

INTEGRATED WEED MANAGEMENT

in Australian cropping systems

**WEED
smart**
every weed every seed
every farm every year

GRDC

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With the termination of the Weeds CRC in 2008, the GRDC saw value in updating the manual so that it remains a relevant reference and training resource for these rapidly changing times. This second edition is an update of the first ground-breaking edition.

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FOREWORD

The Australian grains industry continues to expand and improve its production efficiency, however, we face a number of major challenges that threaten our future capacity to increase production and on-farm profits. One of those challenges is the effective management of weeds in an environment of increasing herbicide resistance.

Weeds are estimated to cost the Australian grains industry over \$2 billion per annum, with herbicide resistant weeds estimated to cost more than \$200 million each year. Despite the advancements we have made in weed management over the last two decades – including the widespread adoption of minimum and no-till cropping practices – the impact of weeds will continue to increase unless we find new solutions through research and development.

Weeds species have become resistant not only to glyphosate but also to multiple herbicide modes-of-action. With no new modes-of-action likely in the near future, growers must maintain the efficacy of those currently available. GRDC continues to invest over \$8 million each year into research that provides growers with new technologies and methods to manage weeds and for sustainable herbicide use. There is no doubt that growers must adopt the integrated weed management practices that emanate from this research in order to maintain the present farming system. There is no ‘silver bullet’ for weed control. An integrated approach combining mechanical, chemical and cultural farm-management techniques is required.

This major update of the Integrated Weed Management (IWM) manual is timely for growers and their advisers seeking the latest tools to maintain productivity. The manual highlights a range of tools that, when incorporated into farming practices, will help to manage both weed burdens as well as maintain our current arsenal of herbicides into the future.

Additions to the manual include information on new tools such as detecting weed sprayers and shielded sprayers, a new section on surveillance for weed incursion after flood events and profiles of 23 weeds, including emerging ones like fumitory, feathertop Rhodes grass and windmill grass. Case studies from across Australia demonstrate the value of IWM on farm, outlining how growers are still farming with the advent of herbicide resistant weeds, through the adoption of integrated practices.

As part of its overall efforts to promote good weed management practice, GRDC has also contributed to an educational program called WeedSmart® which now serves as a first point of call on weed management issues.



The WeedSmart® program centres around a 10-point management plan:

1. Act now to stop weed seed set
2. Capture weed seeds at harvest
3. Rotate crops and herbicide modes of action
4. Test for resistance to establish a clear picture of paddock-by-paddock farm status
5. Aim for 100 per cent control and monitor every spray event
6. Don't automatically reach for glyphosate
7. Never cut the on-label herbicide rate, and carefully manage spray drift and residues
8. Plant clean seed into clean paddocks with clean borders
9. Use the double knock technique
10. Employ crop competitiveness to combat weeds.

This manual, in conjunction with other industry-driven extension efforts like WeedSmart®, will help growers make the right decisions to effectively manage and sustain a viable industry into the future.

John Harvey
Managing Director GRDC



INTRODUCTION

In 2005 weeds were estimated to cost Australian agriculture between \$2.5 billion and \$4.5 billion per annum. For winter cropping systems alone the cost was \$1.3 billion, equivalent to around 20 per cent of the gross value of the Australian wheat crop. In the intervening period herbicide resistance has become far more widespread, reducing the effectiveness of a wide range of herbicide modes-of-action (MOAs). Consequently, any practice that can reduce the weed burden is likely to generate substantial economic benefits to growers and the grains industry.

Of particular concern to farmers is the development of glyphosate resistance. At the time of writing there are 24 weed species around the world that are resistant to glyphosate, with six in Australia. There is also a large increase in species tolerant to various other herbicides, but glyphosate in particular. This loss of glyphosate's effectiveness is creating great concern in industrialised farming systems globally and it is exacerbated by the widespread adoption of herbicide resistant crops estimated at 110 million hectares in 25 countries. Until recently North American research and extension programs have focused on herbicide solutions to herbicide resistance problems; however, with glyphosate resistance they are being forced to look at a more comprehensive weed management program. This puts Australian farmers in the enviable position of having been exposed to the integrated weed management message for nearly 20 years.

Integrated weed management (IWM) is a system for managing weeds over the long term, particularly the management and minimisation of herbicide resistance. There is a need to combine herbicide and non-herbicide methods into an integrated control program. Given that there are additional costs associated with implementing IWM, the main issues for growers are whether it is cost-effective to adopt the system and whether the benefits are likely to be long-term or short-term in nature.

