

Kerribee 2009 Water Use Efficiency Trial

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MSF Kerribee Core site

Key messages:

- The amount of soil water available to the crop at the start of the season was negligible.
- There was no benefit in having a fallow in the 2008 season.
- The Available Soil Nitrogen and the predicted in-crop mineralisation was adequate to supply the crop with enough nitrogen to allow it to reach its potential yield.
- Predicted final yields were not achieved, with final Water Use Efficiencies measured at 12 kg/ha/mm.
- The highest yielding treatment was the continuous cereal rotation.
- Factors other than the amount of nitrogen and moisture are limiting yield.

Aims:

- To compare the performance of different farming systems and rotations.
- To measure the Water Use Efficiency of wheat in Belah soils.

Background:

This trial site was used in the past by the CSIRO to compare the performance of various cropping systems and rotations. This was continued, in a limited manner, this year.

As well there has been a lot more interest recently in Water Use Efficiency of crops and cropping systems, so this trial was also used to look at water and nitrogen utilisation on Belah soils.

About the trial:

The WUE trial was planted at the MSF Kerribee core site in the plots used previously by CSIRO. Within each replicate there were four replicates with treatments randomised within each replicate.

Soil cores were taken in March from each plot of 4 representative treatments. The 120cm cores were separated into 7 samples (0-10, 10-20, 20-40, 40-60, 60-80, 80-100, 100-120 cm). Soils were tested for Nitrate and Ammonium with 200 grams sent away for analysis; the remainder was used to determine soil water percentage.

Unavailable Soil Water and Nitrogen was calculated using the computer program 'Your Soils Potential'.

The fallow plots from 2008 were sprayed at the start of the 2008 spring with a knockdown herbicide, the Conventional Cultivation (CC) plots were cultivated once over summer, while the Reduced Tillage (RD) and Direct Drill (DD) plots were sprayed with a knockdown to control out of season weeds.

The trial was planted on the 1st of May 2009 with the wheat variety Axe, at a seeding rate of 30 kg/ha. MAP fertilizer was applied at a rate of 17 kg /ha (3.7 kg P/ha). Sixty meter long plots were planted with a disc seeder at 15cm row spacings. A knockdown herbicide applied to the trial site prior to planting, as well as a post emergent broadleaf and grass weed herbicide application. No fungicide or insecticide sprays were applied to the crop.

The trial suffered badly from bird damage as the grain matured, especially on the western side. Also in the process of controlling weeds in the fallow plots some plants in adjacent plots suffered from herbicide damage.

Measured yields were low in some plots due to the above reasons (estimated to be between 20 and 60% grain loss) but were compensated for in calculating final plot yields by multiplying measured yield by the estimated % crop lost.

Table 1. Details of Treatments and plot history

Treatment number	Treatment			2005 crop	2006 crop	2007 crop	2008 crop	2009 crop
1	wheat/fallow	CC	DP	Yitpi	fallow	Yitpi	fallow	Axe
2	fallow/wheat	CC	DP	fallow	Yitpi	fallow	Correll	fallow
3	fallow/wheat	RT	DP	fallow	Yitpi	fallow	Correll	fallow
4	wheat/fallow	CC	Ad	Yitpi	fallow	Yitpi	fallow	Axe
5	opportunity crop	DD	Ad	Wyalkatchem	Yitpi	Yitpi	Correll	Axe
6	peas/wheat	RT	Ad	Kaspa peas	Yitpi	Kaspa pea	Correll	Axe
7	wheat/peas	RT	Ad	Yitpi	peas	Yitpi	peas	Axe
8	cereal/canola	RT	Ad	Eyre canola	Yitpi	Stubby canola	Correll	Axe
9	continuous cereal	RT	Ad	SA Sloop	CF Stiletto	CF Stiletto	Correll	Axe
10	wheat/fallow	DD	Ad	Yitpi	fallow	Yitpi	Correll	Axe
11	opportunity crop	RT	Ad	Yitpi	Yitpi	Yitpi	Correll	Axe

CC - Chemical winter fallow then Conventional Cultivation, RT - Chemical winter fallow then Reduced Tillage, DD - Direct Drill, DP - District Practice 50 kg/ha DAP, Ad - Adequate inputs to achieve potential yield.

