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Research Article

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Abstract
Early duration rice culture CB 06 535, a derivative of the cross ADT 43 / RR 272 -1745 was released as TNAU Rice CO 51 during the year 2013 as an alternate variety to ADT 43 with 105 -110 days duration with additional desirable features like high yield, physiological efficiency and better adaptability. This culture with semi dwarf stature has efficient tillering capacity, long droopy panicles with highly acceptable plant characters and is a good replacement for the rice variety ADT 43 due to its high grain yield and pest and disease resistance. In the overall performance, the culture, CB 06 535 recorded a mean productivity of 6623 kg/ha in seven years of trials with 10.72 per cent increase over ADT 43. At Nallampalli, Dharmapuri district, the culture has recorded the highest yield of 11,377 kg/ha among the trials conducted, demonstrating the highest yield potential of this variety. The culture CB 06 535 is moderately resistant to blast, BPH and GLH under artificial condition. It produces medium slender white rice with intermediate amylose, soft gel consistency and moderate gelatinization temperature. It produces good quality cooked rice besides high milling and head rice recovery. CB 06 535 with higher yield, better pest and disease resistance and good cooking quality in comparison to the check ADT 43 is suitable for cultivation during *Kar*/ *Kuruvai* /*Sornavari* /*Navarai* and the seasons / tracts wherever early maturing rice varieties are cultivated throughout Tamil Nadu.

Key words
CO(R) 51, fine grain rice, short duration, amylose, cooking quality, LER

Introduction

In India, rice is the most important and extensively grown crop occupying an area of 43.86 million hectares with a production of 105.48 million tonnes and with an average productivity of 2.4 t/ha. In Tamil Nadu, total area under rice is 18.30 lakh hectares, production of 58.39 lakh tonnes and with a productivity of 3.19 t/ha during 2014-15 (INDIASTAT, 2015). Rice is a major food of Indian people, with an average consumption of 75 kg/year/person. To meet the food demand for growing population, 5 million tonnes additional food is required out of which 2 million tonnes share is of rice. Rice occupies and will continue to occupy a pivotal place in global food and livelihood security systems.

The ultimate goal of crop breeding is to develop varieties with high yield potential and desirable agronomic characteristics. In rice breeding, the most important qualities sought by breeders have been high yield potential; resistance to major diseases and insects; and improved grain and eating quality. However, there seems to be some conflict between these aims. Emphasis on high grain quality tends to result in unstable yields. Conversely, too much emphasis on disease and insect resistance and stable yields leads to poor grain quality. Hence, breeding efforts should concentrate on varieties with the potential to minimize yield losses under unfavourable conditions, and to maximize yields when conditions are favourable (Khush and Aquino1990).

Improvements in rice quality are very important in meeting the demands of consumers for healthy, high-quality food. Most rice breeders feel that popular rice varieties in recent years are possessed with premium quality in terms of grain size, shape, appearance and palatability. There are many difficulties in evaluating consumer preferences, which vary widely from country to country and from person to person. However, consumers generally feel that even the best quality grain of improved high-yielding varieties is not as good as the best quality traditional varieties. Many traditional varieties in both the tropics and the temperate zone have excellent cooking and eating quality, but a low grain yield (Khush and Juliano 1985). For many years, breeders have focused their attention on simultaneous improvement of yield and quality, but with limited success. At present, it is not possible to be very optimistic that we shall be able to develop high-yielding varieties with quality as good as that of traditional varieties, but our efforts continue, as does our work to develop

high-yielding varieties with various grain characteristics suitable for processing (Kim and Virmani, 1989).

Host plant resistance to various biotic stresses is a very important aspect of high yields, and can be expected to play a significant role in sustainable rice production. Intensive efforts have been made over the years to incorporate resistant gene(s) into improved varieties, and there are now numerous varieties resistant to rice blast, bacterial blight, RTD and plant hoppers. Some varieties possess multiple resistances to diseases and insects. But resistance in most varieties is controlled by a single gene and lasts only a few years, after which they become susceptible to serious disease or pest outbreaks. Resistance is often controlled by a single gene (vertical resistance) and lasts only a few years, after which they become susceptible through evolution of diverse races/ biotypes (Khush and Virmani, 1985).

