Rotational weed control practices in rice

A report for the Rural Industries Research and Development Corporation

by Malcolm Taylor, Agropraisals Pty. Ltd.

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Every ricefield and every weed population is different, so appraise yourself of all the facts from all the sources before making your management decisions.

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In submitting this report, the researcher has agreed to RIRDC publishing this material in its edited form

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Foreword

Effective weed management is a critical factor in attaining profitable rice production in all regions of the world. In Australia where rice is produced as an irrigated summer crop, yields must be high (typically > 9 t/ha) in order to be profitable in comparison to competing uses for the limited irrigation water.

Australian ricegrowers aim for freedom from weed competition throughout the life of the crop and particularly the first 45 days after seeding. In order to achieve this, precision field leveling, clean seed, weed free seedbeds and rapid inundation are integrated with timely and accurate herbicide application.

The Australian rice industry has long recognised the importance of effective weed management with constant investment in weed control research for nearly 30 years. Agropraisals Pty. Ltd. have assisted with this research for the past decade.

This project was funded from rice industry revenue which is matched by funds provided by the Federal Government. This report, is an addition to RIRDC’s diverse range of over 1000 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:


**Simon Hearn**
Managing Director
Rural Industries Research and Development Corporation
Acknowledgments

The author wishes to gratefully acknowledge the assistance of the following individuals and companies in the conduct of this research program:


The Rice Research and Development Committee of RIRDC generously funded this program.

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Text in full</th>
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<tr>
<td>gai/ha</td>
<td>grams active ingredient per hectare</td>
</tr>
<tr>
<td>l prod./ha</td>
<td>litres product per hectare</td>
</tr>
<tr>
<td>SCWIIRT</td>
<td>Soluble Chemical Water Injection In Rice Technique</td>
</tr>
<tr>
<td>LSR</td>
<td>Leaf stage rice</td>
</tr>
<tr>
<td>HRAC</td>
<td>Herbicide Resistance Action Committee</td>
</tr>
<tr>
<td>MOA</td>
<td>Mode of action</td>
</tr>
<tr>
<td>EPE</td>
<td>Early post emergence</td>
</tr>
<tr>
<td>PSPE</td>
<td>Post sowing pre emergence</td>
</tr>
<tr>
<td>PFPE</td>
<td>Post flood pre emergence</td>
</tr>
<tr>
<td>PREPW</td>
<td>Pre permanent water</td>
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<tr>
<td>GRDC</td>
<td>Grains Research and Development Corporation</td>
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<thead>
<tr>
<th>Bayer Codes</th>
<th>Species</th>
<th>Common name</th>
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<tbody>
<tr>
<td>ORISA</td>
<td><em>Oryza sativa</em></td>
<td>rice</td>
</tr>
<tr>
<td>ECHCG</td>
<td><em>Echinochloa crus galli</em></td>
<td>barnyard grass</td>
</tr>
<tr>
<td>LEFPA</td>
<td><em>Leptochloa fusca</em></td>
<td>silvertop grass</td>
</tr>
<tr>
<td>CYPDI</td>
<td><em>Cyperus difformis</em></td>
<td>dirty Dora</td>
</tr>
<tr>
<td>DAMMI</td>
<td><em>Damasonium minus</em></td>
<td>starfruit</td>
</tr>
<tr>
<td>SAGMO</td>
<td><em>Sagittaria montevidensis</em></td>
<td>arrowhead</td>
</tr>
<tr>
<td>TYPSP</td>
<td><em>Typha spp.</em></td>
<td>cumbungi</td>
</tr>
<tr>
<td>ELOSS</td>
<td><em>Eleocharis acuta.</em></td>
<td>common spikerush</td>
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Executive Summary

Removal of weed competition using herbicides is a critical requirement for economic direct seeded rice production throughout the world. Direct seeding of rice results in concurrent establishment of rice and weeds. In the event of no control being exercised, weeds will commonly smother the crop with little or no prospect of a harvestable yield; resulting in the worst possible economic and environmental outcome from the resources invested. In Australia herbicides have been used for weed management in rice production for approximately 50 years.

Selection of herbicide resistant weed biotypes was first confirmed in Australian rice in 1993 and they are now common in all rice-growing districts.

In the past decade the Australian rice industry has met the challenges of effective weed management and herbicide resistance development by a measured approach of understanding the issues, researching alternative options, definition of best management practices and enacting these practices by involving and informing key participants at each step.

Australian ricegrowers have sought strategic approaches to herbicide use by attaining a wider range of registered products, multiple sources of generic products and novel approaches to application to improve timeliness, efficiency of delivery and reduction in spray drift hazards.

Agropriasals Pty. Ltd. has played a liaison role between the agro-chemical industry and ricegrowers for 18 years and has generated much of the field research necessary to provide new management options for weed control in rice. Collaboration and co-operation between the RR&DC and agro-chemical manufacturers over the past decade through this program has led to tangible benefits to growers. Australian ricegrowers were the first in the world to use benzofenap and clomazone in water-seeded rice. Registrations are now pending for clomazone in drill seeded rice and bentazon plus MCPA sodium in water-seeded rice. Such rotational options for herbicide use are not available to ricegrowers in California or Italy. By using an increasingly broader array of herbicides, the risks of rapid resistance development in weed populations is eased by permitting multiple mode of action (MOA) programs and seasonal rotation of MOA’s.

Internationally, the flow of new agricultural chemicals has slowed to a trickle due to a combination of patent maturation leading to growing generic competition, increased regulatory hurdles and high costs of new product development. Mycoherbicide research has yet to deliver new products in rice, despite many optimistic forecasts over the past decade. With the increasing adoption of herbicides in rice throughout the world, the significance of the Australian market continues to diminish (<1% of total) making private investment in research increasingly difficult to justify. With fewer prospects for new tools in weed management, innovative and integrated approaches are required that harness both cultural and herbicidal approaches.

Tactical responses also warrant RR&DC input for difficult weeds (eg: water plantain) that are not addressed by individual herbicide manufacturers due to the localised nature of the problems and small market potential.

This program was conducted to assist in management of herbicide resistance in rice by developing alternative and rotational options for weed management.

Specific objectives were:
To develop rotational programs of herbicides coupled with the definition and integration of cultural weed control methods for rice.

Promote adoption of these practices by improving farmer knowledge of these issues through conduct of grower field days, publishing results in a format suitable to growers and assistance with the preparation of annual weed control bulletins

Methods:

Replicated field trials were conducted over a four year period at dedicated laser leveled sites in the southern Riverina. Earthen bunds were constructed around individual plots where floodwater separation was necessary. Herbicide application was by direct application to floodwater (SCWIIRT) or hand held boom sprayers. Assessments included visual ratings of rice injury, weed control efficacy and grain yields.

