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Research Article

Rice CO58 - A mid-early duration aromatic rice variety

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Rice is being cultivated in different regions based on the consumer preferences, marketability and adaptability. Basmati-type rice varieties are unaffordable due to high market prices and are also not recommended for cultivation in Tamil Nadu. Export demand for non-Basmati aromatic long slender grains is constantly increasing in the Middle East and European market. India is the largest producer and exporter of non-basmati rice in the world. Efforts were taken to develop non-basmati aromatic rice lines at TNAU, Coimbatore, and it has resulted in a non-basmati aromatic rice with long slender grain type rice culture CBMAS14142. CBMAS14142 was tested in various yield trials from 2011 to 2023. It registered an overall mean grain yield of 5858 kg/ha, which is 17.00 % higher than the check variety Pusa Basmati. CBMAS14142 is harbouring three major QTLs *viz*., *qDTY 1.1*, *qDTY 2.1* and *qDTY 3.1* from Apo conferring drought tolerance. This culture is suitable for cultivation during the Late Samba, Thaladi and Pisanam seasons in Tamil Nadu under transplanted or direct sown conditions. Hence, this high-yielding, mid-early, non-aromatic long slender rice culture CBMAS14142 with resistance/moderate resistance to pest and disease and good milling and cooking properties in comparison to the check variety Pusa Basmati was released as a new mid-early duration rice variety, CO58. It has also been notified by the State Variety Release Committee vide notification number Regn. No D.L-33004/99, S.No. 4027 dated 09th October 2024 for commercial cultivation in Tamil Nadu.

Keywords: *rice, non-basmati, long slender grains, aromatic rice*

Introduction

In Tamil Nadu, rice is grown in an area of 2.10 million hectares with production of 7.05 million tonnes in the year 2023-24. Medium and mid-early maturing varieties such as ADT 38, ADT 39, ADT 46, ADT 54, CO 50, CO 52, CO 56, TKM 13, TPS 5, Improved White Ponni and BPT5204 are widely cultivated in different regions based on their adaptability, market and consumer preferences. Nevertheless, it is imperative to introduce a greater number of medium- and mid-early duration varieties with a high yield to cater to a wide range of consumer preferences. The marketability and acceptability of rice varieties are determined by the physical and cooking characteristics of the rice grains (Liu et al., 2022). Aroma is one of the primary factors that influences rice prices in both domestic and global markets. The global market offers a limited selection of medium- to short-slender-grain rice varieties with aroma, with the exception of Basmati genotypes with long slender grains. (Ashokkumar et al., 2020). Urbanization and changing food habits among the increasing population warrant special purpose rice varieties suitable for the preparation of biryani, pulao and other dishes. Currently, Basmati or other long, slender rice varieties are utilized for these purposes. However, Basmati-type rice varieties are not affordable due to high market prices and also not recommended for cultivation in Tamil Nadu. The export of non-basmati rice in the country has experienced a significant growth from 8.27 million metric tonnes in 2015 to an impressive 17.26 MMT in 2022, worth 6.12 billion USD. This highlights the considerable demand for non-basmati rice in the global market. Among the non-basmati varieties, long slender and aromatic varieties fetch

premium price in the international market when compared to non-aromatic varieties. In this context, it is very much essential to develop and release non-basmati, aromatic long slender rice varieties to cater the needs of domestic and international demand. Based on this demand, breeding efforts at TNAU have led to the development of aromatic non-basmati rice variety.

Materials and Methods

Improved white ponni (IWP), a medium-duration rice variety with good cooking quality and a fine grain type suitable for cultivation under puddled conditions in Tamil Nadu. But it is susceptible to drought, which can reduce the yield. Apo, an upland rice cultivar harbouring drought tolerant QTLs like *qDTY1.1*, *qDTY2.1* and *qDTY3.1* (Venuprasad et al., 2009; Venuprasad et al., 2012).

