Drought puts new focus on rice improvement program

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IN A RICE HULL

- Low levels of rice production have led to changes in the objectives of the breeding program, with an increased emphasis on improving the cold tolerance of varieties in all grain quality classes
- A greater proportion of breeding program resources will be directed at improving medium grains in all maturity groups, and soft-cooking long grains similar to Langi
- A series of selections from a long-grain line will continue in testing as possible Langi replacements
- On-farm testing of two new fragrant lines will continue in advanced trials, as possible Kyeema replacements
- Two advanced medium-grain lines will be maintained in advanced trials as possible new varieties in the Amaroo and Millin maturity classes

In response to the recent low production seasons, the aims of the rice improvement program have been restricted to a smaller number of key objectives. These include additional emphasis on cold tolerance for all variety classes, water use efficiency, and tailoring grain quality for specific markets.

More than 400 crosses were made in the 2004–05 summer crossing program and of these approximately 30% were aimed at improving cold tolerance, reflecting the recent change in the direction of the rice breeding program. International varieties identified by Rice CRC cold tolerance projects were used as parents.

In addition to using new and diverse parents, the structure of the breeding program has been changed so that selection for cold tolerance is carried out at early stages in the program, with subsequent cycles of selection for grain quality and yield.

Breeding populations are exposed to low temperatures by late sowing at a southern site. Since flowering occurs around 10–14 days after the critical microspore development stage, the panicles which are flowering 10–14 days after a known cold event are tagged for later analysis. During the 2004–05 season approximately 900 panicles were tagged after a known cold event and harvested at maturity from the 18 F_3 populations that were late-sown at Rice Research Australia, at *Old Coree*, Jerilderie. These panicles have all been assessed for the extent of cold induced sterility, and only those with significantly lower levels of floret sterility than the current commercial varieties will be advanced to further cycles of selection for cold tolerance and grain quality.

New molecular markers for fragrance and gelatinisation temperature have recently been developed in a RIRDC-funded project at Southern Cross University (see report *Prefect molecular markers for fragrance and gelatinisation temperature*, pp 38–39 of this edition). The routine use of molecular markers for amylose content and fragrance has improved the efficiency of the breeding program, by allowing selection on key grain quality attributes in early generations. This means a smaller number of lines, but more with suitable grain quality progress to field plots. All new fragrant lines under development have been tested using the new fragrance marker and around 70% of the lines were shown to be true-breeding or segregating for the fragrance gene.

Field program

The size of the field component of the rice improvement program for 2004–05 is shown in Table 1.

In the field, single panicle selections were completed in a timely manner for the 114 F_2 populations. A total of 2621 panicle rows were hand cut and threshed representing a recovery rate of more then 10% of panicle rows sown. A total of 6189 plots were harvested for grain yield and quality evaluation (an equivalent number to the previous season) evaluating a total of 2687 breeding lines in unreplicated, replicated and district trials.

Pure seed lots of both commercial varieties and advanced breeding lines were maintained, at Leeton Field Station, Rice Research Australia Pty Ltd (Jerilderie) and grower's fields in the MIA.

Breeding lines in four variety classes (medium-grains, arborio-types, long-grains and fragrant) were evaluated this season. Cultivars were grouped according to maturity for yield comparisons. Breeding lines including Paragon, Reiziq, YRM64 and YRM68 were compared to Amaroo while the shorter-season breeding lines YRM65 and YRM67 were compared to Quest. Two additional Quest lines were evaluated in this year's trials, Quest_CT18 and Quest_CT19. These different pure seed lines represent different cooking quality, with Quest_CT19 having similar cooking quality to Amaroo. Quest_CT18 is slightly softer cooking, like Millin. The high yielding arborio-type, YRB4, was tested against Illabong.

The advanced long-grain lines YRL118, YRL123, YRL125 and YRL126 were compared to Langi, while the new fragrant lines YRF208 and YRF209 were compared to Kyeema. Details of each of the advanced lines are shown in Table 2.

