Herbicide resistance is an increasing problem facing farmers in the northern grain region. While there are no cases in central Queensland, there are resistant populations in both southern Queensland and northern New South Wales. Data from a 2001 survey was used to identify weeds and systems at risk of herbicide resistance. Preventive strategies for these weeds were tested on-farm and delivered to growers and agronomists through a six monthly newsletter and regionally specific brochures. A 2004 survey identified misconceptions and knowledge gaps about herbicide resistance in the northern grain region and was used to compare the knowledge of those who did and didn’t receive the newsletter. To overcome misconceptions and fill knowledge gaps, action learning modules for growers and agronomists were devised and delivered. Results show that extension and education processes used by the project team have increased the use of alternative weed management practices, suggesting that the project has helped to confine the current weeds with resistance and prevent further resistance, thereby maintaining usefulness of important herbicides and current viable farming systems.

Keywords Herbicide resistance, extension, action learning modules, preventive strategies.

INTRODUCTION
Herbicide resistance is becoming more common in the northern grain region. Currently there are ten resistant weed species in the region with many more identified as being at risk of developing resistance (Walker et al. 2004). The northern grain region is broadly divided into three sub-regions; central Queensland, southern Queensland and northern New South Wales. There are currently no recorded cases of herbicide resistance in central Queensland. In contrast there are seven weeds species documented as resistant in both southern Queensland and northern NSW (Table 1). In northern NSW there are approximately 30 populations of glyphosate resistant annual ryegrass (Preston 2006).

A 2001 postal survey to growers and agronomists identified additional weeds and farming systems in the northern grain region at risk of developing herbicide resistance and weeds for which resistance was likely to spread (Walker et al. 2004, Osten et al. in press). Weeds and mode of actions (MOAs) identified for each region are in Table 1. Farming systems using zero tillage were identified as at greatest risk for herbicide resistance (Walker et al. 2004).

The project team developed research, development and extension (R, D and E) activities based on the 2001 survey outcomes. Through our extension efforts we aim to increase awareness about herbicide resistance and build capacity and willingness in farmers and agronomists to change practice in response to the herbicide resistance threat. We aim to equip land owners with the knowledge and capacity to be able to make informed weed management decisions that will reduce the risk of herbicide resistance.

This paper reports on the R, D and E activities undertaken over the past five years. The paper includes the development of preventive strategies to avoid getting herbicide resistance in ‘at risk’ weeds, the branding and colour scheme of extension outputs, the project’s newsletter and brochures, a survey on understanding herbicide resistance and action learning modules (ALMs).

MATERIALS AND METHODS
Preventive strategies On-farm trials tested preventive strategies on key at risk weeds as identified in the 2001 survey (Table 1). Trials were regionally specific and ran over approximately three years. Strategies tested included applying herbicides from alternative MOAs alone or in mixture, crop rotation, crop competition and cultivation. Strategies were developed in conjunction with agronomists from the northern grain region.

Branding and colour scheme In the early stages of the project we developed a distinct and recognisable branding and colour scheme for all extension efforts including printed material and presentations. The branding contains the catch phrase of ‘Resistance is Futile’ in bright purple, green and gold.
**Newsletter**  The team published a six monthly newsletter titled ‘The Northern Herbicide Resistance Reporter’ which was used as the main avenue of extension. The newsletter followed the colour scheme and was used to distribute data from field trials and any other topical issues relating to herbicide resistance.

**Brochures**  Three brochures titled ‘Stopping herbicide resistance’ were produced for each region within the northern grain region. The brochures aimed to provide a better understanding of herbicide resistance and regionally specific information on key weeds and preventive strategies for these weeds, derived from on-farm testing.

**2004 survey**  An additional survey assessed understanding of herbicide resistance by growers and agronomists, capturing misconceptions and gaps in knowledge. The survey also assessed the impact of our newsletter, with results used to formulate further extension needs. Respondents were also asked to nominate their preferred method for receiving further herbicide resistance information.

The survey was mostly conducted via the phone to 120 respondents. Approximately half of the respondents had completed the survey in 2001, and approximately half of the total surveyed received the reporter.

**Action learning modules**  The concept behind an ALM is that learning is achieved through doing. This is accomplished by incorporating hands-on, interactive activities. The aims of our ALMs are to build capacity in grower and agronomists by overcoming the identified misconceptions and gaps in knowledge and by providing them with viable weed management alternatives. Thereby enabling them to better avoid and/or better manage herbicide resistance.

**RESULTS**

**Preventive strategies**  Preventive strategies were developed for 15 key at risk weeds and MOA groups (Table 1). Integrated weed management principles were used to develop strategies incorporating chemical and non-chemical tactics.

