Managing Risk with the Yield Prophet

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The BCG is working closely with CSIRO to develop risk management tools which will assist farmers to make better decisions in relation to optimising inputs in line with seasonal outcomes.

Summary

The Yield Prophet uses the APSIM model to estimate wheat yields based on seasonal growing conditions and inputs. The outcomes of the Yield Prophet allow farmers to make better pre-sowing and in-crop management decisions which reduce risk and optimise returns.

The Yield Prophet reports on crop growth during the season; availability of soil water and soil N; likely responses to N fertiliser; and calculates probabilities for yield and protein.

The Yield Prophet is a web based service and accessible to subscribers and visitors on www.yieldprophet.com.au/yieldprophet.

What is the Yield Prophet?

The Yield Prophet is an on-line crop production model designed to assist grain growers in making best-bet management decisions which reduce risk and optimise returns. The management decisions are focussed on:

- inputs (especially nitrogen fertiliser)
- operation timing and crop/variety selection
- risk in relation to soil water stored
- risk in relation to seasonal conditions and rainfall forecasts
- potential yield and protein

Yield Prophet uses the Agricultural Production Systems Simulator (APSIM), which was developed by the Agricultural Production Systems Research Unit (APSRU), a joint research unit of Queensland Departments of Primary Industries and Natural Resources and Mines, CSIRO's Divisions of Sustainable Ecosystems and Land & Water, and the University of Queensland.

Yield Prophet is accessed by growers through a web interface that simplifies both the inputs required and outputs generated by APSIM to those relevant to agronomic management. It simulates the production of a wheat crop from the time of sowing to harvest - its primary output is a yield prediction.

How does APSIM work?

The computer model simulates the growth of a crop based on the initial conditions at sowing, the management inputs provided and current weather conditions. At each stage during the season the model calculates a predicted outcome based on a probability function. The probability function is calculated using site specific historical weather data for the last 100 years from Bureau of Meteorology (BoM).

For example, if the model was run on a wheat paddock in Brim for 2004 it will use the 2004 conditions (pre-sowing soil characteristics such as plant available water and available N, fertiliser inputs, sowing date, variety and weather information such as rainfall, temperature, radiation etc) up to the day the model was run, and then the model looks forward for the rest of the season using historical rainfall data from the Brim BoM station. The model uses rainfall data for each individual year over the last 100 years to calculate a yield outcome for each of those years. Because 100 yield outcomes are calculated, probabilities of achieving a particular yield can be calculated.

Methods

In 2004 the Yield Prophet was available to growers in Victoria, northern NSW and the northern agriculture region in WA.

In this paper we will describe how the Yield Prophet was used in 2004 at the three main BCG trial sites as a robust risk management tool.

We outline how the model can be used pre-sowing to determine an optimum and low risk N rate; and also in crop (late tillering – early booting) to investigate whether the crop needs more N and what the risks are of applying N at that stage using rainfall forecasts.

Results

A description of soil types at each site is provided in Table 1.

Table 1. Description of the three sites used in the Yield Prophet.

Site	Location	Soil Type	Plant Available Water Holding Capacity (0-100cm)
Hopetoun	Central Mallee	Sandy loam over clay	99mm
Birchip	Southern Mallee	Mallee clay loam	108mm
Laen	Northern Wimmera	Wimmera clay	167mm

The Hopetoun and Laen sites had no subsoil chemical limitations to root growth. The Birchip site had an EC (Electrical Conductivity) of 0.9 at 50cm depth, at this level of EC the soil is regarded to have a moderate level of subsoil limitations to root growth (roots may penetrate to this depth but their ability to take up water will be reduced).

The soil conditions at sowing, the variety sown and sowing date are listed in Table 2.

Table 2. Conditions at sowing in 2004; including the variety sown and sowing date.

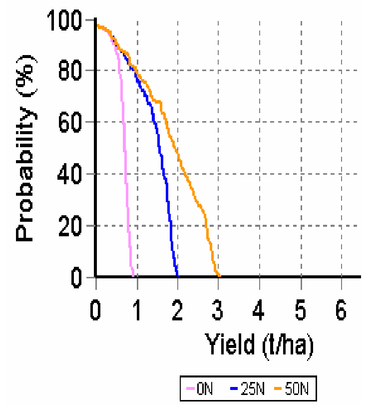
Site	Previous crop type	Plant Available Water (0-100cm) mm	Available N (0-100cm) kg/ha	Variety	Sowing Date
Hopetoun	Canola	9	30	Yitpi	11 May
Birchip	Fallow	0	77	Yitpi	20 May
Laen	Fallow	16	137	Yitpi	1 June

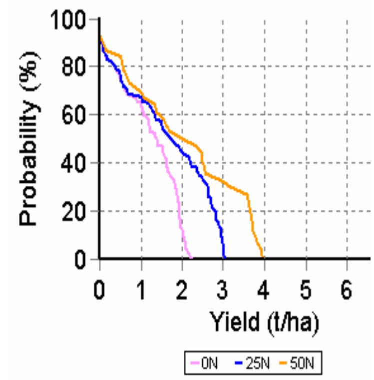
Plant available water was low due to the very dry conditions over summer (the 2003/04 summer was one of the driest summers on record). Available N at Birchip and Laen was reasonably high because the paddocks were fallowed in 2003. The available N at Hopetoun was low.

