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*Full Length Research Paper*

# Exploring the Genetic Variation of Salt-Tolerant Rice Landraces in Vietnam

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**A collection of 200 salt tolerance rice landraces was assessed for genetic diversity using quantitative agro-morphological characters. ANOVA showed highly significant differences (LSD 0.01) among the traits assessed such as grain length, grain width, number of unfilled grains, 1000-grain weight, leaf length and leaf width except panicles per plant and yield. Correlation coefficients showed that all the traits were highly correlated with each other except yield.. The diversity indices (H') for quantitative descriptors were high ranging from 0.68 to 0.95. Overall the mean diversity index for all traits was 0.88). Cluster analysis generated by UPGMA grouped the 200 rice landraces into six clusters with similarity coefficient of 20.61. The six clusters were distinct in terms of culm length, number of filled grains, panicle length, panicles per plant, grain length, grain width, yield and biomass.**

**Key words:** Rice, genetic, landraces, diversities.

## INTRODUCTION

Traditional varieties, some times called landraces or local or farmer varieties form the foundation on which to build better crop plants. Landraces are generally considered to be a rich source of genetic variation. Furthermore, local varieties provide farmers with alternatives in areas where modern crop varieties are not well adapted and contribute to diversity at the field level. However, for rice the number of traditional varieties being planted has reduced, with a few productive and relatively uniform high-yielding varieties dominating the rice landscape (Tran, 2000). Traditional rice varieties though had been documented to have contributed to the origin of 1,709 modern rice varieties in Asia; it can be traced to 11,592 traditional varieties. The pedigrees of IRRI breeding lines and varieties until 1994 can be traced to hundreds of traditional varieties most from Asian countries (Tran, 2000).Genetic diversity is the basic foundation for a species survival. According to Brown et al. (1989), the processes of recombination and gene mutation guarantee continuous inputs for new variants, environmental adaptation and random drift genetic diversity in time and space. Shape the distribution of the easiest and most common tool for gauging genetic diversity is measuring morphological or phenotypic trait differences (Jarvis et al., 2000). Available evidence indicates that farmers use certain phenotypic features of plants for selection and identification (Jarvis et al., 2000). Hence morphological traits are linked to genetic diversity. Therefore giving names to these varieties indicates that farmers have some understanding about the crop genetic diversity in their fields (Jarvis et al., 2000).

Many authorities asserts that characterization and evaluation of diversity among traditional varieties will provide plant breeders information necessary in the identification of initial materials for hybridization to produce varieties with improved productivity and quality (Buu et al., 2002). Therefore the objectives of this study were to:1. Assess genetic diversity of the traditional rice varieties in the genebank of Cuu Long Rice Research Institute, Vietnams 2. Ascertain the correlation among the rice characters for use in rice improvement.

## MATERIALS AND METHODS

### Plant materials

A total of 200 accessions of traditional rice varieties obtained from Cuu Long Rice Research Institute genebank, Vietnam was used for

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the study, The detailed passport information of these accessions is provided by Lang et al. 2007.

**Agro-morphology- based diversity analysis**

The 200 traditional rice varieties were planted in the field at the Cuu Long Rice Research Institute (CLRRI), Vietnam during the 2006/ 2007 wet season. Seeds were sown in raised seedbeds and 18 - 21 day old seedlings were transplanted at one seedling per hill at a spacing of 15 x 20 cm. The standard cultural management practices for rice were followed (Bui, 1986; Buu et al., 1999).

**Data collection**

Data were collected for quantitative traits following the Descriptors for Rice *Oryza sativa* L. (IBPGR–IRRI Advisory Committee, 1980). The following is the list of morphological and agronomic traits and the number of samples that were measured to assess diversity and relationships of the different rice accessions (Table 1).

1. Panicle length (cm) at maturity measured from the base to the tip of the panicle from 10 randomly selected primary panicles per accession per replication,.
2. Number of panicles per plant from 10 randomly selected primary panicles per accession per replication.
3. 1000 g weight at 14% MC from 5 randomly selected primary panicles per accession per replication.
4. Culm length (cm) measured from the ground level to the base of the panicle (from 10 randomly selected primary panicles per accession per replication.
5. Days to maturity- when 80% of the grains are fully ripened on a per replication (Bui, 1986).
6. Number of filled grains)- per panicle from 5 randomly selected primary panicles per accession per replication.
7. Number of unfilled grains per panicle from 5 randomly selected primary panicles per accession per replication.
8. Yield-obtained from the harvested plants in each replication. Harvested grains were threshed, cleaned, dried, and weighed for each accession per replication. Moisture content (MC) per plot was determined immediately after weighing using a moisture meter.

Yield = wt. of harvest (g)/ no. of hills harvest x no. of possible hills x MF

Where; $MF = \frac{100 - MC}{86}$ of the harvest grains

9. Biomass-weight of 10 plants harvested from each accession per replication. Harvested plants were dried before weighing.

10.) $HarvestIndex = \frac{EconomicYield}{Biological Yield} x 100$

Where; Economic Yield is the total weight of grain harvest from 10 plants per accession per replication and Biological Yield is the total grain weight and biomass from 10 plants per accession per replication.
RRL: Rate root length. The root will measure at 30 days stress NaCl (EC = 12 DS/m)

**Data analysis**

**Analysis of variance:** The agro-morphological data collected were analyzed by analysis of variance to verify the genetic variations among the traits measured. Non significant traits based on the F-test, were not considered for further analyses.

