Comparison of stubble management strategies in the high rainfall zone

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Abstract

Heavy crop stubble loads in the high rainfall zone are a consequence of higher grain crop yields compared with other grain growing areas of Australia. A stubble management trial was established in northern Tasmania to evaluate different stubble management options. Five stubble management strategies were compared: stubble fully retained; fully retained with higher sowing rate; incorporated; cut and removed; and burnt. The trial was a randomised complete block design with four replicates and large plots, 50 by 8 m. This paper reports on wheat growth and grain yields for the 2010 season. Full retention of stubble resulted in greater soil moisture early in the season and higher earthworm and slug populations. Plant establishment is commonly a problem with full stubble retention. The higher sowing rate treatment resulted in a correspondingly higher plant establishment and dry matter production at harvest. There were no significant differences in grain yield.

Key words

Direct drill, stubble retention, conservation cropping

Introduction

Minimum tillage and stubble retention practices have been widely adopted due to a number of benefits in particular reduced fuel and labour costs, soil moisture retention and reduced soil erosion (Kirkegaard, 1995; Scott et al., 2013). However, in practice adoption is generally more opportunistic due to issues including machinery trash flow, reduced crop establishment and pest and disease problems (Scott *et al*., 2013). In the high rainfall zone, such as Tasmania, the generally greater crop yields result in additional stubble residue loads further exacerbating these problems. Slugs in particular have become an increasingly major problem. Growers in these areas recognise these issues and will accordingly alter their practices to accommodate the situation. Thus while burning of stubbles prior to sowing the next crop is not common due to environmental and other disadvantages, when there is a large stubble load, burning may become a necessary strategy. For example, with increased seasonal rainfall and additional crop growth the frequency of burning to reduce crop stubbles in Tasmania increased to 36% in 2011 (Edwards *et al*., 2012).

There are a number of alternative practices to assist with excess stubble residue. The aim of this trial was to compare the effects of different stubble treatments on crop establishment, growth and grain yield. The sustainability of treatments was also evaluated with comparison of soil physical and biological characteristics.

Methods

Location, treatments and experimental design

The trial site was established at Perth, Tasmania (41°37'S, 147°15'E) in 2006 as a long term stubble management experiment. The soil is a brown sodosol with a fine grey sandy loam to 25 cm overlying a heavy clay subsoil. The trial had a previous history of wheat, tickbeans, wheat and most recently, canola. Plots were 50 by 8 m with four replicates in a randomised complete block design. Before commencing the trial, discussions to select treatments were held with farmers and advisors. Five stubble treatments were selected: stubble fully retained (SFR); stubble fully retained with a higher sowing rate (SFR + HSR) [prior to 2009 this treatment was incorporation with offset discs]; stubble incorporated with Lemken discs (SI); stubble cut to 150 mm with a windrower and removed from plot (SRC); and stubble removed by burning with a 'cool burn' in autumn (SRB). Herein results of the trial in the 2010 season are reported.

Management and measurements

The trial was sown with Revenue wheat on 24th May at 85 kg/ha (115 kg/ha for SFR + HSR) using a Baldan disc drill. Weeds and pests were controlled as required and two top-dressings of nitrogen (total of 100 kg N/ha) were applied. Growing season rainfall (Apr-Nov) was 502 mm with an additional 150 mm irrigation applied over flowering and grain fill.

Ground cover, establishment counts, soil temperature, gravimetric soil moisture content, penetrometer (Rimik CP20) and weed counts were taken. Additional observations of invertebrate populations and soil fauna biomass were conducted in SFR and SRB plots. Pitfall traps (2 per plot) constructed from plastic tubs containing ethylene glycol, were inserted at ground level and monitored every 14-21 days. Spade tests (5 holes/plot) were dug to assess changes in populations of earthworms. Bacterial and fungal biomass levels were determined by the Soil Foodweb Institute, Lismore. Prior to machine harvest at maturity, dry matter cuts (8 x 0.25m^2) were taken from each plot.

