Herbicide resistance
in the rice growing regions of southern Australia

A report for the Rural Industries Research and Development Corporation

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Foreword

Herbicide resistance in Australia’s rice industry is a major threat to the sustainability of the industry. Weed control in the rice industry has been dependent on only a few herbicides and significant levels of resistance are emerging to one of the major herbicides (bensulfuron or Londax®).

Resistant weed populations have the potential to: significantly reduce the area suitable for rice growing; increase the use of yield damaging herbicides; and increase the possibility of MCPA herbicide drift damaging neighbouring crops e.g. grapes. The environmental effects of resistance include: putting ineffective herbicides into the farming system; the use of increased rates of recommended herbicides and the use of more applications of selective chemicals to control weeds i.e. thiobencarb (Saturn®) for dirty dora.

This report presents base line data on the extent of herbicide resistance in the major weeds of rice to the herbicides used for their control in the Murrumbidgee (MIA), Coleambally (CIA) and Murray Valley (MVID) rice growing regions.

This report, a new addition to RIRDC’s diverse range of over 600 research publications, forms part of our Rice R&D program, which aims to improve the profitability and sustainability of the Australian rice industry.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- downloads at www.rirdc.gov.au/reports/Index.htm
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Peter Core
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Acknowledgments

Ricegrowers Co-operative Mill Laboratories at Leeton for samples provided.

NSW Agriculture personnel for collection of in-field samples

Abbreviations

MIA  Murrumbidgee Irrigation Area
CIA  Coleambally Irrigation Area
MVID  Murray Valley Irrigation Districts
CSU  Charles Sturt University
SU  sulfonylurea
a.i.  active ingredient
0.5R  half recommended rate
1R  recommended rate
2R  twice recommended rate
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Executive Summary

Weed seed samples were collected from across the rice-growing regions of southern New South Wales. These samples were tested against the relevant range of commercial herbicides for their control to establish benchmark levels of resistance for each weed/herbicide combination.

Four species of barnyard grass (*Echinochloa* spp.) were collected during the survey. These species had slightly different germination patterns that resulted in them being at slightly different growth stages during herbicide application. If mixed populations occur in the field this is of major importance when dealing with a herbicide like thiobencarb (Saturn®) which has a narrow range of growth stages for effective application.

High levels of resistance to bensulfuron (Londax®) were detected in all three weeds tested to the herbicide. Approximately 50% of dirty dora (*Cyperus difformis*), 40% of starfruit (*Damasonium minus*) and 35% of arrowhead (*Sagittaria montevidensis*) accessions were classed as resistant. Starfruit accessions collected in the random survey for this project had a higher percentage of resistance to bensulfuron than samples that had been sent to the herbicide resistance testing service at Charles Sturt University.

No accessions of barnyard grass were classed as resistant to any of the herbicides tested (thiobencarb, propanil - Ronacil®, clomazone – Command® and molinate – Ordram®). All accessions of arrowhead and starfruit were susceptible to the tested herbicides other than bensulfuron (benzofenap – Taipan® and MCPA). One dirty dora accession was poorly controlled by MCPA as were two accessions by propanil but all accessions were well controlled by benzofenap.

At present, herbicide resistance in weeds of rice appears to be confined to bensulfuron. However it remains important for farmers to implement appropriate herbicide resistance management in order to protect the viability of the herbicide options.
1. Introduction

1.1 Background

Herbicide resistance in Australia’s rice industry is a major threat to the sustainability of the industry. Weed control in the rice industry has been dependent on only a few herbicides and significant levels of resistance are emerging to one of the major herbicides (bensulfuron or Londaz®). Herbicide resistance testing provided by CSU in collaboration with DuPont Pty Ltd and Ricegrowers Co-operative Ltd has found significant levels of resistance in samples submitted for testing over the past seven seasons (1994 – 75%, 1995 – 86%, 1996 – 83%, 1997 – 87%, 1998 – 94%, 1999 – 100% and 2000 – 58%).