Table 2. Growing Season Rainfall (GSR) at Kerribee 2009

	April	May	June	July	August	September	October	Total
rain (mm)	31	16.5	54.5	17	15	45.2	11.3	190.5

The Growing Season Rainfall (GSR) (see Table1) for Kerribee was close to Decile 5 (184mm for Mildura). The season started out very well but a dry July and August slowed plant development. This coupled with hot weather in spring considerably reduced the potential yield of the crop. The saving grace was the good rain in September which allowed the crop to fill the grain fairly well.

Assessments:

The collection of data at the trial site included:

- Soil cores taken to calculate available soil moisture and nitrogen prior to planting
- Measurement of heads per meter square on the 13th October
- The plots were harvested with a plot harvester on the 18th November and were weighted on site.

Results:

Table 3. Average Measured Soil Water Content and Plant Available Soil Water Content (mm of water / soil layer)

Treatment	Measured Soil Water (mm)				Plant Available water (mm)			
	4	5	7	9	4	5	7	9
Soil depth (cm)								
0-10	10	11	11	10	2	3	3	2
10-20	9	10	10	10	0	1	0	0
20-40	17	17	21	19	-2	-2	2	0
40-60	25	23	27	28	-5	-6	-3	-2
60-80	25	24	25	27	-18	-19	-18	-16
80-100	22	21	21	22	-23	-24	-24	-23
100-120	20	21	22	22				
0-60	61	61	69	67	-5	-4	2	0
0-100	108	106	115	116	-46	-47	-40	-39

Plant Available Water was calculated by subtracting the Unavailable Soil Water from the Measured Soil Water. The Unavailable Soil Water content was determined using the program 'Your Soils Potential', which accounts for all soil constraints (pH, salt, texture) to determine the amount of water the soil holds that the plants cannot use.

The Plant Available Soil Water was less deep in the soil profile, as there are more soil constraints that limit the amount of water the plant can extract from the soil at depth.

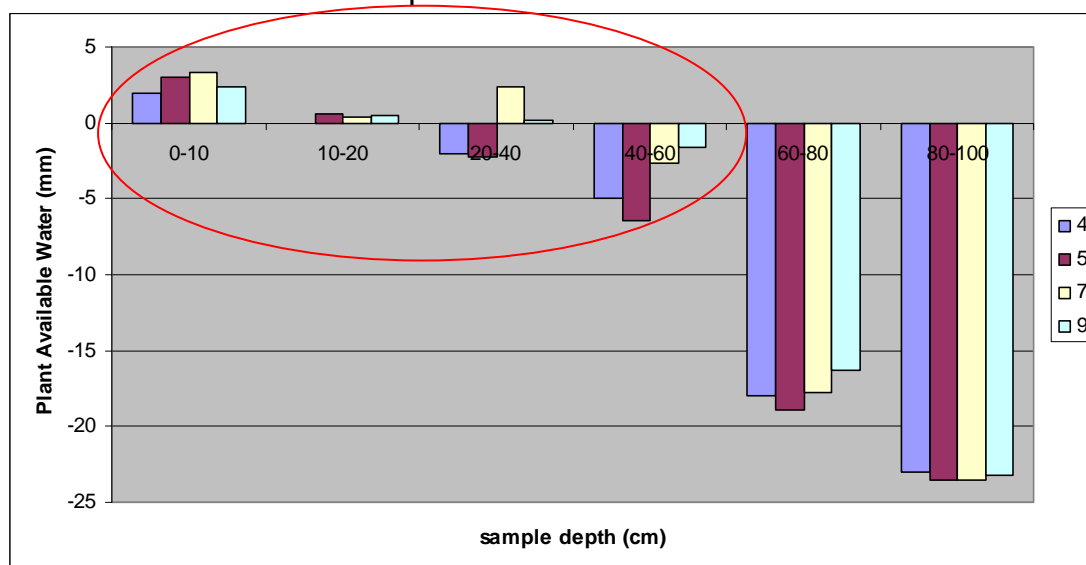


Figure 1. Average Plant Available Soil Moisture (mm) at each sample depth per Treatment

Overall the amount of soil water available to the crop at the start of the season was negligible (Table 3 and Figure 1), especially in the sub-soil. This assumes that there was no more rain after the samples were taken, but prior to planting. In April, 31 mm of rain was recorded at Kerribee, therefore it is likely that at least 10 mm of stored soil moisture was available to the crop.