Is integrated weed management cost-effective?

IWM is definitely cost-effective in the longer term. In the short term, many farms don't adopt IWM because of the added costs and perceived complexity; however, research and farmer experience have shown that failure to adopt IWM leads to herbicide resistance.

In a 2004 survey of Western Australian grain growers it was realised that the adoption of IWM practices was associated with the herbicide resistance status of a farm. Although farms without resistance also used IWM, practices were more likely to be used when herbicide resistance was present. For example, IWM tactics such as the use of crop-topping was three times greater on farms with resistance than on those without. On average, farms with herbicide resistance used a greater number of weed control practices (nine) than farms without herbicide resistance (six). For most Australian farming systems, the adoption of IWM is often an outcome of the identification of herbicide resistance.

There are four key factors that influence the adoption (or non-adoption) of IWM:

1. Expectation of new herbicide technology

Herbicides are regarded as having greater weed control efficacy than non-herbicide controls. While current herbicides remain effective there is reduced incentive to adopt alternative control options. The development of herbicide resistance indicates a reduction in the future effectiveness of herbicide options, and should increase the attractiveness of IWM. A 2002 study found that there was a high level of confidence (among Western Australian growers) that new herbicides with different MOAs would become available, reducing the incentive to adopt IWM.

These attitudes still prevail despite no new post-emergent herbicides with novel MOAs having been developed for major crop weeds such as annual ryegrass, wild radish and wild oats.



2. Regression and mobility of resistance

The 2002 study surveyed growers' perceptions of whether herbicide resistance will disappear of its own accord (when herbicides are no longer used and the less fit of the resistant plants fail to maintain their proportion in the population) and how easily herbicide resistance will spread (via means such as pollen flow, seed movement and contaminated seed and fodder).

The survey found that:

- Up to 46 per cent of growers thought that resistance would disappear of its own accord.
- Nearly 14 per cent thought self-disappearance to be highly likely.
- Fifty-four per cent of growers thought importation of resistance after 10 years was likely.
- Twenty-one per cent believed importation to be highly likely.

A 2006 study found similar trends in a study of farmers and agronomists in the northern grains region (northern New South Wales and Queensland), where 30 per cent of respondents thought herbicide resistance only lasted up to five years while a further 10 per cent did not know.

3. Efficacy of alternative IWM options

In the absence of herbicide resistance, post-emergent selective herbicides are perceived by growers as having the highest reliability and efficacy among available IWM options. In contrast, some 'traditional' control methods such as stubble burning and cultivation are regarded as having much lower efficacy and large variances. Although it is recognised that each control tactic has its own impact on weed mortality and/or seedset, an increasing number of growers realise that very effective weed control can only be achieved with a targeted combination of a wide range of strategies. As control tactics are imposed at different times, their combined impacts are multiplicative rather than additive. For example, the combined effect of two control tactics each with 40 per cent survival is 16 per cent survival.

4. Growers' attitudes to short-term profit versus long-term returns

IWM is widely regarded as providing a long-term approach to weed management, in which there are likely to be initial upfront costs to achieve longer-term gains from reduced weed populations. In some circumstances growers may make suboptimal weed management decisions due to their specific planning objectives. For example, where there are short-term financial pressures (e.g. debt servicing requirements) growers may make decisions that increase current period profits but that may have negative long-term consequences (e.g. herbicide resistance). Since the last edition of this manual in 2006 there have been increased seasonal variations and fluctuating crop yields in many cropping districts, which have reduced growers' interest in increasing their costs through the introduction of non-herbicide management techniques.

Returns of an individual enterprise in the short term are usually measured through a gross margin budget, which is determined by factors such as crop yield, price, the costs of both herbicide and non-herbicide weed control, and other inputs such as seed and fertiliser. Crop yield is directly influenced by weed density, which itself is a function of weed control. For short-term decision making the goal of the grower managing a weed problem is to determine the optimal level of herbicide and non-herbicide inputs for a given weed density that will maximise the crop gross margin.

However, this approach to measuring returns from weed management ignores a critically important economic factor, namely the carryover of the weed seedbank and its impact on returns in future years.

A weed control decision not only has an impact on returns for the current crop, but also affects yields in later years (for good or bad) due to its impact on the weed soil seedbank. Calculating returns over the longer term such as a period of 20 years is a better approach for determining the value of the economic benefits of IWM.



