Framework for economic analysis

Peter Hayman, SARDI Climate Applications, February 2022

APSIM simulated wheat production was used to assist with Activity 4. Investigate the value of information from seasonal climate forecasts and soil moisture monitoring for decision making at least three sites, and specifically with developing V1 of the Economic analysis. This data was provided to the CSIRO team and included in their delivery of Nitrogen report (APSIM x soil water probe visualisation x N decision tool) in collaboration with SARDI Climate Applications and EP Ag Research which is available as an appendix to the CSIRO milestone report. That report details the SARDI milestone of V1 of the Economic analysis and places it in a broader and more useful context for Eyre Peninsula primary producers.

This is an excerpt from the report provided to the CSIRO team.

Using APSIM to analyse nitrogen response in wheat: SSW & N matrix

Bronya Cooper and Peter Hayman, SARDI, Jan 2022

We are using the sophisticated daily timestep model APSIM for analysis of climate and risk for nitrogen decisions, particularly the response of wheat yield to N topdressing.

We are interested in the relative contribution of both N rate and starting soil water (SSW) to the overall yields/profit. This can give an idea of the value of information on these parameters at the start of the season. Our plan is to use the APSIM output for economic analysis.

To investigate, we are using APSIM with various SSW and N rates. This work aligns with the Smart Farming project on Resilient and Profitable Farming on the Eyre Peninsula, and as such we are integrating some of the APSIM components (particularly soils) developed by CSIRO as part of the same project. Our initial focus has been on APSIM output at Cummins (reported here) and Minnipa.

Cummins APSIM setup

Nitrogen

- APSIM runs varying the amount of Nitrogen (as NO3) added at sowing (From 0 – 300kg/ha in increments of 10kg, and 400kg/ha).
- In all cases there is 50kg/ha N in soil (as NO3) reset 14 May (day prior to sowing), which is spread throughout the top 3 layers (0-50cm depth).

Starting soil water

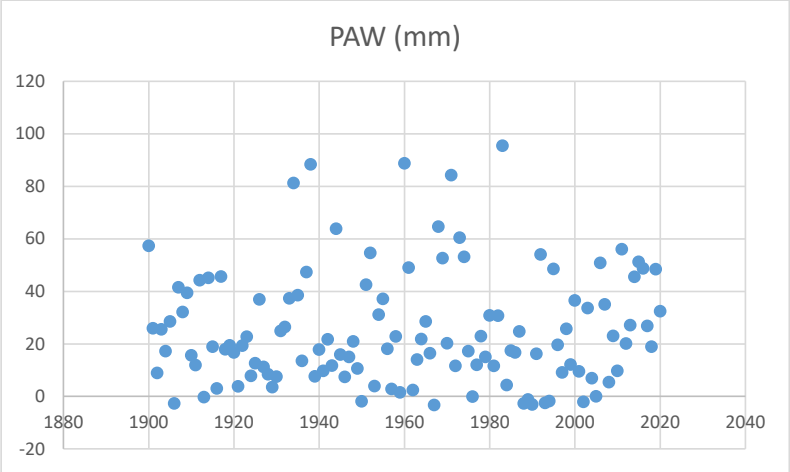
- Matrix uses a range of ssw from 0mm - 60mm (by 10mm), 80mm and 100mm.
- Ssw is filled from top, amount relative to wheat.
- The ssw is also reset 14 May, the day prior to sowing. In an earlier analysis we reset the ssw (Plant Available Water) to 0mm on Jan 1 each year and reported the PAW on 14 May (see Figure 1). This gave a median PAW of 20mm, but with a large range between about 0-100mm.

Soil

- Wilksch Yeelana soil provided by CSIRO ("Wilksch_Yeelana_FrSW"). See Figure 2.
- PAWC 211.2mm
- I also included the updated ini file recommended by CSIRO for better N mineralisation in heavier soils.