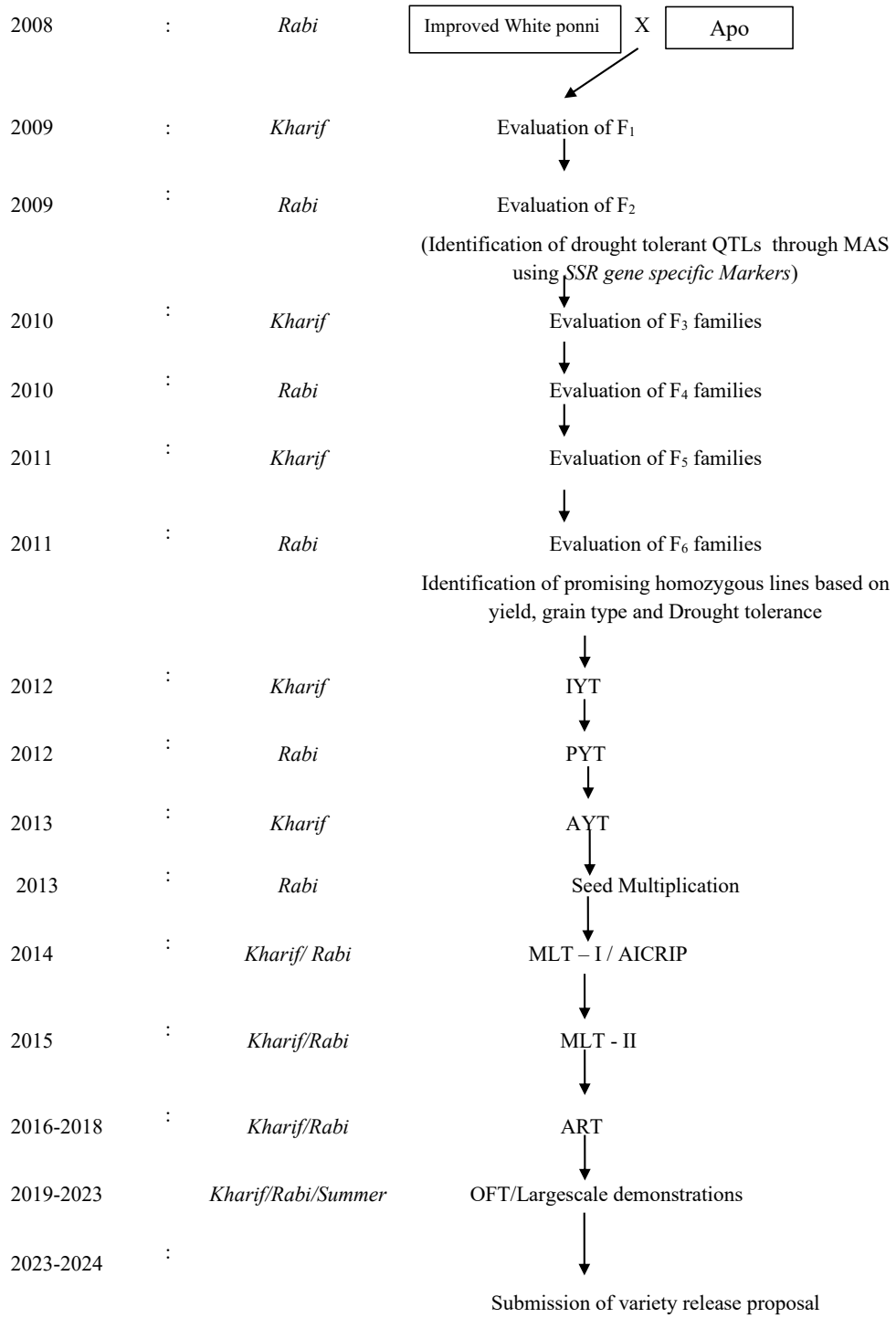

Figure 1. Breeding scheme for the development of CBMAS14142 rice culture

To improve the drought tolerance of the IWP, breeding efforts were started in 2008 at Tamil Nadu Agricultural University (TNAU), Coimbatore. The medium-duration rice variety IWP was crossed with the drought tolerant cultivar, Apo to improve the performance of the improved white ponni under drought conditions. The breeding scheme followed to develop the variety CO58 is presented in Figure 1. After crossing, the true F_1 plants with drought-tolerant QTLs were selected using tightly linked SSR markers. The true F_1s were forwarded to further generations to develop RILs. Evaluation of F_6 families leads to the evolution of a non – basmati aromatic long slender type rice culture CBMAS14142, which has 3 drought-tolerant QTLs (*qDTY1.1, qDTY2.1* and *qDTY3.1*). Further, the culture was tested in a Preliminary yield trial (PYT) during Rabi, 2012 at Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore. During Kharif 2013, the culture was promoted for an advanced yield trial. Then the culture was nominated for multi-location trial (MLT-I & MLT-II) and AICRIP trial during 2014-2015. Adaptive research trials (ART) were conducted at 38 different locations between 2016 and 2018. On-Farm trials (OFT) were conducted between 2019 and 2023 at 30 different farmers' fields.

Results and Discussion