In Tamil Nadu, out of 20.5 lakh hectare, 5 lakh hectare area is covered with short duration rice varieties in all the seasons. Since water has become a scarce commodity, early duration rice varieties maturing in 105-110 days are predominately cultivated in majority of the area. Apart from the *kuruvai* season in cauvery delta zone, farmers of the other areas in Tamil Nadu prefer mostly an early duration rice variety to escape from water shortage. Hence, need for an early duration rice variety with high commercial value is very much essential for the present day situation. Hence, with the objective of development of high yielding, pest and disease resistant fine grain rice variety, TNAU Rice CO 51, the early duration rice variety with the parentage of ADT 43/ RR 272-1745 was developed at Department of Rice, TNAU, Coimbatore.

Materials and Methods

CO(R) 51 is a hybrid derivative of the cross ADT 43 / RR 272 -1745 effected during *Kharif* 2003 and stabilized in F_5 generation and identified as CB 06 535 rice culture during *Rabi* 2005 at Department of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. Performance of the culture was tested in different yield trials at Department of Rice, TNAU from 2009 to 2012 along with short duration checks. The culture was tested in MLT-Early for two years in 2009-10 and 2010-11 in different rice research stations of TNAU covering different ecosystems of Tamil Nadu. Under All India Coordinated Rice Improvement Programme (AICRIP) this new culture was evaluated as IET 21605 in Initial Varietal Trial – Early (IVT-E) and Advanced varietal trial 1 Early in 2009 and 2010 in all the AICRIP centres of India. Based on the performance under MLT, it was tested under Adaptive Research trial during 2010-12 in farmers holdings covering 17 districts of Tamil Nadu comprising of 127 locations. Pest and disease performance was tested under artificial and field conditions at Aduthurai, Coimbatore and Madurai. Agronomical performance of the culture was tested under SRI system of cultivation during 2010-11 at Department of Rice. Physical, cooking and biochemical properties of rice were tested along with checks ADT 43 and ADT (R) 45 at Directorate of Rice Research, Hyderabad and Department of Rice, TNAU, Coimbatore.

Results and Discussion

The culture recorded a mean grain yield of 7880 kg/ha over three years of station trials with 53.9 per cent improvement over ADT 43. In MLT conducted during 2009-10 and 2011-12 its mean grain yield was 6284 kg/ha which was 17.16 per cent higher than ADT 43. CB 06535 was evaluated as IET 21605 under All India Coordinated Rice Improvement Programme for two years during 2009 and 2010 across 35 locations in the country in Initial Varietal Trial – Early and Advanced Varietal Trial – 1 Early during Kharif 2009 and 2010 respectively. This culture registered consistently superior performance in southern region during kharif 2009 and 2010 with more than 15 per cent yield increase over the national checks Annada and Tulasi.

Adaptive Research Trials (ART) were conducted at 127 locations with CB 06 535 during 2010-11 and 2011-12 in 17 districts and recorded over 7000 kg/ha in 38 locations. It recorded a mean grain yield of 6440 kg/ha with 5.10 per cent higher than ADT 43. During the Annual Rice Meet, based on its consistent performance, the culture was recommended for large scale demonstration. On Farm Trials (OFT) were conducted with CB 06 535 during 2010, 2011 and 2012 in 22 locations across seven districts. It recorded a mean grain yield of 7705 kg/ha which was 36.8 per cent higher than ADT 43.

In the overall analysis, the culture, CB 06 535 recorded a mean productivity of 6623 kg/ha in seven years of trials with 10.72 per cent increase over ADT 43. The consolidated results also showed that it recorded a grain yield of 6623 kg/ha in Tamil Nadu. At Nallampalli, Dharmapuri district in Tamil Nadu, the culture has recorded the highest yield of 11,377 kg/ha among the trials conducted, demonstrating the highest yield potential of this variety (Table 1).The Early duration rice culture CB 06 535 is semi dwarf (90-100 cm), erect with strong culm and well exerted -

panicle with duration of 110 days (seed to seed). Distinguishing morphological characters of this variety is given in Table 2. It has long, compact and droopy panicle with a length of 23-28 cm. The variety has 1000 grain weight of 16.0 g.

The culture recorded higher yield under SRI than normal method. It has better agronomic efficiency (37.2 and 48.3% under normal and SRI respectively) than the check variety ADT 43 (30.5 and 33.5% under normal and SRI systems) (Table 3). The culture possesses higher physiological efficiency by registering higher crop growth rate, leaf area Index, better light transmission ratio, spikelet fertility, Dry matter production and Harvest Index. (Table 4). The proposed culture CB 06 535 is an alternative variety with 105 -110 days duration with additional desirable features like high yield, physiological efficiency and better adaptability. The culture has been recommended by Annual Rice Meet 2011 by TNAU.

