Farming to soil potential in the Mallee: how accurate was in-season yield prediction in 2009?

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Key Messages

- Using crop growth models to estimate season to season yield performance on different soil types and predict in-season potential yield can be a useful tool for managing risk and inputs.
- High spatial variability in soils and grain yield presents the prospect of mapping paddocks into zones of similar soil and yield potential to enable farmers to better target input levels as well as understand crop yield potential in different seasons.
- The capacity of a soil to hold water and the water and mineral N levels at sowing are the basic information needed to use Yield Prophet. Given this information, grain yield can be accurately predicted in mallee environments.

Aims:

Managing climatic variability and business risk on farms with highly variable soil types pose difficult challenges to most farmers in the lower rainfall regions of the Mallee. This latest Farming Systems project aims to build resilience into Mallee farms by improving understanding of the interactions between soil potential, climate and management. By running lower risk flexible systems that are more responsive to seasonal indicators such as commodity pricing, weather forecasts etc, farmers are more likely to make better decisions more often. Using the WUE trials at Karoonda, we are testing whether knowledge of soil potential, soil variation and in-season predictions of grain yield with Yield Prophet could be useful to improving management.

About the trial:

The trial site was located on the property of Peter and Hannah Loller near Karoonda. For the purposes of modelling, we assumed that the sandy soils found on the dunes and midslopes were similar to unconstrained sandy loams that we had previous characterised for plant available water capacity (PAWC) at Waikerie. The constrained soils found on the flats were assumed to be similar to sandy loam over clay soils that had been characterised for PAWC at Pinnaroo. Pre-

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sowing soil coring took place on May 12 with cores separated into increments (0-10, 10-20, 20-40, 40-60, 60-80, 80-100 cm from the surface) to determine soil moisture and mineral N prior to sowing. Soil chemical analysis (B, EC and Cl) was also undertaken on these soils and used to adjust potential rooting depth. On site soil characterisation will be undertaken in early 2010.

Predicting in-season yield potential with Yield Prophet:
APSIM is a crop-soil model that simulates the major processes that occur while crops and pastures grow. These include the nitrogen and carbon dynamics in soil, soil water balance (including evaporation, drainage, leaching and runoff), crop growth and interactions with daily temperature, radiation and rainfall. Yield Prophet® is an on-line crop production model (based on APSIM) designed to provide grain growers with real-time information about the crop during growth. To assist in management decisions, growers enter inputs at any time during the season to generate reports of projected yield outcomes showing the impact of crop type and variety, sowing time, nitrogen fertiliser and irrigation. Crop reports were generated several times during the growing season in this study to provide predictions of potential yield for crops grown on sands and flats at Karoonda in 2009.

Results:
Sowing of wheat (cv. Correll) with DAP + Zn at 50 kg/ha plus Urea at 35 kg/ha took place on 15 May after 38 mm of rain had fallen between 25 April and 2 May. There had been virtually no rainfall in the months prior to the season break resulting in very little stored soil moisture at sowing (Fig. 1a and 1b). Soil mineral N was high in the flats (79 kg mineral N/ha in the top 1 m) and moderate on the soils from the sand areas (49 kg mineral N/ha in the top 1 m) (Table 1). As expected, EC, B and Cl reached very high readings at depths greater than 40 cm in the soils of the flats.

Table 1. Pre-sowing mineral N and concentrations of salts (as indicated by Electrical Conductivity (EC) and Chloride) and Boron in the profiles of soils located on the flats and dunes.

