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DEVELOPMENT OF TWO PREMIUM QUALITY SCENTED RICE LINES: At 08-593 (A RED *BASMATHII* TYPE) AND At 06-631 (A *SUDURU SAMBA* TYPE)

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ABSTRACT

Improving aromatic rice varieties with a high consumer preference is a priority in Sri Lanka's rice breeding programme at present. In this context, varietal development programme was conducted at the Rice Research Station, Ambalantota using hybridization followed by modified bulk method. Advanced lines were evaluated mainly for agronomic, yield, aroma, biotic, grain quality and sensory quality traits. Two aromatic elite lines, At 08-593 and At 06-631 possessing most of the expected traits were identified. They mature within the popular maturity group range of 3 to 3½ months. At 08-593 is identified as the first *basmathi* aromatic red pericarped rice in Sri Lanka with long slender grain where as At 06-631 is identified as the first *samba* aromatic white pericarped rice with short round grains developed by the Department of Agriculture.

KEYWORDS: Aroma, Breeding, Red *basmathi*, *Samba* types

INTRODUCTION

Sri Lanka has reached self sufficiency in rice by the year 2010, and the rice production in 2013 was 4.7 million tons (DCS, 2014). Approximately 0.3 million tons of paddy was excess in year 2010 (Sanderatna, 2011). For years emphasis was focused to increase the national rice production and productivity of the country. Presently, attention towards improving the grain quality aspects is in high priority. Rice grain quality consists of physical, milling, nutrition, cooking, keeping and sensory qualities. Among them rice cooking and sensory qualities are the most important qualities for the consumers. Sri Lankan rice market is diverse in rice grain quality aspects. Although preferences vary from one group of consumers to another, cooked rice grains with a pleasant fragrance and a soft textured quality attributes usually achieve higher demand in the national as well as in the international market (Thongbam *et al.*, 2010).

Some farmers still prefer to grow traditional varieties such as *Suwandal* and *Suduru samba* for their fragrance, appearance of milled rice and good cooked rice texture in spite of their low yields, pest and disease susceptibility and lodging compared to improved varieties. Although local fragrant rice varieties which were bred through

national rice breeding programme are available, the demand is less due to some inferior quality aspects such as stickiness and poor keeping qualities. At 405, At 306 and At 309 are some rice varieties which consist of fragrance and *basmathi* type quality attributes. These varieties are of low in amylose types and become sticky when cooked. Sticky rice is not accepted by the local consumer although they contain the fragrance and *basmathi* type grain appearance. Therefore, to fulfil the local consumer demand new varieties with necessary traits have to be bred. In addition performance of varieties towards developing major rice products such as *string hoppers, hoppers* and *kawum* is also in concern. Therefore, the objective of the present study was to develop aromatic rice varieties with acceptable agronomic, yield and grain quality traits. The attention is also paid for sensory quality attributes of cooked rice and major rice based products.

MATERIAL AND METHODS

Crossing and selection programme

Hybridization

A number of crosses were made at Rice Research Station (RRS), Ambalantota for the development of high yielding quality rice varieties. The crosses, At 306/At 03-105 and Bg 98-2571/IR 70422-66-5-2 were done in *maha* 2003/04 and *maha* 1999/2000, respectively (Research report, Ambalantota). Emasculation was done by hot water method and the hand pollination technique was followed for hybridization. Plants of F_1 generation were established in the field and advanced as bulk populations from F_2 generation to F_4 generation (Jennings *et al.*, 1979). Six thousands to ten thousand plants from each cross were maintained as single plant per hill with the spacing of 30x15 cm.

Visual selection was practiced for age, grain type, yield, plant height, reaction for biotic stresses. Few single plants were individually tagged at the F_4 generation and seedlings derived from these selected plants were transplanted as progenies in the following season. Each progeny was maintained in a three row plot planted with the spacing of 20x15 cm and having 120 plants per progeny. After F_5 generation artificial screening for reaction to major insect pests and diseases were done. Test for other grain quality aspects such as aroma, grain colour, translucency, chalkiness, and breakages were performed at observational level. Lines were screened for brown plant hopper (BPH) and blast at the Rice Research and Development Institute (RRDI), Batalagoda using standard protocol. Screening for gall midge (GM) and for bacterial leaf blight (BLB) was carried out at RRS, Ambalantota. Accepted promising progenies were selected to pick three

single plants. Seeds of these selected plants were established in separate progenies in the subsequent season.

