Site Specific Weed Management (SSWM) – Australian potential with annual ryegrass (*Lolium rigidum* L)

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Abstract

Weeds often grow in patches within a paddock. Spraying the whole paddock is the current practice, but there are potential economic and environmental benefits to be gained from Site Specific Weed Management (SSWM), targeting herbicide control measures only to weed patches. Weed patches of many species have been mapped with varying success in studies worldwide. Interest in SSWM is increasing in Australia and overseas as GPS and Precision Agriculture adoption grows. This paper reports recent Australian field research with SSWM of annual ryegrass (*Lolium rigidum* L.)

Herbicide trials conducted in South Australia showed significant advantages in using SSWM for the control of annual ryegrass. At a high density annual ryegrass site trifluralin applied alone at 480 g/ha pre-sowing provided 12% control, while trifularin + triallate (480+500 g/ha) pre-sowing increased control to 72%. However, at a low-density annual ryegrass site mean control was 82% and there was no difference between herbicide treatments.

In another trial in lentils, clethodim applied at 60 g/ha post-emergence controlled 99% and 97% of annual ryegrass in both high and low density populations respectively. However, 12 ryegrass plants/m^2 remained at the high density site compared with 2.3 ryegrass plants/m^2 at the low density site. Ryegrass head numbers in spring were 83 and 33 heads/m^2 for the high and low density sites respectively, indicating influence of initial seedling density on seed production for this treatment. Clethodim rates needed to be increased to 84 g/ha at the high-density site to achieve the level of control provided by 60 g/ha at the low-density site.

Practical progress from the results of field trials presented in this paper will require research to develop a weed mapping system that can accurately map annual ryegrass patches in southern Australian cropping systems.

Key Words

weed control, weed mapping, Precision Agriculture (PA).

Introduction

Weeds are a major cost to Australian cropping systems. The 15 most important weeds of seven winter crops in Australia were estimated to cost A$1182 million in 1998-99, and the greatest component of this cost (A$571 million) was herbicides (Jones *et al.* 2005). Herbicide use may also lead to phyto-toxic effects on the crop that result in reductions in crop yield (Wicks *et al.* 1987; Shaw & Wesley 1991; Sikkema *et al.* 2007). Jones *et al.* (2005) report that annual ryegrass (*Lolium rigidum*), wild oats (*Avena fatua*) and wild radish (*Raphinus raphinistrum*) were the most economically important weeds across all regions.

Weeds, including ryegrass, often grow in patches within a paddock. Spraying the whole paddock is the current practice, but there are potential economic, environmental and social benefits to be gained from Site Specific Weed Management (SSWM) that target herbicide control measures to weed patches only (Christensen *et al.*1998). Herbicide under-dosing and over-dosing are inevitable with blanket herbicide applications when weed distribution and density varies across a paddock (Gerhards, 2007). Goudy *et al.* (2001) report a number of studies where reductions in herbicide used of 12 to 75% are achieved.

Increasing pressure on producers to reduce levels of agrichemicals in streams, rivers and the soil environment add incentive for the use of SSWM, as does increased scrutiny of pesticide levels in food (Gerhards & Christensen 2003; Shaw 2005; Lutman & Miller 2007).

Opportunities for SSWM of annual ryegrass in southern Australian cropping systems using herbicides are limited to a few key timings within the cropping rotation. The timings with the most potential for site-specific application of herbicides are pre-emergence herbicides for wheat and barley, and selective herbicides applied post-emergence in pulse and canola crops. For example, trifluralin might be applied pre-emergence in wheat as a uniform basal treatment, with triallate or metolachlor added as a mixture where ryegrass patches are detected.

This paper presents the results of some recent Australian SSWM research with annual ryegrass. It aims to a) assess the opportunities and potential benefits for SSWM of annual ryegrass in Australia; and b) identify areas of SSWM in need of continued research and development in southern Australian cropping systems.

Methods

Pre-emergence herbicide trial in wheat.

On May 9th 2007 two pre-emergence herbicide trials in wheat (cv Correll) were sprayed in one paddock at Bute, SA. The trials were located at sites that had high and low densities of ryegrass in a lentil crop in 2006. At the time of spraying in 2007 there were 574 and 11 annual ryegrass plants/m^2 at the high and low density sites respectively. Nine treatments were applied, based on various mixtures of trifluralin, triallate and metalochlor (Figure 1 and Table 1). The concentrations of the herbicides used were 480 g/L of trifluralin, 500 g/L of triallate and 720 g/L of metolachlor. The herbicides were applied with a water volume of 70 L/ha using XR 110015 nozzles at a pressure of 150 kPa. Plots were 2.5 x 20m and treatments were replicated four times in a randomised block design. Treatments were assessed by counting annual ryegrass plants and heads 6 and 23 weeks after treatment application, respectively.

Post-emergence herbicide trial in lentils.