**Shannon-weaver diversity index:** Diversity indices for the various traits were computed using the following formula (Shannon and Weaver, 1949):

Where; *n* is the number of phenotypic classes for a character and pi is the portion of the total number of entries belonging to the i class. The standardised Shannon -Weaver diversity index ranging from 0 to 1 was obtained by dividing H' by the $\log_2$ of the total number of phenotypic classes. H'l for each of the morpho-agronomic descriptors of each variety was computed using MS Excel. Mean phenotypic diversity index was computed for the pooled diversity estimates per descriptor.

**Correlation analysis:** Correlation coefficients (r) among agro-morphological traits were calculated by using SAS program.

**Distance matrix:** Distance matrix was calculated by means of Euclidean Distance Coefficient (Sneath and Sokal, 1973):

Where; Eij = 0 to , the larger the value, the more distant the de-gree of relationship
Xi and Xj are the standardized values for the ith and jth characters in kth varieties.

**Cluster analysis:** Cluster analysis for agro-morphology-based genetic distance matrix was generated using UPGMA clustering method of the NTSYS program. The results of the UPGMA were used to draw the dendrogram of the 90 traditional varieties.

**Principal component analysis:** Principal component analysis was done using NTSYS and SAS programs.

## RESULTS AND DISCUSSION

### Diversity analysis using agro-morphological characters

The Table 2 showed that highly significant differences among the various traits in the 90 traditional varieties were obtained for grain length, grain width, number of unfilled grains, 1000-grain weight, leaf length and leaf width. Differences were not significant for panicles per plant.

### Analysis of variance

The mean, range (maximum and minimum), standard deviation, coefficient of variation (CV), mean standard error, and F value of the quantitative traits assessed is presented in Table 2. The results showed that most of the quantitative traits were highly variable. For instance, the early and late maturity dates were 135 and 153 days, respecttively. In general maximum values obtained for yield and number of filled grain was 145.6 g 3.44 tons/ha and 303 g for the variety Nep lemand Thang coi, respectively. Highly significant differences (LSD 0.01) were also ob-served for number of unfilled grains, 1000 g weight leaf length and leaf width. In contrast, no significant differen-ces were observed for panicles per plant.

Frequency distribution of the varieties with respect to

**Table 1.** Passport information of the 200 traditional varieties used in the study (Lang et al 2007).

| No | Accession | Name of variety | Passport information |
|---|---|---|---|
| 1 | 1 | Chiu Han | Kiengiang, Vietnam, 104°40'- 105°32'40 longitude and 9°23'50'' – 10°32'30" latitude |
| 2 | 2 | HTA 88086 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 3 | 3 | HTA 88086 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 4 | 4 | Lua Huong | Lua nuoc troi, Longan, Vietnam, 105°30' 30"-106°47' 02" longitude and 10°23'40"-11°02' 00" latitude, alluvial soil |
| 5 | 5 | Lua Huong | Lua nuoc troi, Longan, Vietnam, 105°30' 30"-106°47' 02" longitude and 10°23'40"-11°02' 00" latitude, alluvial soil |
| 6 | 6 | Ca Hom | Deep water rice, Songhau, Western Vietnam, 106 ° 48'32'' east longitude and 10°35'19'' north latitude |
| 7 | 7 | Trung Dung | Songhau, Western Vietnam, 106° 48' E longitude and 10° 20'north latitude |
| 8 | 8 | Trung Dung | Songhau, Western Vietnam, 106° 48' E longitude and 10° 20' N latitude |
| 9 | 9 | Lua Ba Trang | Mekong Delta, Southeast Vietnam, 106°48'32'' E longitude and 10° 35'19'' N latitude |
| 10 | 375 | Mua So 43 | Cambodia, 102nd -108th eastern longitude and 10th -15th parallels of northern latitude |
| 11 | 11 | HTA 88085 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 12 | 12 | Mot Bui Co Don | Camau peninsula, Vietnam, 104°80 – 105°5 longitude and 8°30 – 9°10 latitude, saline soil |
| 13 | 13 | Mot Bui Co Don | Camau peninsula, Vietnam, 104080 - 10505 longitude and 8030 - 9010 latitude, saline soil |
| 14 | 15 | HTA8037 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 15 | 16 | Co To | Upland rice, Angiang, Vietnam, 105°35 longitude and 10°57 north latitude |
| 16 | 17 | Nang Sao Do Mien Nam | Camau Peninsula, Vietnam, 104080 - 10505 longitude and 8030 - 9010 latitude, saline soil |
| 17 | 18 | HTA 88060 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 18 | 19 | Ao Gia Te | Kien giang, Vietnam , 104040'- 105032'40" longitude, 9023'50- 10032'30", alkaline alluvial soil |
| 19 | 20 | HTA 88085 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 20 | 21 | Bong Cu Tim | Southeast Vietnam, 105048'43" - 106022'48" longitude and 10057'08"-11046'36' latitude ', alluvial soil |
| 21 | 22 | Co Na | Lua nuoc troi, Longan, Vietnam, 105030' 30"-106047' 02" longitude and 10023'40"-11002' 00' latitude , alluvial soil |
| 22 | 23 | Co Na | Lua nuoc troi, Longan, Vietnam, 105030' 30"-106047' 02" longitude and 10023'40"-11002' 00" latitude, alluvial soil |
| 23 | 26 | Ro Dinh Vo Den | Taynguyen, Vietnam |
| 24 | 27 | HTA 88080 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 25 | 29 | Nang Sen Ran | Songhau, Western Vietnam, 106 0 48'32'' east longitude and 10 0 35'19'' north latitude |
| 26 | 31 | HTAFR 88085-14 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 27 | 32 | HTA 88085 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 28 | 33 | HTA 85035 | Wetland rice, Thailand 100 00 longitude and 1500 latitude |

