



# A season to test yield potential of varieties & breeding lines

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## in a rice hull

- The favourable rice growing conditions of the 2005–06 season allowed good expression of genes associated with yield potential in the lines being developed and tested in the rice breeding program
- Reiziq performed well commercially and in trials, however its long-term average yield is similar to Amaroo
- Seed of a new type of Quest (Quest\_CT19) will be available through the pure seed scheme for the 2007–08 crop
- A new medium grain YRM69 combines mid-season maturity, increased cold tolerance and high yield potential, but milling quality needs further evaluation

***A key feature of the 2005–06 rice growing season was the absence of low temperatures during the normal period of microspore development and flowering, which led to high yields at all the district trial sites. This was a stark contrast with the 2004–05 season in which cold conditions resulted in extremely low yields at some sites. The warm conditions of 2005–06 allowed expression of the yield potential of varieties and breeding lines under non-limiting temperatures.***

The rice breeding program focuses on improving yield, grain quality and agronomic characteristics of varieties across a range of classes. The program is tightly linked to the rice industry marketing group and responds as quickly as possible to changes in market requirements.

Recent changes in priorities have resulted in reduced emphasis on fragrant or jasmine rices, and greater emphasis on larger medium-grains and improved cold tolerance for all variety classes.



**Figure 1:** Plots in the northern district trials, showing a sharp contrast in the maturity of some of the lines being tested in the rice breeding program.



**Figure 2:** Col Dunn of the Yanco Rice Breeding team inspecting lines in the rice breeding program.



The program also seeks to maintain and increase links with other research institutions and currently collaborates with Sydney University (development of doubled haploids for rice breeding), Southern Cross University (gene discovery for cold tolerance and grain quality), the University of Queensland (cold tolerance screening), and CSIRO Plant Industry (starch characteristics). Research updates on some of these projects are reported in this edition.

The classes of rice in the breeding program are summarised according to their grain quality class and maturity group (Table 1). Table 1 also shows the current commercial varieties and the breeding lines which may replace them.

The medium-grain class has been divided into two categories (medium-grain and large medium-grain) to reflect the increasing importance of the class which has greater grain

length and length to width ratio to that of Amaroo.

The pedigree and a general description of the breeding lines included in the 2005–06 trial series are shown in Table 2.

### Yield results

The warmer season boosted the four-year average yields for medium grain varieties (Table 3) with all but one variety exceeding the yield of Amaroo for this period.

Regional trial averages for the 2005–06 season (Table 4) reflected the high commercial yields, with Reiziq and a number of advanced breeding lines averaging 12.8 t/ha or greater. Illabong and the Arborio-type breeding line YRB4 had the highest average yields, while the best performing medium-grain varieties were YRM69, a line with enhanced cold tolerance that yielded well even in the cold 2004–05

**Table 1: The types of rice covered by commercial varieties and advanced breeding lines in the rice breeding program conducted from Yanco Agricultural Institute, based on quality class and maturity group.**

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	YRL125, YRL123,
Long-grain fragrant		YRF208	Kyeema, YRF209
Long-grain firm-cooking			Doongara

**Table 2: Pedigree and description of advanced lines included in district trials in 2005–06**

Line	Description
YRM64	(M201/YRM3//Bogan) Semi-dwarf medium-grain, sister line to Paragon. Slightly longer grain length compared with Paragon.
YRM65	(M201/YRM3//Bogan) Semi-dwarf medium-grain, sister line to Paragon. Around 10-14 days earlier to flower than Amaroo.
YRM66	(M103//M201/YRM3) Semi-dwarf medium-grain with exceptionally low levels of chalk. Good grain length, although not particularly a high yielder.
YRM67	(Illabong/M203) Semi-dwarf medium-grain with high yield potential. Around 10-14 days earlier to flower than Amaroo. Chalk may be an issue
YRM68	(M201/YRM3//M102) A full season variety like Amaroo with higher yield potential
YRM69	(YRM33/HR5099-23-1-4-5//M103) Semi-dwarf medium-grain with high levels of cold tolerance. Similar maturity to Quest, however grain dimension more in keeping with Amaroo
YRB4	(YRB3/Arborio) An arborio grain type comparable to Illabong although has slightly higher yield potential
YRL118	(YRL30//YR73/Banat 725//Inga) Acceptable yield and quality although it is more susceptible to straighthead than Langi
YRL123	(Pelde*2/Calrose 76) Langi maturity with acceptable yield and quality
YRL125	(YC71048.111/3/YC303D//Bluebelle/Inga/4/YRL37) A long-grain line with high yield potential. Cooking quality similar to Pelde
YRL126	(Inga//Doongara/YRL39) A new long-grain line with high yield potential and maturity similar to Langi
YRF208	(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
YRF209	(Pelde/Gopalbhog(4)/YC 71048-10//YRL 101) A semi-dwarf sister line to YRF208 with superior yield potential to Kyeema, with a new source of fragrance



