FINAL REPORT

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

DAQ527

Risk assessment and preventive IWM strategies for herbicide resistance in the diverse farming systems in the Northern Region

PROJECT DETAILS

PROJECT CODE:	DAQ527
PROJECT TITLE:	RISK ASSESSMENT AND PREVENTIVE IWM STRATEGIES FOR HERBICIDE RESISTANCE IN THE DIVERSE FARMING SYSTEMS IN THE NORTHERN REGION
START DATE:	01.07.2001
END DATE:	30.06.2005
SUPERVISOR:	STEVEN WALKER
ORGANISATION:	DEPARTMENT OF PRIMARY INDUSTRIES AND FISHERIES
CONTACT NAME:	STEVEN WALKER

Summary

The weeds identified at risk of developing glyphosate# resistance in the northern grains region include common sowthistle and summer grasses, as well as several other summer weeds in central Queensland (QLD) and a mix of summer and winter weeds in southern QLD and northern New South Wales (NSW). In this project, preventive strategies were tested in long term field experiments, and specific tactics were tested in 12 short term trials. The proposed strategies to conserve glyphosate susceptibility involved a variety of chemical and non-chemical alternatives to glyphosate. Findings were communicated to the industry in six newsletters, 61 papers and articles in rural media, and 23 presentations. These strategies have been published in three regional specific brochures.

Report Disclaimer

Refer to 'Report Disclaimer'

Conclusions

1. In central QLD, weeds such as sweet summer grass, barnyard grass, liverseed grass, and common sowthistle are most at risk of developing resistance to Group M herbicides (glyphosate[#]), and parthenium weed, common sowthistle and African turnip weed to Group B herbicides. A range of summer broadleaf and grass weeds are also at risk of resistance to Group C herbicides.

2. In southern QLD, weeds such as barnyard grass, liverseed grass, common sowthistle and wild oats are most at risk of developing resistance to Group M herbicides, paradoxa grass to Group A herbicides, other brassica weeds to Group B herbicides, and barnyard grass to Group C herbicides. The areas of resistant Group A wild oats and Group B broadleaf weeds could increase further.

3. In northern NSW, weeds such as wild oats, barnyard grass, liverseed grass, and common sowthistle are most at risk of developing resistance are to Group M herbicides, annual ryegrass, paradoxa grass and wild oats to Group A herbicides, wild oats, black bindweed and other brassica weeds to Group B herbicides, barnyard grass to Group C herbicides, wild oats to Group K herbicides. Annual ryegrass to Group M herbicides could increase further, as well as more Group B resistant weeds.

4. Preventive strategies based on the rotation of modes of action (MOA) groups, with or without some strategic tillage, were as effective as current practices and cost an additional $0–17/ha, depending on herbicide selection, use of tillage, and extent of preventative actions.

5. Glyphosate resistance in summer grasses could be very expensive, costing an additional $30–57/ha/year, until all resistant seeds were eliminated from the soil seed-bank.

6. Weed management packages need to include multiple herbicide and non-chemical tactics to keep weed numbers low and thus minimise resistance risk.

7. A multi-pronged and extensive communication campaign was successful, particularly using a recognisable project 'brand'.

8. Growers' and agronomists' concerns and awareness of herbicide resistance has increased, as well as receptiveness and adoption of preventive actions.

9. A multi-discipline, regionally-focused and well-coordinated project team is a successful approach for research,

Level 4, East Building | 4 National Circuit, Barton ACT 2600 | PO Box 5367, Kingston ACT 2604 | t. +61 6166 4500 | f. +61 2 6166 4599 | grdc@grdc.com.au | grdc.com.au

development and evaluation (RD&E) on important weed issues such as herbicide resistance.

Recommendations

The project team developed and validated preventive strategies for each key weed at risk of developing resistance to Group A, B, C and M herbicides.

These recommended strategies are published in the three regionally focussed brochures that have been widely distributed to the industry.

Not all tactics or weeds at risk were researched, but these will be covered in the follow-on project.

Outcomes

The project identified the crop and weed management systems at greatest risk of developing herbicide resistance in the diverse cropping systems of the northern region. Subsequently, preventive strategies for the key weeds and systems at risk were developed and validated for effectiveness on-farm. These strategies will ensure maximum effective life of important herbicides, and will maintain the viability and flexibility of conservation cropping in the northern region.

The tactics used in preventive strategies were either as effective as the current district practices or more effective, which would result in less weed problems in the following crops and fallows. In most cases, crop yields were either similar to that achieved with current district practices or improved slightly to substantially. For example, the average yields increased by 6% for both winter and summer crops in southern QLD.

