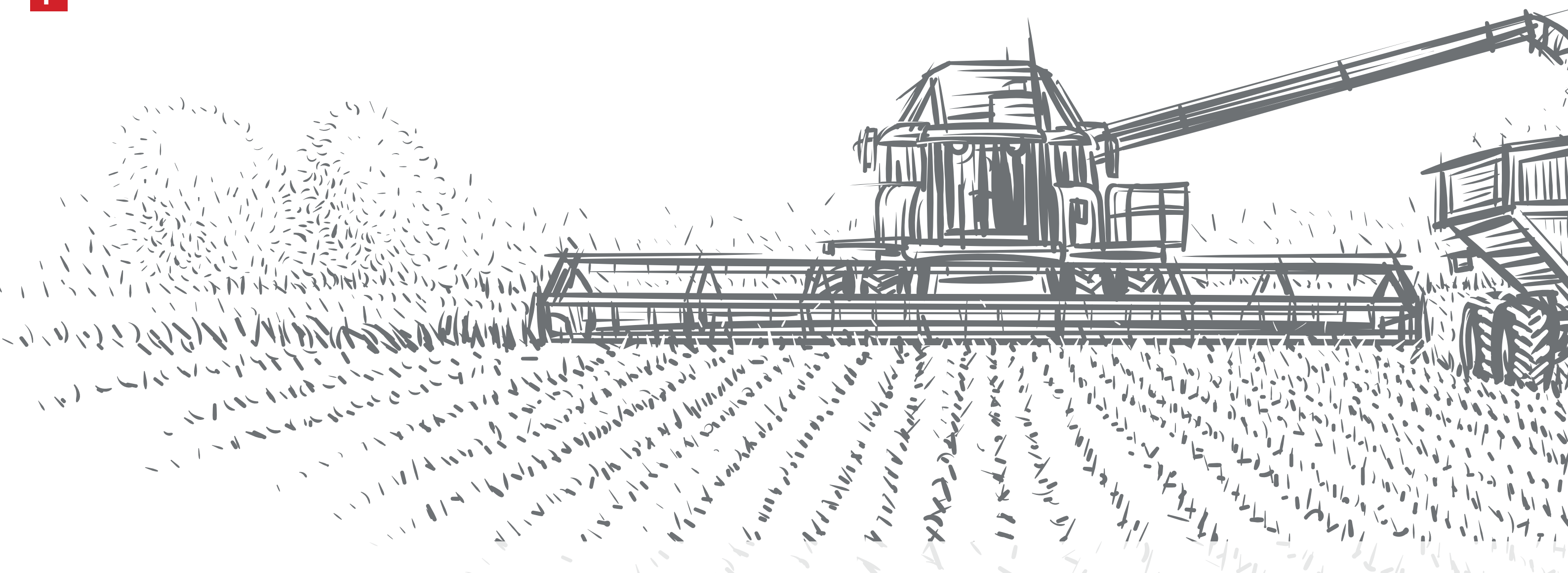
F



Measuring protein directly on the combine

by Phillip Clancy, Next Instruments, Australia

Farmers have commented that if they bought everything that was going to save them money, then they would go broke. No wonder farmers are sceptical about new claims from suppliers that their new product, invention or service is the next big thing in agriculture. This article sets out a number of research findings going back for more than 50 years about the importance of getting the yield and protein balance correct in cereal crops.

What is the yield and protein balance?

The growth and development of plants undergoes a number of stages; emergence, tillering, flowering and filling. Water is the major driver for successful plant and seed development. There are many other nutrients that influence the plants development, but nitrogen is definitely the next most important driver for plant development.

The primary objective of all plants is to reproduce by producing seeds to carry forward the genetic information in the next crop. Plants are programmed through millions of years of evolution to modify the plants growth cycle to ensure that some seeds are produced to procreate the next crop.

As such, if there are insufficient nutrients available at the various stages of development, then the plant will reduce the number of stems, heads or even seeds to ensure that what nutrients are available are used to ensure that seeds are eventually produced and released. These changes to the plant's development effect the yield potential for the plant. Nitrogen is the key nutrient that dictates how the plant will make these changes during the stages of the plant development.

Proteins are composed of approximately 17.5 percent of nitrogen by weight. As such, measuring the protein in the seeds at harvest provides a direct measurement of the availability and uptake of nitrogen in the plants. By measuring protein in real-time on a combine harvester and combining the data with the yield and GPS coordinates, provides a means of generating field maps including: protein, yield, nitrogen removal, gross margin and protein/yield correlation.

What is the significance of protein to yield balance?