season, and Quest\_CT19, a derivative of Quest that exhibits an improvement in grain yield, percentage whole grain and cooking quality. The original seed of Quest was shown to have a mixture of amylose types, with molecular marker tests indicating a mixture of CT18 and CT19 types. The CT18 type is the same as for Millin, and results in slightly softer

cooked rice, while Amaroo and the remaining medium-grains are CT19. Quest\_CT19 has been purified through the pure seed scheme and matches the amylose content and cooking quality of Amaroo. Pure seed of Quest\_CT19 was included in district testing and grain quality trials in 2005–06 and had significantly higher yield at a number of sites.

**Table 3: Mean grain yield (t/ha) of advanced medium grain breeding lines compared with commercial varieties over four years of district trials.**

Variety	Overall Mean	Yield (% of Amaroo)	Rank	Number of trials
Amaroo	9.54	100	14	22
Paragon	10.25	107	6	22
Reiziq	9.69	102	13	22
YRM64	10.17	107	9	22
YRM68	10.25	107	5	12
Opus	9.82	103	12	22
YRM66	8.85	93	15	22
Millin	9.92	104	11	22
Quest	10.22	107	7	22
Quest_CT19	10.34	108	4	12
YRM65	10.22	107	8	22
YRM67	10.10	106	10	22
YRM69	10.82	113	1	6
Illabong	10.52	110	3	22
YRB4	10.59	111	2	22

**Table 4: Average grain yield (t/ha) of advanced medium grain lines at each site in the 2005–06 season**

Variety	WMV	CIA	MIA1	MIA2	EMV1	EMV2	Average
Amaroo	11.44	11.33	13.12	9.49	13.71	10.93	<b>11.67</b>
Paragon	12.20	12.10	14.24	9.93	15.26	12.91	<b>12.77</b>
Reiziq	12.04	12.47	14.60	10.19	15.26	12.27	<b>12.81</b>
YRM64	11.59	12.01	14.23	10.00	15.56	12.15	<b>12.59</b>
YRM68	11.81	12.48	14.02	10.75	15.42	12.40	<b>12.81</b>
Opus	11.53	12.04	13.18	10.65	14.04	11.96	<b>12.24</b>
YRM66	10.88	11.03	12.65	8.95	13.90	10.48	<b>11.31</b>
Millin	11.33	11.73	13.22	10.02	13.94	11.41	<b>11.94</b>
Quest	11.51	11.52	13.97	10.24	13.90	12.14	<b>12.21</b>
Quest_CT19	11.70	12.20	13.87	10.87	15.59	12.48	<b>12.78</b>
YRM65	11.41	11.99	14.00	10.82	15.13	11.75	<b>12.52</b>
YRM67	11.24	11.86	14.40	10.85	14.94	12.58	<b>12.64</b>
YRM69	12.08	12.87	13.86	11.87	15.43	10.69	<b>12.80</b>
Illabong	11.73	12.24	14.26	12.12	14.88	12.79	<b>13.00</b>
YRB4	11.72	12.45	14.56	11.95	14.90	12.69	<b>13.04</b>
<b>Mean</b>	<b>11.61</b>	<b>12.02</b>	<b>13.88</b>	<b>10.58</b>	<b>14.79</b>	<b>11.98</b>	
LSD	0.68	0.67	0.57	0.74	1.09	0.54	
CV	3.39%	3.09%	2.06%	3.27%	4.21%	1.89%	

WMV Western Murray Valley, CIA: Coleambally Irrigation Area, MIA 1 & 2: MIA Murrumbidgee Irrigation Area, EMV1 & 2: Eastern Murray Valley.



