIM to apply the appropriate fertiliser rate from Table 2 depending on the level of stored soil water on the 1 June. To achieve the final run we set up the manager to respond to both the stored soil water and SOI phase. For example, if the stored soil water was 100 mm and the SOI phase was negative, 66 units of N would be applied that year.

Results

Table 2 shows that stored soil water has an impact on the median yield of wheat and consequent N requirement. Some of the phases of the SOI (particularly rising and falling) have significant impact on median wheat yields and N requirement, but other phases have less effect. As the levels of stored soil water increase, the effect of the SOI decreases. As will be discussed in more detail later, for the 90 years simulated, the SOI has been positive and rising more often than it has been falling or negative. Furthermore, in most years the summer fallow has been adequate to fill the profile to half full or wetter.

Table 3 shows that responding to stored soil water and the SOI leads to a considerable range of N rates required over the 90 years. Adjusting N rates each season based on stored soil water leads to an increase in the gross margin of between $5.00 and $71.00. The greatest advantage is found at the very low and very high target yield levels. This is primarily because it brings the average fertiliser rates closer to the optimum. At the low, median and high target yields which are closer to the optimum, the extra profit from adjusting fertiliser rates is modest. Responding to the SOI as well as stored soil water offers an additional benefit, but the gains range between $1.00 and $10.00. Table 3 also shows that for farmers aiming at median target yields, adjusting for stored soil water leads to a higher gross margin in a little over half the time. By using stored soil water, the farmer receives a higher return in 55% of the time, by using the SOI as well as stored soil water, the farmer receives a higher return (albeit by a small amount) 75% of the time.

Risk increases as more N fertiliser is used. Table 3 shows that adjusting N rates leads to an increase in risk for farmers with a very low target yield (because they usually adjust rates up) and a decrease in risk for farmers with a very high target yield (because they usually adjust rates down). Farmers aiming in the 30 to 70 percentile target yield, which is closer to optimum levels of N fertiliser, gain little change in risk by adjusting their rates.

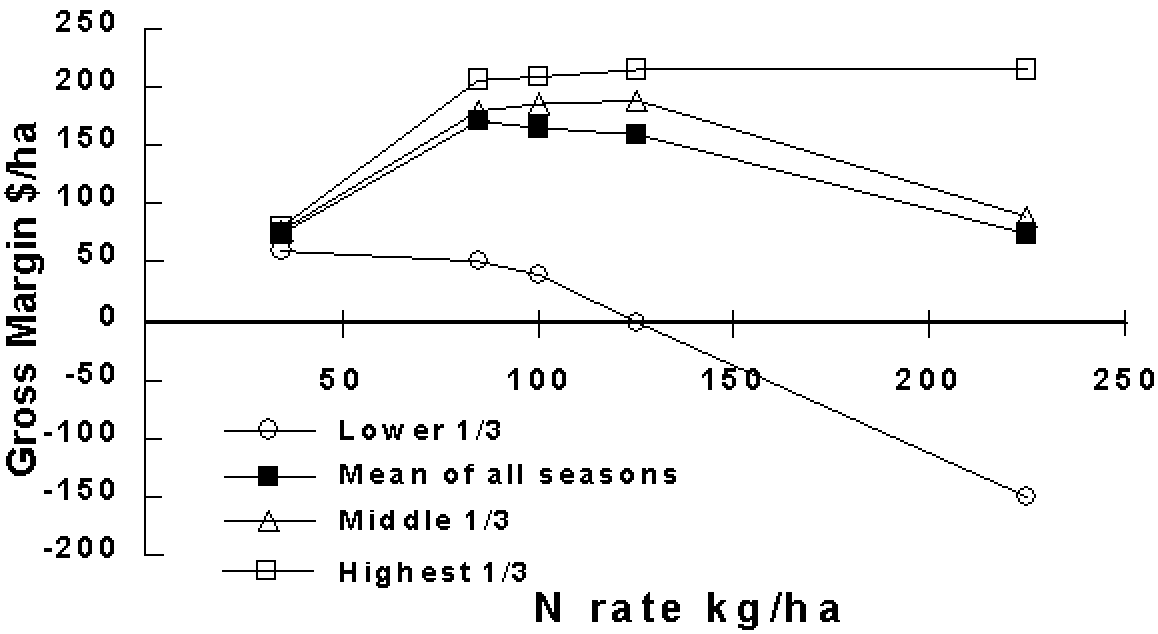

Figure 1

Discussion

The benefits from adjusting N rates at for wheat at Gunnedah after a short fallow are less than we expected given the shifts in median wheat yield caused by stored soil water and the May phase of the SOI (Table 2). One reason for this is that the matrix in Table 2 is not evenly sampled, rather, in most seasons the starting soil water is over 150 mm and hence the impact of the SOI is much less. Fallowing has evolved as a means of managing the variable climate for grain production. After a well managed summer fallow at Gunnedah, farmers usually have enough water stored to ensure an adequate crop and make the N fertiliser decision easy.

It is important to recognise that there are years when adjusting N has a significant advantage, *ie.* years when the profile is less than half full and the SOI is negative or rising. However, these years are relatively rare. In most years, adjusting nitrogen rates for the SOI and/or stored soil water will offer a modest advantage, in a significant minority of years these indicators will provide a false signal. A second reason for the smaller than expected benefit of adjusting fertiliser is the shape of the N response curve as shown in Fig. 1. Farmers who are aiming applying between 85 and 100 units of N are on a relatively flat part of the curve Responding to stored soil water and SOI enables this response curve (which is an average of 90 seasons), to be partitioned into response curves for higher and lower yielding situations. In Fig 1 shows the response curve for the poorer 1/3 of seasons, the middle 1/3 and the best 1/3. A farmer who had perfect information could decide which of the three response curves to use. However, a farmer who just used the average curve and selected a fixed rate between 85 and 100 units will not sacrifice too much potential gross margin in the good seasons nor lose too much in the poor seasons. Once farmers are applying between 85 and 100 units, because the curve is flat, adjusting N rates has a relatively small impact on the gross margin.

A review of research, development and extension of N on cereals in the NE region found a marked difference between extension specialists and researchers on the one hand and farmers on the other in their enthusiasm for adjusting N rates (3). This study, using a simulation model for wheat sown after a short fallow at Gunnedah provides limited support for the extension specialists and researchers. Conclusions might differ for regions other than the Liverpool Plains, more opportunistic cropping systems than the regular 6 month fallow and when off-site pollution is considered.

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