In 2013, Greg McDonald and Peter Hooper, University of Adelaide, School of Agriculture, wrote an article for the GRDC, titled, 'Nitrogen decisions – Guidelines and rules of thumb'. They referenced a paper written in 1963 by JS Russell for the Australian Journal of Experimental Agriculture and Animal Husbandry, where he "described the idea of using grain protein concentration to assess the likelihood of N responsiveness in wheat cropping systems. He suggested that yield responses were most likely when grain protein concentration was < 11.4 percent".

McDonald and Hooper went on to say that, "based on recent trial data, the general conclusion still appears valid: 100 percent of all trials where grain protein concentration of the unfertilised control was <8.5 percent were responsive to N and would have given yield response of 14kg/ kg N."

"When grain protein concentration was >11.5 percent, only 32 percent of the trials were responsive to N and the mean yield response was zero". They concluded, "while this relationship can't be used to make in-season N decisions it may be useful in helping to assess the degree of N stress during the previous season and making post-harvest assessments of N management strategies, which can help in future planning."

Steve Larocque, Beyond Agronomy, Alberta, Canada, publishes a newsletter that is read by more than 8000 precision farmers and agronomists. Mr Larocque pointed out in his newsletter that there is a fine balance in applying nitrogen to a barley crop where the objective is to optimise the yield

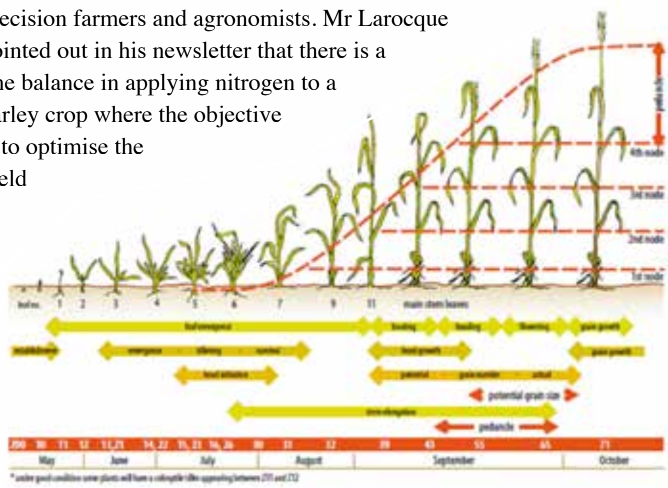
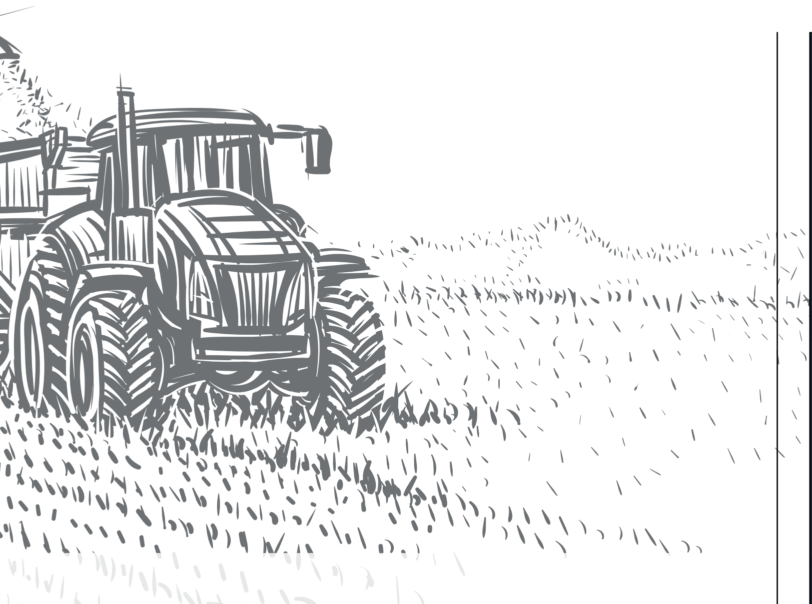


Figure iii: Life cycle of the wheat plant.
Source: Based on M Stapper, 2007.



and restrict the protein to less than 13 percent.

He states, “the hard part is finding the right nitrogen rate to produce maximum yield with a protein that falls below 13 percent but higher than 12 percent. When you’re malt protein is lower than 12.5 percent you know you’re leaving yield on the table. If you shoot too high you end up with high protein and no malt selection.” Mr Larocque referred to the balance as the “sweet spot” where the yield was optimised and the protein grade realised the highest crop payments.