TNAU Rice CO 51 variety has medium slender grain type with an L/B ratio of 3.00. It has good milling percentage (68.5%) and head rice recovery (63.2%) which is in accordance with Shivani *et al*. (2007) and Oko *et al*, (2012) who reported significant positive association of head rice recovery with milling outturn. It has intermediate amylose content (21.60), soft gel consistency and intermediate gelatinization temperature which are the desirable traits for good cooking quality. Upon cooking, linear elongation ratio (LER) and volume expansion (VE) were found to be 1.65 and 5.0 ml respectively (Table 5). It is having medium slender rice with good cooking and organo-leptic properties. The feedback received from the stakeholders proved its acceptance among farmers, millers and consumers.

The culture CB 06 535 was screened against all the epidemic diseases *viz.*, blast, bacterial blight, sheath rot, sheath blight, brown spot and rice tungro disease (RTD) under artificially inoculated conditions during 2009, 2010 and 2011. The culture CB 06 535 is found to be moderately resistant to Blast (scale 5), in 1 to 9 scale. The corresponding scores for ADT 43 are 7 or 9 scale for all the diseases in the order mentioned above (Tables 6 a, b, c, d, e). Under AICRIP, the culture was screened in NSN-1 and DSN-1, wherein CB 06 535 was found to be moderately resistant. It was evaluated for three years (2009, 10 and 11) at Coimbatore, Madurai and Aduthurai against the major pests and the culture CB 06 535 is moderately resistant to GLH (5) and BPH (3) (Table 7 a, b, c & d). TNAU Rice CO 51 with higher yield, pest and disease resistance with superior cooking quality in comparison to the check ADT 43 was released during 2013. This variety can be cultivated as a transplanted crop during *Kar* / *Kuruvai / Sornavari / Navarai* and the seasons / tracts wherever early maturing rice varieties are cultivated throughout Tamil Nadu.

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Table 1. Overall yield performance of culture CB 06 535 in different trials

Name of the Trials	No. of trials	Grain Yield (kg/ha)			
		CB 06 535	**ADT 43**	**ADT (R) 45**	**ASD 16**
Station trials (2006-2008)	3	7880	5120	5363	5100
Multi-location trials (2009-10 & 2010-11_	13	6284	5364	5404	5963
AICRIP- IVT –Early - 2009	16	5780	5152 (Annada)	4786 (Tulasi)	-
AICRIP- AVT 1 –Early - 2010	19	4659	4171 (Annada)	3898 (Tulasi)	-
Adaptive Research trial (2010-11 & 2011-12)	127	6440	6127	-	6251
OFT (2010,11 & 12)	22	7705	5630	-	-
No. of trials		165	165	16	125
Overall weighted Mean Yield in kg/ ha		**6623**	**5982**	**5396**	**6151**
Per cent increase over the checks			**10.72**	**22.74**	**7.67**

Table 2. Distinguishing morphological characters of TNAU Rice CO 51(CB 06 535)

Early plant vigour	: Good
Coleoptile	: Green
Basal leaf sheath colour	: Green
Leaf sheath colour	: Green
Leaf blade colour	: Green
Leaf pubescence	: Intermediate
Leaf length	: 35.0 cm (± 5.0 mm)
Leaf width	: 2.00 cm (± 0.2 mm)
Days to 50% flowering	: 75 to 80 days
Panicle exertion	: Well-exerted panicle
Stigma colour	: White
Apiculus colour	: Light Green
Number of effective tillers	: 15 to 18
Panicle length (cm)	: 23 to 28 cm
No. of Grains/panicle	: 250 to 300
Panicle type	: Intermediate, droopy
Awning	: absent
Days to maturity (days)	: 105 to 110
Seed coat (Kernel) colour	: White
Junction of auricle	: Pale green
1000 grain weight (g)	: 16.0
Hull (husk) colour	: Straw
Threshability	: Good
Aroma	: Absent
Grain yield per plant (g)	: 40 to 50
Grain type	: Medium slender
L x B of grain (mm)	: 5.5 x 1.8
L / B ratio of grain	: 3.0
Rice grade	: Medium slender
Milled rice colour	: White
Abdominal white	: Occasionally present

Table 3. Performance of culture CB 06 535 in agronomy trials (2010- 11)