Findings:

In drill seeded rice clomazone plus propanil treatments demonstrated great reliability and flexibility in timing for control of barnyard grass. Paraquat could be substituted for propanil prior to crop emergence, however this treatment did not exhibit sufficient residual control in instances of long intervals between seeding and permanent water. Sequential application of paraquat (prior to crop emergence) and clomazone (prior to permanent water) gave excellent control of barnyard grass.

Water plantain control was most effectively achieved with a sequential program of benzofenap followed by MCPA sodium. Bensulfuron, dicamba and triclopyr were found to be ineffective against water plantain.

Dirty Dora, starfruit, water plantain, arrowhead, common spikerush and cumbungi were all shown to be susceptible to bentazon as BASAGRAN @ 960 g a.i./ha and bentazon plus MCPA as BAS 433 @ 800 plus 120 g a.i./ha applied from the 4 leaf stage of rice development. Adjuvants (non-ionic surfactant and ethoxylated canola oil) did not assist with bentazon efficacy.

Residue sampling from bentazon experiments was performed to support registration with the NRA.

Pretilachlor (SOFIT) was evaluated for various application timings in dry broadcast seeded rice. A narrow application window (approximately 6-9 days post flood) was defined that would prove impractical for most commercial rice crops.

Prometryne, ametryne and terbutryne failed to exhibit sufficient crop safety to water-seeded rice.

Clomazone plus molinate combinations appeared mildly antagonistic, with a rate of 180 plus 1800 g a.i./ha/ha optimal for barnyard grass control.

Herbicide program performance evaluations were conducted for twelve new or pending programs over two seasons. Most programs tested achieved effective barnyard grass control, however major differences in sedge and broadleaf weed control resulted in substantial differences in average grain yield across 8 experiments.

Trial results and demonstrations conducted in this program have assisted in the acceptance and adoption of a range of new herbicide programs for water seeded rice.

Results from the clomazone and bentazon studies have been used in support of registration submissions for these herbicides in drill and water seeded rice (respectively).
1. Introduction

Removal of weed competition using herbicides is a critical requirement for economic direct seeded rice production throughout the world. Direct seeding of rice results in concurrent establishment of rice and weeds. In the event of no control being exercised, weeds will commonly smother the crop with little or no prospect of a harvestable yield; resulting in the worst possible economic and environmental outcome from the resources invested. In Australia herbicides have been used in rice production for approximately 50 years.

Throughout the 1990's over 90% of the Australian rice crop was treated with the same herbicide program (molinate plus bensulfuron) leading to a very high industry wide selection intensity of herbicide resistant weed biotypes. Selection of herbicide resistant weed biotypes was first confirmed in Australian rice in 1993 and they are now common in all ricegrowing districts.

In the past decade the Australian rice industry has met the challenges of effective weed management and herbicide resistance development by a measured approach of understanding the issues, researching alternative options to define best management practices and enacting these practices by involving and informing key participants at each step.

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Internationally, the flow of new agricultural chemicals has slowed to a trickle due to a combination of patent maturation leading to growing generic competition, increased regulatory hurdles and high costs of new product development. Mycoherbicide research has yet to deliver new products in rice, despite many optimistic forecasts over the past decade. With the increasing adoption of herbicides in rice throughout the world, the significance of the Australian market continues to diminish (<1% of total) making private investment in research increasingly difficult to justify. With fewer prospects for new tools in weed management, innovative and integrated approaches are required that harness both cultural and herbicidal approaches.

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Figure 1 Diagrammatic representation of typical application windows for Australian drill sown rice
Figure 2 Representation of typical application windows for Australian water-seeded rice

Herbicide Application Windows - Water-seeded Rice

Rice growth stages
pre-sow  germination  1 leaf  2 leaf  3 leaf  4 leaf  5 leaf  1 tiller  2 tillers  mid-tillering late tillering panicle initiation
2. Materials and methods

2.1 Location and trial methods

All field trials were undertaken on dedicated laser-leveled sites selected on rice cropping properties near Cobram, Victoria and Finley, Myrtle Park, and Jerilderie, New South Wales to ensure a representative spread of weed flora and soil type.

Upon completion of ground working and grading, drill sown trials were established using a linkage mounted seeder across all plots. Flush irrigations were variously made to germinate and progress the crops to the 2.5 - 4 leaf stage (BBCH 12.5-14); upon which permanent water was introduced to the fields.

Water seeded and dry broadcast seeded trials were bunded with earthen banks around each individual plots, watered independently using siphons and seeded by aircraft or groundrig. Bunds were removed prior to harvest.

All treatments were applied using small plot, propane-powered boom sprayers delivering 90-110 l/ha of spray solution or by syringe directly to floodwater (as a simulated SCWIIRT application).

Plots were typically 3m x 8m for drill sown rice and 3.5 x 6.5m for water seeded rice, arranged in randomised complete block designs with 3-6 replications.

Trials were managed using Pesticide Research Manager (version 4.05) or Agricultural Research Manager (version 5) computer software. All data was subjected to analysis of variance.

See individual treatment application details attached to trial results in the rear Appendix of this report.

2.2 Assessments:

Visual ratings of rice injury were made using a 0-100% linear scale where 0 = no rice injury and 100 = complete death of all rice seedlings.

Visual ratings of weed control were made using a 0-100% linear scale where 0 = no control and 100 = complete control of all weeds.

Weed panicle and umbel densities were recorded in five 0.1m² randomly selected quadrats in each plot.

Grain yields were obtained by direct harvest of each plot using a modified Wintersteiger Seedmaster plot harvester cutting a 1.8m swath through each plot fitted with Ktron on-board electronic weighing and DMC moisture meter. Grain yields were corrected to 14% moisture content.
2.3 Formulations:

**bentazon**  
BASAGRAM Post Emergence Herbicide  
480 g/l bentazone (present as sodium salt)  
B/N 017AG-8-001 Man: Feb 1998  
Agrevo Pty. Ltd.

BAS 433 (BASAGRAM M60)  
400 g/l bentazon, 60 g/l MCPA sodium  
Lot 77-2494 Art: 58892377 DOM: 11-2000  
BASF Australia Ltd.

**surfactant**  
BS 1000 Biodegradable Surfactant  
1000 g/l non-ionic surfactant  
CropCare Australasia Pty. Ltd.

**crop oil**  
DC-TRATE Anti-Evaporate Spray Oil  
B/N 15858  
HASTEN Spray Adjuvant  
704 g/l ethyl and methyl esters of fatty acids produced from  
food grade canola oil  
Victorian Chemical Company

**clomazone**  
MAGISTER Herbicide  
480 g/l emulsifiable concentrate  
FMC International A.G.

**thiobencarb**  
SATURN EC Rice Herbicide  
800 g/l emulsifiable concentrate  
Hoechst Schering Agrevo Pty. Ltd.

**molinate**  
ORDRAM Herbicide  
960 g/l emulsifiable concentrate  
CropCare Australasia Pty. Ltd.

**clomazone**  
COMMAND 480EC Herbicide  
480 g/l emulsifiable concentrate  
FMC International A.G.

MAGISTER Herbicide  
480 g/l emulsifiable concentrate  
FMC International A.G.

