On-the-go Protein Testing

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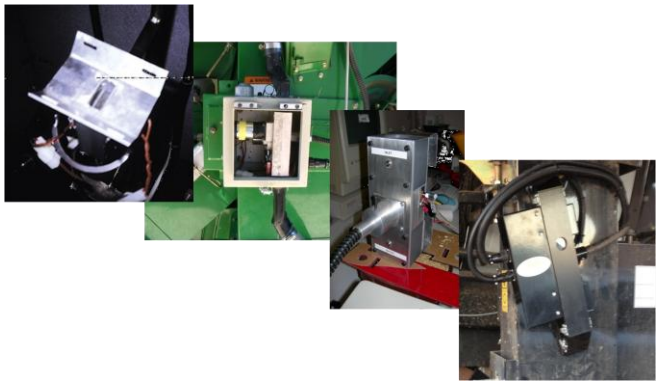
Introduction:

In 2001, the first Near Infrared analysers was fitted to combine harvesters to measure protein and moisture in real time as grain was being stripped in the paddock. This first system worked in reflectance, where as the grains industry had almost universally adopted transmission as the method of choice for measuring whole grains of wheat and barley. In Australia, the trials of this early on-the-go protein analyser were not well received and the product was withdrawn.
At the same time, NIR Technology Systems, Bankstown, NSW, began the development of a transmission based system to mimic the technology used by the grains industry at receival silos. The first prototype used a diode array NIR spectrometer, a remote sampling head and a fibre optic cable to connect the sampling head and the spectrometer. Over the next 12 years the prototype has evolved into the CropScan 3000H On Combine Analyser. The developments have been almost exclusively in the design of the remote sampling head since the technology depended on a consistent flow of grain from the thrasher. NIR Technology Systems has developed 4 remote sampling heads over the last 11 years as listed below:

2002 CropScan 2000H with Plunger Sampling Head
2003 CropScan 2000H with Oscillating Vane Sampling Head
2004 CropScan 2000H with Double Brush Sampling Head plus Touch Screen PC
2013 CropScan 3000H with Flap Sampling Head plus Touch Screen PC



The new CropScan 3000H On Combine Analyser is the latest system developed by NIR Technology Systems. 9 systems have been installed into combine harvesters across the Australia during the 2013 harvest.

Description:

Figure 1. shows a schematic of the CropScan 3000H. Figures 2, 3 and 4 show pictures of the Remote Sampling, the NIR Spectrometer and the Touch Screen PC that make up the system. The Remote Sampling Head is mounted onto the harvester's clean grain elevator. A whole is cut into the up side and the down side of the elevator. As grain travels up the elevator, it falls through the top whole and fills the sampling chamber in the Remote Sampling Head. Steel flaps at the bottom and the top of the sample chamber control the flow of the grain in and out of the chamber.

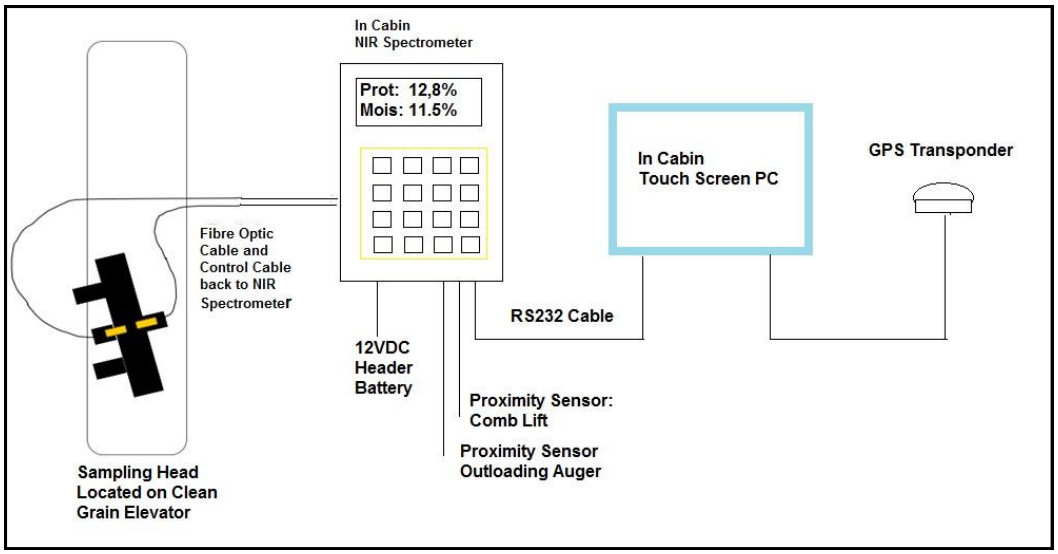


Figure 1. Schematic of the CropScan 3000H On Combine Analyser

Figure 2. Remote Sampling Head shown as fitted to a clean grain elevator

Figure 3. NIR Spectrometers located in the cabin.