On July 28th 2007 two post-emergence herbicide trials in lentils (cv Nugget) were sprayed in one paddock at Bute, SA. The trials were located at sites that had relatively high (936 plants/m^2) and low (71 plants/m^2) annual ryegrass densities. Five treatments were applied: 0, 36, 60, 84 and 120 g/ha of clethodim. The clethodim herbicide had a concentration of 240 g/L active ingredient. The treatments were applied with a water volume of 70 L/ha plus 1% Hasten (704 g/L ethyl and methyl esters of vegetable oil) using XR 110015 nozzles at a pressure of 150 kPa. Trial plots were 2.5 x 15m and treatments were replicated five times in a randomised block design. Treatments were assessed by counting annual ryegrass plants and heads 4 and 12 weeks after treatment application, respectively.

Results and Discussion

Pre-emergence herbicide trial in wheat.

At the low annual ryegrass density site there were no significant differences between treatments. The herbicide treatments at this site had a mean control of 82% relative to the untreated control (Figure 1). At the high-density site there were significant differences between rates and combinations of herbicides. Trifluralin applied at 480 g/ha controlled only 12% of annual ryegrass. Trifluralin applied at 720 and 960 g/ha increased control to 42 and 48% respectively. These results indicate that the suspected annual ryegrass resistance to trifluralin may be reducing the efficacy of trifluralin at this site. The addition of triallate or metolachlor to trifluralin increased ryegrass control significantly compared with trifluralin alone, and triallate was significantly better than metolachlor. The control with the combination of all three herbicides was not significantly better than the combination of trifluralin and triallate. The poorer efficacy of metolachlor compared with triallate may be associated with dry soil conditions following application, reducing the activity of metolachlor which relies on soil moisture for maximum efficacy.

Current costs for each herbicide treatment are shown in Table 1. On the basis of annual ryegrass control, and herbicide costs, the most cost effective strategy in this case would be to apply a base rate of trifluralin at 480g/ha and add triallate at 500 g/ha to annual ryegrass patches to improve control in these areas. Other factors that should be considered are the effects of annual ryegrass surviving herbicide application on crop yield due to competition and the potential for increased seed production from survivors.

The results also indicate that there may be a higher level of trifluralin resistance at the high ryegrass site compared with the low ryegrass site. This possibility is currently under investigation. If herbicide resistance in annual ryegrass is found to have a greater prevalence in higher density patches, then this will provide added impetus for using more efficacious herbicide mixtures in those areas.

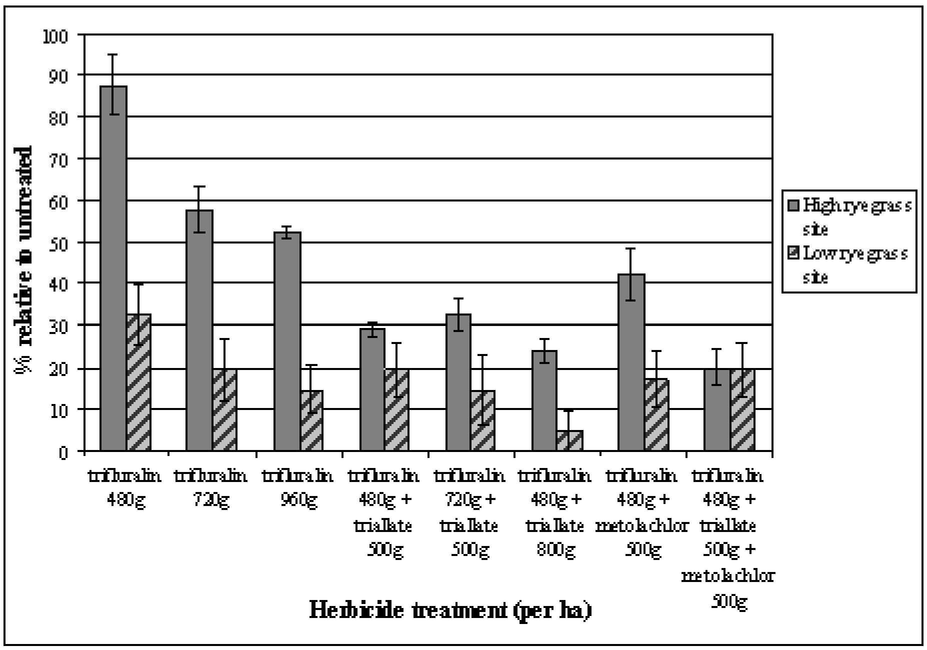

Figure 1. Pre-emergence herbicide effects on annual ryegrass survival relative to the untreated control at two sites in one paddock with differing untreated annual ryegrass population densities (High = 574 plants/m^2, LSD (5%) = 13.2; Low = 11 plants/m^2, differences not significant).

Table 1. Current (2008) costs for pre-emergent herbicide treatments.