**Table 1.** contd.

| | | | |
|---|---|---|---|
| 29 | 34 | HTA 85035 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 30 | 36 | Nep Mua | Mekong Delta Vietnam,<br>106 0 48’32’’ east longitude and 10 0 35’19’’ north latitude |
| 31 | 37 | HTA 88086 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 32 | 38 | Nanh Chon | Vungtau, Vietnam,<br>107’05” east longitude, 10’50” north latitude |
| 33 | 39 | Nanh Chon | Vungtau, Vietnam,<br>107’05” east longitude, 10’50” north latitude |
| 34 | 40 | HTAFR 81031 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 35 | 41 | HTAFR 81031 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 36 | 42 | Goi 2 | Lua nuoc troi, Longan, Vietnam,<br>105030’ 30’’-106047’ 02’’<br>longitude and 10023’40’’-11002’ 00’’ latitude, alluvial soil |
| 37 | 43 | Lua F5 | Baria, Southeast Vietnam, 107’05” east longitude, 10’50” north latitude |
| 38 | 45 | Lua F5 | Baria, Southeast Vietnam, 107’05”<br>east longitude, 10’50” north latitude |
| 39 | 52 | Chet Xanh | Wetland rice, Tu giac Longxuyen, Vietnam,<br>105°35 longitude and 10°57 north latitude |
| 40 | 58 | Nho Thom | Lua nuoc troi, Tiengiang, Vietnam,<br>106 0 48’32’’ east longitude and<br>10 0 35’19’’ north latitude |
| 41 | 59 | Nho Thom | Deep water rice, Songhau, Western Vietnam,<br>106 0 48’ east longitude and 10 0 20’north latitude |
| 42 | 60 | KT | Deep water rice, Songhau, Western Vietnam,<br>106 0 48’32’’ east longitude and 10 0 35’19’’ north latitude |
| 43 | 61 | HTA 88086 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 44 | 376 | Mua so 43 | Cambodia, 102$^{nd}$ -108$^{th}$ eastern longitude and 10$^{th}$ -15$^{th}$ parallels of northern latitude |
| 45 | 65 | Mi Ban To Bo | Kiengiang, Vietnam, 104040’- 105032’40”longitude and 9023’50- 10032’30” latitude, alkaline alluvial soil |
| 46 | 66 | Mi Ban To Bo | Kiengiang, Vietnam, 104040’- 105032’40” longitude,<br>9023’50- 10032’30” latitude |
| 47 | 67 | Nang Thom Hat Lua | Lua nuoc troi, Longan, Vietnam, 105030’ 30’’-106047’ 02’’<br>longitude and 10023’40’’-11002’ 00’’ latitude , alluvial soil |
| 48 | 68 | Do Lun | Plain of Reeds, Vietnam, 105030’ 30’’-106047’ 02’’ longitude and 10023’40’’-11002’ 00’’ latitude, alluvial soil |
| 49 | 69 | Mong Chim | Lua nuoc troi, Kiengiang, Vietnam, 104040’- 105032’40<br>longitude and 9023’50’’ – 10032’30” latitude |
| 50 | 70 | Nang Phet Don | Tiengiang, Vietnam,<br>106 0 48’32’’ east longitude and 10 0 35’19’’ north latitude |
| 51 | 378 | Thang Coi | Camau Peninsula, Vietnam,<br>104080 – 10505 longitude and<br>8030 – 9010 latitude, saline soil |
| 52 | 379 | Mua so53 | Cambodia, 102$^{nd}$ -108$^{th}$ eastern longitude and<br>10$^{th}$ -15$^{th}$ parallels of northern latitude. |
| 53 | 263 | Tien Nu | Tayninh, Vietnam,<br>105048’43” – 106022’48’’ longitude and<br>10057’08’’-11046’36’’ latitude, alluvial soil |
| 54 | 264 | Tien Nu | Tayninh, Vietnam, 105048’43” – 106022’48’’ longitude and 10057’08’’-11046’36’’ latitude, alluvial soil |
| 55 | 265 | Tien Nu | Tayninh, Vietnam, 105048’43” – 106022’48’’ longitude and 10057’08’’-11046’36’’ latitude, alluvial soil |
| 56 | 266 | Nang Ut Som | Deep water rice, Songhau, Western Vietnam,<br>106 0 48’32’’ east longitude and 10 0 35’19’’ north latitude |
| 57 | 267 | Bong Sen | Deep water rice, Songhau, Western Vietnam,<br>106 0 48’ east longitude and 10 0 20’north latitude |

