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Research Article

CO 54 (IET 24313) : An early maturing high yielding rice variety with marketable grain quality suitable for Tamil Nadu

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Abstract
The rice culture, CB 12588 evolved by crossing CB 04110 x CB 05501 was released as CO 54 during the year 2021 as an alternate variety to CO 51 and ADT 43 with 105-110 days duration. CO 54 is a medium tall variety with a profuse tillering habit, long erect leaves and droopy compact panicles possessing more number of filled grains per panicle. CB 12588 recorded an overall mean grain yield of 6354 kg/ha in various yield trials which was 10.83 per cent improvement over CO 51 and 10.35 per cent over ADT 53. CO 54 has got high yielding potential due to its high agronomic and physiological efficiency and the maximum yield of 9259 was recorded in Bhavanisagar, Erode district under multi location trial. A High yield of more than 7000 kg/ha was realized in 16 locations in an adaptive research trial. Besides yield, the culture CB 12588 has got marketable grain type *i.e.* medium slender grains with high milling outturn and head rice recovery percentage. Desirable cooking quality parameters like good linear elongation ratio, high volume expansion, intermediate amylose, soft gel consistency and moderate gelatinization temperature along with highly productive plant traits make CO 54 a suitable alternate variety to CO 51 and ADT 53. The culture CB 12588 is moderately resistant to blast, sheath rot, sheath blight and BPH under artificial conditions. The rice culture CB 12588 was released as CO 54 with a higher yield, better pest and disease resistance and good cooking quality in comparison to the checks CO 51 and ADT 53. It is suitable for cultivation during *Kar/ Kuruvai/Sornavari/ Navarai* and the seasons/tracts wherever early maturing rice varieties are cultivated throughout Tamil Nadu.

Keywords: CO 54, Short duration, high yield, medium slender, cooking quality

INTRODUCTION

Rice being a staple food crop for more than 65% of the population provides 50 to 80% of the daily calorie intake and occupies a major area of 43.66 million hectares out of 141 million hectares of net cultivated area in India(Indiastat, 2020). India has the largest area under rice cultivation in Asia. Owing to green revolution, the country had witnessed a marvellous growth in rice production during the 1960s which transformed its status from begging bowls to self sufficiency. The concerted efforts of rice breeding programmes led to the development of rice varieties with high agronomic efficiency which made India rank second in rice production at the global level with a production of 118.87 million tonnes and a productivity of 2.7 tonnes/hectare (Indiastat, 2020). However, considering

the alarming increase in the population in India which is expected to be1.38 million in 2030, it is estimated that the food production has to be increased by about 1.5 million tonnes/year for feeding the ever growing population (Pathak *et al.,* 2018).On the flip side, due to the dwindling natural resources like land and water, depletion of soil fertility, global warming, evolution of new pathotypes and biotypes a gradual decline in the annual growth rate of rice production is being noticed over years. Thus rice production is not keeping pace with population growth there by threatening the food security of the country (Behera *et al.,* 2018). Sustaining the self sufficiency itself is a herculean task for the rice breeders. Hence, development of high yielding varieties with pest and disease resistance is the need of the hour so as to overcome the challenging task of enhancing the rice production amidst the production challenges like diminishing natural resources combined with climate change associated unpredictable and unseasonal weather patterns.

In recent years like yield, quality is also assuming greater importance in rice breeding programmes, as consumer preference is more towards premium grain quality. Grain quality preferences vary from country to country and region to region (Khush and Juliano, 1985). So, breeders have focused their attention on simultaneous improvement of yield with pest and disease resistance and quality (as per region preferences), but with limited success. This is because emphasis on high grain quality tends to result in unstable yields. Likewise, too much emphasis on disease and insect resistance and stable yields leads to poor grain quality. Moreover, the consumer's opinion is that the grain quality of the high yielding varieties bred by breeders does not match with the traditional varieties known for their premium rice quality but with poor yield. Hence, the breeding programmes towards the improvement of grain quality need to be reoriented to overcome the obstacles and satisfy the consumer demand.