Herbicide resistance testing became available to rice growers in 1994, with very limited uptake. From distributing 2000 testing kits through Ricegrowers Co-operative in 1994 and 1995, and 500 kits in 1996 the service only received 25, 22 and 29 samples respectively. In 1997 the service received 62 samples as a result of DuPont representatives collecting the samples. In 1998 16 samples were received, in 1999 3 samples and in 2000, 33 samples were received (again mainly from DuPont representatives). The vast majority of the samples provided are Cyperus difformis (dirty dora) with only small numbers of Damasonium minus (starfruit), Sagittaria montevidensis (arrowhead) and Echinochloa spp. (barnyard grass) supplied. This decline in farmer supplied samples for testing reduces the ability of the rice industry to monitor herbicide resistance trends.

The Rice Weed Management Working Group (comprising industry representatives from NSW Agriculture, Agropraisals Pty Ltd, chemical companies, RIRDC representatives, rice growers, agronomists and CSU) identified the need to obtain base line data in order to evaluate the performance of herbicide resistance weed management programs proposed by the group each growing season. The effectiveness of these strategies in terms of managing resistance, has not been quantified and thus the extent and levels of resistance need to be established so as to measure future performance. By determining the extent of resistance in various weed populations more strategic recommendations can be developed. This will enhance the life of current herbicides through better rotations; keep additional herbicide use to a minimum; and reduce the incidence of weed control failure due to resistance.

Resistant weed populations have the potential to: significantly reduce the area suitable for rice growing; increase the use of yield damaging herbicides; and increase the possibility of MCPA herbicide drift damaging neighbouring crops e.g. grapes. The environmental effects of resistance include: putting ineffective herbicides into the farming system; the use of increased rates of recommended herbicides and the use of extra chemicals to control selective weeds i.e. thiobencarb (Saturn®) for dirty dora.

1.2. Herbicide resistance in rice

Herbicide resistance is an ever increasing problem in Australia and elsewhere. The first occurrence in Australia was documented by Heap and Knight (1982). Resistance was confirmed in four species by 1987 (Powles 1987), six species in 1990 (Powles and Holtum 1990; Powles and Howat 1990) and seven in 1992 (Howat 1992). This number has increased significantly since then with Preston et al. (1999) documenting 22 species in which resistance has occurred, including three which are weeds of rice (Graham et al. 1996). This includes weed species that have developed resistance to chemicals in lower risk categories.

Given that resistance to sulfonylurea (SU) herbicides has occurred extensively in dryland cropping systems in Australia, it is not surprising that resistance to this herbicide has developed under current
rice farming systems. Bensulfuron (Londax®) has been used extensively and almost exclusively on NSW rice crops for around ten years as the only form of aquatic weed control. However, unlike terrestrial crops where the management options are numerous to overcome the problem of herbicide resistance, very few management tools are currently available to overcome this problem in the rice growing regions of southern Australia (Graham et al. 1996).

A survey of farms conducted in early 1993 where rice crops had received three or more applications of bensulfuron found 94% of dirty dora accessions, 40% of starfruit and 33% of arrowhead to be resistant to bensulfuron (Graham et al. 1996). CSU operates a herbicide resistance screening service for rice weeds and, since 1994, 190 rice weed accessions have been received of which 80% (153) were found to be resistant to bensulfuron. These accessions are biased towards situations where resistance is suspected and cannot be used as an industry benchmark. The current project establishes the benchmarks.

1.3 Objectives

The objective of this work was as follows:

- To determine the base level of herbicide resistance in *Cyperus difformis* (dirty dora), *Damasonium minus* (starfruit), *Sagittaria montevidensis* (arrowhead) and *Echinochloa crus-galli* (barnyard grass).
2. Methodology

2.1 Sample collection

2.1.1 Dirty Dora (Cyperus difformis)

Sixty-seven samples of dirty dora seed were collected for the resistance screening. This seed came from two sources, a random survey by NSW Agriculture personnel and random samples from the Rice Growers Co-operative laboratories. The survey conducted by NSW Agriculture personnel collected 22 samples. The remaining 45 samples were collected from screenings provided from every tenth sample collected by the Rice Growers Co-operative Mill laboratories in Leeton. All mills send a sample to the laboratory of every load of rice received. These samples were then sieved to collect any dirty dora seed.