Other APSIM setup notes

- Cummins SILO met file from 1900-2020 was used (decided not to use the different mat file from Therese that apparently is better for radiation, as it only from 1990 (AWAP).
- Fixed sowing on May 15, cv. V2_P3



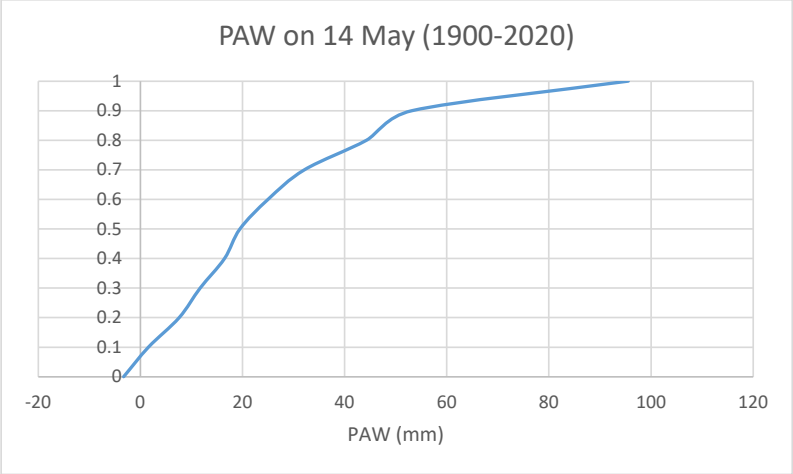


Figure 1: Plant Available Water amount on 14th May, when PAW was reset to 0mm on Jan 1, using APSIM setup for Cummins 1900-2020.

Depth (cm)	BD (g/cc)	AirDry (mm/mm)	LL15 (mm/mm)	DUL (mm/mm)	SAT (mm/mm)	KS (mm/day)	wheat LL (mm/mm)	wheat PAWC 211.2	wheat KL (/day)	wheat XF (0-1)
0-10	1.340	0.040	0.079	0.349	0.464		0.079	27.0	0.06	1.0
10-30	1.380	0.120	0.147	0.361	0.450		0.147	42.8	0.06	1.0
30-50	1.310	0.182	0.182	0.348	0.475		0.182	33.2	0.06	1.0
50-70	1.490	0.208	0.208	0.358	0.408		0.208	30.0	0.06	1.0
70-90	1.460	0.208	0.208	0.369	0.419		0.218	30.2	0.04	1.0
90-130	1.420	0.208	0.208	0.384	0.434		0.264	48.0	0.04	1.0

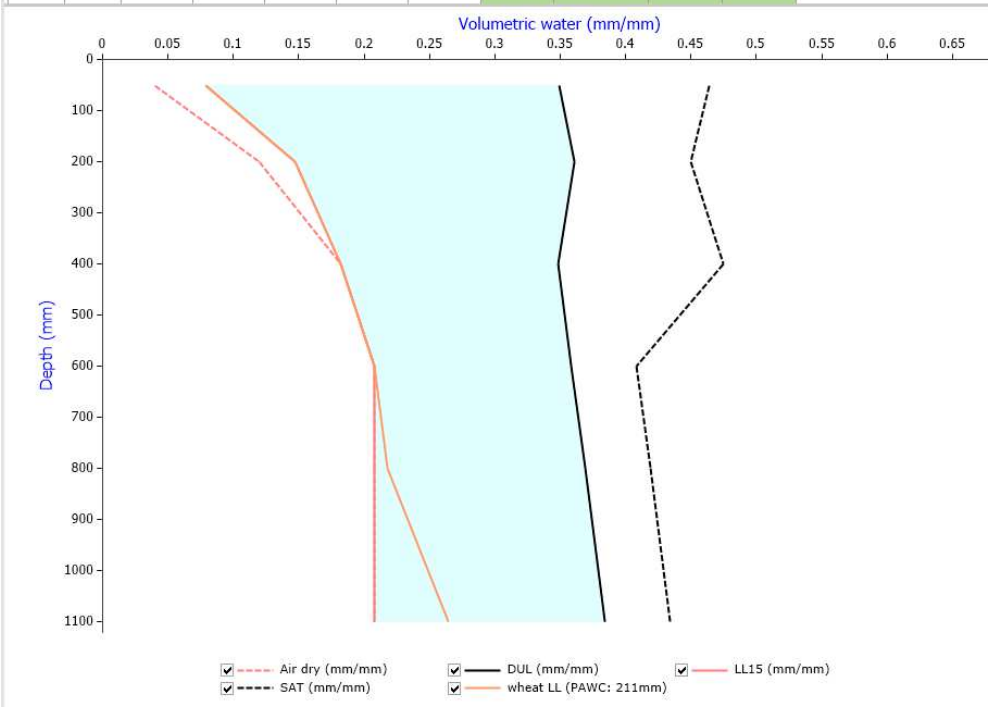


Figure 2: "Wilksch_Yeelana_FrSW" soil (PAWC 211.2) provided by CSIRO.

