Annual ryegrass (*Lolium rigidum*) control with pre-emergent herbicides under different tillage systems

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Abstract
A field experiment was conducted to evaluate the effect of three tillage systems on the control of annual ryegrass (ARG) with pre-emergent herbicides. Even though there were large differences in the efficacy of herbicides on ARG, there was no interaction between tillage systems and herbicides (P>0.05). ARG control ranged from 17-43% for trifluralin as compared to 82-92% for prosulfocarb + S-metolachlor (Boxer Gold®) and 73-88% for pyroxasulfone (Sakura®). Poor efficacy of trifluralin at this site was likely due to herbicide resistance which has been shown to be a widespread problem in South Australia. Wheat seedling establishment was significantly affected by the interaction between herbicides and tillage systems. Trifluralin significantly (P<0.05) reduced wheat emergence under the single disc (51%) but not under the triple disc and knife-point systems. It is quite likely that the triple disc and knife-point systems throw herbicide treated soil out of the furrow whereas the single disc appears to leave herbicide treated soil in the furrow where it is in close proximity to crop seed. Grain yield responses to herbicide treatments were correlated (r^2 = 0.65) with wheat ear density. The crop sown with single disc was unable to fully compensate for reduction in crop density caused by trifluralin and suffered 24% yield loss relative to the non-treated control (3.4 t/ha). Combined effects of poor weed control and reduced crop density in trifluralin treatment under single disc resulted in dominance by ARG and high weed seed production as indicated by ARG spike density.

Key Words
Tillage systems, pre-emergent herbicides, annual ryegrass, wheat

Introduction

No-till tillage systems have been widely adopted in Australia to protect soil from erosion and enable timely seeding of crops. The most commonly used tillage systems are fitted with knife-point openers, which remove soil from the crop row leaving a wide furrow (D'Emden *et al.* 2008). Therefore, pre-emergent herbicides can be used safely with these tillage systems, as the herbicide is removed from the crop row into the inter-row space (Chauhan *et al.* 2007).

Some no-till farmers are making the transition to disc tillage systems or zero-till. These systems provide even lower soil disturbance than knife points, allow faster sowing and, if well set up, more uniform crop establishment (pers. comm. J Desbiolles). However, most pre-emergent herbicides are not registered for use with disc seeders. Even where herbicide labels do not prohibit use of disc seeders, manufacturers will not support their use with disc seeding equipment. The situation is complicated further by the fact that there is a huge range of discs available and they can differ enormously in the level of soil disturbance.

Movement of herbicide treated soil and herbicide incorporation with disc seeders can vary greatly for different disc systems and this can affect the efficacy of pre-emergent herbicides such as trifluralin and pendimethalin (Chauhan *et al.* 2007). These volatile herbicides require incorporation with soil throw at seeding to reduce losses caused by photodecomposition and volatilisation (Grover *et al.* 1997). In contrast, new pre-emergent herbicides prosulfocarb + S-metolachlor (Boxer Gold®) and pyroxasulfone (Sakura®), which also control annual ryegrass (ARG), have low volatility and are much more stable in the soil. However, there has been little research undertaken in Australia to evaluate the performance of these pre-emergent herbicides under disc systems. Here we report data from a field experiment undertaken in South Australia in 2011 to evaluate the effect of three tillage systems on pre-emergent herbicide control of annual ryegrass and phytotoxicity to wheat.

Methods

A field experiment was undertaken in 2011 at Roseworthy (34°32'S, 138°41'E), South Australia, to evaluate the effect of three tillage systems on the control of annual ryegrass with pre-emergent herbicides and their effect on wheat. Zero-till and no-till tillage systems investigated were John Deere 90 single disc, a K-Hart triple disc with Yetter coulter and a DS knife-point and press wheel system. All tillage systems were operated according to manufacturer specifications and sowing speeds. Herbicide treatments used in this study were trifluralin 720 g/ha (Triflur X®), prosulfocarb 2000 g/ha + S-metolachlor 300 g/ha (Boxer Gold®), and pyroxasulfone 100 g/ha (Sakura®). These pre-emergence herbicides were applied no later than 24 hours prior to seeding with a quad-motorbike fitted with a spray boom delivering 100 L/ha water volume. A non-treated weedy control treatment was also included in this study. The experiment was planted with wheat cv. Gladius at 90 kg/ha seed rate on 31st May and 1st of June into a lentil stubble (~2.0 t/ha); the depth of seeding was set at 3 cm. Diammonium phosphate required to supply 18 kg N/ha and 20 kg P/ha was drilled with the wheat seed. Plots were 5 m long and 1.5 m wide, and contained 6 crop rows 0.25 m apart. The experiment was established in a split-plot design with four replicates; tillage systems were assigned to main-plots and herbicides to sub-plots. The efficacy of herbicides on annual ryegrass was evaluated at 30 and 60 days after sowing (DAS). Similarly, annual ryegrass spikes were assessed at maturity. Wheat establishment, wheat seeding depth, ear number and grain yield were also determined. Data were analysed using ANOVA (GenStat Version 10).

