Weed suppression by crop competition in three crop species in Western Australia

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Summary To examine the competitive ability of crop cultivars to suppress weeds in barley, canola and wheat crops, four field experiments were conducted in two locations within the Western Australian (WA) wheatbelt during 2008 and 2009. In 2008, four cultivars of each crop were sown under in-crop herbicide or no in-crop herbicide treatments. In 2009, two selected cultivars of each crop species were sown at two seeding rates under in-crop herbicide and no in-crop herbicide treatments. Initial weed control by in-crop herbicides was more effective in barley and wheat than in canola. Of the three crop species studied, barley and wheat crops appeared more competitive than canola in suppressing annual ryegrass (*Lolium rigidum* Gaud.) heads. Within each crop, some cultivars showed greater competitive ability than others, in terms of grain yield and annual ryegrass suppression. However, the competitive ability of cultivars of a single crop type (barley, canola or wheat) was highly variable, probably due to variation between seasons and sites. In barley, cv. 'Roe' under no in-crop herbicide produced greater grain yield than cv. 'Baudin'. In wheat, cv. 'EGA Bonnie Rock' under no in-crop herbicide produced greater grain yield and suppressed more annual ryegrass than cv. 'Wyalkatchem'. The cereal cultivars that were more competitive also had a larger canopy area at maximum vegetative growth stage and intercepted more light. In canola, the difference in competitive ability between cultivars was not consistent.

Keywords Barley, canola, wheat, annual ryegrass, canopy area, light interception, grain yield, *Lolium rigidum*.

INTRODUCTION

To minimise effects in the event of development of widespread herbicide resistance, considerable research has examined benefits of crop competition for integrated weed management (Lemerle *et al.* 2001). Many farmers in WA are now using high seeding rates of wheat and barley to suppress weeds and manage the herbicide resistant weeds. Although cultivars within a crop do not seem to differ greatly with regard to competitive ability, high seeding rate increases competitive ability of crops (Minkey *et al.* 2000, Lemerle *et al.* 2001, Paynter and Hills 2009). However, aside from the work on barley by Paynter and Hills (2009), a guideline that enables farmers to select the most competitive modern crop cultivars of barley, wheat and canola under weedy situations is not available to WA growers. The aim of this study was to examine the competitive ability of crop cultivars to suppress weeds in wheat, barley and canola grown under in-crop herbicide or no in-crop herbicide treatments, with or without high seeding rates.

MATERIALS AND METHODS

In 2008, four cultivars of each crop (wheat, barley and canola) were grown under in-crop herbicide or no in-crop herbicide conditions at Western Australian No-till Farmers Association (WANTFA) trial location at Meckering and Wongan Hills Research Station, WA (Table 1). Triasulfuron 25 g a.i. ha^{-1} + trifluralin 960 g a.i. ha^{-1} was sprayed in wheat, metribuzin 112 g a.i. ha^{-1} + trifluralin 960 g a.i. ha^{-1} in barley and simazine 1000 g a.i. ha^{-1} in canola immediately before sowing in the weed control plots only. Tralkoxydim 150 g a.i. ha^{-1} was sprayed in the herbicide plots of wheat and barley and atrazine 1000 g a.i. ha^{-1} in canola to control post-emergent weed. Wheat was sown at 70 kg ha^{-1}, barley 80 kg ha^{-1} and canola 3 kg ha^{-1} Crop cultivars were chosen to ensure varying plant height, canopy structure type and growing season duration. In 2009, the interactions of seeding rate (barley 75 or 150, canola 2.5 or 5 and wheat 60 or 120 kg ha^{-1}) and selected crop cultivars were examined with in-crop herbicide or no in-crop herbicide conditions at the same locations as 2008 (Table 1). In 2009, two crop cultivars were chosen from the four cultivars of 2008 based on the performance in 2008 and the popularity of the cultivars, and grown following the same agronomic procedures as 2008.

Measurement Canopy area (canopy height × width) and light interception measured by Sunfleck Ceptometer (Pearcy 1991) by the crop canopy (as opposed to the weed canopy) were measured at maximum tillering stage of wheat or barley and rosette stage of canola. The main weed species at both Meckering

and Wongan Hills was annual ryegrass. Grass weed heads were counted at anthesis of wheat. Grain yield was recorded at harvest.

