Yield Prophet® 2005

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Summary

Yield Prophet® in 2005 had many new features and capabilities and was delivered to 338 paddocks that were subscribed Australia-wide.

From 5 April to 1 December, 6813 reports of various types were generated by subscribers, with most around time of top-dressing.

Final simulated yields for wheat crops, using appropriately measured soil characterisation and initial soil data, fitted observed yields comparable to previous seasons (R2=0.74, 67% of simulated yields within 0.5 t/ha of observed, 98 % within 1.0 t/ha).

Yield Prophet simulates yield more accurately than it does grain protein content

However, overall accuracy for all subscribed crops was lower due to expansion into new regions with less soil characterisation data available.

The 2005 season again emphasises the importance of providing Yield Prophet with quality soil input data.

Background

Yield Prophet (www.yieldprophet.com.au) is a web interface for the crop production model APSIM (www.apsim.info). It simulates crop growth based on paddock-specific inputs of soil type, pre-sowing soil water and nitrogen, rainfall, nitrogen fertiliser applications, irrigation and climate data. Using local meteorological records, it can be used to determine the likely impact of management decisions on crop yield (see article titled 'Yield Prophet® for N fertiliser decisions' in this manual), and is a valuable tool for risk management (see 'In-crop risk management using the Yield Prophet').

2005 is the third year of Yield Prophet's commercial delivery, and 338 paddocks were subscribed to the service. Subscriptions directly involved 236 growers, 38 agronomic consultants, 8 government extension and research officers and 7 grower groups. Users generated 6813 reports from 5 April to 1 December 2005, with most demand experienced during nitrogen top-dress decision making time in August and September.

An appropriately measured soil characterisation is essential for Yield Prophet to simulate crop growth, yield and protein accurately. The plant available water capacity (PAWC) and bulk density of a specific soil type determine how much water and nitrogen within that soil is available to the crop for growth during the season (see www.farmscape.cse.csiro.au/farmscape/SoilMatters for discussion of these terms).

New features made available for the first time in 2005 included a trial barley and sorghum simulation capability (in addition to wheat), a report showing the likely impact on yield of different sowing dates and varieties, a fallow report returning the probability of plant available soil water content at sowing, a set of reports to assist with irrigation scheduling, and a nitrogen gross margin report based on applied fertiliser and grain prices.

Methods

Users registered for Yield Prophet from March until June, and were required to provide segmented soil analysis data (soil water content, nitrate, EC and pH of samples taken from 0-10, 10-40, 40-70, 70-100 cm soil depth) for their paddocks prior to sowing. Some subscribers opted to use 'Deep N' soil test results (nitrate and sometimes soil water content from 0-60 cm soil depth).

The Yield Prophet team have a 'library' of soil characterisations measured for many of the major cropping soil types found within BCG's membership catchment and other regions Australia-wide. However, in 2005 many subscribed paddocks had soil types for which there were no available measured characterisation data. In these circumstances, a soil characterisation was estimated by the Yield Prophet team based on soil type and previous rainfall and crop yields provided by growers, and any information available from existing soil surveys. This process is referred to as 'estimated soil characterisation' (ESC).

One of the major new features of Yield Prophet in 2005 was its ability to simulate barley production. In order to achieve this, parameters in the APSIM wheat module were modified to represent the growth and development of different barley cultivars based on the 2004 data from BCG's variety trial at Lubeck and DPI Victoria phenology observations from Horsham and Walpeup over a number of seasons and varieties. Many new wheat varieties were also added to Yield Prophet in 2005 based on the phenology of different varieties as stated in State Department planting guides, and there were some inconsistency in grouping of varieties by different state departments! Yield Prophet's simulation of wheat and barley development was validated at the end of 2005 using detailed data collected at the main BCG trial sites.

During the 2005 season, subscribers accessed Yield Prophet via the web, updated paddock management and rainfall information, and requested reports at will. During peak times, the time taken for a report to be available after a subscriber had generated it was very long (many hours). To prevent this from happening in the future, the Yield Prophet team have upgraded the single computer used to run simulations for much of 2005 to a 'cluster' of 26 dual-processor computers. This has increased the computing power of Yield Prophet by over fifty times, and will avoid long queue for reports in 2006 and beyond.

After harvest, all subscribers were asked to update their rainfall and management information in Yield Prophet, run a final simulation for each paddock, and report their actual paddock yields and proteins to the Yield Prophet team. Final simulated yields and proteins were compared to actual yields and proteins, and the details of this analysis are provided below.

