The effect of summer weed management on subsequent grain yield and quality

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Summary The impact of various summer growing weed management strategies on the yield and grain quality of subsequent crops is being evaluated in long term field experiments. Preliminary results from a four year project indicate that the control of summer growing weeds can result in an increase in the amount of stored soil moisture. At the majority of sites an increase in stored soil moisture was reflected by an increase in grain yield.

Regular control of summer weeds (i.e. treatment 2) also led to increases in the subsequent grain protein and test weight.

Keywords Summer weeds, soil moisture, grain yield, grain protein.

INTRODUCTION

There are many reasons given for controlling summer growing weeds. They include easier passage of tillage equipment, reducing the buildup of weeds on fencelines, conserving moisture and nutrients, reducing disease carryover, reducing wool contamination and avoiding the poisonous effects of some plants. It is important to identify the main reason for controlling summer weeds as this can influence the timing and method of control.

There is very little quantitative data available on the effects of summer growing weeds on stored soil moisture and soil nitrogen levels at the time of sowing the crop and the impact this has on subsequent crop yields.

It is important to determine the optimum time for control to commence. The number of subsequent herbicide applications or cultivations required is dependent on the number of summer rainfall events large enough to cause a germination of summer weeds.

This paper reports the results of trials that target caltrop (*Tribulus terrestris* L.) (Sites 01 and 12), Afghan melon (*Citrullus lanatus* (Thunb.) Matsum & Nakai var. *lanatus*) and prickly paddy melon (*Cucumis myriocarpus* Naudin) (Site 13) and prickly paddy melon (Site 16).

MATERIALS AND METHODS

Field trials commenced in October 1999 with the establishment of long term monitoring sites in the Murray Mallee and upper Yorke Peninsula of South Australia.

Treatments The treatments applied at each of the monitoring sites depended on the farming system used by the cooperator. The timing of treatments was dependent on rainfall events. The early treatments were applied prior to the end of December if possible and the late treatments were applied in either February or March. Refer to Table 1 for summer and growing season rainfall at each site.

The experimental design was a randomised complete block with four replicates. The plot sizes were 8 × 40 m (Site 01), 8 × 35 m (Site 12), 8 × 30 m (Site 13), and cultivated plots 10 × 32 m and herbicide plots 8 × 32 m (Site 16).

Site 01 – Caltrop The site is established on a sandy clay loam over lime rubble.

Treatments:

- Treatment 1: Untreated control
- Treatment 2: Herbicides applied as necessary (i.e. after every germination)
- Treatment 3: Early cultivation only
- Treatment 4: Early cultivation then herbicides as necessary
- Treatment 5: Late herbicide application only
- Treatment 6: Early herbicide application only

The site was pasture in 2000 and sown to wheat in 2001. Treatments prior to the pasture phase were modified to suit paddock management. Treatment 2 had three herbicide applications, applied on 12 November 1999 (T1), 6 January 2000 (T2) and 1 March 2000 (T3). Treatments 4 and 6 were treated the same as Treatment 2. Treatment 5 was treated at the T2 application.

In the summer prior to the cropping phase Treatments 2 and 6 had one herbicide application applied

Table 1. Summer (November to March) and growing season (April to October) rainfall.

Period	Rainfall (mm)		
	Site 01	Sites 12, 13	Site 16
Summer 1999/2000	188	127	114
Growing season 2000	173	332	207
Summer 2000/2001	110	53	70
Growing season 2001	174	350	198

on 6 January 2001. Treatments 3 and 4 were cultivated on 5 January 2001. Treatment 5 was not treated as the caltrop plants senesced naturally and there were no further germinations of caltrop at this site.

Site 12 – Caltrop The site is established on a calcareous sandy loam over lime rubble.

Treatments:

- Treatment 1: Untreated control
- Treatment 2: Herbicides applied as necessary
- Treatment 3: Early herbicide application only
- Treatment 4: Late herbicide application only
- Treatment 5: Very late herbicide application only

The site was sown to lupins in 2000 and wheat in 2001. In the summer prior to the lupin crop Treatment 2 had two herbicide applications. They were applied on 20 December 1999 (T1) and 10 March 2000 (T3). Treatment 3 was treated at T1, Treatment 4 was treated on 9 February 2000 (T2) and Treatment 5 was treated at T3.

In the summer prior to the wheat crop, Treatment 2 had two herbicide applications. They were applied on 17 January 2001 (T1) and 23 February 2001 (T2). Treatment 3 was treated at T1 and Treatment 4 was treated at T2 application time. Treatment 5 was not treated as the caltrop plants senesced naturally.

Site 13 – Afghan and prickly paddy melon The site is established on a sand over a sandy clay loam.

