Yield Prophet® Climate Change Report

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Aim

To simulate the impacts of likely climate change scenarios on wheat production using the Yield Prophet® Climate Change Report.

Take home messages

- *Average simulated wheat yields of the current ten year period are the worst on record since 1899 at the Birchip site*
- *A comparison of the impacts of climate change in the past 30 years compared with earlier years provides no evidence of an effect on the wheat yields at this site*
- *Given the 'worst case' scenario it is forecast that climate change will cause an increase in temperature and reduction in rainfall in the year 2030 reducing potential crop yields at this site.*

Method

The Yield Prophet® Climate Change Report is broken up into three sections:

- Section 1 relates to the impacts of historic climate variability on potential grain yields;
- Section 2 relates to the impacts of recent climate change on grain yield; and
- Section 3 shows the potential change in temperature and rainfall in the year 2030 using the OzClim scenarios and its effect on yield relative to the historic records.

To generate the climate change report, Yield Prophet runs a number of simulations using crop information for a current Yield Prophet paddock as the basis. The crop information pertaining to this report is:

Location:	Birchip
Sowing date:	10 May 2008
Seeding density:	150 plants/m²
Crop type:	Wheat cv. Yitpi
Soil type:	Clay loam (Culgoa)
Weather station:	Birchip Post Office
Stubble type:	Wheat
Stubble amount:	1t/ha
Nitrogen:	Unlimited

The simulations generated in Sections 1 and 2 use historic climate data from the Bureau of Meteorology (BOM) Patched Point Dataset (PPD).

The simulations generated in Section 3 use two climate change scenarios ('best case' and 'worst case') for the year 2030 from the CSIRO OzClim website (www.csiro.au/ozclim/home.do) and the historic climate data. All climate data relate to the Birchip Post Office.

The 'best case' scenario is based on low emissions and a climate model with low sensitivity to increases in CO_2. The 'worst case' scenario is based on high emissions and high climate sensitivity.

The CO_2 emissions under these scenarios were determined at the second International Governmental Panel on Climate Change (IPCC) assessment report in 1995. It should be noted that CO_2 emissions in 2008 are exceeding the 1995 'worst case' forecast, a consequence of the strong global economic growth over recent years and the lack of a coordinated mitigation response.

Under the 'worst case' scenario, if CO_2 emissions continue at the 1995 rate, by the year 2030 the estimated atmospheric CO_2 concentration will reach 460 parts per million (ppm). If CO_2 emissions are mitigated, the estimated 'best case' scenario for the atmospheric CO_2 concentration is forecast to be 420ppm by 2030.

The atmospheric CO_2 concentrations from each scenario are then provided as inputs to different general circulation models (GCM's) to determine the change in temperature and rainfall at the location of the nominate weather station, in this case the Birchip Post Office. GCM's are computer models used for weather forecasting, understanding climate and projecting climate change.

Results & Interpretation

Once again a number of major cropping regions in Australia received well below average spring rainfall in 2008. Another poor year raises questions about the future and the effect climate change may have on crop production in your region.

Section 1

Figure 1 shows historic potential yield, given unlimited nitrogen, the phenology of Yitpi wheat and modern agronomic practices. The vertical bars represent the potential yield of the crop in each year since 1889 based on the climate data from the Birchip Post Office BOM station selected. The black line denotes the 10-year rolling average yield.

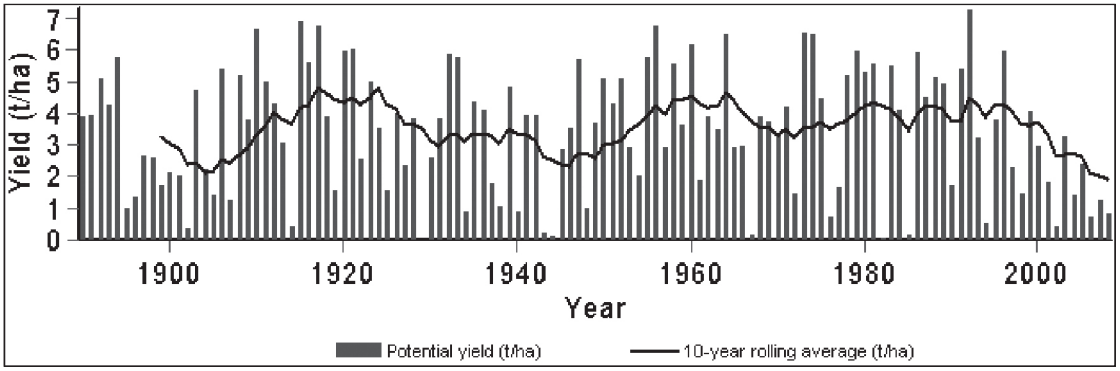

Figure 1. Historic potential yield (nitrogen unlimited) of the current crop.

