Oryza Vol. 51 No.4, 2014 (261-266)

# Genetic variability and diversity of rice landraces of South Western India based on morphological traits

**BR Mani[1], BM Dushyantha Kumar[1] and SL Krishnamurthy[2]***

*[1]College of Agriculture, Shimoga, Karnataka*
*[2]Central Soil Salinity Research Institute (CSSRI), Karnal - 132001Haryana, India*
**Email: krishnagene@gmail.com*

## ABSTRACT

*The present study was conducted to assess the genetic variability and diversity of 49 local landraces of rice. Number of grains exhibited high PCV (21.95) and GCV (16.56) and was followed by number of spikelets harvest index, test weight, and productive tillers. High heritability coupled with high genetic advance as per cent of mean was recorded for all characters. Maximum number of genotypes were present in cluster I (15). Maximum inter-cluster distance was observed between cluster II and IV (115.99) and the maximum intra-cluster distance was noticed in cluster III (32.45) indicating hybridization involving genotypes within this cluster may result in good cross combinations. The maximum contribution towards divergence was made by days to 50 % flowering (54.13%). The genotypes belonging to five different clusters were distinct and diverse hence, better performing genotypes namely, Bangaarugandu, Kempudoddi, Kempukaaru, Gajagunda, Rathnachudi, Bagyajyothi, Maranellu, Dappabatta and Balaji could be utilized in hybridization programme.*

***Key words:*** *genetic variability, diversity, rice, clustering and landraces*

Genetic variability is the important component in development of superior rice varieties. Such variability is available more in local and wild rice genotypes. Therefore, assessment of variability for yield and its component characters in such genotypes is important for genetic improvement. Genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are helpful tools in detecting the amount of variability present in the germplasm. Heritability and genetic advance are important selection parameters in estimating the resultant effect in selection of the best genotypes for yield and its attributing traits.

Development of high yielding varieties and hybrids depends on selection of superior parents which can be achieved by estimation of genetic diversity. Genetic divergence is an efficient tool for an effective choice of parents for hybridization programme. Such study also selects the genetically divergent parents to obtain desirable combinations in the segregating generations. Information on nature and degree of genetic divergence would help in choosing the right parents for the breeding programme. Keeping this in view, the present study was undertaken to assess the genetic variability and diversity in forty nine local land races of rice.

## MATERIALS AND METHOD

The experiment was conducted using forty-nine local landraces of rice following 7×7 Simple lattice design with two replications (Table 1). Observations on days to 50% flowering, days to maturity, total number of tillers per plant, number of productive tillers per plant, plant height, panicle length, panicle exertion, number of spikelet per panicle, number of grains per panicle, spikelet fertility, straw yield per plant, harvest index, 1000 grain weight and grain yield per plant were taken on five randomly selected plants and the mean values are used to estimate the variability parameters and diversity components by following statistical analysis

**Table 1.** List of local landraces of rice evaluated under present study

| Code | Genotype | Code | Genotype | Code | Genotype | Code | Genotype |
|---|---|---|---|---|---|---|---|
| 1 | Bangaarasanna | 14 | Baratharatnachudi | 27 | Holesaalachipiga | 40 | Maranellu |
| 2 | Kempujaddu | 15 | Raajbog | 28 | Dappabatta | 41 | Nettibatta |
| 3 | Kiruvaani | 16 | Raychursanna | 29 | Misebatta | 42 | Buddabatta |
| 4 | Aaadribatta | 17 | Kichadisaayi | 30 | Ippattu | 43 | Siddisanna |
| 5 | Siggikaima | 18 | Sugandi | 31 | Kanadathumba | 44 | jyothi |
| 6 | Beemassale | 19 | Kerekaalumuttiga | 32 | Ratnachudi | 45 | Karimunduga |
| 7 | Mukkanna | 20 | Bangaarugandu | 33 | Jeerigesamba | 46 | Kempudoddagidda |
| 8 | Bagyajyothi | 21 | Yelatakkigidda | 34 | Kempudoddi | 47 | Bangarukaddi |
| 9 | Kaalajeera | 22 | Kempukaaru | 35 | Mullubatta | 48 | Padmarekha |
| 10 | Aaravattelu | 23 | Aaanekombinabatta | 36 | Bilijaadu | 49 | Gourisanna |
| 11 | Puttabatta | 24 | Sannakki | 37 | Nirgulebatta | | |
| 12 | Kaagisaale | 25 | Gajagunda | 38 | Naagabatta | | |
| 13 | Karijaadu | 26 | Balaji | 39 | Doddataikallu | | |

*viz.*, Analysis of Variance, Genotypic and Phenotypic coefficient of variation, Heritability Genetic advance as per cent of mean and Mahalanobis' $D^2$ statistics (1936) using WINDOSTAT and SAS 9.2 software.