Table 1

Rice Varietal Improvement Program for 2004–05

Description	Number of trials	Number of lines tested	Number of plots
F_2 populations	2	114	120
F_3 populations (RRAPL)	1	18	18
Panicle rows (a)	4		22,632
Unreplicated trials	10	1781	2399
Replicated trials			
• Yanco (LFS)	8	478	1912
• RRAPL	7	206	618
Seed increase			
• Yanco (LFS)	9	112	372
• RRAPL	2	56	168
District trials			
• Advanced	6	24	432
• Preliminary	4	18	216
• Preliminary short-season	2	12	72
Pure seed	Produced for all commercial varieties		
Total plots (b)	**48**	**2687**	**6189**

(a) panicle rows are 1 m rows of rice grown from single panicles selected from F_2 populations

(b) panicle rows, F_2 and F_3 populations are not included in the total number of plots

Table 2

Description of advanced lines included in district trials in 2004–05

Medium grain	YRM 64	(M 201/YRM 3//Bogan) Semi-dwarf medium grain, sister line to Paragon. Slightly longer grain length compared with Paragon.
	YRM 65	(M 201/YRM 3//Bogan) Semi-dwarf medium grain, sister line to Paragon. Around 10-14 days earlier to flower than Amaroo.
	YRM 66	(M 103//M 201/YRM 3) Semi-dwarf medium grain with exceptionally low levels of chalk. Good grain length, although not particularly a high yielder.
	YRM 67	(Illabong/M 203) Semi-dwarf medium grain with high yield potential. Around 10-14 days earlier to flower than Amaroo, may be photoperiod sensitive. Chalk may be an issue.
	YRM 68	(M 201/YRM 3//M 102) A full season variety like Amaroo however early indications are it has higher levels of cold tolerance.
Arborio type	YRB 4	(YRB 3/Arborio) An arborio grain type comparable to Illabong although it has slightly higher yield potential.
Long grain	YRL 118	(YRL 30///YR73/Banat 725//Inga) Acceptable yield and quality although it is more susceptible to straighthead than Langi.
	YRL 123	(Pelde*2/Calrose 76) Langi maturity with acceptable yield and quality.
	YRL 125	(YC 71048.111/3/YC 303D//Bluebelle/Inga/4/YRL 37) A long-grain line with high yield potential. Cooking quality similar to Pelde.
	YRL 126	(Inga//Doongara/YRL 39) A new long-grain line with high yield potential and maturity similar to Langi.
Fragrant type	YRF 208	(Pelde/Gopalbhog(4)/YC 71048-10//YRL 101) A new semi-dwarf fragrant line with superior yield potential to Kyeema, with a new source of fragrance.
	YRF 209	(Pelde/Gopalbhog(4)/YC 71048-10//YRL 101) A semi-dwarf sister line to YRF 208 with superior yield potential to Kyeema, with a new source of fragrance.

Medium-grains

Yield differences between medium-grain varieties (Table 3) were less obvious than in previous years due to a number of low yielding trials in 2004–05 which reduced the average yields for the past three seasons. However, past and potential medium-grain varieties all appeared to offer a yield advantage of approximately 5% over Amaroo.

In contrast to the industry-wide regional averages, Quest had greater yield than Amaroo in trials across all valleys, even in severely cold affected sites (Table 4). These yield differences were attributed to sowing Quest at the optimal sowing date (last week in October) at all sites. These sowing dates were later than normal for Amaroo and the shorter vegetative period may have resulted in slightly lower yield potential.

The difference in industry yields between Amaroo and Quest can be partly explained by exposure to cold at critical growth stages.

Table 3
Average grain yield (t/ha) of advanced medium-grain breeding lines compared to commercial varieties over three years of district trials

Variety	Overall Mean	Yield (% of Amaroo)	Rank	Number of trials
Amaroo	8.80	100	13	16
Reiziq	8.68	99	14	16
Paragon	9.48	108	5	16
YRM64	9.34	106	9	16
YRM68	9.40	107	8	6
YRM66	7.89	90	15	16
Opus	8.88	101	11	16
Millin	8.88	101	12	16
Quest	9.52	108	3	16
Quest_CT19	9.60	109	2	6
Quest_CT18	9.76	111	1	6
YRM65	9.42	107	7	16
YRM67	9.24	105	10	16
Illabong	9.50	108	4	16
YRB4	9.48	108	6	16

Figure 1 *The rice breeding team roguing a crop of Reiziq being grown for breeders' seed, at Old Coree, Jerilderie*

Table 4
Average grain yield (t/ha) of advanced medium-grain lines at each site in the 2004–05 season