Results

There were large differences between the three herbicides in their efficacy on ARG. There was also a significant herbicide × time interaction (P<0.001) which was related to further ARG emergence in trifluralin treatment. There was, however, no interaction between the herbicide treatment and the tillage systems (P>0.05). ARG control 30 days after sowing ranged from as low as 43% for trifluralin to as high as 73 and 92% for pyroxasulfone and prosulfocarb + S-metolachlor respectively (Table 1). Even at 60 DAS, ARG control remained above 80% for both prosulfocarb + S-metolachlor and pyroxasulfone whereas trifluralin efficacy diminished from 43 to 17%. Inability of trifluralin to provide effective control of this ARG population under all tillage systems was most likely due to herbicide resistance rather than poor incorporation. The longer residual control for pyroxasulfone and to a lesser extent prosulfocarb + S-metolachlor could be related to their longer persistence in soil than trifluralin.

Table 1. Effect of herbicide treatments on annual ryegrass control (%) at 30 and 60 days after sowing (DAS). Non-treated (control) mean annual ryegrass density was 1183 and 1593 plants/m^2 at 30 and 60 DAS.

	Annual ryegrass control	
Herbicide	30 DAS	60 DAS
	——— % ———	
Trifluralin	43	17
Prosulfocarb + S-metolachlor	92	82
Pyroxasulfone	73	88
LSD (P = 0.05)†	13***	
Tillage system × Herbicide	ns	
Tillage system × Herbicide × Time	ns	

***P < 0.001; ns, not significant

†Represents the significance (P < 0.05) of the interaction between herbicide and time.

Wheat seedling establishment was significantly affected by the interaction between herbicides and tillage systems (Table 2). Trifluralin significantly (P<0.05) reduced wheat emergence under the John Deere single disc (51%) but caused no significant reduction in wheat density under the K-Hart triple disc and knife-point systems. Prosulfocarb + S-metolachlor also reduced wheat establishment by 25%

under the single disc system. In contrast, no crop damage was observed for pyroxasulfone, which appears to be the safest pre-emergent option for use in wheat sown with discs. The higher soil disturbance K-Hart and knife-point systems appear to create enough soil throw to remove herbicide treated soil out of the furrow whereas the single disc appears to leave herbicide treated soil in the furrow where it is in close proximity to crop seed. The greater herbicide phytotoxicity observed under the single disc treatment was not the result of shallower seed placement as measurements determined the wheat seed had been placed at a similar depth in all three tillage systems (data not presented). Movement of herbicide treated soil into the furrow slot by either the single disc and/or closing furrow wheel could have exacerbated crop damage in the single disc system. Further research is required to clarify the influence of disc mechanics and furrow characteristics on herbicide behaviour and crop safety under different disc systems.

Table 2. Effect of tillage systems and herbicides on wheat emergence (plants/m^2) and grain yield (t/ha). Values in parenthesis represent % reduction in wheat emergence for herbicides relative to the non-treated control.

Tillage system	Herbicide			
	Non-treated	Trifluralin	Prosulfocarb + S-metolachlor	Pyroxasulfone
	plants/m^2			
JD90 single disc	176	87 (51)	132 (25)	163 (7)
K-Hart + Yetter coulter	187	193 (0)	170 (9)	203 (0)
DS knife-point	212	188 (11)	189 (11)	207 (2)
LSD (P=0.05)†	26			
	t/ha			
JD90 single disc	3.40	2.59	4.03	4.07
K-Hart + Yetter coulter	3.40	3.50	3.98	3.96
DS knife-point	3.30	3.40	4.04	3.97
LSD (P=0.05)†	0.42			

†Represents the significance ($P < 0.05$) of the interaction between tillage system and herbicide.

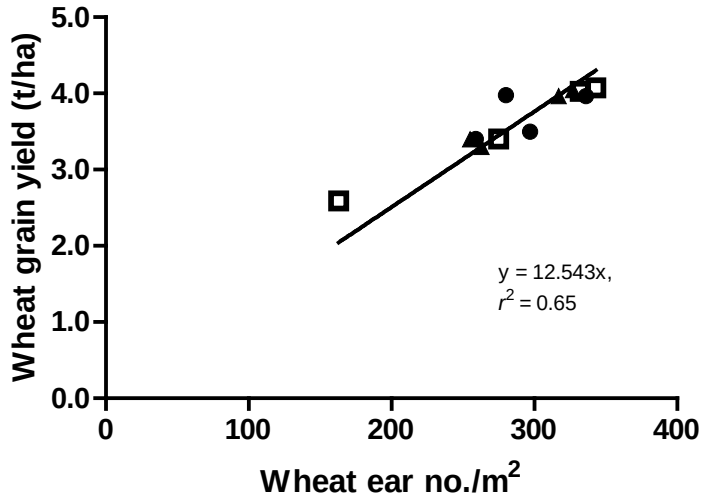

Figure 1. Relationship between mean wheat ear no. and grain yield for different tillage systems (□, JD90 single disc; ●, K-Hart + Yetter coulter; ▲, DS knife-point).