### Grain quality results

#### New Quest has better percentage whole grain

Figure 3 illustrates the percentage whole grain of Quest\_CT19 compared with other commercial varieties over a range of grain moistures for both an early and late sowing date. As expected, the decline in whole grain is tightly linked to maturity differences between the varieties, although other genetic differences also contribute. Among these varieties Quest was the earliest to flower, followed by Millin and Quest\_CT19 with similar maturity, and Amaro with the latest maturity. In the early sowing Quest\_CT19 and Millin performed similarly, with Quest showing lower whole grain at each sample. In the later sowing, Quest and Millin had the lowest whole grain at the later samples. Quest\_CT19 tended to maintain whole grain in the later samplings of both sowing dates. The improved whole grain of Quest\_CT19 was also evident in grain quality analysis of the district trial series (Table 5) with 59% whole grain versus 51% for Quest.

#### YRM69 may have lower percentage whole grain

Across the district trial series, the average percentage

whole grain of YRM69 was 48%, similar but slightly lower than other lines within this maturity group such as Millin, Quest and YRM65 which had percentage whole grain of 51, 51 and 50 respectively. There are significant quantities of breeder's seed of YRM69, and testing in the 2006–07 season will focus on further yield testing and in particular the issue of milling quality. Varieties with shorter growing seasons often encounter conditions of high evaporative demand during grain filling, and this can cause stress cracks in grains, leading to increased grain breakage during milling. The period during which the crop is most sensitive to high evaporation is when the grain is between 23 and 18% moisture, and harvesting as soon as practicable after the grain reaches 23% will minimise the formation of stress cracks.

#### Length to width ratio for medium grains

A new grain quality class for medium grains is based on whether the length to width ratio is equal to or greater than 2.1 as shown in Table 5. Standard size medium-grains such as Amaro commonly have a length to width ratio of less than 2.1, and this can be a critical specification for specific