A long slender red pericarp promising line (At 08-593) was selected from the cross At 306/At 03-105 in *yala* 2008 and a white pericarp, short round variety (At 06-631) was selected from the cross Bg 98-2571/IR 70422-66-5-2 in *maha* 2006/07 season. *At 08-593* was evaluated in the preliminary yield trail (PYT) and major yield trial (MYT) in *maha* 2008/09 and *yala* 2009 seasons. Similarly At 06-631 was tested in PYT and MYT in *yala* 2007 and *maha* 2007/08 season. These two promising lines were tested for its yield potential with standard checks at RRS, Ambalantota in a Randomized Complete Block Design (RCBD) with 4 replications. The plot size was 6 m x 3 m and each plot was sown with standard seed rate which is recommended by the Department of Agriculture. Number of days to 85% maturity, plant height (10 plants/replicate), number of panicles per square meter (3 samples/replicate), number of grains per panicle (NGP) (10 panicles/replicate), number of filled grains per panicle (NFGP), percentage of shattering (10 panicles/replicate) and lodging were assessed as major parameters. Plot grain yield of each replicate at 13% moisture was extrapolated in to tones per hectare.

Both lines were further tested in National Coordinated Rice Varietal Trials (NCRVT) as At 08-593 and At 06-631 in *maha* 2010/11 and *yala* 2009, respectively. NCRVT was conducted in research stations representing three different agro climatic zones throughout three consecutive seasons. At 08-593 was tested in comparison to At 306, a variety having white pericarp, long slender grains while At 06-631 was tested in comparison to Bg 358, the most popular white pericarp short round variety.

At 08-593 and At 06-631 were tested in farmers' fields in Variety Adaptability Trials (VAT) in *maha* 2010/11 and *maha* 2012/13, respectively to test their adaptability in farmers' fields. Trials were managed adopting farmer practices but under the research guidance. At 08-593 was tested in VATs over 3 locations in the Wet Zone and 8 locations in the Dry and Intermediate Zones while At 06-631 was tested in VATs over 10 locations in the Wet Zone and 23 locations in the Dry and Intermediate Zones in 2010/11 *maha* and over 10 locations in the Wet Zone and 13 locations in the Dry and Intermediate Zones in 2011 yala. VAT in each locations conducted in a RCBD. The standard checks used for At 08-593 and At 06-631 were At 306 and Bg 360, respectively.

Leaf aroma test in test tubes

The lines were tested for aroma using leaf samples. Fresh leaves were taken at maximum tillering until panicle initiation. Three to five leaves from second leaf under the

flag leaf of the plant were removed (Lestaria *et al.*, 2011). The leaf samples were cut in to approximately 5 mm pieces and then placed in 10 ml test tubes filled with 5 ml of 1.7% KOH solution. The tube was then covered with aluminum foil and left for 15 minutes. Four panellists were offered with the same set of samples for sensory evaluation to smell the sample. The tube was opened one by one and the leaf aroma was evaluated using scores from 0 to 3; 0-no aroma, 1-faint aroma, 2- medium aroma and 3- strong aroma. The scores of each sample were averaged and differentiated into three groups, namely aromatic (score > 1.0), slightly aromatic (score 0.6-1.0), and not aromatic (score < 0.5).

Grain quality testing

Grains of yield trials were harvested at the physiological maturity and shade dried to a moisture content of 13%. Hundred and fifty grammes of paddy from each treatment were sent through *Satake* husker for de-husking. Obtained brown rice was polished through a *Satake* abrasive mill and milling attributes were recorded. Length and width of ten milled rice kernels were measured with a micro screw gauge and length to width ratios were evaluated. Grain type and chalkiness of grains were evaluated visually and denoted according to the RRDI, standards (Hafeel *et al.*, 2012).