Variety	*CIA*	*MIA1*	*MIA2*	*EMV*	*WMV1*	*WMV2*	*Mean*
Amaroo	9.65	7.18	10.36	5.79	6.73	0.95	6.78
Reiziq	9.40	6.91	11.23	6.09	5.52	0.58	6.62
Paragon	10.63	8.62	10.78	7.42	8.05	2.10	7.93
YRM64	10.45	8.41	10.94	7.06	8.30	2.44	7.93
YRM68	10.62	8.55	10.95	7.11	8.43	2.65	8.05
YRM66	8.72	5.72	9.21	4.58	5.44	2.20	5.98
Opus	10.19	7.80	10.24	5.89	7.63	3.83	7.60
Millin	10.50	8.12	10.83	6.01	5.98	5.81	7.88
Quest	10.61	8.72	11.32	7.39	10.03	2.32	8.40
Quest_CT19	10.73	8.84	11.35	7.68	9.97	2.20	8.46
Quest_CT18	10.92	9.15	11.30	7.87	10.25	2.28	8.63
YRM65	10.56	8.54	11.26	7.11	9.57	2.31	8.23
YRM67	10.44	8.10	11.54	6.47	8.94	1.57	7.84
Illabong	11.12	9.14	11.56	7.04	9.73	5.02	8.94
YRB4	11.19	9.21	11.45	7.11	9.51	5.74	9.04
LSD0.05	0.41	0.32	0.50	0.43	0.75	0.64	
CV%	2.50	2.43	2.77	3.90	5.65	13.75	

CIA: Coleambally Irrigation Area, MIA 1 & 2: Trial sites in MIA Murrumbidgee Irrigation Area, EMV: Eastern Murray Valley, WMV1 & 2: two sites in the Western Murray Valley

Data from the NIR tissue testing service for grower's panicle initiation (PI) dates for Amaroo and Quest are shown in relation to the minimum temperatures experienced during the young microspore stage, in Figure 1. Given that young microspore follows panicle initiation by about 14 days and minimum temperatures below 15°C are conducive to yield loss, it is evident that 50% of Quest crops tested at panicle initiation experienced extremely cold temperature during young microspore, compared to 10% of Amaroo crops. All crops which reached panicle initiation after 20 January would have been subject to low temperatures during their most sensitive stage of pollen development.

Quest's wholegrain returns remain an issue but trial results continue to highlight its superior milling quality over Millin. For example, in a late sown (30 October) quality trial in which maturity differences were minimised (Amaroo was nine days later to flower than Millin), Quest's wholegrain percentage was on par with Amaroo, and significantly higher than that of Millin by 14%.

In response to marketing requests for larger grain size, Quest and other advanced medium-grain lines have significantly longer grains (Table 5) than Amaroo, bringing them in line with the Californian and Egyptian medium-

Table 5
Brown grain dimensions of advanced medium-grain lines compared to commercial standards

Variety	Length	Width	l/w ratio
Amaroo	5.72	2.73	2.10
Reiziq	6.33	2.68	2.36
Paragon	5.70	2.67	2.13
YRM64	5.94	2.69	2.21
YRM68	5.91	2.85	2.07
YRM66	5.88	2.81	2.09
Opus	5.00	2.80	1.79
Millin	5.48	2.65	2.07
Quest	6.02	2.73	2.21
Quest_CT19	5.99	2.70	2.22
Quest_CT18	6.12	2.78	2.20
YRM65	6.06	2.72	2.23
YRM67	5.72	2.76	2.07
Illabong	6.03	3.19	1.89
YRB4	6.04	3.12	1.94
SED	0.05	0.07	N/A

