Making Better Nitrogen Fertilizer Decisions

Yield Gap in Australia

The term Yield Gap refers to the difference between the actual Yield and the potential Yield that can be achieved across a farm or field. Across the world, the Yield for wheat crops varies from approximately 1T/ha to 8.7T/ha. Australia has the lowest average Yield across the country whereas Europe has the highest. Table 1 shows the data from the ABARES [1] on world and Australian wheat production. GRDC [2] have reported that the average Yield Potential for Australia should be 3.4t/ha. As such, Australian wheat farmers are producing around 50% of the wheat that is the potential to produce.

	Units	2017-18	2018-19	2019-20F	2020-21F
World					
Area	Million ha	221	215	218	223
Yield	t/ha	3.4	3.4	3.5	3.4
Production	Mt	759	732	764	766
Australia					
Area	Million ha	10.9	10.1	10.1	12
Yield	t/ha	1.9	1,7	1.5	1.8
Production	Mt	20.9	17.3	15.2	21.3

Table 1. World and Australia wheat production, 2017 to 2021.

Table 2. presents an estimate for the potential increase in farm income across Australia if the Yield Gap could be reduced from 50, 40, 30, 20, 10, 0%.

Reduction in Yield Gap	Current Value @$300/T	Yield Gap 40%	Yield Gap 30%	Yield Gap 20%	Yield Gap 10%	Yield Gap 0%
Wheat Tonnage	25MT	30MT	35MT	40MT	45MT	50MT
Wheat Value, $billion	A$7.5	A$9.0	A$10.5	A$12.0	A$13.5	A$15.0
Barley Tonnage	6MT	7.2MT	8.4MT	9.6MT	10.8MT	12.0MT
Barley Value $billion	A$1.8	A$2.16	A$2.52	A$2.88	A$3.24	A$3.6
Total Increase Tonnes	31MT	6.2MT	12.4MT	18.6MT	24.8MT	31MT
Total Increase Value $billion	**A$9.3**	**A$2.0**	**A$3.7**	**A$5.6**	**A$7.4**	**$9.3**

Table 2. Potential Farm Income Increases by Closing the Yield Gap

How to Close the Yield Gap.
Research around the world have shown that the Yield Gap can be reduced by applying Nitrogen fertiliser to those zones in the field where the Yield was Nitrogen limited and the Protein content of the grains was less than 11.5%. Figure 1. Is a plot of the response in Yield and Protein to the application of additional Nitrogen fertilizer to 10 varieties of commercial wheat varieties by Brill et al in 2012. It shows that the Yield reaches a maximum at additional 90kg/ha of Nitrogen fertilizer, where as the Protein content continues to increase.

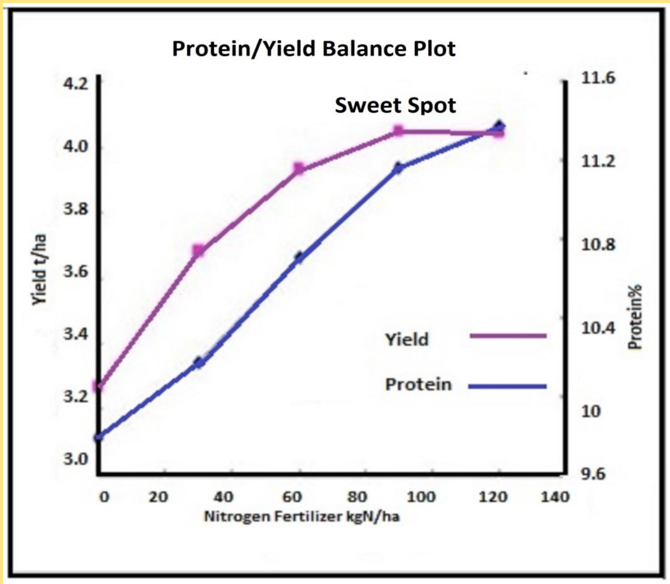

Fig 1. Grain yield (t/ha) and protein concentration (%) from 10 wheat varieties with 0, 30, 60, 90 and 120 kg/ha applied nitrogen in a trial at Parkes in 2011. (Brill et al, 2012, Comparison-of-grain-yield-and-grain-protein-concentration-of-commercial-wheat-varieties)

ABARES data shows that the average Protein content for Australian wheat is 9.5%. As such 50% of wheat cropping land in Australia is under producing in terms of Yield. The rate of increase in Protein is approximately 1.4%/100kg and Yield is approximately 1T/ ha/100kg.

