Making the most of summer rainfall

James Hunt *(BCG);* ***Brooke White*** *(Cropfacts);* ***Fiona Best*** *(BCG) &*
Simon Craig *(BCG)*

Aim

To demonstrate how managing paddock stubble load and weed burden (paddock surface conditions) during summer can affect subsequent crop yield.

Take home messages

- *Allowing weeds to grow during summer reduced subsequent wheat yield by more than 50 percent*
- *Provided summer weeds were controlled, other surface treatments (slashed stubble, standing stubble, cultivation, bare earth) had little effect on crop yield*
- *Controlling summer weeds is one of the most cost-effective input investments available to growers in the Mallee, returning $5 for every $1 invested in this demonstration.*

Method

This demonstration was established at the main site where the collaborating grower's wheat crop (cv. Yitpi) from 2007 had yielded 2t/ha. The paddock thus carried what could be considered an 'average' stubble load for the Mallee, to which a range of treatments was applied (Table 1).

Treatment plots were 6m wide and 28m in length. The bare earth treatments were established by burning the stubble that remained on the plots on 17 December 2007. Chemical control of summer weeds (predominantly common heliotrope and volunteer wheat) was achieved with 1.5L/ha of 540 gai glyphosate (trade name Roundup® PowerMAX™) + ammonium sulphate and additional spikes depending on other minor weeds present. Control by cultivation was achieved with sweeps on 23mm row spacing.

Summer weed species and density were estimated from counts made in ten 0.1m^2 quadrants systematically positioned across the 'stubble' and 'bare earth' components of the treatments on 8 January, and in all treatments on 11 February 2008. All treatments were soil sampled at depths of 0-10, 10-40, 40-70 and 70-100cm on 12 February, 14 May and 27 August 2008 and were analysed for gravimetric soil water content. Nitrate levels were estimated using the 27 August samples.

All treatments were sown to wheat (cv. Young) on 14 May 2008 at a seeding rate of 68kg/ha and with 55kg/ha of MAP and 40kg/ha of urea (18kg/ha of N). Half of the treatment plots were top-dressed with a further 65kg/ha of urea (30kg/ha of N) on 29 August 2008 when the crop was approaching booting.

Dry matter at GS30 was estimated for all treatments from three sub-samples of 1m of crop row taken in each plot on 14 July 2008.

All treatments were harvested on 27 November 2008 and grain yield and quality recorded. A two-tailed Student's t-test assuming equal variance was used to test for significant differences between aggregated soil surface treatment data with sufficient sample sizes to conduct the analysis.

Location: Curyo

Replicates: 1 (Demonstration)

Sowing date: 14 May

Seeding density: Site mean 157 plants/m^2

Crop type: Wheat cv. Young

Seeding equipment: Avon-Richardson, Trimble (Case IH) auto-steer (2cm accuracy) 300mm row spacing

Table 1. Treatments applied to residual stubble from 2007 growing season.

Treatment	Weed control applied if…	Control dates
1. Standing stubble + summer weeds	-	Nil
2. Standing stubble + cultivation as required	Weeds > 10 plants/m^2	8 January 2008 21 January 2008 13 February 2008 7 April 2008
3. Standing stubble + chemical as required	Weeds > 10 plants/m^2	8 January 2008 23 January 2008 7 March 2008
4. Slashed stubble + chemical as required	Weeds > 10 plants/m^2	8 January 2008 23 January 2008 7 March 2008
5. Standing stubble + cultivation after rain	Rainfall event > 10mm	23 December 2007 21 January 2008
6. Bare earth + summer weeds	-	Nil
7. Bare earth + chemical as required	Weeds > 10 plants/m^2	8 January 2008 7 March 2008
8. Bare earth + cultivation as required	Weeds > 10 plants/m^2	8 January 2008 21 January 2008 7 April 2008
9. Bare earth + cultivation after rain	Rainfall event > 10mm	23 December 2007 21 January 2008

Results

A total of 76mm of rain was recorded at the site from the beginning of the trial on 17 December 2007 to the subsequent sowing of the next crop on 14 May 2008, and 127mm of in-crop rain was recorded from sowing on 14 May to 31 October 2008 (Figure 1).

