Clearfield™ wheat to control hard-to-kill weeds

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Summary Four trials were conducted at Wongan Hills and Katanning, WA from 2001 to 2005 to examine the efficacy of Midas® in Clearfield™ wheat sown at different rates and compared with other herbicides. Lime was applied in one trial in 2004 at Katanning to examine if lime can enhance weed emergence. In 2001 at Wongan Hills, high seeding rate such as 100 kg ha^{-1} sprayed with Midas at 450 mL ha^{-1} produced higher grain yield of Clearfield wheat (STL) than at 50 or 150 kg ha^{-1} with Midas at 900 mL ha^{-1}. High seeding rate also provided optimum control of annual ryegrass heads at 450 mL ha^{-1} of Midas in 2002. In 2003 at Katanning, Midas in Clearfield wheat (JNZ) controlled Guildford grass 94% and brome grass 98%, ryegrass 97% and silver grass 100%. Sulfosulfuron and mesosulfuron in wheat CV Westonia and Wyalkatchem provided good control of one or more of the above weeds but not Guildford grass. Wheat CV Westonia and Wyalkatchem produced higher yields than Clearfield wheat in both years at Katanning. However, the greater weed control achieved with Clearfield wheat may benefit the subsequent crop more effectively than the other wheat varieties. Lime applied in 2004 increased soil pH from 5.13 to 6.14 with an increase in the emergence of brome grass in 2005 season.

Keywords Clearfield™ wheat, wild radish, annual ryegrass, Guildford grass, brome grass, herbicides, competition, Midas®.

INTRODUCTION

Clearfield™ wheat (CL wheat) was registered in Australia in 2001 by the Department of Agriculture and Food Western Australia in partnership with BASF for the Clearfield production system (Littlewood 2004). Unlike other wheat cultivars, the CL wheat varieties (STL and JNZ) are tolerant to imidazolinone herbicides. Since CL wheat varieties have been conventionally bred, they are not GMO. Midas® (imazapic 22 g L^{-1}, imazapyr 7.3 g L^{-1}, and MCPA (ethyl hexyl ester) 288.5 g L^{-1}) at 900 mL ha^{-1}, is the recommended herbicide to control weeds such as ryegrass, wild oats, barley grass, brome grass, wild radish, doublegee, wild mustard, wild turnip etc. in CL wheat.

The competitive ability of wheat can be increased by using a high seeding rate (Minkey *et al.* 2000), but a high seeding rate also increases the production cost when combined with full label rate of herbicides. When using high seeding rate, the profitability of this crop should be sustained. Walker *et al.* (1998) showed that herbicide rate might be reduced if barley is sown at a high seeding rate to control weeds. Such interactions between wheat seeding rate and herbicide rate have not been investigated in WA.

Lime may act as a wetting agent and enhance germination of weeds such as brome grass in a non-wetting soil. However, this hypothesis has never been tested under field conditions. While there are few selective herbicides to control the hard-to-kill grass weeds such as brome grass, barley grass, silver grass and Guildford grass, it is useful to examine the efficacy of Midas on these weeds as compared to other herbicides.

The aims of this study was to examine (1) if increasing seeding rate of CL wheat could improve weed control at reduced rate of Midas and (2) the effect of lime and CL wheat on hard-to-kill grass weeds.

MATERIALS AND METHODS

Herbicide and seeding rate interaction at Wongan Hills Two trials were conducted in 2001 and 2002 combining five seeding rates (50, 75, 100, 125 and 150 kg ha^{-1}) of CL wheat (STL) with five rates (0, 225, 450, 675 and 900 mL ha^{-1}) of Midas sprayed at two stages (two and five leaf) of CL wheat. The treatments were laid out in split-split-plot design with stage of herbicide application in the main plot, seeding rate in the sub-plot and herbicide rate in the sub-sub-plots with three replications in each year and location.

Wild radish was the dominant weed species in 2001 and annual ryegrass was the dominant species in 2002 but wild radish was also present in 2002. The crops were sown on 8 June in 2001 and on 6 June in 2002. Wheat yield, crop damage (visual assessment expressed as percent of untreated control) and extent of weed control were recorded.