2.1.2 Starfruit (Damasonium minus)

Thirty-five samples of starfruit seed were collected for this project. This seed came from two sources, a random survey and samples submitted over time to the Farrer Centre herbicide resistance testing service. Fourteen seed samples were collected by NSW Agriculture personnel throughout the CIA (six samples) and MVID (eight samples) rice regions. The other 21 samples were taken from the herbicide resistance testing service seed store representing the three rice growing regions.

2.1.3 Arrowhead (Sagittaria montevidensis)

A random survey was used to collect samples of arrowhead seed in the MIA and CIA. A route was drawn to sample the majority of the two regions. At three kilometre intervals along the route the nearest rice bay was selected for sampling, alternating between fields on the left and right of the road if possible. If no rice was present near a stopping point the next bay along the route was selected. If the bay selected contained no arrowhead this fact was recorded. This survey visited 112 sites of which 80 had arrowhead present, with sufficient amounts of viable seed for resistance testing able to be collected at 69 of these sites.

2.1.4 Barnyard Grass (Echinochloa spp.)

All barnyard grass samples were obtained from the samples of rice screenings from the Rice Growers Co-operative Mill laboratories in Leeton as described for dirty dora. These samples were then sieved to collect any barnyard grass seed, resulting in 64 samples being collected.

2.2. Resistance screening

2.2.1 Plant establishment

Circular plastic tubs (diameter - 11cm, depth - 6cm) were filled to a depth of 3cm with a red clay loam and placed in a glasshouse with the temperature maintained at 20-30°C. The tubs were watered to field capacity and sown with 0.1 g of seed or 25 seeds for the larger seeded species. The tubs were then watered to maintain field capacity until germination was nearly complete at which stage they were flooded to a depth of 2–3cm. The tubs were fertilised with urea at a rate of 50kg N ha\(^{-1}\) when the plants were at the one leaf growth stage.

Slight modifications to the methodology were necessary for the starfruit and barnyard grass tests. For the starfruit, three to four days after sowing, 110mL of a 150µg mL\(^{-1}\) ethephon solution was added to enhance germination. The tubs containing the barnyard grass were not flooded but were maintained at
around field capacity for the entire experiment. All treatments were replicated three times and the tubs were arranged in a randomised block design.

### 2.2.2 Herbicide application

For the four weed species tested, a total of seven herbicides were used. The herbicides used were bensulfuron (Londax®), thiobencarb (Saturn®), benzofenap (Taipan®), MCPA, propanil (Ronacil®), clomazone (Command® or Magister®) and molinate (Ordram®). Table 2.1 shows which herbicides were applied to each of the weed species along with the recommended rate for that herbicide in both litres, or grams, per hectare and grams of active ingredient (a.i.) per hectare.

#### Table 2.1: Herbicides used in the resistance screening

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rec. rate</th>
<th>g a.i. / kg or L</th>
<th>g a.i. / ha</th>
<th>dirty dora</th>
<th>arrowhead</th>
<th>starfruit</th>
<th>barnyard grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>bensulfuron</td>
<td>85 g</td>
<td>600</td>
<td>51</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>thiobencarb</td>
<td>5 L</td>
<td>800</td>
<td>4000</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>benzofenap</td>
<td>2 L</td>
<td>300</td>
<td>600</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCPA</td>
<td>2.7 L</td>
<td>250</td>
<td>675</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>propanil</td>
<td>16 L</td>
<td>360</td>
<td>5760</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>clomazone</td>
<td>0.5 L</td>
<td>600</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>molinate</td>
<td>3.75 L</td>
<td>860</td>
<td>3225</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

- denotes herbicide recommended for weed species

Four rates of herbicide were applied, 0, 0.5, 1 and 2 times the recommended field rate. Herbicides were applied using one of two methods. MCPA and propanil were applied in a spray cabinet using a Tee-Jet nozzle moving at 6km per hour applying 80L of water per hectare at a pressure of 300kPa.

The remaining herbicides were applied at the recommended rate by injecting 10mL of the appropriate dilution into each of the flooded tubs for the recommended rate. For the half and two times recommended rate treatments 5mL and 20mL, respectively, of the same dilution were injected into the tubs. Herbicides were applied when the plants were at the appropriate growth stages as per label recommendations (Table 2.2).