Differences between treatment effects were analysed by ANOVA (Genstat 17, VSN International Ltd). The least significant difference (LSD) was calculated at P = 0.05 for testing differences between treatments.

Results and Discussion

Above average rainfall in the 2010 season in northern Tasmania, particularly over winter and spring, resulted in much of the trial area being waterlogged for extended periods. June in particular was very wet (Decile 8-9). Additional high rainfall over flowering and during grain fill coupled with the supplemental irrigation resulted in limited soil moisture stress during this period.

Stubble residue from the 2009 season canola was low due to a poor yielding crop but there was visually higher stubble residue in the two stubble fully retained plots compared to the other treatments (Table 1). Plant establishment was increased with the higher sowing rate although this was not different to the SI treatment. There was no difference in plant establishment between SI, SRC, SFR and SRB plots (Table 1). In the current trial low stubble loads resulted in minimal sowing problems but Kirkegaard (1995), reviewing previous stubble field trials, notes the common problem of establishing crops with retained stubble. The ground cover scores broadly correlated with soil temperature and reflect the degree of shading. At early establishment the two treatments with the highest residue cover (fully retained) resulted in significantly lower soil temperatures compared with other treatments (Table 1). There were no temperature differences between treatments when the plants were at early stem elongation (data not presented).

Table 1. Effect of stubble management treatments; SFR (stubble fully retained), SFR + HSR (stubble fully retained, with a higher sowing rate), SI (stubble incorporated), SRC (stubble removed, cut) and SRB (stubble removed, burnt), on surface straw, plant establishment and soil temperature (16th June).

Treatment	Surface straw scores 0 (none) – 10 (high, approx. 4 t/ha)	Plant density 1st July (plants/m^2)	Soil temp at 5 cm (°C)
SFR	6.3	104	7.7
SFR + HSR	5.5	124	7.9
SI	2.3	114	8.5
SRC	1.0	106	8.3
SRB	1.5	103	8.4
P value	<0.001	0.007	0.001
$LSD_{0.05}$	1.6	11	0.3

Consistent with other studies e.g. Kirkegaard *et al*., 2001; Scott et al., 2013, there were differences in soil moisture at the beginning of crop establishment. At 40-60 cm depth this difference was significant (P = <0.001) with gravimetric soil moisture content higher in both the stubble fully retained plots (33.7%) compared with SRB and SI treatments (27 and 25.5% respectively, data not presented). The difference at this lower depth was probably carry-over from the previous season. However the soil moisture content was not significantly different between treatments at any other measurement dates (data not presented), likely due to the high rainfall throughout the season masking treatment soil moisture differences.

Penetrometer measurements were taken at crop GS32 when the soil was at soil field capacity. Measurements were made at 0-100, 100-200 and 200-300 mm depth intervals. Penetration resistance was significantly lower for both the SI and SFR +HSR treatments compared with the SFR and SRB treatments at the 0-100 mm depth (Figure 1). The effects of mechanical tillage on soil strength in the SI and the SFR + HSR plots (disced until the previous season) were thus greater than any other stubble management practices.