## RESULTS AND DISCUSSION

A wide range of variation was observed among the forty-nine local landraces of rice for fourteen quantitative characters. The data revealed that variance due to treatment was highly significant (Table 2) for all the characters suggesting that there is an inherent genetic difference among the genotypes.

The phenotypic co-efficient of variation (PCV) was higher than the genotypic co-efficient of variation (GCV). But the differences between PCV and GCV for many traits were very low, suggesting the least influence of environment on those traits. Medium PCV and GCV were observed for all the traits except with panicle length where it was low (Table 3). Similar findings were also reported by Singh *et al.* (2007), Devi *et al.* (2006), Prajapati *et al.* (2011), Ali *et al*. (2013) and Krishnamurthy *et al.* (2013). The traits *viz*., number of spikelet per panicle (21.94; 18.60), number of grains per panicle (21.95; 16.56), test weight (21.02; 18.65), straw yield per plant (21.43; 18.86) and harvest index

**Table 2.** Analysis of variance for 14 characters in local landraces of rice

| Source of variation | df | Days to 50% flowering | Plant height (cm) | Panicle length (cm) | Number of tillers | No. productive tillers | Panicle exertion | No. spikelets panicle$^{-1}$ |
|---|---|---|---|---|---|---|---|---|
| Replication | 1 | 0.01 | 70.11 | 1.77 | 0.21 | 5.05 | 10.76 | 79.67 |
| Blocks within adjusted | 12 | 0.08 | 22.77 | 2.23 | 0.80 | 2.39 | 0.53 | 27.48 |
| Genotypes (unadjusted) | 48 | 292.80** | 508.99** | 8.50** | 10.09** | 8.78** | 5.06** | 707.82** |
| Error intra block | 36 | 0.08 | 13.26 | 1.71 | 1.02 | 1.80 | 0.42 | 49.26 |
| LSD (5%) | | 0.58 | 7.76 | 2.63 | 2.03 | 2.70 | 1.30 | 14.11 |
| SEm | | 0.20 | 2.58 | 0.93 | 0.72 | 1.16 | 0.46 | 4.98 |

| Source of variation | df | No. grains/ panicle | Panicle fertility (%) | Test weight | Straw yield/plant | Days to maturity | Harvest index | Grain yield/ plant (g) |
|---|---|---|---|---|---|---|---|---|
| Replication | 1 | 237.06 | 514.56 | 4.67 | 26.02 | 20.66 | 0.04 | 5.83 |
| Blocks within adjusted | 12 | 57.26 | 62.37 | 1.09 | 1.93 | 1.27 | 0.01 | 0.42 |
| Genotypes (unadjusted) | 48 | 300.74** | 160.50** | 36.38** | 130.51** | 334.31** | 0.03** | 29.71** |
| Error intra block | 36 | 48.72 | 44.01 | 0.71 | 3.88 | 0.54 | 0.002 | 0.38 |
| LSD (5%) | | 14.03 | 13.34 | 1.70 | 3.96 | 1.60 | 0.09 | 1.23 |
| SEm | | 4.95 | 4.70 | 0.59 | 1.40 | 0.52 | 0.03 | 0.44 |

** Significance at 1 %, * Significance at 5 %

(21.33; 18.29) exhibited medium PCV and GCV followed by number of productive tillers (19.87; 15.32), panicle exertion (19.29; 16.83), grain yield per plant (19.70; 17.47), number of tillers (18.94; 15.30), panicle fertility (16.23; 10.73), days to maturity (15.66; 12.65), plant height (13.74; 11.44) and days to 50% per cent flowering (13.19; 11.18) and low PCV and GCV was recorded for the character panicle length (10.83; 08.01). This indicates the existence of wide genetic variability in the genotypes taken for study and possibility of genetic improvement through selection for these traits. This was in conformity with the findings of Bastia *et al.* (2008) and Chauhan *et al.* (1993) who had also reported similar findings in upland rice for the trait plant height.

High heritability estimates along with high genetic advance are more helpful in predicting the gain under selection than heritability estimates alone. Heritability is a good idea of transmission of characters from parents to its progeny. The estimates of heritability help the plant breeder in selection of elite genotypes from diverse genetic population.

