

**'Cutting-edge' weed science
WEEDpak: A weed identification
and management guide for the
Australian cotton industry**

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ABSTRACT

WEEDpak is a comprehensive, integrated, weed identification and management package. It was developed to address the need for easily accessible and readily updateable weed information for the Australian cotton industry. WEEDpak synthesizes more than a decade of research in a single user-friendly A4 folder and is fully downloadable from the internet (www.cotton.crc.com.au). To provide for a whole system integrated weed management (IWM) approach, both weed specific and farming systems issues have been addressed. To enhance this approach, the information contained is linked to other Australian cotton industry publications such as ENTOpak, SPRAYpak and the Integrated Disease Management guidelines. In particular, WEEDpak examines the importance of, and practices involved in IWM. The weed identification and information guide provides a range of growth stage images for each weed species, backed by information on the identification, biology and ecology of each weed. The basic biological information contained in this and other articles is linked to a weed specific best bet management guide. A series of grower, agronomist and consultant interviews were undertaken to help compile this management guide and to ensure that both industry relevance and 'user-friendliness' were achieved. In addition, WEEDpak provides support information on a variety of other weed related issues such as the management of weeds with Roundup Ready® cotton, the management of specific problem weeds and volunteer cotton. Other issues explored in depth are managing herbicide resistance in cotton, managing weeds in rotation crops, farm hygiene and herbicides. WEEDpak has been widely distributed to cotton growers, consulting agronomists and other personnel through the Australian Cotton Cooperative Research Centre (CRC), Technology Resource Centre. The extensive research and extension network within the cotton industry will facilitate additional training and promotion of WEEDpak. Ultimately, we aim to provide the information in WEEDpak in a range of multi-media formats, including a small weed identification guide for farm vehicles and on various CD publications like CottonLOGIC.

Introduction

Weeds pose a significant challenge to the Aus-

tralian cotton industry. Weed management costs Australian cotton producers up to \$400/ha when yield losses and costs associated with control are accounted for (Taylor and Walker, 2002). In the 2001/2002 season this translated into a total expenditure of \$150 million. With increasing efforts towards the development of economically and environmentally sustainable production systems (Taylor and Charles, 2002), the Australian cotton industry recognized the need to adopt a comprehensive and integrated weed management (IWM) approach.

The production of WEEDpak, a comprehensive, integrated weed identification and management package facilitates this IWM approach. The basis for successful weed management needs to be accurate identification of the weed species present combined with effective management practices against these weeds. WEEDpak combines existing identification and management information in a form that is both easy to access and is readily updateable. Previously a number of identification books and guides have been commercially available to growers (Cunningham *et al.*, 1981; Auld and Medd, 1987; Wilson *et al.*, 1995; Wood *et al.*, 2000), but none of these were specific for the suite of weeds that occurred in Australian cotton farming systems. Again, while there was substantial information on the management of some of these weeds published in a number of different articles, (e.g. Charles, 1995; Osten, 1996; Charles, 1997; Johnson, 2000), and in many Australian Cottongrower magazine and Australian Cotton Conference Proceedings, in other cases management information was anecdotal and/or not specific to cotton farming systems. WEEDpak collated and expanded this information.

This paper examines three key areas involved with the content, compilation and future expansion of WEEDpak. Firstly, the breadth of information in WEEDpak is discussed. This information will help growers and other users implement more economic and environmental weed management outcomes in cotton farming systems, both in Australia and worldwide. Secondly, the processes involved in compiling the information, in particular the interviews involved with the production of the best bet management guide are reviewed. The process undertaken for the best bet management guide is of particular interest to industries where weed management information is largely anecdotal and needs to be formalized for industry wide application. Finally, the paper covers how WEEDpak will continue to be updated and expanded in the future.

What is in WEEDpak?

