

What Australian growers will adopt in managing herbicide resistance

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Summary Australian grain growers have considerable experience in managing herbicide resistance. This paper examines the response of growers to the presence and threat of herbicide resistant weed populations. Data from a survey of Western Australian grain growers is used to demonstrate that the adoption of some, but not all, integrated weed management (IWM) practices is closely associated with the presence of herbicide resistant weed populations. Growers perceive herbicide resistance to have a substantial cost, however, several factors act against growers deciding to forego higher short-term profits to invest substantially in conserving the existing herbicide resource. Greater adoption of IWM practices that will help to conserve the herbicide resource may be possible where practices can be shown to offer greater shorter-term value to the farming system, not necessarily just in terms of weed control.

Keywords Integrated weed management, adoption, herbicide resistance, survey, Australia.

INTRODUCTION

Australian grain growers are considered to be managing the world's worst herbicide resistance problem (Preston *et al.* 1999). Since the first confirmed case of herbicide resistance in Australian cropping (Heap and Knight, 1982), a rapidly increasing proportion of Australian grain growers have been managing herbicide resistant weed populations (see surveys by Gill 1995, Nietschke *et al.* 1996, Pratley *et al.* 1993, Walsh *et al.* 2001). A recent random field survey conducted in the wheatbelt of Western Australian, Australia's largest grain-producing state, revealed that the vast majority of paddocks contain a herbicide resistant annual ryegrass (*Lolium rigidum* Gaudin) population (Llewellyn and Powles 2001). In more intensive cropping regions, a majority of paddocks contained a multiple-herbicide resistant weed population. It follows, that the extensive development of herbicide resistance on farms should lead to the extensive development of herbicide resistance management experience by farmers. This paper examines the management response of grain growers to the herbicide resistance problem and some of the factors likely to be influencing this response.

Responses to a herbicide resistance problem can be seen to take two main forms: proactive and

reactive. Both can be described as herbicide resistance management. Reactive management is the most obvious, describing the management of weed populations that have developed resistance to previously effective herbicides. Management intended to delay, or prevent, future herbicide resistance development can be described as proactive. These have also been described as anti-resistance strategies (Orson 1999).

While some surveys of the use of weed control practices by Australian grain growers have been conducted (e.g. Alemseged *et al.* 2001), the association between the adoption of weed management practices and herbicide resistance status has received little attention. Using data from a survey of Western Australian grain growers, the objective of this paper is to provide insight into grower response to herbicide resistance, particularly, the implications for increased adoption of more proactive resistance management. Growers' use of integrated weed management (IWM) practices that reduce the reliance on selective herbicides is examined in the context of herbicide resistance management. For descriptions of most IWM practices mentioned in this paper see Gill and Holmes (1997), Matthews (1994) and Sindel (2000). The adoption levels of IWM practices are presented, followed by grower perceptions of the cost of herbicide resistance management. Opportunities to increase the adoption of practices that may act to conserve the current stock of herbicides are discussed.

DATA

The data referred to in this paper is derived from a survey of 132 randomly selected grain growers from the Western Australian wheatbelt. Growers were from the Dalwallinu (64 growers) and Katanning-Woodanilling shires (68 growers) of Western Australia. Properties managed by growers in the Dalwallinu shire were larger on average (3864 ha), had a greater proportion of land cropped (70%), and received a lower average annual rainfall (approx. 325 mm) compared to properties in the Katanning-Woodanilling shire (1812 ha, 55%, 450 mm). The proportion of growers who reported that they had a herbicide resistant weed population on an area of their farm was 70 per cent and 47 per cent respectively.

Farm visits were conducted prior to crop seeding in February–March 2000 and interviews conducted with the primary cropping decision-maker(s) on each farm, based on a fully-specified questionnaire. Most questions on herbicide resistance and weed management focused on the most important cropping weed, annual ryegrass (Alemseged *et al.* 2001), and resistance to herbicides in the Group A (aryloxyphenoxypropanoate (APP) and cyclohexanedione (CHD) ACCase-inhibitors) and B (ALS-inhibitors) herbicide groups. These represent the most common forms of herbicide resistance in Western Australia (Llewellyn and Powles 2001). Statistical analysis (using ANOVA and logistic regressions) indicated that there was no interaction between resistance status and shire significantly associated with the data presented in this paper. For this reason, and ease of presentation, shire data is not presented separately.

ADOPTION OF IWM PRACTICES BY GROWERS

Growers were asked about their use of listed practices in the current year and whether a practice had been used on their farm in the past four years. The adoption levels of specific practices by growers with and without herbicide resistance indicate what practices are likely to be adopted reactively, in response to herbicide resistance development.