The IWP was crossed with Apo to introgress drought-tolerant QTLs into IWP to develop the drought-tolerant version of IWP (Figure 2). True F_1s were identified and the positive plants were forwarded to F_2. In F_2, the homozygous plants harbouring all the drought tolerant QTLs were identified using SSR markers tightly linked with the QTLs and the positive plants were forwarded up-to F_6 as families. A non – basmati aromatic long slender type rice culture CBMAS14142 was identified and nominated for further yield trials (Figure 3 and 4). CBMAS14142 was tested in various yield trials from 2011 to 2023. In the overall analysis, the culture CBMAS14142 registered 5858 kg/ha which is 17.0% higher than Pusa basmati (5015 kg/ha) (Table 1).

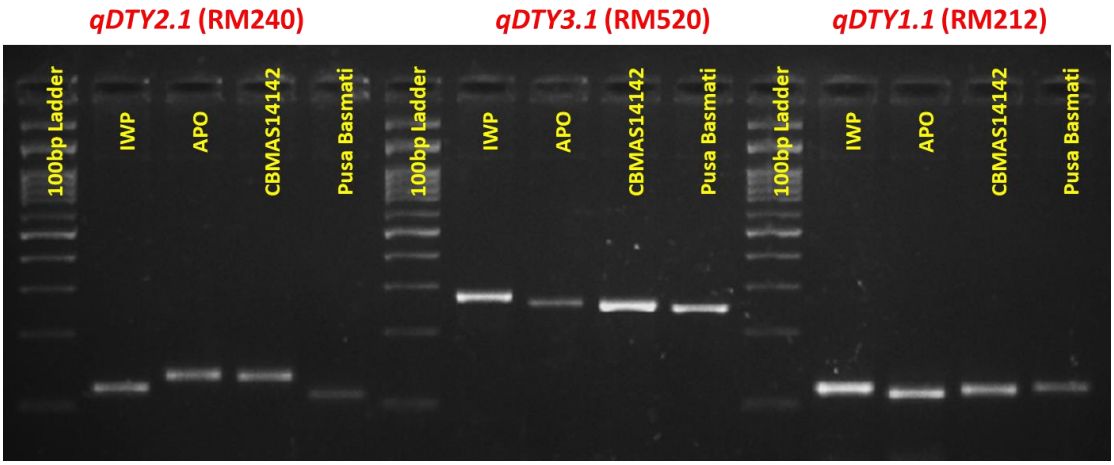

Figure 2. Molecular characterisation of CBMAS14142 for the drought tolerant QTLs

Table 1. Overall yield performance of CBMAS14142 in different trials

Name of the Trials	No. of trials	Grain Yield (kg/ha)	
		CBMAS14142	Pusa Basmati 1
Station trials (2012-2014)	3	7746	6299
Multi-location trials (2015-16)	12	4768	4431
AICRIP IVT- Early	29	5367	4285
Adaptive Research trial (2016-2020)	44	5674	5450
OFT (2020 -23)	30	6660	-
Large scale demonstration	4	6034	-
No. of trials	122		
Overall weighted mean yield (kg/ ha)		5858	5015
Per cent increase over the check			17.00

Figure 3. Field demonstration of the rice culture CBMAS14142

Figure 4. CBMAS14142 grains comparison with Pusa Basmati

Station trials were conducted from 2012 to 2014 with the culture CBMAS14142, it has recorded a mean grain yield of 7746 kg/ha and the yield increase over the check variety (Pusa Basmati) was 22.97 % (Table 2).