There were slight differences between treatments, with treatment 7 (wheat/peas) having 8mm more moisture available in the top 60cm of soil than both treatment 4 (wheat/fallow) and 5 (opportunity crop). This had the potential to produce yield differences of 160 kg/ha between these treatments.

There was no benefit in having a fallow in the 2008 season as very little rain fell over the winter period, thus there was no more water stored compared to the treatments with crops growing in them.

Using a water use efficiency of 20 kg/ha/mm, the calculated potential yield in a Decile 5 year (184 mm GSR) was 1.92 tonne/ha. Potential yield was calculated using the following equation:

$$\text{WUE} = 184 \text{ mm GSR} - 88 \text{ mm evaporation} * 20 \text{ kg/ha/mm}$$

Table 4. Average Measured and Plant Available Soil Nitrogen (kg/ha)

Treatment	Measured Soil Nitrogen (kg/ha)				Plant Available Soil Nitrogen (kg/ha)			
	4	5	7	9	4	5	7	9
Soil depth (cm)								
0-10	17	9	10	11	13	7	7	8
10-20	14	13	13	18	10	9	9	13
20-40	17	22	35	25	11	14	22	16
40-60	32	52	41	43	14	24	19	20
60-80	21	41	26	32	6	12	8	9
80-100	18	30	21	24	5	8	6	7
100-120	20	25	21	25				
0-60	80	96	99	97	48	54	57	57
0-100	119	167	146	153	59	74	71	73

Plant Available Soil Nitrogen (Table 4 & Figure 2) was calculated by subtracting the Measured Soil Nitrogen from the Unavailable Soil Nitrogen. The Unavailable Soil Nitrogen was determined using the program 'Your Soils Potential', which accounts for all soil constraints (pH, salt, texture) to determine the amount of nitrogen the soil holds that the plants cannot use. The Measured Soil Nitrogen was calculated

from the soil Nitrate and Ammonium results obtained from the laboratory analysis of the soil samples.

The amount of Plant Available Soil Nitrogen generally increased down the soil profile until reaching a peak quantity at 60 cm below the soil surface (Table 4 & Figure 2). On average there was 54 kg/ha of nitrogen available to the crop to 60cm, and 69 kg N/ha available to 100 cm soil depth.

The amount of nitrogen required to reach the potential yield of 1.9 tonne/ha and 11.5% protein was 103 kg N/ha. The available soil nitrogen and the predicted in-crop mineralisation (from *Mallee Calculator*) was enough to allow the crop to reach this potential yield (69 kg N/ha from soil N and 37 kg N/ha from in-crop mineralisation). Therefore at the start of the season it was predicted that there would be no need for any nitrogen fertiliser applications to crop.

There were some differences in the amount of soil nitrogen available to the plant between treatments (Table 4 & Figure 2). Treatments 5 (opportunity crop), 7 (wheat/peas), and 9 (continuous cereal) had between 7 and 10 kg/ha more nitrogen than treatment 4 (wheat/fallow) to a depth of 60cm, and between 12 and 15 kg/ha more nitrogen to 100cm depth (Table 4).

