New weed management options for Australian rice

Malcolm Taylor
Agropraisals Pty. Ltd.

in a rice hull

- With long lead times to attain a registered herbicide in rice, our research program for weed control is focussed ahead for the times when irrigation water is once again available
- As a result of contacts made in Japan and the USA during and prior to 2006, four herbicide candidates were field tested in Australia during the 2006–07 summer
- Two experimental herbicides have been identified, one for grass weed control and another for broadleaf and sedge weeds, both of which potentially present new modes of action

Not sowing rice may be a valid herbicide resistance strategy but it is clearly not a preferred pathway for 1600 Riverina rice farmers who remain frustrated with a productive farming system, a strong market for their crop, an innovative processing company, but no water to produce their crop! With long lead times to attain a registered herbicide in rice, our research program for weed control is focussed ahead for the times when irrigation water is once again available.

Weed management programs for water seeded (aerial sown) rice involve integrating physical and chemical interventions to provide unfavourable environments for weed establishment and survival, whilst enabling rice to prosper unhindered by weed competition.

Weed free and level seedbeds, rapid inundation with an even depth of water and maintenance of this inundation for the first 30 days of crop life are all important physical means of attaining clean crops. These are not sufficient however to ensure freedom from weed competition, resulting in our annual reliance upon effective and selective herbicides.

In the past 50 years the range of selective herbicides for rice has broadened to include a multitude of herbicides with differing modes of action. Australia led in the development of herbicides for temperate zone rice during the 1990s, being the first to register clomazone (Magister®) and benzofenap (Taipan®). When analysed critically however, one concludes that we are highly reliant upon only a narrow range of herbicides, particularly group F (Magister and Taipan), group E (molinate and Saturn®) and to an increasing degree group A (Barnstorm®). For example in the 2005–06 season, between 30 and 70% of weed control programs (depending upon the district) relied upon Taipan for sedge and broadleaf weed control. Molinate is a versatile product well suited to water seeded rice culture and compatible locally with water retention ambitions. However, it is the subject of a regulatory review, having been withdrawn from sale in California. A substitute herbicide for in-flood application to control grass weeds is therefore desirable.

Looking for options in Japan

In order to broaden Australian rice growers' options for weed control, the Rice Research and Development Committee of RIRDC commissioned a range of endeavours, commencing in 2006, to identify and screen new herbicides that would suit water seeded rice and present alternate modes of action to currently registered herbicide products.

The author journeyed to Japan in July 2006 for the purpose of studying contemporary rice weed control practices and herbicides in Japanese rice production. The relatively high value of Japanese rice production, coupled with the sophistication of their chemical industry has resulted in much of the global innovation in rice herbicide development occurring in that country. Rice is a major market for herbicides in Japan, with approximately two million hectares of mostly transplanted rice treated annually for a broad suite of temperate weeds. Most agrochemical manufacturers with new chemical synthesis programs operate screening stations in Japan. I attended the annual field day of the Japan Association of Phyto-Regulators (JAPR) – a semi-government body charged with the responsibility to screen agrochemicals for Japanese agriculture.

Japanese transplanted rice culture involves germinating rice seedlings in trays, then mechanically transplanting into a freshly tilled and levelled seedbed. Rice enjoys a head start on germinating weeds with this technique and exhibits a much higher tolerance to herbicides than where herbicides are applied at or around seeding. Accordingly most of the herbicide treatments that are used in transplanted rice are highly damaging if applied to direct seeded (broadcast) rice.

Registration of new herbicides in Japan is strictly regulated, with a minimum of two seasons of field trials conducted by the independent JAPR in local prefectures across Japan. Prior to the prefecture trials, initial studies are conducted in concrete pots at their Ushiku headquarters, approximately 80 km north east of Tokyo (Figure 1). All of these experiments are conducted using transplanted rice, as direct seeding is only rarely practiced in Japan and only on a very small fraction of the area cropped to rice.

In order to control the full spectrum of weed species likely to be encountered across each of the prefectures within Japan, multiple active ingredients are usually co-formulated to deliver a 'one-shot' herbicide concept. In practice these co-formulations are commonly delivered 0–10 days after transplanting.

Possibilities for Australian rice

The objective of the tour was to identify active ingredients in the herbicide mixtures under test that may prove suitable for water seeded rice production in Australia. Many herbicides suited to transplanted rice do not exhibit sufficient crop safety to direct seeded crops, thus it is unlikely that many of the mixtures under test in Japan can be directly adopted in the Australian market. However, careful selection of the individual active ingredients can identify herbicides suited to direct seeded rice, as was the case when benzofenap was selected for development in Australia during the mid 1990s. Of particular interest on this tour were compounds that offer alternate modes of action to benzofenap.