Results

Figure 3 shows the increase in average yields across N rates (from about 3t/ha for N0, to 6-8t/ha for N400. It also shows that average yields increase with higher starting soil water.

The colour formatted tables (Tables 1 & 2) show the nitrogen efficiency for yield (kg increase in yield per kg nitrogen added). They are arranged with N amount along the top (columns) and Years down the left side (rows), where the years are sorted from lowest (top) to highest yield (using yield when 400kg N was added).

The darkest orange highlights negative values. This is where there is a reduction in yield/biomass, even though more N was added. We can see that there are more of these negative values in the lower SSW categories, and also more negatives in yield compared to biomass.

We were interested to see the N response when averaged across deciles of the maximum yield (generally the yields when 400kg/ha N was added). Figure 4a shows the average yields across

deciles, and Figure 4b shows the corresponding N efficiency averaged across deciles. It's interesting to note in 4b that the higher decile yields start with an efficiency of around 40kg yield per unit N added.

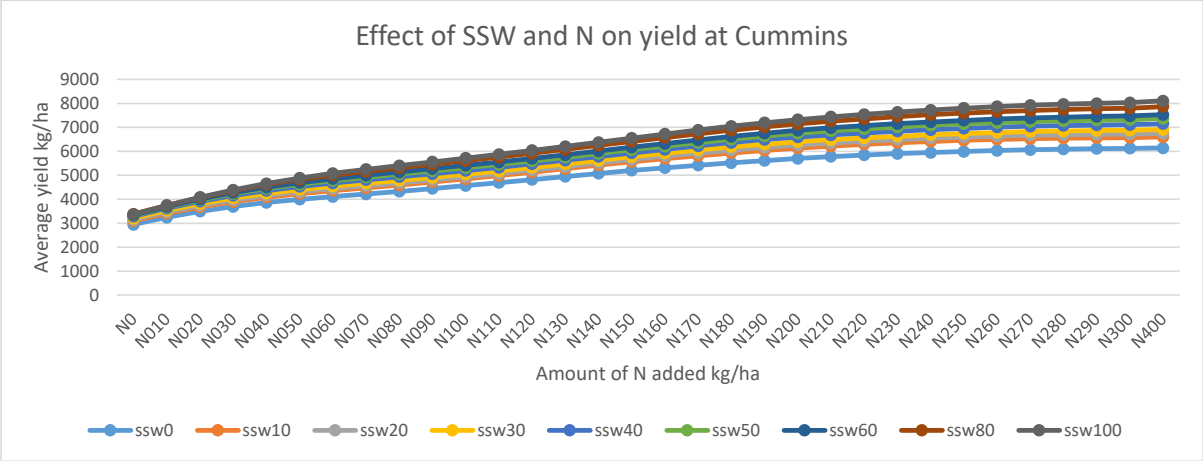


Figure 3: APSIM simulated average wheat yields at Cummins (1900-2020). Various nitrogen rates at sowing and starting soil water (SSW) at sowing were used.