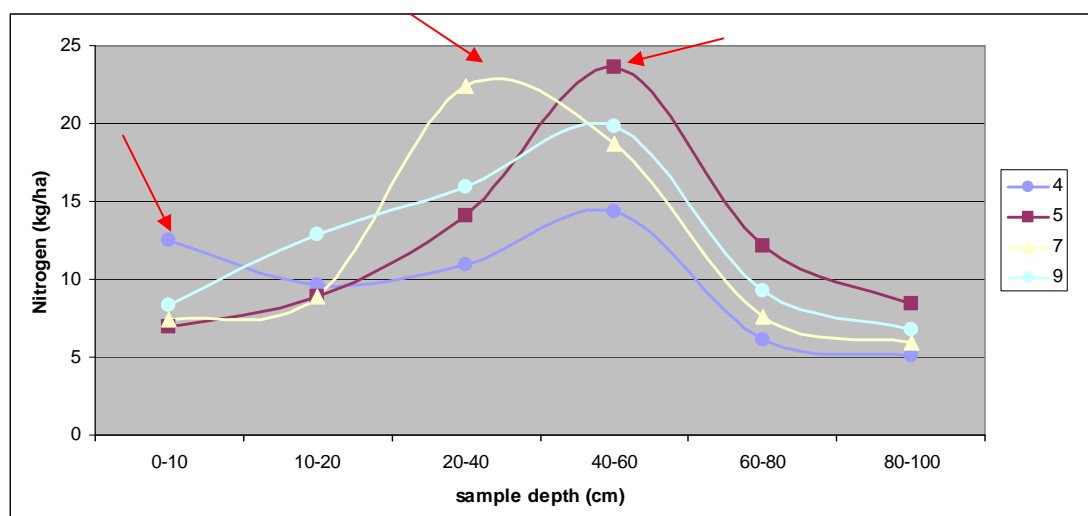


Figure 2. Average Plant Available Soil Nitrogen (kg/ha) at each sample depth per Treatment (smoothed line)

Treatment 4 (mechanical fallow/wheat) had almost twice the quantity of nitrogen in the top soil layer (0-10) compared to the other treatments sampled, all of which were not mechanically fallowed (Table 4 & Figure 2). This high soil nitrogen in the top soil layer of treatment 4 most likely resulted from soil mineralisation following cultivation.

This could have several implications. There is the possibility that this nitrogen could be moved further down, and perhaps out of, the rootzone of the crop with a significant rainfall event. If this nitrogen remains in the top 10cm of soil, it will mean that the young seedling should have ready access to more nitrogen following a fallow compared to a direct drill/no-till crop, resulting in more early growth. There will be some mineralisation following the sowing pass, but it will be related to the amount of soil disturbance. This means that in general direct drill and especially no till crops will need more fertiliser nitrogen at seeding to help get the crop started compared to a crop following a mechanical fallow.

Treatment 7 (pea/wheat) has a large amount of Nitrogen at 20-40 cm depth, compared to the other treatment with their soil nitrogen peak at about 40-60 cm depth (this is shown in Figure 2 as the yellow line having its 'peak' before the 'peak' of the other treatments). This is possibly due to the 'fixing' of soil nitrogen by rhizobium symbiosis in the pea roots at this depth.

Table 5. Treatment grain yield (tonne/ha) and head count data

treatment	average yield tonne/ha	average heads/m2	plot yield variance %	plot head/m2 variance %
1	0.89	161	16	34
4	1.20	171	13	13
5	1.01	151	10	1
6	1.20	178	12	6
7	1.20	189	6	27
8	1.10	201	12	11
9	1.36	174	10	18
10	1.16	194	21	4
11	1.14	178	13	18
average	1.14	177		
std dev	0.13	16		

The average yield across the trial was 1.14 tonne/ha (Table 5 & Figure 3). This translates into a Water Use Efficiency of 11.7 kg/ha/mm (1140 kg/ha / (190 mm GSR - 93 mm evaporation)), assuming there was zero plant available water at the start of the season. The WUE ranged from 9.17 kg/ha/mm to 14.02 kg/ha/mm from the lowest to the highest yielding treatments.

The final harvested grain yield varied greatly across the trial (up to 21% variation between plots of the same treatment) (Table 5). The highest

yield was in treatment 9 (continuous cereal), and lowest yield was in treatment 1 (wheat/fallow). Treatment 9 yielded 53% better than treatment 1, and 13% better than the next best treatment (treatment 4,6 and 7).