**Branding and colour scheme**  We received positive feedback that the branding and colour scheme used throughout the project easily enabled people to quickly identify relevant herbicide resistance information.

**Newsletter**  Six issues of the newsletter have been sent to approximately 550 recipients, mostly in the northern grain region, consisting of growers, agronomists and researchers (Figure 1). The Reporter was considered by a world renowned herbicide resistance researcher from the US as ‘the best example of herbicide resistance research and extension in the world’.

**Brochures**  All three brochures were 16–24 pages and had the following common components:

- why be concerned?
- how does resistance start?
- how does resistance then become a problem?
- general principles to avoid resistance
- know your herbicide groups
- frequently asked questions
- what to do if you think you have resistance.

Through these common topics, recipients have a useful resource to better understand resistance. In addition, information was included on weeds identified at risk for each region (Table 1).

The brochures were distributed to those who receive the newsletter and also made available at grower and agronomist meetings. The brochures are available on the Weeds CRC web site (www.weeds.crc.org.au/publications/other_products.html).
Fifteenth Australian Weeds Conference

2004 survey  This survey was completed by 88 farmers and 32 agronomists. Common misconceptions and gaps in knowledge of both respondent groups identified through the survey were:

• MOA groups (Table 2)
• selection pressure
• poor control versus herbicide resistance
• impact of weed densities
• herbicide resistance reversion (Table 3)
• source of herbicide resistance (Table 4)
• the role of herbicide mixes
• impact of tillage
• how to identify resistance.

The ability of growers to name a herbicide from different MOA groups varied between groups, but was <50% for all MOAs (Table 2). Group M (glyphosate) herbicides are used by almost 100% of growers in the northern grain region (Walker et al. 2004, Osten et al. in press). However, only 43% of respondents were able to correctly identify a group M herbicide.

There was uncertainty about the persistence of resistance with 30% believing it is short-lived (1–5 years) and 10% not knowing duration (Table 3).

Growers believed that the most common source of herbicide resistance was from contaminated seed and incursion from neighbours (Table 4). Resistance was considered less likely to come from pollen or their spraying regime.

When asked to identify situations that placed a weed at higher risk of developing herbicide resistance,
and the number of herbicide applications, herbicide mixing, and cultivation.

Awareness and knowledge of herbicide resistance issues by grower respondents differed depending upon whether they received the newsletter.

Growers who received the newsletter had a higher understanding of herbicide MOA groups (50% versus 18% for groups A, B and M), and had an increased use of preventive strategies. The largest increase was for using competitive crops (15% more using the practice) follow-up herbicides (9%) and cultivation (8%). Respondents receiving the newsletter had a greater understanding of what situations cause herbicide resistance and a greater concern about resistance.

Agronomist responses did not differ consistently based upon whether they received the newsletter.

The preferred methods nominated for further herbicide resistance information were brochures, publications, e-mails and workshops.

**ALMs** Three hands-on components were designed to overcome misconceptions identified in the 2004 survey. Activities include labelling herbicide drums with their corresponding MOA, an interactive activity on demonstrating selection pressure and a puzzle to illustrate how herbicide resistance works. In addition, there are several brainstorming activities where small groups answer questions about herbicide resistance, weed management alternatives and on-farm application of these alternatives.

Five ALMs are planned for delivery in central Queensland in July/August 2006 and approximately an additional eight planned for southern Queensland and northern NSW later in the year.

The effectiveness of the ALMs will be evaluated either by running a follow-up workshop or by approaching participants individually to assess change.

**DISCUSSION**

The project team has successfully used a variety of R, D and E methods to increase awareness and improve management and prevention of herbicide resistance amongst growers and agronomists across the northern grain region.

Whilst there is a diversity of resistant and at risk weeds in the northern grain region, they currently only cover a relatively small area. Through our efforts, we aim to avoid major resistance problems as experienced overseas and in the southern and western cropping systems of Australia and maintain current cropping viability.

**ACKNOWLEDGMENTS**

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**REFERENCES**


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**Table 4.** Where growers think they will get herbicide resistance from. Average ratings are shown for a rating scale from 1 to 5 where 1 = absolutely no chance and 5 = certain to happen.

<table>
<thead>
<tr>
<th>Source of resistance</th>
<th>Mean rating score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollen blowing in from a neighbours' property</td>
<td>2.4</td>
</tr>
<tr>
<td>Resistant weed seed brought in with feed or seed for planting</td>
<td>3.5</td>
</tr>
<tr>
<td>Resistant weed seed blown or washed in from neighbouring properties</td>
<td>3.1</td>
</tr>
<tr>
<td>Their spraying regime</td>
<td>2.9</td>
</tr>
</tbody>
</table>