Managing irrigation & nitrogen in grain crops with Yield Prophet®

James Hunt[1], Catherine Norwood[2], Harm van Rees[3], Zvi Hochman[4], Dean Holzworth[5] & Allan Peake[6]

[1]Yield Prophet Coordinator, Birchip Cropping Group, [2]Communications Officer, Murray Irrigation, [3]Principal Consultant, Birchip Cropping Group, [4]Principal Research Scientist, CSIRO, Sustainable Ecosystems/APSRU, [5]Software Engineer, CSIRO Sustainable Ecosystems/APSRU, [6]Research Officer, CSIRO Sustainable Ecosystems/APSRU

IN A NUTSHELL

- Yield Prophet is an online crop simulation service with great potential for irrigation scheduling and nitrogen management
- Murray Irrigation Limited paid for six growers to use the service in 2006. The amount of time required to set up and learn how to use the model prevented some of these growers from using the service extensively. Those that did said Yield Prophet could prove to be a valuable management tool to maximise crop returns.
- Simulated vs. observed results for the six growers were quite good, but accuracy was lower in comparison to the Mallee and Wimmera due to lack of measured soil characterisation data in the Murray Irrigation region

A pilot test of Yield Prophet in the Murray Irrigation region showed the system to be quite accurate as a management tool for grain crops. The growers involved in the test generally felt that the time investment required could yield worthwhile information to assist with crop management, particularly in evaluating the cost-benefits of fertiliser and irrigation against potential increases in yield and grain quality.

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, irrigation and nitrogen fertiliser applications, and climate data.

Background

Yield Prophet was developed by Birchip Cropping Group (BCG,) in collaboration with CSIRO, as a risk management tool for dryland farming systems in the Victorian Wimmera and Mallee, with an emphasis on decision support for nitrogen fertiliser inputs.

It was first used for wheat at BCG trial sites in 2002, and its early predictions of the failure of that season generated sufficient interest and credibility to allow a commercial release to BCG members in 2003 as a monthly fax-out service. Continuing demand resulted in the development of the Yield Prophet web-interface, which allowed a larger number of subscribers to receive up-to-date crop information and forecasts on demand, in 2004.

In 2004, Yield Prophet was used to schedule irrigation and nitrogen top-dressing for a pivot-irrigated wheat crop near Serpentine in northern Victoria. Under management guided by Yield Prophet, this crop yielded 7.1 t/ha, and BCG and CSIRO decided to invest in developing Yield Prophet as a tool for irrigation scheduling.

In 2005 Murray Irrigation offered to assist growers with the costs of subscription and soil testing. Eight growers initially took up the offer and members of the Yield Prophet team met with them in August 2005. Through discussion a set of tools for irrigation crop monitoring and scheduling was developed, which came on-line in September 2005. As the season progressed six of the eight growers involved in the initial meeting proceeded with their involvement in the program.

Murray Irrigation's support of the program was part of the company's ongoing research into increasing irrigation efficiency and maximising returns to growers, in this case, from irrigated cereals.

How Yield Prophet works

Subscription

Farmers or consultants subscribe to the service in autumn and provide the Yield Prophet team with their paddock names, planned crop and variety, and their closest Bureau of Meteorology (BOM) weather station.

Subscribers are given a user name and password to log onto the Yield Prophet website. Growers may also nominate a consultant who is also given access to data on their paddocks.

Soil sampling

Growers sample their paddocks at different depth intervals down to the maximum rooting depth of their crop (e.g. 0–10, 10–40, 40–70, 70–100 cm). These samples are analysed for water content, nitrate concentration, organic carbon, electrical conductivity and pH. These data are entered by the growers into the Yield Prophet web interface, and are also used by the grower and Yield Prophet team to select a suitable soil characterisation.

Soil characterisation

An appropriately measured soil characterisation is an essential input 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 of the measured water and nitrogen is available to the crop for growth during the season. PAWC is determined by a soil's 'drained upper limit' (DUL, or field capacity) and its 'crop lower limit' (CLL, similar to permanent wilting point).

The Yield Prophet team has a 'library' of soil characterisations measured for many of the major cropping soil types found within BCG's catchment Australia-wide. However, most of the paddocks subscribed by the Murray Irrigation growers had soil types for which there were no characterisation. In these circumstances, a soil characterisation was estimated by the Yield Prophet team based on soil type, previous rainfall and crop yields provided by the growers, and information from existing soil surveys.

Crop growth simulation and prediction

During the season, subscribers enter paddock management details (sowing date, crop type, variety, nitrogen fertiliser and irrigation). When growers wish to find out how much water and nitrogen is currently available to a crop, the likely yield of their crop, or what the likely impact of management events will be, they generate a report.