COMMAND 3ME  
314 g/l micro-encapsulated emulsion  
FMC International A.G.

**propanil**  
RONACIL Rice Herbicide  
360 g/l emulsifiable concentrate  
Agrevo Pty. Ltd.

5
<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Example of commercial name</th>
<th>Mode of Action (GRDC classification)</th>
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<tbody>
<tr>
<td>paraquat</td>
<td>GRAMOXONE W Herbicide</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>200 g/l soluble liquid</td>
<td></td>
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<tr>
<td></td>
<td>CropCare Australasia Pty. Ltd.</td>
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<tr>
<td>pendimethalin</td>
<td>STOMP 330E Herbicide</td>
<td>D</td>
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<tr>
<td></td>
<td>330 g/l emulsifiable concentrate</td>
<td></td>
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<tr>
<td></td>
<td>Cyanamid Australia Pty. Ltd.</td>
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<tr>
<td>benzofenap</td>
<td>TAIPAN Herbicide</td>
<td>F</td>
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<tr>
<td></td>
<td>300 g/l suspension concentrate</td>
<td></td>
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<td></td>
<td>Aventis CropScience Pty. Ltd.</td>
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<tr>
<td>bensulfuron</td>
<td>LONDAX Herbicide</td>
<td>B</td>
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<td></td>
<td>600 g/kg dry flowable</td>
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<td></td>
<td>DuPont (Australia) Ltd.</td>
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<tr>
<td>carfentrazone</td>
<td>SHARK 40DF Herbicide</td>
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<td>400 g/kg dry flowable</td>
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<td>profoxydim</td>
<td>BAS 625 04H</td>
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<td>BASF Australia Ltd.</td>
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<td>ametryne</td>
<td>PRIMATROL Z Herbicide</td>
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<td>500 g/l suspension concentrate</td>
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<td></td>
<td>Syngenta Crop Protection Pty. Ltd.</td>
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<tr>
<td>prometryne</td>
<td>Flowable GESAGARD 500SC Liquid Herbicide</td>
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<td>terbutryne</td>
<td>IGRAN 500SC Herbicide</td>
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<td>500 g/l terbutryne</td>
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<tr>
<td>pretilachlor</td>
<td>SOFIT N Herbicide</td>
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<td>300 g/l pretilachlor 75 g/l fenclorim</td>
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**Table 1 Herbicides used in Australian rice showing mode of action**
3. Results

3.1 Clomazone in drill seeded rice


Twelve replicated field trials were conducted in the southern Riverina of Australia to evaluate the efficacy and crop safety of clomazone plus paraquat or propanil tank mixtures for the control of Echinochloa crus galli (barnyard grass) and Leptochloa fusca (silvertop grass) in drill-seeded rice.

Dry rice was drill sown into prepared seedbeds, flush irrigated 1-3 times, then permanent flood applied once the rice reached 2.5-5 leaf stage. Trial designs were randomised complete blocks using three - six replications.

Treatments variously included clomazone @ 240 – 360 g a.i./ha plus paraquat @ 200 g a.i./ha/ha applied post-sowing, pre-emergence and clomazone @ 240-360 g a.i./ha/ha plus propanil @ 900 – 3600 g a.i./ha/ha applied early post –emergence (just prior to permanent water), a range of commercial standards and an untreated control. All treatments were applied to drained fields using a small plot boom sprayer delivering 90 – 110 l/ha.

Post sowing pre-emergence application of clomazone plus paraquat @ 240 –360 g a.i./ha plus 200 g a.i./ha (respectively) achieved excellent control of barnyard grass and silvertop grass provided permanent water was applied to the field within two weeks of application.

Late germinations of barnyard grass escaped control by clomazone plus paraquat if permanent flooding was delayed by slow crop emergence (due to deep seeding and/or cool weather).

Clomazone plus propanil @ 240 g a.i./ha plus 1800 – 3600 g a.i./ha provided excellent control of 0-4 leaf barnyard grass. Results with this treatment waned if weeds were drought stressed and/or excessively advanced in growth stages. Increasing clomazone rates above 240 g a.i./ha in post-emergence applications to rice sometimes excessively injured the crop.

A micro-encapsulated formulation of clomazone (COMMAND 3ME) proved significantly less effective in controlling barnyard grass the equivalent rates of the commercial emulsifiable concentrate formulation (COMMAND or MAGISTER 480 EC).
Figure 3  Barnyard grass control with clomazone mixtures in drill sown rice, 1998-99 season

cломазон in drill-sown rice barnyard grass control

Figure 4  Barnyard grass control with clomazone mixtures in drill sown rice, 1999-2000 season

cломазон in drill seeded rice Time of application x mixture

Trial 118-97, Cobram, Vic.

Post sowing, pre-emergence application of clomazone plus paraquat provided excellent control of barnyard grass that exceeded results with the commercial standard of pendimethalin plus paraquat.

Minor bleaching of the first two leaves of rice seedlings as they emerged was noted, however rice tolerance was acceptable overall with clomazone treatments.
**Trial 20-98, Cobram, Vic.**

This crop emerged slowly as a result of cool weather conditions after sowing.

Barnyard grass control was excellent with post sowing pre-emergence application of clomazone plus paraquat @ 240 + 200 g a.i./ha.

Rice injury was excessive with clomazone(+/- propanil) applied early post emergence @ 360 g a.i./ha, but was acceptable with earlier post sowing pre-emergence applications of the same treatment.

Combinations of clomazone plus paraquat and clomazone plus propanil were amongst the highest yielding treatments.

**Trial 22-98, Jerilderie, New South Wales**

Rice seed was sown excessively deep at this site and the crop was very slow to emerge.

No rice injury was noted at this trial.

Residual control of barnyard grass using post sowing pre-emergence applications of clomazone eventually failed as late barnyard grass germinations escaped control. Increasing the rate of clomazone application above 240 g a.i./ha improved barnyard grass control, however no treatment was effective.

**Trial 27-98, Cobram, Vic.**

This crop germinated on rainfall in a moist seabed, with long periods between wetting and re-flooding. A total of 41 days ensued between seeding and permanent water.

Early post emergence application of clomazone plus propanil resulted in the highest barnyard grass control ratings and rice grain yields. Post sowing pre-emergence treatments of clomazone plus paraquat achieved lower barnyard grass control ratings and rice grain yields than clomazone plus propanil.

Clomazone plus paraquat applied post sowing pre-emergence resulted in higher silvertop control ratings than early post emergence application of clomazone plus propanil.

Minor-moderate rice bleaching was noted with early post emergence applications of clomazone, especially at the higher rate of 360 g a.i./ha.

**Trial 60-98, Cobram, Victoria**

All treatments were applied early post emergence to emerged barnyard grass and rice.