To Close the Yield Gap for Australian wheat crops, then farmers will need to increase their application of Nitrogen fertilizer.

James Hunt, Latrobe University, and James Murray, BCG, recently wrote: "Australian wheat yields are only half what they could be for the rainfall received. Nitrogen (N) deficiency is the single biggest factor contributing to this yield gap."[3] The article goes on to state; "N fertiliser is a costly input and use of it increases cost of production and value-at-risk for growers. Growers fear that over-fertilisation will result in 'haying off', which reduces both yield and quality. There is also concern that overapplied fertiliser not used by crops is lost to the environment by leaching, volatilisation and denitrification." The challenge is to predict the amount of N fertilizer required.

Measuring Nitrogen
Nitrogen in the soil is measured prior to sowing. Soil Nitrogen sets the N bank available to the plant. The amount of fertilizer to supplement the N bank can be estimated using a Nitrogen Removal computation based on the previous year's Yield and average Protein.

However, Protein and Yield vary significantly within a field and across a farm. As such the Nitrogen Removal can only provide an average for each field. It cannot identify which zones in the field require more Nitrogen than other zones.

Satellite Imagery and NDVI provide a qualitative assessment of the crop's development from Stem Elongation and Leaf Development to Flowering. Top Dressing N fertilizer based on NDVI measurements is a popular fertilization strategy, however NDVI maps do not differentiate between zones that are Nitrogen deficient vs water problems vs soil problem vs disease. As well NDVI does not provide a quantitative measurement of how much N fertilizer needs to be applied.

An On-Combine NIR Grain Analysers measures Protein in grains and oil seeds as they are harvested. Since Proteins contain 17% Nitrogen by weight, then measuring Protein in the grains is a direct measurement of Nitrogen Availability and Uptake by the grains. By combining Protein and Yield along with GPS coordinates, then a new tool is available that identifies the Nitrogen limited zones. Figure 2 shows the Protein, Yield and Protein/Yield Correlation Quadrant (PYCQ) map for a wheat field in Western Victoria.

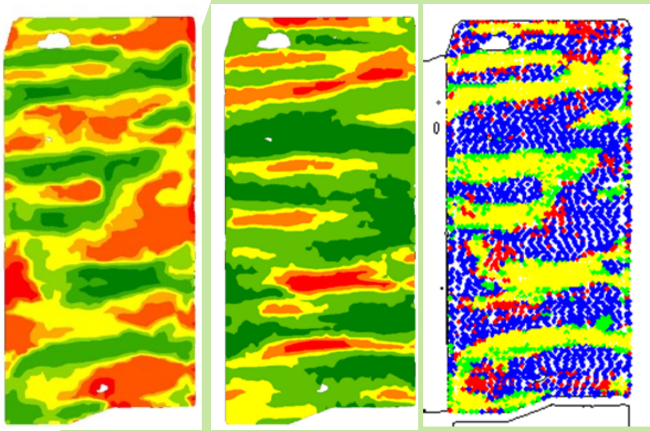

Figure 2 Yield Map | Protein Map | Protein/Yield Correlation Quadrant

The Protein/Yield Correlation Quadrant maps identifies 4 Performance Zones:

Green:	High Yield/High Protein
Blue:	Low Yield/High Protein
Yellow:	High Yield/Low Protein
Red:	Low Yield/Low Protein

The Yellow and the Red zones show in the PYCQ map are where a Positive Yield Response can be achieved by applying higher rates of Nitrogen fertilizer. The Green zones are where the Yield and Protein are optimized, i.e., the Sweet Spot. It may be possible to decrease the Nitrogen rate in the Green zones if high protein is not required by the market. The Blue zones are where other factors have caused a Low Yield. These factors may be water and/or soil issues. Applying more fertiliser into the Blue zones will most likely not increase Yield. However around 30% of this field are Yellow and Red zones which will respond to the application of more Nitrogen fertiliser.