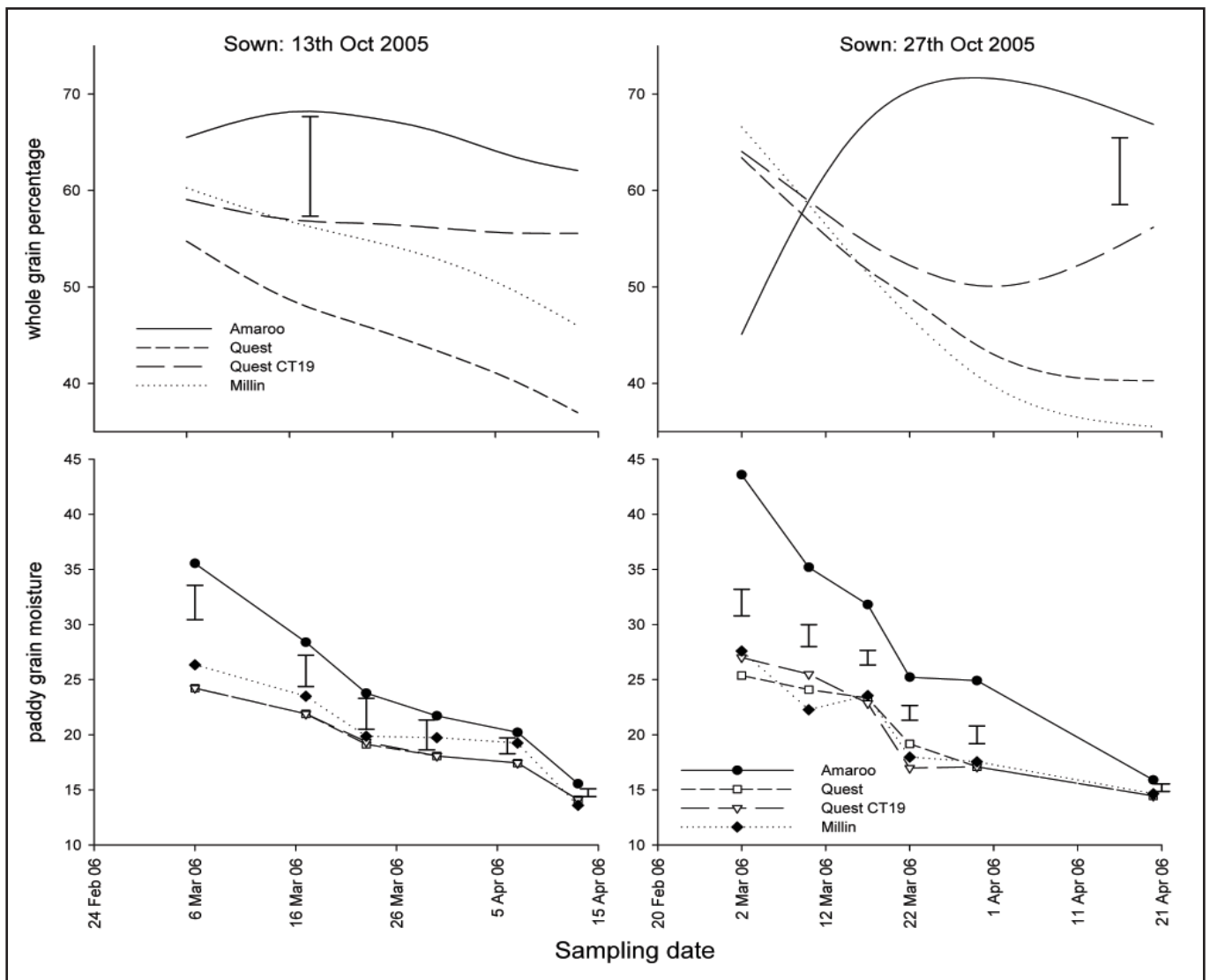


Figure 3: A comparison of four medium-grain varieties, showing paddy grain moisture and whole grain percentage at six sampling dates, for two sowing times.



international markets. Reiziq clearly meets the requirement for larger grain size and exceeds the required length to width ratio. A number of breeding lines and varieties (such as Quest and Quest\_CT19) also meet this requirement. Decisions regarding the development and release of future varieties will depend on rice industry requirements for varieties within the different grain quality classes.

### Long-grain results

The average long-grain yields over four years were lower than for the medium-grains, and there were few significant differences between varieties (Table 6). The principal comparison was between the breeding line YRL125 and a number of YRL125 re-selections which vary slightly in cooking quality, maturity and pubescence. YRL125 and its

variants have been developed specifically to combine slightly softer cooking (similar to the old variety Pelde) with good yield potential. Unfortunately few long-grains demonstrated significantly higher yield than Langi. The most desirable YRL125 selection (YRL125 P/S04 6) had only 89% of Langi yield when averaged over four years of trials. Other YRL125 selections had better performance, and will be maintained in the district testing program, while other re-selections will be added to the trial series. The two fragrant lines, YRF208 and YRF209, had very similar yields to Kyeema in 2005–06, and did not show significant yield advantage – despite having semi-dwarf plant stature, in contrast to Kyeema.

The long-grain results for 2005–06 trials again reflect the high industry average yield for the season, with high yields even for cold sensitive varieties such as Doongara evident

**Table 5: Percentage whole grain and milled grain dimensions of advanced medium grain lines across six sites in the 2005–06 season**

Variety	% whole grain	Grain length (mm)	Grain width (mm)	Length:width ratio
Amaroo	65.8	5.31	2.63	2.02
Paragon	61.3	5.43	2.63	2.07
Reiziq	63.0	5.82	2.62	2.23
YRM64	61.2	5.64	2.66	2.12
YRM68	61.6	5.51	2.66	2.07
Opus	63.8	4.74	2.71	1.75
YRM66	64.5	5.52	2.60	2.12
Millin	51.4	5.28	2.67	1.98
Quest	51.3	5.65	2.65	2.13
Quest_CT19	59.1	5.61	2.65	2.11
YRM65	50.1	5.70	2.67	2.14
YRM67	61.0	5.30	2.67	1.98
YRM69	48.1	5.37	2.63	2.04
Illabong	51.3	5.59	3.00	1.87
YRB4	50.3	5.64	2.97	1.90
SED	1.3	0.10	0.00	Na