Yield Prophet simulates daily crop growth from sowing up to the day of the report using the paddock specific rainfall and management data entered by the subscriber, and climate data (maximum and minimum temperature, radiation, evaporation and air pressure) from the nominated BOM weather station.

At every day Yield Prophet calculates the water and nitrogen available to the crop, and the water and nitrogen demand of the crop. This determines if the crop is suffering stress from lack of either of these resources, and any subsequent reduction in growth and yield potential. This information is then presented to subscribers in reports returned to the subscribers' account (Figure 1).

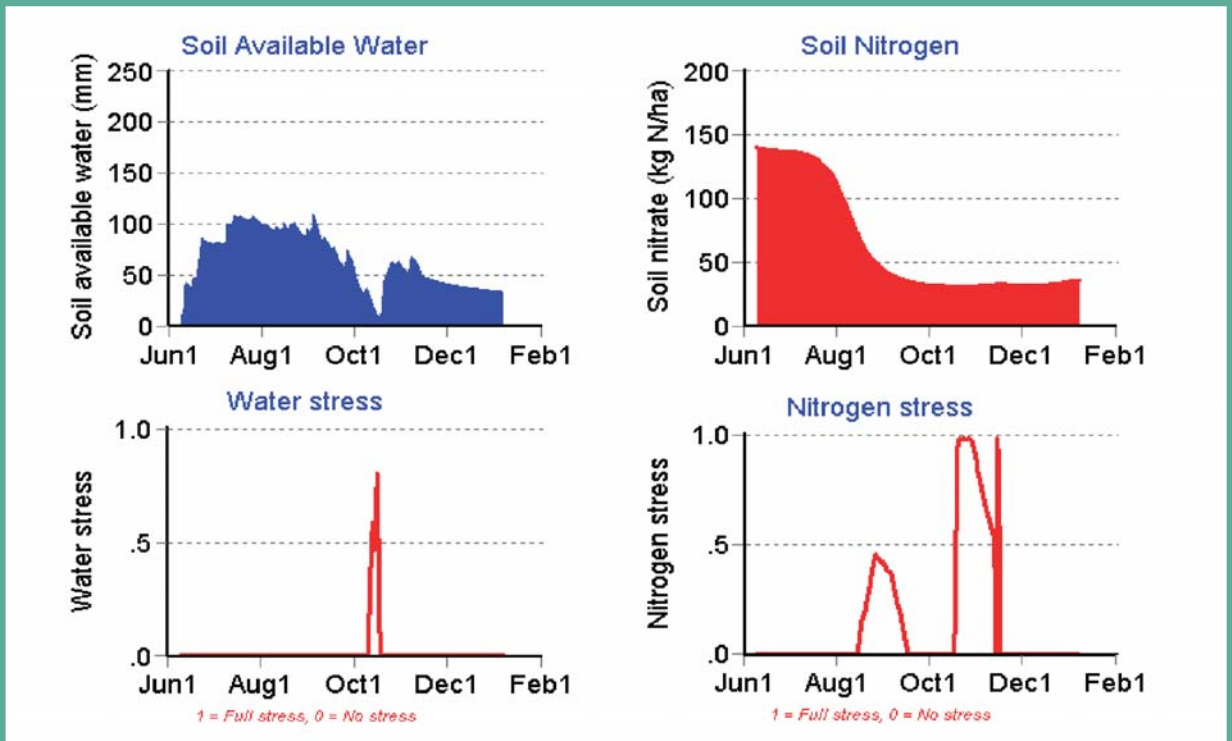

Figure 1 *Output from Yield Prophet indicating the amounts of water and nitrogen available to the crop during the season. The stress graphs indicate loss of potential growth and carbon fixation, i.e. on a day when the graph is at 0.5, the crop is growing and photosynthesising at half its potential rate.*

Yield prediction

In order to make predictions about crop yield, Yield Prophet uses the last one hundred years of climate data taken from the nominated BOM station to continue the simulation from the date of report generation to the end of the season. The model simulates one hundred different crop yields and proteins, based on the current season up until the day the report is generated, and on the season finishes of the past one hundred years. These yields are then plotted as a probability curve (Figure 2), which provides growers with an estimate of the probabilities of obtaining different yields. This range of probabilities narrows as the season progresses and components of yield become more certain.