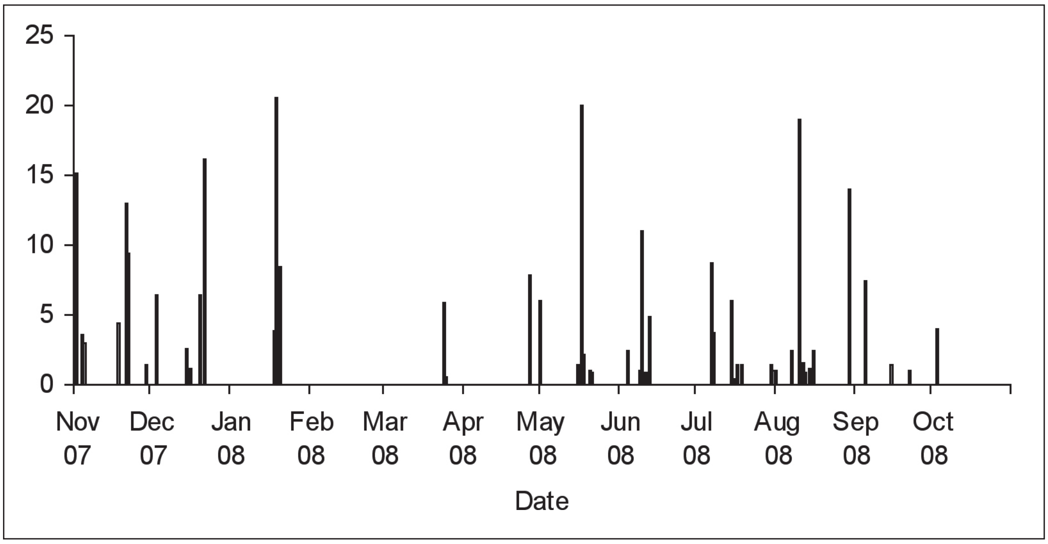

Figure 1. Daily rainfall recorded by Peter and Brenda Doran adjacent to the main site for the 12 months from 1 November 2007 to 31 October 2008.

On 8 January 2008 there were 37 common heliotrope plants/m^2 and three volunteer cereal plants/m2 in the 'stubble' half of the demonstration and only 16 common heliotrope plants/m^2 and five volunteer cereal plants/m^2 in the 'bare earth' half.

On 11 February 2008 there had been considerable numbers of summer weeds emerge (over the course of several rainfall events) that had already been controlled to varying levels of efficacy (Table 2).

Table 2. Weed density in each treatment on 11 February 2008.

Treatment	Common heliotrope plants/m^2	Volunteer cereal plants/m^2	Total plants/m^2
1. Standing stubble + summer weeds	39	2	41
2. Standing stubble + cultivation as required	3	26	29
3. Standing stubble + chemical as required	1	3	4
4. Slashed stubble + chemical as required	0	4	4
5. Standing stubble + cultivation after rain	0	5	5
6. Bare earth + summer weeds	15	18	33
7. Bare earth + chemical as required	0	6	6
8. Bare earth + cultivation as required	0	10	10
9. Bare earth + cultivation after rain	0	5	5

The presence of summer weeds had an impact on dry matter at GS30 and final grain yields with and without nitrogen top-dressed (Table 3).

Table 3. Dry matter and grain yield for each treatment with and without 65kg/ha urea (30kg/ha N) top-dressed on 29 August 2008.

Treatment	Dry matter at GS30 kg/ha	Grain yield no N t/ha	Grain yield 30kg/ha N t/ha	Nitrogen response t/ha
1. Standing stubble + summer weeds	175	0.9	1.3	0.4
2. Standing stubble + cultivation as required	399	2.2	2.7	0.5
3. Standing stubble + chemical as required	326	2.1	2.3	0.2
4. Slashed stubble + chemical as required	441	2.1	2.1	0.0
5. Standing stubble + cultivation after rain	419	2.3	2.6	0.3
6. Bare earth + summer weeds	267	1.3	1.2	-0.1
7. Bare earth + chemical as required	272	2.4	2.6	0.2
8. Bare earth + cultivation as required	360	2.4	2.4	0.0
9. Bare earth + cultivation after rain	365	2.6	2.5	0.0

There is a strong negative relationship (R^2 = 0.72) between summer weed density on 11 February 2008 and subsequent crop yield (Figure 2).