**Table 6: Average grain yield (t/ha) of advanced long-grain breeding lines compared with commercial varieties over four years of district trials**

Variety	Overall mean	Yield (% of Langi)	Rank	Number of trials
Langi	9.47	100	5	22
Doongara	8.07	85	10	22
YRL118	9.15	97	7	22
YRL123	9.25	98	6	22
YRL125	9.65	102	2	22
YRL125 P/S04 6	8.43	89	8	5
YRL125 P/S04 9	9.60	101	3	5
YRL125 P/S04 19	9.81	104	1	5
YRL126	9.59	101	4	11
Kyeema	7.97	84	11	22
YRF208	8.19	86	9	11
YRF209	7.53	79	12	11



across all regions (Table 7). Two of the three YRL125 derivatives had higher yield than Langi in their first season of district testing, while the second year of testing for fragrant lines YRF208 and YRF209 indicates a moderate increase in yield potential over Kyeema, but increased variability in yield across the rice-growing regions.

Although the new long-grain lines are slightly longer duration than Langi (Table 8) they are generally shorter in stature than their commercial counterparts which should reduce lodging susceptibility under high yield conditions. In addition to agronomic characteristics, there is a continued focus on cooking quality with molecular markers for amylose content (CT) and fragrance being employed in the pure-seed program to ensure we maintain our unique market in

soft-cooking long grain. This is highlighted in the YRL125 derivatives where CT18 (Pelde like) types have been selected and progressed for further testing.

All advanced materials are superior in whole grain and lower in chalk, but are slightly shorter than the commercial varieties in terms of brown grain length (Table 9). This translates to lower length to width ratio for almost all advanced long-grain lines when compared to Langi, and when combined with their later maturity, limits their prospects as replacements. However improved cooking quality (eg the slightly softer CT18 types) may compensate in part for the slightly shorter grain length. This will be determined in consultation with marketing staff and detailed consumer testing.

**Table 7: Average grain yield (t/ha) of advanced long grain lines at each site in the 2005–06 season**

Variety	WMV	CIA	MIA1	MIA2	EMV	Average
Langi	9.71	11.21	12.76	11.13	11.71	<b>11.30</b>
Doongara	10.49	11.52	12.72	9.86	11.95	<b>11.31</b>
YRL118	10.47	12.31	13.78	9.71	12.17	<b>11.69</b>
YRL123	9.80	11.69	13.64	10.72	11.73	<b>11.52</b>
YRL125	10.66	12.13	13.96	10.77	13.01	<b>12.11</b>
YRL125 P/S04-6	10.20	11.49	13.48	9.36	11.77	<b>11.26</b>
YRL125 P/S04-9	11.00	13.06	14.19	9.82	12.78	<b>12.17</b>
YRL125 P/S04-19	11.13	12.38	13.99	10.40	12.95	<b>12.17</b>
YRL126	9.44	11.70	13.73	10.68	12.11	<b>11.5</b>
Kyeema	8.60	10.91	10.87	10.46	11.59	<b>10.49</b>
YRF208	9.62	11.92	12.81	8.82	11.53	<b>10.94</b>
YRF209	9.33	11.29	12.86	8.89	11.42	<b>10.76</b>
<b>Mean</b>	<b>10.04</b>	<b>11.80</b>	<b>13.23</b>	<b>10.05</b>	<b>12.06</b>	
LSD	0.238	0.784	0.585	0.874	0.485	
cv%	1.47%	4.17%	2.75%	5.39%	2.50%	

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: Agronomic characteristics, cooking quality (CTn) and fragrance of advanced long grain lines**

