Optimising profitability of high rainfall zone farming systems

Trial Hosts: Preston Family and Ashton Hood

Key Messages

- **Matching a wheat variety maturity to the growing season length was critical to maximising yields at West Cranbrook and South Stirlings**
- **Long-season wheats (winter-types) sown mid-April can yield equivalently to Scepter wheat sown in mid-May in the high rainfall zone of WA.**
- **Deep ripping on South Stirlings sand plain showed a yield increase of 370kg/ha which closed the gap between the harvested yield and the water-limited yield potential (WLYP) by 8%.**
- **Barley yielded more than wheat at both trial sites and was closer to the WLYP. Barley was more profitable at the South Stirlings trial but not the West Cranbrook site.**

Background

The High Rainfall Zone Systems project is a sister project to the Hyper Yielding Crops and focuses on expanding research results from the Hyper Yielding Crop Focus Centre into broadacre farm trials. Without results from the Focus Centre in the first season of the project, a trial design was created in consultation with SEPWA and DPIRD that included treatments of deep ripping, sowing time and variety. There were two sites installed – one in South Stirlings and the other in West Cranbrook.

Summary

At Cranbrook, Illabo (winter) wheat sown on the 20th of April yielded statistically equivalent to Scepter (spring) wheat sown on 13th May. Both of these treatments yielded significantly higher than Scepter wheat sown on the 20th April. Planet barley, planted on 13th May, yielded 470kg more than Scepter seeded on the same day. Deep ripping at this site showed no yield benefits, typical for forest gravel soils where compaction is not a constraint.

At South Stirlings, there was no significant yield difference between either time of sowing for Scepter wheat. The mid-short maturity of Scepter meant that the 9th June sowing date, which had better soil moisture conditions, caught up to 16th May sown Scepter. Illabo was only planted on 16th May because of the late seasonal break. Illabo wheat yields were not significantly different to Scepter wheat treatment in the challenging 2020 season. Planet barley yielded significantly higher than the wheat at South Stirlings and had a higher gross margin.

The deep ripping across this site achieved a 370kg yield advantage over the un-ripped soil. Deep ripping closed the gap between the WLYP and the harvested yields. The ripped wheat yields only averaged 78% of the WLYP, whereas the ripped barley was >100% using the French & Shulz model. Crop biomass data collected by drone on 29th July showed a significant increase from the ripped plots compared to the unripped plots. The dry finish to the season meant the 29th July biomass differences did not translate to the final yields.

Although the South Stirlings site yielded much less than the Cranbrook trial in 2020, both data sets showed the highest yielding varieties were the ones whose maturity best matched the growing season length. For example, long season winter wheat (Illabo) yielded competitively with Scepter in the long growing season at Cranbrook. The short-mid maturity of the Scepter was advantageous at South Stirlings in 2020 because of the shorter growing season.

Results

Cranbrook

The later sown Scepter wheat and early sown Illabo wheat yielded significantly higher, average of 880kg/ha, than 20th April planted Scepter. The data indicates that early sowing of long-season wheat can pay off in the region. However, it is critical to seed a longer maturing variety earlier to maximise yields. Longer season varieties can also drive other benefits for growers, such as grazing and utilising early subsoil water to reduce peak season waterlogging. There were no significant differences in yields for any varieties or sowing times after being ripped, indicating that soil compaction was not a constraint that limited yield at this site.

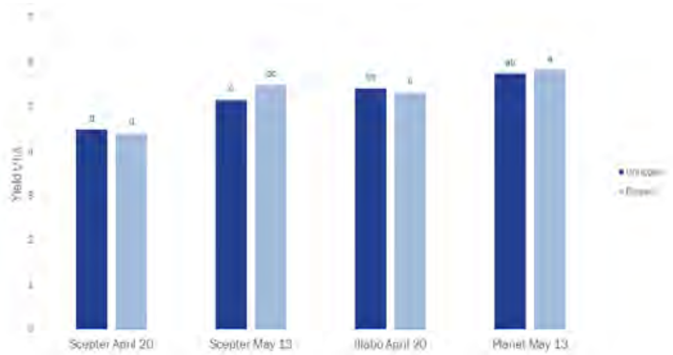

Figure 1: Grain yields (t/ha) for April 20 and May 13 sown, Scepter wheat, Illabo wheat and Planet barley over ripped and unripped treatments for the West Cranbrook site in the 2020 season.

