Genetic Variability, Heritability and Genetic Advance Studies in Rice (*Oryza sativa* L.)

S. Sandeep[1*], M. Sujatha[2], L.V. Subbarao[3] and C.N. Neeraja[3]

[1]*Agricultural Research Station, Tandur, Professor Jayashankar Telangana State Agriculture University, Rajendranagar, Hyderabad (Telangana) – 501141, India*
[2]*Department of Genetics and Plant Breeding, College of Agriculture, Professor Jayashankar Telangana State Agriculture University, Rajendranagar, Hyderabad (Telangana) – 500030, India*
[3]*Indian Institute of Rice Research, Hyderabad (Telangana) – 500030, India*

*Corresponding author

A B S T R A C T

The experimental was carried out at Indian Institute of Rice Research Farm, ICRISAT, Patencheru, Hyderabad, Telangana, India, during *Rabi,* 2014-2015 in order to estimate genetic variability, heritability and genetic advance in two hundred genotypes of rice. Analysis of variance revealed highly significant differences among the genotypes for all the characters indicating sufficient variability existed in the present material selected for the study. Environmental influence was very meagre on the expression of all the characters as there is a narrow difference between genotypic and phenotypic coefficients of variation. Genotypic and phenotypic coefficients of variability were high for single plant yield, number of grains per panicle, number of tillers per hill, pollen viability and spikelet fertility. The characters *viz.,* spikelet fertility, plant height, single plant yield, number of grains per panicle, number of tillers per hill, pollen viability, number of productive tillers per hill, panicle length and 1000 grain weight exhibited high heritability estimates coupled with high genetic advance as per cent of mean which suggested that these traits were amenable for further improvement by following simple selection methods.

Introduction

Rice (*Oryza sativa* L.) is the most important staple food crop for more than 60 per cent of the global population and forms the cheapest source of food energy and protein. By origin, the crop is native to South East Asia with two cultivated (*Oryza sativa* and *Oryza glaberrima*) and 22 wild species. It belongs to the genus *Oryza* and grass family *Poaceae.* The crop is cultivated under a wide range of agro-ecological situations. Although the crop is widely adoptable it is sensitive to high temperatures. Globally, it is grown in an area of 162.71 m ha with an annual production of 741.47 m t and productivity of 4556 kg ha^{-1}. It is the most important food crop of India with world ranking first in area (43.85 m

ha) and second to China in production (FAO, 2014). In India, rice is cultivated in an area of 43.49 m ha with an annual production of 104.40 m t and average productivity of 2400 kg ha^{-1}. In Telangana, it covers an area of 1.04 m ha with a production of 3.04 m t tonnes and average productivity of 2913 kg ha^{-1} (Indiastat, 2015-16). The slogan- "Rice is life "is due to its overwhelming importance as staple food and also a source of livelihood for about 120-150 million rural households of the country.Rice is central to the lives of billions of people around the world. With the growth of world's population towards 10 billion by 2050, the demand for rice will grow faster than for other crops. Global warming has a significant effect on rice production. Over the past 100 years, global average temperature has increased by 0.6°C and is projected to continue to rise at a rapid rate, with another 0.5–2.8°C increase predicted by the end of 21st century (Vuuren *et al.,* 2008). Because of higher recurrence of extreme high-temperature events and a projected global average surface temperature increase of 1.5 to 4.8°C by 2100 yield decrease in the 2nd half of the century is predicted to be even stronger in the tropics than in the temperate areas (Intergovernmental Panel on Climate Change 2014). Most of the rice is currently grown in regions where current temperatures are already close to optimum for rice production. Heat waves are expected to be more intense and frequent in the future, which could jeopardize more rice areas. Therefore, any further increases in mean temperatures or of short episodes of high temperatures during sensitive stages, may be supra optimal and reduce grain yield. Though rice originated from the tropics, temperature over 35°C at flowering stage causes high pollen and spikelet sterility, leads to serious yield losses, low grain quality and low harvest index. It was suggested that spikelet fertility at high temperature can be used as a screening tool for heat tolerance during flowering stage (Prasad *et al.,* 2006).Genetic variability is of greatest interest to the plant breeder as it plays a vital role in framing successful breeding programme. Heritability of a metric character is a parameter of particular significance to the breeder as it measures the degree of resemblance between the parents and the off-springs and its magnitude indicates the heritability with which a genotype can be identified by its phenotypic expression, while genetic advance aids in exercising the necessary selection pressure.