Variety	Days to flower	Plant height	Pubescence	Amylose CT#	Fragrance
Langi	104.9	91.3	Smooth	19	-
Doongara	107.1	85.0	Smooth	14	-
YRL118	104.5	79.1	Pubescent	19	-
YRL123	105.8	82.4	Pubescent	18	-
YRL125	107.2	83.7	Smooth/ Pubescent	18/19	-
YRL125 P/S04 6	107.8	83.7	Smooth	18	-
YRL125 P/S04 9	108.4	83.7	Smooth	18	-
YRL125 P/S04 19	108.2	83.7	Pub	18	-
YRL126	105.3	94.5	Smooth	19	-
Kyeema	108.8	88.6	Pubescent	18	+
YRF208	104.3	84.3	Pubescent	18	+/-
YRF209	106.0	84.3	Smooth/ Pubescent	18	+
SED	1.3	4.0	NA	NA	NA



## Breeding program priorities

Further testing of YRF208 and YRF209 will continue, but breeding of fragrant rices has been assigned a lower priority within the breeding program. It is ironic that these changes in priority coincide with the implementation of a routine molecular marker test for fragrance, giving the breeding program the tools for more efficient selection and variety development. However, in response to industry direction, seed from fragrant trial plots grown in 2005–06 will be dried down and placed into long-term low temperature storage, and resources directed at more pressing issues, such as general improvement of cold tolerance throughout the entire suite of grain quality classes.

A total of 11.1 tonnes of breeder seed of YRM69 is available for sowing in 2006–07, and this will allow continued seed increase and further commercial scale milling evaluation. This quantity of seed allows for the release of YRM69 at the 2008 Rice Field Day, provided that it continues to meet yield, quality and agronomic requirements.

## Diagnostic tests for varieties using molecular markers

A number of Amaroo crops flowered extremely early during the 2005–06 season. This was an unusual event, presumably related to temperatures experienced during the season, and it seemed more likely in lower fertility areas.

Molecular markers were used for the first time in the 2005–

06 season to verify the identity of early-flowering crops. Unfortunately the whole process took longer than it should have. Crops were identified around the 10–15 January, and fresh plant material collected in the week following. DNA extractions were carried out over the following week and initial marker analysis work done at Yanco. The marker used had been noted to vary between Jarrah and Amaroo, however in the first series of marker tests, conducted on known samples of Jarrah and Amaroo, the marker was unable to distinguish these two varieties. At this point it was decided to opt for the more expensive diversity array analysis (DArT) to verify the identity of the early-flowering lines. These results showed more than 100 markers that varied among the varieties, demonstrating with extremely high probability (>99%) that the suspect crops matched the seed issue.

For the future, a series of molecular markers that distinguish all commercial varieties will be developed, and these tests can be done at Yanco and will cost much less than the \$50 per sample costs of the DArT technology. This will be incorporated as a routine part of the pure seed process either at the long-row stage or breeders seed stage. 🌾

### RIRDC Project DAN-220A

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**Table 9: Grain quality of long grain lines at optimal moisture from YIQ06**

Variety	% whole grain	Chalk	Yellowness	Grain length (mm)	Grain width (mm)	Length:width ratio
Langi	52.4	4.80	27.11	7.49	2.14	3.5
Doongara	47.6	8.43	29.06	7.30	2.16	3.4
YRL118	49.9	6.26	29.41	7.04	2.11	3.3
YRL123	52.8	1.50	29.85	7.34	2.17	3.4
YRL125	55.1	5.05	27.63	7.36	2.20	3.4
YRL125 P/S04 6	53.1	3.11	27.33	7.07	2.14	3.3
YRL125 P/S04 9	54.1	3.37	27.30	7.31	2.17	3.4
YRL125 P/S04 19	56.5	3.42	28.57	7.23	2.18	3.3
YRL126	52.8	5.01	28.06	7.50	2.15	3.5
Kyeema	44.6	5.03	27.87	7.27	2.16	3.4
YRF208	48.0	5.26	31.90	7.36	2.15	3.4
YRF209	58.5	2.07	30.65	7.23	2.12	3.4
SED	3.9	0.87	0.93	0.06	0.02	NA