Figure 4. Touch Screen PC mounted in cabin

The grain is trapped in the chamber where light passes through the grain sample and is collected by a fibre optic cable on the opposite side of the chamber. The fibre optic cable connects the Remote Sampling Head to the NIR Spectrometer which is located inside the cabin of the combine. The light that passes through the grain is transmitted back to the spectrometer where it separates the light into the NIR spectrum and applies the calibration models for protein, oil and moisture. The flap opens and the grain drops out and returns to the down side of the elevator. The chamber refills with grain and the next NIR spectrum is collected. A 100% reference scan is collected every 30 minutes by closing the top flap and opening the bottom flap so that the chamber is completely empty. The system then collects the 100% reference scan so that lamp drift or changes in the system temperature can be compensated for.

The NIR spectrometer is based on a flat field spectrograph and a silicon photodiode array detector. The advantage of the diode array spectrometer lie in that there are no moving parts. The spectrometer is robust enough to work in the harsh environment of a combine harvester, compact enough to fit inside the cabin of the combine and powerful enough to provide data as good, if not better, than a bench top analyser used in a laboratory. The fibre optic cable allows the NIR spectra to be collected remotely thus removing the spectrometer from the sampling head.

The Touch Screen PC controls the entire system. Running a program developed by NIR Technology Systems, the PC controls the flaps, the lamp, the sensors on the output auger and the comb lift. The CropScan 3000H software computes the protein, moisture and oil data for each sample and the results are presented to the combine operator in a number of formats:

- Real time paddock map for protein
- Scan by scan protein, oil and moisture data along with a moving average of 5 readings and a bin average of the grain stored in each bin load.
- Trend plots for protein and moisture.
- Running bin averages.

Figure 5, 6 and 7 show the different data formats.

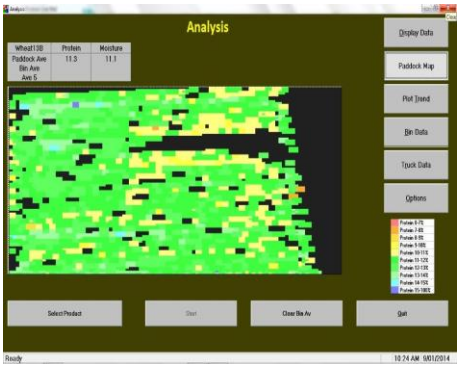


Figure 5. Real Time Paddock Map

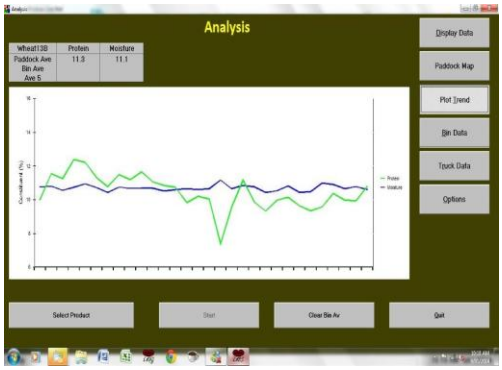


Figure 6. Trend Plot

Wheat2011	Protein	Moisture
Paddock Ave	10.8	10.5
Bin Ave		
Ave 5		
Bin62		
Bin61	10.1	9.5
Bin60	9.5	9.5
Bin49	9.6	9.3
Bin48	10.7	9.2
Bin47	11.7	9.6
Bin46	10.2	9.5
Bin45	9.8	9.6
Bin44	10.2	9.5
Bin43	10.0	9.3
Bin42	11.3	9.2
Bin41	10.5	9.4
Bin40	10.2	9.6
Bin39	10.3	9.5
Bin38	10.3	9.6
Bin37	10.7	9.6
Bin36	10.4	9.8
Bin35	11.8	9.7
Bin34	11.8	9.7
Bin33	11.1	9.8
Bin32	11.0	9.9
Bin31	11.1	9.7
Bin30	10.9	9.8
Bin29	12.6	9.7
Bin28	12.4	9.8