Lime, variety and herbicide effects at Katanning Two trials were conducted at Katanning, WA in 2003 and 2004. In 2003, wheat varieties (Westonia, Wyalkatchem and CL wheat (JNZ)) were grown with herbicides (sulfosulfuron, mesosulfuron, and Midas) in a randomised complete block design with three replications. No lime was used in 2003. In 2004, the wheat varieties and herbicides were combined with three rates of lime (0, 2.5, 5 t ha^{-1}) in a criss-cross design with lime in strip A and a combination of varieties and herbicides in strip B, replicated three times. An untreated control was included in both years. Trifluralin (720 g a.i. ha^{-1}) was incorporated by seeding in both years in all plots except in the untreated control plots. No post-emergent herbicide was used in either year. Weed and crop emergence, weed control, crop grain yield were recorded. In 2005, each unit plot of 2004 trial was split into two sub-plots and a non-CL wheat crop (CV Arrino) was sown in one sub-plot and a lupin crop was sown in the other sub-plot. Crop damage (visual assessment of weed growth reduction expressed as percent of untreated control) and soil pH were recorded in 2005.

Data from each trial were analysed by ANOVA and treatments were separated by LSD (P = 0.05).

RESULTS

Wheat yield at Wongan Hills In 2001, the highest wheat yield was produced at 100 kg ha^{-1} seed rate and Midas at 450 mL ha^{-1} sprayed at five leaf stage of wheat (Figure 1). Wheat grain yield did not increase with increases in Midas rate over 450 mL ha^{-1}.

In 2002, wheat yield increased with increasing Midas rate up to 900 mL ha^{-1} although yield was slightly higher when Midas was sprayed at two leaf stage than at five leaf stage of wheat (Figure 2).

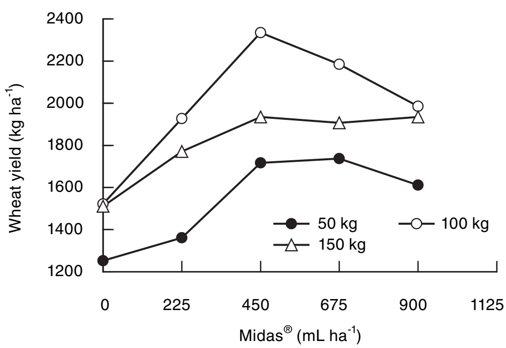

Figure 1. Effect of wheat seed rate and Midas® on the yield of Clearfield wheat sprayed at five leaf stage of wheat at Wongan Hills in 2001. LSD (P = 0.05) = 293.8 kg ha^{-1}.

Weed control at Wongan Hills In 2001, wild radish control was 100% when Midas at 250 mL ha^{-1} was sprayed at two leaf stage of wheat. However, 900 mL ha^{-1} was required to effectively control wild radish when sprayed at five leaf stage (Figure 3). In 2002, Midas at 900 mL ha^{-1} controlled 96% heads of ryegrass at 50 kg ha^{-1} of wheat and 98% at 75 or 100 kg ha^{-1} seeding rate of wheat sprayed with Midas at 450 mL ha^{-1} (Figure 4).

Crop damage at Wongan Hills No crop damage was visible in 2001. In 2002, 5% crop damage (leaf blade abortion of fully expanded leaves) was recorded when Midas was sprayed at two leaf stage of wheat while only 0.4% crop damage was recorded at five leaf stage (data not presented). Wheat plants recovered from Midas damage in about three to four weeks.

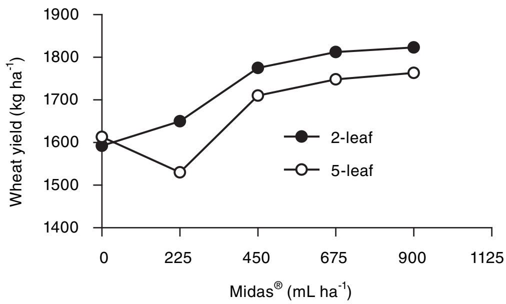

Figure 2. Effect of Midas® applied at two or five leaf stage of wheat on the yield of Clearfield wheat at Wongan Hills in 2002. LSD (P = 0.05) = 98.7 kg ha^{-1}.