Shown in Table 1 is the proportion of growers who have used selected weed management practices over the previous four years. Some practices are much more likely to be used by growers who have lost the effective use of some herbicides on an area of their farm due to herbicide resistance, while other practices do not appear to be associated with herbicide resistance status. For example, the proportion of growers using crop-topping is more than three times greater for growers with herbicide resistance (47 per cent) than for those without herbicide resistance (15 per cent). Crop-topping is defined as the use of a non-selective herbicide for late-season control of weed seed set in a crop. Other practices that are substantially more likely to be used by growers with herbicide resistance than growers without herbicide resistance include catching, HLNSB, swathing for weed control purposes, autumn tickle and fallow.

Of the listed practices, seed catching has been the least used practices, having been used by 10 per cent of growers at some time in the past four years (Table 1). The intended use of catching in the year of the survey reflects some disadoption, with only two percent of growers without resistance, and 10 percent of growers with resistance intending to use the practice in the 2000 season (data not shown in table).

Table 1. Percentage of all growers and growers with (HR, n=77) and without (NoHR, n=55) a paddock with a herbicide resistant ryegrass population, who have used the weed control practices on some area of their farm in the past four years.

Practice	All growers	Resistance status	
		HR	NoHR
Stubble burning (whole paddock)	79	87	67
Catching (e.g. chaff cart)	10	13	6
Cultivation (for weed control)	57	56	58
Autumn tickle	49	62	31
Delayed seeding ^a	41	47	33
Crop-topping	33	47	15
Manuring ^b	14	16	11
Spray-top pasture	98	97	98
Higher wheat seeding rate (>64 kg ha ⁻¹) ^c	56	57	55
Barley for weed control	29	35	20
Heavy grazing	61	62	60
Pasture phase (treated)	55	58	49
Fallow	24	36	6
HLNSB ^d	21	31	7
Swathing for weed control	14	17	9

^a Deliberate delay of seeding by two weeks or more prior to knockdown.

^b Either green manuring or 'brown' manuring using a non-selective herbicide to sacrifice a sown crop.

^c Based on whether average wheat seeding rate to be used in 2000 was 65 kg ha⁻¹ or greater.

^d HLNSB: Harvesting lower than normal, no spreading of residue, burning of windrows.

The use of some other practices, such as higher wheat seeding rates, cultivation for weed control and heavy grazing is relatively similar for growers with and without resistance (Table 1). Overall, pasture spray-topping and stubble burning were the two most commonly used practices.

While all growers were shown to use several IWM practices, growers with herbicide resistance used approximately two more IWM practices, on average, than growers without herbicide resistance. The practices used predominantly by growers with herbicide resistance include: catching, crop-topping, fallow, HLNSB and the swathing of crops for weed control purposes (Table 1). These practices have several characteristics in common. Most are used primarily for weed control

purposes (in this case, ryegrass control) and offer few benefits other than weed control. When factors such as time, risk, and equipment costs are taken into account, they are likely to be perceived as costly relative to effective selective herbicides. It is when resistance causes selective herbicides to fail, that they become relatively more cost-effective and become more likely to be adopted.

Other practices that are widely used, independent of resistance status, may offer greater benefits to a grower's farming system other than just weed control, for example stubble burning (residue management, disease control), cultivation (seed bed preparation), and heavy grazing. Some practices may be very cost-effective in terms of weed control alone (spray-topping pasture). These practices are more likely to offer greater utility in a wider range of situations and form part of the optimal farming system in the absence of herbicide resistant weed populations.

The results suggest that practices promoted for herbicide resistance management are more likely to be adopted proactively if they offer higher short-term value to the farming system. That value may not necessarily be entirely derived from the control of resistance-prone weeds, but it will act to reduce the cost of herbicide resistance management. Examples using existing practices include possible development and extension relating to: the fodder value of material caught in the catching/chaff-cart process, opportunities to reduce frost-risk through delayed seeding, and the value of even crop maturation through crop-topping. The relatively recent broad adoption of higher wheat seeding rates may be partly attributed to research and extension lowering the perceived risk (or cost) of higher wheat seeding rates resulting in lower grain quality.