In Tamil Nadu, out of the total 19 lakh hectare, one -third area of *Kuruvai* and another two lakh hectare areas in non- delta regions are being cultivated with short duration rice varieties (Department of Agriculture, 2021). Delay in monsoon in *Samba* season also makes the farmers to shift to early duration varieties. Farmer's expectations for fine grain varieties (*i.e.* medium slender or short slender grain type with 14 -16 grams 1000 grain weight) gain importance day by day starting from the release of ADT 43, ADT 45, CO 51, ADT 53 and it goes on as this grain type fetches premium price in the market. Hence, there is always a need to identify high yielding early duration rice variety, (maturing in 110-115 days) possessing fine grain quality with desirable cooking quality to satisfy both farmers as well as the consumer requirements. With this objective, CO 54, the early duration rice variety was evolved using the parents CB 04110 / CB 05501 at the Department of Rice, Tamil Nadu Agricultural University (TNAU), Coimbatore.

MATERIALS AND METHODS

CO54 derived from the cross CB 04110 x CB 05501 was effected during *Kharif,*2007 and was stabilized in the F_5 generation and identified as rice culture CB 12588 during *Rabi,2010-11* at the Department of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore **(Fig. 1)**. To assess the performance of the culture, it was evaluated along with short duration checks in different yield trials during 2012-13 at Department of Rice, TNAU. Based on its superiority in yield trials it was nominated for testing in Multi Location Trial (MLT) wherein it was tested for two consecutive years 2014-15 and 2015-16 under various research stations/ institutes/ colleges of TNAU located at different agro climatic zones of Tamil Nadu. Simultaneously during *Kharif,* 2014 the identified culture was evaluated as IET 24313 under the All India Coordinated Rice Improvement Programme (AICRIP) in Initial Varietal Trial – Early (IVT-E) in various AICRIP testing centres (wherein early transplanted rice trials were conducted) located at different zones of India. Based on the performance of the culture under MLT for two consecutive years it was promoted for testing under Adaptive Research trial (ART) during 2016-18 in coordination with the Department of Agriculture. Under ART, rice culture CB 12588 was assessed along with short duration check varieties in 106 locations (farmer's holdings) covering 19 districts in Tamil Nadu. To know about the resistance or susceptibility reaction of the rice culture CB 12588 to major pests and diseases it was evaluated under artificial as well as field conditions at Aduthurai, Coimbatore, Madurai and Killikulam. Agronomic performance and input responsiveness of the culture was tested using different graded levels of nutrients during 2019-20 at the Department of Rice. Similarly, the physiological efficiency of the culture was also assessed based on various physiological parameters associated with source sink relationship during 2018 – 2020. Physical, cooking and biochemical properties of rice were tested along with checks ADT 43 and ADT 53 and CO 51 at TRRI Aduthurai and Home Science College and Research Institute, Madurai.

RESULTS AND DISCUSSION

The culture CB 12588 registered a mean grain yield of 8332 kg/ha in three years of evaluation under station trials and surpassed CO 51 and ADT 43 by 18.59 and 25.30 per cent, respectively. CB 12588 was evaluated in MLT for two years 2014-15 and 2015-16. In 2014-15, its mean grain yield was 6405 kg/ha which was 23.10 and 26.00 per cent higher than CO 51 and ADT (R) respectively. In 2015-16, its mean grain yield was 5848 kg/ha which was 3.52 and 22.5 per cent higher than CO 51 and ADT 43, respectively. CB 12588 was evaluated as IET 24313 in Initial Varietal Trial- Early under All India Coordinated Rice Improvement Programme during *Kharif*, 2014 across 28 locations in the country. In IVT-E, it recorded a mean grain yield of 5505 kg/ha with a 12.28 per cent increase over the national check IR 64.

