



Rice improvement in tough times

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in a rice hull

- The key feature of the 2006–07 rice season was the reduction in trials of advanced breeding lines due to water restrictions
- A full suite of 14 on-farm trials was sown but most were de-watered and only five were harvested
- While water limitations restricted evaluation of advanced lines, the program re-focused attention on screening early-generation material through increased use of DNA markers, and field-based screens for cold tolerance and straighthead
- Linkage to and development of new projects is providing new varieties for breeding and a flow of information on traits such as cold tolerance, adaptation to aerobic conditions and the genetic control of chalk in rice grains

The rice breeding program focuses on improving yield, grain quality and agronomic characteristics of varieties across a range of classes of rice. Breeding lines are constantly being evaluated against present commercial varieties in research station trials and on-farm trials throughout the rice growing area.

The grain quality class and maturity group of the existing commercial varieties and their possible replacements are shown in Table 1.

With limited water availability and subsequent changes to allocations throughout the rice season of 2006–07, a number of on-farm trials were abandoned. Of the six advanced trials sown, three were harvested; one at Coleambally, one at Rice Research Australia (RRAPL) at Jerilderie, and one in the western Murray Valley. This data-set is too small to allow a complete statistical 'variety by location' analysis, however average yields are presented. The remaining trials completed in the season included one preliminary trial at RRAPL (Jerilderie) and a late-sown trial at Coleambally.



Figure 1: Rice breeding trials at Leeton Field Station March 2007. The total area of rice breeding trials is approximately 18 ha. Photo courtesy Neville White



Yield

Yield results for the medium grain lines from the advanced trials are shown in Table 2. In the Coleambally Irrigation Area (CIA) trial, the breeding line YRM68 performed well, as did Quest_CT19 and Reiziq. Paragon and YRM65 had the lowest yields. There were very minor differences among the long grains in this trial, with most lines averaging 11 t/ha.

All medium grain lines had high yields in the advanced trial in the western Murray Valley (WMV), with an overall mean of 12.8 t/ha. Similarly the long grain lines all had similar yield with an overall average of 12.3 t/ha

In general, trials sown in early October (CIA and WMV) had higher grain yields (mean yield 11 t/ha) while those sown in late October incurred a yield penalty (mean yield approximately 9 t/ha). In the later-sown trial (EMV) the cold tolerant line YRM69 out-yielded Amaroo by 4 t/ha, which is consistent with the greater floret fertility exhibited

by this line in field screens for cold tolerance. There was significant variability in yield among the medium grain lines with Paragon, Reiziq and YRM66 having the lowest yields, probably due to their greater susceptibility to low temperatures.

The long grain lines at this site also showed significant yield variability, with the fragrant lines YRF209 having the lowest yield and Kyeema the highest.

The preliminary trial at RRAPL highlighted differences between Quest and Quest_CT19, with the latter having greater yield. The two lines also have differing maturity with Quest_CT19 later flowering than Quest (4–5 days in October-sown trials, 6–7 days later in later sowings). Reiziq and YRM69 had greater yield than Amaroo in this trial. The preliminary lines included in this trial included two arborio types, four medium grains and three long grains. The arborio types had similar yield to Illabong, which had the highest yield of all varieties in the trial.

Table 1: Commercial varieties and advanced breeding lines of rice included in the breeding program conducted by NSW DPI from Yanco Agricultural Institute.

Quality Class	Maturity group		
	Short season	Mid season	Long season
Medium grain (Amaroo)	Jarrah	Millin, Quest, YRM69, YRM67	Amaroo, YRM68
Large medium grain (Reiziq)		YRM64, YRM65	Reiziq, YRM66
Short grain (Opus)			Opus, Koshihikari
Arborio (Illabong)			Illabong, YRB4
Long grain (Langi)		Langi, YRL118, YRL126	YRL123, YRL125 and 3 selections
Long grain fragrant		YRF208	Kyeema, YRF209
Long grain firm-cooking			Doongara

Table 2: Average yield (t/ha at 14% moisture) of lines in three advanced trials in the Coleambally Irrigation Area (CIA), eastern Murray Valley (EMV) and western Murray Valley (WMV).