#### Table 2.2: Stage at which herbicides were applied to different weed species

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>dirty dora</th>
<th>arrowhead</th>
<th>starfruit</th>
<th>barnyard grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>bensulfuron</td>
<td>0-3 leaf</td>
<td>0-3 leaf</td>
<td>0-3 leaf</td>
<td>-</td>
</tr>
<tr>
<td>thiobencarb</td>
<td>0-2 leaf</td>
<td>-</td>
<td>-</td>
<td>0-3 leaf</td>
</tr>
<tr>
<td>benzofenap</td>
<td>0-3 leaf</td>
<td>0-3 leaf</td>
<td>0-3 leaf</td>
<td>-</td>
</tr>
<tr>
<td>MCPA</td>
<td>0-3 leaf</td>
<td>0-3 leaf</td>
<td>0-3 leaf</td>
<td>-</td>
</tr>
<tr>
<td>propanil</td>
<td>0-2 leaf</td>
<td>-</td>
<td>-</td>
<td>4-5 leaf</td>
</tr>
<tr>
<td>clomazone</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1-4 leaf</td>
</tr>
<tr>
<td>molinate</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1-4 leaf</td>
</tr>
</tbody>
</table>

Twenty-eight days after herbicide application the tubs were visually scored based on percentage survival in comparison to the control. The control is rated 10 and each treatment within that replication is then compared to it. Data analysis was conducted using two-way analysis of variance with scores expressed as proportions of their untreated controls.
3. Results

3.1 Sample Collection

3.1.1 Arrowhead (*Sagittaria montevidensis*)

In the two rice growing regions (MIA and CIA) surveyed 112 sites were selected for collection of arrowhead seed. Of these 80 had arrowhead seed present although at eleven of the sites there was insufficient viable seed present to allow the full range of resistance screening to be undertaken and these samples were omitted from that part of the project.

The proportion of sites with arrowhead present was different in the two regions. Eighty-five percent of sites in the MIA contained arrowhead while only 50 percent of the sites surveyed in the CIA contained arrowhead plants (Figure 3.1).

![Figure 3.1: Presence of arrowhead samples in random survey](image)

3.1.2 Barnyard Grass (*Echinochloa* spp.)

Among the 70 samples of barnyard grass collected it was noted that four different species of *Echinochloa* were present. The majority of the samples were *E. crus-galli* or barnyard grass. The three other species present were *E. oryzoides* or hairy millet, *E. colona* (awnless barnyard grass) and *E. microstachya* (prickly barnyard grass). The samples of *E. oryzoides* had a slightly different germination pattern than the other three species which led to problems with the application of thiobencarb.
3.2 Resistance screening

For all herbicides except MCPA, accessions were classified as resistant if for two of the three herbicide rates used (half recommended rate (0.5R), recommended rate (1R) or twice recommended rate (2R)) they had an average score of greater than two or a score higher than the least significant difference after statistical analysis if that was greater than two. For the accessions sprayed with MCPA the threshold used was 2.5 or the least significant difference as the MCPA was applied to the plants at a later growth stage.

3.2.1 Dirty Dora (Cyperus difformis)

Sixty-seven seed accessions were screened to the five herbicides selected for dirty dora. All accessions were well controlled by the application of benzofenap.

Two accessions were poorly controlled by propanil. Both of these accessions had scores of greater than 6 at 0.5R (l.s.d. = 1.6, P<0.001). At 1R these samples had scores of 4 and 2 while at 2R the scores were 0.33 and 0 respectively. Further testing needs to be carried out on these accessions to confirm if the reason for the poor control is resistance or the result of other factors.

Sixty-six samples were well controlled by the application of MCPA. The remaining sample had scores of 0.67, 5.67 and 2.67 for 0.5R, 1R and 2R respectively (l.s.d. = 1.8, P<0.001). There was, however, a large variability in the scores obtained for each replicate at 1R and 2R. At 1R the replicate scores were 8, 9 and 0 while for 2R they were 8, 0 and 0. This accession is being screened to MCPA again to confirm resistance or otherwise.