Design and analysis A split-slit plot design was employed in both years. In 2008, crop type was assigned in the main plots, weed treatment in the sub-plots and cultivar in the sub-sub-plots. In 2009, crop type was assigned in the main plots, weed treatment in the sub-plot, seeding rate in the sub-sub-plots and cultivars in the sub-sub-sub-plots.

Data were subjected to ANOVA and means were separated by LSD using GENSTAT. For grain yield of crops, ANOVA was performed for each crop separately to minimise the confounding effects of crop species. For ANOVA of other measurements such as crop canopy area and weed seed heads, crop species was used as the main factor.

RESULTS

Initial weed control Initial in-crop weed control due to herbicide use varied between crops, seasons and locations. Weed control was generally more effective in wheat and barley than in canola (data not shown).

Grain yield of crops Interaction of weed control and cultivars influenced grain yield of wheat and barley in all trials except at Meckering 2008. In canola, a significant interaction between herbicide use and cultivars was found at Meckering 2008 and Wongan Hills 2009 (Table 1).

In barley, 'Roe' and 'Hindmarsh' yielded better than 'Baudin' and 'Buloke' at both locations in 2008 regardless of herbicide (Table 1). Under no in-crop herbicide, 'Hindmarsh' at 'Meckering' and 'Baudin' at Wongan Hills produced a lower yield than under herbicide.

In canola, 'Bravo' and 'Thunder' produced greater grain yield under herbicide than under no herbicide at Meckering in 2008 (Table 1). Under herbicide treatment, 'Tanami' produced greater grain yield than 'Bravo' in 2008 but reverse was found in 2009. In 2009, herbicide significantly improved yield of 'Tanami' and 'Bravo'.

In wheat, 'Wyalkatchem' yielded better under herbicide than no herbicide in two out of four trials and 'EGA Bonnie Rock' yielded better under herbicide than no herbicide in three out of four trials. The other two cultivars did not respond to herbicide application in any season or location (Table 1).

Use of higher seeding rates in 2009 did not affect crop yield of canola and wheat at either location (Table 1). High seeding rate (150 kg ha^{-1}) of barley increased barley grain yield by 13% at Meckering in 2009 but not at Wongan Hills where ryegrass density was greater (Table 2).

Annual ryegrass heads On average, barley and wheat cultivars had fewer annual ryegrass heads at maturity than canola cultivars (Table 2). Annual ryegrass head numbers were not recorded at Wongan Hills in 2008. In barley, herbicide reduced annual ryegrass heads in 'Buloke' at Meckering in 2008, 'Roe' at Meckering and Wongan Hills in 2009, and 'Buadin' at Wongan Hills in 2009. However, annual ryegrass heads were not influenced by barley cultivar alone in no-herbicide plots. In canola, herbicide reduced number of ryegrass heads but cultivar alone did not influence annual ryegrass head number.

In wheat, herbicide reduced annual ryegrass heads in most cultivars in all the trials. Under no herbicide, 'Wyalkatchem' had more annual ryegrass heads than other cultivars at Meckering in 2008 and at Wongan Hills in 2009 (Table 2).

Canopy area At maximum vegetative stage, barley had a larger canopy area than wheat and wheat had larger canopy area than canola (data not shown). However, some cultivars of canola such as 'Thunder' had greater light interception than wheat or barley, possibly due to the larger leaf size than other crops and cultivars. Regardless of crops, larger canopy area and greater light interception in most cultivars did not result in greater grain yield.

DISCUSSION

On average, barley and wheat reduced annual ryegrass head number more than canola. Barley was shown to be more competitive than wheat in the UK (Seavers and Wright 1999) and wheat was shown to be more competitive than canola in the USA (Holman *et al.* 2004). In contrast, Lemerle *et al.* (1995) found canola was more competitive than wheat or barley in southern Australia.

In barley, 'Roe' produced a higher grain yield (under herbicide and no herbicide conditions) than 'Buloke' at both locations in 2008. 'Roe' also had greater canopy area and intercepted more light than 'Baudin' in both seasons (data not shown). Barley 'Buloke' appeared to have larger canopy area at the maximum tillering stage than 'Baudin'. However, this did not result in higher grain yield of Buloke, suggesting that there was a shift in the competitiveness of this cultivar. Further studies involving more frequent measurements on the canopy area and canopy light interception to examine the canopy dominance should reveal a possible shift in the competitive ability of crop cultivars.