At present, southern QLD growers spend approximately $50–100/ha/year on weed control in winter and summer grain crop rotations. Glyphosate[#] resistance, if developed in a major summer grass, was estimated to cost growers an additional $30/ha/year in regions that are able to grow both winter and summer crops reliably, but could make cropping unviable in the more marginal cropping areas.

Therefore, there are substantial economic benefits for growers if they adopt some preventive actions now, particularly those at high risk of their weeds developing Group A and/or Group M resistance in the near future.

Another advantage of this large multi-agency, multi-discipline project, was that it avoided duplication and increased synergy in RD&E on herbicide resistance in the northern region.

Achievements/Benefits

Survey and risk assessment:

The main weeds and weed management practices used in grain cropping areas of the northern region were identified, based on a comprehensive postal survey of 250 growers and agronomists. A very diverse weed flora of 105 weeds from 91 genera was identified. 23 weeds were common to all cropping zones. The major common weeds were sowthistle, turnip weed, barnyard and liverseed grasses. More genera were recorded in the fallows than in crops, and those in summer fallows exceeded the number in winter. Across the region, weed management relied heavily on herbicides. In fallows, glyphosate[#] and mixes with glyphosate were very common, but the glyphosate mix partner differed between the cropping zones. Use and importance of pre-emergent herbicides in-crop varied considerably between zones. In wheat, more graminicides were used in northern NSW than in southern QLD, and virtually none was used in central QLD, reflecting the differences in winter grass weed flora across the region. Atrazine[#] was the major herbicide used in sorghum, although metolachlor[#] was also used predominantly in northern NSW. Fallow and inter-row cultivation were used more often in the southern areas of the region. Grazing of fallows was more prominent in northern NSW. High crop seeding rates were not commonly recorded, indicating growers are not using crop competition as a tool for weed management.

The risk assessment concluded that mostly summer weeds are at risk in central QLD, whereas a mix of summer and winter weeds are at risk in southern QLD and northern NSW. In all parts of the region, the risk is greatest for the cropping systems using zero tillage (ZT) with only limited rotation between summer and winter crops.

In central QLD, no weeds are confirmed resistant, but sweet summer grass, barnyard grass, liverseed grass, and common

Refer to 'Report Disclaimer'

sowthistle are at most risk of resistance to Group M herbicides (glyphosate), and parthenium weed to Group B herbicides. Other weeds at risk are common sowthistle and African turnip weed to Group B herbicides, and a range of summer broadleaf and grass weeds to Group C herbicides.

In southern QLD, seven weeds are confirmed resistant – wild oats (Group A herbicides), turnip weed, African turnip weed, Indian hedge mustard, common sowthistle and black bindweed (Group B herbicides), and liverseed grass (Group C herbicides). The areas of Group A resistant wild oats and Group B resistant broadleaf weeds could increase further, particularly in those parts of the region that grow predominantly winter crops. New weeds at most risk of developing resistance in southern QLD are barnyard grass, liverseed grass, common sowthistle and wild oats, to Group M herbicides. Other weeds at risk, but to a lesser extent, are paradoxa grass to Group A herbicides, other brassica weeds to Group B herbicides, and barnyard grass to Group C herbicides.

In northern NSW, nine weeds are confirmed resistant – wild oats and paradoxa grass to Group A herbicides, turnip weed, Indian hedge mustard, common sowthistle and charlock to Group B herbicides, barnyard grass to Group C herbicides, wild oats to Group K herbicides, and annual ryegrass to Group M herbicides. The risk for further spread of these weeds is high for wild oats and paradoxa grass to Group A herbicides, and ryegrass to Group M herbicides, moderate for brassica weeds to Group B herbicides and barnyard grass to Group C herbicides, and moderately low for common sowthistle to Group B herbicides. New weeds at most risk of developing resistance are wild oats, barnyard grass, liverseed grass, common sowthistle to Group M herbicides, ryegrass to Group A herbicides, and black bindweed and other brassica weeds to Group B herbicides. More recently, wild oats were assessed at risk of developing resistance to Group B herbicides.

Devising and testing resistance strategies:

Preventative strategies were developed for annual ryegrass, wild oats and paradoxa grass (Group A, M); barnyard grass, liverseed grass and sweet summer grass (Group C, M); common sowthistle (Group B, M); parthenium weed and brassica weeds (Group B). This was done in consultation with industry and other researchers.