Materials and Methods

The experimental material comprised of two hundred germplasm of rice (*Oryza sativa* L.) grown in Augmented RBD at IIRR Farm, ICRISAT, Patencheru, Hyderabad, Telangana, India, during *Rabi* 2014-2015. The recommended agronomic and plant protection measures were followed in order to raise a normal crop. Observations on eleven different quantitative characters viz., days to 50% flowering, days to maturity, plant height, panicle length, number of tillers per hill, number of productive tillers per hill, number of grains per panicle, spikelet fertility, 1000 grain weight, pollen viability and single plant yield were recorded on five randomly selected competitive plants for each genotype except for days to 50% flowering, and days to maturity where data is recorded on plot basis during various phenophases of the crop. Mean values from the five randomly selected plants for each genotype were averaged and expressed as the mean of the respective character and considered for statistical analysis. Analysis of variance was computed based on Randomized Block Design for each of the character separately as per standard statistical procedure given by (Panse and Sukhatme, 1978). Heritability (h²) in the broad sense was calculated according to the formula given by (Allard, 1960) for all characters. Phenotypic and genotypic coefficients of variation (PCV and GCV) were computed

according to (Burton, 1952). For statistical analysis, Windostat Version 9.1 software package was used.

Results and Discussion

Analysis of variance for the experiment involving a set of 200 germplasm lines of rice for eleven characters *viz.,* days to 50% flowering, days to maturity, plant height, panicle length, number of tillers per hill, number of productive tillers per hill, number of grains per panicle, spikelet fertility, 1000 grain weight, pollen viability and single plant yield revealed highly significant differences among the genotypes for all the characters indicating sufficient variability existed in the present material selected for the study and indicating the scope for selection of suitable initial breeding material for crop improvement.

The results pertaining to genetic parameters *viz.*, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability (h^2_{bs}) and genetic advance as percent of mean (GAM) for all the eleven characters are furnished in Table 1 and Figure 1. It is apparent from the Table 1 that there is almost perfect relation between PCV and GCV of each character. This could be seen from the highest magnitude of both PCV (39.43%) and GCV (39.15%) for single plant yield, number of grains per panicle (31.85-31.44%), number of tillers per hill (23.99-23.43%), pollen viability (22.63-21.98%) and spikelet fertility (20.50-20.44%) suggesting that these characters were under the influence of genetic control. So the characters can be relied upon and simple selection can be practiced for further improvement. The characters number of productive tillers per hill(19.10-18.39%), plant height (16.56-16.47%), 1000 grain weight (16.41-14.93%) and panicle length(11.80-11.02%) were recorded for moderate

magnitudes of both PCV and GCV, respectively. The traits days to flowering (6.32-6.16%) and days to maturity (4.56-1.75%) showed lower magnitudes of both PCV and GCV, respectively. Similar results were reported by Harsh *et al.,* (2015) and Umarani *et al.,* (2017) for single plant yield; Ketan and Sarkar (2014), Khare *et al.,* (2014) and Tiwari (2017) for number of grains per panicle; Kumar *et al.,* (2013) and Ketan and Sarkar (2014) for spikelet fertility; Padmaja *et al.,* (2008) for number of tillers per hill; Konate *et al.,* (2016), Kumar and Verma (2016), Rohit *et al.,* (2017) and Rashid *et al.,* (2107) for number of productive tillers per hill; Khare *et al.,* (2014) for plant height, panicle length and 1000 grain weight; Bhati *et al.,* (2015) and Rohit *et al.,* (2017) for days to 50% flowering and days to maturity.

The phenotypic coefficient of variation was higher than genotypic coefficient of variation (GCV) for all the characters under study but the GCV was greater than the variation produced by the environment for all the characters. The results are in agreement with the findings of Bai *et al.,* (1992).The difference between the estimates of PCV and GCV were low for days to 50% flowering, days to maturity, plant height, panicle length, number of tillers per hill, number of productive tillers per hill, number of grains per panicle, spikelet fertility, pollen viability and single plant yield showing thereby lesser role played by the environment in the expression of these characters. The difference between the estimates of PCV and GCV was high for 1000 grain weight,indicating the significant role played by the environment in the expression of this character.