In a comparison of the commercial emulsifiable concentrate formulation of clomazone weeds and a north-American micro-encapsulated formulation (COMMAND 480EC versus COMMAND 314ME), barnyard grass control was significantly higher with the EC formulation.

Addition of propanil to clomazone EC significantly improved control of barnyard grass and silvertop grass.
**Trial 94-98, Tocumwal, New South Wales**

This late-sown experiment was sprayed in very hot weather onto drought-stressed barnyard grass and rice two days before permanent water.

Molinate was the most effective treatment in this experiment; exhibiting a very rapid desiccation of barnyard grass foliage in the two days after application prior to flooding.

Addition of propanil to clomazone significantly improved barnyard grass control, however results were not satisfactory with any of the clomazone treatments.

**Trial 20-99, Cobram, Victoria**

All clomazone treatments recorded minor-moderate rice injury ratings. Increasing the clomazone application rate from 240 – 360 g a.i./ha increased rice injury ratings, significantly so at the early post emergence timing.

In the third assessment of rice injury, early post emergence treatments of clomazone provided significantly more rice injury than post sowing pre-emergence treatments.

Combinations of clomazone plus paraquat or paraquat followed by clomazone and clomazone plus propanil or achieved approximately equivalent high rice grain yields.

Early post emergence combinations of clomazone plus propanil achieved lower barnyard grass control ratings and recorded higher of barnyard grass panicle densities than post sowing pre-emergence treatments of clomazone plus paraquat.

Early post emergence applications of clomazone plus propanil recorded moderate silvertop grass control ratings that were consistently and markedly lower than post sowing pre-emergence applications of clomazone plus paraquat. Tank mixing clomazone with propanil resulted in significantly higher silvertop grass control ratings than either herbicide applied alone of the same timing, of which both recorded very low control ratings for this species.

Lowering propanil rate from 1800 down to 900 g a.i./ha in combination with clomazone markedly reduced barnyard grass and silvertop grass control ratings.

**Trial 21-99, Cobram, Victoria**

All treatments were applied early post emergence.

Increasing the application rate of propanil from 900 – 3600 g a.i./ha only slightly increased rice injury ratings, with all treatments providing acceptable crop tolerance.

**All clomazone treatments (including clomazone alone) achieved excellent control of barnyard grass.**

Clomazone alone the only provided marginal control of silvertop grass. Addition of propanil (at all rates tested) to clomazone significantly improved control of silvertop grass.

Clomazone alone failed to exhibit any control of dirty Dora or starfruit. Addition of propanil to clomazone gave significant (although marginal) control of dirty Dora and starfruit.
Tank mixtures of propanil plus clomazone recorded the lowest panicle densities of barnyard grass and silvertop grass.

All herbicide treatments significantly increased rice grain yield. Addition of clomazone to propanil significantly increased rice grain yield. All combinations of propanil plus clomazone and propanil plus pendimethalin provided the highest rice grain yields.

**Trial 22-99, Finley, New South Wales**

No rice injury was observed with any treatment in this experiment.

Post sowing pre-emergence treatments of clomazone tank mixed or applied sequentially with paraquat provided very high control ratings of barnyard grass and silvertop grass and significantly reduced barnyard grass panicle densities to low numbers.

Combinations of clomazone plus propanil applied early post emergence failed to effectively control either barnyard grass or silvertop grass. Reducing the propanil rate from 1800 g a.i./ha/ha to 900 g a.i./ha markedly reduced barnyard grass and silvertop grass control.

Rice grain yields were significantly increased by all treatments. Tank mixtures or sequential application of clomazone plus paraquat provided significantly higher rice grain yields than tank mixtures of clomazone plus propanil applied at a later timing.

**Trial 24-99, Myrtle Park, New South Wales**

All treatments were applied early post emergence, 11 days prior to permanent water.

Minor rice injury was noted with all herbicide treatments. Combinations of propanil plus clomazone tended to have higher rice injury ratings than either herbicide alone.

Propanil plus clomazone tank mixtures provided marginal levels of barnyard grass control that was significantly higher than either herbicide applied alone. Highest barnyard grass control ratings and lowest panicle densities were recorded with the highest rates of clomazone plus propanil (240 + 1800 g a.i./ha).

All herbicide treatments significantly increased rice grain yields. Combinations of clomazone plus propanil provided higher rice grain yields than either herbicide applied alone.

**Trial 42-99, Cobram, Victoria**

All treatments were applied early post emergence four days prior to permanent water.

Moderate bleaching of rice was recorded with all clomazone treatments. Propanil rate had little impact on rice injury.

Addition of propanil to clomazone significantly increased the speed of onset of herbicide symptoms as evidenced in the rating conducted on 21-10-99 (immediately prior to flooding).

Barnyard grass control ratings showed a significant response to increases in propanil rate. Rates of propanil in excess of 900 g a.i./ha were required in mixtures with clomazone to achieve successful control of barnyard grass and silvertop grass.
All combinations of clomazone plus propanil provided higher barnyard grass and silvertop grass control ratings and lower weed panicle densities than the commercial standard of pendimethalin plus propanil.

No treatment proved effective in controlling dirty Dora.

Rice grain yields were significantly increased by clomazone plus propanil mixtures at rates in excess of 240 + 900 g a.i./ha. Highest rice grain yields were provided by clomazone plus propanil mixtures at the two highest rates tested (240 + 3600 and 240 + 2700 g a.i./ha).

**Trial 86-99, Myrtle Park, New South Wales**

All treatments were applied early post emergence, three days prior to permanent water.

Barnyard grass was not effectively controlled by any combination of clomazone plus propanil. The highest rates of this combination resulted in the highest barnyard grass control ratings, the lowest panicle density and the highest rice grain yields.

Rice grain yields were significantly increased by all clomazone plus propanil mixtures, however all grain yields were disappointingly low.

**Trial 99-99, Myrtle Park, New South Wales**

All treatments were applied early post emergence, two days prior to permanent flooding of a very late sown experiment.

Significant rate responses were demonstrated in barnyard grass control ratings, panicle densities and rice grain yields to increasing rates of propanil in mixtures with clomazone.

Reducing clomazone application rate in mixtures with propanil from 240 g a.i./ha down to 180 g a.i./ha resulted in an appreciable drop in barnyard grass control ratings and an increase in barnyard grass panicle densities.

Rice grain yields did not differ significantly between any herbicide treatments and the untreated control.

### 3.2 Multiple MOA programs for grass weed control in drill sown rice

See trial 49-98.

Concurrent delivery of two or three residual herbicides prior to crop emergence was the objective of this experiment. Crop emergence was slowed by a combination of excessive seeding depth and cold spring weather.

Neither clomazone, pendimethalin nor thiobencarb individually achieved effective residual control of barnyard grass when applied PFPE. Tank mixing half rates of clomazone plus pendimethalin resulted in much higher barnyard grass control ratings than full rate of either herbicide alone.
3.3 Pretilachlor in dry broadcast seeded rice

See trials 12-00, 50-00, 02-01, 27-01 and 65-01.