How much Nitrogen fertilizer to apply?

A WA farmer conducted strip trials on a wheat field where the Protein content was on average 8.5% with a Yield of 3.7 t/ha. He increased the rate of Flexi N liquid fertiliser by 0, 50, 100, 150 and 200 litres/ha. The increase in Yield and Protein are show in table 3.

A plot of the Protein and Yield responses vs Nitrogen application rate is shown in figure 3. The slope of the line shows the response rate for Protein and Yield. It was calculated that 100 Litres/ha of Flexi N would result in an increase in Yield of 0.6 t/ha and Protein of 0.9%.

For this WA farmer, an additional 300L of Flexi N would have increased his Protein to 11.5% and the Yield to approximately 6.3T/ha. The potential increase in income for this farmer was calculated at $298/ha after the cost of the additional fertiliser was taken out.

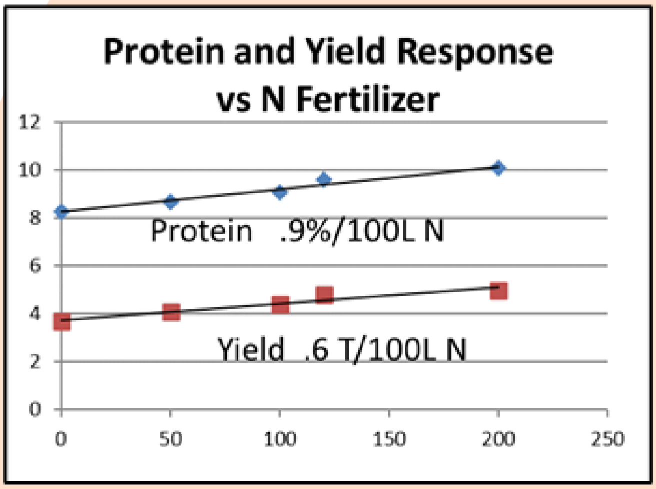

Figure 3. Plot of Protein and Yield Response to additional N Fertilizer

Discussion:

The above analysis makes it look simple to "Close the Yield Gap", but nothing is ever exactly like what appears on paper. Water and Nitrogen are the two major nutrients that drive crop production, however other nutrient also impact Yield. The above discussion assumes that there is sufficient moisture available to ensure a full crop and the discussion does not consider other nutrients. There is a strategy that is recommended for using the Protein/Yield Correlation map as a new agronomic tool.

Year 1:

- Measure the Protein, Oil and Moisture across your fields.
- Capture grade premiums based on segregation and blending
- Generate field maps.

Year 2:

- Apply more N fertiliser to the Yellow and Red zones.
- Capture grade premiums based on segregation and blending
- Generate field maps.

Year 3:

- Fine Tune the VRF applications in the Yellow and Red Zones
- Capture grade premiums based on segregation and blending
- Generate field maps.
- Get a Soil Scientist to diagnose the problems in the Blue zones

Year 4 and 5:

- Correct the soil problems
- Capture grade premiums based on segregation and blending
- Generate field maps.

The result should be a far more consistent and higher Yield across each field and an optimized quality based on Protein and Oil content.

NextInstruments

Next Instruments Pty Ltd
B1 366 Edgar Street, Condell Park, NSW, 2200, Australia
Tel: +612 9771 5444, Fax: +612 9771 5255
Email: sales@cropscanag.com Web: www.cropscanag.com