Characters	CB 06 535		ADT 43	
	Normal	SRI	Normal	SRI
No. of productive tillers per hill	15-18	35-40	10-12	25-30
SPAD reading at flowering	35.5	36.7	34.6	35.7
Plant height at harvest (cm)	92.6	94.4	85.0	88.0
Panicle weight (g)	2.97	3.41	2.40	2.60
Grains per panicle (No)	272	305	210	235
Grain yield (kg/ha)	6840	7950	5850	6250
Straw yield (kg/ha)	8702	9575	6435	7520
Bio Mass (t/ha)	15542	17525	12285	13770
Agronomic efficiency (%)	37.2	48.3	30.5	33.5

Table 4. Physiological characters of culture CB 06 535

Characters	CB 06 535	ADT 43
Leaf Area Index (at flowering)	7.53	6.76
Crop Growth Rate ($g/m^2/day$)	28.10	16.71
Active Tillering- Panicle Initiation	48.30	41.06
Panicle Initiation - Flowering	67.16	53.54
Flowering - Grain Filling		
Light Transmission Ratio	10.63	11.36
Spikelet fertility (%)	94.03	88.26
Total Dry matter Production (g/plant)	96.71	81.23
Harvest Index	46.33	40.23
Specific leaf weight (SLW) (mg/cm^{-2}) at flowering	2.83	2.30
Total chlorophyll content (mg/g) at flowering	3.16	2.67

Table 5. Quality characteristics of culture CB 06 535

a) Milling quality traits

Variety	Hulling %	Milling %	Head Rice Recovery %
CB 06535	74.3	68.5	63.2
ADT 43	71.0	65.0	58.5
ADT (R) 45	75.5	68.0	59.8

b) Physical grain quality traits

Variety	kernel Length (mm)	Kernel Breadth (mm)	L:B ratio	Grain type
CB 06535	5.7	1.9	3.0	MS
ADT 43	5.7	1.9	3.0	MS
ADT (R) 45	5.8	1.8	3.2	MS

c) Cooking quality traits

Variety	KLAC (mm)	KBAC (mm)	LER	BER	VE (ml)	Alkali Spreading value	GC
CB 06535	9.4	2.4	1.65	1.26	5.0	2	84
ADT 43	8.8	2.2	1.54	1.15	5.5	5	88
ADT (R) 45	9.6	2.8	1.65	1.55	4.4	3	70

KLAC – Kernel Length after cooking; KBAC – Kernel Breadth after cooking;
LER – Linear Elongation ratio; BER – Breadthwise Expansion Ratio;
VE – Volume Expansion; GC - Gel consistency

d) Biochemical properties

Traits	CB 06535	ADT 43	ADT (R) 45
Amylose content (%)	21.6	21.5	22.2

(Annual Research Meet, Rice, 2010)

e) Organo-leptic evaluation of cooked rice

Details	CB 06535	ADT 43	ADT (R) 45
Colour and appearance	8	7	7
Flavour	8	7	7
Texture	8	8	6
Taste	7	7	7
Overall acceptability	8	7	7

(Maximum score= 10)

Table 6a. Reaction of culture CB 06 535 against major rice diseases in 2009- 10

Sl. No.	Culture	Blast	Sheath rot		BB		Sheath blight		Brown spot	RTD
		CBE[a]	ADT[f]	CBE[a]	ADT[f]	MDU[f]	ADT[f]	MDU[f]	CBE[f]	CBE[a]
1.	CB 06535	5	7	5	5	5	7	5	7	5
2.	ADT 43	9	9	7	9	9	7	7	7	7
3.	ADT (R) 45	9	7	5	9	7	5	7	7	7
4.	ASD 16	9	9	7	9	5	5	3	9	7

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

Table 6b. Reaction of culture CB 06 535 against major rice diseases in 2010- 11

Sl. No.	Culture	Sheath rot		Sheath blight		Blast	BB	Brown spot	
		ADT	MDU	ADT	MDU	CBE	MDU	ADT	MDU
1.	CB 06535	5	5	7	5	5	5	7	5
2.	ADT (R) 45	7	7	7	7	7	5	9	5
3.	ASD 16	9	5	9	5	7	5	5	5

Table 6c. Reaction of culture CB 06 535 against major rice diseases in 2011- 12

Sl. No.	Culture	Blast	Sheath rot		Sheath blight		BB	Brown spot	RTD
		CBE	CBE	MDU	MDU	CBE	MDU	MDU	CBE
1.	CB 06535	5	5	5	7	5	7	5	7
2.	ADT 43	8	9	5	7	9	7	5	9
3.	ADT (R) 45	6	7	7	7	7	7	7	7
4.	ASD 16	8	9	7	9	9	9	5	9

