Influence of disc seeding systems on pre-emergence herbicide control of annual ryegrass (*Lolium rigidum*) in wheat

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Summary Pre-emergence herbicides placed too close to crop seed can cause crop damage. No crop damage was observed from pre-emergence herbicides when used with triple disc seeders. In contrast, crop damage caused by pre-emergence herbicides varied considerably between different single disc configurations. Pyroxasulfone caused no damage to wheat and provided >79% control of annual ryegrass and appears to be the most suitable pre-emergence herbicide for use with single discs. By comparison, trifluralin significantly ($P < 0.05$) reduced wheat density in single discs (<50%) but not with triple disc seeders. Crop damage from trifluralin and prosulfocarb + *S*-metolachlor in single discs was significantly reduced (<20%) when residue managers were fitted in front of the disc blade. Increasing the operating depth of the single disc by 15 mm also reduced crop damage from trifluralin and prosulfocarb + *S*-metolachlor.

Keywords Disc seeding systems, pre-emergence, annual ryegrass, wheat.

INTRODUCTION

Disc-based zero-till seeding systems are being adopted by an increasing number of no-till farmers. These systems enable greater residue retention, allow faster sowing and can result in more uniform crop establishment (Desbiolles 2011). However, disc seeding systems have significantly reduced soil disturbance compared with narrow-point openers. In Australia, herbicide labels support the use of pre-emergence herbicides with knife points in no-till seeding systems; however, pre-emergence herbicide labels do not always cover their use with disc seeders, presumably due to concerns about crop safety. A wide range of disc seeders are now available on the Australian market, further complicating the situation for the growers. At present growers are uncertain about the risk of crop damage when using pre-emergence herbicides in different single disc systems.

Herbicide safety at sowing in no-till is largely dependent on creating physical separation between germinating crop and herbicide (positional selectivity). Under knife-point and press wheel systems, satisfactory seed-herbicide separation and good crop safety are achieved by the removal of herbicide from the crop row into the inter-row space (Chauhan *et al.* 2007, Solhjou *et al.* 2012). However, disc seeding systems often lack adequate separation between the herbicide and germinating seedlings, which can result in significant crop damage.

The level of herbicide incorporation can vary greatly with different disc seeders and configurations, and this can affect the efficacy of volatile pre-emergence herbicides such as trifluralin and pendimethalin (Chauhan *et al.* 2007). These herbicides require mechanical incorporation into the soil at seeding to reduce losses from photodecomposition and volatilisation (Grover *et al.* 1997). In contrast, new pre-emergence herbicides prosulfocarb + *S*-metolachlor (Boxer Gold®) and pyroxasulfone (Sakura®), which also control annual ryegrass, have low volatility and are highly stable in the soil (P. Boutsalis pers. comm.). Therefore, a field study was undertaken to evaluate the effect of three pre-emergence herbicides on annual ryegrass control and crop phytotoxicity in four different disc seeding systems.

MATERIALS AND METHODS

A field experiment was undertaken in 2012 at Roseworthy (34°32'S, 138°41'E), South Australia, to evaluate the effect of four different disc seeding systems on the control of annual ryegrass with pre-emergence herbicides and their effect on wheat. The soil at the field site was a sandy loam over medium calcareous clay. The disc systems investigated were John Deere (90 series), and NDF (650 series) single discs; Bertini and KHart triple discs. All disc systems were operated according to manufacturer specifications and sowing speeds. Herbicide treatments used in the study were trifluralin 720 g ha^{-1} (Triflur X®), recommended rate of prosulfocarb 2000 g ha^{-1} + *S*-metolachlor 300 g ha^{-1} (Boxer Gold®), double the recommended rate of prosulfocarb 4000 g ha^{-1} + *S*-metolachlor 600 g ha^{-1}, and pyroxasulfone 100 g ha^{-1} (Sakura®). These pre-emergence herbicides were applied no later than 24 hours prior to seeding wheat with a hand-held spray boom delivering 100 L ha^{-1} water volume. A non-treated weedy control treatment was also included in

the study. The experiment was planted with wheat cv. Mace at 90 kg ha^{-1} seed rate from 19th to 28th of June into a lentil stubble (~2.0 t ha^{-1}); the depth of seeding was set at 3 cm except for the NDF double shoot (DS) single disc where depth of seeding was set at 4−5 cm. Diammonium phosphate required to supply 18 kg N ha^{-1} and 20 kg P ha^{-1} was banded with the wheat seed at sowing. Plots were 5 m long and 1.5 m wide, and contained 6 crop rows 0.25 m apart for John Deere, KHart and Bertini, and 4 crop rows 0.375 m apart for NDF disc system. The experiment was established as a split-plot design with four replicates; disc systems were assigned to the main-plots and herbicides to the sub-plots. The efficacy of herbicides on annual ryegrass was evaluated 60 days after sowing (DAS) and spike density was assessed at maturity. Wheat establishment, wheat seeding depth, ear number and grain yield were also determined. Data were analysed using ANOVA (GenStat Version 10.0).

