

## Molecular characterization of selected cultivars of rice, *Oryza sativa* L. using Random Amplified Polymorphic DNA (RAPD) markers

<sup>1</sup>Rajani, J., <sup>2\*</sup>Deepu, V., <sup>3</sup>Nair, G. M. and <sup>1</sup>Nair, A. J.

<sup>1</sup>Department of Biotechnology, University of Kerala, Thiruvananthapuram, Kerala, India

<sup>2</sup>Crop Improvement and Biotechnology Division, Centre for Medicinal Plants Research (CMPR), Arya Vaidya Sala, Changuvetty, Kottakkal 676 503, Malappuram, Kerala, India

<sup>3</sup>School of Biosciences, Central University of Kerala, Kasaragod, Kerala, India

### Article history

Received: 6 August 2012

Received in revised form:

4 October 2012

Accepted: 5 October 2012

### Abstract

Random Amplified Polymorphic DNA (RAPD) analysis was performed to assess the genetic diversity in ten selected cultivars of rice, *Oryza sativa* L. using 30 decamer random primers. Out of 30, 25 RAPD primers revealed polymorphism while the remaining 5 primers showed no reaction. The primers produced a total of 428 bands of which 363 were polymorphic (85.02%). The number of polymorphic fragments for each primer varied from 7 to 23 with an average of 14 polymorphic fragments. The primer OPB-17 produced the maximum number of polymorphic bands. The RAPD data was analyzed to determine the genetic similarity coefficients which ranged from 0.46 to 0.81. Cluster analysis was performed using Unweighted Paired Group of Arithmetic Means (UPGMA) using the Jaccard's similarity coefficient. The UPGMA dendrogram resolved the selected rice cultivars into two major clusters.

### Keywords

Genetic variation  
molecular markers  
*Oryza sativa*  
UPGMA

© All Rights Reserved

### Introduction

Rice (*Oryza sativa* L.) is one of the most important crops that provide food for more than half of the world population (Malik *et al.*, 2008). India has a long history of rice cultivation and stands first in rice area and second in rice production, after China. Approximately 90% of the world's rice is grown in the Asian continent and constitutes a staple food for 2.7 billion people worldwide (Salim *et al.*, 2003; Paranthaman *et al.*, 2009). The genus *Oryza* contains 25 recognized species, of which 23 are wild species and the remaining two are *O. sativa* and *O. glaberrima* which are cultivated species (Brar and Khush, 2003; Chang, 2003). *O. sativa* is the most widely grown worldwide including in Asian, North and South American, European Union, Middle Eastern and African countries.

The world's rice production has doubled during last 25 years, largely due to the use of improved technology such as high yielding varieties and better crop management practices (Byerlee, 1996). Demand for rice is growing every year and it is estimated that in 2025 AD the requirement would be 140 million tones. The land available for cultivation is decreasing due to continuous urbanization and inappropriate

land use (Khush, 1997; Fischer *et al.*, 2000). To sustain present food self sufficiency and to meet future food requirements, India has to increase its rice productivity by 3 per cent per annum (Thiyagarajan and Selvaraju, 2001).

Further scope of crop improvement depends on the conserved use of genetic variability and diversity in plant breeding programmes and use of new biotechnological tools. Molecular characterization can reveal the maximum genetic variation or genetic relatedness found in a population (Xu *et al.*, 2000). Chakravarthi and Naravaneni (2006) reported the usefulness of preservation and conservation of genetic resources since genetic diversity provides information to monitor germplasm and prediction of potential genetic gains. Information regarding genetic variability at molecular level could be used to help, identify and develop genetically unique germplasm that compliments existing cultivars (Ni *et al.*, 2002; Ravi *et al.*, 2003; Chakravarthi and Naravaneni, 2006). DNA based molecular markers have proven to be powerful tools in the assessment of genetic variation and in the elucidation of genetic relationships within and among the species of rice (Ragunathanchari *et al.*, 1999, 2000; Shivapriya and Hittalmani, 2006). The present investigation was

\*Corresponding author.

