Agrichemical industry initiatives to combat development of herbicide resistance

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Summary
Currently six species of four weeds in Australia are resistant to herbicides. They are barley grass, *Hordeum glaucum* and *H. leporinum*, capeweed, *Arctotheca calendula*, annual ryegrass, *Lolium rigidum* and wild oat, *Avena fatua* and *A. sterilis*. Resistance to annual ryegrass is rapidly spreading and is a serious threat to viable winter cropping. Many, but not all, selections of annual ryegrass exhibit cross and multiple resistances. Wild oat resistance is likely to spread rapidly and become a serious problem if farmers don't quickly adopt measures to check its development.

To assist farmers combat the threat of resistance, the Australian agricultural chemical industry formed, under the auspices of The Agricultural and Veterinary Chemicals Association, a Herbicides Resistance Action Committee. The committee formulates and promotes the industry's strategies to minimise the risk, and delay the development, of resistance. The committee's current emphasis is focused on strategies to combat annual ryegrass and wild oat resistance. The activities of this Committee are detailed.

Introduction

Predictions that the repeated use of herbicides would select for resistance were made as early as the mid 1950's (1). This was not an unreasonable prediction given that resistance was already a reality with all other groups of pesticides. Scientists of the day were advising agriculturalists to rotate herbicides to prevent the development of resistance (1). However, in most instances, this advice was not heeded and large areas of monoculture farming were established (1). The first report of herbicide resistance in the USA was in 1970 to common groundsel, *Senecio vulgaris* L., following one or two annual applications of simazine for 10-12 years (1). Since this first report of herbicide resistance many other cases have been identified throughout the world. Today, there are many weed species that have developed resistance to a diverse range of herbicides.

In Australia there are currently six species of four weeds that have developed resistance to herbicides. Barley grass, *Hordeum glaucum* Steud. and *H. leporinum* Link, resistance to paraquat has been selected for by a paraquat + diquat herbicide, and occurs on nine lucerne, *Medicago sativa* L., paddocks on four farms near Ararat in Victoria, and in some lucerne paddocks in Tasmania and South Australia (2).

A population of Capeweed, *Arctotheca calendula* (L.) Levyns, in one of the same lucerne paddocks near Ararat is resistant to paraquat and diquat (2).

Two species of wild oat, *Avena fatua* L. and A. *sterilis* L., have developed resistance. It is estimated there are 20-30 cases of *A. fatua* resistance to the aryloxyphenoxypropionate ("fop") herbicide, diclofop-methyl, spread over Western Australia, South Australia, Victoria and New South Wales. There does not at this stage appear to be any cross resistance to other herbicides with

the same mode of action, namely the "fop" or cyclohexanedione ("dim") herbicides (2). There is one population of *A. sterilis* resistant to the "fop" herbicide, haloxyfop-methyl, near Bordertown in South Australia. This population is also resistant to other "fop" herbicides and the "dim" herbicides (S.B. Powles, pers. comm., 1991).

The most serious and widespread herbicide resistance in Australia is that of annual ryegrass, *Lolium rigidum* Gaudin. It is estimated there are 600-1,000 cases spread across Western Australia, South Australia, Victoria and New South Wales. In most cases resistance has, initially at least, been selected for by diclofop-methyl. Many, but not all, populations exhibit various forms of cross and multiple resistance to some (in a few cases nearly all) of the "fop", "dim", sulfonylurea, imidazolinone, triazine, and urea herbicides, and the dinitroaniline, trifluralin. In addition to those populations selected for primarily by diclofopmethyl, there are three cases of annual ryegrass resistance selected for by the sulfonylurea, chlorsulfuron. These populations are resistant to herbicides whose mode of action is to inhibit the enzyme acetolactate synthase (ALS), i.e. sulfonylureas and imidazolinones.

AVCA Herbicides Resistance Action Committee

The Agricultural & Veterinary Chemicals Association of Australia (AVCA) represents the interests of manufacturers, marketers, wholesalers and retailers of farm chemicals. Some agricultural consultancy organisations are also members.

AVCA has established Insecticides, Fungicides and Herbicides Resistance Action Committees. Each of these committees have a number of working groups. The AVCA Herbicides Resistance Action Committee (AHRAC) was formed in July 1986. AHRAC was the first herbicides resistance action committee to be formed anywhere in the world. Current AHRAC members are Bayer, Ciba-Geigy, Cyanamid, Dow Elanco, Du Pont, Hoechst, ICI, Nufarm, Sandoz, Schering and Shell. Since February 1991 AHRAC has two working groups; the ALS Inhibitors Working Group and the "Fop" & "Dim" Working Group.