Table 6d. Reaction of culture CB 06 535 against major rice Diseases in AICRIP (NSN 1)

Sl. No.	Culture	Blast	Neck Blast	Bacterial Blight	Brown spot	Sheath blight	Sheath rot	RTD
1.	CB 06535	4	5	7	5	7	5	5

(Source : AICRIP Progress Report 2010)

Table 6e. Reaction of culture CB 06 535 against major rice Diseases in AICRIP (DSN)

Sl. No.	Culture	Blast	Neck Blast	Bacterial Blight	Brown spot	Sheath blight	Sheath rot	RTD
1.	CB 06535	4	5	7	5	7	5	3

(Source : AICRIP Progress Report 2010)

Table 7a. Reaction of culture CB 06 535 against major rice pests in 2009-10

Sl. No.	Culture	BPH		WBPH	GLH	SB	LF
		CBE[a]	MDU				
1.	CB 06535	1	3	7	1	3	3
2.	ADT 43	9	9	3	3	5	5
3.	ADT (R) 45	9	7	9	9	5	5
4.	ASD 16	9	5	5	7	5	5

[f]. under field condition [a]. under artificial condition scale: 0 - 9
BPH : Brown plant hopper WBPH : White backed plant hopper
GLH : Green leaf hopper SB : Stem Borer
LF : Leaf folder

Table 7b. Reaction of culture CB 06 535 against major rice pests in 2011-12 (field condition)

Sl. No.	Culture	Stem borer		Leaf folder % damage	BPH
		% Dead heart	% White ear		No / hill
1.	CB 06535	2.85	6.74	0.24	3.12
2.	ADT 43	1.94	5.55	1.19	2.77
3.	ADT (R) 45	3.06	3.21	1.20	3.96
4.	ASD 16	2.00	3.75	0.70	4.00

(Source : 31st ARW on Rice 2012)

Table 7c. Reaction of culture CB 06 535 against major rice pests in 2011-12 under controlled / artificial condition (Coimbatore) (scale: 0 – 9)

Sl. No.	Culture	BPH	WBPH	GLH
1.	CB 06535	3	5	5
2.	ADT 43	7	9	5
3.	ADT (R) 45	7	9	5
4.	ASD 16	5	7	5

(Source : 31st ARW on Rice 2012)

Table 7d. Reaction of culture CB 06 535 against major rice pests in AICRIP 2010 (scale: 0 – 9)

Sl. No.	Culture	WBPH	GLH	SB (DH)	LF
1.	CB 06535	3.0	5.0	3.0	3.0

(Source : AICRIP Progress Report 2010)