Broad sense heritability ($h^2$) was higher for days to 50% flowering (89.94%), days to maturity (89.83%), grain yield per plant (87.49%), 1000 grain weight (86.15), plant height (84.92%), straw yield per plant(84.22%), harvest index (79.44%), number of spikelet per panicle (76.98%), number of grains per panicle (62.11%), and panicle length (56.52%), which suggested that these traits would respond to selection owing to their high genetic variability and transmissibility. Thus, selection based on phenotypic values would be effective for these traits. These findings are in agreement with those of Venuprasad *et al.* (2003), Kundu *et al.* (2008) and Kole and Hasib (2008). But panicle fertility had showed medium heritability (56.96%), which is on far with results obtained by Karim *et a*l. (2007). These characters indicate the predominance of additive gene effects in their expression and would respond to selection effectively as they are least influenced by environment. These results are complementary with the results obtained by Krishna *et al.* (2010), Kundu *et al.* (2008), Singh *et al*. (2007) and Sharma *et al*. (2014).

High heritability associated with moderate genetic advance as per cent of mean was observed with panicle length (56.52: 18.77%) and days to maturity (89.83: 25.47%). While moderate heritability coupled with moderate genetic advance as per cent mean was observed for panicle fertility (46.96: 23.89%) and indicted the predominance of both additive and non additive gene effects. Similar results were also recorded by Venuprasad *et al.* (2003), Verma *et al*. (2000), Ganesan *et al.* (1995) and Krishnamurthy *et al*. (2014a).

The set of 49 land races of rice were clustered in to five different clusters based on 14 agro-morphological traits through tocher method. Maximum number of genotypes was grouped in cluster I (15). Cluster II and III had 14 genotypes each and cluster IV consists of 5 genotypes followed by cluster V with one genotype (Table 4). The overall composition of the clustering pattern showed that the landraces of rice were highly diverse and hence, they were distributed

**Table 3.** Estimates of mean, range, variability, heritability and genetic advance for 14 characters in local landraces of rice.

| Character | Mean± SE | Range | PCV (%) | GCV (%) | $H^2$ BroadSense (%) | GAM (%) |
|---|---|---|---|---|---|---|
| Days to 50% flowering | 108.10 ± 0.29 | 86.15 - 131.00 | 13.19 | 11.19 | 89.94 | 31.83 |
| Plant height | 137.57 ± 3.64 | 94.66 - 162.60 | 13.74 | 11.44 | 84.92 | 31.84 |
| Panicle length | 22.99 ± 1.31 | 17.90 - 27.00 | 10.83 | 08.01 | 56.52 | 18.77 |
| Number of tillers | 13.91 ± 1.01 | 10.50 - 20.50 | 18.94 | 15.30 | 71.59 | 39.25 |
| No. productive tillers | 12.19 ± 1.34 | 7.80 - 16.20 | 19.87 | 15.32 | 55.93 | 35.82 |
| Panicle exertion | 9.05 ± 0.65 | 6.35 - 12.80 | 19.29 | 16.83 | 74.62 | 45.05 |
| No of spikelets /panicle | 97.57 ± 7.02 | 75.00 - 188.00 | 21.94 | 18.60 | 76.98 | 49.23 |
| No of grains per panicle | 67.80 ± 6.98 | 43.87 - 98.35 | 21.95 | 16.56 | 62.11 | 40.45 |
| Panicle fertility (%) | 71.12 ± 6.63 | 47.10 - 90.16 | 16.23 | 10.73 | 46.96 | 23.89 |
| Test weight | 22.65 ± 0.84 | 17.05 - 33.61 | 21.02 | 18.65 | 86.15 | 52.17 |
| Straw yield / plant | 42.19 ± 1.97 | 31.5 - 67.00 | 21.43 | 18.86 | 84.22 | 52.10 |
| Days to maturity | 144.46 ± 0.74 | 123 - 160.00 | 15.66 | 12.65 | 89.83 | 25.47 |
| Harvest index | 0.71 ± 0.04 | 0.46 - 0.94 | 21.33 | 18.29 | 79.44 | 49.95 |
| Grain yield / plant | 21.67 ± 0.61 | 10.1 - 32.70 | 19.70 | 17.47 | 87.49 | 49.12 |