RESULTS

Annual ryegrass control was significantly affected ($P < 0.05$) by the interaction between the type of disc system (single vs. triple disc) and herbicide treatment (Table 1). In the untreated control, annual ryegrass establishment was greater under the Bertini and KHart triple discs (360 and 380 plants m^{-2}) relative to the JD and NDF single disc openers (153 and 210 plants m^{-2}). However, in spite of greater annual ryegrass density in the triple disc systems than single discs, weed control with trifluralin was much higher under triple disc seeding systems (70–80%) than the single discs (10–31%). Prosulfocarb + *S*-metolachlor at the recommended and double the label rate and pyroxasulfone provided effective control of annual ryegrass under both types of disc systems (71–97%). Not surprisingly, highest levels of ryegrass control (>89%) was achieved in the 2-fold rate of prosulfocarb + *S*-metolachlor under all the disc systems.

Wheat seedling establishment was significantly affected by the interaction between herbicides and seeding systems. Trifluralin significantly reduced wheat emergence under the JD (59%) and NDF (48%) single disc systems but not under the Bertini or KHart triple discs (Table 1). Prosulfocarb + *S*-metolachlor at the recommended and 2-fold recommended label rates also caused significant crop damage in the single disc systems. In contrast, no crop damage was observed for pyroxasulfone. Herbicide damage from trifluralin and prosulfocarb + *S*-metolachlor was significantly reduced (<20%) by the use of residue managers on the JD single disc system (Figure 1). In addition, increased sowing depth in NDF double shoot single disc (40.5 mm) also reduced herbicide damage to wheat establishment in trifluralin and prosulfocarb + *S*-metolachlor relative to shallow sowing (25.2 mm) with the single shoot version of the same disc (Figure 2).

Table 1. Effect of disc systems and pre-emergence herbicides on annual ryegrass density and wheat emergence (plants m^{-2}). Values in parentheses represent control of annual ryegrass (%) and reduction in wheat emergence (%) relative to the non-treated control.

		Herbicide (g a.i. ha^{-1})				
		Non-treated	Trifluralin	Prosulfocarb + *S*-metolachlor		Pyroxasulfone
Disc system		0	720	2000 + 300	4000 + 600	100
		Ryegrass (plants m^{-2})				
Single disc	JD90	153	137 (10)	45 (71)	18 (89)	24 (84)
	NDF650	210	144 (31)	46 (78)	20 (91)	44 (79)
Triple disc	Bertini	360	107 (70)	41 (89)	11 (97)	70 (81)
	KHart	380	77 (80)	53 (86)	26 (93)	65 (83)
LSD (P = 0.05)†				93.1		
		Wheat (plants m^{-2})				
Single disc	JD90	211	87 (59)	90 (58)	90 (58)	202 (5)
	NDF650	176	92 (48)	78 (56)	36 (80)	179 (0)
Triple disc	Bertini	215	198 (8)	206 (4)	199 (8)	211 (2)
	KHart	213	192 (10)	209 (2)	202 (5)	208 (2)
LSD (P = 0.05) †				36.7		

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

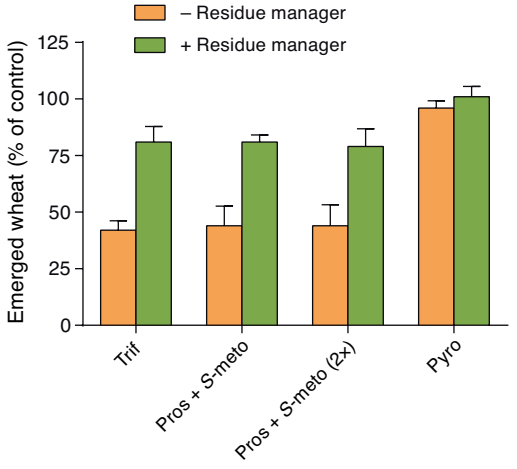

Figure 1. Effect of pre-emergence herbicides on wheat emergence (% of control) in JD single discs fitted with and without Arricks residue managers. Herbicides were trifluralin (Trif), prosulfocarb (Pros) + *S*-metolachlor (*S*-meto) and pyroxasulfone (Pyro). Bars represent standard error (SE) of mean.