Treatments:

- Treatment 1: Untreated control
- Treatment 2: Herbicides applied as necessary
- Treatment 3: Late herbicide application only
- Treatment 4: Early herbicide application only

The site was sown to wheat in 2000 and was pasture in 2001. In the summer prior to the wheat crop, Treatment 2 had two herbicide applications. They were applied on 21 December 1999 (T1) and 10 March 2000 (T3). Treatment 4 was applied at T1 and Treatment 3 was applied on 9 February (T2).

Site 16 – Prickly paddy melon The site is established on a shallow loamy sand over lime rubble and calcrete.

Treatments:

- Treatment 1: Untreated control
- Treatment 2: Herbicides applied as necessary
- Treatment 3: Early cultivation then a late herbicide application
- Treatment 4: Early herbicide application then a late cultivation
- Treatment 5: Late herbicide application only
- Treatment 6: Early herbicide application only

The site was sown to wheat in 2000 and barley in 2001. The site had been cultivated on 7 October and 6 November 1999 prior to the site being selected. In addition to these cultivations Treatment 2 had two herbicide applications. They were applied on 6 January 2000 (T1) and 2 March 2000 (T2). The early applications of Treatments 3 and 6 were deemed to have been applied as the cultivation performed on 6 November. The late herbicide applications in Treatments 3 and 5 were applied at T2 and Treatment 4 was cultivated on 23 February 2000.

Assessments Seedling populations of the weeds were counted in eight quadrats per plot (either 866 mm by 866 mm or 1.0 m by 1.0 m) and expressed as plants m^{-2}. Soil moisture was determined immediately prior to seeding by taking four cores from each plot up to a depth of 70 cm where possible. These cores were divided into 0–10, 10–20, 20–30, 30–45, 45–60 and 60–70 cm segments and oven dried to determine soil moisture content. Soil nitrate nitrogen was measured in the top 45 cm of Treatments 1 and 2 from a composite sample of all four cores from each plot. Grain yield was determined by harvesting one or two 1.6 m strips from the total length of each plot. Grain samples were tested at AusBulk Limited grain receival terminals for grain protein, screenings and test weight using the same equipment used to test commercial grain samples.

RESULTS

Site 01 – Caltrop The initial site population was 55 plants m^{-2} with an additional 170 plants m^{-2} germinating in Treatment 1. There were significant differences in soil moisture below 10 cm between Treatment 1 and Treatment 2. This equates to an extra 18.1 mm of moisture between 10 and 70 cm in Treatment 2. There were no differences in soil nitrogen. Differences in pasture composition were also recorded. Table 2 shows the pasture composition for Treatments 1, 2 and 5.

There were differences between treatments in the initial germination of caltrop in the consecutive summer. Treatment 1 had an initial germination of 11.3 m^{-2}, while Treatment 2 had 2.1 plants m^{-2}. There was also an extra 11.2 mm of moisture in Treatment 2 between 0 and 60 cm, compared to Treatment 1.

Table 2. Pasture composition at Site 01, 2000.

Treatment No.	Medic %	Plant residue %	Bare ground %
1	63	13	16
2	86	0.25	4
5	78	2	8

There were no differences in soil nitrogen. Significant differences in grain yield and protein were recorded. Table 3 shows grain yield, protein and test weight for all treatments at Site 01.

Site 12 – Caltrop The initial site population was 58 plants m^{-2} with an additional 40 plants m^{-2} germinating in Treatment 2. There were significant differences in stored soil moisture below 10 cm between Treatment 1 and Treatment 2. This equates to an extra 21.4 mm of moisture between 10 and 60 cm in Treatment 2. There were no differences in nitrogen. There was a significant difference in the yield of lupins between Treatment 1 and Treatment 2. Table 4 shows the yield and protein for all treatments.

Although the plant numbers are low, there were differences between treatments in the initial germination of caltrop in the consecutive summer. Treatment 1 had an initial germination of 3.5 plants m^{-2}, while Treatment 2 had 1.6 plants m^{-2}. There were significant differences in soil moisture to a depth of 45 cm. These differences equate to an extra 9.5 mm in Treatment 2 between 0 and 45 cm. There were no significant differences in soil nitrogen. There were significant differences in yield between Treatment 1 and Treatment 2. Table 5 shows the yield, protein and test weight for wheat at Site 12.

Site 13 – Afghan and prickly paddy melon The initial population at this site was 0.83 and 0.52 Afghan and prickly paddy melon plants m^{-2} respectively. A further germination of 0.38 Afghan melon plants m^{-2} and 0.01 prickly paddy melon plants m^{-2} in Treatment 1 and 0.27 Afghan melon plants m^{-2} and 0.16 prickly paddy melon plants m^{-2} in Treatment 2 occurred prior to T2. There were significant differences in stored soil moisture below 30 cm between Treatment 1 and Treatment 2. This equates to an extra 11.4 mm of moisture between 30 and 70 cm in Treatment 2. There were no differences in soil nitrogen. There were no significant differences in grain yield for any of the treatments. The grain protein level of Treatment 2 was significantly higher than Treatment 1 and the test weight of Treatments 2 and 5 was significantly higher than Treatment 1. Table 6 shows grain yield, protein and test weight.

