Herbicide resistance in the northern grain region of Australia: developments in research from 1993 to present

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Summary The Tropical and Sub-tropical Weeds Research Unit (TWSRU) at The University of Queensland has conducted ongoing research into herbicide resistance in the northern grain region of Australia since 1993. The Grains Research and Development Corporation (GRDC), the Queensland Department of Primary Industries (QDPI) and NSW Agriculture have supported this work. There were no reported cases of herbicide resistance in the northern grain region prior to 1993 but there are now in excess of 83 weed populations that have been confirmed resistant to Group A, B or C herbicides. Current paper is describing the extent of resistance in the northern grain region through a random sampling procedure. The Rothamsted Rapid Resistance Test (RRRT) has been employed to detect resistance to Group A herbicides.

Keywords Herbicide resistance, northern grain region, RRRT.

INTRODUCTION

The TWSRU at The University of Queensland, with support from GRDC, QDPI and NSW Agriculture, has conducted ongoing research into herbicide resistance in the northern grain region of Australia since 1993.

Between 1993 and 1997, five broadleaf weed and two grass weed species were identified as being resistant to herbicides from three chemical groups. Turnip weed (*Rapistrum rugosum* L.), climbing buckwheat (*Fallopia convolvlus* (L.) Á.Löve), African turnip weed (*Sisymbrium thellungii* O.E.Schultz), common sowthistle (*Sonchus oleraceus* L.) and Indian hedge mustard (*Sisymbrium orientale* L.) were resistant to the recommended rates of the Group B (acetolactate synthase – ALS inhibitors) herbicide, chlorsulfuron. Liverseed grass (*Urochloa panicoides* P.Beauv) was resistant to the recommended rate of the Group C (inhibitor of photosynthesis at photosystem II) herbicide, atrazine, and wild oat (*Avena sterilis* L. ssp. *ludoviciana* (Durieu) Nyman) was resistant to the recommended rate of the Group A (acetyl CoA carboxylase – ACCase inhibitor) herbicide, clodinafop-propargyl (Adkins *et al*. 1997). This was the first ever reported case of herbicide resistance in populations of turnip weed, climbing buckwheat, African turnip weed and liverseed grass. Resistance was found to have developed after 3–10 years of chlorsulfuron use, five years of 'fop' use or 2–15 years of atrazine use. There was no correlation between the frequency of use and the degree of resistance. Cross resistance to herbicides from the same group was common but there was no evidence of multiple herbicide resistance (Adkins *et al*. 1997).

Since 1997, a further 17 wild oat populations resistant to Group A herbicides and the first Australian case of Group A resistant paradoxa grass (*Phalaris paradoxa* L.) have been reported.

The current phase of research is attempting to describe the extent of herbicide resistance in the northern grain region by random survey of paddocks in the main cropping shires of the northern region. Weeds from sprayed fallows are also being sampled in an attempt to detect glyphosate resistant weed populations.

The Geographical Information System (GIS) ArcView™, is being used to record the location of all new and previously confirmed occurrences of herbicide resistant weeds in the northern grain region as well as the herbicide-use history at those locations.

A further component of the current project is the development of molecular diagnostics to rapidly detect gene mutations conferring resistance to Group A and Group D (inhibitors of tubulin formation) herbicides.

MATERIALS AND METHODS

Current research Weed seed was collected by randomly sampling paddocks from 24 shires in the northern grain region. A total of 121 in-crop paddocks were sampled between October–November 2001 (winter 2001 collection). Ninety-eight of the sampled winter paddocks were dominated by wild oats, *Avena* species (either *A. sterilis* L. ssp. *ludoviciana* (Durieu) Nyman or *A. fatua* L.). The remainder of the winter-seed collection were broadleaf weeds such as climbing buckwheat, African turnip weed, common sowthistle and turnip weed.

An additional 14 wild oat samples were received from private individuals for screening by the Herbicide Resistance Testing Service (HeRTS) which is being offered to farmers as part of the current project.

