Summer rain and stubble management

Funded by the GRDC Water Use Efficiency Initiative and conducted in collaboration with SARDI and the University of Adelaide.

Key findings

- Wheat yield increased from 2.6 t/ha in controls to 3.2 t/ha in plots receiving the equivalent of summer rainfall decile 5 (50mm) or decile 9 (100mm) in a single event in February.
- Stubble treatments (bare ground control, standing 2 t stubble/ha, flat 2 t stubble/ha, flat 5 t stubble/ha) did not affect the dynamics of soil water nor grain yield.

Why do the trial?

In south-eastern Australia, cereals depend on two sources of water: water stored in the soil during summer fallow, and in-season rainfall. However, the actual value of capturing out-of season water in the Mid-north region of SA is uncertain. In contrast to the dominance of small events in winter rainfall, summer rainfall is characterised by large storm events. The potential for deep-storage of water in soils is greater in large events.

This trial aimed to measure the interaction between stubble management and soil moisture on:

1. the retention of soil water accumulated outside the growing season.
2. the value of stored water to crop physiological traits and yield.

How was it done?

Plot size	5m x 6m	**Fertiliser**	DAP @ 65 kg/ha
Seeding date	8th May 2009	**Variety**	Gladius

The trial was a randomised complete block design with 3 replicates and 12 treatments resulting from the combination of four stubble treatments and three water regimes.

Rainfall treatments:

- Control (no added water)
- Decile 5 (50mm applied with trickle irrigation)
- Decile 9 (100mm applied with trickle irrigation)

Stubble treatments:

- Standing (2 t/ha)
- Flat (2 t/ha)
- Additional flat stubble (5 t/ha)
- Bare ground control

Soil moisture content was intensively monitored using capacitance probes from the establishment of the experiment to harvest, to determine the fate of the summer rainfall and the effects of stubble. Crop phenology and growth were monitored during the season, and grain yield and yield components determined at maturity.

Crop evapotranspiration (ET) was calculated as the difference between soil water at sowing and maturity plus the rainfall during this period. Water use efficiency (WUE) was calculated by dividing yield (kg/ha) by ET (mm).

Interception of photosynthetically active radiation (PAR) was recorded throughout the season using a ceptometer. Radiation use efficiency (RUE) was calculated by dividing shoot biomass by cumulative PAR. RUE is grams of biomass per MJ radiation intercepted and is a measure of the photosynthetic efficiency of the crop.

Results

Stubble effects

Stubble had a transient effect on top-soil temperature during fallow and crop establishment. The top soil in the plots with 5t stubble/ha had lower maximum temperature and higher minimum temperature than bare ground controls. This insulating effect favoured faster emergence, but differences in development were not evident after emergence. Stubble treatments did not affect the capture and dynamics of soil water and had no measurable effect on grain yield. The analysis in the following section therefore pools the data across stubble treatments.

Yield value of summer rainfall

At sowing, the decile 9 treatment had 46mm extra soil water in the soil profile compared to the control treatment (Fig 1a, Table 1). Approximately half the water applied through summer rainfall was retained and the remainder was lost to evaporation.

This high fallow efficiency can be attributed to the large size of the single rainfall event. It is likely that if the same amount of rain had fallen over a number of events more of the water would be lost through evaporation with a consequent lower fallow efficiency.