**Table 1.** contd.

| | | | |
|---|---|---|---|
| 58 | 268 | Cao Don | Western Vietnam, 105048'43" - 106022'48'' longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 59 | 269 | Nep Lem | Plain of reeds, Vietnam, 105030' 30"-106047' 02" longitude and 10023'40"-11002' 00" latitude, alluvial soil |
| 60 | 270 | Ba Reo | Southeast Vietnam, 105048'43" - 106022'48'' longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 61 | 271 | Lua Thuoc Co | Longan, Vietnam, 105030' 30"-106047' 02'' longitude and 10023'40"-11002' 00" latitude |
| 62 | 296 | Mua So 68 | Longan, Vietnam, 105030' 30"' longitude and 10023'40" latitude |
| 63 | 299 | Trang Cut | Deep water rice, Songhau, Western Vietnam, 106 0 48'32'' east longitude and 10 0 35'19'' north latitude |
| 64 | 300 | Trang Cut | Deep water rice, Songhau, Western Vietnam, 10 0 20'north latitude and 106 0 48' east longitude |
| 65 | 303 | Trang Tep | Camau peninsula, Vietnam, 104080 - 10505 longitude and 8030 - 9010 latitude, saline soil |
| 66 | 304 | Mua So 19 | Cambodia, 102nd -108th eastern longitude and 10th -15$^{th}$ parallels of northern latitude |
| 67 | 305 | Mua So 19 | Cambodia, 102nd -108th eastern longitude and 10th -15th parallels of northern latitude |
| 68 | 306 | Trang Quang | Cambodia, 102nd -108th eastern longitude and 10th -15$^{th}$ parallels of northern latitude |
| 69 | 307 | Mua So 58 | Cambodia, 102nd -108th eastern longitude and 10th -15$^{th}$ parallels of northern latitude |
| 70 | 308 | LPT 123 | Wetland rice, Thailand, 15 00 N, 100 00 E |
| 71 | 309 | Gian Cao 69B | Southeast Vietnam, 105048'43" - 106022'48'' longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 72 | 310 | Gian Cao 69B | Southeast Vietnam, 105048'43" - 106022'48'' longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 73 | 311 | Lua Mem | Southeast Vietnam, 105048'43" - 106022'48'' longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 74 | 312 | Lua Mem | Songhau, Western Vietnam, , 106 0 48'32'' longitude and 10 0 35'19'' latitude |
| 75 | 313 | Nang Cua | Songhau, Western Vietnam, 106 0 48' east longitude and 10 0 20'north latitude |
| 76 | 314 | Troi Cho | Songhau, Western Vietnam, 106 0 48' east longitude and 10 0 20'north latitude |
| 77 | 315 | Canh Nong Lun | Southeast Vietnam, 105048'43" - 106022'48'' longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 78 | 316 | Mong Chim Lun | Kiengiang, Vietnam, 104040'- 105032'40 longitude and 9023'50'' - 10032'30" latitude, Acid sulfate soil |
| 79 | 317 | Mua So 69 | Cambodia, 102nd -108th eastern longitude and 10th -15th parallels of northern latitude |
| 80 | 318 | Ba Bui | Camau peninsula, Vietnam, 104080 - 10505 East longitude and 8030 - 9010 North latitude, saline soil |
| 81 | 374 | Bang Rut | Southeast Vietnam, 105048'43" - 106022'48'' longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 82 | 362 | Mua So 44 | Cambodia, 102nd -108th eastern longitude and 10th -15th parallels of northern latitude |
| 83 | 363 | Tau Vang | Deep water rice, Songhau, Western Vietnam, 10 0 20'north latitude and 106 0 48' east longitude |

**Table 1.** contd.

| | | | |
|---|---|---|---|
| 84 | 365 | Tau Vang | Angiang, Vietnam, 10°57 north latitude and 105°35 longitude |
| 85 | 366 | Tau Vang | Wetland rice, Tu giac Longxuyen, Vietnam, 105°35 longitude and 10°57 north latitude |
| 86 | 368 | Nang Tay Dum | Wetland rice, Tu giac Longxuyen, Vietnam, 105°35 longitude and 10°57 north latitude |
| 87 | 369 | Nang Tay Dum | Lua noi, Tugiac Longxuyen, Vietnam. 105°35 longitude, 10°57 north latitude |
| 88 | 405 | Song Doi | Wetland rice, Songhau, Western, Vietnam, 106 0 48’32’’ east longitude, 10 0 35’19’’ north latitude |
| 89 | 372 | Rong Xanh | Camau peninsula, Vietnam, 104080 - 10505 longitude 8030 - 9010 altitude, saline soil |
| 90 | 373 | Rong Xanh | Plain of Reeds, Vietnam, 105030' 30"-106047' 02" longitude and 10023'40"-11002' 00" latitude, alluvial soil |
| 91 | 374 | Bang Rut | Southeast Vietnam, 105048'43” - 106022'48"longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 92 | 375 | Mua so 43 | Mekong, 102nd -108th eastern longitude and 10th -15th parallels of northern latitude |
| 93 | 376 | Mua so 43 | Mekong, 102nd -108th eastern longitude and 10th -15th parallels of northern latitude |
| 94 | 378 | Thang coi | Camau Peninsula, Vietnam, 104080 - 10505 longitude and 8030 - 9010 latitude, saline soil |
| 95 | 379 | Mua so 53 | Mekong |
| 96 | 380 | Mbakit | Kien giang |
| 97 | 381 | Mbakit | Kien giang |
| 98 | 382 | Lua Ba Trang | Mekong Delta, Southeast Vietnam, 106 0 48’32’’ east longitude and 10 0 35’19’’ north latitude |
| 99 | 384 | Nang tay | Mekong |
| 100 | 387 | Nang thuoc | Mekong |
| 101 | 388 | Nang thuoc | Mekong |
| 102 | 389 | Nang thuoc | Mekong |
| 103 | 390 | Nahng nah | Mekong |
| 104 | 391 | Nahng nah | Mekong |
| 105 | 392 | Nahng nah | Mekong |
| 106 | 393 | Nahng nah | Mekong |
| 107 | 394 | Nahng nah | Mekong |
| 108 | 395 | Nong nghiep | Mekong |
| 109 | 396 | Bang minh coc | Mekong |
| 110 | 397 | Bang minh coc | Mekong |
| 111 | 400 | Bang tay me | Mekong |
| 112 | 401 | Nen con sam | Mekong |
| 113 | 402 | Trang lon | Mekong |
| 114 | 404 | Thang con | Mekong |
| 115 | 405 | Song doi | Wetland rice, Songhau, Western, Vietnam, 106 0 48’32’’ east longitude, 10 0 35’19’’ north latitude |
| 116 | 408 | Mua so 42 | Mekong |
| 117 | 409 | Mua so 45 | Mekong |
| 118 | 433 | LPT 123 | Mekong |
| 119 | 434 | Nang Chi | Mekong |
| 120 | 435 | Do sao | Mekong |
| 121 | 436 | Trang lun | Mekong |
| 122 | 437 | Ba Thiet Xanh | Mekong |
| 123 | 438 | Do sao muon | Mekong |