Yield

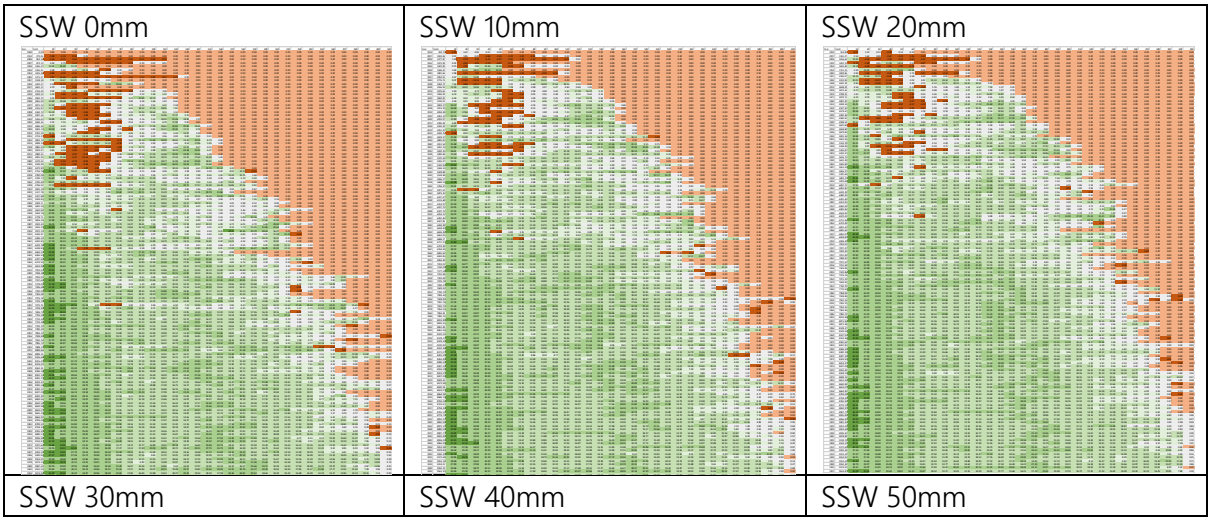


Table 1: APSIM simulations of nitrogen efficiency for yield (kg increase in yield per kg N added) across different starting soil water (SSW) amounts at Cummins. Rows are years between 1900-2020, ordered from lowest (top) to highest yield when 400kg N is added (to represent N unlimited yields). Columns are the different N amounts added at sowing, between 0-300kg/ha in increments of 10kgN/ha, and far right with 400kg N/ha added.

Biomass

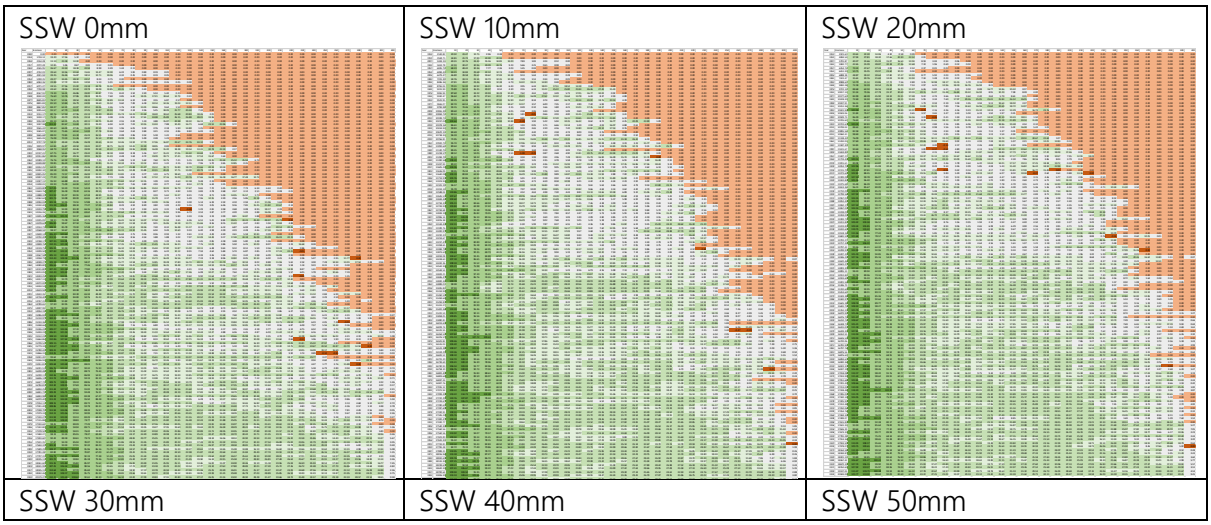


Table 2: APSIM simulations of nitrogen efficiency for biomass (kg increase in biomass per kg N added) across different starting soil water (SSW) amounts at Cummins. Rows are years between 1900-2020, ordered from lowest (top) to highest biomass when 400kg N is added (to represent N unlimited yields). Columns are the different N amounts added at sowing, between 0-300kg/ha in increments of 10kgN/ha, and far right with 400kg N/ha added.