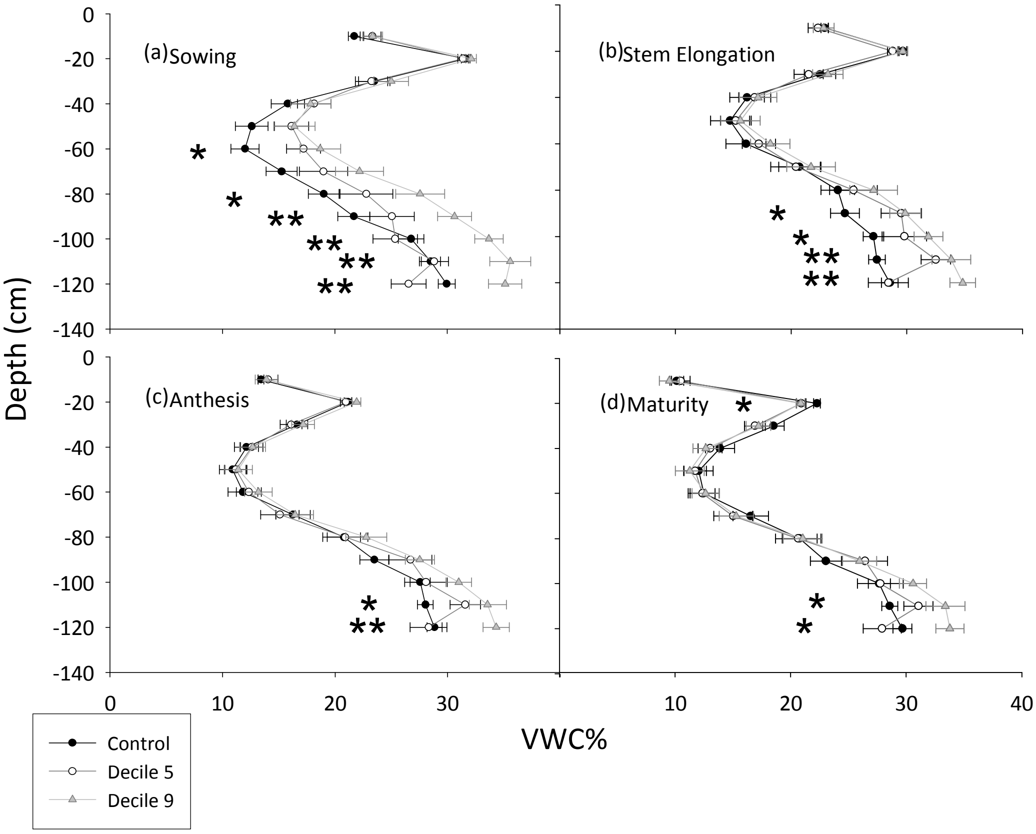

Figure 1. Soil Volumetric Water Content (VWC%) at depth split by summer rainfall treatments. Results from sowing (a), stem elongation (b), anthesis (c) and maturity (d). Stars indicate significant difference (* <0.05, ** <0.005).

Table 1. Additional available soil water at critical crop stages calculated as difference between irrigated and control treatments.

Depth	Sowing		Stem Elongation		Anthesis		Maturity	
(cm)	Decile 5	Decile 9	Decile 5	Decile 9	Decile 5	Decile 9	Decile 5	Decile 9
0-50	7.0	9.5	-1.3	2.4	0.7	2.8	-3.8	-5.3
50-100	14.7	38.1	9.7	16.2	3.2	11.0	1.7	5.0
0-100	21.7	47.5	8.4	18.6	3.9	13.9	-2.1	-0.3

The additional soil moisture in the profile from the summer rainfall treatments affected crop growth earlier than expected. Differences in shoot biomass (Figure 2) and crop water use (not shown) were evident in the first sampling date at stem elongation. The additional water, although deep in the profile, had significantly increased the biomass by over 0.5 t/ha, and by maturity the difference between the control and summer rainfall treatments exceeded 1.0 t/ha (Figure 3). Despite the difference in additional soil water shown between decile 5 and decile 9 treatments, there were no differences between the two for grain yield or any yield components.