**Table 1.** contd.

| | | | |
|---|---|---|---|
| 124 | 439 | Mua so 5 | Mekong |
| 125 | 440 | Thom Mx | Mekong |
| 126 | 442 | Nha Trang | Mekong |
| 127 | 443 | Trang ong 7 | Mekong |
| 128 | 444 | Mua so 23 | Mekong |
| 129 | 445 | Khong ten | Mekong |
| 130 | 446 | Trang phuoc 2 | Mekong |
| 131 | 447 | Cong Ca | Mekong |
| 132 | 448 | Mua so 47 | Mekong |
| 133 | 449 | SG Giai Phong | Mekong |
| 134 | 450 | Tieu Nhum | Mekong |
| 135 | 451 | Nang loan | Mekong |
| 136 | 452 | Nep ao gia | Mekong |
| 137 | 476 | Tau binh rau | Mekong |
| 138 | 477 | Nho do | Mekong |
| 139 | 478 | Trang hoa binh | Mekong |
| 140 | 481 | Gie noi 1035 | Mekong |
| 141 | 493 | Nang Tay | An Giang |
| 142 | 494 | Mua so 5 | Mekong |
| 143 | 1331 | Hai sung | Mekong |
| 144 | 1332 | Nep chuot che | Kien Giang |
| 145 | 1333 | Nep chuot che | Kien Giang |
| 146 | 1334 | Nep chuot che | Kien Giang |
| 147 | 1348 | Mashuri | An Giang |
| 148 | 1349 | Tep trang | Mekong |
| 149 | 1350 | Nep nhung | Mekong |
| 150 | 1351 | Trang lun | Mekong |
| 151 | 1352 | Kien Giang lon | Kien Giang |
| 152 | 1353 | Bong dinh | Mekong |
| 153 | 1356 | Rong xanh | Camau peninsula, Vietnam,<br>104080 - 10505 longitude 8030 - 9010 altitude, saline soil |
| 154 | 1357 | Lua soi vang | Mekong |
| 155 | 1359 | Chiem do | Mekong |
| 156 | 1364 | Hue ky Bd | Mekong |
| 157 | 1365 | Nang soi | Mekong |
| 158 | 1376 | Lua noi | Mekong |
| 159 | 1377 | K297 | Mekong |
| 160 | 1390 | Truong hung | Mekong |
| 161 | 1391 | Den vo do ruot | Mekong |
| 162 | 1392 | Cach met | Mekong |
| 163 | 1396 | Nep mo | Mekong |
| 164 | 1397 | Nang co | Mekong |
| 165 | 1398 | Barvul runtai | Mekong |
| 166 | 1399 | PCR93206 | Mekong |
| 167 | 1400 | Than nong mua | Mekong |
| 168 | 1437 | Lua Do | Mekong |
| 169 | 1438 | Ca Dung Go Cong | Mekong |
| 170 | 1439 | Ca Dung Go Cong | Mekong |
| 171 | 1440 | Mui Ruoc | Mekong |
| 172 | 1441 | Nep Tha | Mekong |
| 173 | 1442 | Ca Dung Do | Mekong |
| 174 | 1443 | Ca Dung Do | Mekong |