Results

The observed yields of 151 paddocks and proteins of 116 paddocks were returned at the time of writing. Figure 1 shows a plot of simulated versus observed yields and proteins for all paddocks for which observations were reported, excluding nine paddocks which were seriously affected by disease or weeds. It shows that while Yield Prophet can account for 50% of the variation observed in yield (R2=0.50), there are many simulated yields that deviate significantly from those observed. Table 1 shows that in 54% of returned yields, there was a greater than 0.5 t/ha difference between simulated and observed values. Compared with Yield Prophet results for previous years (an R^2=0.88 in 2004, R^2=0.72 in 2003), this is a disappointing result. However, there are several good reasons for the level of error observed, mostly to do with inputs, which are discussed below. Simulation of grain protein was not as accurate as that of yield (Figure 1, Table 2). This is because in APSIM an accurate estimate of grain protein requires accurate simulation of

more processes than does yield (mineralisation, nitrogen uptake, partitioning etc.). Consequently, simulation of protein is more sensitive to error than simulation of yield, and will never be as accurate.

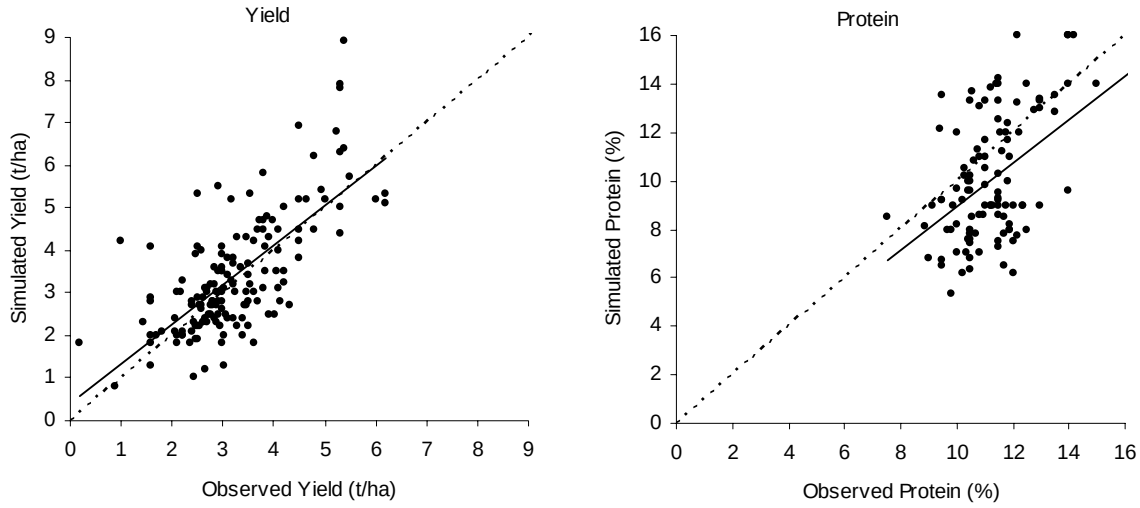

Figure 1: All returned simulated vs. observed yields and grain protein contents for Yield Prophet in 2005. A linear function (solid line - for yield y = 0.94x + 0.37, for protein y = 0.89x + 0.02) was fitted to the data points using least-squares regression (for yield R2=0.50, for protein R2=0.25). The dashed line represents y=x, or where all data points would lie if the both the simulation and observed data were perfectly accurate.

Table 1: The number of simulated yields within 0.5 and 1.0 t/ha of observed results for paddocks of different input data quality.

Data	Number of Returned Yields	Percentage of simulated yields within 0.5 t/ha (%)	Percentage of simulated yields within 1.0 t/ha (%)
All results (wheat and barley)	151	46%	76%
Measured soil characterisations and segmented soil input data (wheat and barley)	57	67%	95%
Measured soil characterisations and segmented soil input data (wheat)	46	67%	98%

Table 2: The number of simulated grain protein contents within 1 and 2 % of observed results for paddocks of different input data quality.