Figure 7. Bin Average Plots

Trial Results

Calibrations were developed using a CropScan 1000B Whole Grain Analyser, a benchtop analyser based on the same NIR spectrometer used in the CropScan 3000H. Hundreds of samples of wheat, barley, canola and sorghum collected from the 2012 harvest, were scanned on the CropScan 1000B. A Partial Least Squares Regression analysis was used to develop PLS calibrations for protein, moisture and oil in the various grains. These calibrations were downloaded into the CropScan 3000H's PC. 5 reference samples of each grain were used to slope and bias the calibration models so that they read accurately.

Figure 8 and 9 show the slope and bias plots for a protein and moisture in wheat.
Once the calibrations are setup, the CropScan 3000H is ready to be used in the field. Figure 10 shows data collected from a paddock in Wakeri, SA.

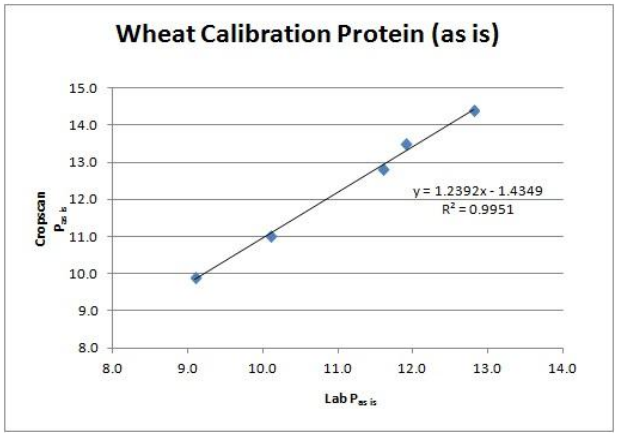


Figure 8. Wheat Protein S&B Plot

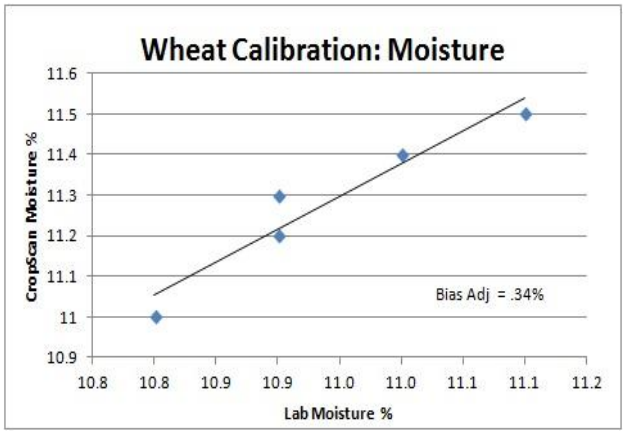


Figure 9. Wheat Moisture S&B Plot

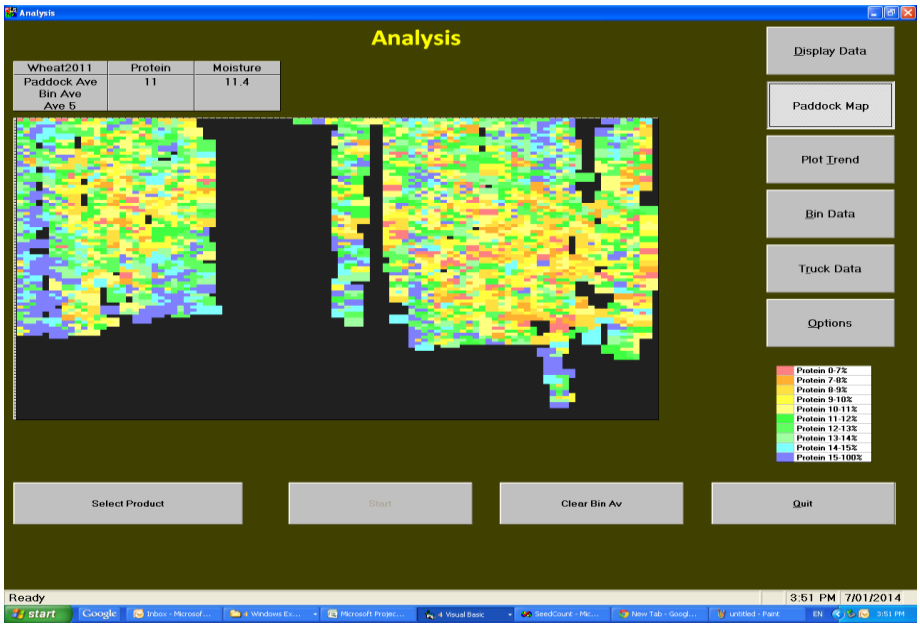


Figure 10. Protein Paddock Map generated from a paddock in Wakeri, SA.

The CropScan 3000H is designed to measure the grain and then return it to the clean grain elevator. As such it is difficult to collect samples from the combine and then correlate the data to a laboratory based analysis of the samples. However the bin average of each bin load was recorded in the system's PC. Growers who have used the CropScan 3000H have reported that the truck averages are generally within 0.1% to 0.2% of the protein and moisture reported at the receival silo. Since many of the growers stored their grain on farm, then they did not have correlation data between the local receival silo and the CropScan 3000H.

User Comments:
Ashley Wakefield crops wheat, barley and canola on the York Peninsula, SA. Ashley has been involved with the development of the CropScan 2000H since 2005 and this year updated to the new CropScan 3000H. Figure 11 showed a paddock map produced by the CropScan 3000H software in real time as wheat was being stripped. When asked to describe his experiences with the CropScan 3000H, he had the following comments:

After a few years trialing the 3000H we have now got a reliable and accurate system that is easy to install and run. The software has come a long way and is now intuitive and very user friendly. The applications are numerous depending on your focus. I have also found that once calibrated it is within .1-.2 of the silo reading.

Luke Follet, Euston, NSW, has used a CropScan 1000G On Farm Analyser for a few years to measure protein and moisture in wheat and barley load by load. He traded in his CropScan 1000G for a new CropScan 3000H so that he could get real-time data as he stripped his crops. Figure 13 shows data from his wheat paddocks. Luke made the following comments about the CropScan 3000H.