**Table 1.** contd.

| | | | |
|---|---|---|---|
| 175 | 1465 | Nep Tau Huong | Mekong |
| 176 | 1467 | Bang Rut | Southeast Vietnam, 105048'43" - 106022'48" longitude and 10057'08"-11046'36" latitude, alluvial soil |
| 177 | 1468 | Ta Lay | Mekong |
| 178 | 1469 | Nang Thom Ben Luc | Long An |
| 179 | 1470 | Nang Thom Ben Luc | Long An |
| 180 | 1471 | Rohyd Wrar6 | Mekong |
| 181 | 1484 | K302 | Mekong |
| 182 | 1488 | Nang So Lon LA | Long An |
| 183 | 1489 | Nang Thom Can Duoc | Long An |
| 184 | 1490 | Tai Nguyen Can Duoc | Long An |
| 185 | 1491 | Nang Quoc | Mekong |
| 186 | 1492 | Chum Ruot Xanh | Mekong |
| 187 | 1493 | Lua Nen | Mekong |
| 188 | 1494 | Mong Chim Do | Mekong |
| 189 | 1495 | Nang Triet | Mekong |
| 190 | 1496 | Nang Thom Can Duoc | Long An |
| 191 | 1497 | K229 | Mekong |
| 192 | 1498 | Mot Bui Lun | Mekong |
| 193 | 1499 | Nang Le | Mekong |
| 194 | 1500 | Ca Tha Tia | Mekong |
| 195 | 1501 | Nang Phet Don | Tiengiang, Vietnam, 106 0 48'32'' east longitude and 10 0 35'19'' north latitude |
| 196 | 1503 | Nang Thom Ben Luc | Long AN |
| 197 | 1505 | Nha Trang | Mekong |
| 198 | 1506 | Lua Cai Lay | Mekong |
| 199 | 1507 | Nep Lem | Plain of reeds, Vietnam, 105030' 30"-106047' 02" longitude and 10023'40"-11002' 00" latitude, alluvial soil |
| 200 | 1509 | Ca Dung Ket | Mekong |

Quantitative traits data collected included

maturity, culm length, panicles per plant, number of filled grains, number of unfilled grains, 1000-g weight, yield, biomass, RRL and harvest index showed the diversity of traditional varieties Figure 1.These quantitative characters were found to be significant at 1% and all measurements were not too far from normal distribution. Distribution of varieties for the number of filled grains was slightly skewed to the right with only a few varieties near the maximum value (Figure 1a). For traits like number of unfilled grains, leaf length, yield and panicles per plant, unimodal distributions were observed with most varieties skewed to the left of the curve. Such distribution is favorable particularly with respect to number of unfilled grains because lower number of unfilled grains would mean higher yield. This is an important objective for most plant breeders in improving present day varieties. It was and still being considered as one of the major breeding objectives in developing rice varieties. (No evidence elsewhere to support the discussions presented) Grain width, biomass and harvest index showed normal distribution. With regards to maturity, almost half of the varieties investigated exhibited long maturity duration.

Analysis of variance (ANOVA) showed high variability among the varieties in terms of number of unfilled grains, yield, number of filled grains, and biomass (Table 2 -15). For 1000 g weight, only six varieties had weight less than 20 g (Figure 1g,) (No the axes do not corresponds that is, vertical is number of varieties but horizontal is RRL! Therefore need to revisit this). Since the trait is one of the most important components of yield, the materials can be important source for development of varieties with higher grain weight. This study also found out that most of the varieties are tall. Only 40 varieties had heights less than 120 cm (Figure 1a). Nowadays, reduced culm length is most preferred in modern varieties (Khush, 1997). The semi-dwarf stature contributed most to production of grains during the green revolution due to associated improvements in harvest index and reduced lodging under heavy dosage of fertilizer (Hargrove et al., 1980). Regarding maturity, most varieties matured after 138 days

**Table 3.** ANOVA for culm length among 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 49853.19 | 547.8 | 5.45 | <.0001 |
| Error | 178 | 17889.10 | 100.5 | | |
| Total | 269 | 67742.30 | | | |

**Table 4.** ANOVA for number of filled grains of 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 251715.11 | 2766.100 | 3.50 | <.0001 |
| Error | 178 | 140684.22 | 790.3608 | | |
| Total | 269 | 392399.40 | | | |

**Table 5.** ANOVA for number of unfilled grains of 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 528645.14 | 5809.28 | 2.77 | <.0001 |
| Error | 178 | 373215.23 | 2096.71 | | |
| Total | 269 | 901860.38 | | | |

**Table 6.** ANOVA for panicle length among 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 1710.023 | 18.79 | 5.5 | <.0001 |
| Error | 178 | 602.899 | 3.38 | | |
| Total | 269 | 2312.92 | | | |

**Table 7.** ANOVA for number of panicles per plant among 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 6503.23 | 71.46 | 2.30 | <.0001 |
| Error | 178 | 5524.30 | 31.03 | | |
| Total | 269 | 1207.54 | | | |

**Table 8.** ANOVA for grain length among 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 165.27 | 1.81 | 48.85 | <.0001 |
| Error | 178 | 6.617 | 0.03 | | |
| Total | 269 | 171.89 | | | |

**Table 9.** ANOVA for grain width among 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 16.85 | 0.185 | 39.91 | <.0001 |
| Error | 178 | 0.826 | 0.004 | | |
| Total | 269 | 17.68 | | | |

**Table 10.** ANOVA for 1000 grain weight of 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 2709.1 | 29.77 | 15.21 | <.0001 |
| Error | 178 | 348.32 | 1.95 | | |
| Total | 269 | 3057.43 | | | |

**Table 11.** ANOVA for maturity of 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 10595.3 | 116.4 | Infty | <.0001 |
| Error | 178 | 0.00000 | 0.0000 | | |
| Total | 269 | 10595.3 | | | |