Table one indicates that the West Cranbrook (Preston) trial site yielded close to its water-limited yield potential and even exceeded the original French and Schultz equation of:

(Attainable Yield) = (April to October rainfall – 110mm) * 20 kg/ha/mm

The GRDC publication, '*Water use efficiency of grain crops in Australia: principles, benchmarks and management*' (Sandras & McDonald 2012), suggests that modern wheat varieties can achieve 25 kg/ha/mm of grain. The paper also talks about other factors that can affect the evaporation figure of 110mm including, vapour pressure, nitrogen availability, previous crop and rainfall intensity. For simplicity, we decided to use the original 110mm evaporation figure to analyse our two trial sites in 2020.

Table 1: Summary of the harvested grain yields (t/ha) of the West Cranbrook trial in 2020 in comparison to the water-limited yield potential (WLYP) calculated using the French & Schultz (1984) method using either 20 kg grain/ha/mm or 25 kg grain/ha/mm.

Treatment		Yield		% WLYP	% WLYP
		t/ha		t/ha (20mm)	t/ha (25mm)
Scepter wheat April 20	Ripped	4.40	d	83.3	66.7
Scepter wheat April 20	Unripped	4.48	d	84.8	67.9
Illabo wheat April 20	Ripped	5.32	c	100.8	80.6
Illabo wheat April 20	Unripped	5.41	bc	102.5	82.0
Scepter wheat May 13	Ripped	5.48	bc	103.8	83.0
Scepter wheat May 13	Unripped	5.15	c	97.5	78.0
Planet barley May 13	Ripped	5.83	a	110.4	88.3
Planet barley May 13	Unripped	5.74	ab	108.7	87.0
Water Limited Yield Potential (t/ha)		5.28t/ha		(374mm-110mm) * 20kg/ha/mm	
Water Limited Yield Potential (t/ha)		6.60t/ha		(374mm-110mm) * 25kg/ha/mm	
Average % WLYP Ripped treatments				99.6%	79.7%
Average % WLYP Unripped treatments				98.4%	78.7%

The most water-efficient treatment in the trial was the ripped Planet barley sown on 13th May at 88% of WLYP. The best wheat treatment (Scepter 13th May) was 5% lower in water use efficiency than the ripped Planet barley. The growers applied 110kg/ha of nitrogen (N) fertiliser over the growing season and, combined with the soil stored N, should have been enough to grow the maximum WLYP of 6.60t/ha.

One of the known limitations of French and Schultz's model is that it does not account for rainfall intensity over the growing season (Sandras & McDonald, 2012). The growing season rainfall displayed in table two shows an even spread of rain from April to October, and the site had no observable signs of

waterlogging in 2020. The most likely reason for not reaching the WLYP was the dry October (17.2mm) and dry April (20.5mm).

The ripping resulted in a slight decrease in all protein levels than the unripped treatments; however, it was only significant in the late sown Scepter. The lower protein levels in the ripped 13th May Scepter wheat could be because of the slightly higher yields diluting the protein levels.

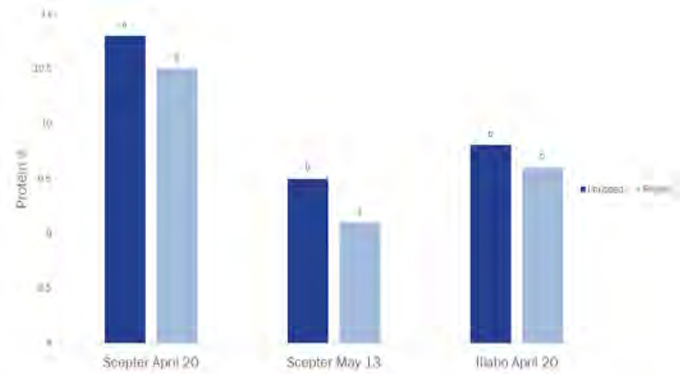

Figure 2: Grain protein (%) for April 20 and May 13 sown, Scepter and Illabo wheat varieties over ripped and unripped treatments for the West Cranbrook site in the 2020 season.

Table 2: The estimated growing season rainfall at the West Cranbrook trial site (34.316955, 117.373124) based on the Doppler radar service provided by the Bureau of Meteorology under licence to DPIRD.

Month	Growing Season
	Rainfall (mm)
Apr	20.5
May	97.8
Jun	43.3
Jul	41.5
Aug	94.6
Sep	59.1
Oct	17.2
Total	374

There was a significant increase in plant density for the May sown Scepter wheat over the 20th April sown Scepter. In May, the higher plant establishment was due to better soil moisture from 34mm of rain received before the second TOS. The higher plant counts were not seen in the later sown Planet barley because it was only seeded at 100kg/ha compared to the wheat at 120kg/ha. There was a decrease in plant density in the ripping treatments for all varieties and sowing times, although this was only statistically significant for the Illabo wheat.