Table 2. Performance of CBMAS14142 in station trials (Dept of Rice)

S. No	Trials	Yield (kg/ha		Duration (days)	
		CBMAS14142	Pusa Basmati	CBMAS14142	Pusa Basmati
1.	IYT - 2012	7865	6558	125	127
2.	PYT - 2013	7436	6215	122	128
3.	AYT - 2014	7936	6125	123	126
	Mean (3)	7746	6299	123	127
Percent increase over check			22.97 %		

CBMAS14142 was evaluated in multilocation trials during 2014 and 2015. It recorded an overall grain yield of 4653 kg/ha which is 7.6 % higher than Pusa Basmati. Adaptive research trials were conducted from 2016 to 2019 in selective districts of western and central zones viz., Dharmapuri, Vellore, Salem, Erode, Coimbatore, Trichy, Dindigul, and Theni

due to favourable climatic conditions for the expression of aroma. In ART the test culture registered an overall mean of 5788 kg/ha with 3.68 % per cent increase over Pusa Basmati. On farm trials (OFTs) were conducted in 30 farmers field from 2019 to 2023. CBMAS14142 recorded an overall mean grain yield of 6660 kg/ha as against the check varieties ADT 39, ADT 36 and the yield increase being 33.46 %. In addition to OFTs, large scale demonstration trials were also laid at Department of Rice, TNAU, Coimbatore and Agricultural Research Station, Bhavanisagar, Erode. The grain yield of 6034 kg/ha was registered by the CBMAS14142, which is 26.55 % higher than the check varieties.

The culture CBMAS14142 was screened against all major diseases of rice *viz*., blast, bacterial blight, sheath rot, sheath blight, brown spot and rice tungro disease (RTD) under artificial and field conditions during 2019-20 (Table. 3a & 3b).

Table 3a. Reaction of CBMAS14142 against major diseases of rice (2019-20)

S. No	Culture	BLB	Sheath Blight	Sheath Rot		FS	RTD	Blast			Brown spot	
		MDU	ASD	MDU	TPS*	ASD	CBE*	ASD	CBE	TPS*	CBE*	MDU
1.	CBMAS14142	-	1	-	5.0	3	3	3	5	0.0	4	-
2.	Pusa Basmati	-	3	-	5.0	9	5	5	9	3.0	5	-

*Artificial inoculation Source: 39th Rice scientists meet, 2020

Table 3b. Reaction of CBMAS14142 against major diseases of rice, Aduthurai (2019-20)

S.No	Culture	BLB*	Sheath Blight*	Sheath Rot	Brown spot
1.	CBMAS14142	7	5	3	9
2.	Pusa Basmati	3	5	5	3

*Artificial inoculation Source: 39th Rice scientists meet, 2020

The culture CBMAS14142 was evaluated during 2014-16 under TNAU - ART Trial for resistance against major sucking pests at Coimbatore and Aduthurai under artificial condition wherein the culture CBMAS14142 had registered moderate resistance to WBPH and GLH (Table 4a and 4b).

Table 4a. Reaction of CBMAS14142 against major sucking pests of rice under artificial condition during 2015-16 (SES Scoring system of IRRI, 2013)

S. No.	Cultures	BPH			WBPH	GLH
		CBE	ADT	MDU	CBE	CBE
1.	CBMAS14142	5	7	3	5	5
2.	Pusa Basmati 1	7	9	7	7	7

(Source: 35thCSM on Rice, 2016)

Table 4b. Reaction of CBMAS14142 against major pests of rice during 2014-15 under field screening