One cup (bulk volume 90 ml) of milled rice from each variety was poured in to a mini rice cooker (300 ml) and cooked with 180 ml of water. At the automatic switch off samples were offered to 18 panellists to evaluate the aroma and taste according hedonic scale (Meilgard *et al.*, 2007). Milled rice from each variety was used to prepare major local rice products, Sting hoppers, Hoppers and Kawum. The products made of At 08-593 and At 06-631 were evaluated for appearance and taste through 18 panellists and compared with At 306 and Bg 360, respectively. The rankings, Very good, Good and Poor were given based on the percentage, more than 70%, between 40 to 70 and less than 40 respectively. Samples were evaluated through 5 point hedonic scale and presented in percentage.

Statistical analysis

Statistical analysis of yield trials was performed using SAS.

RESULTS AND DISCUSSION

Agronomic, yield and grain quality characteristics of At 08-593 and At 06-631 are given in Tables 1 and 2, respectively. The aroma score assigned to both At 08-593 and At 06-631was 2. At 08-593 matured within 92 days in *maha* 2008/2009 and 95 days

in yala 2009 where the At 06-631 had taken 104 and 101 days in *yala* 2007 and *maha* 2007/2008, respectively. At 08-593 is in 3 and At 06-631 is in 3½ month maturity groups. Compared to the check variety At 306, At 08-593 has produced more number of panicles. Majority of the farmers of the country grow rice in 3 to 3½ months variety groups (Jayawardane *et al.*, 2010). Three month varieties cover approximately 30% of rice lands in the country (RRDI, 2014). Thus, two new lines are expected to be popular among farmers as they are in short maturity groups. The two developed lines could withstand lodging during both seasons, whereas Bg 300 and Bg 358 could not during both seasons at RRS, Ambalantota (Table 1). The reason may be that the both new lines were shorter than their respective standard checks.

At 08-593 had higher number of panicles per square meter and higher filled grain percentage while the NGP and NFGP were significantly higher compared to the standard check. In addition At 08-593 gave higher yield and head grain percentage than that of the standard check. This is the first aromatic red *basmathi* type variety with long slender grains developed in the Department of Agriculture. At 06-631, has produced more number of panicles in *yala* than the standard check (*samba* type grain). Although At 06-631 gave lower grain yields, it had the smallest grains and the highest head grain percentage when compared to the standard checks. Considering the promising characteristics for quality rice both At 08-593 and At 06-631 were nominated for NCRVT. The grain yield, age and adaptability ranks of At 08-593 and At 06-631 in CRVT are presented in Table 3.

At 08-593 has given comparable yields to its standard check At 306 but more adaptable in the Dry, Intermediate and Wet Zones than the standard check. Although At 06-631 was inferior to Bg 358 the standard check with respect to yield and adaptability. It was related for VAT as its grain quality was superior to Bg 358. At 06-631 is the only aromatic *samba* variety so far developed by the Department of Agriculture.

Performance of At 08-593 and At 06-631 in VATs are presented in Table 4. At 08-593 was superior to At 306 in the Wet Zone but comparable in the Dry and intermediate zones regarding in adaptability over diverse environments. At 06-631 was comparable to Bg 360 at least in one *maha* and one *yala* season in adaptability over diverse environments.

Table 1. **Agronomic, yield and grain quality characteristics of tested lines compared to standard checks in preliminary yield trial in *maha* 2008/09 and major yield trial in *yala* 2009.**

Variety/ Line	Varietal characteristics													
	Leaf aroma score	Days to Maturity	Mean plant height (cm)	Number of panicles/m^2	Lodging	NGP	NFGP	Filled grain %	Mean Shattering (%)	Mean Yield (t/ha)	Mean thousand grain mass (g)	Grain type and colour	Head grain (%)	Chalkiness
Preliminary yield trial in 2008/09 Maha														
At 08-593	2	92	88	356	0	132b	95b	72	3	5.3b	20.2b	LS/R	61.2	WB-1
At 306	2	93	89	344	0	88c	59c	67	4	5.0c	24.2a	LS/W	48.0	WC-1
Bg 300	0	92	90	356	7	151a	123a	81	4	5.7a	24.5a	IB/W	70.1	WB-3
Bg 357	0	100	100	344	0	149a	105b	70	6	5.0c	24.2a	LM/W	52.0	WB-3
Major yield trial in 2009 Yala														
At 08-593	2	95	91	456	0	96b	95b	99	1	5.1b	20.2c	LS/R	60.2	WB-1
At 306	2	95	96	400	0	101b	90b	89	1	4.6c	23.7b	LS/W	47.2	WC-1
Bg 300	0	96	99	411	5	128a	118a	92	3	6.4a	26.4a	IB/W	73.5	WB-3
At 303	0	94	98	422	0	143a	132a	92	2	6.8a	26.0a	LM/R	62.6	WB -2/3