Chloroacetamide and oxyacetamide herbicides (HRAC Group K3) such as pretilachlor, butachlor and mefenacet are widely used in rice internationally; often in direct-seeded culture. Previous work in Australia has shown that pretilachlor is difficult to fit in water-seeded rice due to the prolonged fill-up periods staggering rice and weed development stages. These stages tend to be more synchronized in dry broadcast seeded rice. This latter form of crop establishment has increased in popularity in Australia in recent seasons; prompting a re-evaluation of pretilachlor for dry broadcast seeded rice.

Four trials were conducted to evaluate pretilachlor @ 300 - 600 g a.i./ha (plus fenclorim crop safener) applied at varying intervals after flooding. Useful control of barnyard grass, dirty Dora and starfruit was recorded; whilst arrowhead often survived treatment. Weed control declined with treatments applied > 6 days post flooding. Rice tolerance was inadequate with pretilachlor applied < 9 days post flooding. A very narrow window of application was therefore observed for pretilachlor that is unlikely to be consistently achieved under commercial conditions.

Figure 5 Rice injury ratings with pretilachlor in dry broadcast seeded rice, 2001-2002 season

3.4 Bentazon in water seeded and dry broadcast seeded rice

See trials 47-99, 51-99, 84-99, 85-99, 87-99, 88-99, 05-00, 06-00, 08-00, 43-00, 20-01, 56-01, 71-01

Thirteen field trials were conducted in the Riverina region of Australia over three seasons (1999-2000, 2000-2001 and 2001-2002) to evaluate the efficacy and crop safety of bentazon (alone or in combination with MCPA sodium) for the control of Cyperus difformis (dirty Dora), Alisma plantago aquatica (water plantain), Sagittaria montevideosis (arrowhead) Eleocharis acuta (common spikerush), Typha spp. (cumbungi) and Damasonium minus (starfruit) in water-seeded rice.

Pre-germinated or dry rice was broadcast into standing water or dry fields in all plots approximately
28 - 50 days before application of treatments. Trial designs were randomised complete blocks using three, four or six replications.

Treatments variously included bentazon @ 480 - 1440 g a.i./ha (alone or in mixtures with MCPA sodium), commercial standards of MCPA sodium @ 700 g a.i./ha and an untreated control. All treatments were applied to exposed weeds and rice using a small plot boom sprayer delivering 90-115 l/ha.
Bentazon alone @ 960 - 1440 g a.i./ha provided highly effective control of dirty Dora, starfruit, arrowhead, water plantain, common spikerush and seedling cumbungi. Addition of MCPA sodium @ 125 g a.i./ha to bentazon @ 960 g a.i./ha bolstered control of most of the above species.

Rice injury with bentazon alone was generally indiscernible and contrasted markedly with the commercial standard of MCPA sodium @ 700 g a.i./ha that often induced major secondary root pruning, distention of the main shoot-tiller angle and leaf yellowing. Addition of MCPA sodium @ 125 g a.i./ha to bentazon resulted in minor presentation of the above symptoms that were often difficult to observe.
Rice grain yields were obtained from most of the above experiments. Bentazon plus MCPA sodium achieved the highest grain yields, followed by bentazon alone @ 1440 g a.i./ha and MCPA sodium alone @ 700 g a.i./ha.

The addition of crop oil concentrates (DC-TRATE or HASTEN) and non-ionic surfactant (BS-1000) adjuvants to bentazon was evaluated. No advantage was demonstrated for any adjuvant against dirty Dora or starfruit.

Floodwater, forage, grain and straw samples from four experiments were collected and stored frozen for analysis for bentazon (BASAGRAN) residues.

Grain yields for bentazon plus MCPA sodium @ 800 plus 120 g a.i./ha averaged approximately 5% higher than MCPA sodium alone across the three experiments harvested during the 2000-2001 season.

A single time of application study (trial H20-01) demonstrated an optimal window of application for bentazon plus MCPA sodium of 45-50 DAS (days after sowing) to control dirty Dora, whilst grain yields were optimized by application 32-35 DAS.

Figure 8 Effect of application timing (days after seeding) of BAS 433 on control of dirty Dora, 2001-2002 season.
3.5 Clomazone plus molinate combinations

See trials 09-01, 29-01, 43-01 and 66-01.

Registration of clomazone (HRAC group C) for grass weed control in water seeded rice provides a rotational option from molinate or thiobencarb (HRAC group N). Concurrent delivery of the two MOA herbicides was evaluated in four trials during 2001-2002 to determine the efficacy and crop safety of clomazone plus molinate mixtures in water seeded rice.

Treatments included clomazone @ 60-240 g a.i./ha, molinate @ 600 - 2400 g a.i./ha alone or in tank mixtures delivered at sowing into floodwater.

Mixtures generally bolstered control of barnyard grass and silvertop grass over either herbicide alone with adequate crop tolerance. Application of Colby's formula to the pooled results suggested antagonism between the two herbicides for both barnyard grass and silvertop grass control. The 1:10 ratio appeared approximately correct based upon the performance of the individual herbicides alone; with a rate of 180 + 1800 g a.i./ha optimal.
Figure 10 Barnyard grass control with clomazone and molinate combinations, 2001-2002 season

Figure 11 Silvertop grass control with clomazone and molinate combinations, 2001-2002 season

Clomazone plus molinate
Barnyard grass control

Clomazone plus molinate
Silvertop grass control
3.6 Triazines in water seeded rice

See trials 13-01 and 26-01.

Triazine herbicides (HRAC group C) such as simetryne and dimethametryne have long been used in rice culture internationally for aquatic weed and algae control. Three triazine herbicides commercially available in Australia for alternative crops were evaluated in 2001-2002 for their selectivity and efficacy in water seeded rice.

Prometryne, ametryne and terbutryne @ 25-240 g a.i./ha were applied into floodwater at sowing and 1-1.5 LSR. Rice injury was excessive with all three herbicides; especially terbutryne. At sowing applications induced more rice injury than later timings. Moderate - good control of water plantain, loosestrife (Lythrum hyssopifolia) and dirty Dora was obtained with each triazine herbicide, but not with an adequate margin of crop tolerance.

3.7 Water plantain control in water seeded rice

See trials 21-98, 03-00, 28-01 and 62-01

In trial 21-98, bensulfuron and thiobencarb were inactive against water plantain. Benzofenap alone and MCPA sodium alone were moderately effective at full rates against this species. A sequential treatment of benzofenap followed by MCPA sodium was the most effective treatment against water plantain (in addition to dirty Dora, starfruit and arrowhead) in this experiment.

All bensulfuron treatments failed to effectively control water plantain in trials 03-00, 28-01 and 62-01.

