FAST Points The Way To Profitable Wheat Crops

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Background

The FAST (Farm Management 500 and Sustainable Technology) was initiated to uncover what makes for profitable and sustainable crop production. There are many approaches to answering this question. In the past long-term replicated experiments have been conducted to identify trends in productivity and to monitor the underlying changes in soil fertility that follow from a change in rotation. An alternative approach is to use computer simulation models of the relevant crop and soil processes to indicate what might happen with a change in cropping practice - for example with a change to a more intensive cropping system.

However, both of these approaches have their limitations. In the first case, long-term experiments are costly to establish and maintain, and the results may be too long in coming to affect what farmers do. In the second case, the projections based on simulation model are limited by our current understandings of the processes which we believe to be relevant and which are captured in the simulation models.

FAST was based on the premise that many of the indicators, clues and answers to profitability and sustainability already exist within the records and experience of farmers themselves. Most farmers are active experimenters and FAST sought to work with farmers to interpret their collective experience. To date farmers have had little opportunity to fully exploit the opportunity to learn from their individual experiments because they are, by their nature, site and season specific. The power of the FAST approach lay in harnessing the collective experience of farmers for the benefit of the whole farming community.

Over the last two years FAST has reviewed the financial performance of 80 Victorian grain-producing farms and has identified some important indicators of farm viability and sustainability. Some of these have been linked to the underlying productivity and the use of specific inputs - for example fertiliser. Another component of FAST was the detailed monitoring of crops, in crop sequences extending over three years, in order to identify and highlight the key elements that contribute to profitable crops and sustainable cropping systems. This article reports on the findings from 26 wheat crops grown in Victoria during 1993, 1994 and 1995.

Wheat Crops Monitored

The wheat crops monitored were grown on duplex soils in the Western District, on red-brown earths around Charlton and St Arnaud, on grey clays in the Wimmera, and on sandy clay loams in the southern Mallee.

Growing season rainfall (GSR, mid-April to mid-November) varied from as low as 107 mm at Raywood in 1994, to 435 mm at Marnoo in 1995. In addition, three crops had access to significant amounts of soil water (90-110 mm) left after previous grain legume crops. None of the crops monitored had access to water stored under long-fallows. Soil water was monitored under all crops at sowing, flowering and harvest.

Sixteen of the 26 wheat crops were sown after a grain legume. Four of the crops were sown after canola. Most of the remainder were sown after pasture.

Sowing dates ranged from 7th May to 22nd June. Varieties sown included Meering, Rosella, Cocamba, Kellallac, Barunga and Ouyen. Rates of nitrogen fertiliser sown with the crop varied from zero to 67 kg N/ha. There were no cases where nitrogen was top-dressed.

The Impact Of Growing Season Rainfall

Wheat yields generally increased with growing season rainfall (GSR) according to the equation:

Yield = 11.94 + 8.24 GSR

This equation, which accounts for 58% of the observed variation in wheat yields, suggests a water use efficiency (WUE) of 8.24 kg/mm, on average, for the conversion of GSR into yield.

We then re-examined the data to identify what might be done to obtain above average water use efficiencies. We found that WUE was higher in crops that had taken up more nitrogen by flowering, and that crops that had taken up an extra 50 kg N/ha exhibited a WUE advantage of 3.4 kg/mm.

In addition, wheat after break crops, and in particular canola, also exhibited an advantage in WUE, which varied from 2.1 kg/mm after grain legumes to 4.2 kg/mm after canola.

These are important findings because they show that it is the combination of good nitrogen nutrition and use of break crops which leads to higher WUE: taken together they can readily increase WUE by 3.5-8.0 kg/mm. An improvement of 6 kg/mm in WUE translates to yield increase of 1.8 t/ha in areas characterised by a GSR of 300 mm. Even if this requires the application of an additional 80 kg N/ha as fertiliser, the extra returns of $300/ha (1.8t @ $170) easily outweigh the cost of the nitrogen fertiliser ($80/ha).