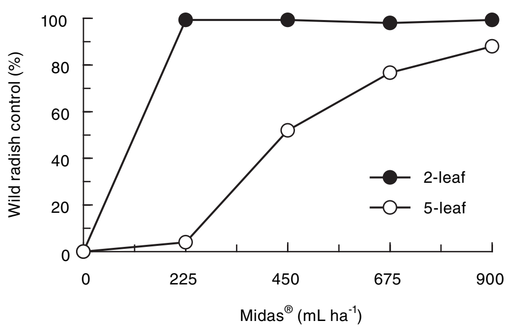

Figure 3. Wild radish control by Midas® applied at two or five leaf stage of wheat at Wongan Hills in 2001. LSD (P = 0.05) for wild radish control = 6.84%.

Wheat yield at Katanning On average, wheat yield increased significantly in all wheat varieties due to weed control. In the absence of weed control, Westonia produced the highest yield in both years (Table 1). Regardless of the weed control level achieved by the various herbicides, grain yields of Wyalkatchem and Westonia wheat were higher than CL wheat (JNZ) when sprayed with herbicides. Lime did not influence emergence of weeds or yields of wheat in 2004.

Weed control at Katanning In 2003, Guilford grass was the most dominant weed species followed by ryegrass, brome grass and silver grass. In the untreated plots, the number of Guildford grass plants was 309 m^{-2}, brome grass 20 m^{-2}, ryegrass 71 m^{-2} and silver grass 12 m^{-2}. Regardless of wheat varieties, sulfosulfuron controlled 27, 89, 42, and 97% of Guildford grass, brome grass, ryegrass and silver grass while mesosulfuron controlled 12, 41, 69, and 62% of these weeds respectively (Figure 5). In contrast, Midas in CL wheat controlled 94% of Guildford grass, 100% brome grass, 98% ryegrass and 94% silver grass plants in 2003.

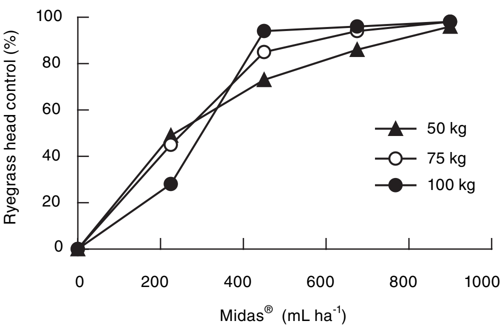

Figure 4. Interaction of wheat seeding rate and Midas® on the control of ryegrass heads at Wongan Hills in 2002. LSD (P = 0.05) for ryegrass head control = 15.13%.

Table 1. Effect of controlling weeds by herbicides on the grain yield of three wheat varieties at Katanning, averaged over 2003 and 2004 seasons.

Herbicides (unit ha^{-1})	Wheat grain yield (kg ha^{-1})		
	Westonia	Wyalkatchem	CL wheat
Untreated	1720	1538	1112
Sulfosulfuron 19 g	2441	2598	–
Mesosulfuron 10 g	2201	2462	1722
Midas® 900 mL	–	–	2038
LSD (P = 0.05)		256.8	

In 2004, ryegrass was the most dominant weed species followed by barley grass and brome grass. There were only a few plants of Guildford grass plants present randomly at the site. Based on the number of weed heads, sulfosulfuron controlled 39, 96, and 52% of brome grass, barley grass and ryegrass while mesosulfuron controlled 30, 97 and 73% of these grass weeds respectively. In contrast, Midas controlled 86, 100 and 97% heads of brome grass, barley grass and ryegrass respectively (data not presented).

Soil pH measured in October 2004 in limed plots was the same as no-lime plots and there was no difference in weed emergence. In 2005, emergence of brome grass increased with a significant increase in soil pH from 5.13 to 6.14 in the limed plots compared to the no-lime plots (Table 2).