Heritability estimates revealed the heritable portion of variability present in different characters. The knowledge of heritability enables the plant breeder to decide the course of selection procedure to be followed under a

given situation (Li and Yang, 1985). All the characters recorded high estimates of heritability. Broad sense heritability estimates ranged from 82.82 percent (1000 grain weight) to 99.43 percent (spikelet fertility). The characters like plant height (98.98%), single plant yield (98.60%), number of grains per panicle(97.42%), number of tillers per hill(95.34%), days to 50% flowering (94.89%), pollen viability (94.38%), number of productive tillers per hill(92.71%), panicle length (87.19) and days to maturity (87.14%) exhibited high heritability. The results are in consonance with the reports given by Tiwari *et al.,* (2015), Rashid *et al.,* (2017) and Rohit *et al.,* (2017) for days to 50% flowering, days to maturity, plant height, 1000 grain weight and single plant yield; Kumar *et al.,* (2013), Harsh *et al.,* (2015) and Prasad *et al.,* (2017) for panicle length, number of tillers per hill and number of productive tillers per hill;Ketan and Sarkar (2014), SubrataChakraborty and Chaturvedi (2014), Tiwari (2017) and Umarani *et al.,* (2017) for spikelet fertility.

All the characters recorded high estimates of heritability indicating that they were least influenced by the environmental effects, however selection for improvement of such characters may not be useful, because broad sense heritability is based on total genetic variance which includes additive, dominant and epistatic variances. Thus, the heritability values along with estimates of genetic advance would be more reliable than heritability alone (Johnson *et al.,* 1967).The genetic advance expressed as percent of mean values ranged from 8.77 percent (days to maturity) to 80.10 percent (single plant yield). The character, single plant yield (80.10%) recorded for highest magnitude of genetic advance as percent of mean followed by number of grains per panicle (63.93%), number of tillers per hill (47.12%), pollen viability (44.00%), spikelet fertility (41.98%), number of productive tillers per hill (36.49%), plant height (33.77%), 1000

grain weight (28.00%) and panicle length (21.20%). The character days to 50% flowering (12.37%) showed moderate magnitude of genetic advance as percent of mean. The trait days to maturity (8.77%) recorded the lowest magnitude of genetic advance as percent of mean.

Maximum amount of genetic advance was found for single plant yield followed by number of grains per panicle, number of tillers per hill, pollen viability, spikelet fertility, number of productive tillers per hill, plant height, 1000 grain weight and panicle length. Similar results for high genetic advance were reported by Gokulakrishnan *et al.,* (2014), Kishore *et al.,* (2015), Rohit *et al.,* (2017) and Prasad *et al.,* (2017) for single plant yield; Rakesh Kumar *et al.,* (2013) and Khare *et al.,* (2014) for plant height, number of productive tillers per hill and panicle length; Sharma and GK Koutu (2013) for number of tillers per hill; Padmaja *et al.,* (2008) and Binse *et al.,* (2009) for number of grains per panicle and spikelet fertility; Nandan and Sweta Singh (2010), Fiyaz *et al.,* (2011) and Kumar and Verma (2016) for 1000 grain weight.

All the characters recorded high estimates of heritability indicating that they were least influenced by the environmental effects, however selection for improvement of such characters may not be useful, because broad sense heritability is based on total genetic variance which includes additive, dominant and epistatic variances. Thus, the heritability values along with estimates of genetic advance would be more useful on correlating selection criteria than heritability alone (Johnson *et al.,* 1967).

High heritability with moderate genetic advance was recorded for days to 50% flowering. These traits appear to be under the control of both additive and non additive gene actions.

Table.1 Estimation of genetic parameters for eleven characters in rice (*Oryza sativa* L.)

S.No.	Characters	PCV (%)	GCV (%)	ECV (%)	Heritability (h^2_{bs}) (%)	Genetic Advance (1%)	Genetic Advance as percent of Mean (1%)
1.	Days to 50% flowering	6.32	6.16	1.43	94.89	12.81	12.37
2.	Days to maturity	4.88	4.56	1.75	87.14	11.72	8.77
3.	Plant height (cm)	16.56	16.47	1.67	98.98	31.56	33.77
4.	Panicle length (cm)	11.80	11.02	4.22	87.19	4.72	21.20
5.	Number of tillers per hill	23.99	23.43	5.18	95.34	7.70	47.12
6	Number of productive tillers per hill	19.10	18.39	5.15	92.71	4.48	36.49
7.	Number of grains per panicle	31.85	31.44	5.11	97.42	65.02	63.93
8.	Spikelet fertility (%)	20.50	20.44	1.55	99.43	31.82	41.98
9.	1000-grain weight (g)	16.41	14.93	6.80	82.82	5.56	28.00
10.	Pollen viability (%)	22.63	21.98	5.36	94.38	32.19	44.00
11.	Single plant yield (g)	39.43	39.15	4.66	98.60	16.01	80.10