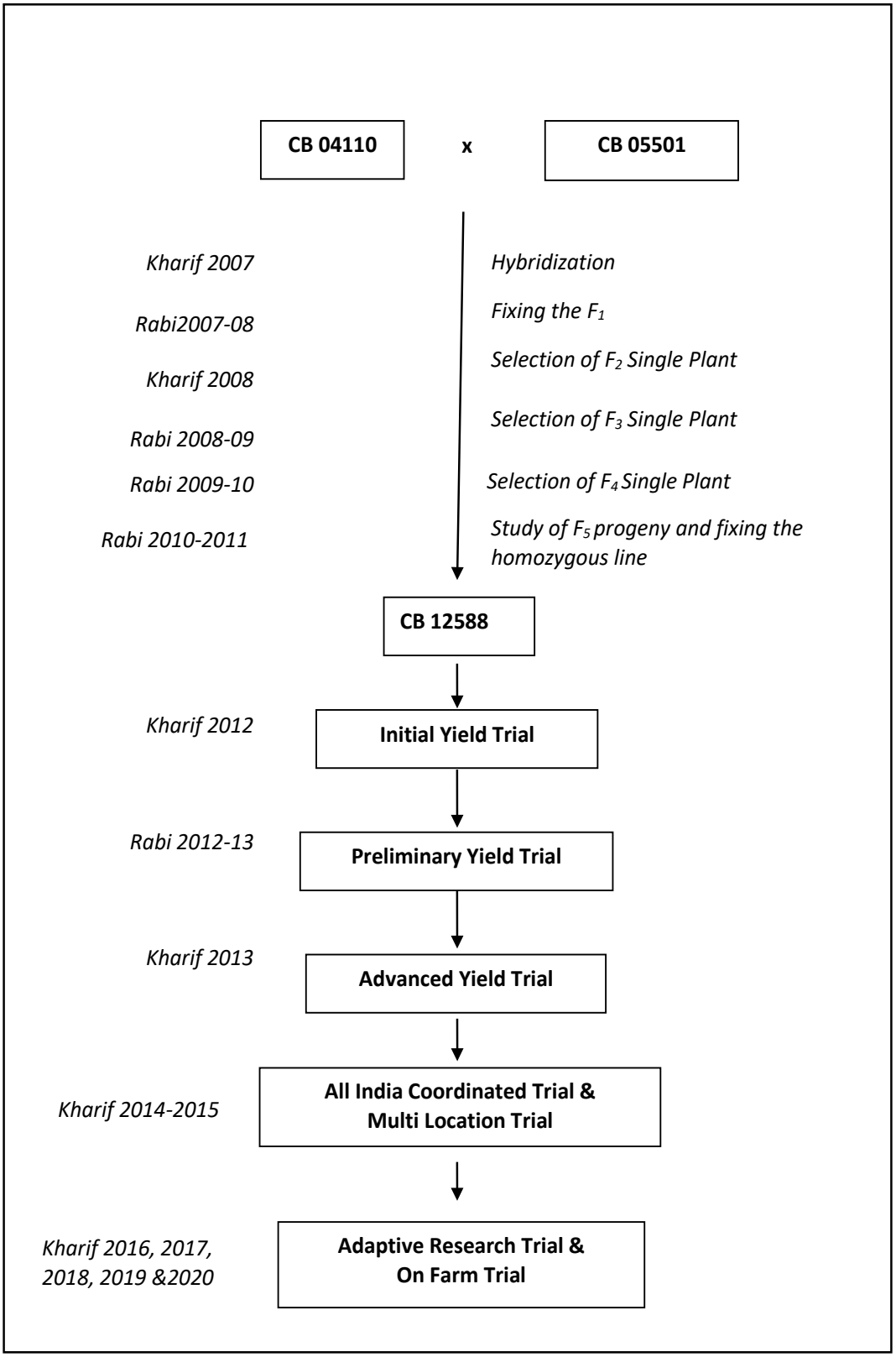

Fig. 1. Pedigree Chart of CB 12588

Under Adaptive Research Trials (ART) during 2016-17 and 2017-18, CB 12588 was tested in 106 locations in Tamil Nadu, of which the culture recorded more than 7000 kg/ha in 19 locations. It recorded a mean grain yield of 6128 kg/ha which was 7.64 per cent higher than CO 51. As the culture CB 12588 had consistently shown superior performance over the CO 51 it was recommended for large scale demonstration in the Annual Rice Meet, 2018. In OFT, in one acre plot demonstration across different districts of Tamil Nadu, the culture recorded a mean grain yield of 6978 kg/ha in 11 locations which were 21.53 per cent higher than CO 51 during 2018-19; in 2019-20 it recorded a mean grain yield of 7414 kg/ha in 15 locations which was 20.08 and 28.76 per cent higher than CO 51 and ADT 53, respectively.

The culture CB 12588 recorded an overall mean grain yield of 6354 kg/ha which was 10.83 per cent improvement over CO 51 and 10.35 per cent over ADT 53 (**Table 1**). The short duration rice culture CB 12588 is a medium tall (95-105 cm) genotype with long erect leaves, sturdy culm and well exerted long droopy compact panicles. The duration of the culture is 115-118 days. The culture possesses medium slender white rice with a 1000 grain weight of 15.44 g (**Table 2**).

In the agronomy trial evaluated during 2019-20 CB 12588 had better agronomic efficiency than CO 51 and ADT 53, by registering more number of grains per panicle and higher grain yield. Nutrient use efficiency was also higher under 100% NPK / ha (150:50:50 kg /ha) when compared to higher graded level of nutrients (125 % of NPK/ha) (**Table 3a & b**). The culture was evaluated under a physiology trial during 2018-20, wherein it possesses higher physiological efficiency by registering higher crop growth rate, leaf area Index, better light transmission ratio, photosynthetic rate and dry matter production (**Table 4**).