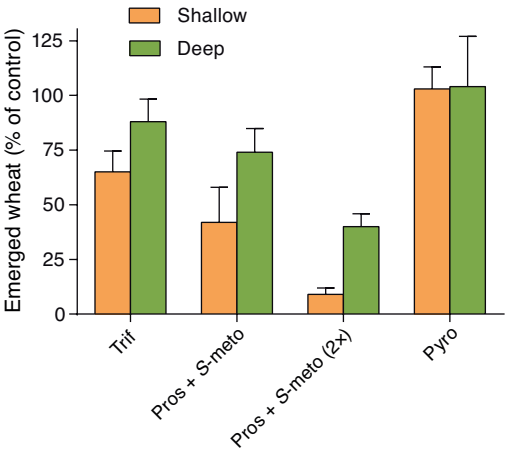

Figure 2. Influence of disc operating depth (shallow vs. deep) on wheat emergence (% of control) with different pre-emergence herbicides. The single disc system was NDF (single vs. double shoot). Mean shallow and deep sowing depths were 25.2 and 40.5 mm respectively. Bars represent standard error (SE) of mean.

There was a significant ($P < 0.001$) negative relationship between ryegrass spike density and wheat grain yield (Figure 3). The combination of poor weed control and herbicide damage from trifluralin in single discs, resulted in a significant increase in ryegrass spike density at the expense of crop yield. In contrast, the highest wheat grain yield (>4.0 t ha^{-1}) was observed in disc systems where ryegrass was effectively controlled with prosulfocarb + *S*-metolachlor and pyroxasulfone with little or no reduction in wheat density.

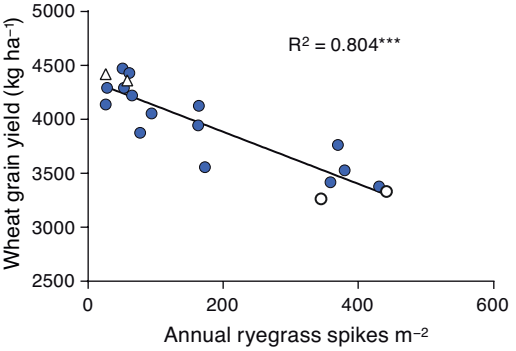

Figure 3. The relationship between mean annual ryegrass spike density after treatment with pre-emergence herbicides, and wheat grain yield in different disc systems. Open circles and triangles represent trifluralin (○) and pyroxasulfone (△) treatments in single disc systems.

Although, prosulfocarb + *S*-metolachlor caused a significant reduction in wheat plant density under JD and NDF single discs, the crop was able to partially recover, thereby reducing the extent of yield loss.

DISCUSSION

Seedling recruitment of annual ryegrass tends to increase substantially in high soil disturbance seeding systems (Chauhan *et al.* 2006a). Therefore, higher soil disturbance in triple discs (Bertini and KHart) was the likely cause of greater ryegrass establishment in triple discs than single discs (JD and NDF). Annual ryegrass seeds buried at a shallow depth experience more favourable conditions for germination as compared to weed seeds on the soil surface that tend to experience rapid wetting and drying cycles. Poor efficacy of trifluralin in the single discs (JD and NDF: 10–31%) than triple discs (70–80%) is likely to be due to poor incorporation of this herbicide by single discs.

Previous research has shown that when applied in single disc systems, most of the applied trifluralin remains on the soil surface even after sowing, where it is susceptible to losses through volatilisation and photodecomposition (Chauhan *et al.* 2006b). Consistent performance of prosulfocarb + *S*-metolachlor and pyroxasulfone in both types of disc systems could be related to their much lower volatility than trifluralin. In addition, these new herbicides possess moderate water solubility, which would allow some herbicide movement into surface soil where most of the ryegrass seedbank is present in disc systems (Chauhan *et al.* 2006a).

Trifluralin and prosulfocarb + *S*-metolachlor caused significant damage to wheat in the single discs but not in triple discs. Removal of herbicide treated soil from the furrow in the triple discs (Bertini and KHart) appears to be responsible for low herbicide damage in these systems. In contrast, the single discs (JD and NDF) appear to leave herbicide treated soil in the furrow where it damages wheat seedlings. However, herbicide damage was significantly reduced by the residue managers fitted in front of the single disc modules. These residue managers appeared to remove some herbicide treated soil from the furrow, which in turn would have reduced crop damage from pre-emergence herbicides. Reduced crop damage from pre-emergence herbicides due to increased sowing depth in the NDF single disc could also be related to greater removal of herbicide treated soil from the furrow. However, increasing sowing depth can be an issue for disc seeders; particularly on compacted soils were disc penetration is reduced.

In contrast to trifluralin and prosulfocarb + *S*-metolachlor, no crop damage was observed with pyroxasulfone, which appears to be the safest herbicide option for use in wheat sown with low soil disturbance single disc seeding systems.

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