Data	Number of returned protein contents	Percentage of simulated protein contents within 1% (%)	Percentage of simulated protein contents within 2% (%)
All results (wheat and barley)	116	34%	57%
Measured soil characterisations and segmented soil input data (wheat and barley)	36	33%	58%
Measured soil characterisations and segmented soil input data (wheat)	28	36%	61%

A frustrating source of error in 2005 was the selection of an incorrect soil type for a paddock at the start of the season. Discrepancies between observed and simulated yields at the end of the season showed that the soil type was clearly inappropriate. This was judged to have occurred in 11% of paddocks for which observed yields were returned in 2005. About half of these paddocks were Deep N sampled (a single sample used to determine water and nitrogen in the 0-60 cm zone). The results of Deep N samples provide far less information on which to base soil type selection than the recommended segmented sampling. In many of these cases a more appropriate soil characterisation existed in the Yield Prophet soil-library and could have been used.

Another disadvantage of Deep N samples as an input for Yield Prophet was clearly illustrated this season. Deep N samples are somewhat misleading in name being only taken typically to depth of 60 cm. With the soft finish experienced in many regions, crop roots have been observed by BCG growing to a depth of 1 m or more. The default Yield Prophet set up assumes that there is no available moisture or nitrogen below the sampling zone. This means that plants probably had access to soil water and nitrogen which was not measured at the start of the season. This obviously provides crops with a considerable source of water and nitrogen that is not accounted for by Yield Prophet, and which resulted in Yield Prophet under-predicting yield and protein in many paddocks that were not sampled to full rooting depth.

One of the major differences between Yield Prophet in 2005 and previous years was the greater geographical distribution of paddocks. Yield Prophet paddocks in 2003 and 2004 were all largely within BCG's catchment area and other study regions where soils had been characterised over time. In 2005, Yield Prophet paddocks came from all over Australia (36% from Vic., 32% from SA, 20% from NSW, 10% from WA and 2% Qld.), and whilst some subscribers could provide measured characterisations for their soil type, the majority could not. So that these new subscribers would be able to use Yield Prophet in 2005, the Yield Prophet team estimated soil characteristics (ESC) as described in the Methods section. An estimated characterisation will never be as good as measured data, and this is reflected in the increase in accuracy of yield simulation for paddocks with appropriate measured characterisations (Figure 2), where the R2 value increases to 0.67 for yield and 0.44 for protein.

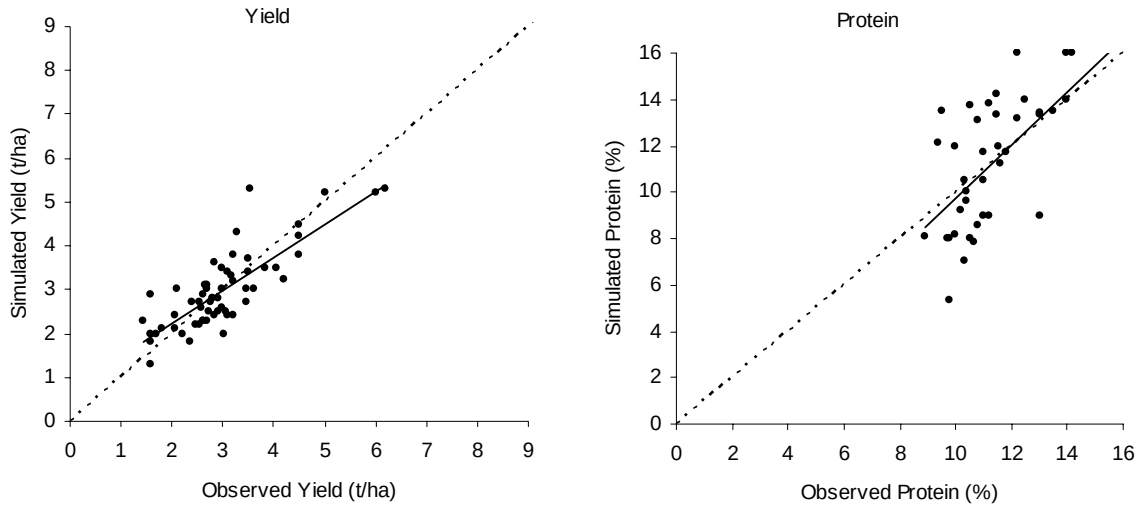

Figure 2: Simulated vs. observed yields and grain protein contents for paddocks with appropriate measured soil characterisation and segmented inputs in Yield Prophet in 2005. A linear function (solid line – for yield y = 0.76x + 0.70, for protein y = 1.14x – 1.65) was fitted to the data points using least-squares regression (yield R2=0.67, protein R2=0.44). The dashed line represents y=x.