For the bensulfuron screening, accessions with a value of 3.0 or greater were classified as resistant (l.s.d. = 2.802, P<0.001). Of the 67 accessions, 31 were considered resistant as they had scores of greater than 3.0 for two of the three herbicide rates used (Figure 3.2).

![Figure 3.2: Range of scores for dirty dora accessions after treatment with bensulfuron at 0.5R, 1R and 2R](image-url)

Figure 3.2: Range of scores for dirty dora accessions after treatment with bensulfuron at 0.5R, 1R and 2R
Twenty-one accessions were poorly controlled in the first screening to thiobencarb and were therefore retested. The criteria for retesting was that accessions with a score greater than two for one replicate at either 1R or 2R or two replicates at 05R. In the second screening all accessions were well controlled by this herbicide and therefore none of the 21 accessions were classified as resistant. The poor control experienced for some accessions in the first test may have been the result of the herbicide being applied at too late a growth stage.

3.2.2 Starfruit (*Damasonium minus*)

Thirty-five accessions of starfruit were screened to three herbicides. Of the 35 samples, one was a known susceptible from an organic rice farm, 14 were collected in a random survey and the remaining 20 were from the Farrer Centre herbicide resistance testing service seed collection. All accessions were well controlled by the application of benzofenap or MCPA and therefore no accessions were classified as resistant to either of these herbicides.

When treated with bensulfuron accessions with a score of 2.5 or greater were classed as resistant (l.s.d. = 2.471, P<0.001). Fifteen accessions were classified as resistant (Figure 3.3) and of these seven were from the survey and the other eight from the resistance testing service.

There was no difference in the level of resistance for the two regions from which samples were obtained in the random survey. Fifty percent of samples from both regions were classed resistant, three out of six from the CIA and four out of eight from the MVID.

3.2.3 Arrowhead (*Sagittaria montevidensis*)

Sixty-nine accessions of arrowhead were screened to three herbicides. No accessions were classified as resistant to either benzofenap or MCPA. However, the results of the bensulfuron were markedly different. Accessions with a value of 3.6 were classified resistant (l.s.d. = 3.596, P<0.001). Of the 69 accessions, 24 were considered resistant as they had scores of greater than 3.6 for two of the three herbicide rates (Figure 3.4).
There was a great difference in the level of resistance present in the two regions surveyed. Twenty of the 39 samples from the CIA were resistant (51 percent) while only six out of 24 samples tested from the MIA were resistant (25 percent).

### 3.2.4 Barnyard grass (*Echinochloa* spp.)

Seventy seed accessions were tested to four herbicides in the barnyard grass screening. No accessions were classed as resistant to three of the herbicides; propanil, molinate or clomazone. At the recommended rate of these herbicides no accession had a score of greater than 1.4 (Figure 3.5).

Initial screening to thiobencarb showed a lot of accessions were poorly controlled by the herbicide. Any accessions where the score was greater than two for one replicate at either 1R or 2R or two replicates at 0.5R was selected for retesting. Upon retesting all samples were well controlled resulting in no samples being classed as resistant suggesting, as with dirty dora, that the poor timing of the herbicide application had an impact on the level of control experienced.
4. Discussion

Of all the different herbicides evaluated in this trial only bensulfuron exhibited high levels of resistance. With the exception of MCPA and propanil no accessions were classed as resistant for any of the other herbicides used in this project. The possible resistance to MCPA and propanil needs to be confirmed with further testing.

All three weed species in this survey controlled by bensulfuron exhibited levels of resistance of greater than 35 percent to the herbicide. This herbicide is a member of the sulfonylurea group of herbicides which is classified as high risk in the development of herbicide resistance. In addition, it has been the herbicide of choice for many rice farmers due to its ease of use and wide spectrum of weed species controlled. This repeated use of an individual herbicide is a major factor in the development of herbicide resistance in any farming system.

All other herbicides tested in this survey are classed as herbicides with a moderate risk of herbicide resistance development with the exception of MCPA that is classed as low risk. This factor and the fact that these herbicides do not have the same history of intensive use in rice crops as bensulfuron is reflected in the results with only three accessions of the four species tested being poorly controlled by any of the other herbicides (Table 4.1). These samples need to be retested to confirm that the poor control is due to resistance and not other factors.