DISCUSSION

In 2001 at Wongan Hills, wheat yield at 100 or 150 kg ha^{-1} was nearly 20% higher than the yield at 50 kg ha^{-1} in the absence of Midas. Grain yield of CL wheat sown at 100 kg ha^{-1} and sprayed with Midas at 450 mL ha^{-1}, was 36% higher than at 50 kg ha^{-1} of wheat sprayed with Midas at 900 mL ha^{-1} (Figure 1). Lower Midas rate (450 mL ha^{-1}) in combination with higher seeding rate such as 100 kg ha^{-1} gave similar control of ryegrass heads to Midas at 900 mL ha^{-1} at lower seeding rate such as 50 kg ha^{-1} in 2002 (Figure 2), indicating that additional competitive pressure exerted

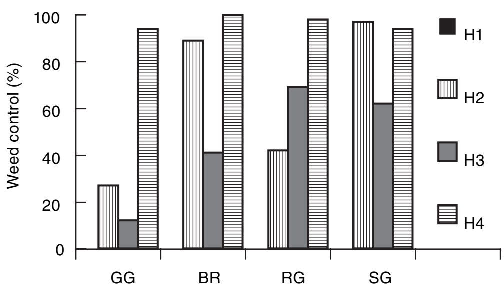

Figure 5. Effect of three herbicides on the control of weed heads expressed as the percent of untreated control in 2003, averaged over wheat varieties at Katanning. H1 = Untreated; H2 = trifluralin 720 g ha^{-1} + sulfosulfuron 19 g ha^{-1}; H3 = trifluralin 720 g ha^{-1} + mesosulfuron 10g ha^{-1}; H4 = trifluralin 720 g ha^{-1} + Midas® 900 mL ha^{-1}; GG = Guildford grass; BR = brome grass; RG = ryegrass; SG = silver grass.

by higher seeding rate of wheat could compensate for lower rate of Midas. Walker *et al.* (1998) found similar results in Queensland. In 2001 at Wongan Hills, Midas at 225 mL ha^{-1} sprayed at two leaf stage gave 100% control of wild radish while at five leaf stage 900 mL ha^{-1} of Midas was required to achieve optimum wild radish control (Figure 3). Such yield advantage may not always be achievable as wheat is susceptible to herbicide damage especially when Midas is applied at two leaf stage under cold and saturated soil conditions although only 5% damage (abortion of leaf blades of fully expanded leaves) was recorded in this trial.

Sulfosulfuron was effective for brome grass and silver grass control at Katanning in 2003 and 2004, whereas mesosulfuron was moderately effective on ryegrass and silver grass but neither herbicides was effective on Guildford grass. Midas was highly effective on all four weed species in 2003 and 2004.

Midas should be sprayed at five leaf stage of CL wheat varieties. If sprayed at two leaf stage, higher weed control efficacy may be achieved if a weed such as wild radish is the dominant weed but crop damage is expected. When wild radish was the main weed species, a seeding rate of 100 kg ha^{-1} sprayed with Midas at 450 mL ha^{-1} produced higher wheat yield at Wongan Hills than 150 kg ha^{-1} sprayed with Midas at 450 mL ha^{-1}. It was possible that higher leaf area from higher wheat density at 150 kg ha^{-1} utilised more stored soil moisture than 100 kg ha^{-1}, leading to a restriction on number of grains produced per head and abortion of some tillers.

Midas effectively controlled Guildford grass, brome grass, barley grass, silver grass and ryegrass leading to an increase in wheat yield by 83%. Although the absolute yield in CL wheat was less than Westonia and Wyalkatchem, good weed control achieved by the CL wheat crop may have less weed burden in the subsequent crop than other varieties of wheat.

Lime applied in 2004 increased soil pH by one unit in 2005 season with an increase in brome grass emergence. Significant increase in soil pH may help in a relatively irreversible adsorption of Midas molecule with soil particles leading to a shorter residual persistence of imidazolinone herbicides in Midas. As there was no symptom of herbicide damage in non-CL wheat variety in 2005 from the residues of Midas applied in 2004, it is probable that the imidazolinone herbicides which are highly toxic to non-CL wheat varieties was lost from soil. A combination of microbial degradation and leaching of imidazolinone herbicides beyond the crop root zone by 415 mm of rains that occurred from 17 June 2004 to 31 May 2005 at Katanning may have caused this loss.

Table 2. Effect of lime applied in 2004 wheat crop on the soil pH and brome grass emergence in 2005 wheat and lupin crops at Katanning.

Lime (t ha^{-1})	pH in October 2004	pH in November 2005		Brome grass in 2005 (plants m^{-2})
		Lupin	Wheat	
0	5.1	5.13	5.13	0.27
2.5	5.5	–	–	1.44
5.0	5.6	6.06	6.23	1.92
LSD (P = 0.05)	0.22	0.197		ns

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