Email: [deepundd@gmail.com](mailto:deepundd@gmail.com)

undertaken for the assessment of genetic diversity among the selected rice cultivars with the help of RAPD markers.

## Materials and Methods

### *Plant materials and genomic DNA isolation*

The plant materials selected for the present study were ten different cultivars of rice (Table 1). The seeds of four varieties (GOURI-MO20, BHADRA-MO4, PAVIZHAM-MO6 and JYOTHI-PTB39) were collected from Rice Research Station, Mankomb, Kerala, India. The seeds of remaining six varieties were collected from traditional farmers of Palakkad, Kerala, India.

Healthy seeds of each variety were sowed in soil pots containing water under appropriate growth conditions for getting fresh leaves. DNA extraction was carried out from the fresh leaves collected from tillers following cetyl trimethyl ammonium bromide (CTAB) method (Doyle and Doyle, 1987) with some modifications. Freshly germinated 500 milligrams of young leaves were ground to a very fine powder in liquid nitrogen and dispersed in 3mL of pre-warmed (65°C) CTAB DNA extraction buffer (2% CTAB; 1.4 M NaCl; 100 mM Tris-HCl, pH 8.0; 20 mM EDTA, p.H. 8.0; 0.2% - mercaptoethanol (added just before use). Oakridge tubes containing samples were incubated at 65°C for 30 min in a water bath. The samples were swirled every 10 min. After incubation the mixture was cooled down to room temperature and emulsified with an equal volume of chloroform: isoamyl alcohol (24:1) and centrifuged at 8000 rpm for 10 min. Following centrifugation, the aqueous phase was collected and nucleic acid was precipitated by mixing with equal volume of chilled isopropanol. The precipitated nucleic acid was centrifuged at 12000 rpm for 10 min and the pellet was washed with 70% ethanol. The DNA pellet obtained was dried and stored in 400 µL TE buffer.

### *Purification of DNA*

The RNA was removed by RNase treatment at 37°C for 30 min in a water bath. After incubation, DNA solution was extracted with an equal volume of chloroform: isoamyl alcohol (24:1). The upper aqueous phase was collected after centrifugation at 8000 rpm for 10 min and mixed with 50 µL of 3M sodium acetate. DNA was precipitated by adding two volumes of chilled absolute alcohol. The DNA pellet was air dried and dissolved in 100 µL TE buffer. Two µL of genomic DNA isolated was subjected to electrophoresis on 0.8% agarose gel containing 1 mg/mL ethidium bromide and the quantity of genomic DNA was assessed using undigested lambda DNA as

Table 1. List of selected rice cultivars used in the genetic analysis

Sl. No.	Name of cultivars	Source
1	GOURI-MO20	Rice Research Station, Mankomb, Kerala, India
2	PAVIZHAM-MO6	Rice Research Station, Mankomb, Kerala, India
3	BHADRA-MO4	Rice Research Station, Mankomb, Kerala, India
4	JYOTHI-PTB39	Rice Research Station, Mankomb, Kerala, India
5	AST 120	Chittoor, Palakkad, Kerala, India
6	JAYA	Chittoor, Palakkad, Kerala, India
7	JYOTHI	Chittoor, Palakkad, Kerala, India
8	KANCHANA	Chittoor, Palakkad, Kerala, India
9	PONMANI	Chittoor, Palakkad, Kerala, India
10	SUJATHA	Chittoor, Palakkad, Kerala, India

control. For further use in PCR the DNA was diluted to a concentration of approximately 25 ng/µL.

### *RAPD analysis*

For the RAPD analysis of rice cultivars thirty deca-nucleotide primers of Operon Technology Inc. (Alameda, CA, USA) were used. The reaction was carried out in 25 µL reaction volume containing 25 nanogram genomic DNA, 2.5 µL 10X PCR buffer, 2 µL 25 mM MgCl<sub>2</sub>, 2.5 µL 2.5 mM dNTPs, 0.4 µL Taq DNA polymerase and 2 µL primer. All the reaction chemicals except primers were procured from M/s. Genei, Bangalore, India.