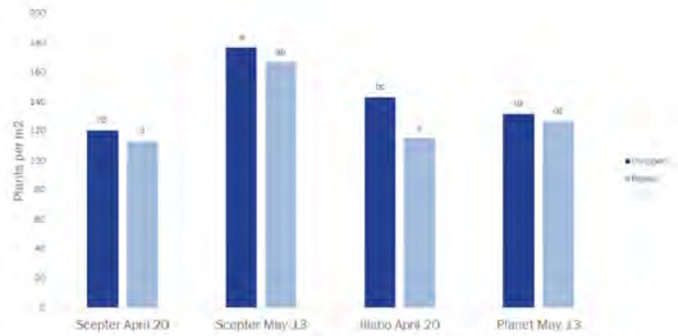

Figure 3: Plant density counts (plants/m2) for April 20 and May 13 sown, Scepter, Illabo and Planet varieties over ripped and unripped treatments for the West Cranbrook site in the 2020 season.

South Stirlings

There was a significant difference when comparing the barley yields to the wheat yields. This is consistent with local farmers' experience where barley consistently yields higher than wheat. There was a significant yield increase of 380kg/Ha, from deep ripping , for the late Scepter and early Illabo treatments.

There were no significant differences in yield at the South Stirling site when comparing wheat varieties or time of sowing (TOS). The lack of yield difference between sowing dates could be attributed to the growing season rainfall and timing of rainfall events. With the dry start to the season, the first TOS did not receive a significant rainfall event until 9.6mm fell on the 6th May. A further 12.6mm fell on 30th May, which assisted plant establishment.

The second TOS germinated off stored soil moisture and benefited from the 11.2mm of rain received three days after planting. It was very dry from 11th June onwards, and there was no single rainfall event over 10mm until 3rd August. Over this time, most crops in the region, including at the trial site, were significantly water-stressed.

There was a 31mm rain event on the 3rd November that may have benefited the later sown Scepter and long season Illabo. The early sown Scepter had reached maturity by this date and therefore not benefited from the late rainfall.

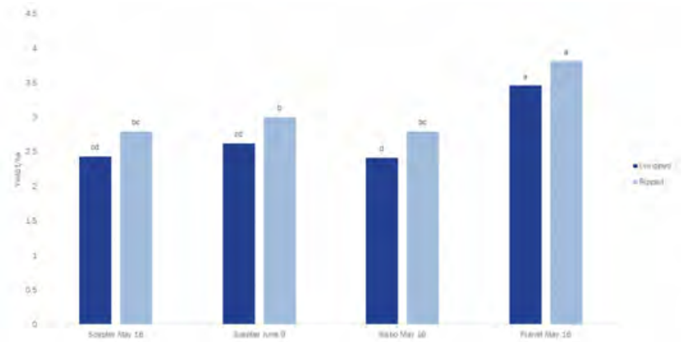

Figure 4: Grain yields (t/ha) for May 16 and June 9 sown, Scepter, Illabo and Planet varieties over ripped and unripped treatments for the South Stirling site in the 2020 season.

Table 3: Summary of the harvested grain yields (t/ha) of the Kojaneerup trial in 2020 compared to the water-limited yield potential calculated using the French & Schultz (1984) method with either 20 kg grain /ha/mm or 25 kg grain /ha/

Treatment		Yield		% WLYP	% WLYP
		t/ha		t/ha (20mm)	t/ha (25mm)
Scepter May 16	Ripped	3.00	b	81	65.2
Scepter May 16	Unripped	2.62	cd	71	57.0
Illabo May 16	Ripped	2.79	bc	75	60.7
Illabo May 16	Unripped	2.41	d	65	52.4
Scepter June 9	Ripped	2.79	bc	75	60.7
Scepter June 9	Unripped	2.43	cd	66	52.8
Planet May 16	Ripped	3.81	a	103	82.8
Planet May 16	Unripped	3.46	a	94	75.2
Water Limited Yield Potential (t/ha)		3.68t/ha		(294mm-110mm)* 20kg/ha/mm	
Water Limited Yield Potential (t/ha)		4.60 t/ha		(294mm-110mm)* 25kg/ha/mm	
Average % WLYP Ripped treatments				84.2%	67.3%
Average % WLYP Unripped treatments				74.2%	59.3%

Using the 25 kg grain /ha/mm figure in the French & Schultz equation showed the Kojaneerup trial site was only 67.3% of the WLYP in the ripped plots and 59.3% in the unripped plots. Unlike the west Cranbrook trial, ripping at this site has closed the margin between the actual yields and Water-limited yield potential (WLYP), indicating that compaction was yield constraining. However, there is still a large gap between the real yields and the WLYP.