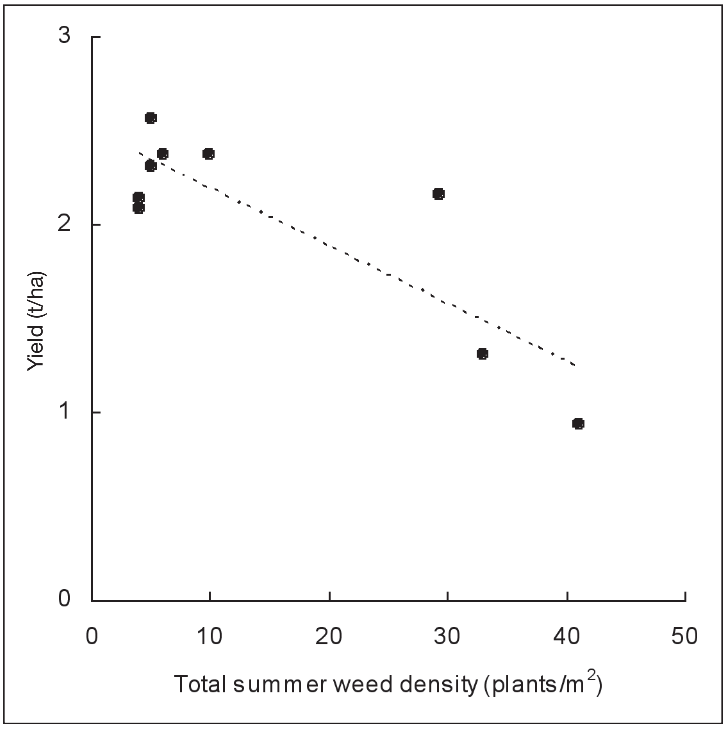

Figure 2. Total summer weed density recorded on 11 February 2008 and subsequent grain yield of all treatments. A linear function fitted to the data by least-squares regression (----) shows a strong negative relationship between weed density and subsequent yield (R^2 = 0.72).

To better understand the effects of the treatments applied in this demonstration, results for individual treatments were aggregated into different broad groups with common treatment characteristics eg. treatments in which summer weeds were controlled are aggregated into one group, and those in which they were not are aggregated into another (Table 4). The mean yield for treatments in which summer weeds were allowed to grow were significantly less ($P<0.05$) than those in which summer weeds were controlled (Table 4). Due to paddock variability, there was no significant difference ($P>0.05$) measured in available soil water at sowing in treatments where weeds had been allowed to grow compared to where they had been controlled (Table 4). There was significantly ($P<0.05$) more

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nitrate available in the treatments where summer weeds had been allowed to grow compared to those where they had not (Table 4).

Table 4. Mean plant available water at sowing, nitrate at 27 August 2008 and grain yield with and without 65kg/ha urea (30kg/ha N) top-dressed on 29 August 2008 for data aggregated from treatments either with or without summer weeds.

Aggregated treatments	Plant available water 14 May 2008 mm	Nitrate at 27 August 2008 kg/ha	Grain yield no N t/ha	Grain yield 30 kg/ha N t/ha
Summer weeds (treatments 1 & 6)	-22	26	1.1	1.2
No summer weeds (treatments 2- 5 and 7-9)	2	12	2.3	2.5
P value	**0.21 (not significant)**	**0.01 (significant)**	**0.0 (significant)**	**0.0 (significant)**

When no additional nitrogen is applied, the mean yield of stubble treatments in which weeds were controlled was significantly less ($P<0.05$) than the mean of bare earth treatments in which weeds were controlled, but when nitrogen is top-dressed, there is no significant difference between the two (Table 5).

Table 5. Mean grain yield with and without 65kg/ha urea (30kg/ha N) top-dressed on 29 August 2008 for data aggregated from treatments in which weeds were controlled and that were either based on stubble or bare earth.

Aggregated treatments	Grain yield no N t/ha	Grain yield 30kg/ha N t/ha
Stubble + weed control (treatments 2-5)	2.2	2.4
Bare earth + weed control (treatments 7-9)	2.4	2.5
P value	**0.02 (significant)**	**0.64 (not significant)**

Interpretation

This trial was an unreplicated demonstration, and so it is impossible to tell if differences in yield and other parameters are due to the effect of individual treatments, or the result of paddock variability and chance. However, by aggregating treatments into surface treatment categories (Tables 4 and 5), we are able to detect some interesting differences.