### *RAPD amplification procedure*

Samples for amplification were carried out using the method stipulated by Williams *et al.* (1990) with some modifications of thermal cycles. Amplification was performed in a thermal cycler with an initial denaturation of 94°C for 5 min followed by 35 cycles which contains denaturation at 94°C for 1 min followed by annealing in which the annealing temperature was adjusted based on the T<sub>m</sub> value of each primers and finally extension at 72°C for 2 min. After 35 cycles, there was a final extension step at 72°C for 10 min. All the reactions were amplified in a Gradient Palmcycler (Corbett Research, CG-96, Australia). Each amplification reaction for the screened primers was replicated two times individually with the same procedure in order to verify that the RAPD markers were reproducible and consistent.

### *Electrophoresis and visualization of RAPD products*

Amplified products were fractionated by 1.5% agarose gel in 1X TBE buffer (pH-8.0) at 100 V for 2 h and stained with ethidium bromide. 1kb DNA ladder was used as size marker. The gels were visualized under a UV transilluminator and documented using a digital camera. Total number of bands and number of polymorphic bands present in each cultivar was detected from the gels and scored manually. Each polymorphic band was considered as binary characters and was scored 1 (presence) or 0 (absence) for each sample. Only those fragments with medium and high intensity were taken into consideration.

### Data analysis

The gel images were scored using a binary scoring system that recorded the presence and absence of bands as “1” and “0” respectively. From the binary data, the similarity coefficient values between the cultivars were derived based on the probability that a particular character of one accession will also be present in another with the Jaccard’s correlation analysis using the statistical software “SPSS” version 7.5 for Windows. The statistical analysis is performed using NTSYSpc version 2.1 (Rohlf, 1998). The data matrix was used to construct a phenetic dendrogram using UPGMA (unweighted pair group method of arithmetic averages) (Sneath and Sokal, 1973) in order to cluster the accessions.

### Results and Discussion

The results of present study indicated a considerable level of genetic diversity among the cultivars selected. Among 30 primers used in this study, results of 25 primers were taken into consideration since they had given reproducible bands. Each polymorphic RAPD marker was considered as a locus so that every locus had two alleles, identified by the presence and absence of the band. A total of 428 DNA fragments were generated by 25 primers out of which 363 were polymorphic (85.02% polymorphism) (Table 2). Out of 25 primers, only 16 primers exhibited more than 80% polymorphism. The number of polymorphic fragments for each primer varied from 7 to 23 with an average of 14 polymorphic fragments. The primer OPB-17 produced the maximum number of polymorphic bands. The percentage of polymorphism was calculated as 85.02%. The size of amplified fragments ranges between 250 bp to 2500 bp (Figure 1). It was observed that the level of polymorphism with primers differed between the cultivars. Similarity between the cultivars was derived by Jaccard’s correlation coefficient (Jaccard, 1908). Correlation matrices obtained from all the primers used were consolidated in one single matrix and the mean values were presented (Table 3).

Jaccard’s pair-wise similarities computed between the cultivars showed that SUJATHA and AST 120 were the closest (0.81). The greatest distance was observed between the cultivars KANCHANA and JYOTHI (0.47). RAPD data generated by twenty five primers were subjected to UPGMA cluster analysis and the dendrogram was constructed (Figure 2). Cluster analysis revealed the similarity between the rice cultivars and it ranged from 52% to 81%. The dendrogram classified the cultivars into two distinct clusters. The first cluster included three cultivars,

Table 2. Sequence of 25 random primers with the number of scorable, amplified and polymorphic bands