Table 1. Grain yield (kg ha^{-1}) of different crop cultivars grown under in-crop herbicide and no herbicide conditions at Meckering and Wongan Hills in 2008 and 2009.

	Meckering				Wongan Hills			
	2008		2009		2008		2009	
Crop/Cultivar	Herbicide	No herbicide	Herbicide	No herbicide	Herbicide	No herbicide	Herbicide	No herbicide
Barley								
Roe	2474	2443	3323	2987	2444	2379	2500	2253
Hindmarsh	2405	2189	–[A]	–	2500	2611	–	–
Baudin	1817	1686	3264	2741	2203	1951	2419	2083
Buloke	1928	1981	–	–	2145	2015	–	–
LSD (P = 0.05)	NS		453.5		216.9		187.9	
Canola								
CB™ Tanami	960	789	595	595	1104	1063	980	571
CB™ Boomer	817	717	–	–	972	889	–	–
Bravo	863	540	618	530	1007	951	1057	637
Thunder	934	706	–	–	965	931	–	–
LSD (P = 0.05)	211.8		NS		NS		82.2	
Wheat								
Wyalkatchem	1011	928	2441	1959	2396	2250	2319	1879
Yitpi	1323	1305	–	–	2194	2125	–	–
Calingiri	944	785	–	–	2326	2174	–	–
EG Bonnie Rock	1416	1409	2252	1902	2208	2424	2407	1960
LSD (P = 0.05)	NS		431.5		150.4		174.2	

[A]– means this cultivar was not used in 2009 trials.

Table 2. Effect herbicide and different crop cultivars grown under in-crop herbicide and no herbicide conditions on annual ryegrass heads (number m^{-2}) at Meckering and Wongan Hills in 2008 and 2009.

	Meckering				Wongan Hills[A]	
	2008		2009		2009	
Crop/Cultivar	Herbicide	No herbicide	Herbicide	No herbicide	Herbicide	No herbicide
Barley						
Roe	1	11	16	40	36	145
Hindmarsh	3	9	–	–	–	–
Baudin	2	9	15	28	35	181
Buloke	1	19	–	–	–	–
Canola						
CB™ Tanami	7	34	20	51	175	426
CB™ Boomer	18	37	–	–	–	–
Bravo	17	24	24	53	80	465
Thunder	16	35	–	–	–	–
Wheat						
Wyalkatchem	1	25	18	47	32	204
Yitpi	3	11				
EGA Bonnie Rock	2	13	14	37	26	140
Calingiri	1	15				
LSD (P = 0.05)	11.5		20.6		111.9	

[A]Annual ryegrass head number was not available for Wongan Hills in 2008.

Reduction in annual ryegrass head numbers in wheat and barley even under no in-crop herbicide also suggests that these two crops were more competitive than canola. Similar results were reported in barley (Paynter and Hills 2009) and wheat (Minkey *et al.* 2000).

In wheat, 'Bonnie Rock' had the largest canopy area and light interception at maximum tillering stage but did not appear to produce greater grain yield and suppress more ryegrass heads than other cultivars except at Meckering in 2008. Of the remaining three cultivars of wheat, 'Calingiri' showed higher canopy area and light interception at maximum tillering stage, but did not show a yield advantage in weedy or herbicide situations, suggesting that there was a shift in the competitiveness of this cultivar after vegetative stages.

In barley, seeding rate increased grain yield at one location. An increase in grain yield due to increased barley seeding rate was also found by Paynter and Hills (2009).

Seasonal and site conditions, such as time of sowing, rate and speed of crop emergence, herbicide efficacy, herbicide toxicity, emergence time and type of weed present, all have a large influence on crop-weed dynamics. Even though there was not much difference in the suppression of annual ryegrass heads by crop cultivars, measurements on the amount of annual ryegrass seed production may indicate if cultivars affect ryegrass seed production as a consequence of competition.

Competitive ability may change during the cropping season in crops such as wheat and weeds such as Italian ryegrass (*Lolium multiflorum* Lam) (Hashem *et al.* 1998). Further research is required on the competitive ability of these crops with frequent measurements in light interception over the entire season to maximise crop yield.

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