Better Defining Yield Potential for the Upper Eyre Peninsula

RESEARCH

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Key messages

- **On zones where wheat growth is not constrained the French and Schultz method gives a realistic potential yield estimate based on growing season rainfall (GSR) and a soil water evaporation term of 110 mm.**
- **Where soil water evaporation is higher because of sub soil constraints and other factors that affect the growth of wheat, the soil water evaporation term must be adjusted.**
- **Zoning your paddocks into areas of performance and soil testing these areas separately for soil nutrients can improve decisions on where to apply nutrients for the best return.**
- **Fertiliser application rates at sowing should be strategic i.e. based on the yield potential of the zone and soil test results (e.g. a sowing application of DAP or MAP on a soil with high yield potential should be supplemented with topdressing applications of N if seasonal conditions are good).**

Why do the trial?

The Eyre Peninsula environment is one of the most challenging regions of the world to farm profitably and sustainably, particularly in the last decade. Despite these challenges, many farmers show that it is possible to do so with modern technology, sound business skills and an understanding of the environment. The responsive farming systems approach adopted by the latest GRDC EP Farming Systems 3 project aims to build resilience into EP farms by understanding the interactions between soil potential, climate and management. Critical to this is establishing realistic yield potential targets. The most commonly used method used has been that established by French and Schultz (1984) and more recently using the APSIM soil-crop models. The potential yield calculation is a simple and widely used method for predicting potential grain yield. The loss term of 110 mm commonly used to account for soil water evaporation, runoff and drainage (the latter two typically low in upper EP environments) frequently overestimates soil evaporation, but may even underestimate them on constrained soils. This paper suggests more realistic loss terms based on deciles and soil types for 3 sites across the EP.

How it was done?

The majority of research activities in the current EP water use efficiency initiative are taking place at focus paddocks located at Mudamuckla, Minnipa and Wharminda. At each site the use of EM38 survey, yield maps and soil testing have been used to create zones representing good, medium and poor performing areas of each paddock. Representative soils within these zones have been characterised for plant available water capacity (PAWC) by determining the drained upper limit (DUL) and the crop lower limit (CLL), as well as chemical analysis for plant available nutrients (e.g. mineral N, Colwell P, S, exchangeable cations) and chemical constraints such as pH, boron and chloride.

Three approaches were used to estimate how much yield Yitpi wheat should have achieved in these three environments in each of the last hundred years, assuming current management approaches, paddock conditions and no nutrient deficiencies.

Method of potential yield estimate

APSIM: Using the APSIM crop model and long term weather records sourced from nearby meteorological stations, wheat growth was simulated for the period 1910 to 2009 using modern varieties and management and assuming no nutrient constraints. The effects of rainfall, evaporation, drainage and water extraction by the crops were all calculated by the model. Wheat (cv. Yitpi) was sown between 25 April and 30 June and sowing within this period was triggered by the first rainfall event of 10 mm or more over 5 days. Cumulative growing season rainfall and soil evaporation was for the April to October period of each year.

French and Schultz (1984): This method was based on the collection of data described in French and Schultz (1984) to define a linear boundary function describing grain yield per unit of water use (i.e. 20 kg grain/ha.mm for wheat grain, or transpiration efficiency). A loss term, or the x-intercept of this line, accounting for soil evaporation in the original papers was 110 mm, although it was noted to range from 30-170 mm depending on soil type and rainfall pattern. Accounting for soil moisture at sowing and harvest to better estimate how much moisture in addition to GSR the crop has access to, was also recommended. The equation is therefore:

Yield = (water use − soil evaporation) x transpiration efficiency

French and Schultz (EP2010): Assuming that transpiration efficiency is constant, soil evaporation is the only term available to adjust water use. APSIM was used to calculate April to October in-crop soil evaporation for all seasons from 1910 to 2009 at a range of sites and soils. Runoff and drainage was also calculated but was found to be negligible in the majority of seasons and therefore ignored. This paper presents the soil evaporation terms that could be used to replace the standard figure normally used in the FS calculation (see equation above and Table 2).

Comparison of potential yield methods vs observed data for MAC

An evaluation of the 3 methods was undertaken using long term farm records from MAC to establish the average grain yield of all paddocks that were sown to wheat for the seasons between 1972 and 2007. This includes paddocks that have been in long term cereal or other rotations as well as paddocks coming out of pasture rotation. No management information about variety, planting date, fertiliser or stage of rotation was available. Potential Yield for each season was then calculated by:

1. as reported by Whitbread and Hancock (2008) APSIM was also used to simulate the growth of wheat for zones represented by loam and shallow heavy loam soils that were characterised at MAC. The average farm yield was then calculated assuming that 2/3 of the area grown to wheat was located on the zones represented by loams and 1/3 represented by shallow heavy loam zones;
2. based on GSR and ignoring soil moisture that may have been stored in the soil profile at sowing and harvest, potential yield was calculated using the French and Schultz (1984) method with a 110 mm soil evaporation term; and
3. based on GSR and ignoring soil moisture that may have been stored in the soil profile at sowing and harvest, potential yield was calculated using the French and Schultz (EP2010) method with APSIM used to calculated soil evaporation for each season and soil. An average yield for the 2 zones was calculated as for the APSIM method.

What happened?

The 3 methods used to calculate potential yield for each zone of the focus site are presented in Table 1. In the French and Shultz (1984) method, the soil water loss term remains as 110 mm for all sites, seasons and soils resulting in average growing season rainfall defining yield potential. In the French and Shultz (EP2010) method, soil evaporation increases with growing season rainfall and is also influenced by the soil type of the zone (Table 2). The zones with the least constrained soils, namely sand, loam and deep sand found at Mudamuckla, Minnipa and Wharminda respectively, have the lowest soil evaporation terms and consequently the highest potential yield estimates. These are lower than those estimated by French and Shultz (1984) and APSIM for the same zones. Soil evaporation increases on the less favourable soils, therefore reducing the water available for transpiration and consequently the potential yield (Table 2).