It is evident from Figure 1 that there has been significant variation in the potential yields over the 119 year period with simulated yields ranging from 0t/ha to 7t/ha. (NB. Yield Prophet simulations do not account for external factors such as frost, disease, poor weed management etc.) It is apparent from the rolling average that there have been periods of consecutive years of both high and low yield potential. Interestingly, the current ten year period is now the worst on record having dropped below the 1895 to 1905 and 1936 to 1946 periods.

Section 2

Most of Australia has recorded a warming trend (as well as rising CO2 levels) over the last 50 years. By comparing the yield potential over the last 30 years with that of prior years, it is possible to get

an impression of whether climate change has already had an impact on yield potential. The 'gateway' year of 1977 is used as there is a consensus in the scientific community that some effects of climate change became apparent at this time.

As there is little difference between the potential yields from 1889 to 1976 and 1977 to 2008 (Figure 2), it is evident that climate change has to date had minimal effect on potential yield. The slight discrepancies across the range of probabilities could be due to the small sample size (30 years) of the recent probability distribution curve.

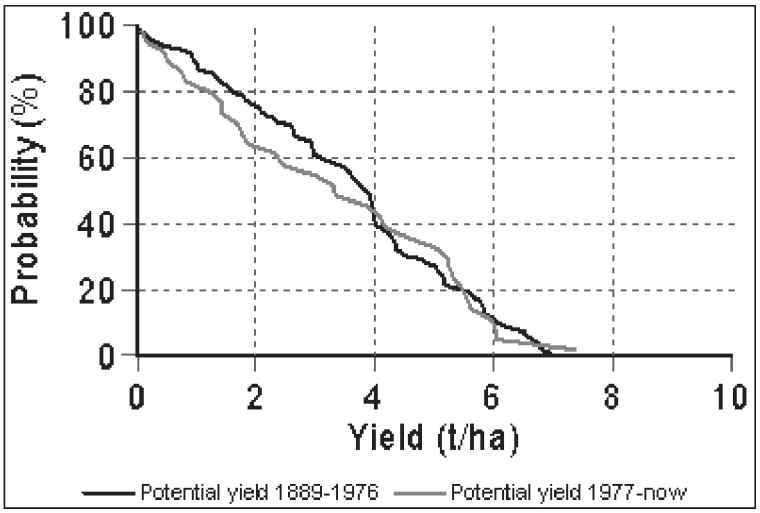

Figure 2. Comparison of the potential yield from 1889 to 1976 versus the potential yield from 1977 to 2008 of the current crop.

Section 3

Using CSIRO GCMs, Figure 3 shows that the Birchip Post Office weather station, under the 'best case' scenario, would be expected to experience a slight (< 1ºC) increase in temperature across each month relative to the 1889 to 2008 period. The concurrent change in rainfall has small but noteworthy deviations in both directions, with increases in rainfall over the summer months and decreases over winter and spring. The net change in annual rainfall is estimated to decrease by 2.5mm, a -0.7 percent deviation from the mean of 374.1mm.

Climate Change Scenarios from CSIRO's OzClim website (www.cmar.csiro.au/ozclim)

	Best case Based on low emissions and low climate sensitivity		**Worst case** Based on high emissions and high climate sensitivity	
CO2	420 ppm		460 ppm	
	Temperature	**Rainfall**	**Temperature**	**Rainfall**
Jan	0.8 °C	2.2 mm	1.2 °C	0.0 mm
Feb	0.7 °C	1.4 mm	1.0 °C	0.1 mm
Mar	0.6 °C	0.4 mm	1.2 °C	-1.9 mm
Apr	0.6 °C	-0.3 mm	1.0 °C	0.4 mm
May	0.5 °C	0.0 mm	0.9 °C	-1.7 mm
Jun	0.5 °C	0.3 mm	0.9 °C	0.4 mm
Jul	0.4 °C	-1.0 mm	0.9 °C	-5.0 mm
Aug	0.4 °C	-1.5 mm	1.0 °C	-9.1 mm
Sep	0.4 °C	-2.3 mm	1.3 °C	-15.9 mm
Oct	0.6 °C	-4.0 mm	1.4 °C	-8.1 mm
Nov	0.7 °C	0.6 mm	1.1 °C	0.2 mm
Dec	0.8 °C	1.7 mm	1.1 °C	0.5 mm

Figure 3. 2030 climate change scenario for the Birchip Post Office BOM station from the CSIRO's OzClim website (www.cmar.csiro.au/ozclim).

Given the worst case scenario, estimated increases in temperature in each month will be slightly larger than those under the 'best case' scenario (Figure 3). The largest monthly increase in temperature is estimated to occur in October with a 1.4ºC change. Of greater note is the predicted effect on rainfall of the 'worst case' scenario.