Note: Values followed by the same letter within a column are not significantly different at p=0.05. NGP=Number of grains per panicle, NFGP=Number of filled grains per panicle. LS=Long Slender, Long Medum, IB=Intermediate bold, R=red, W=white, WB=white belly, WC=White Centre.

Table 2. **Agronomic, yield and grain quality characteristics of tested lines compared to standard checks in preliminary yield trial in *yala* 2007 and major yield trial in *maha* 2007/2008 seasons.**

Variety/ Line	Varietal characteristics														
	Leaf aroma score	Days to Mature	Mean plant height (cm)	Number of panicles/m^2	Lodging	NGP	NFGP	Filled grain %	Mean Shattering (%)	Mean Yield (t/ha)	Mean thousand grain mass (g)	Grain type and colour	Head grain (%)	Chalkiness
Preliminary yield trial in Yala 2007														
At 06-631	1	104	96	344	0	154b	145b	94	7	5.3c	11.0c	SR/W	61.2	WC-1
Bg 358	0	102	110	244	5	133c	121c	91	6	5.9b	17.5b	SR/W	54.3	WC-2/3
Bg 357	0	103	96	278	0	200a	169a	85	-	7.0a	25.0a	LM/W	51.0	WB-3
Major yield trial in Maha 2007/2008														
At 06-631	1	101	83	444	0	199a	165b	83	10	4.4c	11.0c	IB/W	73.0	WC-1
Bg 358	0	103	102	367	7	213a	192a	90	4	5.7b	17.0b	SR/W	60.0	WC-2/3
At 362	0	106	89	378	0	157b	143c	91	5	5.9ab	26.6a	LM/R	74.2	WB-3
Bg 357	0	101	85	378	0	120c	107d	89	10	6.2a	25.0a	LM/W	61.0	WB-3

Notes: Values followed by the same letter in each column are not significantly different at p=0.05; NGP=Number of grains per panicle, NFGP=Number of filled grains per panicle. LS=Long Slender, Long Medum, IB=Intermediate bold, R-red, W=white, WB=white belly, WC=White Centre.

Table 3. **Mean grain yield, maturity duration and adaptability rank of At 08-593 and At 06-631 compared to standard checks in NCRVT.**

Season	Variety	Maturity duration (days)		Grain yield* (t/ha)		Adaptability** rank	
		D/IZ	WZ	D/IZ	WZ	D/IZ	WZ
Maha 2010/11	At 08-593	94	92	3.42	3.49	1	1
	At 306	95	93	3.20	3.52	2	2
Yala 2011	At 08-593	96	90	4.69	4.07	1	1
	At 306	95	91	4.28	3.93	2	2
Yala 2009	At 06-631	101	104	3.71	2.44	2	2
	Bg 358	103	105	4.97	3.20	1	1
Maha 2009/10	At 06-631	101	104	4.31	2.87	2	2
	Bg 358	100	105	5.10	4.03	1	1

Notes: *WZ=Wet Zone, DZ= Dry Zone, ** Lower the rank higher the adaptability.