Aims of AHRAC

1. To identify and monitor all cases of resistance by weeds to all classes of herbicides.
2. To support and liaise with centres for screening and testing for resistance.
3. To generate interest within the scientific community, and to allocate resources for investigating resistance with a view to discovering fundamental mechanisms of resistance and practical means of control.
4. To formulate and promote use strategies to minimise the risk of resistance, delay the development of resistance, and provide practical control of resistance.
5. To develop a united and responsible industry response to the management of resistance.
6. To liaise with overseas resistance action committees and other interested bodies.

Recent activities of AHRAC and its members

The early activities of AHRAC were reported by Howat, 1987 (1). Many of these

activities are of an on-going nature and are not recorded here. Recent activities of AHRAC and its member companies include:

1. Regular meetings of AHRAC and its working groups to discuss and make industry-binding decisions in line with its aims.
2. Write papers on herbicide resistance and its management for presentation at conferences and publication in journals.
3. Make press releases, and give radio and press interviews on herbicide resistance management, and the activities of AHRAC.
4. Collect seed samples and collate paddock histories for resistance testing. Use the results and paddock information to formulate herbicide resistance management strategies.
5. Produce AHRAC brochures on herbicide resistance management e.g. "The facts about Herbicide Resistance" (1987) and "AVCA Guidelines: Integrated strategies for Annual Ryegrass Control" (1991).
6. Numerous resistance management brochures produced by member companies. These comply with AHRAC guidelines, but more specifically tailor the recommendations to the use of their products in resistance management.
7. Resistance management education meetings for personnel giving advice to farmers on the use of agricultural chemicals. These meetings being either organised and led by AHRAC members, or AHRAC speakers at meetings organised by state Department's of Agriculture.
8. Company in-house herbicide resistance training sessions.
9. Financial support given to resistance research e.g. Technician conducting annual ryegrass resistance tests at Waite Agricultural Research Institute (WARI), research project titled "Practical means of combating resistance" at WARI, sponsoring WARI research personnel to attend conferences and public education meetings, and the provision of equipment required by WARI for investigating the mechanisms of resistance.
10. Two AHRAC representatives of the "National Working Party on Herbicide Resistance in Weeds" which reviewed the current status of resistance, the research and extension currently underway, and made recommendations to the Plant Production Committee for immediate improvements, and for the future direction of research and extension.
11. Farmer education meetings and in-field resistance management advice given by company representatives.
12. Adoption of a standard "Resistant Weeds Warning" and herbicides mode of action groups for herbicide labels.
13. Numerous company research projects; includes basic mechanistic studies of resistance, and applied field control trials with new herbicides, herbicide combinations, and management practices to bring under control existing resistant populations.

Current activities of AHRAC and its members

1. **Updating and broadening the herbicide resistance management strategies to cover all grasses and broadleaf weeds.**
2. **Production of an expanded AHRAC resistance brochure, with emphasis on annual ryegrass and wild oat.**
3. **Planning the design and implementation of market research to determine: (a) the extent of annual ryegrass resistance**

(b) farmer awareness and adoption of resistance management strategies
(c) agricultural practices that have, and have not, led to resistance

4. Production of company resistance brochures that comply with AHRAC guidelines, but are more specifically tailored to the use of that company's products in resistance management.
5. Resistance management education meetings for personnel giving advice to farmers on the use of agricultural chemicals. These meetings being either organised and led by AHRAC members, or AHRAC speakers at meetings organised by state Department's of Agriculture.
6. Farmer education meetings and in-held resistance management advice by company representatives.
7. Continuation of the basic and applied research projects currently underway by member companies.

The future

AHRAC believes that through the co-operation of AVCA members, resistance researchers, farm chemical suppliers, and farmers, sound practical strategies can be developed and implemented to manage the use of herbicides in the face of threatening herbicide resistance.

The herbicide tools available to farmers today have never been better. New herbicides and new modes of action are fewer and further between due to the immense cost of developing new agricultural chemicals and the rigorous health and environmental safety standards being adopted by the research based companies.

Farmers must adopt resistance management strategies to preserve the effectiveness of the current herbicides, and hence the long term viability of their farming enterprises.

References

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2. Powles, S.B. and Holtum, J.A.M. (1990). Herbicide Resistant Weeds in Australia. Proceedings 9th Australian Weeds Conference, pp 185-93.