in different clusters. Similar findings were reported by Ushakumari and Rangaswamy (1997), Nayak *et al*. (2004) and Krishnamurthy *et al*. (2015). Inter cluster distance was higher than intra cluster distance indicating wider genetic diversity among the land races (Table 5). The maximum inter cluster distance was observed between cluster II and IV (115.99) followed by between cluster II and V (92.36) and between cluster I and II (86.68) indicating wider genetic diversity among the genotypes between these groups. Similar observations were also made by Subudhi *et al*. (2009) and Krishnamurthy *et al*. (2014b). The maximum intra cluster distance was observed in cluster III (32.45) followed by cluster IV (32.12) and cluster II (30.90). Hence, selection within these clusters may be practiced based on the highest priority for the desirable traits, which would be made use of in improvement through inter-varietal hybridization.

The results of cluster means (Table 6) revealed that cluster IV with five genotypes exhibited lowest mean value for days to fifty per cent flowering (89 days) followed by cluster I (98.63). Cluster IV showed maximum panicle length (23.62cm) followed by cluster III with 23.18cm. Number of tillers and productive tillers per plant were highest in cluster I (15.85; 13.60) followed by cluster IV with 15.06 and 13.55, respectively. Maximum panicle exertion was observed in cluster I with 10.82cm followed by cluster IV (9.70cm). Cluster IV was characterized by having more number of spikelets per panicle (106.31) followed by cluster II (99.23). Similarly, number of grains per panicle were highest in cluster III (71.37) followed by cluster II (70.49). Cluster I had highest mean values for test weight (23.66) and harvest index (0.76). Local land races like Nagabatta, Dappabatta, Aaravattelu, Kanadathuba and Misebatta from Cluster IV showed lowest days to maturity (124.80 days). Grain yield was highest in cluster V (32.75 g) with solitary genotype Balaji followed by cluster I (22.64).

No cluster had genotypes with all the desirable traits which could be directly selected and utilized. All the minimum and maximum cluster mean values were distributed in relatively distant clusters. However, the cluster V recorded desirable mean value for plant height, number of tillers, number of productive tillers, panicle fertility and grain yield. Similar results were also reported by Bose and Pradhan (2005) while studying the divergence in deep water rice genotypes, thereby underlining the fact that the hybridization between genotypes of different clusters is necessary for the development of desirable genotypes.

**Table 4.** Clustering Pattern of 49 local land races of rice

| Clusters | No. of Entries | Genotypes |
|---|---|---|
| I | 15 | Bheemasaale, Kempudoddagidda, Bangaarugandu, Kempukaaru, Karimunduga, Siddidisanna, Bangaarugandu, Jeerigesaamba, Kempudoddi, Siggikaime, Sugandi, Aadribatta, Kempujaadu, Holesaalachipiga and Jyothi. |
| II | 14 | Baangaarukaddi, Gourisanna, Buddabatta, Doddataikallu, Mukunna, Aanekombinabatta, Nettibatta, Gajagunda, Puttabatta, Raajbog, Kaalajeera, Ratnachudi, Yelatakkigidda and Sannakki. |
| III | 14 | Baratharatnachudi, Nirgulebatta, Ippattu, Padmarekha, Jeerigesamba, Karijaadu, Raychursanna, Bhagyajyothi, Kaagisaale, Kiruvaani, Kichadisaayi, Maranellu, Bilijaddu and Kerekaalumuttiga. |
| IV | 05 | Naagabatta, Dappabatta, Aaravattelu. Kanadathumba and Misebatta. |
| V | 01 | Balaji. |

**Table 5.** Average Inter and intra cluster distances in characters of local landraces of rice

| Cluster | I | II | III | IV | V |
|---|---|---|---|---|---|
| **I** | **30.37** | 86.68 | 51.15 | 44.17 | 48.15 |
| **II** | | **30.90** | 51.81 | 115.99 | 92.36 |
| **III** | | | **32.45** | 77.21 | 60.42 |
| **IV** | | | | **32.12** | 54.83 |
| **V** | | | | | **0.00** |

Among the traits studied, maximum divergence was contributed by days to fifty percent flowering (54.13%) and grain yield (9.18) Table 7. Similar observation was made by Babu *et al*. (2003) and Rajesh *et al*. (2010). It was followed by panicle exertion (9.10%) and number of productive tillers per plant (5.46%). Other characters *viz.*, straw yield per plant (4.42%), number of tillers