Table 4.1: Benchmark levels of resistance for the four species surveyed.

<table>
<thead>
<tr>
<th></th>
<th>Dirty dora</th>
<th>Starfruit</th>
<th>Arrowhead</th>
<th>Barnyard Grass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. of samples</strong></td>
<td>67</td>
<td>35</td>
<td>69</td>
<td>70</td>
</tr>
<tr>
<td><strong>Herbicide</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bensulfuron</td>
<td>31</td>
<td>46.2</td>
<td>15</td>
<td>42.8</td>
</tr>
<tr>
<td>Thiobencarb</td>
<td>0</td>
<td>0</td>
<td>na</td>
<td>-</td>
</tr>
<tr>
<td>Benzofenap</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MCPA</td>
<td>1*</td>
<td>1.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Propanil</td>
<td>2*</td>
<td>3</td>
<td>na</td>
<td>-</td>
</tr>
<tr>
<td>Clomazone</td>
<td>na</td>
<td>-</td>
<td>na</td>
<td>-</td>
</tr>
<tr>
<td>Molinate</td>
<td>na</td>
<td>-</td>
<td>na</td>
<td>-</td>
</tr>
</tbody>
</table>

* - to be confirmed

The three accessions were poorly controlled by herbicides other than bensulfuron were all dirty dora accessions. Two of the accessions were poorly controlled by propanil and one by MCPA. While these accessions may be resistant to the herbicide other factors may be involved in the poor control experienced. Dirty dora seedlings have an erect growth habit with narrow, shiny leaves and the two herbicides with poor control are the only two where the method of application is by spraying and not adding a herbicide solution to the flooded tubs. These accessions may have been poorly controlled simply as a result of insufficient herbicide being absorbed by the plant for it to be effective because of the characteristics of the plant itself.

A large number of accessions were poorly controlled after treatment with thiobencarb for both dirty dora and barnyard grass. Upon retesting all of these accessions were well controlled by the herbicide. The most likely cause for the high scores in the first test for these two species is that the herbicide was applied at later than the recommended growth stage and this resulted in the poor control. This emphasises the need for accurate record keeping and resistance testing to firstly determine that the herbicide was applied at the correct time and rate and then confirm that the reason for poor control is due to resistance and not some other factor.

The four different species of barnyard grass collected in the survey had slightly differing germination patterns. The result of this was that the majority of samples that were retested to thiobencarb were E.
oryzoides. The dirty dora accessions, although one species, also exhibited slight differences in the germination rate.

5. Implications

The differing germination regime of the four barnyard grass species has major implications for effective herbicide use especially when using thiobencarb. If mixed populations of these species are present in the field, difficulties may arise in the timing of the herbicide application as there is only a small window of growth stages at which this herbicide is effective.

The high level of resistance to bensulfuron in the three major weeds it controls is of major concern for the rice industry. No other herbicide has the same spectrum of weeds controlled, with the same window of application or lack of constraints on application. Resistance to this herbicide will result in other less effective, harder to use herbicides being necessary to control these weeds with and decrease in the profitability of the rice industry as a whole.

That poor control can be experienced even under the most controlled of conditions means that care needs to be taken with herbicide application on farm to ensure maximum efficacy of the herbicide applied. Poor control, in many cases, may be due to poor application technique or timing rather than resistance. Management needs to be good enough to enable maximum benefit from herbicide use. This benchmarking study provides appropriate background against which to generate extension programs.

6. Other Issues

6.1 Water plantain (*Alisma plantago-aquatica*)

This project was also to include evaluation of water plantain. However this proved more complicated that originally considered. There were issues of regeneration from seedlings versus regeneration from corms as well as achieving adequate germination. This aspect has been transferred to project UCS-20A which is investigating these aspects more fully.

6.2 MCPA efficacy

At the most recent meeting of the Rice Weeds Management Group, concern was expressed regarding variable performance of MCPA. It was agreed that CSU would endeavour to investigate aspects of this problem. This has also been transferred to project UCS-20A for a more complete investigation.
7. References