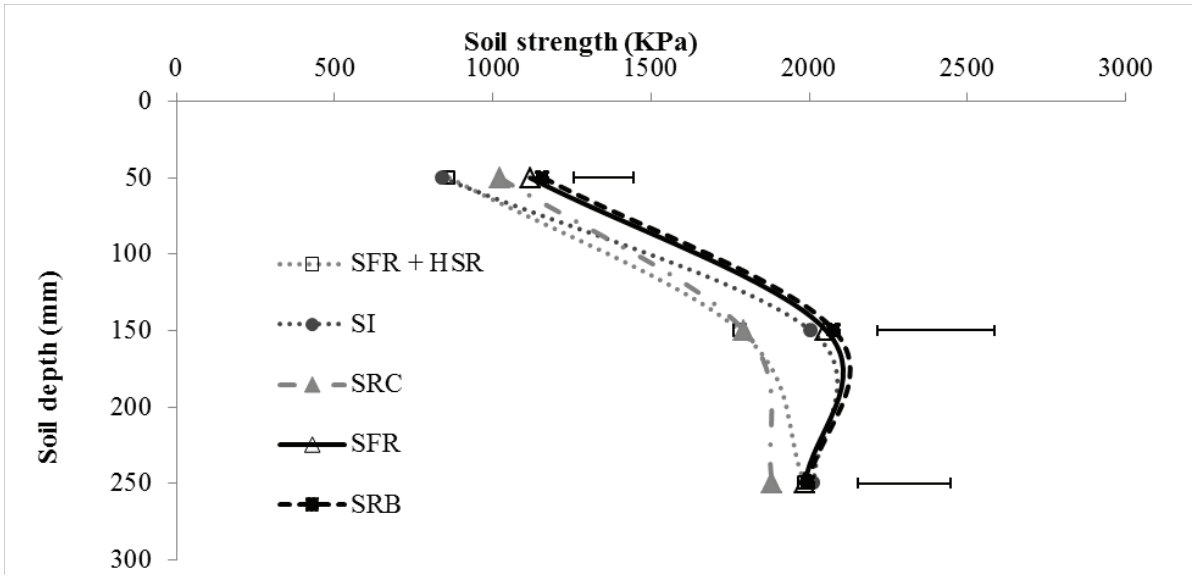

Figure 1. Effect of stubble management treatments; SFR (stubble fully retained), SFR + HSR (stubble fully retained, with a higher sowing rate[previously disced]), SI (stubble incorporated), SRC (stubble removed, cut) and SRB (stubble removed, burnt) on soils strength (KPa). Bars represent LSD (0.05).

With weed populations, toadrush (*Juncus bufonius*) density varied between plots with the stubble fully retained plots showing the lowest populations (Figure 2). These weeds were probably symptomatic of the observed higher incidence of waterlogging and surface water in the plots where stubble had been removed or incorporated. There were no differences between treatments with the populations of other weeds in particular ryegrass (*Lolium rigidum*), sub clover (*Trifolium subterraneum*), spear thistle (*Cirsium vulgare*) and field madder (*Sherardia arvensis*) (data not presented).