Yield Prophet Pre-sowing

Pre-sowing a decision had to be made whether the crop should be fertilised with extra N fertiliser. The model was run on May 1, 2004 making an assumption that the sowing date would be in the middle of May. Soil samples (in increments down to 1m depth) had been taken in early April and analysed for soil nitrate, soil water and EC. The model was run for three rates of pre-drilled N (none 0kgN, moderate 25 kgN and high 50 kgN) (Figure 1).

Hopetoun	Birchip	Laen





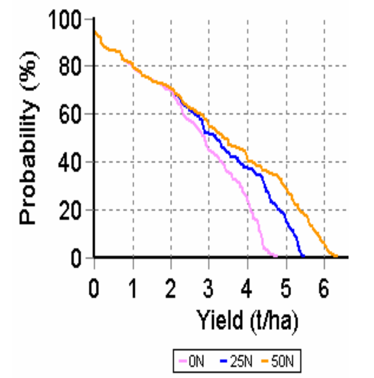


Figure 1. Pre-sowing APSIM simulations for three rates of N (May 1, 2004)

As a risk management guide we argue that before any input is considered, we need to be able to demonstrate a 3:1 return on investment. With nitrogen costing approximately $1/kg (hence 25kg N = $25/ha) we would need to demonstrate a 3 x $25 return or $75/ha which is equivalent to 0.5 t/ha of wheat.

At Hopetoun there was a 75% chance that 25kg N would add more than 0.5 t/ha to the harvest yield, at Birchip the chance was less than 40% and at Laen less than 30% (the response at the latter two sites was low due to the high soil N levels). Based on this information it was decided to apply N pre-sowing only at Hopetoun (25kg of N was spread immediately prior to sowing).

Mid season – climate forecast

At the end of tillering the model was run again – for ease of presentation we outline the results for the model runs on August 1. During the cropping season we also include the SOI (Southern Oscillation Index) forecasts for seasonal rain as a climate risk management tool.

On the first of August, 2004 the SOI phase for June/July was ‘negative’. A ‘negative’ phase for June/July has a strong probability that the finish to the season will be drier than average (Figure 2).

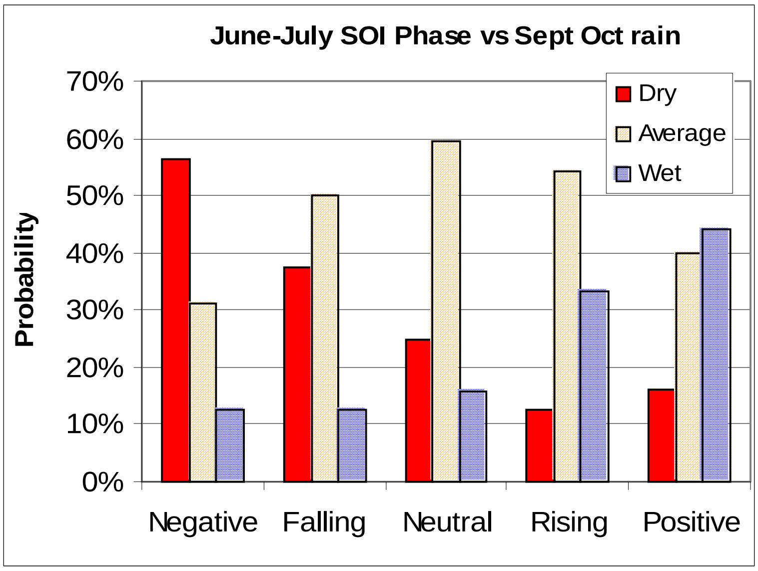


Figure 2. June/July SOI phase in relation to probability for rainfall in September and October, for the Birchip BoM site. Legend Sept-Oct rain: Dry (years with lowest 25%); Middle (average 26-74%); Wet (highest 75 to 100% of rainfall during September and October).

16 years in the last 100 had a 'negative' phase for the SOI in June and July. Of these 16 years, the rainfall in Birchip for September/October was 'dry' for 9 years (56%); 'average' for 5 years (31%); and 'wet' for only 2 years (13%). Hence, with a 'negative' SOI phase in June/July the chances of a dry finish are much higher than a wet finish. This was also reflected by the estimated yield outcomes when we ran the model in early August.

<u>Mid season – yield estimate</u>

When we run the APSIM model during the season it uses current season rainfall, temperature etc. on a daily basis and then models potential outcomes for the rest of the season based on historical rainfall. At the end of tillering we investigate not only the response to N over 100 years of historical rainfall but also the response in those years represented by the then current phase of the SOI (Southern Oscillation Index) (Figure 3).