S. No	Cultures	Dead heart (%)		White ear (%)		Leaf folder (%)	Gall Midge (SS%)
		ADT	MDU	ADT	MDU	ADT	ADT
1.	CBMAS14142	0	0	16.9	7.9	5.3	27.3
2.	Pusa Basmati 1	2.6	2.4	2.5	13.2	7.0	25.8

(Source: 34th CSM on Rice, 2015)

CBMAS14142 was evaluated to study the growth and yield attributes, nutrient response, agronomic efficiency of the crop during Kharif, 2023 at Paddy Breeding Station, TNAU, Coimbatore. CBMAS14142 recorded higher grain yield (5672 kg ha^{-1}) and agronomic efficiency (23 kg/kg N applied) than check variety. Nutrient response is 100% NPK / ha (150:50:50 kg /ha) recorded higher nutrient use efficiency, Net return (Rs. 70,612/-) and BCR (2.74) when compared to higher graded level (125% NPK). Hence, 100% NPK / ha (150:50:50 kg /ha) is recommended for CBMAS14142 (Table 5a to 5d). The rice culture CBMAS14142 is having more greenness/healthy plant (NDVI), better chlorophyll index (a non-destructive method of chlorophyll estimation by using CCM meter), higher photosynthetic rate, soluble protein content (which indirectly shows the Rubisco enzyme activity) and NRase enzyme activity (essential for nitrogen assimilation) than the check variety, Pusa Basmati (Table 6).

Table 5a. Response of CBMAS14142 to graded doses of nutrients

Nutrient levels	Grain yield (kg/ha)	
	CBMAS14142	ADT 39
Control	2243	2173
75% recommended dose of NPK / ha	5185	4782
100% recommended dose of NPK / ha	5672	5547
125% recommended dose of NPK / ha	5754	5624

Table 5b. Performance of CBMAS14142 in Agronomy trials (2023)

Characters	CBMAS14142
Days to 50% flowering	89
No. of productive tillers / hill	13-15
Plant height at harvest (cm)	93.5
Panicle weight (g)	3.32
Number of grains/panicles	237
Grain yield (kg/ha)	5672
Straw yield (kg/ha)	7124
Biomass (kg/ha)	12142
Agronomic efficiency (kg/kg)	23

Table 5c. Economics (100% NPK)

Particulars	CBMAS14142	ADT 39
Cost of cultivation (Rs. /ha)	48,500	48,500
Gross return (Rs.)	1,33,112	97,605
Net return (Rs.)	70,612	48,705
BC ratio	2.74	2.01

Table 5d. Economics (125% NPK)

Particulars	CBMAS14142	ADT 39
Cost of cultivation (Rs. /ha)	49,400	49,400
Gross return (Rs.)	1,34,834	98,760
Net return (Rs.)	85,434	50,360

Table 6. performance of CBMAS14142 for Physiological parameter

S. No	Physiological traits	CBMAS14142	Pusa Basmati
1	Chlorophyll index (CCM Value)	21.90	19.14
2	Normalized Difference Vegetation Index (NDVI)	0.76	0.72
3	Photosynthetic rate (µmol $CO_2/m^2/s$)	18.13	12.80
4	Soluble protein content (mg/g)	12.57	11.33
5	NRase Activity (µg NO_2/g/hr)	84.73	78.23

The rice culture CBMAS14142 has long slender grain type with good milling percentage (62.0%) and head rice recovery (55.8%). It has good linear elongation ratio (2.0), high volume expansion (3.60), intermediate amylose content and gelatinization temperature and soft gel consistency which are the desirable traits for good cooking quality (Table 7a-d).