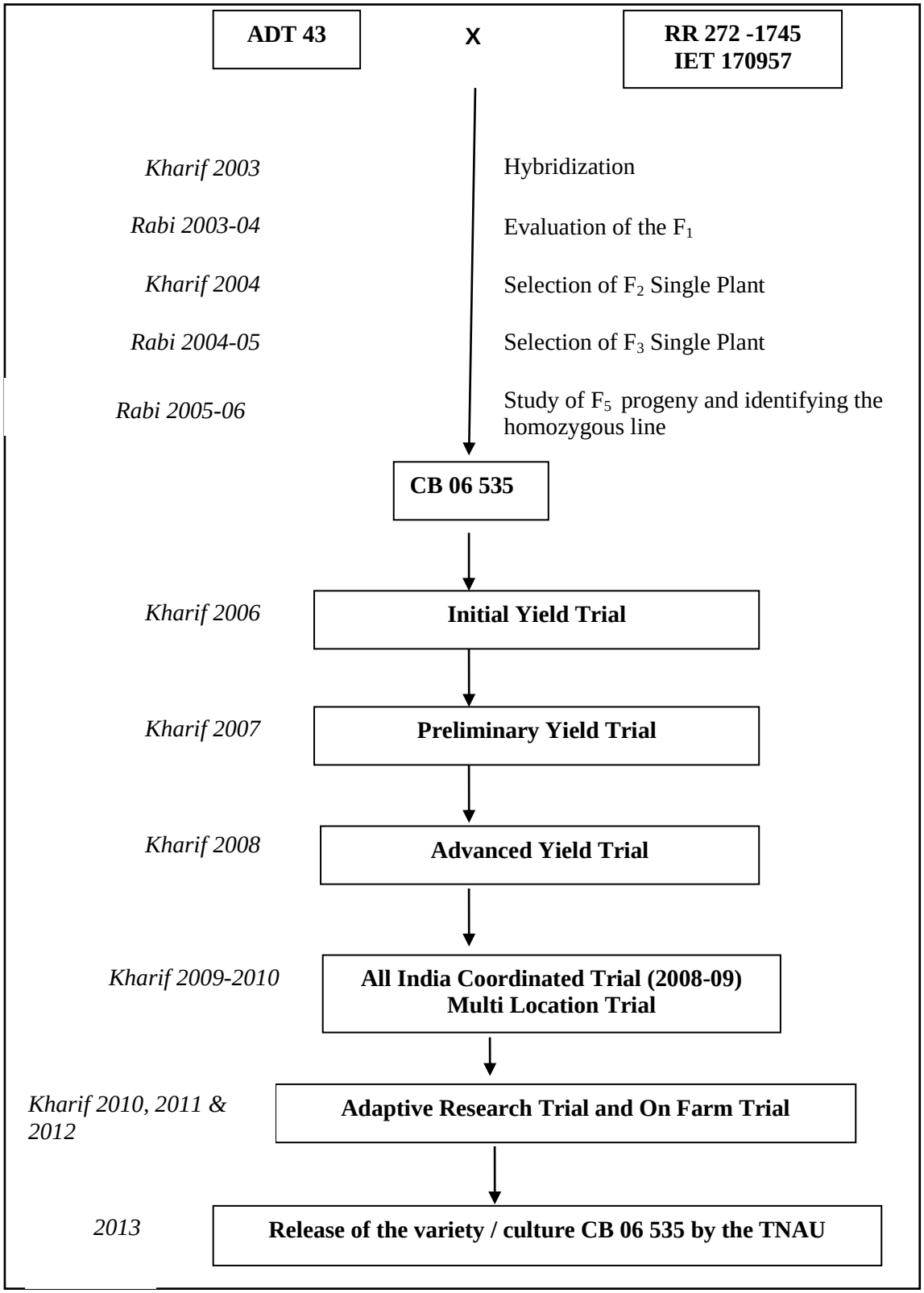
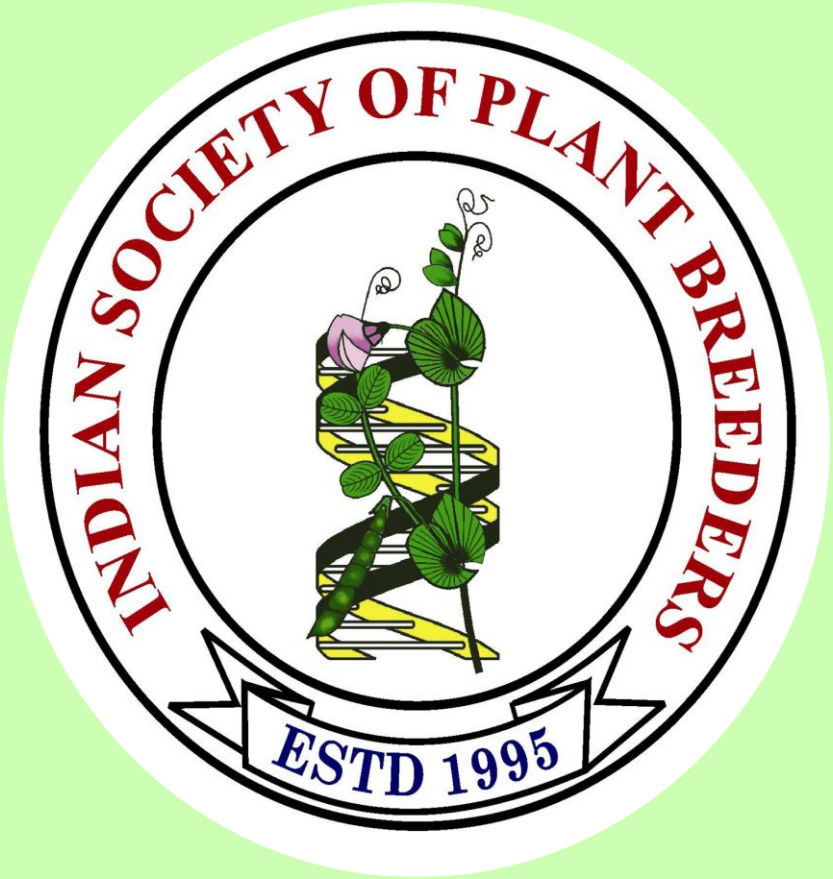


Fig. 1. Pedigree Chart of TNAU Rice CO 51



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