Grain yield responses to herbicide treatments were correlated ($r^2 = 0.65$) to wheat ear density (Figure 1). The crop sown with single disc had lower ear density because it was unable to fully compensate for reduced plant density when treated with trifluralin. Therefore, single disc system treated with trifluralin suffered a 24% yield loss relative to the non-treated control (3.40 t/ha) (Table 2). This negative effect of trifluralin under the single disc was exacerbated by the failure of this herbicide to

control ARG, which was likely due to herbicide resistance. The greatest increase in wheat grain yield (≥4.0 t/ha) was observed in tillage systems where ARG was effectively controlled with prosulfocarb + S-metolachlor and pyroxasulfone with little or no reduction in wheat plant density (Table 2). ARG competition reduced wheat yields by as much as 20% in non-treated and trifluralin treated plots relative to prosulfocarb + S-metolachlor and pyroxasulfone. In trifluralin treatment under the single disc, where weed control failed and crop density declined due to phytotoxicity, there would have been massive seed set by ARG because of its extremely high spike density (Figure 2). Such high levels of ARG seed production would be expected to have serious effects on productivity of subsequent crops in the rotation. Consistent with the trends in weed density, the greatest reduction in ARG seed production potential, as indicated by ARG spike density, was observed under prosulfocarb + S-metolachlor and pyroxasulfone in all three tillage systems.

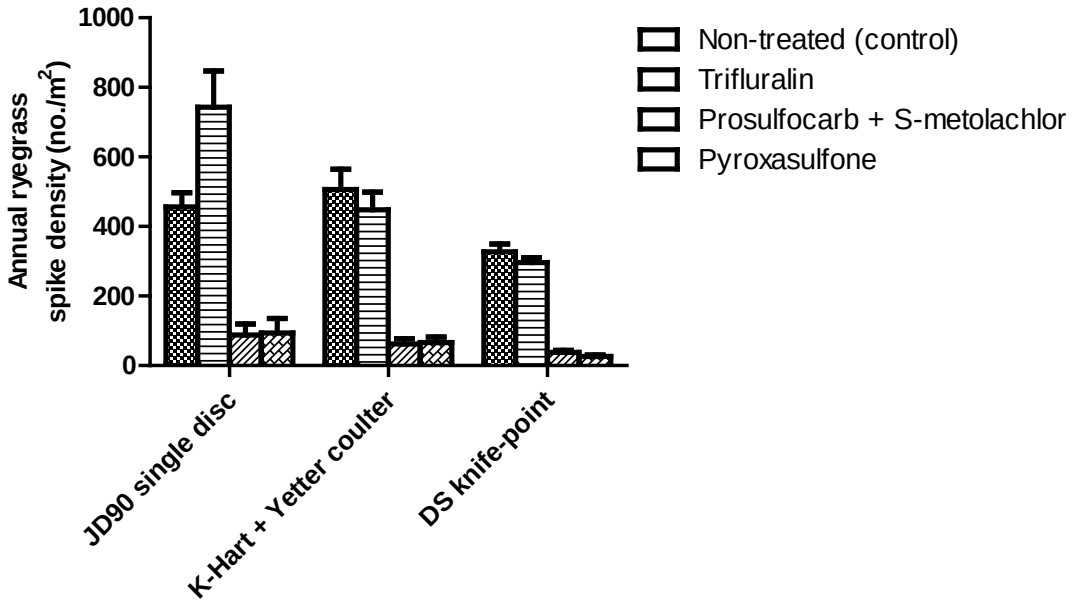

Figure 2. Annual ryegrass spike density (no./m^2) in response to tillage systems and herbicides. Bars represent standard error (SE) of mean.

Conclusion

At present there are no pre-emergent herbicides registered for use in wheat under discs and this is impeding the adoption of zero-tillage in southern Australia. The study reported here has shown that wheat crops can be seriously damaged by the use of trifluralin under single disc systems. In contrast, the new herbicide pyroxasulfone caused no damage to wheat establishment even under the single disc system and was highly effective against ARG. Based on these results, pyroxasulfone appears to be the most suitable pre-emergent herbicide for use in wheat under discs. Although, prosulfocarb + S-metolachlor caused a significant reduction in wheat plant density under the single disc, the crop was able to fully recover and did not suffer any yield penalty.

References

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