PCV= Phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, ECV= Environmental coefficient of variation and GAM= Genetic Advance as percent of mean at 5% level

Fig.1 Graph showing distribution of genetic parameters for yield and yield components in rice
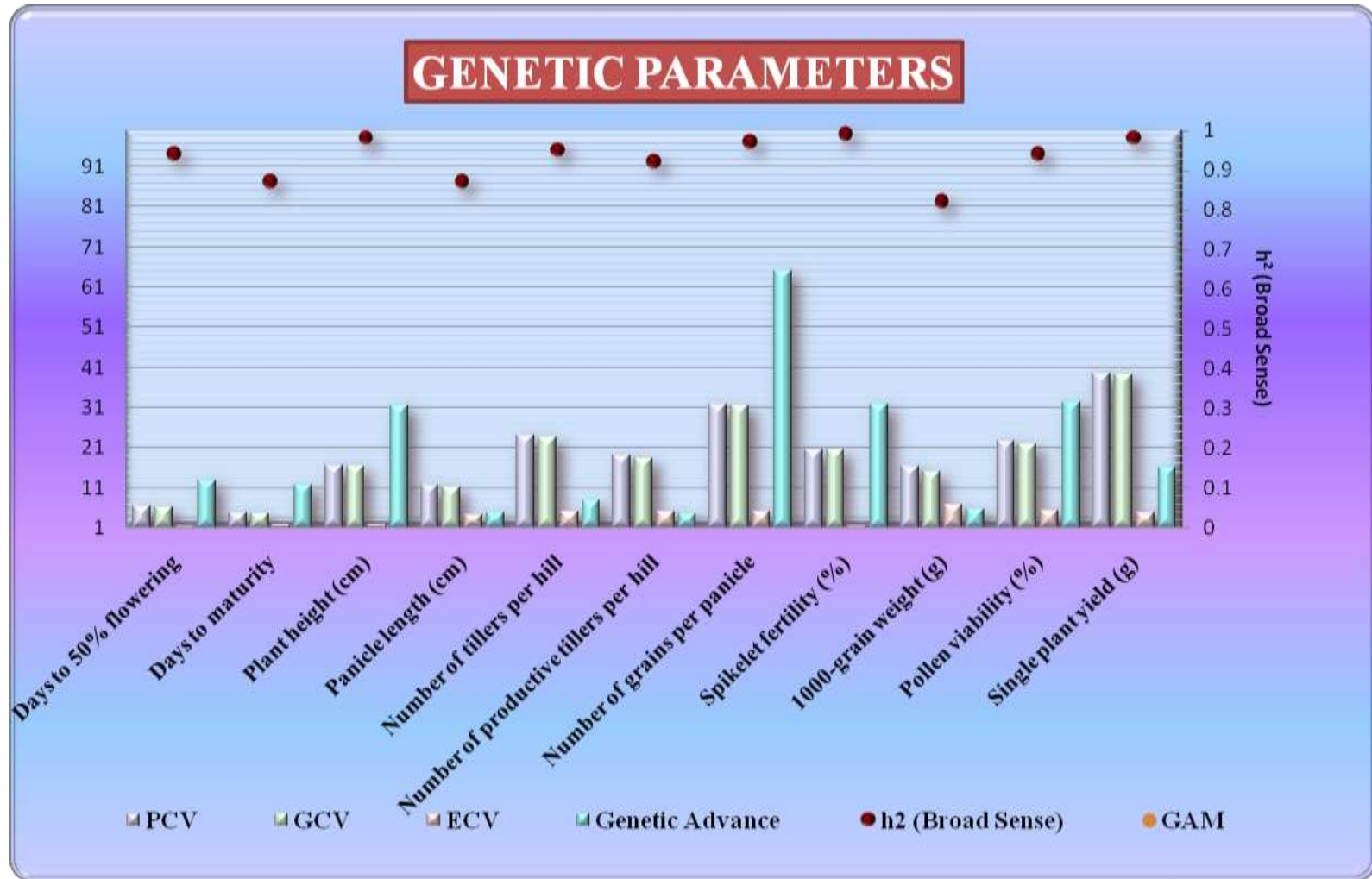
The present finding is in consonance with the findings of Padmaja *et al.,* (2008), Kumar *et al.,* (2013), Gokulakrishnan *et al.,* (2014), Ketan and Sarkar (2014), Khare *et al.,* (2014), Subrata Chakraborty and Chaturvedi (2014), Tiwari *et al.,* (2015) and Konate *et al.,* (2016).High heritability with low genetic advance was recorded for days to maturity, indicating non additive gene action. The high heritability is being exhibited due to favourable influence of environment rather than genotype and hence, selection for such traits may not be rewarding. Similar results were reported by Bhati *et al.,* (2015)In the present investigation, high heritability coupled with high genetic advance was observed for spikelet fertility, plant height, single plant yield, number of grains per panicle, number of tillers per hill, pollen viability, number of productive tillers per hill, panicle length and 1000 grain weight. Thus, these traits are predominantly under the control of additive gene action and hence these characters can be improved by pedigree method of breeding. Similar results for high heritability coupled with high genetic advance for various traits were earlier reported by Gokulakrishnan *et al.,* (2014), Ketan and Sarkar (2014), Chakraborty and Chaturvedi (2014), Harsh *et al.,* (2015), Bhati *et al.,* (2015), Tiwari *et al.,* (2015), Bhinda *et al.,* (2017) and Rashid *et al.,* (2017) for plant height and number of grains per panicle; Nayak *et al.,* (2002), Sabesan *et al.,* (2009), and Khare *et al.,* (2014) for panicle length;Sharma and GK Koutu (2013) and Prasad *et al.,* (2017) for number of tillers per hill and number of productive tillers per hill; Padmaja *et al.,* (2008), Bisne *et al.,* (2009) and Kumar *et al.,* (2013) for spikelet fertility; Bharadwaj*etal.* (2007), Nandan and Sweta Singh (2010), Fiyaz*etal.* (2011),Khare *et al.,* (2014), Srihima *et al.,* (2015), Kumar and Verma (2016) for 1000 grain weight; Nayudu *et al.,* (2007), Anbanandan*etal.* (2009), Garg *et al.,* (2010), Kishore *et al.,* (2015) and Rohit *et al.,* (2017) for single plant yield.