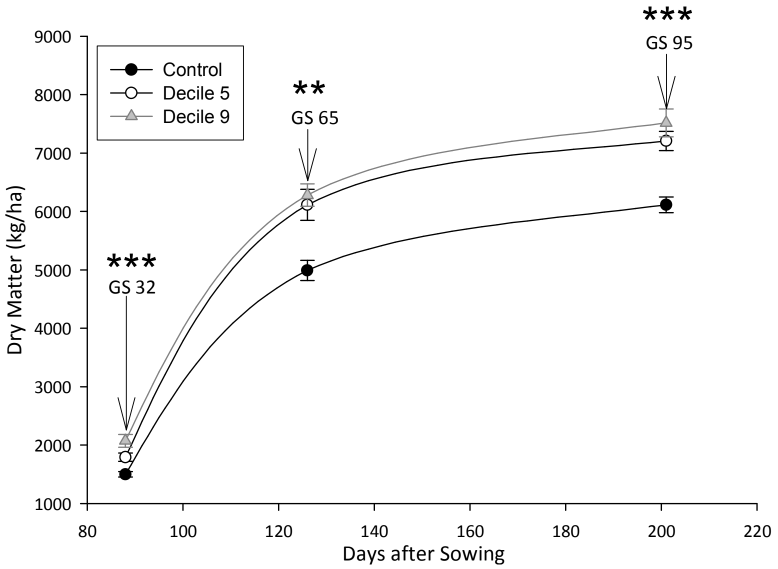

Figure 2. Shoot dry matter at crop stage GS 32 (Stem Elongation), GS 65 (Anthesis), and GS 95 (Maturity). Stars indicate level of significance (**<0.005, ***<0.0005).

The early difference in growth was maintained throughout the season, and was responsible for increasing the yield of the crop as harvest index was unaffected (Table 2). Water use, rather than water use efficiency, accounted for the difference in growth and yield with additional water.

Table 2. Grain and biomass yield and yield components and their corresponding radiation use efficiency (RUE) and water use efficiency (WUE). WUE and ET calculated using 100cm profile.

Measurement	Summer Rainfall Decile			Significance
	Control	Decile 5	Decile 9	
Grain Yield (t/ha)	2.6	3.2	3.2	<0.005
Dry Matter Yield (t/ha)	6.1	7.2	7.5	<0.0001
Harvest Index (%)	43.2	43.9	42.3	Not significant
RUE (g/MJ)	1.0	1.1	1.1	<0.05
WUE (Grain, kg/ha/mm)	9.2	10.0	9.5	Not significant
WUE (Biomass, kg/ha/mm)	21.2	22.8	22.4	Not significant
ET (mm)	288.6	313.0	335.7	<0.0001
No. Heads/m^2	220.0	254.0	263.0	<0.005
Grains/m^2	6185.0	7420.0	7432.0	<0.001
1000 Grain Wt (g)	42.5	42.8	42.8	Not significant

The increase in early growth due to the additional moisture was unexpected. Many reports suggest the greatest benefit of subsoil moisture is through the grain filling period.

Insufficient nitrogen may account for the lack of yield difference between the decile 5 and decile 9 treatments and for the residual water in the soil at maturity in the decile 9 treatments (Fig. 1).

Conclusion

- Summer rainfall corresponding to deciles 5 and 9 increased yield by 0.5t/ha in relation to controls.
- The extra 50mm of rainfall added in the decile 9 treatment did not increase grain yield from decile 5.
- Contrary to the expectation that stored soil water would contribute to yield late in the season, we found subsoil water effects on growth were evident early in the season.
- Subsoil moisture increased yield by increasing early growth and number of heads and therefore grains per m^2.
- It is likely that the lack of stubble effect on retaining moisture, and the high fallow efficiency was partially due to the large single event that was applied.
- Subsoil constraints or shortage of nitrogen could reduce the yield benefits of summer rainfall stored in the subsoil.

Further Work

This trial will be repeated in the coming season with some changes to adjust for the lessons learnt in the 2009 trial. The number of sites will be increased, the effect of rainfall event size will be investigated, and nitrogen treatments will also be included.

Hart's Matt Dare speaking at the
2009 Hart Field Day