Weed management as a key driver of crop agronomy

Rick S. Llewellyn[1], Jackie Ouzman[1], Allan Mayfield[2], Steve Walker[3], David Ronning[4], Michael Clark[4]

[1] CSIRO, Agriculture Flagship, PMB 2, Glen Osmond SA 5067, rick.llewellyn@csiro.au
[2] Allan Mayfield Consulting, 14 Vanga Ave, Clare SA 5453, allan@asmayfield.com.au
[3] stevenroywalker@gmail.com
[4] AgEconPlus, info@AgEconPlus.com.au

Abstract
Weed control objectives are increasingly determining how cropping systems are managed. This study examines the current influence of weed management across 13 major grain growing zones of the western, southern and northern cropping regions of Australia. Information from 602 farms was collected in 2014 and used in conjunction with ABS statistics on crop production and information from a range of regional sources to quantify herbicide and non-herbicide practice use and costs. Growers are demonstrating an ongoing willingness to invest heavily to avoid yield losses and large weed seedbanks. Consistent with findings from paddock surveys, weed densities in crop are typically being kept low, even in the presence of increasing herbicide resistance. In addition to herbicide use, this involves increasing use of practices that reduce stubble retention levels. The results also show how weed constraints are reducing the area sown to otherwise preferred cereal crops. Increasing herbicide resistance and other new weed challenges mean that grower efforts to maintain low weed densities are having rapidly intensifying implications for cropping systems.

Key words
Integrated weed management, herbicide resistance, cultivation, burning, stubble retention

Introduction

The availability of cost-effective herbicides since the 1980s enabled Australian farming systems to shift away from cultivation and rotation-based weed control. At the same time herbicides provided such effective and readily available weed control that to a large extent other aspects of crop agronomy (e.g. crop choice, cropping intensity, stubble management, time of sowing, row spacing) could begin to be considered almost independently of weed management decisions. The preferred cropping systems that have evolved are now under increasing pressure from new and evolving weed management challenges. In addition to herbicide resistance (e.g. Owen et al. 2014; Boutsalis et al. 2012; Walker et al. 2011) , these challenges include shifts in weed populations associated with changes in tillage regimes and more frequent cropping (e.g. Kleeman and Gill 2013), the herbicide tolerance of some summer-growing weed species, and new weed incursions.

Effective weed management in cropping systems involves managing a range of constantly evolving targets with shifting priorities and threats. The last major national study of the distribution and economic impact of weeds in Australian cropping systems was conducted 15 years ago (Jones et al. 2000). The results presented in this paper are part of a larger Grains Research and Development Corporation (GRDC) supported study to quantify the costs of weeds and their management across Australian grain growing regions, crops and weed types. A general aim is to identify where and how the greatest weed management costs are being incurred and to inform R, D & E investment in improved weed management strategies. Here the focus is on the weed management practices and trends that are challenging the ability of agronomists and researchers to consider optimal crop agronomy independently of what growers need to do to meet weed management objectives.

Method

The study covers the 13 major agro-ecological zones (AEZs) across the western, southern and northern grain growing regions and the major crop types of wheat, barley, oats, canola, pulses and grain sorghum (see AEZ list in Figure 1 and www.grdc.com.au/uploads/documents/grall.jpg). The relatively small Tasmania grain and Victoria high rainfall AEZs were merged for the purpose of this study.

Farm-level data for the analysis were drawn from interviews conducted March to July 2014 with 602 grain growers selected at random to represent each agro-ecological zone, used in conjunction with ABS statistics

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on crop production and information on practice costs from regional agronomists and a range of other sources. Respondents needed to be identified as primary cropping decision makers and have a crop area greater than 500ha of crop, with the exception of the High Rainfall Victoria and Tasmanian zone (250ha). Based on the total number of primary cropping decision makers directly approached for participation, the response rate was 44%.