Factors Affecting Nitrogen Uptake At Flowering

We have argued that high nitrogen uptake at flowering (N-uptake) is needed to guarantee high water use efficiency in wheat. However, if this knowledge is to be exploited we need to understand how to increase the uptake of nitrogen by the crop.

Surprisingly, we were unable to show that nitrate N in the soil at sowing affected the N-uptake of these crops. Previously we were able to demonstrate this in data obtained from a more restricted set of experiments conducted in the Donald-Warracknabeal area in the period 1990-1992. However, soil fertility measured as organic carbon (OC) positively affected N-uptake, and the effect was more marked as GSR increased. Likewise, the application of N fertiliser also exerted a positive effect on N-uptake and again the effect was more marked as GSR increased. These effects can be summarised as follows:-

Each 1% increase in OC increases N-uptake by 0.081 Kg N/mm of GSR
Each additional 50 kg N applied increases N-uptake by 0.1012 kg N/mm/mm of GSR

In this study organic carbon levels (OC, 0-10 cm) ranged from 0.6 to 2.2%. In a situation where GSR is 300 mm, the lowest OC will only provide for 14 kg N-uptake/ha whereas the highest OC will provide for 53 kg N-uptake. Other things being equal, this difference in OC will give rise to an 800 kg/ha difference in yield.

Alternatively, this shortfall in N-uptake could be addressed with the application of fertiliser N. To obtain an additional 39 kg N-uptake will require the application of an extra 65 kg N as fertiliser (because 50 kg N delivers only 30 kg N-uptake at GSR 300 mm).

Given that it would take at least 20 years under lucerne pasture to lift OC from 0.6 to 2.2%, it would appear that low OC is best addressed through the application of 65 kg N/ha (cost $65/ha) for a return of 800 kg/ha wheat worth about $135/ha.

The other point to note is that the efficiency with which organic or fertiliser derived nitrogen is taken up by wheat is increased in seasons of high GSR. A doubling in GSR from 200 to 400 mm increases N-uptake from each unit of OC from 16 to 32 kg N/ha. Likewise the application of 50 kg N/ha only increases N-uptake by 20 kg N/ha when GSR is 200 mm, but this increase is 40 kg N/ha when GSR is 400 mm. This suggests that the residual effect of nitrogen applied to crops in poor seasons should be quite large with as much as 60% of the fertiliser left unused.

Effects On Grain Protein

Protein content varied from 7.7 to 13.2% across the 26 crops. At best we could only explain about 55% of the observed variation in protein content. Yield had the largest effect on protein content with each 1000 kg/ha increase in yield reducing protein content by 1.1%. However, this effect could be counteracted through the use of higher rates of fertiliser nitrogen. On average, each 50 kg N/ha applied increased protein content by 2.1%. In addition, high soil nitrate (0-60 cm) at sowing also increased protein content, but each 50 kg of nitrate N in the soil only increased protein by 1%. Hence, soil nitrate appeared to be only half as effective as fertiliser nitrogen in lifting protein content.

Hence, if target yields are increased by 1000 kg/ha an additional 25 kg N/ha will be needed just to maintain protein content. This is addition to the nitrogen needed to grow the extra yield - say 46 kg N applied to increase yield by 1000 kg/ha in a good season with GSR 400 mm.

Summary

This study of Victorian wheat crops shows that:-

- increasing the uptake of nitrogen by 50 kg N/ha improves WUE by 3.4 kg/mm
- introducing a break crop increases WUE by 2.1-4.2 kg/mm
- the efficiency with which fertiliser nitrogen is taken up by wheat increases from 40% to 80% as GSR increases from 200 mm to 400 mm.
- each 1% of OC contributes from 16 kg N/ha (GSR = 200 mm) to 32 kg N/ha (GSR = 400 mm) to the uptake of nitrogen.
- at current prices for fertiliser N ($1.00/kg N), and for wheat ($170/t), it is still more economic to apply fertiliser N than to increase N supply by raising OC levels with pasture.
- grain protein levels tend to fall by 1% for each 1000 kg/ha increase in yields

the decline in grain protein with each 1000 kg/ha increase in yield can be overcome by the application of an additional 25 kg N/ha as fertiliser.