Zone	Depth	Nitrate N	Ammonium N	Total mineral N	EC	Boron	Chloride
		mg/kg	mg/kg	(kg/ha)	dS/m	mg/kg	mg/kg
Flats	0-20	18.3	3.4	33	588	2.5	222
	20-40	9.3	0.8	15	1240	13.6	1258
	40-60	6.1	0.8	11	1283	22.6	1266
	60-80	5.1	1.1	10	1213	21.1	1268
	80-100	4.7	2.0	10	1161	13.8	924
	Total Mineral N (0-100 cm)			79			
Dunes	0-10	5	2.1	11	37	0.3	4
	10-20	3.1	1.1	7	27	0.3	96
	20-40	1.4	1.1	8	18	0.3	6
	40-60	0.8	0.9	5	22	0.8	10
	60-80	1.4	1.1	8	49	1.6	13
	80-100	1.7	1.4	10	87	2.5	14
	Total Mineral N (0-100 cm)			49			

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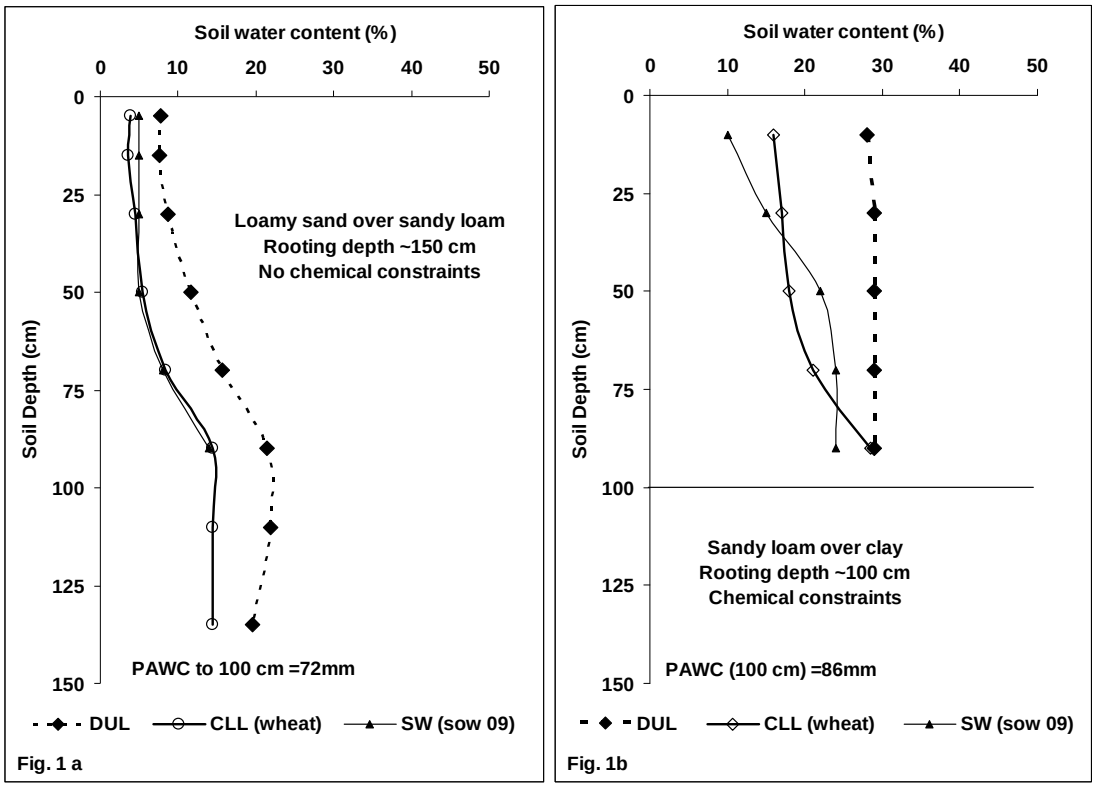

Figure 1. Plant available water capacity (PAWC) obtained by characterising the crop lower limit (CLL) of wheat and drained upper limit (DUL) of a sandy loam (Fig. 1a) representing soils found on the dunes/mid-slopes and a constrained sandy loam over clay (Fig. 1b) representing soils found on the flats. Plant available water (PAW) measured at sowing is also plotted.