Primer name	Sequence (5'-3')	Total number of bands	Number of polymorphic bands	Percentage of polymorphism
OPA-01	CAGGCCCTTC	11	11	100
OPA-04	AATCGGGCTG	14	14	100
OPA-13	CAGCACCCAC	24	21	87.5
OPA-17	GACCGCTTGT	15	15	100
OPA-18	AGGTGACCGT	20	16	80
OPB-08	GTCCACACGG	21	20	95
OPB-12	CCTTGACGCA	16	13	81
OPB-17	AGGGAACGAG	23	23	100
OPC-04	CCGCATCTAC	19	16	84
OPC-16	CACACTCCAG	13	13	100
OPC-20	ACTTCGCCAC	12	7	58
OPD-05	TGAGCGGACA	18	17	94
OPD-06	ACCTGAACGG	13	13	100
OPD-07	TTGGCACGGG	17	10	59
OPD-08	GTGTGCGCCA	23	14	61
OPD-15	CATCCGTGCT	14	11	79
OPD-20	ACCCGGTCAC	20	16	80
OPE-01	CCCAAGGTCC	14	13	93
OPG-02	GGCACTGAGG	21	20	95
OPG-04	AGCGTGTCTG	13	10	77
OPH-05	AGTCGTCCCC	19	15	79
OPK-16	GAGCGTCGAA	18	18	100
OPT-17	CCAACGTCGT	12	9	75
OPX-11	GGAGCCTCAG	18	14	78
OPY-11	AGACGATGGG	20	14	70
	<b>Total</b>	<b>428</b>	<b>363</b>	<b>85.02</b>

Table 3. Similarity matrix of ten rice cultivars based on Jaccard’s similarity index

	1	2	3	4	5	6	7	8	9	10
1	1									
2	0.62	1								
3	0.60	0.58	1							
4	0.48	0.55	0.55	1						
5	0.59	0.58	0.60	0.56	1					
6	0.51	0.51	0.50	0.49	0.58	1				
7	0.55	0.56	0.58	0.55	0.63	0.61	1			
8	0.54	0.57	0.57	0.49	0.67	0.58	0.81	1		
9	0.52	0.57	0.55	0.54	0.61	0.47	0.56	0.55	1	
10	0.49	0.50	0.50	0.46	0.60	0.53	0.63	0.63	0.61	1

1) GOURI MO-20, 2) PAVIZHAM MO-6, 3) BHADRA MO-4, 4) JYOTHI PTB-39, 5) JAYA, 6) KANCHANA, 7) SUJATHA, 8) AST 120, 9) JYOTHI, 10) PONMANI

GOURI MO-20, PAVIZHAM MO-6 and BHADRA MO-4. The second cluster included six cultivars collected from Palakkad.

The present investigation revealed the effectiveness of RAPD in detecting polymorphism among different cultivars of rice. The success of RAPD analysis in *O. sativa* accessions were also reported earlier (Muhammad *et al.*, 2005; Rahman *et al.*, 2007; Malik *et al.*, 2008). The percentage of polymorphism was found to be 85.02%. One of the reasons for this high level of polymorphism can be due to intraspecific variation among the cultivars. Information on intraspecific variation from the present study might be useful in making decision for

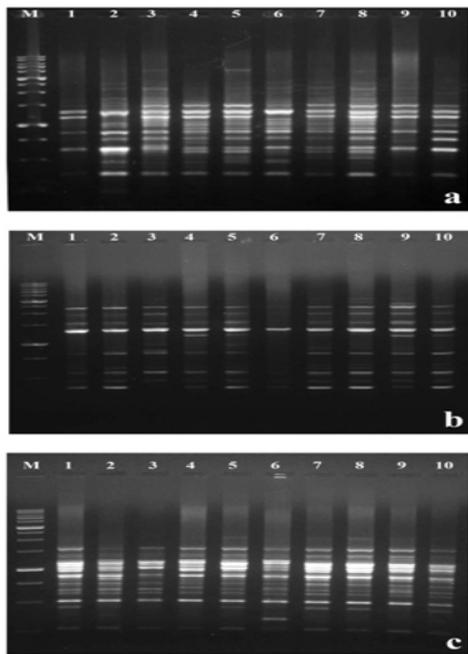


Figure 1. RAPD profiles of ten different rice cultivars using primers (a) OPA-18, (b) OPC-04 and (c) OPD-07

M- 1kb ladder, 1) GOURI MO-20, 2) PAVIZHAM MO-6, 3) BHADRA MO-4, 4) JYOTHI PTB-39, 5) JAYA, 6) KANCHANA, 7) SUJATHA, 8) AST 120, 9) JYOTHI, 10) PONMANI