Although plant numbers were low in the consecutive summer there were differences between the treatments for the two germinations that occurred. Total plant numbers were of 1.66 Afghan melon plants m^{-2} and 0.25 prickly paddy melon plants m^{-2} in Treatment 1 and 0.23 Afghan melon plants m^{-2} and 0.09 prickly paddy melon plants m^{-2} in Treatment 2.

Table 3. Grain yield, protein and test weight of wheat crop at Site 01, 2001.

Treatment No.	Grain yield kg ha^{-1}	Grain protein %	Test weight kg HL^{-1}
1	1277	14.40	83.79
2	1877	13.63	83.57
3	1693	14.03	83.80
4	1716	13.90	84.15
5	1382	14.38	84.23
6	1770	13.70	83.81
LSD (P=0.05)	108.7	0.48	0.83

Table 4. Grain yield and protein of lupins at Site 12, 2000.

Treatment No.	Yield kg ha^{-1}	Protein %
1	1759	31.02
2	1884	30.82
3	1832	30.95
4	1805	30.30
5	1784	30.32
LSD (P=0.05)	110.8	0.69

Table 5. Grain yield, protein and test weight of wheat crop at Site 12, 2001.

Treatment No.	Grain yield kg ha^{-1}	Grain protein %	Test weight kg HL^{-1}
1	5213	10.75	80.32
2	5892	11.43	79.76
3	5448	10.70	79.92
4	5687	10.83	80.36
5	5862	11.38	79.00
LSD (P=0.05)	525.9	0.58	1.55

Table 6. Grain yield, protein and test weight of wheat crop at Site 13, 2000.

Treatment No.	Grain yield kg ha^{-1}	Grain protein %	Test weight kg HL^{-1}
1	1699	9.70	73.1
2	1757	10.30	75.3
3	1688	10.00	74.4
4	1677	9.85	75.8
LSD (P=0.05)	85.9	0.46	2.1

Site 16 – Prickly paddy melon The initial site population was four plants m^{-2} with an additional 12 and 32 plants m^{-2} germinating in Treatments 1 and 2 respectively. There were significant differences in soil moisture between Treatment 1 and Treatment 2 at a depth of 10 to 45 cm. These differences equate to an extra 6.2 mm of moisture between 10 and 45 cm in Treatment 2. There were no differences in soil nitrogen. There were significant differences in grain yield but not protein or test weight. Table 7 shows the yield, protein and test weight for all treatments.

There were differences between treatments in the initial germination of melons in the consecutive summer. Treatment 1 had an initial germination of 53 plants m^{-2}, while Treatment 2 had six plants m^{-2}. There were significant differences in soil moisture between Treatment 1 and Treatment 2 between 10 and 60 cm. These differences equate to an extra 16.9 mm of moisture in this zone in Treatment 2. There were no differences in soil nitrogen. There were significant differences between some treatments for yield but not for protein or test weight. Table 8 shows yield, protein and test weight for barley at Site 16.

Table 7. Grain yield, protein and test weight of wheat crop at Site 16, 2000.

Treatment No.	Grain yield kg ha^{-1}	Grain protein %	Test weight kg HL^{-1}
1	1738	10.68	81.93
2	2258	11.28	81.74
3	1821	10.90	81.51
4	2220	11.00	82.06
5	1752	11.18	82.12
6	1615	10.50	81.29
LSD (P=0.05)	274.1	0.63	1.02

Table 8. Grain yield, protein and test weight of barley crop at Site 16, 2001.

Treatment No.	Grain yield kg ha^{-1}	Grain protein %	Test weight kg HL^{-1}
1	1178	10.42	64.82
2	1378	11.25	63.68
3	1271	10.80	66.02
4	1391	10.65	62.82
5	1163	10.58	62.60
6	1213	10.30	62.88
LSD (P=0.05)	143.9	0.98	2.58

DISCUSSION

All sites had significantly greater stored soil moisture for Treatment 2, compared to Treatment 1. The depth at which these differences occurred varied between sites and seasons. Treatments which contained an early herbicide application or cultivation were more likely to have greater stored soil moisture than the late treatments. Sites 01, 12 and 16 also had significantly higher grain yields for Treatment 2 compared with Treatment 1. Although no strong trend is apparent some early treatments at some sites also had a significant increase in grain yield. Although Site 13 had no significant difference in yield there was still a significant difference in grain protein and test weight between Treatments 1 and 2. For Site 01 the significant increase in grain yield from Treatment 1 to Treatment 2 was accompanied by a decrease in grain protein. There were no differences in soil nitrogen at any of the sites.

Limited data on plant numbers in consecutive summers is inconclusive. However, there may be a trend appearing where control of plants in the previous summer leads to a reduction in plant numbers in the consecutive summer.

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