Overall, the short-term and long-term trials in the three cropping zones demonstrated that the proposed preventive weed management strategies were highly effective in weed control, and did not have any unfavourable impacts on crop yield. In fact, the southern QLD long-term trials indicated that yields were increased by 6% using strategies based on rotation of herbicide MOA groups and using more effective options.

The short-term seasonal field trials in southern QLD tested the effectiveness of herbicide alternatives to Group M herbicides for sowthistle (two trials), liverseed grass (one trial) and wild oats (one trial) in fallow. The central QLD trial targeted sweet summer grass. Alternatives included Group L (Sprayseed®#) alone, Group M + B, M + I mixes, and double knockdown (Group M followed by Group L). Treatments were applied early (plants less than 3cm diameter) and late (plants up to 10cm diameter). For each weed, control was maximised when spraying young weeds that weren't moisture stressed. Also, maximum control required herbicides to be applied at a high rate, especially if in a mixture (to avoid antagonism between Group M and some Group I herbicides). For Group L herbicides, the water volume had to be increased to 100 L/ha for better plant coverage, as Sprayseed® applied at a water volume of 60L/ha achieved poor weed control. The most effective alternatives were Group L applied alone, M + I mixtures and double knockdown treatments when applied correctly.

Short-term trials in central and southern QLD on crop competition demonstrated that wheat row spacing and population had a substantial impact on crop yield and weed control. Wheat yields were lower and weed control poorer when the crop was sown in rows greater than 35cm and in populations less than one million plants per hectare. These findings support earlier research on crop competition.

The short-term trials in NSW tested herbicide alternatives to glyphosate for barnyard grass (one trial), and alternative options for herbicide resistant wild oats (three trials), annual ryegrass (two trials) and wild radish (one trial). Flame®# (Group B) gave very good residual control of barnyard grass, and paraquat# and Sprayseed® were highly effective but application timing was more critical. Mataven®# (Group K) was effective on Group A resistant wild oats, but herbicide options for Group A & K plus possibly Group B resistant wild oats are very restricted for winter crops. Double knock with Group L herbicides was effective on glyphosate resistant annual ryegrass, as well as several residual Group B herbicides when activated by following rain. Group A herbicides worked under favourable conditions but were ineffective on larger plants under harsh conditions.

The southern QLD long-term on-farm field trails tested six different weed management strategies, integrating crop competition, herbicide MOA group rotation, herbicide mixes, cultivation, double knockdown and crop rotation. Preventive

Refer to 'Report Disclaimer'

strategies were tested in a commonly used summer and winter cropping rotation with weed control, seed bank replenishment and crop yield compared against that achieved by district practices, as identified through grower and agronomist workshops. The preventive strategies differed from district practices with some having only one change or addition per season and others having several changes per season. The trials were done on four paddocks over two years.

They showed that preventive strategies achieved equal, if not better, weed control of the target weeds than the district practices. Overall, weed control was generally 100% in preventive strategies and weed emergence reduced by 80–100% over the two years of the trials. Growing a competitive crop species (barley) achieved 100% weed control without herbicides. Group L effectively controlled target weeds, and cultivation at planting eliminated a pre-plant herbicide application. These are both viable alternatives to applying Group M herbicides. Using the preventive strategies did not compromise crop (wheat, sorghum and chickpeas) yield.

The central QLD long-term on-farm field trial showed some initial promising results on the management of sweet summer grass, but adverse weather (drought and then floods) forced the trial site to be abandoned.

The NSW long-term trials were conducted at Spring Ridge, Edgeroi and Coonamble between December 2002 and June 2005. Main weeds at the Spring Ridge site included glyphosate resistant annual ryegrass, plus wild oats, black bindweed and awnless barnyard grass, while Coonamble had Group A resistant wild oats, plus paradoxa grass, annual ryegrass, black bindweed, wireweed and turnip weed, and Edgeroi had wild oat, black bindweed, sowthistle and awnless barnyard grass.

Species shift began within a relatively short period of time. For example, annual ryegrass numbers increased due to the focus on managing Group A resistant wild oats at the Coonamble site.

Multiple management techniques were required each season. The 'old' technique of applying a pre or post emergent herbicide and walk away are finished. The trials showed that early herbicide applications needed to be used in combination with crop competition, full disturbance sowing, selective spray-topping and crop-topping or desiccation to eliminate seed set and manage weed seed banks.