Barley was trialled in Yield Prophet for the first time in 2005, and varieties were parameterised using data from BCG's 2004 Lubeck variety trial. One serious limitation of these data was that in 2004, barley varieties suffered terminal drought stress during grain fill. This meant that it was very difficult to estimate correct parameters for rate of potential grain-fill. Also, obtaining phenology parameterisation data from a small number of geographically close site makes it difficult to have confidence in simulations for crops in regions a long way from the parameterisation sites.

So, in order to genuinely compare the results of 2005 with those from 2004 and 2003, and provide a true indication of Yield Prophet's performance without the noise created by input error, the results from wheat paddocks alone on appropriate, measured soil characterisations and with segmented initial soil samples taken at depth are presented in Figure 3 (38% of all paddocks with returned yield data). This shows that given appropriate inputs, Yield Prophet can account for 74% of the variation observed in yield, with over two thirds of simulated yields falling within 0.5 t/ha of observed yields, and 98% within 1.0 t/ha.

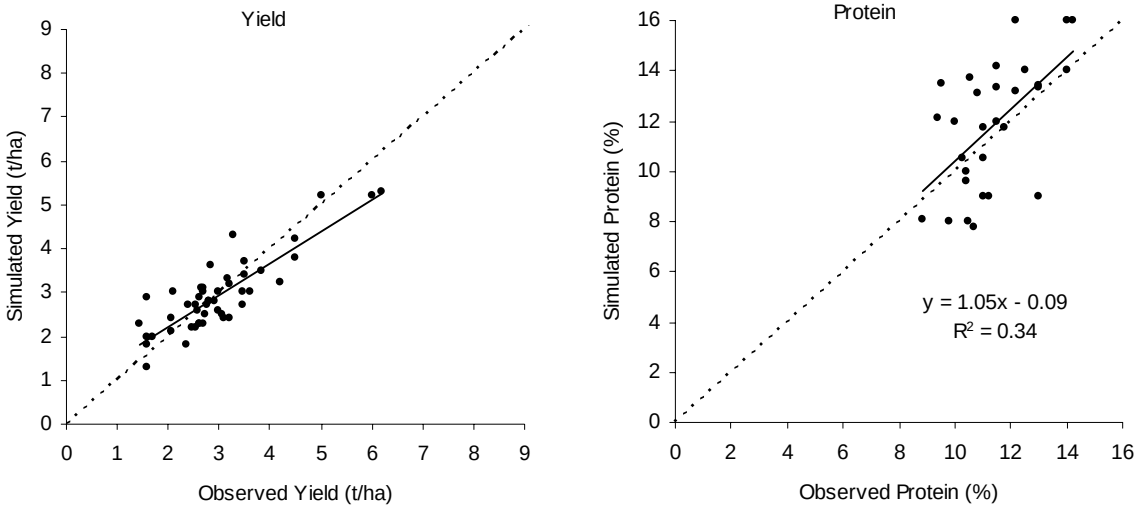

Figure 3: Simulated vs. observed yields and grain protein contents for wheat paddocks with appropriate measured soil characterisation and segmented inputs in Yield Prophet in 2005. A linear function (solid line – for yield y = 0.72x + 0.77, for protein y = 1.05x – 0.09) was fitted to the data points using least-squares regression (yield R2=0.74, protein R2=0.34). The dashed line represents y=x.

Commercial Practice

The value of Yield Prophet as a tool for crop management was demonstrated by its high level of use in 2005

To be confident of obtaining accurate simulations, subscribers should provide Yield Prophet with appropriate inputs i.e. measured soil characterisations and segmented initial soil data including recommended analyses

The accuracy of the barley module will be improved for 2006 using 2005 yield data from around Australia

If you would like to subscribe to Yield Prophet in 2006, please contact James Hunt on 03 9354 1654, mobile 0429 922 787 or e-mail james.hunt@aanet.com.au

If you are interested in characterising your soil (measuring PAWC), contact Neal Dalgliesh on 07 46881376, mobile 0427 725955 or e-mail Neal.Dalgliesh@csiro.au

Postscript

The amount of water available to a crop is a function of rainfall and soil type (particularly PAWC) of a soil. An awful lot of attention gets payed to rainfall (everyone knows their seasonal average, keeps a rain gauge and records etc.), but very little to PAWC. Without accurate measurements of PAWC, you will never know how much of the water that is in your soil, and which may subsequently arrive as rainfall, will be available to your crop. In other words, your capacity to confidently calculate a potential yield for your crops is limited without knowing the PAWC of your soil. For the information that it provides you with, measuring your PAWC isn't that difficult or expensive, and CSIRO and BCG are able to help.