The rice culture CB 12588 released as CO 54 has a medium slender grain type with a good milling percentage (66.5%) and head rice recovery (60.7%). In general, the degree of milling is negatively correlated with head rice recovery (Paul *et al*., 2019) but this culture with positive attributes of physical grain quality parameters will be a boon to the rice stakeholders. It has intermediate amylose content (22.9 %) gelatinization temperature and soft gel consistency. Upon cooking, linear elongation ratio (LER) and volume expansion (VE) were found to be in desirable level *i.e.,* 1.65 and 5.0 ml respectively. The breadth wise expansion ratio (BER) of the culture CB 12588 is also less (1.44) (**Table 5**). Thus the culture with preferable cooking quality traits like good linear elongation ratio, volume expansion, intermediate amylose content gelatinization temperature and soft gel consistency (Sharma and Khanna, 2020) will satisfy the consumer demands.

Table 1. Overall yield performance of CB 12588 in different trials

Name of the Trials	Number of trials	Grain yield (kg/ha)				
		CB 12588	CO 51	ADT 43	ADT 45	ADT 53
Station trials (2012-2013)	3	8332 (115)	7026 (114)	6648 (113)	-	-
Multi-location trials (2014-15)	9	6405 (118)	5205 (114)	-	5084 (113)	-
Multi-location trials (2015-16)	8	5848 (118)	5649 (113)	4772 (113)	-	-
AICRIP- IVT * 2014)	28	5505 (124)	4902 (120) (IR 64 NC)	-	-	-
Adaptive Research trial (2016-17)	55	6200 (115)	5760 (113)	-	5613 (115)	-
Adaptive Research trial (2017-18)	51	6055 (113)	5605 (114)	-	-	-
OFT(2018-19)	11	6878 (111)	5742 (108)	-	-	-
OFT (2019- 20)	15	7414 (114)	6174 (112)	-	-	5758 (116)
No. of trials (180)		180	152	11	64	15
Overall weighted Mean yield in kg/ ha		**6354 (115)**	**5733 (112)**	**5283 (113)**	**5538 (113)**	**5758 (116)**
Per cent increase over the checks			**10.83**	**20.27**	**14.73**	**10.35**