The yield probability curve is the main output of Yield Prophet, and its value is increased by incorporating seasonal forecasts, such as the Southern Oscillation Index (SOI) phase system. In this case, instead of using season finishes for the last one hundred years, Yield Prophet selects the years in which the SOI phase was the same as in the current year, and runs the future part of the simulation using only the finishes from those years. This creates another probability curve which growers can use if the SOI phase is strongly indicating wet or dry conditions (Figure 3).

Scenario predictions

The likely impact of different irrigation and nitrogen applications can then be determined by simulating different nitrogen and irrigation 'scenarios'.

Yield Prophet calculates a probability curve for each scenario, and subscribers use this to determine the likelihood of achieving a yield or protein response from the addition or water or nitrogen (Figure 4).

Irrigation scheduling

Because Yield Prophet calculates the amount of water available to a crop, and average evaporation and transpiration based on 100 years of data, it has the potential to be a very effective tool for irrigation scheduling.

Figure 5 shows the Irrigation Scheduling report from Yield Prophet. The graph shows the PAWC of the soil that is being accessed by the crop as roots grow, and the amount of PAW calculated from initial measured soil water plus rainfall and irrigation, subtract evaporation and transpiration. The red section of the line is a projection of PAW over the future two weeks assuming no rain, and growers can use this to determine when to water, and how much water to apply. The impact of any irrigation can be calculated from the probability curves in the irrigation comparison report described above (Figure 5).

Yield Prophet performance for MIL growers

Of the 12 paddocks subscribed by Murray Irrigation, four were seriously affected by disease or weeds, or were grazed. Yield Prophet cannot account for any of these factors, and these paddocks were removed from analysis.

For the remaining eight, Yield Prophet could account for 72% of the variation observed in yield and in six out of the eight, simulated yields were within 1.0 t/ha of observed yields.

Whilst in modelling terms this is a good result, Yield Prophet has the potential to do much better in this region. This is largely due to the soil characterisations used for the Murray Irrigation growers, which as mentioned before were estimated.

An estimated characterisation will never be as good as measured data, and this is reflected in the results for the Murray Irrigation growers in comparison to other paddocks from around Australia with measured soil characterisations, where Yield Prophet could account for 75% of the variation observed in yield, and 70% of simulated yields were within 0.5 t/ha of observed yields, and 98% within 1.0 t/ha.

The growers' perspective

Of the six growers who took up the program through Murray Irrigation, four indicated that the need to use computers was

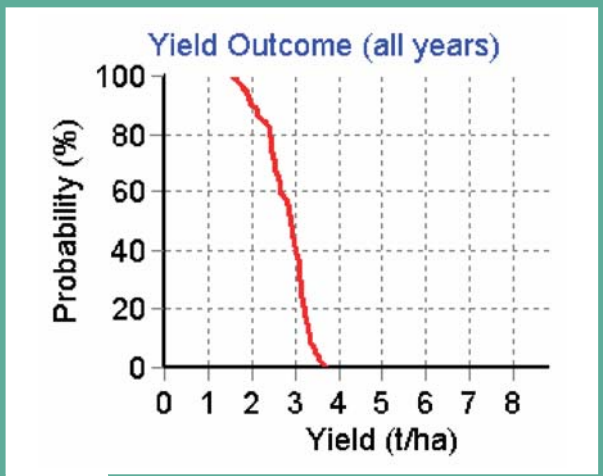

Figure 2 *The main output from Yield Prophet is a yield prediction, which is a probability curve showing the likelihood of achieving different yields based on the season up until the day of the report and on season finishes of the past 100 years.*

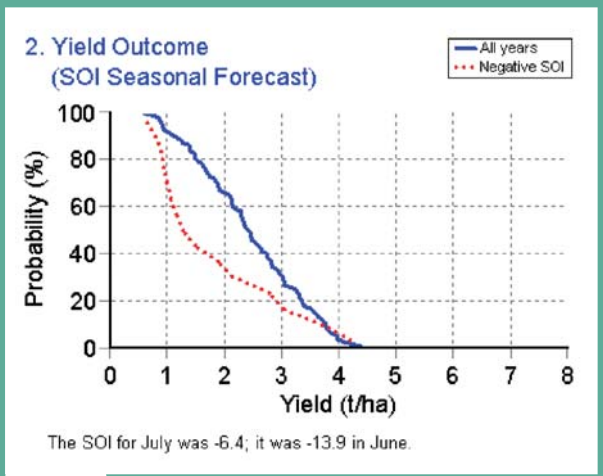

Figure 3 *Yield probability curve using season finishes for 100 years of climate data (solid blue line), and only those years when the SOI phase was the same as the time the report was generated (red dotted line). In this example, it is years with a negative SOI phase in June-July. The report was generated in early August 2004.*

an issue. Three said the time required for data entry was a problem; they "had a bit of a look at it," or "didn't get around to it". Another cited difficulty accessing the Yield Prophet program via the internet as an issue.

