Conserving moisture during summer

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Take home messages

- *Conserving summer rain is one of the most effective ways of improving crop yield.*
- *Summer weeds have the biggest impact on how much summer rain is stored and made available to crops. A zero-tolerance control policy for summer weeds pays off in the majority of years.*
- *The presence of stubble has never been shown to have a large positive effect on the storage of summer rain in southern Australia, but it might lengthen the sowing window after the break and improve establishment.*

Background

Capturing, storing and using summer or out-of-season (November – March) rainfall is one of the most effective ways of improving crop yields in the Mallee. This can be demonstrated by APSIM modelling (Table 1), and has been continually reinforced in both farmer paddocks and BCG demonstration trials (Hunt *et al*. 2009; van Rees and Jackman 2001) during the last decade of below average growing season rainfall.

Historically, out-of-season rainfall can potentially account for over a third of Victorian Mallee water-limited wheat yields (Table 1). During the millennium drought period (1997 – 2009), there has been an increase in the proportion of out-of-season rainfall relative to growing season rainfall, meaning that out-of-season rainfall is now more important to crop production than it has been before. Future climate modelling based on CO_2 emission scenarios indicates that spring rainfall is likely to decline whilst summer rainfall is likely to increase. Therefore, capturing, storing and using out-of-season rainfall will be vital to maintaining productivity in the face of climate change. BCG has identified utilising out-of-season rainfall as one of the ways most likely to achieve a 10% improvement in water use efficiency in the Wimmera Mallee.

Table 1. APSIM-simulated mean water-limited attainable yields for different locations and soil types in north-west Victoria with and without out-of-season rainfall (OSR) for the period 1889 – 2008.

Location	Surface soil type	Grain yield (t/ha)		Yield attributable to OSR (%)	WUE attributable to OSR (%)
		Without OSR	With OSR		
Walpeup	Sandy loam	2.0	3.2	38	26
Swan Hill	Sandy clay loam	1.7	2.7	37	30
Swan Hill	Sandy loam	2.4	3.8	38	25
Hopetoun	Clay loam	1.2	2.0	38	37
Hopetoun	Sandy loam	2.0	3.3	38	29
Kerang	Clay loam	2.1	3.1	33	27
Charlton	Clay	2.4	3.1	24	22
Longerenong	Clay	2.8	3.8	25	24

Soil surface conditions influence how well summer rain is captured and stored. Stubble improves infiltration of intense rainfall events and slows evaporation. However, if conditions remain dry for an extended period, evaporation will be the same whether stubble is present or not. Weeds and volunteer plants growing over summer use water and nitrogen that could otherwise be used by the next crop. Previous BCG experiments have shown that weeds are the most important factor in determining how much soil water is stored and hence the yield of subsequent crops (Hunt *et al.* 2009).

Rainfall events of around 20mm are usually sufficient to allow summer weeds and volunteers to emerge. However, on most Mallee soils this amount of rain is likely to evaporate and not be stored for subsequent crops. This presents a challenge for growers who must decide whether weeds should be controlled in their vulnerable juvenile stage, or left to die if there is no more rain.

Aim

To quantify how paddock stubble load and weed burden during summer can affect soil water, nutrients and subsequent crop yield.

Method

This experiment was established 13km south-east of Hopetoun on Warrakirri's *Bullarto Downs* property and was repeated on 2 different soil types typical to the region, 2km apart. The sand site was on top of an east-west dune with sandy topsoil and a clay subsoil. The clay site was a low-lying flat with clay loam topsoil and moderate subsoil constraints. These experiments were established in paddocks that had just grown a wheat crop and there was a stubble load of 2.4t/ha and 2.7t/ha at the clay and sand sites respectively.

