Protein Achievement and Grain Yield

in Southern Australian Wheat Varieties

August 2013

AGT

Key Messages

- High yielding wheat varieties that have recently been adopted by growers in Southern Australia are better at accumulating protein than older, lower yielding varieties
- Although new varieties produce more protein per hectare, their higher yield means that grain protein concentration (expressed as a % of grain weight) is actually lower
- As growers are paid more for grain yield than protein content, the newer wheat varieties have been, on average, a higher gross margin option
- Mace® seems to respond very positively to nitrogen application, perhaps providing growers the option to improve their profits by increasing nitrogen supply to the crop

Why do the trial?

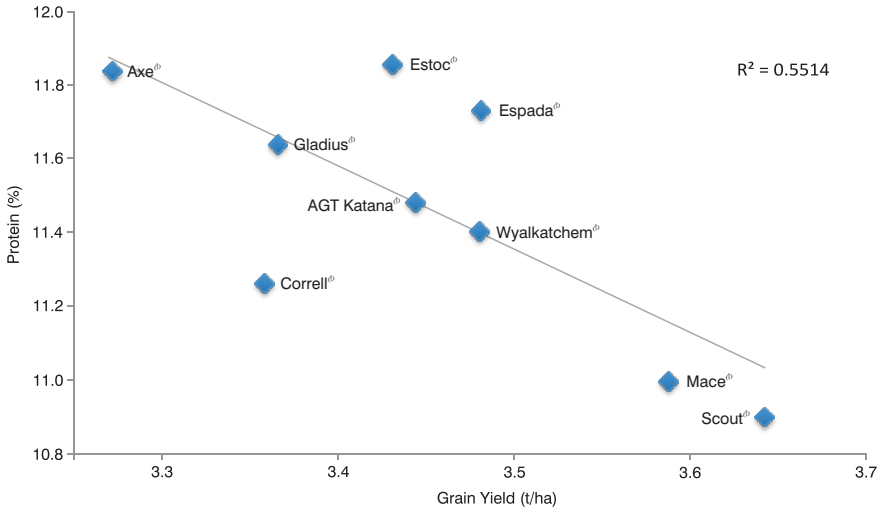
With the adoption of new high yielding wheat varieties, farmers have been reporting lower grain protein percentage when compared to older varieties that were previously being grown. We wanted to find out how big this difference in protein percentage is, what financial impact it has, and help growers maximise return on nitrogen application.

Why is this important? Slipping just one grade from AH2 to APW over the past ten years would have cost growers an average $16/t or 6% of their gross income. However, new varieties are also higher yielding, leading to an increase in income. So we need to know how growers can best manipulate nitrogen inputs to manage both grain yield and grain protein in these new varieties. To do this, it is important that we understand if the underlying cause of this reduction in grain protein content is due to a change in the genetics of the new varieties, or can also be managed through interactions with management practices.

How was it done?

The quantity of protein in wheat grain is largely determined by nitrogen (a key constituent of protein) supply and availability to the plant. Within the plant there are actually three components that drive grain protein percentage; 1) the plant's ability to uptake nitrogen, 2) the plant's ability to remobilise nitrogen from its vegetative tissues and store it in the grain, 3) the ratio of starch to nitrogen that is finally loaded into the grain. For example, in drought stressed environments, starch deposition is much slower than protein formation, which leads to an increase in the percentage of the grain which is made of protein. The opposite is also true in seasons and locations that experience a more favourable finish to the season. To investigate the nitrogen use efficiency (NUE) and nitrogen response of South Australian wheat varieties, two sets of data were used. Firstly, the National Variety Trials (NVT) grain yield and protein data from 2009 to 2012, and secondly, a set of NUE trials conducted by AGT.

Figure 1. The average grain yield v's average grain protein of nine important varieties present in all South Australian NVT's during the 2009 to 2012 period.



NVT grain yield and protein data

A study was performed using grain yield and grain protein percentage from the 2009 to 2012 NVT in South Australia. Trials affected by severe rust infection were removed from the dataset prior to the analysis. The average grain yield,

grain protein, screenings and hectolitre weights were calculated for varieties that were present in all of the South Australian NVT's during the 2009 to 2012 period.