Table 4. **Mean grain yield, variance in grain yield and adaptability rank of At 08-593 and At 06-631 in VATs in the Dry, Intermediate and Wet Zones in different seasons.**

Season	Variety	WZ		DZ	
		Mean yield (t/ha)	Adaptability rank	Mean yield (t/ha)	Adaptability rank
Maha 2012/13	At 08-593	3.46	1	5.05	1
	At 306	3.06	2	4.67	1
Maha 2010/11	At 06-631	3.74	1	4.56	2
	Bg 360	3.83	1	5.16	1
Yala 2011	At 06-631	3.31	2	5.12	1
	Bg 360	3.41	1	5.58	1

Notes: WZ=Wet Zone, DZ=Dry Zone; *=Adaptability rank.

Reaction to pest and diseases

At 08-593 and At 06-631 showed resistant to moderately resistant levels for Galle midge (GM), brown plant hopper (BPH), bacterial leaf blight (BLB) and rice blast (BL). The line reactions varied little across seasons. Both varieties performed well against major pests and diseases compared to standard checks (Table 5).

Rice quality

Based on the sensory scores, both At 08-593 and At 06-631 have been ranked better in both aroma and taste than that of replicative standard checks (Figure 1). It is interesting to note that Bg 360, the standard check to compare At 06-631 is popular among consumers for grain quality particularly for soft textured cooked rice (Jayawardana *et al.*, 2010). The promising two lines performed well in producing major 3

rice based products (Figure 2). Performance of At 08-593 was beyond the check, except for the attribute appearance of string hoppers. At 06-631, showed comparable sensory scores for appearance and taste in all three products against the check (Figure 3). The two test lines with promising sensory attributes may attract the consumer as well as the rice producer.

Table 5. Reactions of At 08-593 and At 06-631 against major pest and diseases in comparison to standard checks

Season	Variety	GM	BPH	BLB	BL
		Screening records obtained from PYT trials			
Maha 2008/09	At 08-593	R	R*	MR	R/MR*
	At 306	MR	R/MR*	MR/MS	MR*
Yala 2007	At 06-631	R	R/MR*	R/MR	MR*
	Bg 358	R/MR	MR*	MS	MR*
		Screening records of CRVT report **			
Maha 2010/11	At 08-593	MR	MR	MS	MR
	At 306	MR	R/MR	MR/MS	MR
Yala 2011	At 08-593	R/MR	MR	MS	MR
	At 306	R/MR	R/MR	MR/MS	MR
Yala 2009	At 06-631	R	MR	MR	MR
	Bg 358	R/MR	MR	MS	R/MR
Maha 2009/10	At 06-631	R	MR/MS	MR/MS	MR/MS
	Bg 358	R/MR	MR	MS	MR

Notes: GM=Rice gall midge, BPH=Brown plant hopper, BLB=Bacterial leaf blight, BL=Blast. R= Resistant, MR=Moderately resistant, MS=Moderately Susceptible, S=Susceptible.

Sources: * RRDI,2007; RRDI, 2009 ** RRDI, 2010a; RRDI, 2010b; RRDI, 2011; RRDI, 2012.

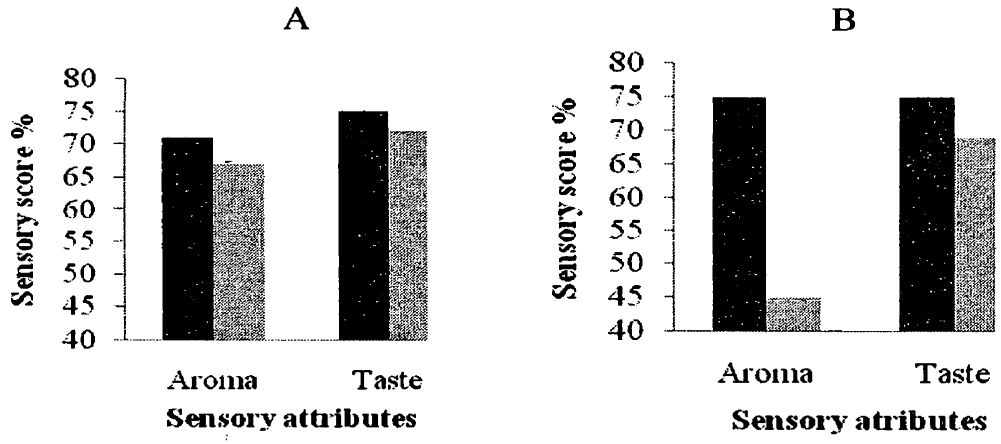

Figure 1. Sensory scores of Aroma and taste of cooked rice

Note:(A) ■At 08-593 and ▨At 306, (B) ■At 06-631 and ▨g 360.