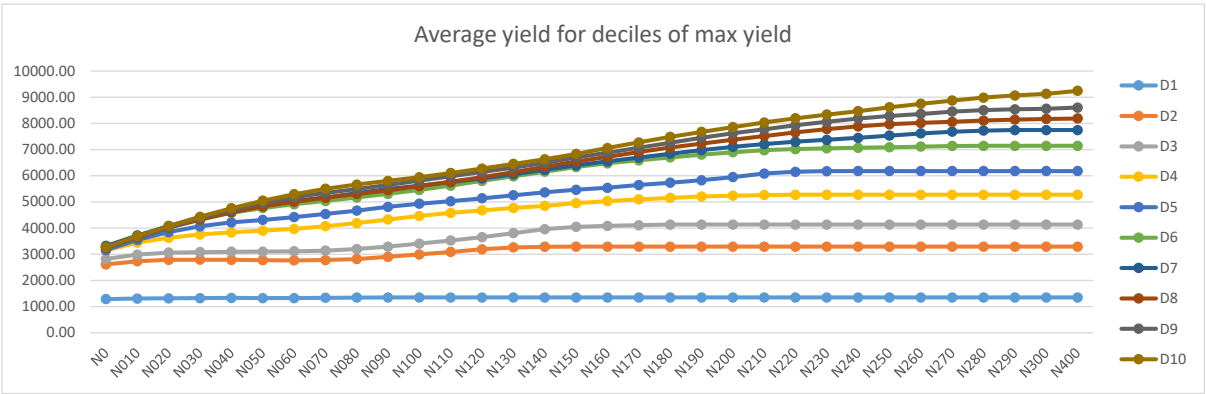


Figure 4a: Yield response to N averaged over deciles of the maximum yield. For example, "D1" shows the yields across various N rates averaged over the 10% of years that have the lowest maximum yields.

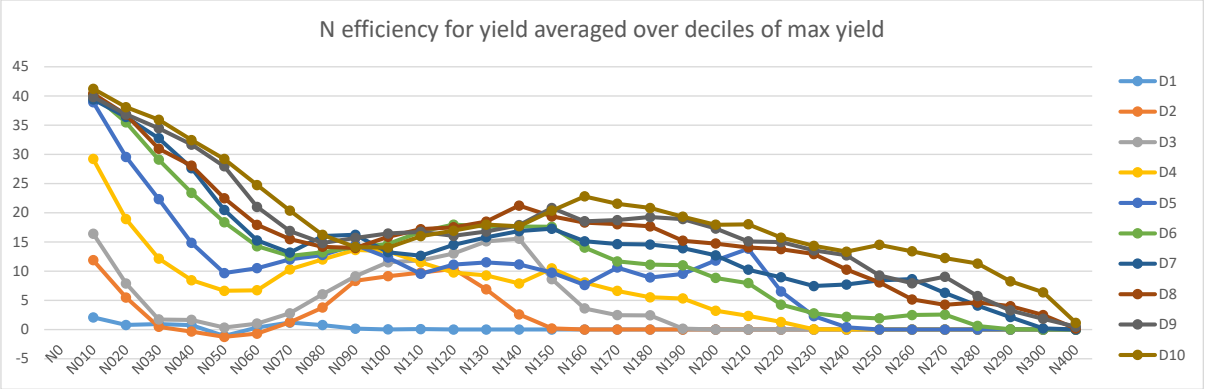


Figure 4b: N efficiency (increase in yield per unit N added), averaged over deciles of maximum yield.

Implications

We'd planned to use the APSIM output for economic analysis. However, for this to lead to sensible conclusions the APSIM yield response needs to follow a diminishing marginal return pattern, where the change in yield per unit nitrogen added could be expected to be larger at a low N rate, and diminish as the N rate increases to the point of the system being N unlimiting. This is not what we are finding in the APSIM data shown here. The worst cases have been highlighted (in dark orange in Tables 1 & 2) where we are seeing a reduction in yield/biomass, even though more N was added. However, even in cases that only have increased yield with N rates, we are finding most don't follow a diminishing marginal return. Our initial response has been to look at fitting a curve to the APSIM output to force a diminishing return. This is explored further in the summary document "N response using a quadratic".

Project Funders
Australian Government
National Landcare Programme
Project Proponents
AIR EP Ag Innovation & Research Eyre Peninsula
CSIRO
Regional Connections
Project Partners
SARDI
SquareV
EPAG
COUTTS J&R