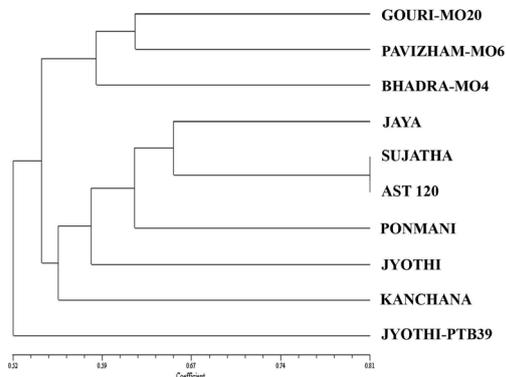


Figure 2. Dendrogram showing clustering pattern of ten rice cultivars based on 25 RAPD primers using UPGMA method

improvement of rice cultivars. Similarity level up to 50% in cluster analysis is indicative of plant derived from interspecific hybridization (Marsolais *et al.*, 1993). Three cultivars (GOURI MO-20, PAVIZHAM MO-6 and BHADRA MO-4) collected from Rice Research Station, Mankomb were grouped in a single cluster indicating more similarity among them and expressed more diversity from all the cultivars collected from traditional farmers of Palakkad. It is interesting to note that JYOTHI PTB-39 collected from Rice Research Station, Mankomb was totally excluded from both the clusters. The findings of Reby Skaria *et al.* (2011) indicate that PAVIZHAM MO-6 and JYOTHI PTB-39 are genetically distant.

The present findings confirm that genetic diversity of the plants is closely related to their geographic distribution. It has been reported that species with a wide geographic area generally have more genetic diversity (Wilikie *et al.*, 1993). The present investigation reveals that RAPD is a valuable tool for estimating the extent of genetic diversity as well as to ascertain the genetic relationship between different cultivars of *Oryza sativa*.

## Conclusion

The present study revealed that the levels of genetic differentiation between cultivars of *O. sativa* increased with geographical distance. The polymorphism detected among the accessions will be helpful in selecting genetically diverse cultivars in future breeding programme. However, there were some precincts in the present study that only ten cultivars and thirty primers were used in RAPD analysis and hence reduce the chance to obtain a reliable knowledge precisely about the genetic structure of each cultivar of rice. Further studies involving large number of accessions and primers need to be conducted to get more precise information.

## Acknowledgement

The authors gratefully acknowledge Rice Research Station, Mankomb, Kerala, India for providing the seed material of improved cultivars of rice.

## References

- Brar, D. S. and Khush, G. S. 2003. Utilization of wild species of genus *Oryza* in rice improvement, p. 283-309. In: Nanda, JS, Sharma SD (Eds.). Monograph on Genus *Oryza*.
- Byerlee, D. 1996. Knowledge-Intensive Crop Management Technologies: Concepts, Impacts, and Prospects in Asian Agriculture. International Rice Research Conference, Bangkok, Thailand, 3rd -5th June, 1996.
- Chakravarthi, B. K. and Naravaneni, R. 2006. SSR marker based DNA fingerprinting and diversity study in rice (*Oryza sativa* L.). African Journal of Biotechnology 5(9): 684-688.
- Chang, T. T. 2003. Origin, domestication and diversification. In: Smith, C.W. (Ed.), Rice: Origin, history, technology and production. John Wiley & Sons, Inc.
- Doyle, J. J. and Doyle, J. L. 1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. Phytochemical Bulletin 19: 11-15.
- Fischer, K. S., Barton, J., Khush, G. S., Leung, H. and Cantrell, R. 2000. Collaborations in rice. Science 290: 279-280.
- Jaccard, P. 1908. Nouvelles recherches sur la distribution florale. Bulletin de la Societe Vaudoise des Sciences