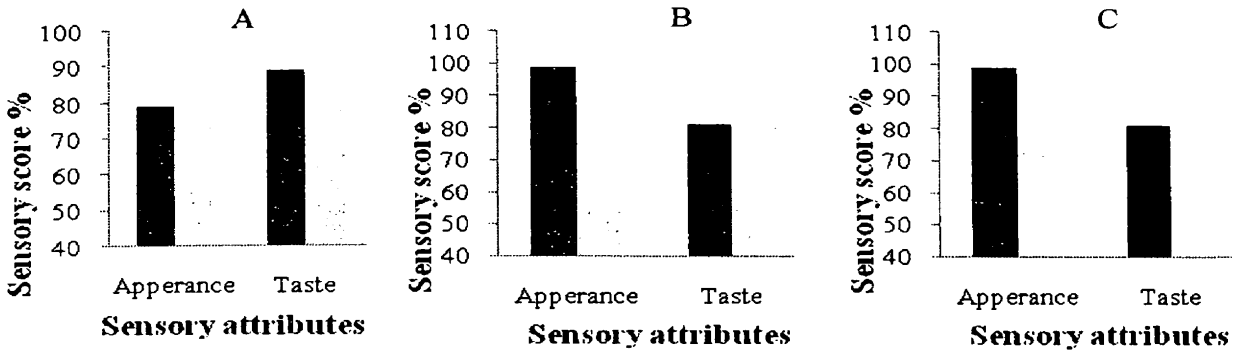

Figure 2. **Sensory scores for appearance and taste of major rice products**
Notes: (A) *String hopper*. (B) *Hopper* and (C) *Kawum* prepared with ■At 08-593 and □At 306.

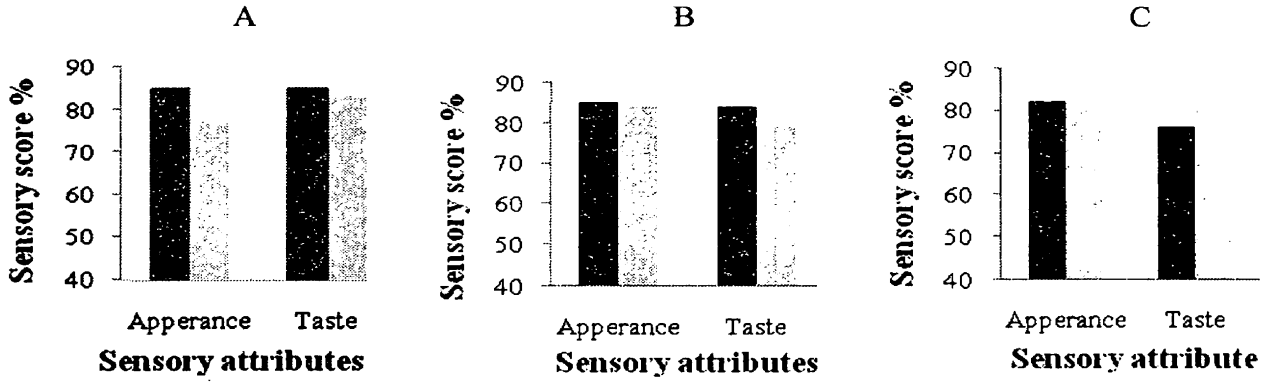

Figure 3. **Sensory scores for appearance and taste of major rice products.**
Notes: (A) *String hopper*. (B) *Hopper* and (C) *Kawum* prepared with ■At 06-631, □Bg 360

CONCLUSIONS

Two promising aromatic lines namely At 08-593 with *basmathi* type long slender red pericarped grains and At 06-631with *Suduru samba* type grain have been developed at Rice Research Station, Ambalantota to cater the quality rice market in Sri Lanka. Based on their performances, both lines are suitable for general cultivation in Sri Lanka.

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