Integrated weed management

The central theme of WEEDpak is the development of integrated weed management (IWM) systems within the Australian cotton industry. Integrated weed

management is important to allow for long-term sustainable weed management within these systems. Previously, insecticide resistance precipitated a change in insect management and the adoption of an integrated insect management (IIM) approach to help manage these insects. IWM seeks to prevent similar outbreaks of resistance to herbicides, in particular with the increased use of glyphosate in Roundup Ready® cotton varieties. IWM is more than just preventing herbicide resistance; it is the use of many methods of weed control in synergy with one another. The overall results of IWM will be a reduction in the current reliance on herbicides for weed management, a minimalization in the development of herbicide resistance and species shift and a reduction on the impact of herbicides on the environment. Given the importance of IWM to the farming system, the section on IWM has been placed at the front immediately after the weed identification and information guide in WEEDpak so that users of the manual have ready access to it.

Weed identification and information guide

Well over 200 weed species are weeds of significance on Australian cotton farms. Many of these weeds are native species and were present before production commenced. Many more have been introduced on farm and are now successfully established. Positive identification of a weed and an understanding of the weeds lifecycle are important first steps in integrated weed management. Positive identification is important to match a weed species to the correct herbicide, and also to other control measures, while a sound knowledge of the lifecycle of the weed will help in targeting control measures before seed set and further spread. This unique and outstanding guide covers a range of seedling and adult plant photos, with associated text descriptions, so that positive identification can be made at any stage during the plants lifecycle, and management implemented. The identification and information guide has been located at the front of WEEDpak for ready access. Because of the large number of weed species the industry encounters, this guide will continue to be updated in the years to come.

Herbicide resistance

There are an increasing number of weeds that are becoming resistant to herbicides. Fortunately there are no herbicide resistant weeds currently known to exist in the cotton cropping phase in the Australian cotton industry. This section details how a resistance free status can best be maintained by using an integrated approach to weed management. The overuse of herbicides will also result in a weed spectrum shift from those species that are susceptible to the herbicide to those that are more tolerant. To overcome both species shift and herbicide resistance, many means of weed management must be used in synergy with one another. Various weed management tools to overcome these problems are discussed in this article and in the section

on IWM guidelines outlined above.

Herbicides

The use of herbicides is an important tool in any IWM program, particularly after the correct identification of the target weed has been achieved. The selection of the most appropriate herbicide from the many options available, and the correct application of that herbicide, is a crucial step in most weed management programs. All the currently registered herbicide options available to Australian producers are outlined in this section, with general guidelines then given for effective application techniques. This section refers the user to further information on the many aspects of correct pesticide application covered in SPRAYpak, an Australian Cotton Cooperative Research Centre (CRC) publication.

Roundup Ready® cotton

The introduction of Roundup Ready® cotton offers a number of advantages to the cotton industry for weed management, and especially as another tool in an IWM program. When the technology is used as part of an integrated weed management system, the dependence on residual herbicides can be reduced, improved management of many weeds can be achieved, more flexible weed management programs can be put in place, in particular to reduce costs associated with chipping and cultivation, and, with the attendant reduction in pre-emergent herbicides, the establishment and vigor of cotton seedlings should be enhanced. The use of this new technology also has some limitations, particularly with the potential for spray drift, for herbicide contact with the lower parts of the plant with directed applications, and with application timing. The two articles in this section draw together a large pool of research and grower information to help users of Roundup Ready® cotton achieve good results by avoiding many of the possible mistakes.

Farm hygiene

Good farm hygiene is an important part of any integrated weed management strategy. The four articles contained highlight the importance of managing weeds that grow in cotton crops, in fallows, along roads, channels and waterways and in other waste areas on the farm. In particular, one article outlines the management of volunteer cotton, one of the more prevalent weeds in many cotton-farming systems. Good farm hygiene is a necessary part of integrated insect and disease management (IIM and IDM) also. The various interactions between weeds and both insects and pathogens are highlighted with reference made to ENTopak, an Australian Cotton CRC publication that examines insects and their management in Australian cotton crops. ENTopak is also available on the Australian Cotton CRC website.

Best bet management guide

Successful integrated weed management is driven by knowledge, whether that is supplied by in-depth research on key weed species, (covered in the next section of WEEDpak), or by much broader anecdotal observations gained via trial and error by growers and consultants in their everyday weed management practices. This guide covers the best bet management options for a range of weed species that are difficult-to-control in Australian cotton farming systems. The information was derived from a range of grower, agronomist and consultant interviews and aims to pass on the experiences of those industry leaders to the wider grower and consultant community. The compilation of this information has been covered in more detail in a later section of this paper.