AGT NUE trials

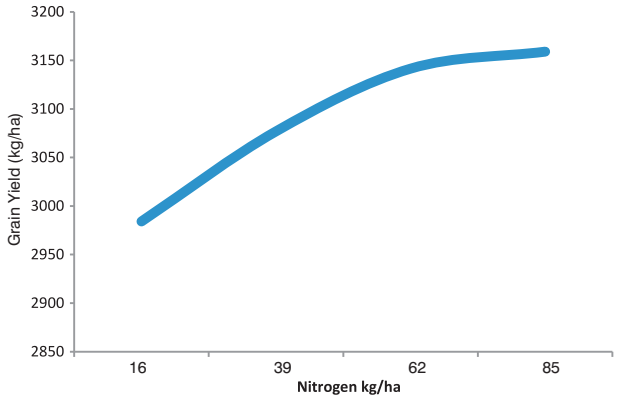
Eight NUE field experiments were run by AGT between 2009 and 2012. These experiments included between 24 and 37 entries that consisted of important varieties and advanced breeders lines, with a core group of eight varieties common to each experiment. The experiments had three replicates and either three (16, 39, 85 kg N ha^{-1}) or four (16, 39, 62, 85 kg N ha^{-1}) nitrogen treatments. The nitrogen was applied in furrow at seeding time with an additional 42 kg N ha^{-1} of nitrogen applied, prior to the initiation of stem elongation, to all treatments in two of the experiments which had sufficient moisture available. All other aspects of experimental management followed local best practice. Experiments were run at Cummins, Rudall, Mintaro, Pinnaroo and Roseworthy.

What happened?

Highest yielding = lowest protein (The NVT story)

Figure 1 illustrates that varieties with the highest average grain yields also have the lowest grain protein contents. Conversely, varieties with the lowest grain yield achieved the highest grain protein. This result strongly supports the hypothesis that nitrogen supply has not been sufficient to ensure that grain protein content is maintained for the higher yielding varieties. Rather, for these elite varieties, protein content is diluted by higher levels of starch deposition during grain fill. This hypothesis can be confirmed further by comparing the protein yields of each of the varieties. The protein yield (kg of protein per ha) of each variety can be calculated by multiplying the grain yield of each variety by its corresponding protein percentage (Figure 2). This figure allows us to more fairly compare the relative nitrogen use efficiency of each variety. We can then answer the question: "Which, if any, varieties extract and mobilise nitrogen more effectively and therefore provide growers with greater overall protein production?" It was found that the majority of the varieties from this trial performed within a narrow range of just 5 kg of protein per ha, except for Correll$^{\Phi}$ that was both low yielding and low protein, and Espada$^{\Phi}$ and Estoc$^{\Phi}$ which appeared to have slightly higher NUE.

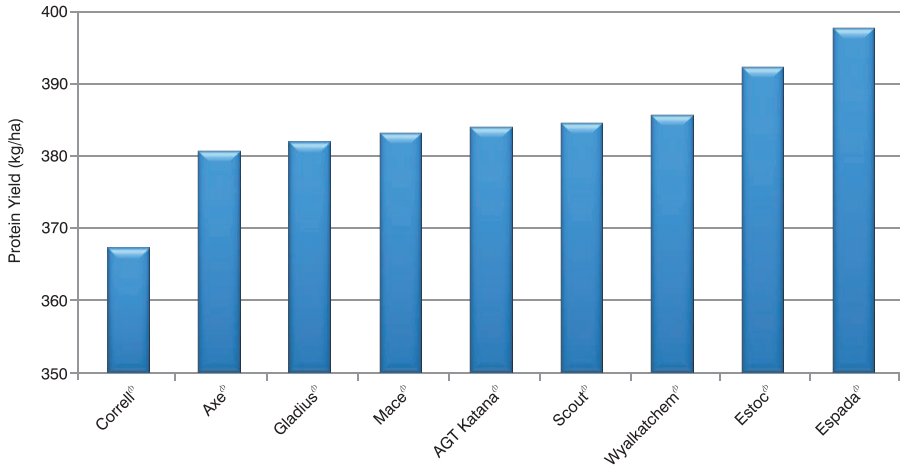
Figure 3. The average nitrogen response in the eight NUE experiments.



Are these varieties responsive to nitrogen?

With the NVT data we can therefore conclude that most varieties produce a similar amount of grain protein per hectare, but that higher yielding varieties are usually the most profitable because growers are paid more for total grain production rather than grain protein percentage. However, an important question still remains. Do new elite yielding varieties respond differently to nitrogen application, and can growers use this to their advantage?

Figure 2. The average protein yield of nine important varieties present in all South Australian NVT's during the 2009 to 2012 period.

