Significance of mixed infestations of wild oats species for integrated management

**Summary**

Two species of wild oats are commonly found in cropping systems in eastern Australia, *Avena fatua* and *A. sterilis* ssp. *ludoviciana*. They often occur as mixtures within fields. In an earlier survey in Western Australia (WA), *A. fatua* was found to be widespread, whereas *A. sterilis* was very uncommon. Anecdotal reports by chemical company trials officers suggest that *A. sterilis* is increasing in the west and in the east it now appears to be more frequent than in earlier surveys. Why should *A. sterilis* be increasing and what are the implications for integrated management of this intractable weed? If populations based on extensive knowledge of *A. fatua* are managed, will it simply encourage greater infestations of *A. sterilis*? Or can they continue to be treated as a single weed? Ecological differences between the species have been documented overseas, but will these have any significance for weed management?

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Conclusions
A. fatua and A. sterilis will continue to be a widespread problem for growers throughout the southern Australian wheatbelt. The majority of wild oat infestations contain both A. fatua and A. sterilis. In addition, since previous surveys, A. sterilis has become a greater and more widespread weed problem in WA. Differences in the ecology and herbicide sensitivity of these two species indicate that control techniques aimed generically at wild oats may provide inadequate control of one or the other species. This may be part of the success of wild oats in Australia. The pool of variation in behaviour is enhanced by the presence of more than one species, rather than relying on variation within a single species.

Recommendations
The type of data collected in this study, as well as in other recent studies of wild radish, together with the many studies of annual ryegrass, are only the starting point for making scientifically-based predictions. There is now considerable information on many weeds, but this needs to be put into action. A research project is needed in which these data are brought together in a more mechanistic framework than, for example, the ryegrass integrated management (RIM) model. Considerable advances towards this were made by Ken Young and Darren Kriticos, but their work remains unfunded. A research group such as theirs need to have the time to achieve the most out of the data.

The clearest results of this project were the differences in seedbank behaviour between sites in different climatic regions, and between soil types. The ecological work on weeds funded by GRDC is invariably based at a single site. Often it includes comparison of weed populations, but in this study the environmental effects were greater than the genetic variation. If one is to generalise across regions in the wheat belt, or to make statements about regional differences, then projects must make the study of this variation a priority in their objectives. The Cooperative Research Centre (CRC) for Weed Management Systems attempted multi-site competition and radish emergence studies, but these were unsuccessful. Opportunities were therefore lost.

Outcomes
Expected Outcome (benefits)

Economic Outcomes
Knowledge of differences in herbicide tolerance may impact on the effectiveness of herbicide applications and hence impact on chemical costs. However, more research is needed first.

Environmental Outcomes
The detailed knowledge of wild oats gained here will enable a better understanding of one of the worst weeds. Together with
existing information, it will help management of this weed in a more effective way.

Social Outcomes

This project has trained a postgraduate student, reaching a high level of performance, who will be an excellent resource for the grains industry.

Achievements/Benefits

Overview of Project Achievements

Background and Importance

The overall objective of the current research was to investigate the comparative ecology of the two species of wild oats in Australia so that the implications for integrated weed management (IWM) could be assessed. In addition, the aim was to survey the herbicide sensitivity of the two species under Australian conditions.

Major Achievements

Distribution of wild oats

A survey of the frequency and distribution of *A. fatua* and *A. sterilis* was conducted throughout the southern Australian wheatbelt. Mixed infestations of *A. fatua* and *A. sterilis* were typical throughout the east. In eastern Australia, 81% of infestations contained both species. The frequency of *A. fatua* decreased at more northern latitudes, but both species were still common in Queensland (QLD). In WA, 46% of infestations contain both species. The frequency of *A. sterilis* in WA is far greater than previously reported. It is not possible to determine the cause of this increase, but it is likely to result from both movement of contaminated grain within WA, as well as from interstate.

Germination potential of *A. fatua* and *A. sterilis*

The distribution of the two wild oats species has commonly been attributed to the germination requirements of *A. fatua* and *A. sterilis*. The current study demonstrated that there is an annual cycle of dormancy which determines the germination potential of seed at any point in time. The rate at which dormancy was released in seeds of both species was differentially affected by the interaction between temperature and water availability. Low temperatures promoted the release of dormancy in *A. sterilis* more than in *A. fatua*. The study demonstrated the way that the initiation of emergence in both species was related to the times when field temperatures overlapped with the annual cycling of temperature requirements for germination. Further studies indicated a differential germination response in seed types of both *A. fatua* and *A. sterilis* to water availability. The results form the basis for a future model to predict the release of dormancy, the resulting germination potential of seeds and emergence of both species in different environments within Australia.