Wide rows reduced crop competition but created an opportunity for inter-row spraying. This was clearly shown at the Coonamble site in chickpeas, where excellent weed and seed set control was achieved with shielded inter-row spraying of paraquat after pre- and post-emergent herbicide treatments. The availability of precision steering mechanisms will allow the development and adoption of inter-row spraying and cultivation.

Residual herbicides need to be targeted at fallow weed control. These trials found that the use of short term residual herbicides in fallow can reduce the need for up to three glyphosate applications. This has the benefits of reducing the selection pressure on glyphosate and creating better and more timely weed control, because other paddocks can be sprayed at the optimum time.

Keeping weed numbers low is a key to resistance management. The Edgeroi site started with low weed numbers and these were kept low with diligent yet relatively simple strategies.

Communication:

The project extension efforts raised awareness of herbicide resistance and increased the capacity of weed managers and advisers to slow or prevent development of herbicide resistance. The activities leading to this result were

- A communication strategy with appropriate key messages and an identifiable project 'brand'
- A database of herbicide resistance extension material
- A database of growers and agronomists interested in herbicide resistance information
- Six issues of the biannual project newsletter 'Northern Herbicide Resistance Reporter' delivered to 550 growers, agronomists and researchers
- 10 workshops held across the northern grains region (Goondiwindi, Spring Ridge, Coonamble, Edgeroi, Croppa Creek, Dalby, Roma, Miles, Emerald, Biloela) and attended by 225 growers
- 25 presentations and field days communicating the project messages to growers and agronomists
- 55 articles in rural media and magazines for the wider audience
- Four presentations at national conferences for other herbicide resistance researchers
- One journal paper
- Three brochures, one for each of the three cropping zones, with locally-relevant preventive management strategies for

key weeds at risk of resistance.

In 2004 the project team surveyed 120 agronomists and growers in the northern region to evaluate the impact of our project. Key findings were that

- Concern and awareness of herbicide resistance had increased
- Understanding of many resistance issues was high, but there were misconceptions for some important issues
- Advisers' confidence was high in the information they deliver
- The majority of advisers recommend some form of preventive actions
- Many growers are now taking some preventive actions for Group A and B but not for Group M
- Usefulness of the project's newsletter was rated moderate to high
- Growers receiving the project's newsletter had greater concern and awareness, and used more preventive actions.

This project has successfully delivered all planned outputs that will help ensure the maximum effective life of important herbicides that play a pivotal role in the viability and flexibility of conservation cropping in the northern region.

Other research

National collaboration and co-ordination with other research, development and evaluation (RD&E) activities on herbicide resistance is important, and being addressed by the project team being members of the national Glyphosate Sustainability Working Group (GSWG) and contributing to activities within the Cooperative Research Centre (CRC) for Australian Weed Management.

This project identified a range of potential preventive actions, but it became very obvious that research was needed to rank these options in effectiveness in preventing resistance, as well as identify the most appropriate timing to impose these tactics in the cropping systems. This will be achieved in the new project 'Modelling for sustainable use of glyphosate in the northern region' (DAQ00079).

Not all potential preventative options were researched in this project for the major weeds identified at risk. As well, other important weeds at risk need preventative strategies, and weeds that recently developed resistance to Group A, K and M need new management plans. This will be achieved in the follow-on project 'Risk assessment and preventative strategies for herbicide resistance in the northern region (Phase II)'.

It is evident that resistance is a low risk in paddocks with low weed numbers. RD&E is still needed on improved management of the region's major weeds to run-down and keep the seed-bank low. This is being addressed to some extent with current projects in central QLD and southern QLD, for example DAQ00064 and Weeds CRC 2.2.2.2, but more is needed particularly for weeds in northern NSW.

Additional information

Osten, Walker, Storrie, Widderick, Moylan, Robinson & Galea (2005). Weed diversity and management in relation to cropping practices in the north-eastern grain region of Australia. Australian Journal of Experimental Agriculture.
Storrie & Cook (2002). Glyphosate resistance in northern New South Wales - a growing concern. 13th Aust Weeds Conf, Perth.
Storrie & Cook (2002). Management of acetyl coA carboxylase (ACCASE) inhibitor resistant wild oats in northern NSW 13th Aust Weeds Conf, Perth.
Walker, Osten, Storrie, Robinson, Cook & Galea (2002). Weeds at risk of developing herbicide resistance in the different cropping systems of the northern region. 13th Aust Weeds Conf, Perth.
Walker, Widderick, Storrie, Osten (2004). Preventing glyphosate resistance in weeds of the northern grain region. 14th Aust Weeds Conf, Wagga Wagga.