Treatment	Cost ($/ha)
Nil	0
Trifluralin, 480 g/ha	7.75
Trifluralin, 720 g/ha	11.63

Trifluralin, 960 g/ha	15.50
Trifluralin + triallate, 480 + 500 g/ha	26.25
Trifluralin + triallate, 720 + 500 g/ha	30.13
Trifluralin + triallate, 480 + 800 g/ha	37.35
Trifluralin + metolachlor, 480 + 500 g/ha	18.75
Trifluralin + triallate + metolachlor, 480 + 500 + 500 g/ha	37.25

Post-emergence herbicide trial in lentils.

Annual ryegrass plant survival data (Table 2) show that at the high-density site 84 and 120 g/ha of clethodim provided significantly greater control than 60 g/ha. At the low density site there was no significant difference between these three rates, but they provided significantly greater control than 36 g/ha. There are several reasons for using higher rates of grass selective herbicides in thicker patches of annual ryegrass: (a) in dense ryegrass patches plants overlap and shade each other, increasing the risk that individuals will not receive a lethal dose; (b) annual ryegrass resistance to clethodim may vary spatially across a paddock, and occur mostly in dense patches; and (c) achieving an acceptable level of control in high density patches. At 60 g/ha the level of annual ryegrass control was 99 and 97% in the high and low-density sites respectively. This result suggests that overlapping plants and increased levels of resistance in higher density patches did not affect herbicide efficacy. The decision to vary rates would therefore be based on what is an acceptable level of control. Although 60g/ha provided slightly better control at the high ryegrass site (99%) compared with the low ryegrass site (97%), there are still higher ryegrass numbers at the high ryegrass site. This is also observed with annual ryegrass head counts, with 83 heads/m^2 at the high density site and 33 heads/m^2 at the low density site, indicating a much greater potential to produce seed and build up seed bank numbers at the high density site. To achieve equivalent ryegrass numbers after control at the high-density site would require 84 g/ha clethodim to be applied compared with 60g/ha at the low-density site. More research needs to be done to identify an acceptable level of annual ryegrass survival in terms of competition with the crop and population dynamics across seasons from seed bank replenishment. This also needs to be considered in terms of the whole cropping system, for example in this trial desiccation of the lentil crop and annual ryegrass when the crop had matured would reduce the seed production of the annual ryegrass that had survived the initial clethodim application.

Table 2. Effect of a range of clethodim rates on annual ryegrass (ARG) plant numbers and seed head production at two sites within a paddock at Bute (SA) with differing annual ryegrass densities, and associated treatment costs.

Clethodim rate (g ai/ha)	ARG plant density (plant/m^2)		ARG seed head density (plant/m^2)		Cost (AU$/ha)
	High density	Low density	High density	Low density	
0	936 a	71 a	1558 a	557 a	0

36	50 b	6.8 b	249 b	59 b	3.75
60	12 c	2.3 c	83 c	33 b	6.25
84	5.5 d	0.4 c	43 c	17 c	8.75
120	3.3 d	0.6 c	15 d	3.3 d	12.5

Treatments that are significantly (5% level) different from one another are denoted by different letters.

Weeds are a significant cost in southern Australian cropping systems and annual ryegrass has been identified as the most important weed on many farms. Control of annual ryegrass with herbicides can be a major cost, therefore application systems that enable more expensive treatments to be targeted to areas of actual need rather, than the whole paddock, could significantly reduce herbicide costs. Results from the field trials reported in this paper indicate significant benefits for SSWM of annual ryegrass, due to improved efficiency of herbicide use, by reducing herbicide inputs in low-density patches but maintaining a higher level of control with increased herbicide inputs into higher density patches.

Further research is needed to determine an economically acceptable level of control, to improve the reliability of economic decisions. This will include an understanding of the population dynamics and the effect of survivors on seed bank replenishment and future weed populations. It should also include some research into the effect on yield due to crop competition from surviving plants. The economic benefit of using SSWM is also related to the number, size, distribution and shape of weed patches, the spatial resolution of sampling and spraying technologies and the cost of herbicides (Ruiz *et* al 2006). Therefore systems that can accurately map and treat annual ryegrass patches will need to be developed if any benefits are to be recognised.

Conclusion

Site Specific Weed Management (SSWM) has potential economic and environmental benefits, however techniques need to be adapted for Australian cropping systems. Efficient mapping methods and effective direct-injection sprayers are the current bottlenecks, but if these can be overcome overseas research suggests herbicide savings of between 12 and 75%. Recent field research reported in this paper highlights the potential benefits to be gained in Australian cropping systems by using SSWM strategies in annual ryegrass. That is improved weed control in high-density patches through targeted application of more efficacious herbicide mixes and reduced herbicide inputs at low-density sites where acceptable control can be achieved with a cheaper and less efficacious herbicide mix. Research needs to focus on mapping systems, temporal stability of spatial weed distribution, herbicide decisions under Australian conditions and VRT spraying technology.

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