The poorer water use efficiency at this site can be attributed to a couple of factors. Firstly, the rainfall distribution was not ideal with a very dry June and July period. August had 134.6 mm of rain, which effectively saved crops in the area from becoming droughted. Septembers 52.0mm was adequate before the season finished early, with only 12.0 mm recorded in October. (See table four for full details).

According to *'Water use efficiency of grain crops in Australia: principles, benchmarks and management'* (Sandras & McDonald 2012), dry conditions at the start of the growing season will significantly increase the crop's evaporation. For example, high frequency of small rainfall events and leaf area reduction increase the proportion of rain lost as soil evaporation. Sandras & McDonald (2012) display a graph suggesting evaporation at -34 latitude could range from 90 mm to 160 mm in the best to worst conditions. Given the sandplain soil and exceptionally dry start to the growing season, we suspect the Kojaneerup trial site may have experienced high evaporative conditions in 2020.

If we use the highest evaporation figure of 160mm, the French and Schultz model shows an estimated WLYP of 3.35t/ha, which the Planet barley was able to exceed in both the ripped and unripped plots. The highest yielding wheat treatment (3.00t/ha), ripped Scepter, seeded on the 16th May, was able to get within 90% of its WLYP. We suspect the 2020 evaporation conditions were closer to the 160 mm figure than the 90 mm number, which would explain why the yields were so far off the WLYP calculated from the original French & Schultz model.

There were significant differences in the protein levels when comparing late and early Scepter wheat and Illabo wheat. The early Scepter had the highest protein, followed by early Illabo and then late Scepter. The protein yield difference was only minor and is explained mainly by the variation across the trial. This would indicate that the protein percentage difference is most likely due to the yield difference of the treatments and some variation within the trial site.

There was also a significant benefit to early biomass growth from deep ripping measured via drone imagery on July 29. For all varieties and TOS, ripping improved ground cover percentage on average by 15.5%. As expected, the Planet barley had significantly higher ground cover over the wheat treatments due to its tillering structure.

Table 4: The growing season rainfall at Ashton Hood's 2020 Kojaneerup trial site based on the DPIRD Kojaneerup South (K0002) weather station data. (3.5km from the trial site).

Month	Growing Season
	Rainfall (mm)
Apr	6.2
May	46.8
Jun	20.6
Jul	21.8
Aug	134.6
Sep	52
Oct	12
Total	294

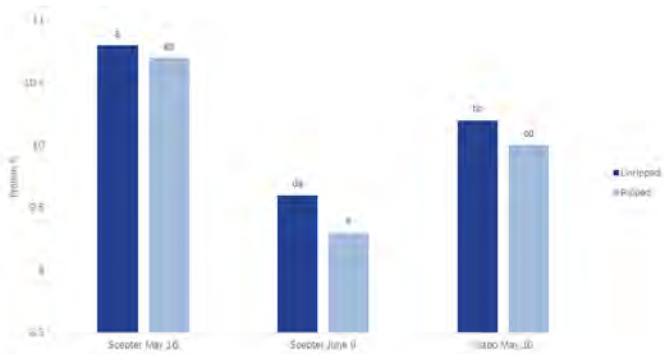

Figure 5: Grain protein levels (%) for May 16 and June 9 sown, Scepter wheat, Illabo wheat and Planet barley over ripped and unripped treatments for the South Stirling site in the 2020 season.

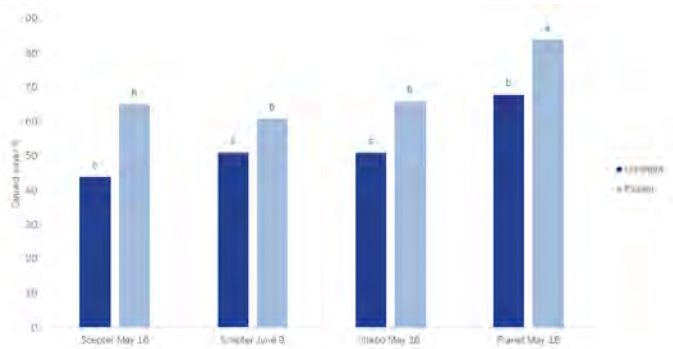

Figure 7: Ground cover calculations (%) from a drone flight on July 29 for May 16 and June 9 sown, Scepter, Illabo and Planet varieties over ripped and unripped treatments for the South Stirling site in the 2020 season.

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