Medium grain variety/line	CIA	EMV	WMV	Long grain variety/line	CIA	EMV	WMV
Amaroo	11.7	8.4	12.6	Doongara	11.2	8.4	12.2
Illabong	12.0	9.1	13.2	Kyeema	11.6	10.7	11.6
Millin	12.1	8.3	12.3	Langi	11.1	9.6	12.2
Opus	11.5	7.1	13.1	YRF208	11.9	8.8	12.7
Paragon	11.0	5.5	13.3	YRF209	11.2	6.0	11.9
Quest	11.9	8.6	13.4	YRL118	11.4	8.0	12.9
Quest_CT19	12.0	8.8	13.1	YRL123	11.4	7.6	12.8
Reiziq	12.0	6.7	13.6	YRL125	11.6	10.1	13.4
YRM64	11.7	10.4	13.5	YRL125 P/S 14	11.8	9.5	11.9
YRM65	11.1	9.2	12.8	YRL125 P/S 19	12.4	7.7	12.2
YRM66	11.9	7.3	11.2	YRL125 P/S 9	13.2	9.4	11.7
YRM67	12.0	10.0	14.1	YRL126	11.3	10.5	12.5
YRM68	12.2	9.0	11.4				
YRM69	11.8	12.4	12.7				
YRM69 P/S 2	11.8	11.5	12.8				
Std error	0.19	0.58	0.44		0.19	0.58	0.44



Seed increase & testing

Aerial sown foundation seed lots of YRM68 and YRM69 were sown at RRAPL, to provide the quantity of grain necessary to determine grain yield and milling quality on a commercial scale. At this stage limited information is available but generally the primary concern of these two lines is the grain size, with dimensions similar to Amaroo rather than the increased grain length of Quest or Reiziq which are similar to the Californian varieties.

Grain quality

Each season grain quality attributes are assessed on current varieties and new breeding lines using serial samples from a trial specifically aimed at tracking grain quality changes as the crop matures.

First indications from the sequential harvest samples taken from the Yanco quality trial (YIQ07), show YRM68 with very similar maturity and percentage whole grain to Amaroo, while YRM69 had similar maturity to Quest and Millin, and showed similar rapid decline in whole grain across sample dates (Table 3).

Among the early-maturing (or mid-season) group, Quest_CT19 had the greatest whole grain at each of the harvest dates, while Millin had low whole grain at early harvest. All remaining varieties performed similarly at later harvests.

The grain moisture content at harvest for each variety and harvest date are shown in Table 4.

High evaporative demand during grain filling can cause stress cracks in grains, leading to increased grain breakage during milling. When grain moisture declines below 23% the occurrence of hot, dry days will result in the formation of stress cracks. The moisture range during which grains are most sensitive is between 23% and 18%.

All of the mid-season lines were at or below 23% moisture at the time of the first harvest, and YRM69 had the lowest grain moisture reflecting its earlier maturity than the rest of the mid-season group. The milling quality of YRM69 was lower than Quest, however grain moisture at harvest was likewise lower than Quest at the first three sample dates resulting in greater exposure to conditions conducive to cracking. The breeding line YRM69_LT2 appears to have better whole grain and will be evaluated further.

Table 3: Whole grain (%) of commercial varieties and breeding lines across a range of harvest dates in the Yanco grain quality trial (YIQ07)

Variety	Date of harvest					
	Mar 28	Apr 04	Apr 11	Apr 16	Apr 24	May 07
Long-season lines						
Amaroo	62.1	64.8	65.3	61.9	61.9	57.9
Reiziq	66.1	65.9	67.0	65.7	66.1	59.7
YRM68	63.8	66.9	68.4	65.5	64.6	61.3
Mid-season lines						
Quest_CT19	65.3	63.2	67.1	62.2	62.6	57.0
Millin	38.3	41.6	43.0	42.0	35.9	38.6
Quest	50.4	50.4	48.0	44.8	42.5	39.9
YRM69	47.3	46.0	45.9	44.7	44.3	35.6
YRM69_LT2 ¹	54.7	52.8	48.3	43.1	43.8	35.1

¹YRM69_LT2 is an additional selection from within original YRM69.

Table 4: Moisture content (%) of commercial varieties and breeding lines across a range of harvest dates in grain quality trial YIQ07.