*: Not included in the calculation of mean

Table 2. Distinguishing morphological characters of CO 54(CB 12588)

Traits		Description
Basal leaf : sheath colour	:	Green
Leaf : Pubescence of blade surface	:	Strong
Leaf : Auricles	:	Present
Leaf : Anthocyanin colouration of Auricles	:	Colourless
Leaf Collar	:	Present
Leaf : Anthocyanin colouration of collar	:	Colourless
Leaf : Ligule	:	Present
Leaf : Shape of ligule	:	Split
Leaf : Colour of ligule	:	White
Leaf : Length of blade	:	40.0 cm (± 5.0 mm)
Leaf : Width of Blade	:	1.8 cm (± 5.0 mm)
Culm: Attitude	:	Erect
Time of heading	:	85- 88 days
Flag leaf: Attitude of Blade	:	Semi erect
Spikelet: Density of pubescence of lemma	:	Medium
Male sterility	:	Absent
Spikelet: Colour of stigma	:	White
Stem: Length	:	85-87 cm
Stem: Anthocyanin colouration of nodes	:	Absent
Stem: Anthocyanin colouration of internodes	:	Absent
Panicle: Length of main axis	:	28 - 30 cm
Flag leaf: Attitude of blade (late observation)	:	Semi-erect
Panicle: Curvature of main axis	:	Semi straight
Panicle: Number per plant	:	14 -16
Spikelet: Colour of tip of lemma	:	Yellowish
Lemma and palea: Colour	:	Straw
Panicle: Awns	:	Absent
Panicle: presence of secondary branching	:	Present
Panicle : Secondary branching	:	Strong

Table 3a. Performance of CB 12588 in agronomy trials

Characters	CB 12588	CO 51	ADT 53
Days to 50% flowering	84	81	84
Number of productive tillers / hill	13-15	13-15	12-14
Plant height at harvest (cm)	92.8	92.2	88.4
Panicle weight (g)	3.02	2.51	2.12
Number of grains/panicle	267	244	219
Grain yield (kg/ha)	6950	6730	6610
Straw yield (kg/ha)	9275	8260	8165
Biomass (kg/ha)	16225	15390	15075
Agronomic efficiency (%)	32	31	30

Table 3b. Response of CB 12588 to graded doses of nutrients

Nutrient levels	Grain yield (kg / ha)		
	CB 12588	CO 51	ADT 53
Control	2150	2180	2215
50% recommended dose of NPK / ha	3830	3730	3640
100% recommended dose of NPK / ha	6950	6730	6610
125% recommended dose of NPK / ha	6985	6755	6660

Table 4. Physiological characters of CB 12588

Parameters	CB 12588	CO 51	ADT 53
Total Dry Matter Production (g plant^{-1}) at 50% flowering	82.25	72.60	64.31
Leaf Area Index at 50% flowering	5.22	4.55	3.94
Crop Growth Rate (g m^{-2} day^{-1}) at PI-50% F	51.78	42.82	41.09
Flag leaf length (cm) at 50% flowering	34.76	27.66	26.35
Photosynthetic rate (µmol CO_2 m^{-2} s^{-1}) at 50% flowering	32.86	25.27	23.93
Transpiration rate(mmol H_2O m^{-2} s^{-1}) at 50% flowering	12.81	8.98	6.36
Total chlorophyll content (mg g^{-1}) at 50% flowering	3.00	2.42	2.18
Light Transmission Ratio (%) at 50% flowering	23.62	34.36	31.99
Leaf Nitrogen (%) at 50% flowering	4.31	3.43	3.13