Managing problem weeds

Most weeds are adequately managed by good IWM practices on Australian cotton farms. There are a suite of problem weeds that are not well controlled by these practices and continue to spread and become worse year after year despite the best efforts of cotton growers. A specific set of management practices for three problem weeds, nutgrass (the *Cyperus* species), cowvine (*Ipomoea lonchophylla*) and polymeria take-all (*Polymeria longifolia*) have been outlined. This section will expand as more research on other difficult-to-control species is published.

Rotation crops

The use of rotation crops and fallows are an important tool in IWM, allowing alternative management methods to be implemented for weeds, as well as helping with disease, pest and soil management issues. One issue that needs particular attention is the use of residual herbicides and plant-back restrictions coming out of, or going back into cotton cropping. The single article contained deals with weed control in pigeon pea crops, commonly planted to aid in integrated insect management as trap crops, insect nurseries and refugia for beneficial insects. As more research is completed into weed control in other rotation crops, this section will continue to be expanded.

Appendices

There are five appendices that give valuable support to WEEDpak. The first appendix is a regional listing of weeds identified by grower, agronomist and consultant interviews and via weed surveys conducted by research staff. The lists, combined with the second appendix that contains a comprehensive list of over 200 plant species that may occur as weeds on Australian cotton farms, will help managers become aware of the weeds in their areas. Since both appendices mention new weed incursions, it is hoped that timely identification and management of these new weeds will enhance management of these species. The third appendix lists a number of references that may assist in weed identification, biology and general management.

The fourth and fifth appendices contain an abbreviation list and a glossary respectively.

The processes involved in compiling WEEDpak

There were three key processes that were integral in the compilation of WEEDpak. Firstly, specific cotton weed research was compiled, secondly, research of information that was not specific to cotton farming systems was drawn together, and the third and most unique, a series of grower, agronomist and consultant interviews was conducted that enabled the compilation of the best bet management guide.

The compilation of specific cotton weed research

The Australian cotton industry has commissioned research into a variety of weed management issues over many years, most notably through the Cotton Research and Development Corporation (CRDC). The outcomes of this research formed the major part of the material that was compiled and published in WEEDpak.

Researching information that was not cotton farming system specific

Because of the large number of weeds that cotton growers in Australia have to manage, much of the information on the basic biology of the weeds has not yet been generated by specific research in cotton farming systems. For this reason, much of the information sourced for the weed identification and information guide came from research from other agricultural production or environmental management systems. Where this information was not available, the information was sourced from plant identification and general weed control books, and from internet based material.

Grower, agronomist and consultant interviews for the best bet management guide

While there is good management information on a range of the most common and problematic weeds that Australian cotton growers encounter, there is a lack of readily available, cotton system specific weed management information on a wider range of other species. Given that successful management is already occurring for many of these species, grower, agronomist and consultant interviews were undertaken to collate this anecdotal information, and to publish it in a form that would enhance weed management industry wide. During the individual interviews and focus groups, participants were asked specific directed questions, particularly on how they managed the problematic weed species they encountered. Participants were asked to elaborate if further information was required.

There were two important factors that aided the collection of information. Firstly, approximately fifty

leading growers, agronomists and consultants were contacted through the local cotton extension officers employed by the Australian Cotton CRC. Secondly, these participants were drawn from a wide geographic area throughout the Australian cotton growing area from the north (Emerald in central Queensland) to the south (Hillston in south western New South Wales). This enabled a comprehensive view of weed management to be gained for a range of different species by talking with this limited number of participants. This process was aided by interviews with private consultants who dealt with many small growers, and large farm agronomists who often worked on farms that covered many times the areas of smaller grower farms.

The information derived from these interviews was compiled on a species-specific basis and then summarized into the form that has been presented in WEEDpak. Sufficient information was derived for 38 of the most problematic weed species. Further work is needed to complete this section since in excess of 200 plant species are found as weeds on Australian cotton farms.

WEEDpak today and in the future - a living, breathing document

Since WEEDpak was first published in August 2002, over 500 paper copies have been distributed to cotton growers, on-farm and sales agronomists, private consultants and other personnel throughout the cotton industry. This has been facilitated through the Australian Cotton CRC's Technology Resource Centre together with the National Cotton Extension Network. The information in WEEDpak has been a focus of the CRC extension network this season for on-farm demonstrations.