The real yields measured at MAC reached a maximum of about 2.9 t/ha with 287 mm April to October rainfall (data not shown) presumably due to constraints such as N limitation. Predictions of grain yield based on the French and Schultz (1984) approach are considerably higher in most seasons, particularly in the higher yield or higher rainfall seasons. A regression of the predicted against observed yields (Figure 1) was a poor fit of the data. Predictions of grain yield using APSIM more closely match the measured data for April to October rainfall up to 300 mm, but in seasons where rainfall exceeds this amount, APSIM also predicts higher yield than achieved. A regression of the predicted against observed yields was a similarly poor fit (Figure 1). The French and Schultz (EP2010) method closely matched the APSIM predictions.

Farming Systems

Table 1 Potential wheat grain yield (average of 1910 to 2009) calculated using the standard French and Schultz (1984) method with water loss term of 110 mm, a modified French and Schultz (EP2010) using a water loss term calculated for each season and soil by APSIM and the APSIM N-unlimited potential yield.

	Soil type-zone	F&S (1984) (t/ha)	F&S (EP2010) (t/ha)	APSIM (t/ha)
Mudamuckla	Sand	2.1	1.9	1.9
	Grey loam	2.1	1.0	0.8
	Shallow heavy loam	2.1	1.2	1.1
Minnipa	Loam	2.5	1.8	2.4
	Shallow loam	2.5	1.7	2.1
	Shallow heavy loam	2.5	1.5	1.1
Wharminda	Deep sand	2.5	2.1	2.9
	Shallow sand	2.5	1.7	2.0
	Shallow loam	2.5	1.3	1.0

What does this mean?

- On zones where wheat growth is not seriously constrained by factors such as shallow rooting depth, the French and Schultz (1984) method results in realistic potential yield estimates based on GSR and a soil water evaporation term of 110mm. Where soil water evaporation is likely to be higher because of sub soil constraints and other factors that affect the growth of wheat, the soil water evaporation term must be adjusted.
- Table 2 presents soil evaporation terms for all deciles and soil types and is based on APSIM simulations for the seasons between 1910 and 2009.
- Zoning your paddocks into areas of like performance and soil testing these areas separately for soil nutrients can inform decisions on where to apply nutrients for the best return.
- Fertiliser application rates at sowing should be strategic i.e. based on the yield potential of the zone and soil test results. For example a typical sowing application of DAP or MAP on a soil with high yield potential should be supplemented with topdressing applications of N if seasonal conditions are good. In regions like Wharminda, multiple small applications of N could be most efficiently used.

References

French R J Schultz J E (1984). Water use efficiency of wheat in a Mediterranean-type environment. I. The relation between yield, water use and climate. Australian Journal of Agricultural Research 35, 743-764

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***Table 2** Look-up table for cumulative soil evaporation (mm) from April to October for deciles as calculated by APSIM based on 100 year unlimited-N simulations at each site and soil type of the focus sites.*

Decile	Mudamuckla			Minnipa			Wharminda		
	Sand	Grey loam	Shallow grey loam	Loam	Shallow loam	Shallow heavy loam	Deep sand	Shallow sand	Shallow loam
1	96	132	126	133	144	152	118	140	156
2	103	142	135	139	149	158	122	144	162
3	108	149	142	142	152	162	125	147	167
4	112	157	149	146	155	166	129	150	173
5	117	165	155	149	157	169	132	153	176
6	120	169	159	152	160	172	136	156	182
7	124	175	164	156	163	176	142	161	190
8	127	180	169	162	168	182	145	164	195
9	133	190	178	169	174	190	150	168	201
10	158	228	213	182	186	204	169	185	229

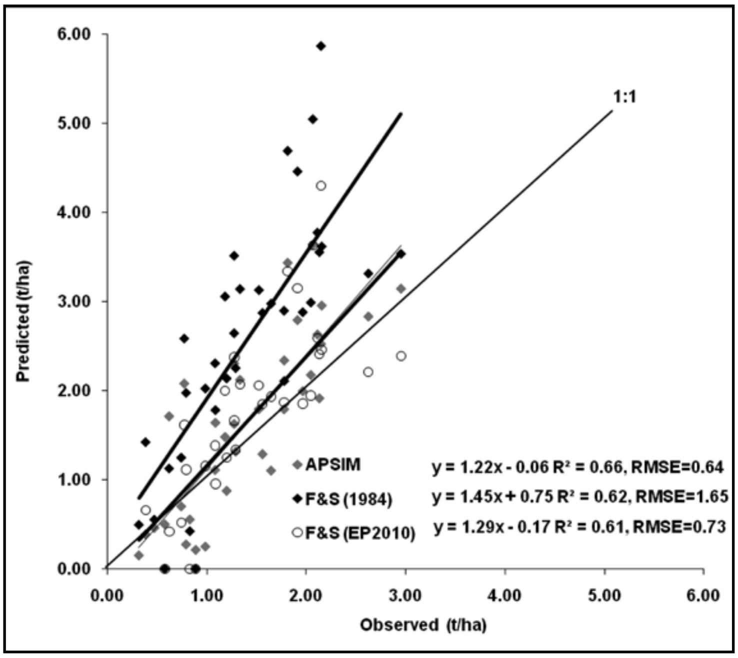

***Figure 1** Comparison of observed average wheat yield (t/ha) at MAC for seasons between 1972 and 2006 with potential yield estimates calculated using French and Schultz (1984), French and Schultz (EP2010) and APSIM.*