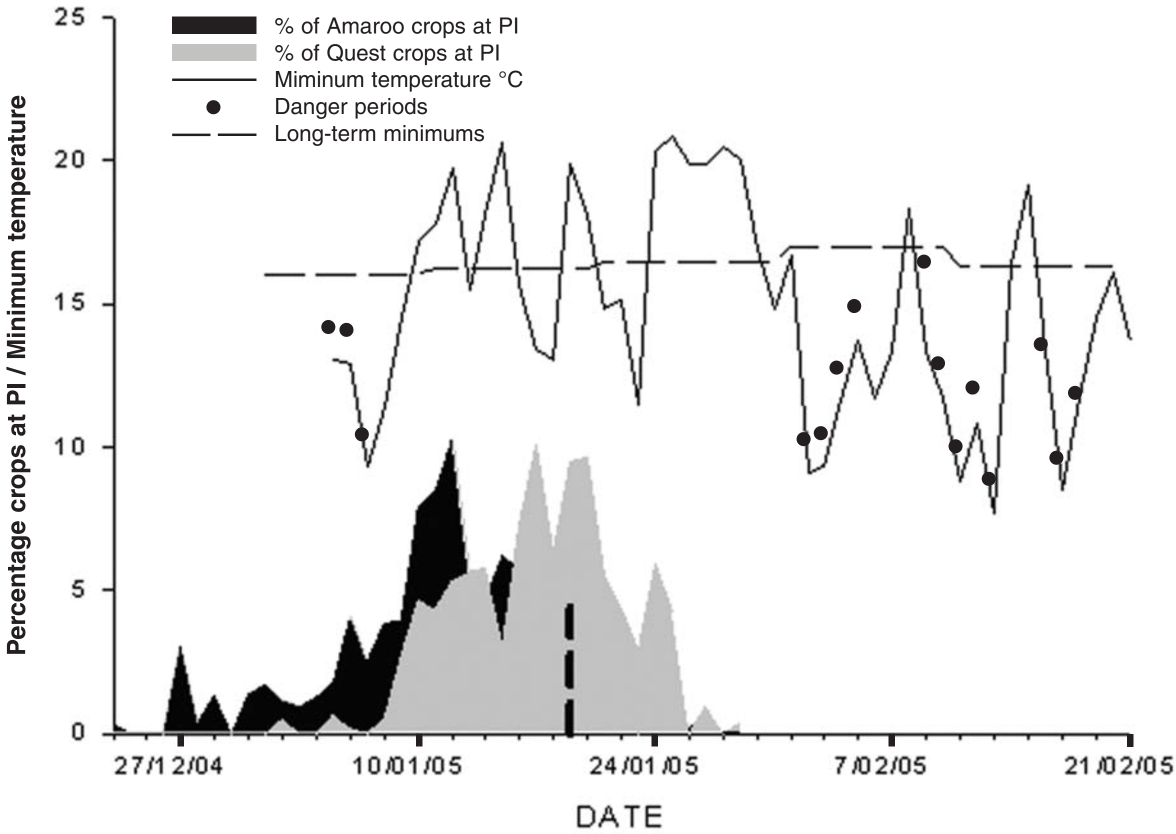

Figure 2 *The percentage of commercial Amaroo and Quest crops at panicle initiation (PI) from late December 2004 to late January 2005. Given that the critical young microspore stage occurs about 14 days after panicle initiation, about 50% of Quest crops were potentially damaged by low temperatures which coincided with the young microspore development stage.*

grain benchmark. The most recent release, Reiziq, has the longest grain and a length to width ratio which significantly exceeds 2.1, an important physical specification for a number of medium-grain markets.

Long-grains

One new advanced long-grain line and two fragrant lines were added to this year's advanced district trials (Table 2). The two fragrant lines have a different source of the fragrance gene to Kyeema (which obtained its fragrance from southern US variety Della). YRF 208 and YRF 209 have a fragrance gene which comes from the Indian variety Gopalbhog. Generally long-grain yields were lower and varietal differences (Table 6) less evident than in the previous season, with YRL125 only achieving a 1% advantage over Langi while last year it was 7% greater. Low yields throughout the region (Table 7) were again attributed to cold and comparable to industry-wide averages, with earlier maturing varieties like Langi and YRL126 yielding the highest at sites were they escaped the low temperatures during the young microspore stage.

Although the new long-grain lines are slightly longer duration varieties than Langi (Table 8) they are generally shorter in stature then their commercial counterparts. In addition to agronomic characteristics there is a continued focus on cooking quality, with molecular markers for amylose content (CT marker) and fragrance being used in the pure-seed program to ensure we maintain our unique soft-cooking long grains, and that the fragrant lines are true breeding. For example, three separate pure seed accessions of YRL125 are currently in seed multiplication, each of which has superior cooking quality to Langi and agronomic and milling quality superior to the original YRL125 breeding line.

Table 6
Average grain yield (t/ha) of advanced long-grain breeding lines compared to commercial varieties over three years of district trials

Variety	*Overall Mean*	*Yield (% of Langi)*	*Rank*	*Number of trials*
Langi	8.87	100	3	17
Doongara	7.02	79	8	17
YRL118	8.41	95	5	17
YRL123	8.57	97	4	17
YRL125	8.94	101	2	17
YRL126	9.00	101	1	6
Kyeema	7.31	82	7	17
YF208	7.64	86	6	6
YRF209	6.90	78	9	6

Table 7
Average grain yield (t/ha) of advanced long-grain lines at each site in the 2004–05 season