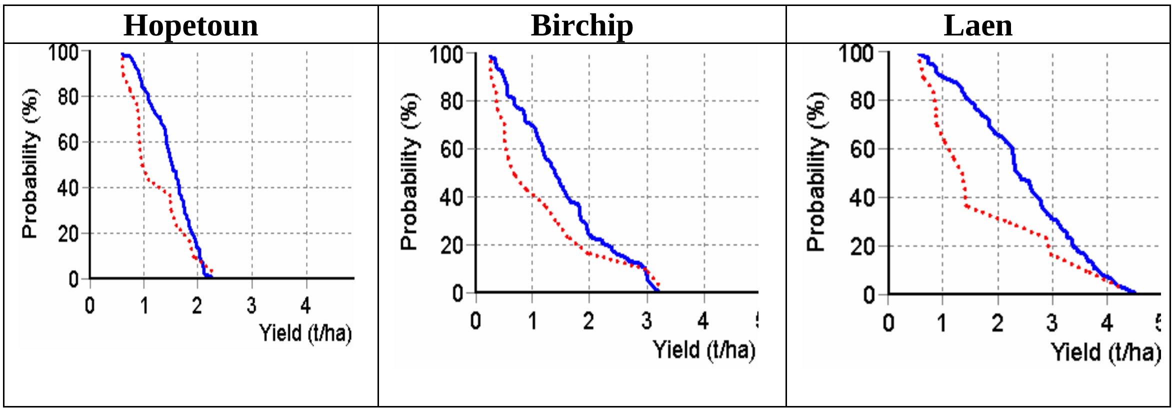


Figure 3. Yield estimates at 1 August, 2004. Presenting both one hundred years of modelled data (solid line) and those years with a 'negative' SOI phase for June/July (broken line).

In the middle of the cropping season, when the crops were approximately at the end of tillering stage, the yield outcomes looked much worse for those years with a 'negative' SOI phase in June/July compared to the simulations of 100 years of rainfall data. This result should temper enthusiasm for topdressing nitrogen fertiliser even if the crop 'looks' good above ground.

When we looked at the likely N fertiliser response for those years with a 'negative' SOI phase the outlook was very poor for getting an economic return on the investment of more N fertiliser (Figure 4).

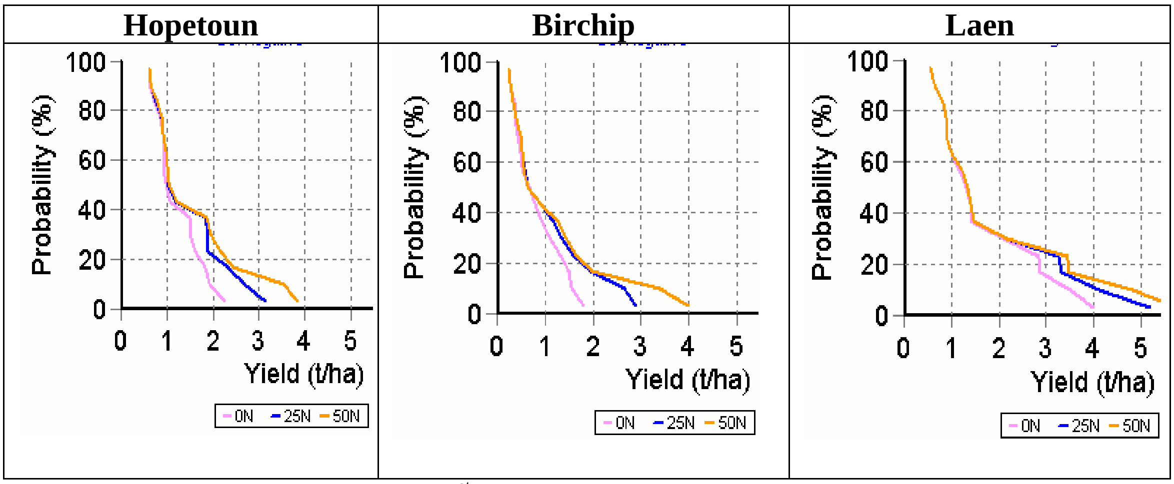


Figure 4. Modelled output on the 1st of August, 2004 for a 'negative' phase of the SOI for June and July.

The likelihood of getting an economic response (of 0.5 t/ha) was 10% or less. Clearly the risk was too high for these sites to be top-dressed with N fertiliser in the middle of the season.

Interpretation

The Yield Prophet is a very useful tool for making risk management decisions pre-seeding as well as during the cropping season. The Yield Prophet is available to subscribers over the internet (www.yieldprophet.com.au/yieldprophet). For the 2004 season, subscribers had three reports available (a basic agronomy report; a climate risk report; and a N fertiliser response report). New reports which will be available for the 2005 season will include a $ return on N cost report; a variety by sowing date report; and a special service on a limited basis for irrigation farmers focussed on irrigation scheduling and N requirements. APSIM is currently being validated for crops other than wheat.

The APSIM crop model is very sensitive to accurate measurement and description of soil water properties. For the model to work it needs accurate CLL (Crop Lower Limit) and DUL (Drained Upper Limit) for the soils in a paddock. The model also needs the amount of stored water and nitrogen in the soil to be measured prior to sowing. These requirements are a limitation to using the model but at the same time it reflects reality in that no model can work for Australian conditions if it does not take into account the importance of soil water and nitrogen in our cropping systems.