For the purpose of determining the cost of weeds in grain production as a function of losses due to reduction in crop returns and expenditure for weed control, data on typical in-crop weed densities (and type) and weed control practices were collected. These included herbicides (knockdown, pre-emergent, post-emergent, fallow weed control, and herbicides for croptopping, spraytopping, manuring/hayfreezing and double knockdown), cultivation, burning stubble, manuring, mouldboard ploughing to bury weed seeds, delayed seeding (with knockdown herbicides), chaff carts and narrow windrow burning. The extent of use of each practice was collected along with the year that the practice was first used on the farm, allowing trends in adoption across regions and AEZs to be identified. For cultivation and burning, growers were asked to apportion the reasoning for their use to weed management relative to other possible reasons for implementing these practices (e.g. disease and pest management). The influence of weeds on crop choice (e.g. growing a less profitable break crop or pasture rather than a cereal due to grass weeds) was investigated by asking what crop area changes would be made if weed management was not a consideration.

Results and Discussion

Respondents commonly had cropping with some livestock (73%) and had an average age between 55-64 years old, with 20% younger than 45 years. The average annual crop area was 1981ha and 58% pay a consultant for cropping advice. A majority (82%) grew either pulses or canola in addition to cereals. In the northern region, 58% grew sorghum.

Weed control

Overall, 54% of growers stated that their most common weed competing with cereal crops later in the season is usually only present at less than 1/m^2. Only 11% reported densities greater than 10/m^2. This is consistent with previous multi-year field studies where it was found that growers generally only allow low weed densities to survive past mid-season, including populations with high levels of herbicide resistance (Llewellyn et al. 2009). In a 2010 study that inspected 466 Western Australian cropping paddocks, only 5% were assessed to have an annual ryegrass density (the most common weed) greater than 10 plants/m^2 (Owen et al. 2012). The five most common weeds identified by growers as competing with cereal crops later in the season were annual ryegrass, wild radish, wild oats, brome grass and wild turnip.

Weed management practices

Weed management is the most important reason for cultivation prior to seeding (Table 1). Overall, 71% of growers seeding with prior cultivation cite weed management as a main reason for their use of cultivation. Although no-till is the most common seeding system, in the southern region 27% of land is cultivated at or prior to seeding. Cultivation in fallows for the primary purpose of weed control is more common, particularly in the northern region (Table 1) and Central NSW AEZ. Burning of crop residues is common and primarily for weed control, except in the northern region. Narrow windrow burning, a practice that can remove approximately half of crop residue (Walsh and Newman 2007), is particularly common in the western region (Table 1) but use is rapidly increasing in other AEZs (Figure 1).

Table 1. Use of practices for weed management.

	Southern	Western	Northern
Cropping land cultivated prior to or at seeding (i.e. not under zero or no-till) (%)	27	9	20
Growers who cite weed management as the main reason for cultivation prior to seeding as proportion of growers seeding with prior cultivation (%)	67	76	78
Growers who cite weed management as main reason for cultivation prior to seeding expressed as proportion of all growers (%)	30	15	27
Growers using cultivation of fallows primarily for weed control (%)	37	30	66
Area to be cropped that is cultivated during the fallow by users (%)	31	19	28
Growers burning stubble – whole paddock (%)	52	40	12
Cropping land burnt by users – not including windrow burning (%)	19	11	3
Growers who cite weed management as the main reason for burning (whole paddock) as a proportion of users (%)	66	68	29
Growers using narrow windrow burning (%)	28	51	4
Proportion of crop area treated with narrow windrow burning by users (%)	23	30	23