**Table 6.** Cluster means for 14 characters in local landraces of rice

| Clusters | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | Overalls core | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 98.63 (2) | 135.05 (4) | 22.90 (3) | 13.73 (4) | 12.61 (3) | 10.82 (1) | 93.51 (5) | 69.93 (3) | 71.62 (4) | 23.66 (1) | 40.91 (4) | 140.47 (3) | 0.76 (1) | 22.64 (2) | 40 | 2.5 |
| II | 123.29 (5) | 144.25 (2) | 22.81 (4) | 13.50 (5) | 10.98 (5) | 8.57 (4) | 99.23 (2) | 70.49 (2) | 75.29 (3) | 22.13 (3) | 45.24 (2) | 150.32 (5) | 0.72 (3) | 21.49 (3) | 48 | 5.0 |
| III | 110.57 (4) | 136.34 (3) | 23.18 (2) | 14.03 (3) | 12.32 (4) | 8.64 (3) | 98.70 (3) | 71.37 (1) | 75.61 (2) | 23.51 (2) | 40.76 (5) | 149.54 (4) | 0.66 (4) | 21.29 (4) | 44 | 4.0 |
| IV | 89.00 (1) | 120.38 (5) | 23.62 (1) | 15.06 (2) | 13.55 (2) | 9.70 (2) | 106.31 (1) | 59.46 (5) | 62.41 (5) | 20.66 (5) | 42.37 (3) | 124.80 (1) | 0.75 (2) | 20.60 (5) | 40 | 2.5 |
| V | 100.00 (3) | 153.75 (1) | 21.70 (5) | 15.85 (1) | 13.60 (1) | 6.75 (5) | 95.04 (4) | 61.55 (4) | 77.19 (1) | 20.90 (4) | 62.45 (1) | 140.00 (2) | 0.51 (5) | 32.75 (1) | 38 | 1.0 |

Figures in parenthesis indicate the ranks based on cluster mean, highest (1) to lowest (5), except for days to 50 per cent flowering and days to maturity where least value is given highest rank. Overall score is the summation of rank number for 16 characters.

Where,

C1- Days to 50% flowering
C2- Plant height (cm)
C3- Panicle length (cm)
C4- Number of tillers
C5- No. productive tillers
C6- Panicle exertion
C7- No. spikelets/ panicle
C8- No. grains/panicle
C9- Panicle fertility (%)
C10- Test weight
C11- Straw yield/plant (g)
C12- Days to maturity
C13- Harvest index
C14- Grain yield/plant (g)

(4.38%), panicle length (3.71%) and plant height (3.57%) had average contribution to the divergence. Hence, these characters should be given importance during hybridization and selection in the segregating population.

From these studies, it can be concluded that traits *viz.*, plant height, panicle length, number of tillers and number of effective tillers per plant, number of spikelet's and number of grains per panicle and grain weight per panicle were controlled by additive gene action, which could be improved through simple selection methods. Based on diversity analysis, the genotypes belonging to five different clusters were distinct and diverse hence better performing genotypes namely, Bangaarugandu, Kempudoddi, Kempukaaru, Gajagunda, Rathnachudi, Bagyajyothi, Maranellu, Dappabatta, and Balaji could be utilized in hybridization programme to get superior combinations.

**Table 7.** Contribution of each character to the divergence in local landraces of rice

| Character | Per cent contribution |
|---|---|
| Days to 50% flowering | 54.13 |
| Grain yield/plant | 9.18 |
| Panicle exertion | 9.10 |
| Number of productive tillers | 5.46 |
| Straw yield/plant | 4.42 |
| Number of tillers per plant | 4.38 |
| Panicle length | 3.71 |
| Plant height | 3.57 |
| Number of grains per panicle | 2.30 |
| Number of spikelet per panicle | 1.02 |
| Per cent panicle fertility | 1.02 |
| Test weight | 1.02 |
| Harvest index | 0.43 |
| Days to maturity | 0.26 |
| Total | 100.00 |

## REFERENCES

Ali S, Gautam RK, Mahajan R, Krishnamurthy S L, Sarangi SK 2013. Genetic variability and association analysis for grain yield components among SALTOL QTL introgressed rice genotypes under normal and environments. J. Indian Soc. Coastal agric. Res. 31(1), 34-40.

Babu S, Anbumalarmathi J, Yogameenakshi P, Sheeba A, Rangasamy P 2003. Genetic divergence studies in rice *(Oryza sativa* L.). Crop Res. 25 (2), 280-286.