Benzofenap, bentazon plus MCPA and MCPA sodium alone all proved effective in controlling water plantain in these three experiments. Carfentrazone @ 150 g a.i./ha was only marginally effective against water plantain in trial 03-00.
3.8 Water seeded rice herbicide program performance evaluation

See trials 01-00, 02-00, 03-00, 04-00, 03-01, 28-01, 41-01 and 62-01.

Four trials per season over two seasons were conducted to compare the performance of new and existing herbicide programs for water seeded rice. Results have been compiled by species and yields (expressed as a percentage increase over the untreated control) averaged across all sites.

Barnyard grass control was high for all programs. Where the interval between first and second application of split thiobencarb was prolonged barnyard grass escapes occurred. If profoxydim was tank mixed with bentazon plus MCPA sodium (2000-2001 trials) barnyard grass control was antagonised.

Clomazone plus benzofenap and a molinate primer followed by thiobencarb plus bensulfuron exhibited poor control of silvertop grass. Best results against silvertop grass were obtained with molinate plus benzenfenap (alone or followed by thiobencarb).

All bensulfuron programs failed to effectively and consistently control dirty Dora, arrowhead and water plantain. Benzofenap, bentazon plus MCPA sodium and MCPA sodium alone were effective against dirty Dora, arrowhead and water plantain. Benzofenap was ineffective against common spikerush, whilst bensulfuron was highly active against this species.

Split thiobencarb and carfentrazone plus bensulfuron treatments often induced excessive rice injury.

Highest rice yields were obtained with benzofenap plus molinate and molinate followed by bentazon plus MCPA sodium or MCPA sodium alone.

Many of the programs under evaluation did not include a follow-up early-mid tillering application of MCPA sodium (for resistance management purposes). Improved yield performance could be
expected as this late re-treatment would control broadleaf and sedge weeds that escaped the initial treatments.

Figure 13 Barnyard grass control ratings from 2000-2001 and 2001-2002 seasons

Barnyard grass control (8 trials)
Figure 14 Dirty Dora control ratings from 2000-2001 and 2001-2002 seasons

Dirty Dora control (8 trials)

Figure 15 Arrowhead control ratings from 2000-2001 and 2001-2002 seasons

Arrowhead control (7 trials)
Figure 16 Water plantain control ratings from 2000-2001 and 2001-2002 seasons

Water plantain control (5 trials)

Figure 17 Silvertop grass control ratings from 2000-2001 and 2001-2002 seasons

Silvertop grass control (3 trials)
Figure 18 Common spikerush control ratings from 2000-2001 and 2001-2002 seasons

Spikerush control (3 trials)

Figure 19 Rice grain yields (expressed as an average percentage increase over the untreated controls) from 2000-2001 and 2001-2002 seasons

Rice Grain Yield
Mean Percentage Increase Over Untreated
4. Discussion

4.1 Drill sown rice

The absence of a reliable means to achieve residual control of barnyard grass and the attendant risk of massive weed escapes have dissuaded many Australian ricegrowers from establishing crops by drill seeding. This seeding technique enables the use of novel herbicides (e.g., paraquat, glyphosate and pendimethalin) that present alternate MOA's to those available to when establishing rice by water-seeding. Improving the reliability of drill seeding by developing better residual barnyard grass control treatments was therefore awarded a high priority during the initial years of this program. Clomazone was the most obvious candidate for this role.

Two distinct windows of application for clomazone in drill sown rice were identified and demonstrated within this program. Post-sowing, pre-emergence applications involved using the residual properties of clomazone to prevent barnyard grass establishment for the period from application to (and beyond) permanent flooding of the crop. Germination of both rice and barnyard grass have commenced at this application timing, usually with some barnyard grass emergence and rice yet to emerge from the ground. This presents an opportunity to use a non-selective knockdown herbicide (paraquat) that is economical to use, has a broad spectrum of activity against any grass or broadleaf seedling weed and is an alternative mode of action herbicide (Group I) to clomazone (Group F) thereby presenting an inherently lower risk of resistance development. Use of clomazone plus paraquat tank mixtures requires that the crop has yet to emerge and therefore the application window can be quite narrow, given the field must first dry after the initial flush irrigation in order to be trafficked by a ground-based boom sprayer.

The above circumstances will not always be achieved by drill seeded rice producers, thus the substitution of propanil for paraquat in combination with clomazone produces an excellent fall-back position if the crop emerges prior to the application of clomazone. Propanil is selective to emerged rice, an alternate mode of action herbicide (group C) to clomazone (group F) and has a broad range of activity beyond barnyard grass including some annual sedges and broadleaf weeds. Unfortunately propanil is not particularly effective against barnyard grass beyond the three leaf stage of development and this is especially the case in cool weather with days below 25 degrees Celsius. In this series of experiments a strong contrast in efficacy of clomazone plus propanil treatments between the 1998 and 1999 seasons can be attributed to the particularly cool weather after application of propanil in 1999.

A potential pitfall associated with using clomazone as a residual herbicide is the prospect that if the period between application and permanent flooding exceeds the period of effective residual control then late barnyard grass germinations will escape treatment. To avoid this problem attention needs to be paid to seeding depth of rice because rice sown too deep will take an inordinately long time to emerge. In the case of experiments H20-98 and H22-98 intervals of in excess of 40 days ensued between seeding and permanent water, resulting in late barnyard grass germinations.

Propanil is a relatively expensive herbicide for rice-growing in Australia, especially when compared to paraquat. Attempts were made in this program to determine what minimum rate of propanil is required in combination with clomazone to ensure adequate post emergence barnyard grass and silvertop grass control. Under warm conditions the rate of 1800 g a.i./ha of propanil proved effective. In cool weather responses to increasing propanil rate were demonstrated right through to the top rate tested (3600 g a.i./ha). Such a treatment is unlikely to be economically attractive for Australian ricegrowers. These issues with propanil highlight the attractiveness of combining clomazone with paraquat at the earlier post sowing pre-emergence application time.

Ground-based boom application of clomazone plus paraquat or clomazone plus propanil will require
special attention be paid to the prevention of drift from the field to adjoining crops. Low pressure, low drift nozzles ought to be specified to minimise the reduction of fine droplets that may drift from the target zone within the paddy. In fields that present particular risks of drift to adjoining crops an alternative to boom application of clomazone plus propanil or clomazone plus paraquat would be the sequence of paraquat applied post sowing pre-emergence (to remove the first cohort of barnyard grass seedlings) followed by clomazone applied by drip application into permanent water as the field is inundated. This latter treatment is a derivation of the sequential application of paraquat plus clomazone evaluated in a number of experiments in the 1999 season. Given that these experiments were not banded, it was not possible to emulate drip application of clomazone, therefore the clomazone treatment in this sequence was boom sprayed. Further evaluation of paraquat followed by clomazone drip into floodwater is warranted as a means to ensure that no spray drift of clomazone can occur.