If the protein concentration in the final grains seeds is less than 11.5 percent in wheat and 12 percent in barley then the crop has not had sufficient nitrogen available to achieve the full yield potential. The soil nitrogen may have been low or it may not have been accessible to the plant at the correct times. Nonetheless, all the research supports the premise that yield response would have been positive to N fertilisation if the protein levels in the grains is less than 11.5 percent.

Relationship between nitrogen and protein

Protein is a generic term used to characterise a large class of bio molecules that have common chemical characteristics. In truth, proteins are polymer chains formed from peptides which are made up of amino acids. Humans and animals eat proteins so that they can digest the proteins and release the amino acids from them in order to rebuild body tissues, e.g. skin, muscle, organs etc. Plants such as wheat, soy beans, corn, rice etc make amino acids which after digestion in the human or animal gut, then go to make peptides which then go to make proteins.

The proteins found in the seeds of a plant have approximately 16-18 percent nitrogen in them. As such for every load of grain stripped from a field, then there is a portion of the load that is protein and nitrogen.

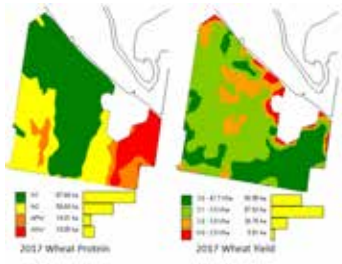
For example, if the protein content of the soy beans is 20 percent then 200kg of each tonne of grain is protein. And out of this 200 kg of protein there is 16 percent nitrogen, i.e. 32kg. This means that for every tonne of soy bean harvested, 32kg of nitrogen is removed from the soil. Of course, nitrogen is found in other parts of the plant tissue, but in the majority of plants nitrogen ends up in the seeds as protein.

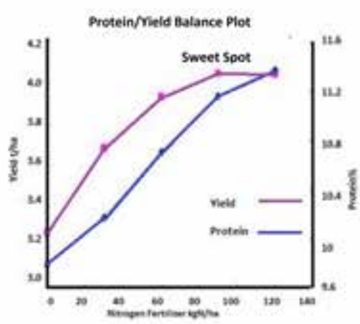
The more complete story

Yield maps measure the mass of grain that is stripped per acre or hectare. Yet, for the last 25 years, yield maps have been used as a proxy for nitrogen uptake. Protein maps provide an assessment of the plant’s performance as a function of the available nitrogen. Together protein and yield maps provide a more complete picture of the nitrogen uptake and availability across the fields.

In a perfect world there needs to be an instrument that measures the nitrogen in the soil throughout the plant's growth and development cycle. At this time, there is no instrument that can perform such a measurement in real-time. However, an On Combine NIR Analyser, such as the CropScan 3300H, is designed to measure protein, oil and moisture in grain and oil seeds as they are harvested.

Since protein is a direct measure of the nitrogen in the seeds, then this instrument can be used to generate a nitrogen removal map.





Case studies

Broden Holland, Young, NSW, installed a Model 3000H Grain Analyser with his new CaseIH 7240 Combine, leading up to the 2016 harvest. The Model 3000H collected protein, oil and moisture data at approximately every 15-20 metres across their 4500ha farm where they grow wheat and canola.

Combining historical yield data and protein data, they have been able to develop three zones to apply urea at three different rates as top dressing. Broden quickly linked low protein response to crop performance, he developed a simple application strategy:

By simply converting protein data collected from the Model 3000H into a zonal urea application, he was able to increase the protein levels across the fields. In 2016, the field had only .21 hectares that produced H1 grade wheat. In contrast, in 2017, 87.9 hectares realised H1 grade. As well, there were 38.8 hectares that realised APW grade in 2016 and H2 grade in 2017. A rough estimate of the increase in crop payments from this field were $2482, or $13.60 /ha.

Assessing the yield and protein response post-harvest is critical to assess whether the VRA had a positive or negative outcome. The 2017 yield response shows to be a 40 percent reduction in the variation in yield, across the field, as compared with the 2016 yield map.

Adam Gurr, Brandon, Manitoba, also installed a CropScan 3000H in 2017 onto his Claas Lexion combine. His soybean maps provide examples of how protein varies in crops other than cereals. The protein varies across this field from 20 percent to 37 percent, with an average of 32 percent for loads delivered to the elevator.

It is generally expected that soybeans will exhibit an inverse relation between yield and protein, i.e. the dilution theory.

In conclusion

Farmers generally farm for 40 harvests. As such they only get 40 chances to "get it right", so to speak. In order to change things, then they need tools to be able to measure the parameters that influence their crops. The CropScan 33300H On Combine Analyser provides the missing piece of the PA puzzle, the nitrogen uptake and availability.