Despite this limited use they found the modelled results of the program to be reasonably accurate. One grower commented that it had confirmed his visual observations and management decisions. Another said with more extensive use he expected it would allow him to better benchmark his fertiliser use against crop yield.

Another grower used the program extensively and said he believed more detailed soil data was required to provide more accurate results. Of the four paddocks he modelled through the program, the predicted yield of two crops of wheat was quite close to actual yield, while the predictions for two barley crops were inaccurate, although these were both affected by disease. With more fine tuning for local soils he believed it offered good potential for supporting management decisions and forecasting yield in irrigated crops, where it was possible to control both soil moisture and nitrogen.

One grower used the program in conjunction with his agronomist who organised soil testing and undertook the related data entry. He reported that modelled crop results were reasonably accurate, and based on the modelling he had decided to add nitrogen to his dryland wheat crop, (contrary to advice from other sources) and achieved the predicted protein increases. In the coming year this grower is planning to add soil moisture probes to his paddocks to more accurately assess crop water requirements, in conjunction with the Yield Prophet program.

Conclusions

Yield Prophet has the potential to be a very useful tool for scheduling irrigation and managing nitrogen in grain crops. Accuracy in the Murray Irrigation region, and indeed much of the country, is currently limited by the quality of available soil characterisation data.

Yield Prophet is 'data hungry' and requires an investment in time to set up and learn to use properly. However, the information that it is capable of providing for farm managers and their consultants make this a worthy investment.

Acknowledgements

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Further information

James Hunt
Yield Prophet Coordinator, Birchip Cropping Group
T: 03 9350 4742
M: 0429 922 787
E: james.hunt@aanet.com.au

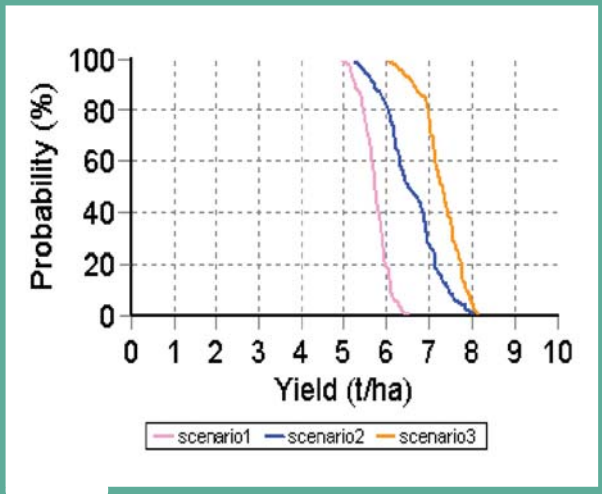

Figure 4 *Yield probability curves for three different nitrogen and irrigation scenarios generated for an irrigated wheat crop on 3 October 2005. Scenario 1 (pink line) adding no further water or nitrogen; Scenario 2 (blue line) an additional 50 kg/ha of nitrogen top-dressed on 3 October; Scenario 3 50 kg/ha of nitrogen top-dressed on 3 October and two additional 25 mm irrigations on 3 and 17 October.*

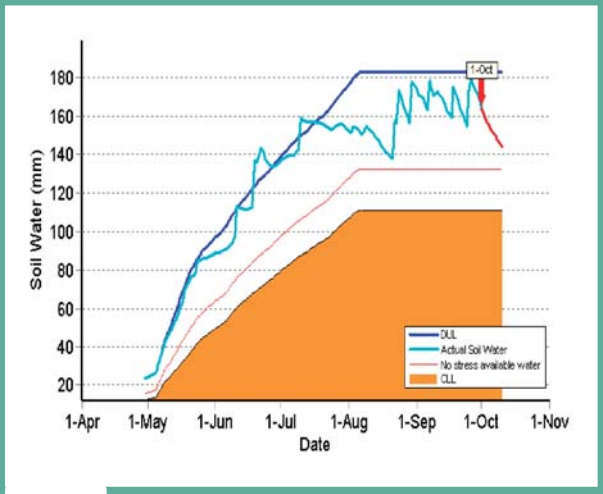

Figure 5 *The graphic display of soil water from the Irrigation Scheduling Report in Yield Prophet, showing the drained upper limit (dark blue line) and the crop lower limit (orange block), and the water available to plant (light blue line) leading up to the report and the prediction of water available to plants based on 100 years data for the season finish (red line).*