Targeting the same cohort of weeds with alternate MOA herbicides simultaneously is a desirable goal of any herbicide resistance management strategy as this markedly reduces the selection intensity for the individual herbicides within the mixture. Concurrent delivery of clomazone and pendimethalin or thiobencarb was attempted in trial H49-98. Although the time from seeding to permanent flood was prolonged, reduced rates of clomazone plus pendimethalin resulted in improved barnyard grass control over either herbicide alone. If drill seeding of rice is awarded higher interest by local ricegrowers then this mixture warrants further evaluation.

4.2 Water seeded rice

Water plantain control in commercial fields has been problematic over the past decade due to the ubiquitous use of bensulfuron as the primary (and often sole) means of herbicidal control. We consistently demonstrated the tolerance of water plantain to bensulfuron and susceptibility to both benzofenap and MCPA sodium. Sequencing these two latter herbicides provided the best control results; controlling both seedling and corm plants. Bentazon plus MCPA sodium also proved highly effective against water plantain; thus potentially providing three alternate MOA herbicides for it's management.

Clomazone plus molinate mixtures proved effective for barnyard grass and silvertop grass control, however mild antagonism between the two herbicides prevented any substantial reductions in application rates. Accordingly these mixtures are unlikely to present any economic benefit over robust rates of either herbicide alone. Rotation of the two herbicides for barnyard grass control is therefore more viable commercially than mixtures.

Triazine herbicides failed to demonstrate any useful margin of tolerance in water seeded rice. This highlights a common feature of many dedicated rice herbicides where tolerance is achieved using transplanted rice seedlings but germinating seedlings in direct seeded culture are susceptible to excessive injury. No further evaluation of ametryne, terbutryne or Prometryne appears warranted for water seeded rice.

Across three seasons with a total of thirteen experiments conducted, two aspects of bentazon plus MCPA sodium performance were consistent and notable, namely symptomology/efficacy of weed kill and crop tolerance.

Speed of development of the symptoms of bentazon plus MCPA sodium were much more rapid than with either of the herbicides alone, combining yellowing and desiccation from bentazon with epinasty from MCPA. Inspections conducted 5-7 days after application would often reveal complete collapse and desiccation of weeds treated with bentazon plus MCPA sodium, whilst weeds treated with MCPA sodium alone would be yellowing and twisted, but remained turgid and apparently capable of on-going competition with the crop.
Whilst the application rates of the bentazon plus MCPA sodium tank mixture were not identical to those used in the BAS 433 treatments, they remained close over the range of 2-2.5 l/ha of BAS 433. This similarity, coupled with bridging treatments of a bentazon plus MCPA sodium tank mixture in the 2000-2001 trials enable conclusions to be drawn by pooling both seasons of field trials.

Substitution of bentazon plus MCPA sodium for MCPA sodium alone often reduced rice injury. This would enable commercial ricegrowers to have more confidence in targeting weed escapes from earlier treatments without fear of excessively damaging young crops. This latter concern often delays commercial applications of MCPA sodium, prolonging weed competition and reducing yield potential.

Optimum application timings for bentazon plus MCPA sodium for yield enhancement were earlier than those demonstrated for weed control. This highlighted the common dilemma for timing post-emergence herbicides when early removal minimizes weed competition, whilst delays ensure the highest proportion of weeds have developed to a stage capable of being targeted.

Early season (eg: 4 leaf - 1 tiller rice) application of bentazon plus MCPA sodium can be difficult to manage in large commercial ricefields due to the problems inherent in draining sufficient water from the field to enable an exposed target to be obtained. Prolonged exposure of mud will encourage late germinations of barnyard grass (Echinochloa spp.), hence growers have to manage a compromise timing that is not aided if aerial application is delayed due to unfavorable weather. Success in management of this compromise simply reflects skill in management. Having a broad application window (as bentazon plus MCPA sodium clearly presents) eases this problem.

Concurrent delivery of two alternate mode of action herbicides covering the same co-hort of the same weed species is a major goal in any herbicide resistance management strategy. Bentazon plus MCPA sodium presents such an opportunity, with the primary mode of action (bentazon @ 800-1000 g a.i./ha) novel to most rice growing areas in Australia. Local weed populations have seen minimal exposure to propanil (another group C herbicide) in the past 30 years, whilst an increasing exposure to MCPA sodium (group I) since the development of widespread bensulfuron resistance over the past six seasons. Substitution of bentazon plus MCPA sodium for MCPA sodium alone therefore is a sound strategy for delaying the selection of MCPA sodium resistant weed biotypes.

Comparisons of new and existing herbicide programs highlighted strengths and weaknesses of many programs currently promoted to ricegrowers. These trials provided a great deal of interest to growers and agronomists during the annual January field day/inspection tour. The failure of bensulfuron to control most major aquatic weeds due to the presence of resistant biotypes became glaringly obvious as did the success of benzofenap against the same species. New treatments such as bentazon plus MCPA sodium were also highly effective against this suite of weeds. Profoxydim was noteworthy in controlling advanced barnyard grass and silvertop grass. Control of dirty Dora with carfentrazone was inadequate @ 150 g a.i./ha in the 2000-2001 season, whilst rice injury was excessive in the following season @ 225 g a.i./ha.

Interpretation from these comparisons need to be treated cautiously as in many instances a following treatment might be contemplated (eg: bensulfuron plus molinate followed by MCPA sodium) that could radically change a treatment's ranking in relation to any particular weed spectrum. The results serve to highlight the strengths and weaknesses of individual programs and could be used to improve extension bulletins available to growers and agronomists.
4.3 Dry broadcast seeded rice

Dry broadcast seeding of rice is gaining popularity given the logistical ease and reduced costs compared to water-seeding (aerial sowing). Considerable disadvantages also exist by dry broadcast seeding, including loss of seed due to burial or bird feeding. Crop and weed development becomes more synchronous with dry broadcast seeding; potentially providing opportunities for alternate herbicides.

Pretilachlor provide unsuited to the large scale establishment techniques used for rice in Australia. Internationally, it is widely used as an application to 0.5 leaf rice with weeds having commenced germination. Tolerance in direct seeded culture is enhanced by addition of a crop safener (fenclorim) that is principally absorbed at the radicle of the germinating rice seedling. This explains why applications of pretilachlor made less than 9 days after flooding were excessively injured. Pretilachlor is primarily a pre-emergence herbicide, thus wanes in efficacy rapidly as weeds establish. Thus a very narrow window of application exists in temperate direct seeded rice culture due to the slow crop development relative to weeds.

Pre-flood applications of pretilachlor were not tested in this program and therefore warrant future consideration.
5. Conclusions

In drill seeded rice clomazone plus propanil treatments demonstrated great reliability and flexibility in timing for control of barnyard grass.

Post sowing pre-emergence application of clomazone plus paraquat @ 240 – 360 g a.i./ha plus 200 g a.i./ha (respectively) achieved excellent control of barnyard grass and silvertop grass provided that permanent water was applied to the field within two weeks of application.