**Table 12.** ANOVA for leaf length of 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 13365.53 | 146.8 | 4.64 | <.0001 |
| Error | 178 | 5633.13 | 31.64 | | |
| Total | 269 | 18998.6 | | | |

**Table 13.** ANOVA for leaf width of 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 12.50 | 0.137 | 6.22 | <.0001 |
| Error | 178 | 3.933 | 0.022 | | |
| Total | 269 | 16.43 | | | |

**Table 14.** ANOVA for yield of 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 276184.2 | 3034.9 | 1.98 | <.0001 |
| Error | 178 | 272577 | 1531.3 | | |
| Total | 269 | 548761.2 | | | |

**Table 15.** ANOVA for biomass of 200 traditional varieties.

| Source | DF | Sum of squares | Mean square | F value | PR>F |
|---|---|---|---|---|---|
| Model | 201 | 101346.36 | 1113.69 | 2.64 | <.0001 |
| Error | 178 | 74954.6 | 421.09 | | |
| Total | 269 | 176300.96 | | | |

found between culm length and number of filled grains (r = 0.602), panicle length (r = 0.596).This association can be explained by the principle of morphogenic compatibility in rice plant architecture. Other traits that were strongly correlated with culm length and panicle length, number of unfilled grains, 1000-g weight, yield and biomass. Maturity was found to be poorly correlated with other agro-morphological traits. It exhibited negative correlation with ten other traits and only slightly correlated with biomass (r = -0.026), panicles per plant (r = -0.072) and yield (r = -0.044).In the analysis of quantitative traits, the range of the coefficients of variability was high. It varied from the

**Table 16.** Correlation coefficients among 11 agro-morphological traits of200 traditional rice varieties, Vietnam, 2006/07.

| | Culm length | Panicles per plant | 1000 g weight | Filled grains | Unfilled grains | Panicle length | Biomass-weight | Yield obtained | HI | Days to maturity | RRL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Culm length | 1.000 | -0.283 | 0.003 | 0.602** | 0.108 | 0.596** | 0.163 | 0.087 | 0.055 | 0.114 | -0.130 |
| Panicles per plant | -0.283 | 1.000 | 0.048 | -0.113 | -0.013 | -0.108 | 0.718** | 0.797** | 0.345* | -0.072 | 0.098 |
| 1000-grain weight | 0.003 | 0.048 | 1.000 | -0.360 | 0.078 | 0.004 | 0.007 | 0.070 | 0.152 | -0.141 | -0.008 |
| Filled grains | 0.602** | -0.113 | -0.360 | 1.000 | -0.182 | 0.518** | 0.226 | 0.394 | 0.365 | 0.147 | 0.007 |
| Unfilled grains | 0.108 | -0.013 | 0.078 | -0.182 | 1.000 | 0.082 | -0.026 | -0.100 | -0.139 | -0.056 | -0.059 |
| Panicle length | 0.596** | -0.108 | 0.004 | 0.518** | 0.082 | 1.000 | 0.169 | 0.220 | 0.246 | 0.131 | -0.093 |
| Biomass-weight | 0.163 | 0.718** | 0.007 | 0.226 | -0.026 | 0.169 | 1.000 | 0.793** | 0.016 | -0.026 | -0.009 |
| Yield-obtained | 0.087 | 0.797** | 0.070 | 0.394* | -0.100 | 0.220 | 0.793** | 1.000 | 0.556** | -0.044 | 0.106 |
| HI | 0.055 | 0.345 | 0.152 | 0.365* | -0.139 | 0.246 | 0.016 | 0.556 | 1.000 | -0.030 | 0.119 |
| Days to maturity | 0.114 | -0.072 | -0.141 | 0.147 | -0.056 | 0.131 | -0.026 | -0.044 | -0.030 | 1.000 | -0.048 |
| RRL | -0.130 | 0.098 | -0.008 | 0.007 | -0.059 | -0.093 | -0.009 | 0.106 | 0.119 | -0.048 | 1.000 |

Indicate the level of significance by *
* P=0.05 and **P=0.01
HI: Havest index; RRL: relation root length (EC = 12 DS/m)

many traits such as unfilling, color, shape. This shows that the seed length less variation compared to another characters, second some traites are also have lowest values indicated that it less variation with the environment. The variation in grain characters such as size, shape and color are useful in distinguishing the different landraces or traditional varieties. These traits can be considered as the most stable characters as exemplifed by their coefficients of variability. The highest values is unfilling grain (34%) indicated that this character more effected by the environment and cultural management practices of the farmer. The means of measurements of quantitative traits were higher. The variation in grain characters such as (yield for salt tolerance and some line susceptible with salt stress) are useful in distinguishing the different landraces or traditional varieties.

**Shannon-Weaver Diversity Indices among 200 Traditional rice Varieties**

Table 17 presents the Shannon-Weaver diversity indices (H') of the 11 quantitative agro-morphological traits. The H' ranged from 0.68 - 0.95 with a mean of 0.88. The highest and low-est diversity index of 0.94 and 0.68 was observ-ed for grain width and 1000 grain weight, respectively, However, no significant differences was observed among culm length (H' = 0.92), filled grains (H' = 0.92), panicles/plant etc. Overall, the 200 traditional varieties held in the Cuu Long genebank exhibited high diversity in the agro-morphological characters assessed. This therefore means that the collections can be available resource for developing rice varieties for Mekong Delta. In addition, this information will also be useful for germplasm managers in planning for future germplasm acquisitions (Again evidences from related/other studies are needed to support the assertion).