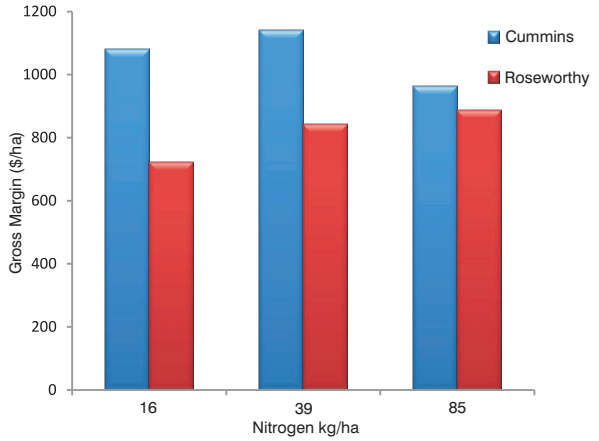


The average nitrogen response in the eight NUE experiments is illustrated by Figure 3. In the eight NUE experiments that AGT has run in SA over the last four years, a grain yield response to nitrogen application was observed six times. In five of these six experiments, the response was positive. However, at Pinnaroo in the dry season of 2012, increased nitrogen application actually lead to a reduction in grain yield. On average across the eight experiments, grain yield increased by 2.6 kg/ha for every kg of N applied above the lowest rate (16 kg/ha). This response is only half that

required to be economic, if one kg of nitrogen costs $1.30 (Urea $600 tonne) and a kg of wheat is worth $0.25 (long term APW price $252), a response of 5.2 kg/ha for every kg of N applied is required to break even for the cost of nitrogen alone, without the cost of application. Interestingly, across these six experiments, varieties only differed in their grain yield response to nitrogen application at three sites: Pinnaroo in 2009, Mintaro in 2010 and Roseworthy in 2011. When these three sites were then re-analysed as one dataset, we saw that nitrogen response was consistent across sites. This demonstrates that the response to nitrogen is entirely due to the inherent genetic response of the varieties and not the interaction between variety and location.

At the three sites where varieties differed in their response to nitrogen, Mace$^{\phi}$ had the greatest response to nitrogen with a grain yield increase of 7.5 kg/ha for every kg of N applied, while Yitpi$^{\phi}$'s response was the poorest at 6.9 kg/ha for every kg of N applied. Mace$^{\phi}$'s response to nitrogen was also more linear than Yitpi$^{\phi}$'s which tended to plateau off at higher rates of N application. In other words, even with the addition of more nitrogen, Mace$^{\phi}$ maintained its nitrogen use efficiency, while the other varieties became less efficient at using nitrogen as more nitrogen was applied. When protein, grain size, test weight and black point were used to calculate relative return on nitrogen application in 2011, Mace$^{\phi}$'s return (adjusted for the cost of N application) tended to be maximised at the moderate (Cummins) or high (Roseworthy) rates of N application (figure 4).

Figure 4. The gross margins achieved by Mace$^{\phi}$, when grown under three different nitrogen regimes at Cummins and Roseworthy.



What impact does nitrogen have on grain size, screenings and test weight?

Although increased nitrogen application generally increases grain yields there are potential negative implications for physical grain quality that need to be considered. Increased nitrogen application reduced thousand grain weights in all eight experiments with significant interactions between variety and nitrogen treatments in seven of the eight experiments. Although this impact on grain size appears to be very strong, the percentage of screenings, which is the receival standard at the silo, only increased as a consequence of nitrogen application at three of the experiments. Higher nitrogen application reduced test weight in three and increased test weight in one experiment. There were significant interactions between variety and nitrogen treatments for test weight in four experiments.

What does this mean?

- Claims of 'high protein achievement' should be treated with caution by growers – high grain protein concentration (%) is usually associated with lower grain yield achievement and therefore lower financial returns
- Although it can be disappointing to miss out on higher quality grades due to lower protein concentration, growing higher yielding varieties has been shown on average to increase return through higher productivity
- Other receival standards such as screenings loss, black point and sprouting susceptibility, as well as test weight are probably more important than protein concentration to take into consideration when selecting wheat varieties
- Some wheat varieties, such as Mace$^{\phi}$, do seem to respond more strongly to nitrogen application, suggesting that growers may be able to apply greater nitrogen to these varieties as a way to extract greater returns

Acknowledgements

The authors acknowledge Neale Sutton (Australian Crop Accreditation System Limited) for supplying the NVT grain yield and physical grain quality data.

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