Bastia D, Mishra TK, Das SR 2008. Genetic variability and selection indices for grain yield in upland rice. Oryza. 45 (1), 72-75.

Bose LK, Pradhan SK 2005. Genetic divergence in deep water rice genotypes. J. Central European Agricul. 6 (4), 635-640.

Chauhan JS, Chauhan VS, Variar M 1993. Genetic variation and character association in rainfed upland rice. Oryza. 30, 116-119.

Devi SL, Raina FA, Pandey MK Cole CR 2006. Genetic parameters of variation for grain yield and its components in rice. Crop Res. 32 (1), 69-71.

Ganesan K, Manuel WW, Sundaran T 1995. Analysis of yield and yield components in rice. International Rice Research Notes. 20, 4-12.

Karim D, Sarkar U, Siddique MNA, Khalequemiah MA Hasnat MZ 2007. Variability and genetic parameter analysis in aromatic rice. Int. J. Sustain. Crop Prod. 2(5), 15-18.

Kole PC, Hasib KM 2008. Correlation and regression analysis in scented rice. Madras Agric J. 95 (1-6), 178-182.

Krishna T, Kavita A, Pushpalata T 2010. Genetic variability, heritability and genetic advance for quantitative traits in rice (*Oryza sativa* L.) accession. Agricul. and Bio. Res. 26(1), 13-19.

Krishnamurthy SL, Madhavi RK, Mohan RA 2013. Genetic variation, path and correlation analysis in crosses among Indian and Taiwan parents in chilli. Vegetable Sciences. 40(2), 210-213.

Krishnamurthy SL, Sharma SK, Gautam RK, Kumar V 2014a. Path and Association analysis and Stress indices for salinity tolerance traits in promising rice (*Oryza sativa* L.) genotypes. Cereal Res. Commun. 42(3), 474–483.

Krishnamurthy SL, Sharma SK, Kumar V, Tiwari S, Batra V, Singh NK 2014b. Assessment of genetic diversity in rice genotypes for salinity tolerance using *Saltol* markers of Chromosome 1. Indian J. Genet Pl. Breed. 74(2), 243-247.

Krishnamurthy SL, Prashanth Y, Mohan RA, Madhavi RK, Ramachandra R 2015. Assessment of AFLP marker based genetic diversity in chilli. (*Capsicum annuum* L. & *C. baccatum* L.) Indian J.Biotech. 14, 49-54.

Kundu A, Senapati BK, Bakshi A, Mandal GS 2008. Genetic variability of panicle characters in tall indica aman rice. Oryza. 45(4), 320-323.

Mahalanobis PC 1936. On the generalized distance statistics. In the proceedings 2 India: National Institute of Science. pp 49-55.

Nayak AR, Chaudhery D, Reddy JN 2004. Genetic divergence in scented rice. Oryza. 41(4), 79-82.

Prajapati M, Singh CM, Suresh BG, Lavanya GR, Jadhav P 2011. Genetic parameters for grain yield and its component characters in rice. Elec. J. Pl. Breed. 2(2), 235-238.

Rajesh T, Paramasivam K, Thirumeni S. 2010. Genetic in land races of rice. Electron J. Plant Breed. 1(2), 199-204.

Sharma SK, Singh J, Chauhan MS and Krishnamurthy SL 2014. Multivariate Analysis of Phenotypic Diversity of Rice germplasm in North-West India. Indian J. Agric. Sci. 84 (1), 120–124.

Singh M, Kumar K, Singh RP, 2007. Study of co-efficient of variation, heritability and genetic advance in hybrid rice. Oryza. 44(2), 160-162.

Singh Y, Singh US 2008. Genetic diversity analysis in aromatic rice germplasm using agro- morphological traits. J. Pl. Genet. Resour. 21(1), 32-37.

Subudhi HN, Meher J, Bose LK, Sanjukta D 2009. Genetic diversity studies of promising varieties of eastern India based on quality characters. Oryza. 46(4), 271-274.

Ushakumari R, Rangaswamy P 1997. Studies on genetic diversity in International early rice genotypes. Ann. Agric. Res. 18, 29-33.

Venuprasad R, Shashidhar HE, Shailaja H 2003. Evaluation of performance of rain fed lowland rice cultivars of south Karnataka in two diverse environments. Mysore J. Agril. Sci. 37(4),294-300.

Verma OP, Santoshi Singh, Dwivedi JL Singh RP 2000. Genetic variability, heritability and genetic advance for quantitative traits in rice. Oryza. 37(2), 38-40.