Variety	Date of harvest					
	Mar 28	Apr 04	Apr 11	Apr 16	Apr 24	May 07
Long-season lines						
Amaroo	23.1	22.6	21.2	18.0	17.8	16.9
Reiziq	24.4	22.2	20.5	17.8	17.2	16.1
YRM68	23.9	24.5	23.2	19.4	19.1	16.8
Mid-season lines						
Quest_CT19	22.8	22.7	21.0	18.3	17.3	15.9
Millin	20.5	19.2	19.7	17.8	16.6	16.4
Quest	21.0	20.3	19.7	16.6	16.5	16.3
YRM69	19.5	18.9	17.7	16.3	16.6	16.2
¹ YRM69_LT2	22.0	18.9	18.5	16.4	17.2	16.2

¹YRM69_LT2 is an additional selection from within original YRM69.



Early generations

A significantly greater number of crosses were made in the 2006–07 season, reflecting utilisation of additional space in the new glasshouse facility commissioned in August 2006 (Figure 2).

Of the 678 crosses made in total, more than half were made to transfer cold tolerance into parent lines with a suitably adapted genetic background and approximately half of these crosses were backcrosses (in which multiple crosses are made in succession to the adapted parent, to transfer specific traits such as cold tolerance into existing varieties) and the remainder were triple crosses. Triple crosses involve crossing the F₁ plant to a third parent, to maximise the opportunity for genetic recombination and subsequent recovery of good combinations of traits in the progeny.

The new glasshouse was also used to produce increased quantities of F₂ seed from F₁ plants thereby increasing the opportunity for selecting desirable combinations from F₂ populations in the field. The increased cross numbers and seed production are about three times the average over past years, due to increased glasshouse space and better control of heating and cooling systems.

Future plans

The release of a new variety is unlikely for at least the next two years, as drought and the lack of irrigation water has significantly restricted the multi-location and on-farm testing phase of evaluation for the rice improvement program.

The impact of the drought on the breeding program has been to restrict on-farm testing of advanced lines and through reduced funding, no replacement of capital items and some reduction in labour and operational funds. During this period the strategy is to re-direct efforts towards early generation selection for key traits using a combination of field or glasshouse based screening nurseries or molecular markers. Increased selection pressure is applied in early generations for cold tolerance, salt tolerance, straight-head tolerance, stress cracking, amylose content and gel temperature. When the industry returns to full production, lines progressing through the breeding program will be better characterised for each of these traits. Increasing the number of lines already selected for key quality and stress tolerance traits will lead to better prospects for selecting varieties that vary in more complex traits such as yield.



Figure 2: Rice breeding staff, from left, Greg Napier, David Troidahl, Peter Snell, Russell Reinke, Fred Ciccio, Anne Sheldrick (retired) and Col Dunn, at the unofficial opening of the new rice breeding glasshouse July 2006.

While the research levy is limited by reduced production levels we are seeking to continue research linked to breeding program priorities with alternative funding sources. The breeding program is currently linked to two ACIAR-funded projects.

The first is an Australia-China linkage project specifically aimed at scientific linkages for improved cold tolerance. An international workshop was held at Yanco in December 2006 as part of this project, and significant linkages established with research institutions in high altitude areas (Yunnan Province) and high latitude rice growing regions (Liaoning and Heilongjiang Provinces, 41°N and 46°N respectively). Exchange of germplasm with these regions will be invaluable in broadening the genetic base of the breeding program, and in utilising new genes for improved tolerance to low temperatures (Figure 3).

This project also funded the rice breeders and selected Rice Research Committee members to go on a study tour of relevant regions of China during September 2007 to develop future projects and enhance the linkages. As a result of this visit there are good prospects of new projects focussing both on cold tolerance and adaptation to non-flooded conditions (aerobic rice).

The second ACIAR project is based at the International Rice Research Institute (IRRI), and is focused on uncovering the genetic basis of chalk formation in rice grains through examination of variation in panicle structure, the flow of photosynthates in the rice plant during late grain filling, and the activity of starch synthesis enzymes. While the bulk of the gene discovery work will take place at IRRI, populations which vary in chalk are being developed at Yanco, and the molecular markers developed will be tested in our *temperate japonica* rice background.

International linkages such as these are essential in guaranteeing a flow of information and germplasm that will enable future progress. 🌾

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Figure 3: Rice plots growing at Heilongjiang Academy of Agricultural Science in northern China (46°N). Erect-panicle rice variety on the left in contrast to the normal panicle variety on the right.