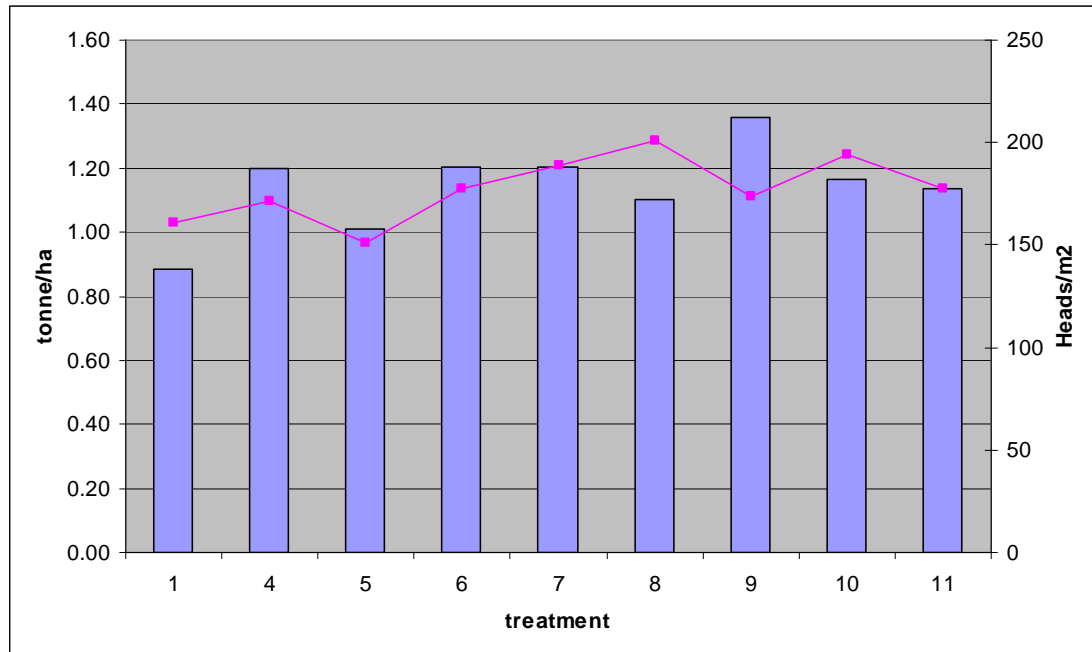


Figure 3. Average Treatment yield (tonne/ha) and Heads/m²

The head count data from Table 5 shows that the average number of heads per meter square is 177. This was used to calculate a predicted yield prior to harvest of 1.91 tonne/ha ($177 \text{ heads/m}^2 * 30 \text{ grains/head} * 0.036 \text{ grams/grain}$). This predicted yield ranged from 1.63 tonne/ha to 2.17 tonne/ha between treatments.

The predicted yield from the head count data was very similar to the potential yield calculated at the start of the season (1.91 compared to 1.92 tonne/ha). So the potential yield based on the number of heads produce was achieved, but this did not translate into final yield. This could be due to either the number of grains per head or grain weight not being realised due to dry and warm conditions during head development and also at grain fill.

Potential yield and Water Use Efficiency were not achieved in this trial, even though there were adequate inputs to do so. Other factors may have limited the potential of the crop. These factors may include other plant available nutrient deficiencies, root and leaf disease and climatic impacts at critical stages.

Who's Involved:

The trial is supported by;

- Maynard Family
- MSF

Activities, Events and Industry Participation:

MSF Kerribee field day August 2009.

Kerribee and Trentham Cliffs Crop walk in October 2009.

Future Directions:

It is planned to continue to study the relationship between WUE and cropping system/rotation on Belah soils at the MSF Kerribee core site.

Also another trial has started which will more closely examine the differences between systems that rotate between cereal types, wheat varieties and that which continuously use the same wheat variety.

Acknowledgements:

Thanks also go to Peter Jessop and Eric Bailey from I&I NSW for their assistance in planting and harvesting this trial.

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