The trial was pegged out (in December 2008) using a randomised complete block design with 6 surface treatments and 4 replicates – plot size 4 x 14m. The stubble treatments were applied on 10 December 2008 with the stubble on treatments 3, 4 and 5 being slashed with a whipper-snipper and then raked from plots in treatments 4 and 5. The treatments were:

1. Standing stubble
2. Standing stubble and summer weeds
3. Slashed stubble

4. Bare earth
5. Bare earth and summer weeds
6. Cultivation

Two soil cores per plot were taken on 11 December 2008, 22 April 2009 and again on 12 November 2009. These were to a depth of 1.3m in order to calculate gravimetric soil moisture. Samples were segmented into depths of 0 – 10, 10 – 20, 20 – 40, 40 – 70, 70 – 100 and 100 – 130cm. Samples were then sent away for full nutrient analysis. The soil water measurement made in November 2009 was assumed to be crop lower limit (CLL) and was used to calculate plant available water (PAW) at sowing. Pending actual measurements of bulk density, PAW was calculated using estimated bulk densities of 1.6g/ml and 1.4g/ml for the sand and clay site respectively.

Following rain in December 2008, summer weeds (volunteer cereals, melons and heliotrope) emerged in all treatments and weed densities were measured at both sites. On 16 January 2009, treatments 1, 3 and 4 were sprayed and kept clean until sowing. Treatment 6 was cultivated after rainfall events and subsequent weed emergence. Summer weeds in treatments 2 and 5 were allowed to continue growing throughout summer.

All treatments were sown dry to Hindmarsh barley on 22 and 23 April 2009. Plots were kept weed-free throughout the season. Dry matter production was measured at flowering and then again at maturity. Grain yield was measured with a plot harvester and grain quality analysed (protein, moisture and screenings).

After harvest the 6 weed and stubble treatments were re-implemented and the experiment will be repeated at the same sites for the next 3 years.

Location:	Hopetoun
Replicates:	4
Sowing date:	22 April 2009 (sandy site) 23 April 2009 (clay site)
Seeding density:	120 plants/m^2
Crop type/s:	Hindmarsh barley
Seeding equipment:	Knife points, press wheels, inter-row sown 30cm row spacing
Growing season rain:	Sand site – 213mm; clay site – 202mm
Soil fertility:	Sand site: 145kg/ha N, 24mg/kg Colwell P, 35 PBI
	Clay site: 166kg/ha N, 29mg/kg Colwell P, 147 PBI
Fertiliser:	Both sites – 35kg/ha MAP at sowing; sand site – 20kg/ha N top-dressed as urea on 26 June and 20kg/ha N top-dressed as ammonium sulfate on 9 July.

Results

From November 2008 until April 2009, 90mm of rain fell at the site (Figure 1). There was no difference ($P>0.05$) in PAW at sowing between the 2 sites, and when treatments were averaged for both sites, there was approximately 10mm more water available from 0 – 40cm depth at sowing in the treatments with stubble and no summer weeds compared to the treatments with weeds (Table 2).

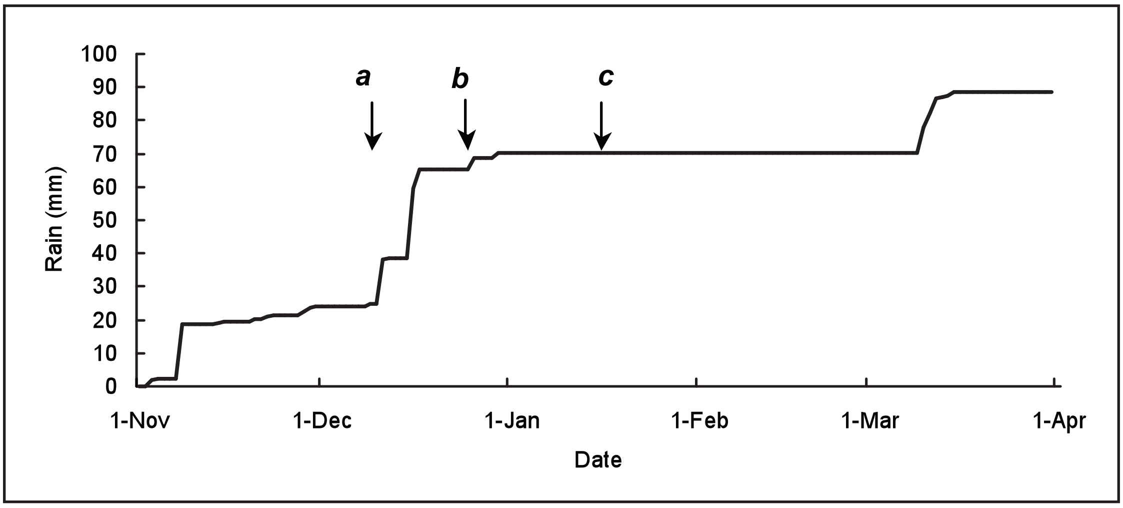

Figure 1. Cumulative daily rainfall recorded at Hopetoun from November 2008 – April 2009.