THE COST OF RESISTANCE MANAGEMENT

Proactive resistance management requires growers to adopt resistance management strategies with the objective of delaying, or preventing, further herbicide resistance development. This can be seen as an investment in conserving the herbicide resource (Llewellyn *et al.* 2001). In the context of this study, it may involve the adoption of practices most commonly used for reactive resistance management (e.g. catching, crop-topping) to be used proactively, in advance of the need to control a resistant weed population. It is likely to involve a decision to incur greater costs in the short term in order to reduce the costs of herbicide resistance in the future. The costs are incurred as a result of not using preferred herbicides (in the case of this study, post-emergent, ryegrass selective herbicides) and having to rely on alternative management

strategies. This is essentially the case for both proactive and reactive management. The alternative management may involve more than just the use of substitute weed control practices. It may include changes in the type of crops grown and changes in cropping intensity, for example, reduced cropping intensity, increased grazing, less non-cereal crops. Evaluating the costs of such changes is complex.

Measuring the cost of resistance In this study, the perceived cost of not using post-emergent selective herbicides for ryegrass control was evaluated using growers' willingness to pay (WTP) for cropping land with different levels of herbicide resistance. As the potential future returns of agricultural land are capitalised into land prices (Just and Miranowski 1993), agricultural land that offers lower expected returns from agricultural production, due to resistance for example, can be expected to have a lower price if all other factors remain the same.

As described in Llewellyn *et al.* (2002), growers were asked to assume that they wanted to buy more cropping land, and the only land available was neighbouring land identical to their typical cropping land in all respects. Their WTP for this typical land was then compared to their WTP for land identical in all respects except for resistance status. To account for the resistance status of 'typical' paddocks, a hypothetical paddock that had no herbicide resistance and had no herbicide application history was also valued. However, with one exception, ryegrass populations in all typical paddocks could be controlled by at least one Group A herbicide.

The majority of growers indicated that they would be willing to pay less for land with herbicide resistant ryegrass compared to land with susceptible ryegrass. Approximately 73 per cent of all growers stated a devalued WTP for land with ryegrass resistant to all Group A fop herbicides, with 82 per cent of growers devaluing land with ryegrass resistant to all Group A and B herbicides. On average, growers were shown to be willing to pay approximately 25 per cent less for land where no Group A and B herbicides could control the ryegrass than for land with fully susceptible ryegrass. For example, where growers were willing to pay \$1000 ha⁻¹ for cropping land with fully susceptible ryegrass, they were willing to pay \$750 ha⁻¹ for land with ryegrass unable to be controlled by any Group A or B herbicide. Growers, on average, discounted land on which the ryegrass was resistant to only Group A 'fops' by 16 per cent. Land on which the ryegrass was resistant to Group A 'fops' and Group B herbicides (i.e. where Group A 'dims' remained effective) was discounted by 19 per cent. Clearly, growers generally

perceive the ability to use effective herbicides to have a value and, similarly, herbicide resistance management to have a cost.

Investment in proactive resistance management

There are several socio-economic factors that are likely to influence the decision of a grain grower to incur costs for not using particular herbicides for the purpose of delaying or preventing herbicide resistance, that is, proactive herbicide resistance management (Llewellyn *et al.* 2001, Pannell and Zilberman 2001). These include risk and uncertainty about the timing of resistance development, the discounting of future annual profits relative to present annual profits and the possibility that new herbicide technology may become available. For these reasons, most growers are unlikely to forego substantial short-term returns to conserve the efficacy of currently available herbicides for use in the longer-term.

This is partly reflected in the expectations of future herbicide use by growers' in this study. Growers were asked how they expected the number of herbicide applications (of any type) to be used on their cropping land in 10 years time to differ from the number currently used. Despite expectations of increasing resistance to existing herbicides (Llewellyn *et al.* 2002), growers generally expected no decline in total herbicide use. Eighty seven per cent of growers expect to be using the same or more herbicide applications on their cropping land in 10 years time. This indicates that the vast majority of growers expect herbicides, whether existing products or new products, to remain the primary weed control method and foresee no reduction in the overall number of herbicide applications used on their property in the longer term.

CONCLUSIONS

All growers will adopt some practices in their farming system that contribute to IWM. Several of these practices are often used primarily for reasons other than weed control. Growers with herbicide resistance become more likely to adopt certain additional IWM practices. The use of these additional practices and other necessary farming system changes to replace the use of effective herbicides is perceived by growers to have a significant cost. However, there are a number of factors that act against growers making a substantial investment in proactive resistance management to prevent, or delay, this cost. Compared to directly promoting investment in proactive resistance management, more conservative use of the current stock of herbicides may be more likely if the real and perceived cost of using additional IWM practices can be reduced. One possible avenue to achieving this is

through the concerted development and extension of aspects of IWM practices, beyond just weed and resistance management, that add to the overall profitability of the farming system.

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