Table 5. Quality characteristics of CB 12588

a) Milling quality traits

Variety	Hulling %	Milling %	Head Rice Recovery %
CB 12588	76.0	66.5	60.7
CO 51	75.6	63.8	60.3
ADT 43	75.0	62.5	56.2
ADT 53	70.2	62.0	58.3

b) Physical grain quality traits

Variety	Kernal length (mm)	Kernal breadth (mm)	LB ratio	Grain type
CB 12588	5.58	1.83	3.05	MS
CO 51	5.93	1.98	3.00	MS
ADT 43	5.80	1.90	3.05	MS
ADT 53	5.90	1.95	3.03	MS

c) Cooking quality traits

Variety	KLAC (mm)	KBAC (mm)	LER	BER	VE (ml)	Alkali Spreading value	GC
CB 12588	8.73	2.83	1.56	1.44	3.8	5	98.7
CO 51	8.80	2.80	1.48	1.43	3.7	3	103.7
ADT 43	8.80	2.80	1.51	1.47	3.9	2	119.0
ADT 53	8.75	2.65	1.48	1.35	3.5	4	61.5

d) Biochemical properties of CB 06535

Traits	CB 12588	CO 51	ADT 43	ADT 53
Amylose content (%)	22.9	23.5	24.5	24.1

e) Organo-leptic evaluation of cooked rice

Details	CB 12588	CO 51	A DT 43	ADT 53
Colour and appearance	8	7	8	7
Flavour	8	7	8	7
Texture	8	8	8	6
Taste	7	7	7	7
Overall acceptability	8	7	8	7

(Maximum score = 10)

Table 6a. Reaction of CB 12588 against major rice diseases in 2014- 15

S. No.	Culture	Blast	Sheath blight	Sheath rot	Brown spot
		CBE[a]	MDU[f]	MDU[f]	ADT[f]
1.	CB 12588	0	5	5	3
2.	CO 51	2	5	5	3
3.	ADT 45	2	7	7	5

Table 6b. Reaction of CB 12588 against major rice diseases in 2015- 16

S. No.	Culture	Blast	Sheath blight	Sheath rot
		Coimbatore[a]	Madurai[f]	Madurai[f]
1.	CB 12588	5	5	5
2.	CO 51	3	5	5
3.	ADT 43	4	3	5

Table 6c. Reaction of CB 12588 against major rice diseases in 2017-2018

S. No.	Cultures	Blast	Brown spot		RTD
		Coimbatore[a]	Aduthurai	Coimbatore	Coimbatore[a]
1.	CB 12588	1	5	3	7
2.	CO 51	1	3	3	5

[a].under artificial condition [f]. under field condition

Table 6d. Reaction of CB 12588 against major rice diseases under artificial conditions in 2020-21

S. No.	Cultures	Blast	Brown spot	RTD
1.	CB 12588	3.4	5.5	6.2
2.	CO 51	3.1	4.8	5.0
3.	ADT 53	4.7	7.2	5.7

Table 6e. Resistance reaction of CB 12588 against major rice diseases in AICRIP (NSN 2)-2014

S. No.	Culture	Leaf blast	Neck blast	BLB	Brown spot	Sheath blight	Sheath rot	Grain discolouration	RTD
1	CB 12588	5.2	7.4	5.8	4.9	6.5	4.6	7	6.3
2	T(N) 1	3.9	7.0	6.4	4.9	6.4	5.4	5	7.0
3	CO 39	6.0	7.4	7.4	6.2	7.3	5.5	7	7.0

Table 6f. Resistance reaction of CB 12588 against major rice diseases in AICRIP (DSN)

S. No.	Culture	Blast	Neck blast	Sheath blight	Sheath Rot	BLB	Brown spot	RTD	GD
1.	CB 12588	5.1	6.6	5.9	5.0	5.9	5.5	5.7	7
2.	T(N) 1	5.2	6.8	6.0	4.9	6.9	4.7	7.7	7
3.	CO 39	6.7	7.7	6.7	5.7	6.7	6.0	7.0	7

Table 7a. Reaction of CB 12588 against major sucking pests of rice under field/artificial condition in 2015-16