a – stubble management treatments applied and all plots were soil sampled (December 2008)

b – emergence of summer weeds

c – commenced summer weed control

Table 2. Mean plant available water at sowing (0 – 40cm) for all treatments at both sites and PAW averaged for both sites.

	PAW sand (mm)	PAW clay (mm)	PAW mean for both sites (mm)
Bare earth	-1	-1	-4^{ab}
Bare earth & summer weeds	-12	-8	-10^{a}
Cultivation	-4.	-4	-4^{ab}
Slashed stubble	4	0	2^{b}
Standing stubble	2	1	1^{b}
Standing stubble & summer weeds	-11	-3	-7^{a}
P value	**NS**	**NS**	**0.04**
LSD (P=0.05)	**-**	**-**	**8**

Both sites had good barley crop establishment with an average of 123 plants/m^2 and 110 plants/m^2 respectively. There was no significant effect (P>0.05) of site or treatment on plant dry matter at flowering (5.1t/ha) or maturity (6.7t/ha). There was no treatment effect on grain yield or screenings, but the sand site yielded significantly more grain (3.4t/ha) compared to the clay site (2.8t/ha) and also had less screenings (4.6% vs 6.0%). There was no site or treatment effect on protein (11.4%).

Interpretation

Despite a total of 90mm of summer rain falling at the site in 2008 – 2009, no individual event was larger than 27mm. Rainfall events smaller than 20mm do not infiltrate deeply enough into the soil to be protected from evaporation. This meant that controlling summer weeds and retaining stubble only increased the amount of plant available water at sowing at both sites by approximately 10mm. Based on known values of transpiration efficiency for dry matter and grain (French and Schultz 1984), a difference of 10mm of soil water will, at best, result in only an extra 0.6t/ha of dry matter or 0.2t/ha of grain. In field-based experiments, it is difficult to detect such a level of difference in either dry matter or grain yield.

In 2008 – 2009, this experiment described a worst-case scenario for farmers who adopt a zero-tolerance policy to summer weeds. Sufficient rain fell to cause summer weeds to emerge, but not to store a large amount of soil water. This meant that an investment in summer weed control was not met with a measurable return in crop yield. Fortunately, the historic climate record indicates that such instances are rare, particularly on lighter soils with better fallow efficiencies (Table 3) and that in the Mallee, a zero-tolerance summer weed policy pays off in the long-term.

Table 3. Number of years from 1889 – 2008 in which an out-of-season rainfall event in excess of 20mm occurred (assumed to result in emergence of summer weeds) but APSIM simulated less than 10mm of soil water available prior to sowing, ie return on investment in summer weed control is unlikely.

Location	Surface soil type	No. of years 1889 – 2008 in which there is no return on investment in summer weed control
Walpeup	Sandy loam	3
Swan Hill	Sandy clay loam	19
Swan Hill	Sandy loam	2
Hopetoun	Clay loam	31
Hopetoun	Sandy loam	2
Kerang	Clay loam	13
Charlton	Clay	35
Longerenong	Clay	21

Whilst the stubble treatments in this experiment did not increase PAW at sowing or yield relative to the bare earth or cultivation treatments, it was only the stubble treatments that stored significantly more water in comparison to the treatments with weeds. This indicates that controlling weeds and retaining stubble made a small contribution to the increased soil water. It is also worth pointing out that system benefits of stubble retention such as a lengthened sowing window and improved establishment following marginal autumn breaks are not captured in this experiment.

Since harvest, the sand and clay sites have to-date received 151 and 187mm of rain respectively. As this experiment will be repeated for the next 3 seasons, it is anticipated that treatment effects will be more apparent in the 2010 growing season.

Acknowledgments

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