Late germinations of barnyard grass may escape control by clomazone plus paraquat if permanent flooding is delayed by slow crop emergence (due to deep seeding and/or cool weather).

Clomazone plus propanil @ 240 g a.i./ha plus 1800 – 3600 g a.i./ha will provide excellent control of 0-4 leaf barnyard grass. Results with this treatment can wane if weeds are drought stressed and/or excessively advanced in growth stages. High rates of propanil are required if cold weather prevails during and after application.

Increasing clomazone rates above 240 g a.i./ha in post-emergence applications to rice may excessively injure the crop.

Mixtures of clomazone plus pendimethalin applied PFPE provided higher levels of barnyard grass control than either herbicide applied alone in drill sown rice.

A micro-encapsulated formulation of clomazone (COMMAND 3ME) proved significantly less effective in controlling barnyard grass the equivalent rates of the commercial emulsifiable concentrate formulation (COMMAND or MAGISTER 480 EC) when applied as a spray application in drill sown rice.

Water plantain control was most effectively achieved with a sequential program of benzofenap followed by MCPA sodium. Bensulfuron, thiobencarb, dicamba and triclopyr were found to be ineffective against water plantain.

Dirty Dora, starfruit, water plantain, arrowhead, common spikerush and cumbungi were all shown to be susceptible to bentazon as BASAGRAN @ 960 g a.i./ha and bentazon plus MCPA as BAS 433 @ 800 plus 120 g a.i./ha applied from the 4 leaf stage of rice development. Adjuvants (non-ionic surfactant and ethoxylated canola oil) did not assist with bentazon efficacy.

Rice injury with bentazon plus MCPA sodium was reduced in comparison with the commercial standard of MCPA sodium alone @ 700 g a.i./ha.

Rice grain yields were slightly higher with bentazon plus MCPA sodium than with MCPA sodium alone.

Pretilachlor was evaluated for various application timings in dry broadcast seeded rice. A narrow application window (approximately 6-9 days post flood) was defined that would prove impractical for most commercial rice crops.

The triazine herbicides prometryne, ametryne and terbutryne all failed to exhibit sufficient crop safety to water-seeded rice.

Clomazone plus molinate combinations applied into floodwater appeared mildly antagonistic, with a rate of 180 plus 1800 g a.i./ha/ha optimal for barnyard grass control.
Herbicide program performance evaluations were conducted for twelve new or pending programs over two seasons. Most programs tested achieved effective barnyard grass control, however major differences in sedge and broadleaf weed control resulted in substantial differences in average grain yield across 8 experiments.

Trial results and demonstrations conducted in this program have assisted in the acceptance and adoption of a range of new herbicide programs for water seeded rice.

Results from the clomazone and bentazon studies were used in support of registration submissions for these herbicides in drill and water seeded rice (respectively).
6. Recommendations

Herbicide program performance evaluations be continued and expanded to ensure accurate comparative data is published to assist in the choice of programs appropriate to individual ricegrowers fields. Results from the herbicide program performance comparisons ought be tabulated and incorporated in rice weed control extension bulletins.

Results from future work ought to be reported annually in order for rapid interpretation by growers and agronomists.

Results from these experiments could be used to justify a submission to the NRA for extension of the clomazone label to permit the application of clomazone plus paraquat mixtures for control of barnyard grass and silvertop grass in drill seeded rice.

Results from these experiments could be used to justify a submission to the NRA or extension of the clomazone label to permit the application of clomazone plus propanil mixtures for control of barnyard grass in drill seeded rice.

Detailed varietal tolerance experiments be established to test the tolerance of all commercial rice varieties to clomazone plus paraquat and clomazone plus propanil mixtures under weed free conditions.

Combinations of clomazone plus thiobencarb be evaluated in drill sown rice in order that residual control of dirty Dora might be achieved after permanent water is introduced.

Combinations of clomazone plus pendimethalin be evaluated in drill seeded rice as a means of concurrent delivery of alternate mode of action herbicides to delay herbicide resistance development in barnyard grass populations.

Results from these experiments could be used to support a submission to register bentazon plus MCPA sodium (as BAS 433) @ 2.0 - 2.5 l/ha for control of dirty Dora, starfruit, arrowhead, water plantain, common spikerush and seedling cumbungi in water and dry-broadcast seeded rice.

Pre-flood applications of pretilachlor be evaluated in dry broadcast and water seeded rice.

No further evaluation of prometryne, ametryne or terbutryne is warranted in water-seeded rice.

No further evaluation of clomazone plus molinate mixtures is warranted in water-seeded rice.

Where water plantain is known to infest ricefields, herbicide programs previously using bensulfuron ought to be supplanted or augmented with benzoftenap, bentazon and/or MCPA sodium.
7. Publications

Taylor, M.C. (2001) Efficacy and crop safety of bentazon (alone or in combinations with MCPA) for the control of Cyperus difformis, Alisma plantago aquatica, Sagittaria montevidensis, Eleocharis acuta, Typha spp. and Damasonium minus in water seeded and dry seeded rice, Riverina, Australia Report submitted to BASF Australia Ltd.


8. Table of field trials

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>Title</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>H20-98</td>
<td>Clomazone and molinate and propanil combinations in drill sown rice</td>
<td>Cobram, VIC</td>
</tr>
<tr>
<td>H21-98</td>
<td>Water plantain control in aerial sown rice</td>
<td>Cobram, VIC</td>
</tr>
<tr>
<td>H22-98</td>
<td>Clomazone and molinate and propanil combinations in drill sown rice</td>
<td>Jerilderie, NSW</td>
</tr>
<tr>
<td>H24-98</td>
<td>Multiple MOA programs for grass weed control in water seeded rice</td>
<td>Cobram, VIC</td>
</tr>
<tr>
<td>H25-98</td>
<td>Multiple MOA programs for grass weed control in water seeded rice</td>
<td>Myrtle Park, NSW</td>
</tr>
<tr>
<td>H27-98</td>
<td>Clomazone and molinate and propanil combinations in drill sown rice</td>
<td>Cobram, VIC</td>
</tr>
<tr>
<td>H45-98</td>
<td>New MOA herbicides for drill sown rice</td>
<td>Cobram, VIC</td>
</tr>
<tr>
<td>H49-98</td>
<td>Multiple MOA herbicide programs for drill sown rice</td>
<td>Cobram, VIC</td>
</tr>
<tr>
<td>H60-98</td>
<td>Command EC versus ME formulation comparisons</td>
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<td>Application timing of pretilachlor in dry broadcast seeded rice</td>
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<td>Pretilachlor mixtures in dry broadcast seeded rice</td>
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<td>Triazines in water seeded rice</td>
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<td>BAS 433 - Time of application</td>
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<td>Triazines in water seeded rice</td>
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<td>Pretilachlor mixtures in dry broadcast seeded rice</td>
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<td>Foliar herbicides for aquatic weed control in rice</td>
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