The net change in annual rainfall is estimated to decrease by 40.1mm, a -10.7 percent deviation from the mean of 374.1mm, with the majority of this change expected to occur in winter and spring. The net change in winter and spring rainfall is respectively estimated to decrease by 13.7mm and 23.8mm, a -12.0 and -22.9 percent deviation from the mean of 114.6mm and 103.9mm. It is important to note that higher atmospheric CO_2 may partially compensate for warmer temperatures and lower rainfall provided adequate nitrogen is available.

The output shown in Figure 4 uses the temperature and rainfall results in Figure 3 to generate three probability of exceedence curves for comparison ('historic', 'best case' and 'worst case'). As the 'historic' and 'best case' probability of exceedence curves are relatively similar, it can be assumed that expected yields under the 'best case' scenario would be comparable with the past.

However, if the 'worse case' scenario were to eventuate it is apparent that crop yields could be reduced across the majority of probabilities. It is important to remember that these outputs relate to current farming practices and varieties. With slight adjustments to these, the reduction in potential yield under the 'worst case' scenario may be compensated for.

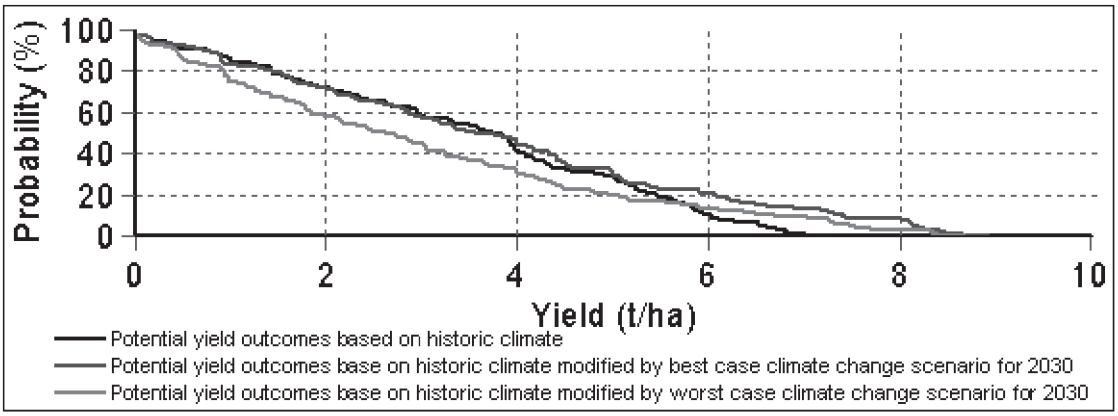

Figure 4. Impact of climate change scenarios at the Birchip Post Office weather station on the potential yield (nitrogen unlimited) of the current crop.

Using the 'historic' 'best case' and 'worst case' simulations from Figure 4, Yield Prophet evaluates the likelihood of frost and heat shock on the crop (Figure 5). When analysing these results carefully some of the information appears to be counterintuitive. Under the 'best case' there would be an increase in the number of frost events compared to the 'historic', despite a forecast average monthly increase in temperature of 0.58°C. Conversely, the number of heat shock events under both the 'best' and 'worst case' scenarios decreases compared to the 'historic', despite the increase in temperatures. These counterintuitive results can be explained by the increase in winter temperatures causing the crop to mature faster. The crop flowering at an earlier time of year is exposed to a greater chance of a frost event. Similarly, the fast growth causes the crop to reach grain filling earlier in the year reducing its exposure to heat shock.

Percentage of years in which frost occurs	Climate Scenarios		
Mild	**Historic**	**Best case**	**Worst case**
Minimum temperature between 2 and 0°C during flowering (Z60-69)	25%	33%	23%
Moderate			
Minimum temperature between 0 and -2°C during flowering and early grain fill (Z60-75)	4%	8%	4%
Severe			
Minimum temperature less than -2°C during flowering and grain fill (Z60-79)	0%	0%	0%
Percentage of years in which heat shock occurs during grain fill (Z70-79)			
Mild	**Historic**	**Best case**	**Worst case**
Maximum temperature between 32 and 34°C	31%	25%	24%
Moderate			
Maximum temperature between 34 and 36°C	13%	9%	13%
Severe			
Maximum temperature above 36°	10%	8%	6%

Figure 5. Impact of climate change scenarios on frost and heat shock for the current crop.

Another interesting observation is that a crop that reaches maturity faster has a reduced growing season and limited exposure to the forecast reduction in spring rainfall under the 'worst case' scenario. However, under this scenario the reliance on winter rainfall becomes more pronounced. These changes will force growers to make adjustments to their agronomic decisions and explore different techniques to compensate.

An obvious response to the forecast changes in the is to adapt our agronomic practices eg. sowing date. Under climate change it may be beneficial to sow crops earlier than we do now. Even though this may increase exposure to frost, it may become a viable management option if frost resistant crops were to become available.

Yield Prophet subscribers will soon have the ability to investigate the effects of adjusting their agronomic practices in response to changed climatic conditions through the Climate Adaptation Report. The Climate Change Report presented here is now available to Yield Prophet subscribers.