Yield Prophet Prediction for 2009:

Crop reports generated on 14 July corresponding with growth stage Z14 or early tillering, indicated that potential yield, unlimited by available N in the soil profile, ranged from 0.6 to 5 t/ha regardless of soil type. Due to high soil N available in the profile of the soil on the flats, there was very little difference between the yield outcome with the actual N and the simulated yield outcomes with unlimited N. In the crop reports generated on 14 and 22 July for the sand, yield potential was limited by N. By 19 Aug (growth stage 37, flag leaf), yield potential was significantly reduced because of water stress on both soil types regardless of N level. Following good rains on 24 August there was little water stress experienced by the crops for the remainder of the season– in fact, the finish of the season fell in the top 5 % of seasons experienced in the last 100 years.

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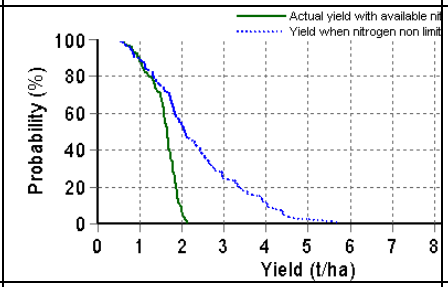
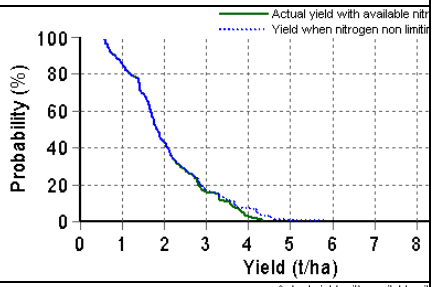
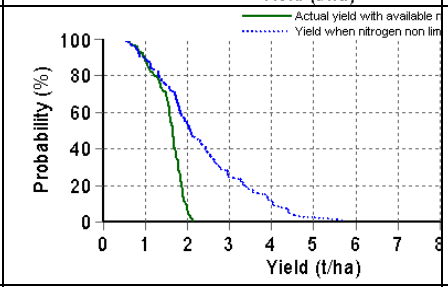
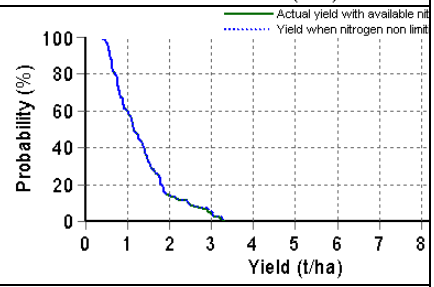
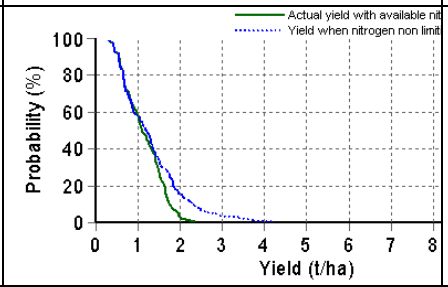
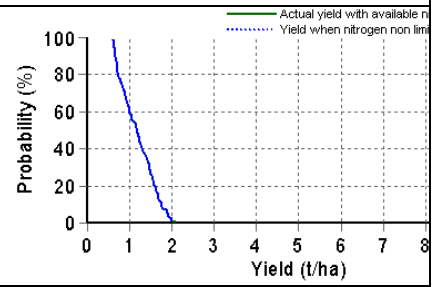
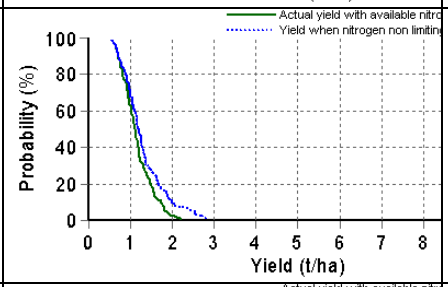
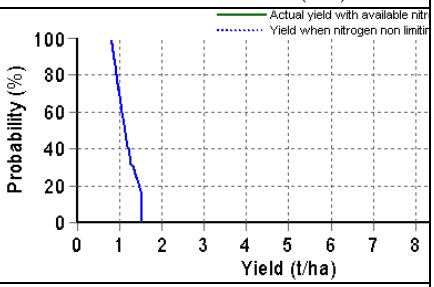
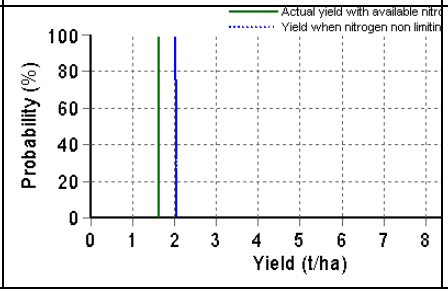
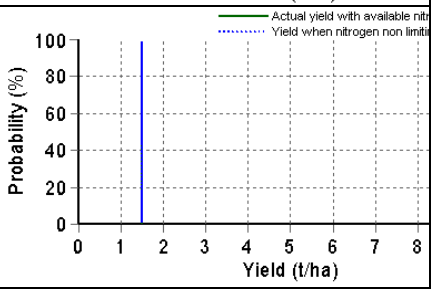
Table 2. Predictions of grain yield outcomes for wheat (cv. Yitpi) sown 15 May on dunes/midslope soils and on flats.