A longer-term approach is also able to account for important economic factors such as changes to weed seedbanks from one year to the next due to weed management actions and the impact of herbicide resistance. The role of good agronomic practices such as more competitive crops, alternative crops in a rotation and pasture phases should be valued along with weed management tactics.

The longer-term view of weed management can be assisted by adopting the concept of Tactic Groups (see below). This approach coordinates weed control practices with the life cycle of weeds, and emphasises the need to avoid any practices which may add viable weed seeds to the seedbank.

Management of weeds using tactic groups

Integrated weed management in Australian cropping systems approaches weed management in a novel manner by introducing the concept of Tactic Groups. This concept creates new options and opportunities for weed management and has been designed to change the focus of growers and advisers from crop yield to weed life cycle.

Individual weed management tactics are packaged into tactic groups according to the target growth stage of the weed. The tactic groups are based on the five key objectives of all weed control strategies (see table below):

Tactic group	Aim
1	Deplete weed seed in the target area soil seedbank.
2	Kill weeds/seedlings in the target area.
3	Stop weed seedset.
4	Prevent viable weed seeds within the target area being added to the soil seedbank.
5	Prevent introduction of viable weed seed from external sources.

In a well-integrated weed management plan each target weed will be attacked by a number of tactics, each from a different tactic group. They should be combined in the same way herbicides from different MOA groups are rotated. Integrating tactic groups and MOA groups will reduce weed numbers, stop replenishment of the seedbank and minimise the risk of developing populations of herbicide resistant weeds.

When selecting a tactic, consider the aim of the group to which each tactic belongs, and evaluate the suitability of the activity to the target weed and the weed's growth stage. Some weed management tactics such as manuring significantly reduce crop production or yield, often producing a dramatic reduction in gross margin for that paddock. Instead of excluding such tactics, consider the option of using them as a one-off solution in problem situations. Tactics used in this way can be highly effective, reducing weed seedbank numbers by up to 95 per cent in a single year.

Taking control of weed management

Significant or subtle changes in agronomy can enhance the impact of weed management tactics. Increases in sowing rate, reduction in row spacing, adjustments to fertiliser application rate and changes in crop variety choice can significantly improve crop competition, which in turn improves weed control results. More substantial changes, such as choosing a different crop type, can enable the inclusion of additional tactics and expand the opportunities for highly effective weed control.

Most importantly, get out and have a look! Useful knowledge of the weed species in the target area includes observations of population density, distribution across the paddock, growth cycle and the growth stages when the weeds are most vulnerable to weed management tactics. Knowing the problem that is to be faced is essential to solving the weed management dilemma.

– Andrew Storrie



MANUAL OUTLINE

The manual is divided into seven sections, to assist the reader make the development of an integrated weed management (IWM) plan a simple process.

Section 1 Economic benefits of adopting IWM	Outlines the economic benefits of IWM in Australian cropping systems using computer model simulations.
Section 2 Herbicide resistance	A knowledge resource clarifying aspects of herbicide resistance in weed populations. It is crucial to understand the basics of herbicide resistance when managing weed populations that are resistant to one or more herbicide groups, or are at risk of becoming resistant.
Section 3 Agronomy to enhance the implementation and benefits of weed management tactics	Discusses a range of agronomic practices that can be used to enhance the results of the specific weed management tactics employed. It includes many simple and cost-effective management changes that can be made to improve the competitive ability of the crop.
Section 4 Tactics for managing weed populations	Provides detailed information on available weed management tactics and presents trial results from across Australia. The tactics, sorted by Tactic Group, are addressed individually. Where a tactic can fall into two Tactic Groups because it impacts on two stages of the weed's life cycle, it has been grouped according to its major aim.
Section 5 Implementing an IWM program using tactic groups	The 'doing' part of the manual, outlining how best to assess the on-farm situation and implement the IWM plan on-farm. The information that should be collected for each paddock is listed, so that an effective weed management plan can be prepared.
Section 6 Profiles of common weeds of cropping	Details the characteristics of 23 key weeds of annual cropping across Australia. Information includes basic identification, distribution and traits that make the weed a significant problem in cropping systems. For each weed there is a recommendation of the most suited weed management tactics for control.
Section 7 Case studies	Includes a number of grower case studies collected from across Australia. These are an invaluable resource highlighting how growers are actually implementing IWM. What made them change? What has been successful? What have been the challenges?



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NOTES