Sulphonyl urea (ALS inhibitor) herbicides were the dominant active ingredients in Japanese rice herbicides throughout the 1990s; with bensulfuron and pyrazosulfuron most commonly used. ALS resistance in populations of several weeds is now widespread, dictating alternative mode of action herbicides be included in commercial one-shot products. Early one-shot herbicides often used first-generation protox inhibitors such as oxadiazon, and thiocarbamates such as molinate and thiobencarb. These materials have been withdrawn or superseded, often due to residue detections in drainage water.

Most combinations now include a HRAC[1] Group K (cell division inhibitor) mode of action herbicide. Historically these herbicides have demonstrated insufficient tolerance in broadcast seeded rice culture, suggesting that the majority of one-shot products under evaluation in the JAPR early stage trial at Ushiku are unlikely to be suitable for water seeded rice in Australia (or elsewhere).

Herbicides that are HPPD inhibitors (HRAC Group F) now feature strongly in many mixtures in Japan. They vary subtly in their weed spectrum, prompting in some instances mixtures of two herbicides from this same group. Australia has a similar instance where we recommend clomazone benzofenap mixtures (same herbicide grouping although acting at different enzyme sites).

New generation protox inhibitors (HRAC Group E) are under development in transplanted rice, however their crop safety in water seeded rice culture is generally unknown. One herbicide in this group, carfentrazone is used commercially in California @ 180–224 gai/ha as an in-flood treatment applied the 2-leaf stage of rice for sedge and broadleaf weed control. Crop injury with this treatment is common.

Significantly, whilst a range of new herbicide active ingredients have been introduced in Japan in the past decade, they have not arisen from new modes of action.

Crop safeners (daimron and fenclorim) are commonly co-formulated to reduce rice injury from ALS inhibitors and pretilachlor (respectively) in many one-shot herbicide mixtures. Fenclorim has been evaluated in previous RIRDC sponsored field trials in water seeded rice in Australia, however safening effects on pretilachlor (SOFIT EC) were insufficient to enable reliable crop tolerance in local medium grain rice varieties.

[1]Herbicides are classified on the basis of their mode of action, as designated by the Herbicide Resistance Action Committee (HRAC), an international body founded by the agrochemical industry which has the general purpose of supporting a cooperative approach to the management of herbicide resistance.

Figure 1. View of JAPR Ushiku pot testing facility – over 200 herbicide combinations under simultaneous testing in transplanted rice

Figure 2. Australian field testing facility near Cobram, Victoria in November 2006

Australian testing

As a result of contacts made in Japan and the USA during and prior to 2006, four herbicide candidates were field tested in Australia during the 2006–07 summer. The candidates and their basic characteristics are listed in Table 1.

Nine replicated field trials were conducted at a dedicated test facility near Cobram, Victoria during the 2006–07 season in water-seeded medium grain rice to evaluate the efficacy and crop safety of the four experimental herbicides.

AGR-601 demonstrated insufficient crop safety to water seeded rice when applied at 0–2 leaf stage or rice, whilst efficacy against aquatic broadleaf weeds was poor.

AGR-602 was combined with AGR-601 to broaden weed spectrum and act as a crop safener. No crop safening was observed to 0–2 leaf rice, nor was there a discernible improvement in weed control efficacy. No further work is warranted with either AGR-601 or 602.

AGR-603 was targeted at grass weeds at the 0–2 leaf stage of rice development. Crop safety was marginal at 1500–3000 gai/ha, whilst barnyard grass was controlled at rates higher than 500 gai/ha. Combinations of AGR-603 plus benzofenap provided an adequate margin of rice tolerance and effective control of grass, sedge and broadleaf weeds. Differences in field performance of alternate AGR-603 formulations warrant investigations to optimise efficacy.

AGR-604 was targeted at sedge and broadleaf aquatic weeds. Crop safety was acceptable when applied at 200–400 gai/ha to rice at the 2–4 leaf stage of rice. Earlier applications proved excessively phytotoxic to water seeded rice.

The significance of the above information is that we have identified two experimental herbicides that potentially fit the profiles we are searching for: namely one herbicide (AGR-603) for grass weed control and another (AGR-604) for broadleaf and sedge weeds, both of which present new modes of action and can be delivered directly into floodwater to selectively control weeds in water seeded rice.

RIRDC Project AGR-9A

Malcolm Taylor
Agropraisals P/L
T: 03 5872 2892
E: malcolmc.taylor@bigpond.com

Figure 3. Comparison of untreated control (left) and AGR-604 @ 300 gai/ha applied 4 days after sowing to Quest rice, Cobram, 2006

Table 1. Possible new herbicides for Australian rice crops (the products are coded in order to maintain commercial confidentiality)

Code	HRAC classification	Target weeds	Rice culture
AGR-601	Group G	barnyard grass, dirty Dora, water plantain, starfruit	Water seeded
AGR-602	Group G plus unknown	barnyard grass, dirty Dora, water plantain, starfruit	Water seeded
AGR-603	Unknown	barnyard grass, silvertop grass	Water seeded
AGR-604	Group G	arrowhead, dirty Dora water plantain, starfruit	Water seeded