- Naturelles 44: 223-270.
- Khush, G. S. 1997. Origin, dispersal, cultivation and variation of rice. *Plant Molecular Biology* 35: 25–34.
- Malik, A. R., Zahida, H. P. and Muhammad, S. M. 2008. Genetic diversity analysis of traditional and improved cultivars of Pakistani rice (*Oryza sativa* L.) using RAPD markers. *Electronic Journal of Biotechnology* 11(3): 1-10.
- Marsolais, J. V., Pringle, J. S. and White, B. N. 1993. Assessment of random amplified polymorphic DNA (RAPD) as genetic marker for determining the origin of interspecific lilac hybrids. *Taxon* 42: 531–537.
- Muhammad, A., Samina, K., Muhammad, A. B., Anjuman, A. and Yusuf, Z. 2005. Genetic diversity among rice genotypes of Pakistan through Random Amplified Polymorphic DNA (RAPD) analysis. *Pakistan Journal of Botany* 37(3): 585-592.
- Ni, J., Colowit, P. M. and Mackill, D. J. 2002. Evaluation of genetic diversity in rice subspecies using microsatellite markers. *Crop Science* 42: 601-607.
- Paranthaman, R., Alagusundaram, K. and Indhumathi, J. 2009. Production of Protease from Rice Mill Wastes by *Aspergillus niger* in Solid State Fermentation. *World Journal of Agricultural Sciences* 5: 308-312.
- Ragunathanchari, P., Khanna, V. K., Singh, U. S. and Singh, N. K. 1999. RAPD analysis of genetic variability in Indian scented rice germplasm *Oryza sativa* L. *Current Sciences* 79: 994-998.
- Ragunathanchari, P., Khanna, V. K., Singh, N. K. and Singh, U. S. 2000. A comparison of agarose RAPD and polyacrylamide RAPD to study genetic variability in *Oryza sativa* L. *Acta Botany Indica* 27: 41-44.
- Rahman, S. N., Islam, M. S., Alam, M. S. and Nasiruddin, K. M. 2007. Genetic polymorphism in rice (*Oryza sativa* L.) through RAPD analysis. *Indian Journal of Biotechnology* 6(2): 224-229.
- Ravi, M., Geethanjali, S., Sameeyafarheen, F. and Maheswaran, M. 2003. Molecular marker based genetic diversity analysis in rice (*Oryza sativa* L.) using RAPD and SSR markers. *Euphytica* 133: 243-252.
- Reby, S., Sen, S. and Muneer, P. M. A. 2011. Analysis of Genetic Variability in Rice Varieties (*Oryza sativa* L) of Kerala using RAPD Markers. *Genetic Engineering and Biotechnology Journal* GEBJ-24.
- Rohlf, F. J. 1998. NTSYS-pc Numerical taxonomy and multivariate analysis system. Version 2.0. Exeter Publ, Setauket, New York.
- Salim, M., Akram, M., Akhtar, M. E. and Ashraf, M. 2003. Rice, A production Hand Book. Pakistan Agricultural Research Council, Islamabad, p. 70.
- Shivapriya, M. and Hittalmani, S. 2006. Detection of genotype specific fingerprints and molecular diversity of selected Indian locals and landraces of rice (*Oryza sativa* L.) using DNA markers. *Indian Journal of Genetic and Plant Breeding* 66: 1-5.
- Sneath, P. H. A. and Sokal, R. R. 1973. Numerical taxonomy. Freeman, San Francisco, California, p. 573.
- Thiyagarajan, T. M. and Selvaraju, R. 2001. Water saving in rice cultivation in India. In: Proceedings of an international workshop on water saving rice production systems. Nanjing University, China p. 15-45.
- Wilikie, S. E., Issac, P. G. and Slater, R. J. 1993. Random amplified polymorphic DNA (RAPD) markers for genetic analysis in *Allium*. *Theoretical and Applied Genetics* 87: 668-672.
- Williams, J. G. K., Kubelik, A. R., Livak, K. J., Rafalski, J. A. and Tingey, S. V. 1990. DNA polymorphisms amplified by arbitrary primers are useful as genetic markers. *Nucleic Acids Research* 18: 6531-6535.
- Xu, R., Norihiko, T., Vaughan, A. D. and Doi, K. 2000. The *Vigna angularis* complex: Genetic variation and relationships revealed by RAPD analysis and their implications for *In-situ* conservation and domestication. *Genetic Resources and Crop Evolution* 47: 123-134.