S. No.	Culture	BPH			WBPH	GLH	Leaf folder Damage (%)	Stem Borer (Dead heart %)		
		ADT[a]	CBE[a]	MDU[f]	CBE[a]	CBE[a]	ADT[f]	ADT[f]	MDU[f]	KKM[f]
1.	CB 12588	3	7	3	7	7	3.2	2.1	0	4.1
2.	ADT 43	9	5	1	5	7	2.7	2.8	7.69	2.01

ADT: Aduthurai, CBE: Coimbatore, MDU: Madurai, KKM: Killikulam

Table 7b. Reaction of CB 12588 against major insect pests of rice under field /artificial condition in 2017-18

S. No.	Culture	WBPH	GLH	Silver shoot (%)	Dead heart (%)	White ear (%)	Leaf folder (%)
		CBE[a]	CBE[a]	ADT[f]	ADT[f]	ADT[f]	ADT[f]
1.	CB 12588	7	7	0.70	1.50	6.00	2.60
2.	CO 51	7	9	1.60	2.40	2.10	1.20
3.	TN 1	9	9	-	-	-	-

Table 7c. Reaction of CB 12588 against major insect pests of rice under artificial condition during 2019-20

S. No.	Culture	BPH	WBPH	GLH
1.	CB 12588	5.0	7.0	7.0
2.	CO 51	7.0	7.0	7.0
3.	ADT 53	7.0	7.0	7.0

BPH : Brown plant hopper WBPH : White backed plant hopper
GLH : Green leaf hopper [a]. under artificial condition [f]. under field condition

Table 7d. Resistance reaction of CB 12588 against major rice pests in AICRIP (NSN 2)

S. No.	Culture	Plant Hopper	Gall midge		Stem borer (% of Dead heart)		
		Gangavati	Sambalpur	Aduthurai	Aduthurai	Ludhiana	Sambalpur
1.	CB 12588	3.0	4.8	1.0	7.9	1.3	2.0
2.	TN1	7.0	1.7	1.5	6.3	8.1	10.0

S. No.	Culture	Stem borer (% of white ear)			Leaf folder (% of damaged leaves)		
		Aduthurai	Sambalpur	Ghaghraghat	Aduthurai	Puducherry	Ragolu
1.	CB 12588	4.8	3.1	3.0	8.6	5.0	3.5
2.	TN1	5.7	6.0	3.0	7.7	-	5.3

Table 7e. Resistance reaction of CB 12588 against plant hoppers in AICRIP (Plant hoppers screening trial)

S. No.	Culture	Rajendranagar	Pantnagar	Coimbatore
1.	CB 12588	7.0	5.0	7.0
2.	TN1	9.0	7.0	9.0
3.	PTB 33	-	7.0	5.0

The rice variety CO 54 was screened against all the epidemic diseases *viz.,* blast, sheath rot, sheath blight, brown spot and rice tungro disease (RTD) under artificially inoculated conditions during 2015, 2016 and 2018. The culture CB 12588 is found to be moderately resistant to blast (score 5), sheath rot (5), and brown spot (5), in 1 to 9 scale. Under AICRIP, the culture was screened in NSN-2 and DSN, wherein CB 12588 was found to be moderately resistant to major diseases (**Table 6**). The culture CB 12588 was evaluated for four years (2016, 2018, 2019 & 2020) at Coimbatore, Madurai, Killikulam and Aduthurai against the major pests and the culture is moderately resistant to BPH (5) (**Table 7**). The rice culture CB 12588 with a higher yield, better pest and disease resistance and good cooking quality in comparison to the checks CO 51 and ADT 53 was released as CO 54 during 2021 and the same was notified in gazette notification number SO 8 (E) dt 24.12.2021. It is recommended for cultivation during *Kar*/*Kuruvai / Sornavari/Navarai* and the seasons/ tracts wherever early maturing rice varieties are cultivated throughout Tamil Nadu.

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