The 98 wild oat populations from the winter 2001 collection and the additional 14 populations were screened for Group A resistance using the Rothamsted Rapid Resistance Test (RRRT) developed by Moss (1999). Seed were cleaned and then after-ripened for eight weeks in an incubator set at a constant 35°C. For each of the ninety-eight samples, 50 seed were placed into each of four 9 cm Petri dishes containing three Whatman No. 1 filter papers. For the herbicide treatments, the herbicide Wildcat® (100 g L^{-1} fenoxaprop-P-ethyl, Aventis Crop Science) was diluted to obtain a solution containing 7.5 parts-per-million (ppm) of fenoxaprop-P-ethyl and 9 mL of this solution was then added to two of the Petri dishes of each population. The other two Petri dishes had 9 mL of de-ionised water added. The treatment and control Petri dishes were placed into separate, sealed plastic sleeves and then placed in a germination incubator with a daily temperature and photoperiod regime set at 17 ± 0.5°C for 14 h with lighting and 10 ± 0.5°C for 10 hours without lighting. Germination was assessed on day 21 and results were interpreted using the protocol developed by Moss (1999).

RESULTS

Current research Of the 98 randomly collected wild oat populations, two were found to be highly resistant and another eight populations showed marginal insensitivity to fenoxaprop-P-ethyl (Table 1). Eight out of the 14 wild oat populations submitted by private individuals to HeRTS were strongly resistant to fenoxaprop-P-ethyl.

Table 1. Results of the RRRT for 98 wild oat populations collected in winter 2001 and the 14 samples submitted to HeRTS. Populations have been classified as either Resistant (R), Susceptible (S), or showing Marginal insensitivity (Mi) to the Group A chemical, fenoxaprop-P-ethyl.

Shire or statistical division	R	S	Mi
Emerald		1	
Banana		2	
Chinchilla		2	
Wambo		1	
Tara	7*	11	1
Milmerran		1	1
Waggamba		9	1
Jondaryan		1	
Pittsworth			1
Bungil		2	
Balonne		4	
Yallaroi	1*	5	
Inverell		2	
Gunnedah		3	1
Quirindi		2	
Moree Plains		15	
Narrabri		7	
Walgett		7	1
Coonamble		3	1
Warren	1	3	
Bogan		5	
Coonabarabran		2	
Gilgandra	1	3	
Narromine		3	1

* samples submitted to HeRTS.

DISCUSSION

Prior to 1993 there were no reports of herbicide resistant weeds in the northern grains region. There are now in excess of 83 populations of grass and broadleaf weeds where resistance has been confirmed. Group A resistance is most prevalent and the single largest group of species with Group A resistance is the wild oats, with just over 40 confirmed resistant populations, followed by paradoxa grass with three resistant populations. Group B resistance is confirmed for sowthistle, Indian hedge mustard, turnip weed, African turnip weed and climbing buckwheat in 19, 9, 2 and 2 populations, respectively. Seven populations of liverseed grass are resistant to Group C herbicides.

Nearly all of the known resistant populations have been discovered through targeted sampling. The current research, which is sampling paddocks in a random manner, discovered additional two resistant wild oat populations from the 98 populations that were collected in winter 2001. Targeted sampling, after analysis of herbicide-use or cropping sequence histories, has discovered a greater number of resistant weed populations in both absolute and relative (as a proportion of the paddocks sampled) terms.

Samples submitted to HeRTS will provide useful statistics on the extent of resistance in the northern region. More than half the wild oats samples submitted to HeRTS in the first six months of the current project were resistant. HeRTS has been offered as a free service to limit constraints and encourage farmers to have suspect seed tested earlier rather than later.

By the end of the current project it is anticipated that approximately 5% of grain producing farms in the northern region will have been randomly sampled. Sampling in the final year of the project will attempt to combine a stratified random-sampling approach in

each of the cropping districts, based on farmer surveys or other information that describe herbicide-use and cropping-sequence histories (Walker *et al*. 2002). This would make for greater sampling efficiency and allow a truer description of the extent of herbicide resistance in the northern region.

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