Variety	*CIA*	*MIA1*	*MIA2*	*EMV*	*WMV1*	*WMV2*	*Mean*
Langi	10.37	7.39	10.77	7.09	7.68	2.91	7.70
Doongara	8.94	3.68	9.98	4.27	2.90	0.50	5.05
YRL118	10.75	5.77	10.75	5.63	5.68	1.63	6.70
YRL123	10.45	4.27	10.99	4.45	5.18	1.99	6.22
YRL125	10.54	7.25	10.37	5.75	5.11	2.37	6.90
YRL126	10.23	6.83	10.55	6.54	7.53	3.08	7.46
Kyeema	9.03	3.16	9.52	4.9	3.07	1.86	5.25
YRF208	10.25	3.18	10.26	5.1	3.24	0.91	5.49
YRF209	9.14	3.33	9.17	4.39	3.73	0.18	4.99
LSD	0.71	0.70	0.58	0.55	0.21	0.71	
CV (%)	4.42	8.66	3.58	6.21	2.47	25.96	

CIA: Coleambally Irrigation Area, MIA 1 & 2: Trial sites in MIA Murrumbidgee Irrigation Area, EMV: Eastern Murray Valley, WMV1 & 2: two sites in the Western Murray Valley

Table 8
Days to flowering, plant height (cm), grain pubescence, cooking quality (CTn) and fragrance of advanced long-grain lines

Variety	*Days to flower*	*Height*	*Pubescence*	*CT*	*Fragrance*
Langi	110.8	79.1	Smooth	19	-
Doongara	116.6	69.0	Smooth	14	-
YRL118	119.6	73.9	Pubescent	19	-
YRL123	112.8	81.2	Pubescent	18	-
YRL125	115.8	74.0	Smooth/Pub. mix	18/19	-
YRL126	111.7	76.6	Smooth	19	-
Kyeema	109.5	80.2	Pubescent	18	+
YRF208	122.9	66.2	Pubescent	18	H
YRF209	113.3	71.0	Smooth/Pub. mix	18	+
SED	3.1	3.3	N/A	N/A	N/A

In addition, preliminary cooking and taste tests of the fragrant lines YRF208 and YRF209 indicate that the type and degree of fragrance is different to Kyeema, and matches the Thai jasmine types more closely. However, further testing of the final cooked product is required to benchmark quality against imported products.

Summary

The changed objectives of the breeding program have resulted in additional effort being directed at sowing bulk F_3 populations in the southern rice growing area, using early and late sowing dates, to maximise the chances of exposure to cold events. All populations developed from crosses with cold-tolerant parents will be exposed to low temperatures in early generations to ensure good selection pressure for cold tolerance.

As a result of changing production levels and the relative importance of specific markets, a greater proportion of breeding program resources will be directed at improving medium grains in all maturity groups, and soft-cooking long grains similar to Langi. Fewer resources will be directed at specialty types such as the fragrant and Japanese quality classes.

Two new fragrant lines YRF 208 and YRF 209 will continue in on-farm testing in advanced trials as possible Kyeema replacements. The best prospect for a Langi replacement is one of the segregants from the breeding line YRL 125. Among the medium grains YRM 68 and YRM 65 will continue in advanced trials as possible new varieties in the Amaroo and Millin maturity classes respectively.

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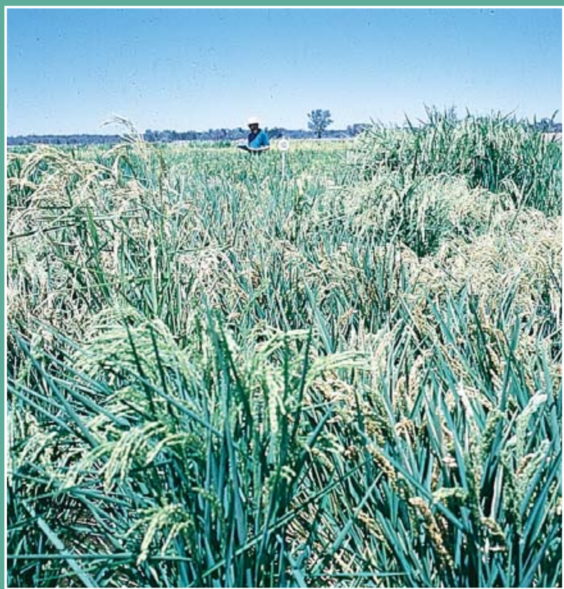

Figure 3 *The rice improvement program now has a strong focus on improving cold tolerance, and is using new and diverse varieties as parents of breeding lines*