Table 7. Quality characteristics of CBMAS14142

Table 7a. Milling quality traits

Variety	Hulling %	Milling %	Head Rice Recovery %
CBMAS14142	70.0	62.0	55.8
Pusa Basmati 1	42.5	35	20.7

Table 7b. Physical grain quality traits

Variety	Kernal Length (mm)	Kernal Breadth (mm)	LB ratio	Grain type
CBMAS14142	6.3	1.6	3.94	LS
VG 09006	5.2	1.8	2.89	SS
TKM 13	5.0	1.8	2.78	MS
Pusa Basmati 1	7.6	1.7	4.47	ELS
Jeeraga Samba	4.4	1.9	2.32	SS

Table 7c. Cooking quality traits

Variety	KLAC (mm)	KBAC (mm)	LER	BER	VE (ml)	Alkali Spreading value	GC (mm)
CBMAS14142	12.8	2.4	2.03	1.5	3.6	7	80
VG 09006	8.4	3.0	1.62	1.7	4.3	2	53
TKM 13	8.0	2.5	1.6	1.4	4.2	2	76
Pusa Basmati 1	14.7	2.8	1.9	1.6	4.5	7	76
Jeeraga Samba	7.0	2.0	1.7	1.2	4.1	4	56

Table 7d. Biochemical properties of CB MAS 14142

Traits	CB MAS14142	VG 09006	TKM 13	Pusa Basmati 1	Jeeraga Samba
Amylose content (%)	22.15	21.94	19.40	17.89	16.10

(37th Annual Research Meet - 2018)

The rice culture has introgression of drought QTLs (*qDTY1.1*, *qDTY2.1* and *qDTY 3.1*) from the parent Apo. It recorded 49.91 % increased yield over Improved white ponni under drought stress conditions (Table 8).

Table 8. Comparison table of yield traits in control vs drought stress

S. No.	Genotype	Single plant Yield (g)		Yield per hectare (kg/ha)
		Control	Stress	
1	IWP	33.06	8.79	1054
2	CBMAS14142 (IWP x Apo)	33.91	13.17	1580

% increase over IWP – 49.91% under drought stress

CBMAS14142 was also tested under National trials (AICRP Rice – IVT ETP) (IET 25577) during 2015, wherein, it recorded 5367 kg/ha and the per cent increase over Pusa Basmati was 25.30 % (Table 9). It also surpassed the yield of National Check (Anjali) and Zonal Check (DRR Dhan 43) with 33.38 and 6.7 per cent respectively. The comparison of DUS traits for CBMAS14142 with Pusa Basmati was given in Table 10.

Table 9. Performance of CBMAS14142 (IET 25577) in AICRIP: IVT - Early – Kharif 2015

Sl. No	Location	Yield (kg/ha)		
		CBMAS14142	Anjali (NC)	DRR Dhan 43 (ZC)
1	PNT	6974	5854	6149
2	LPN	4573	2904	-
3	KUL	6600	5150	4400
4	JYP	9048	4390	6146
5	PTN-ICAR	4294	3711	4594
6	SBR	3348	2158	2760
7	RCI*	300	350	700
8	CHN	6406	3118	3515
9	PNB	3157	4219	1850
10	KOL	6070	6445	4975
11	VRN	6420	4815	5905
12	ARD	5296	1993	3371
13	WRS	7411	6250	7393
14	JBR	8835	8203	5638
15	SKL	4587	3747	4393

16	KJT	5421	2421	4673
17	VDG	2976	3902	4497
18	VYR	4205	4339	6788
19	DBH	3799	3333	5784
20	MTU	5507	1902	3261
21	KNM	4730	4340	5301
22	CBT	4132	2746	6364
23	ADT	2600	3933	4800
24	PTB	5063	2813	6975
25	MNC	3571	2407	4647
26	MND	3706	2857	4017
27	KRM*	1682	1398	1789
28	GNV	8731	4631	6950
29	KBP	7438	6063	5625
Mean		5367	4024	5030
Per cent increase over check			33.38	6.70