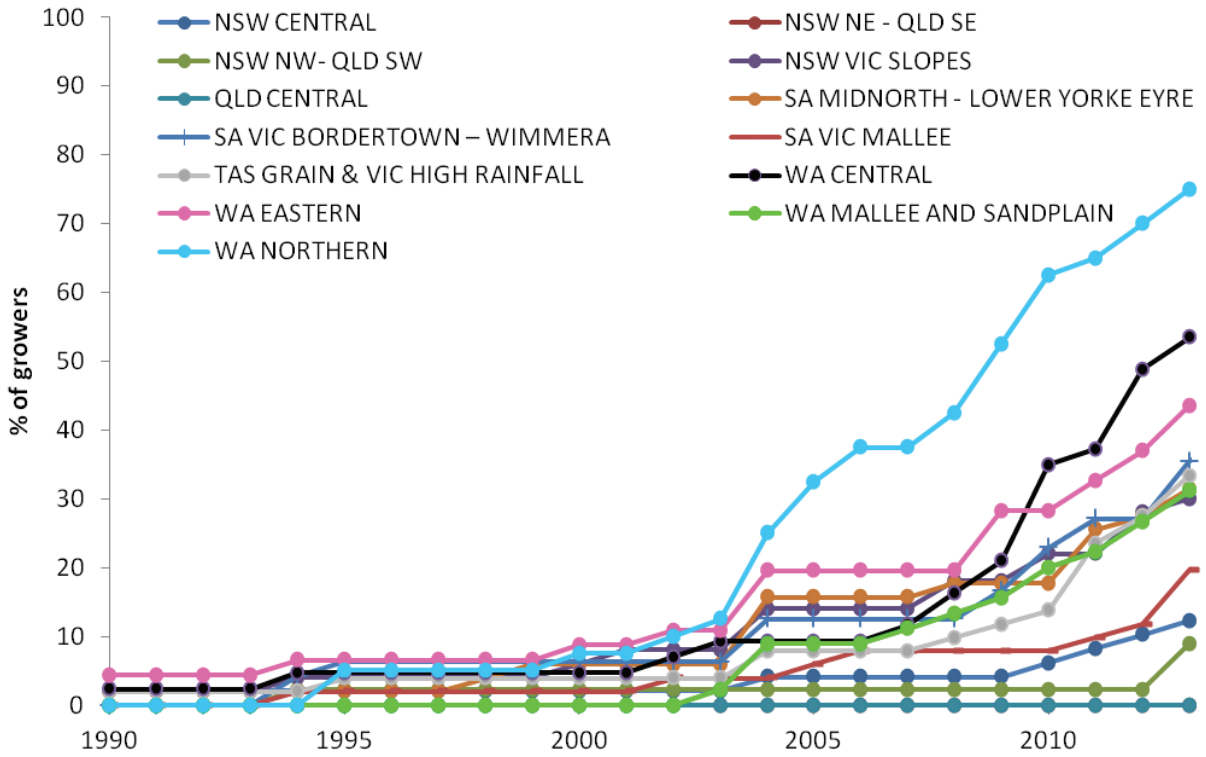

Figure 1. Cumulative adoption of narrow windrow burning by agroecological zone (% growers who have used the practice)

Crop choice

Another impact of weeds is on crop sequence and land use decisions. The results show that weed considerations influence land use and crop choice for a substantial number of growers. Growers were asked if they would change the areas of what they would grow if they had no weed considerations. In the western region 26% said they would change what they grow; 25% in the southern region and 32% in the northern region. Most commonly growers would grow more cereals (mainly wheat) if weeds were less influential.

Conclusions

Australian grain growers invest heavily in practices to keep weed densities and subsequent crop yield losses low. This is contributing to increasingly extensive crop residue burning, cultivation and influences on crop choice primarily driven by weed management objectives. The development and implementation of optimal

crop agronomy and farming systems cannot be considered independently of the constraints caused by increasingly challenging weed populations.

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References

Boutsalis P, Gill G, Preston C (2012) Incidence of herbicide resistance in rigid ryegrass across southeastern Australia. Weed Technology **26**,391-398

Jones R, Alemseged Y, Medd R and Vere D (2000) Distribution, density and economic impact of weeds in the Australian annual winter cropping system. CRC for Weed Management Systems Technical Series No. 4

Kleemann SGL and Gill GS (2013) Seed dormancy and seedling emergence in ripgut brome populations in southern Australia. Weed Science **61**, 222-229.

Llewellyn RS, D'Emden FH, Owen MJ, Powles SB (2009) Herbicide resistance in rigid ryegrass has not led to higher weed densities in Western Australian cropping fields. Weed Science **57**, 61-65.

Owen M J, Martinez N J, Powles S B (2014). Multiple herbicide-resistant *Lolium rigidum* now dominates across the Western Australian grain belt. Weed Research 54:314-324.

Walker S, Bell K, Robinson G, Widderick M (2011) Flaxleaf fleabane populations have developed glyphosate resistance in north-east Australian cropping fields. Crop Protection **30**, 311-317.

Walsh M, Newman P (2007) Burning narrow windrows for weed seed destruction. Field Crops Research **104**, 24-30.