Summer weeds have the greatest impact of all surface treatments on subsequent crop yield. The mean yield of treatments in which weeds were controlled was more than twice the mean yield of plots in which summer weeds were allowed to grow unchecked (Table 4). There is also a strong negative relationship between summer weed density and subsequent crop yield of all treatments (Figure 2). Because there is still a reduction in yield in treatments with weeds in comparison to those without when additional nitrogen fertiliser was top-dressed (Table 4), it is likely that the yield reduction in response to summer weeds observed here is due to differences in available water accumulated over the summer period. However, due to high levels of variability in soil water measurements, we were unable to detect a statistically significant difference between treatments (Table 4). All previous summer weed control demonstrations conducted by BCG have shown a strong reduction in yield of subsequent crop in treatments where summer weeds were allowed to grow (BCG 2000 and 2006).

It is difficult to say what the role of nitrogen in the results of this demonstration might be. When nitrogen was measured in late August, any effect on nitrogen levels caused by summer weeds had been confounded by the treatments with more water available being able to accumulate more biomass (Table 3). Hence there was significantly more nitrogen available in the weedy treatments compared to those without weeds (Table 2 and 3).

When no additional nitrogen is applied, stubble treatments in which weeds were controlled yielded less than the bare earth treatments in which weeds were controlled (Table 5). However, when nitrogen was top-dressed, there was no significant difference between the two. It is not possible to tell if this is a direct effect of the stubble (ie. immobilisation of nitrogen by micro-organisms decomposing stubble), or because the moisture-conserving effect of the stubble allowed for earlier and denser establishment of summer weeds in the crop row in December 2007, which because of their size and protection by stubble were not killed by the first application of herbicide. Total weed density in the stubble treatments on 8 January 2008 was 40 plants/m^2 compared to only 21 plants/m^2 in the bare earth treatments. This greater density and duration of weed pressure would have extracted more water and immobilised more nitrogen in the stubble treatments compared to the bare earth treatments, potentially causing the observed differences in yield. However, there was a response to nitrogen of 0.4t/ha in the treatment with stubble and summer weeds, but a response of -0.1t/ha in the treatment with bare earth and summer weeds (Table 3), which suggests that immobilisation of nitrogen by micro-organisms decomposing stubble has had a more substantial impact on yield than immobilisation of nitrogen by summer weeds. A Yield Prophet® simulation conducted at the site indicates that immobilisation by micro-organisms decomposing stubble would have been responsible for a net reduction in available nitrogen of 11kg/ha.

The fact that the negative impact of summer weeds on subsequent crop yield observed in this demonstration is most likely explained by differences in available soil water, rather than nitrogen, stands in contrast to the findings of Osten *et al.* (2006), who concluded that differences in yield due to summer weeds could be explained by differences in nitrogen alone.

BCG has initiated a fully replicated version of this demonstration which will be repeated for the next four years as part of a GRDC-funded project aimed at improving regional water-use efficiency. This will provide a much more comprehensive picture of the interactions between summer weeds, stubble, soil water, nitrogen and crop yield than the demonstration described here.

Application

These results clearly show that there are substantial benefits to be gained from controlling summer weeds in the Mallee, even in a summer such as 2007/2008 when individual rainfall events were not that large (Figure 1). A very simple economic analysis of the above demonstration shows that there was a five-fold return on money invested in control of summer weeds (Table 6). This is a very substantial return on investment, and should allow growers and their consultants to confidently invest in rigorous summer weed control, despite seemingly high costs.

Table 6. Simple economic analysis of summer weed control demonstration. Assumes that cost of each control event (cultivation or chemical including machinery costs and labour) is $20/ha and grain price is $250/t on-farm.

Aggregated treatments	No. of control events	Total cost of control $/ha	Grain yield no N t/ha	Gross income $/ha	Return on investment in control
Summer weeds (treatments 1 & 6)	0	$0	1.1	$275	
No summer weeds (treatments 2- 5 and 7-9)	3	$60	2.3	$575	500%

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References

BCG (2000) Summer weed control options. In The Mallee and Wimmera crop and pasture production manual 1999-2000 BCG trial results, p 84-86.

BCG (2006) Summer weed trial. In 2005 Crop and Pasture Production Manual, p161-165.

Osten V, Hashem A, Koetz E, Lemerle D, Pathan S, Wright G (2006) Impacts of summer fallow weeds on soil nitrogen and wheat in the southern, western and northern Australian grain regions. In: Proceedings of the 15th Australian Weeds Conference, Eds C Preston, JH Watts and ND Crossman. Weed Management Society of South Australia, Adelaide.