*Since the experimental mean yield was less it was not included in mean analysis

Table 10. Comparison table of DUS traits for CBMAS14142 with Pusa Basmati

S. No.	Descriptor	CBMAS14142	Pusa Basmati
1	Designation	CBMAS14142	Variety
2	Variety group	*Indica*	*Indica*
3	Plant height (cm)	107 cm (Semi Dwarf)	92 cm (Semi Dwarf)
	LEAF: below the flag leaf		
4	Length (cm)	48.5	32.5
5	Width (cm)	1.2	0.9
6	Blade pubescence	Strong	Strong
7	Blade colour	Medium	Medium
8	Basal leaf sheath colour	Green	Green
9	Flag leaf angle	Erect	Intermediate
10	Flag leaf length (cm)	33.8	29.5
11	Flag leaf width (cm)	1.4	1.2
	LIGULE		
12	Leaf ligule	Present	Present
13	Length (cm)	3.6	2.2
14	Colour	White	White
15	Shape	Split	Split
16	Collar anthocyanin colouration	Absent	Absent
17	Auricle colour	Colourless	Colourless
	Days to heading		
18	Days to first flowering	85	84
19	Days to 50% flowering	90	90
	CULM		
20	Length (cm)	100-105	85-90
21	Number/ Total tillers	28-30	25-30
22	Total productive tillers	25-28	23-25
23	Culm attitude	Erect	Erect
24	Stem: Thickness (cm)	2.3 cm	2.1 cm
25	Stem anthocyanin colouration of nodes	Green	Green
29	Strength	Strong	Strong
30	Length (cm)	23-26 cm	27-30 cm
31	Type	Intermediate	Intermediate
32	Panicle Secondary branching	Present	Present
33	Exertion	Well exerted	Well exerted
34	Axis	Droopy	Droopy

35	Shattering	Low	Low
36	Thresh ability	Good	Good
37	No. of spikelets/panicle	210-260	170-180
38	No. of filled spikelets/panicle	195-220	160-165
39	Spikelet fertility %	80-90	80-90%
	GRAIN		
40	Awning	Absent (Occasionally present)	Present
41	Awn colour	Yellowish white	Yellowish white
42	Distribution of awns	Tip only	Whole length
43	Tip colour	White	White
44	Stigma colour	White	White
45	Lemma and palea colour	Straw	Straw
46	Lemma & palea pubescence	Weak	Weak
47	Sterile lemma colour	Straw	Straw
48	Sterile lemma length (mm)	3.00	2.00
49	Grain length (mm)	6.3	7.6
50	Grain width (mm)	1.6	1.7
51	Seed coat colour (dehulled)	Light Brown	Light brown
52	Endosperm type	Non-Glutinous	Non-Glutinous
53	Aroma	Present	Present
54	Maturity (days)	120-125 days	120-125 days
55	1000 grain weight (g)	19.32	20.67
56	Single plant yield (g)	34-37	25-30
	QUALITY		
57	Hulling%	70%	42.5%
58	Milling%	62%	35%
59	Head rice recovery%	55.8%	20.7%
60	Length class	Long	Long
61	Shape class	Long slender	Extra Long slender
62	L/B ratio	3.94	4.47
63	Length elongation ratio	1.3	1.9
64	Breadth elongation ratio	1.5	1.6
65	Amylose content	Intermediate	Intermediate
67	Gelatinization temperature	High	High
68	Gel consistency	Soft	Soft

Distinguishing morphological traits	CBMAS14142	Pusa Basmati
Awning	Absent (Very occasionally present short and partly)	Present Long and fully awned
Flag leaf angle	Erect	Intermediate

Conclusion

The culture CBMAS4142 with higher yield than Pusa basmati and aromatic property, better pest and disease resistance and good grain quality was released as a new rice variety Rice CO 58 during January 2024 and notified for cultivation (Regn. No D.L-33004/99, S.No. 4027 dated 09.10.2024).

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Author contributions

Raveendran Muthurajan- Conceptualization, implementation, monitoring, Bharathi Ayyenar, Williams Mohanavel, Veera Ranjani Rajagopalan - implementation, data collection, formal analysis and writing original draft, Manonmani Swaminathan, Sudha Manickam[1], Umadevi Manivannan[2], Suresh Ramalingam - Reviewing, investigation and monitoring

Competing interest

The authors declare that, no competing interest.

Ethics approval

Not applicable.

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AI Tool Usage Declaration

We declare that, we did not used any AI tool for writing manuscript. The authors were only utilized the AI tool (Grammarly) for improving the grammars/spell check.

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