Date of report/ Growth stage/ GSR	Sandy soils- dunes/midslopes	Flats
14 July GS14 Early tillering GSR 69 mm		
22 July GS16 Late tillering GSR 74mm		
24 Aug GS37 flag leaf GSR 85 mm		
18 Sept GS65 - mid flowering GSR 122 mm		
9 Nov Maturity GSR 193 mm		

Measured VS predicted wheat growth:

Measured grain yields on the sandy parts of the trial ranged from 1.2 to 1.5 t/ha (predicted 1.6 t/ha) while the points closest to the flats yielded the lowest at 1 t/ha with yield rapidly increasing up the slope to 1.7 t/ha (predicted 1.4) (Table 3). The Yield Prophet predictions for

the 2 soil types for both biomass at anthesis and for final grain yield were very close to the measured values.

Table 3. The range in observed anthesis dry matter and grain yield from 3 points closest to the dune and flats, compared to the Yield prophet predictions.

		Biomass @ anthesis 23/09/09 (t/ha)	Biomass @ Harvest	Grain yield Maturity (t/ha)	HI Maturity
Observed	Dune	2.3-2.5		1.2-1.5	
	Flats	2.9-3.3		1.0-1.7	
Predicted	Dune	3.1	4.2	1.6	0.38
	Flats	2.6	3.4	1.4	0.41

What does this mean?

- The Yield Prophet system is a tool that integrates the multiple drivers of crop growth (soil moisture, soil nutrition, crop stage, seasonal outlook and soil potential) into a prediction of in-season grain yield outcomes. This has been achieved by combining a complex soil-crop simulation model with real time soil, crop and weather information and some seasonal forecasts. Provided that soils are accurately characterised, APSIM can accurately predict cereal yields in the Mallee.
- The question posed by this work was whether predicting crop performance in-season could be useful in the management of responsive faming systems. In addition to the grain yield outcomes presented in this article, there is information contained in the Yield Prophet reports such as predicted dates of crop stages, frost and heat risk assessment and yield predictions for years where SOI has an influence on rainfall. This information is useful in planning crop-stage dependent herbicide applications, or understanding the drivers of crop performance for instance.
- On soil types where there may be responses to in-season applications of N, crop reports generated around the crop stage Z30-32 (1st and 2nd node) can be useful in deciding whether to topdress. The reports generated on July 22 for the sand indicated that there was little difference between yield achieved with actual and unlimited N in about 40 % of seasons – given the very dry conditions during August we decided against topdressing and probably foregoing 300 to 400 kg/ha of grain at harvest on the sands.
- The range in yield of the predictions made near anthesis and later become very valuable decisions made for crop insurance estimates, forward commitments to wheat pools or obtaining early commitment bonuses.
- The long term yield performance and season to season yield variation of different soil types is critical information in designing lower risk farming systems. This may include deciding on areas most suitable for various landuses

(continuous cereal cropping, season responsive rotations, permanent pastures) and for designing robust paddock zones in precision agriculture applications.

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