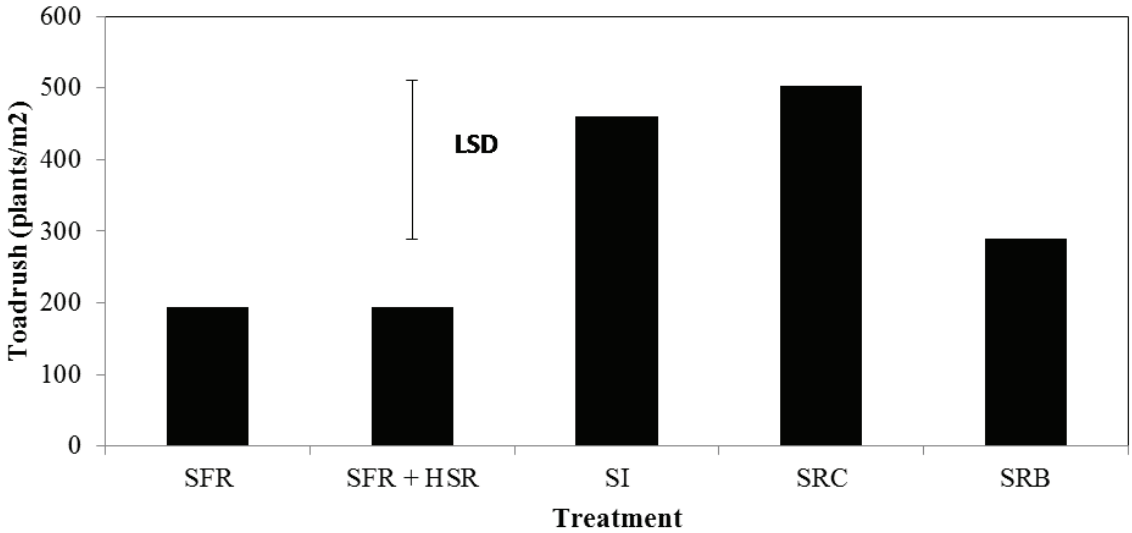

Figure 2. Effect of stubble management treatments; SFR (stubble fully retained), SFR + HSR (stubble fully retained, with a higher sowing rate), SI (stubble incorporated), SRC (stubble removed, cut) and SRB (stubble removed, burnt), on plant density (plants per m2) of toadrush (*Juncus bufonius*). Bar represents LSD (0.05).

Earthworm and slug numbers were higher in SFR compared with SRB plots (Table 2). Bacterial and fungal biomass levels were in the desired range according to Soil Foodweb Institute; however there were no differences between treatments (Table 2). There were also no differences in the biomass of other soil fauna tested, namely flagellates, amoebae, ciliates or actinobacteria nor the ratio of bacteria to fungi between treatments (data not presented). Kirkegaard *et al*., (2001) reported higher populations of earthworms but also increased microbial biomass. It is possible the very wet conditions in the current trial were detrimental to microbial biomass. The negative effect of increased slug numbers with stubble retention has been highlighted elsewhere (Scott *et a*l., 2013).

Table 2. Effect of stubble management treatments; SFR (stubble fully retained), and SRB (stubble removed, burnt), on invertebrate populations and microbial biomass.

Treatment	Spade test (average)	Tile trap (average)	Total bacteria	Total fungi
	earthworms	slugs	(µg/g)	(µg/g)
SFR	5.8	9.3	96	245
SRB	1.1	3.3	111	191
P value	0.001	0.027	ns	ns

Dry matter production from the different treatments prior to harvest were comparable between treatments aside from the SFR + HSR plots which produced significantly higher biomass than other treatments (Table 3). Although not significant (P=0.08) this difference tended to carry through to final grain yield (Table 3). Poorer establishment with full stubble retention is commonly observed (e.g. Kirkegaard, 1995; Scott *et al*., 2013) and the early effects on plant density with the higher sowing rate may alleviate this. Under the wet seasonal conditions plant tillering was likely to have been reduced and thus the benefit of the higher sowing rate more likely to be expressed. In previous trials at the site (2006, 2008), plant establishment and grain yield of wheat have both been negatively affected by retained stubble compared with burnt plots. In contrast in the current trial, plant establishment, dry matter production and yield of the SFR treatment was not significantly lower, again suggesting the importance of adequate initial plant establishment.

Table 3. Effect of stubble management treatments SFR (stubble fully retained), SFR + HSR (stubble fully retained, with a higher sowing rate), SI (stubble incorporated), SRC (stubble removed, cut) and SRB (stubble removed, burnt) on dry matter production at harvest and grain yield.

Treatment	Dry matter at harvest (t/ha)	Grain yield (t/ha)
SFR	14.5	6.1
SFR + HSR	17.5	6.7
SI	15.1	5.8
SRC	15.3	6.1
SRB	13.8	5.3
P value	0.027	0.076
$LSD_{0.05}$	2.08	-

Conclusions

Full retention of stubble resulted in increased soil moisture early in the season and higher earthworm populations. There was also an increase in slug numbers with retained stubble. There was no effect of stubble management on grain yield; however the higher sowing rate tended to increase yield compared to other treatments. The increased sowing rate also resulted in higher plant establishment and dry matter production at harvest suggesting the importance of this factor in alleviating lower yields commonly associated with full stubble retention.

Acknowledgments

The authors are grateful for the financial support provided by the Grains Research and Development Corporation (Project SFS14), NRM North and TIA. We thank Bill and Jill Chilvers for their land on which the trial was conducted and Brett Davey, Rob Howard and Rebecca Fish for technical assistance.

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