Seedbank decline of wild oats

Seedbank decline after two years of soil burial was site, soil and population-dependent. Under a more Mediterranean climate (e.g. hotter summer and colder winter), a seedbank decline of approx. 90% was recorded in both species, whereas at a more temperate environment (e.g. cooler summer and warmer winter), seedbank decline was only 60%. In addition, soils with greater bulk density had decreased rates of seedbank decline. Seedbank decline in both *A. fatua* and *A. sterilis* was primarily due to seedling emergence. Soils with low bulk density and greater water availability promoted the germination and emergence of both *A. fatua* and *A. sterilis*. Seedbank decline in seed types (primary and secondary seeds within a spikelet) of *A. fatua* and *A. sterilis* was significantly different. Primary seeds in both species generally emerged in a single flush following the break of the first season after dispersal. Secondary seeds represent the more persistent fraction of the seedbank, enabling recruitment in later years.

Herbicide tolerance

A total of 34 collections of *A. fatua* and *A. sterilis* from throughout the southern Australian wheat belt were tested for herbicide tolerance. Collections of *A. fatua* and *A. sterilis* showed continual variation, from non-resistant to resistant. Cases of resistance to Achieve®##, Hoegrass®## and Mataven®## were found including cross resistance between different herbicide groups. Achieve®## provided better control than Hoegrass® or Mataven®. As collections of *A. fatua* and *A. sterilis* were made
from mixed infestations, the behaviour of both species at a field level was shown to range from similar to divergent in response to different herbicides. This indicates that herbicide application could promote the abundance of one wild oat species over another. Overall, there was a trend for *A. sterilis* to be slightly more tolerant to Hoegrass® than was *A. fatua*.

**Growth, development and competition**

In general, *A. fatua* and *A. sterilis* have a similar competitive ability when grown in competition with wheat. This was found to be consistent across sites and soil types. Although small differences were noted in their growth and development, with *A. sterilis* flowering and dispersing seeds slightly earlier than *A. fatua*, the implications for management are negligible. Relationships between day degrees, growth and development were established and provide the data to simulate crop weed competition across a range of weed densities, relative time of emergence and different environments. Seed production across a range of densities, relative time of emergence and sites was shown to be similar in both species and correlated with plant biomass. The thorough knowledge of the development of both species provided by the current research may help to improve management techniques including post emergent and spray topping herbicide application aimed at reducing seed production.

**Modelling**

Results from the study were used to run a population model developed by Randall Jones (Agriculture New South Wales (NSW)). Predicted rates of increase and of seed decline were similar in the two species over a range of management and ecological scenarios. The least understood parameter, the proportion of seed lost between production and entry to the seedbank, had the greatest effect on the predictions, but had little effect on the relative performances of the species.

**Communication extension**

Results from the current project have been presented in numerous forums including the 12th Australian Weeds Conference 12-16 September, 1999, a CRC for Weed Management Systems postgraduate meeting (Wagga Wagga - June 1999), a CRC seedbank workshop (Adelaide - March 2001), and CRDC Update meetings at Wagga Wagga and Temora (2000). The work was the basis for an article in Ground Cover Issue 35, Winter 2001 'Some wild oats are wilder than others'. Detailed information will be in a PhD thesis to be held in the University of Melbourne library. It is anticipated that at least four papers will be published in leading journals.

**Benefits to the industry**

Increased awareness of the frequency of mixed infestations of *A. fatua* and *A. sterilis*, along with their differences in ecology and herbicide sensitivity, will hopefully assist in the development of management programs for the species. Detailed knowledge of weeds and the appreciation of seedbank management in Australia have been forged on the basis of postgraduate research projects such as this one. Many of the benefits are indirect, simply helping to 'know our enemy', so that successes and failures in weed control are better understood and to modify management practices accordingly. For example, earlier flowering in *A. sterilis* may mean that it is less amenable to crop-topping, or at least that timings may have to be different for the two species. It is also important to appreciate that one species in a field may become resistant to a herbicide, while the other is still controlled adequately. This will help growers to make more informed decisions on appropriate weed control strategies.

While herbicides continue to work well in the majority of fields, an understanding of the biology of *A. fatua* and *A. sterilis* may not be of great importance. However, the presence of resistant and cross resistant collections of *A. fatua* and *A. sterilis* to major chemical groups used in their control, highlights the need to understand the distinction between the two species and their differing ecology. Moreover, the continuous range of tolerance sown across wild oat populations demonstrates that increased tolerance, if not full resistance, is now common.

**Other research**

Although providing the most detailed study of the two species yet, there are still gaps in knowledge. The possible difference in tolerance to herbicides between the two species is worthy of more detailed work. A detailed emergence model is needed if questions concerning the timing of emergence of the two species under different climates are to be answered. Further data are needed on the relative competitiveness of primary and secondary seeds. A population model more suited to the species...
should be constructed to examine management implications. To gain some idea of the origins of increased *A. sterilis* in WA, a detailed genetic survey is needed in that state, along with comparison with collections from the eastern states.

**Intellectual property summary**

Postgraduate theses are protected by standard university intellectual property (IP) regulations.

**Additional information**

**Publication**


**Attachment**

Detailed report including summary of thesis results.