With a high degree of computer access among cotton producers and improving on-line facilities 'in the bush' we have also recently provided WEEDpak in two electronic formats. The first is on the Australian Cotton CRC web site where the information is fully searchable and available in downloadable .pdf format, available not only to the Australian industry that supported its development, but also to world agriculture.

The second electronic format is the inclusion of WEEDpak with other Australian Cotton CRC information packages like ENTOPak, SOILpak, NUTRIpak, SPRAYpak, MACHINEpak and the Integrated Disease Management guidelines on the COTTONpak compact disk (CD). This CD has been developed by the Australian Cotton CRC Technology Resource Centre and will allow users to access the information quickly from their own computers and help in cross-referencing between different publications. The information in WEEDpak may also be published with other decision support software like CottonLOGIC, now available on small handheld computers like the Palm Pilot®. This means of distribution is under investigation.

Aside from the multi-media delivery modes outlined above, we ultimately aim to provide the information in WEEDpak in a number of other formats. For example, there is considerable potential to publish a separate weeds identification and information guide for the Australian cotton industry in a format that can be carried around in farm vehicles. Many of the existing guides do not have a wide range of seedling and adult plant images, and the inclusion on these images in our guide would be an important step in helping to address this problem. The information in WEEDpak can be readily adapted for other industry specific and general IWM information packages and books in the future.

Sections of WEEDpak will continue to be updated on a yearly basis with all changes available instantly on the Australian Cotton CRC website and sent to registered users of the printed version of WEEDpak. Both sectioned page numbering and the easy removal of pages in the ring folder hard copy will facilitate this. All the contents of WEEDpak will continue to be reviewed and updated as more information comes to hand.

Conclusion

WEEDpak is a first for the Australian cotton industry and for the world. It is a comprehensive, integrated weed management guide that is both easily accessible on the internet <http://www.cotton.crc.org.au/Publicat/Weeds/index.htm> and readily updateable. It provides a whole system integrated weed management (IWM) approach to a number of weed specific and farming system issues. Hard copies of WEEDpak have been widely distributed within the Australian cotton industry and information delivery will continue through a variety of multi-media formats.

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References

- Auld, B.A. and Medd, R.W. (1987). Weeds. An Illustrated Botanical Guide to the Weeds of Australia. Inkata Press, Melbourne. pp. 255.
- Charles, G.W. (1995). Nutgrass (*Cyperus rotundus* L.) control in cotton (*Gossypium hirsutum* L.). *Australian Journal of Experimental Agriculture*, **35**: 633-639.
- Charles, G.W. (1997). Herbicide strategies for reducing nutgrass (*Cyperus rotundus* L.) density in cotton (*Gossypium hirsutum* L.). *Australian Journal of Experimental Agriculture*, **37**: 231-241.
- Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. and Leigh, J.H. (1981). Plants of Western New South Wales. Inkata Press, Melbourne. pp. 776.
- Johnson, S.B. (2000). Biology and management of the 'take-all' weed, *Polymeria longifolia* (Peak Downs curse), in cotton. Doctor of Philosophy thesis. University of New England, Armidale. pp. 291.
- Osten, V.A. (1996). *Haloragis aspera* Lindley (raspsweed). Master of Agricultural Science thesis. The University of Queensland. pp. 177.
- Taylor, I. and Charles, G. (2002). Integrated weed management for Australian cotton production systems. *Proceedings 11th Australian Cotton Conference*, Brisbane, Queensland. p133-145.
- Taylor, I. and Walker, S.R. (2002). A scoping study on weed issues and their economic impact in dry-land systems with cotton. Final Report for the Cotton Research and Development Corporation. p. 16.
- Wilson, B.J., Hawton, D. and Duff, A.A. (1995). Crop Weeds of Northern Australia. Queensland Department of Primary Industries, Brisbane. p. 160.
- Wood, P., Cahill, M., Marlow, G. and Douglas, N. (compilers) (2000). Weeds: The Ute Guide, Northern Grain Belt Edition. Queensland Department of Primary Industries, Brisbane. p. 190.