What Drives Grain Protein?

Understanding protein levels in Western Australian wheat

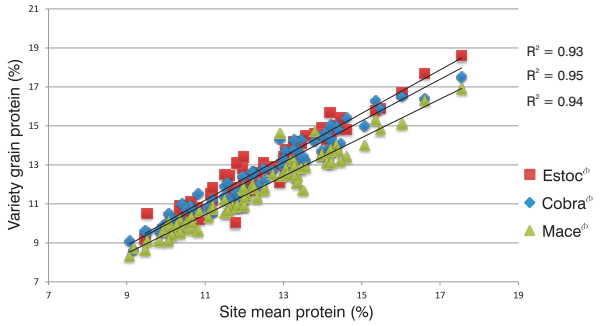
Background

Grain protein is a key factor in baking and noodle quality and the level achieved by a wheat crop contributes to the grade it is accepted into at receival. Recently, the release of new wheat varieties with improved grain yield has generated industry discussion about a related lower grain protein achievement. Anecdotal evidence has suggested that some varieties have greater ability to accumulate grain protein than others. In wheat, nitrogen taken up by the plants is used for growth (biomass production) and during reproductive development, either remobilised within the plant or directly transported to the developing grain to be stored as protein.

Understanding protein achievement

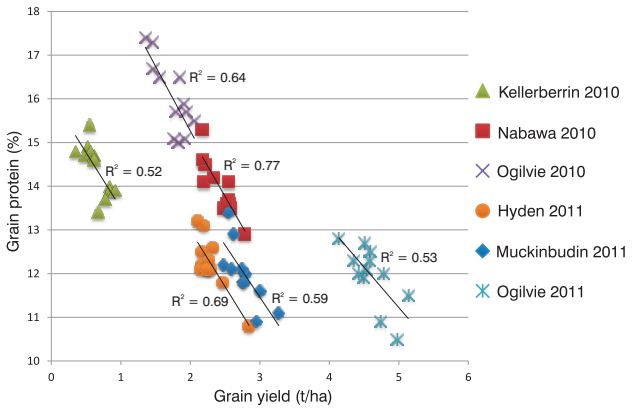
Figure 3 shows the protein achievement of three varieties plotted against the mean protein achieved by all varieties

Figure 3. Protein achievement by three varieties plotted against site average protein percentage. Data presented from all sites conducted by the National Variety Trials (NVT) across Western Australia in 2010 and 2011



at that site. Estoc[Φ] looks to be a higher protein achiever than Cobra[Φ] and Mace[Φ], with Mace[Φ] generally achieving lower protein. Although this graph looks to be conclusive in terms of showing genetic differences between wheat varieties for their ability to accumulate protein, it does not account for differences in grain yield that contributes to final protein achievement through what is commonly called a 'dilution effect'.

Figure 4. Relationship between grain yield and protein level of twelve West Australian varieties in six National Variety Trials in 2010 and 2011



The 'dilution effect' explained

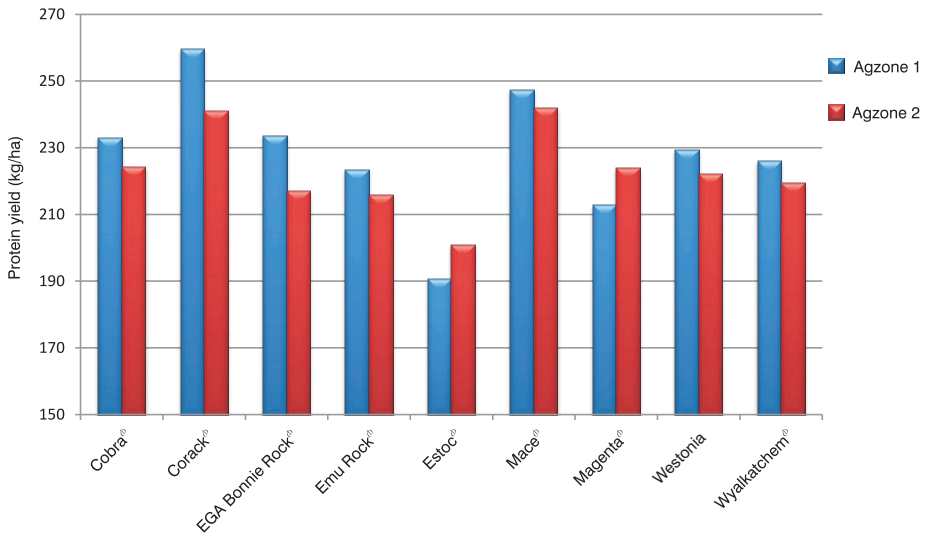
In the wheat plant, a key driver of grain yield is the number of grains set and the final size of the grains formed (see Bennett et al. 2012 and Zhang et al. 2008 for further information on this). Varieties of course differ in the number of grains set and the extent to which they are filled as these are the main components of grain yield. Therefore, nitrogen (the main component of protein) is generally distributed amongst a differing number and/or size of grains between different wheat varieties. This is usually called the nitrogen or protein "dilution effect". That is, in higher yielding plants the nitrogen available to a given plant is distributed amongst a greater number of grains or within larger grains, therefore diluting the protein concentration in each grain. A large number of scientific studies have demonstrated this "dilution effect" (for example, Simmonds, 1995, Terman et al., 1969 and Whitfield and Smith, 1992), where higher yielding varieties tend to produce a lower percentage of grain protein when grown under the same conditions as lower yielding varieties. This relationship can be observed in Figure 4, which shows the strong correlation between grain yield and grain protein content at various yield levels, using National Variety Trial data from 2010 and 2011. It can be clearly seen that at every site the higher the yield the lower the protein.

Yield and protein relationship

Given this strong negative relationship between grain protein percentage and grain yield, protein levels need to be considered in conjunction with grain yield when

determining how a variety accumulates protein. Some people might say that if a variety produces low grain protein that it is a low protein achiever but this statement may in fact be very incorrect or misleading. A simple way of determining the real protein achieving ability of a variety is to look at protein yield. 'Protein yield', expressed in kilograms of protein per hectare, is calculated by simply multiplying grain yield by protein percentage or more simply is the amount of protein harvested from a hectare of crop. Figure 5 presents the average protein yield of some key varieties in Ag Zones 1 and 2 across 2010 and 2011 as an example. Estoc(ᵇ), which appeared to be a high protein achiever in Figure 3, actually was the lowest protein achiever of all the varieties presented, largely a function of its low yield in these two Ag Zones. Conversely, Corack(ᵇ), a very high yielding variety in the same trials, accumulated the highest amount of protein.

Figure 5. Mean protein yield of ten varieties in Ag Zones 1 and 2 during the 2010 and 2011 seasons.



Conclusion

Grain protein levels have the potential to influence a growers' financial return through determining the grade that their grain can be accepted into. However, claims of high protein achievement should be treated with caution by growers when assessing varietal performance, as high grain protein concentration (%) is more often than not associated with lower grain yield. The full financial return that takes into account both yield and protein, as well as other factors including likely downgrading due to blackpoint, sprouting, small grain or test weight, needs to be considered when choosing varieties. Careful management of inputs, such as nitrogen, will maximise the grain yield of new, elite wheat varieties. Given that grain yield is ultimately the key determinant of financial return in Western Australian farming systems, this should provide greater returns than selecting varieties based on their perceived grain protein accumulation capacity.

References

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