" Firstly I would like to say that the 3000H has been a huge benefit to our business. We know that we cannot produce huge yields so the quality of our product has to be sorted. As you know we have standing silos with one auger and to segregate the product in the paddock before it reaches the silos helps us no end.

The mechanics of the machine are very simple with gravity doing most of the work. Being fitted on the clean grain elevator the machine opens a trap door on the delivery side (upside) then after the sample has been taken a trap door opens and lets it go on the down side.

The installation process for me was quite easy, with Matt doing all the work. The process of the machine going into the header was very clean and neat and the appearance of the machine looks like it is meant to be on the header.

We send our grain to a flour mill 350 kms from our farm and the accuracy of the 3000H is within 0.2 percent protein of their machine. Their machine has the final say so it is good to know that when we send a truck down it does not get rejected.

The software support that comes with the 3000H is second to none, with any problems experienced being quickly fixed. The graphics on the screen are simple and coherent to be watching while harvesting. Also if any problems occur with the machine itself Matt is happy to be of assistance.

Conclusion:

On-the-go protein, oil and moisture measurements can now be made reliably and accurately using the CropScan 3000H On Combine Analyser. Like all new technologies, improvements are ongoing. The CropScan 3000H is the second generation of On Combine Analysers developed by NIR Technology Systems. The most significant improvements have come from the design of the new Remote Sampling Head. The 9 systems in operation throughout Australia during the 2013 harvest recorded an impressive 1,600,000 analyses. The data provided growers with the ability to sort their grain bin by bin for on farm storage as well as to segregate their grain between what they sent to the silo versus what they stored on farm.

Precision Farming practises are not every grower's objective in using an on combine analyser, however several of the 9 growers will be very keen to process their data using more sophisticated paddock mapping software and to look for the variations in protein/nitrogen across their paddocks. This may lead them to variable rate fertilisation so that they can reduce their fertiliser costs and to optimise the protein levels in their crops.

Not only can the data be logged in the CropScan 3000H's PC but the software will automatically post the data to our CropNet web site in real time. Potentially CropNet will enable growers to sell their grain directly off the header.