**Cluster analysis among traditional varieties**

The 200 traditional rice varieties were classified based on agro-morphological markers using UPGMA and SAHN clustering methods (Figure 2). At similarity coefficient of 20.61 (abstract is talking of 20.61) please harmonise this, the den-drogram generated three clusters: I, II, III and many subcluster. Characters that were distinct in the formation of the 6 clusters included origin of the varieties and 11 agro-morphological cha-racters (especially culm length, filled grains and RRL). The clusters are as follows: Cluster I con-sisted of one traditional variety, namely 378-Thangcoi. Cluster II included 9 traditiona varie-

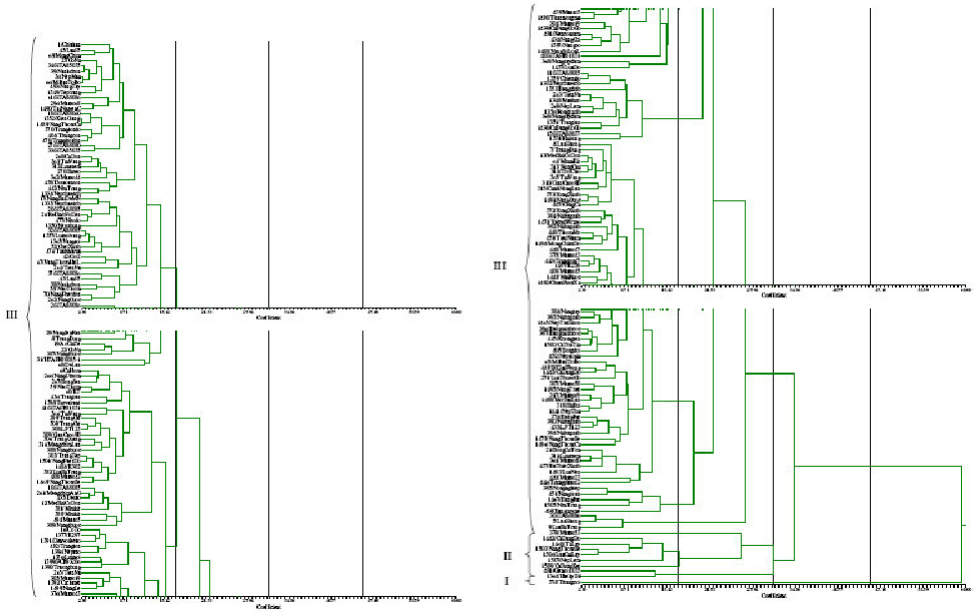

**Figure 2**. Dendrogram of 200 traditional rice varieties based on Euclidean distance coefficients estimated from the 11 agro-morphological traits.

**Table 17.** Shannon-Weaver diversity indices for quantitative traits of the 200 traditional rice varieties, Vietnam, 2006/07.

| Traits | H' |
|---|---|
| Culm-length | 0.92 |
| Filled Grain | 0.92 |
| Panicle Length | 0.90 |
| Panicles/ Plant | 0.92 |
| Grain Length | 0.88 |
| Grain Width | 0.95 |
| Unfilled Grain | 0.85 |
| 1000-grain weight | 0.68 |
| Maturity | 0.82 |
| Leaf length | 0.85 |
| Leaf width | 0.91 |
| Yield | 0.94 |
| Biomass | 0.85 |

ties. Cluster III includes most traditional varieties. The varieties in this cluster were collections from different places: Southeast Vietnam (seven varieties), Songhau, Western Vietnam and (An Giang) (four varieties each), Camau Peninsula Vietnam (three varieties) and Kiengiang, Plain of Reeds, Longan, Longxuyen of Vietnam and Mekong river (one variety each). These show that although these varieties came from different places, they are grouped together because of close similarities in terms of quantitative traits. They may also have descended from related parents (Harlan, 1965).

The multivariate analysis showed significant differences among the 200 traditional rice varieties. The growing environment of the region likely influenced the structure and level of morphological variation among the rice landraces. Analyses of variation in quantitative traits among the accessions were important in discriminating these rice landraces. Although they were collected from different areas, they were grouped together suggesting that they may have probably originated from the same population. As man moved to different places, they bring and maintain genotypes where continuous selection adapted these genotypes to their places, hence changing genetic constitution of the original variety (Harlan, 1965).

## Conclusions

Knowledge of the traits and information on the genetic variation and relationships in germplasm is crucial in determining the value of the collection for utilization and in deciding conservation strategies. Agro-morphological characters have provided valuable information about genetic diversity of rice collection in CLRRI. Quantitative agro-morphological characters of 200 accessions were analyzed using hierarchical clustering, correlation coefficient, principal component analysis and analysis of variance. Diversity of the collection was analyzed using Shannon-Weaver diversity index. Although, this study has shown significant differences in agro-morphological traits of the traditional rice varieties. There is need for fur-ther study to confirm these findings. Additionally, exten-sive molecular marker analysis using more primers may

need to be considered for relevant application and efficient attainment of breeding objectives in rice improvement. Continue analysis to study correlation among the characters and to relate results between morphological characters and molecular markers is recommended.


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