In conclusion, high estimates of PCV and GCV were recorded for single plant yield, number of grains per panicle, number of tillers per hill, pollen viability and spikelet fertilitywhich provides considerable variability and offers scope for genetic improvement through selection. Further high heritability coupled with high genetic advance were observed for spikelet fertility, plant height, single plant yield, number of grains per panicle, number of tillers per hill, pollen viability, number of productive tillers per hill, panicle length and 1000 grain weight indicates the role of additive gene action in controlling the traits, hence pedigree method of breeding will be a rewarding one to improve the traits under investigation.

References

Allard, R.W. 1960. Principles of Plant Breeding. *John Wiley and Sons Inc*. New York. pp. 485.

Anbanandan, V., Saravonan, K and Sahesan, T. 2009. Variability, heritability and genetic advance in rice. *International Journal of Plant Sciences*. 4 (1): 61-63.

Bai, R., Regina, A., Devika, R and Joseph, C.A. 1992. Genetic variability and association of characters in medium duration rice genotypes. *Oryza.* 29: 19-22.

Bharadwaj, C., Rajesh Mishra, Satyavathi, C.T., Rao, S.K and Kumar, K.S. 2007. Genetic variability, heritability and genetic advance in some new plant type based crosses of rice (*Oryzasativa* L.).*Indian Journal of Agricultural Research*. 41 (3): 189-194.

Bhati, M., SureshBabu, G and Aishwarya, S.R. 2015. Genetic variability, correlation and path coefficient for grain yield and quantitative traits of elite rice (*Oryzasativa* L.) genotypes at uttarpradesh. *Electronic Journal of Plant Breeding*. 6 (2): 586-591.

Bhinda, M.S., Karnwal, M.K and Choudhary, M.K., 2017. Estimates of genetic variability, heritability and genetic

advance for yield contributing and quality traits in advance breeding lines of rice (*Oryza sativa* L.). *International Journal of Advanced Biotechnology Research.* 7 (2): 229-233.

Bisne, R., Sarawgi, A.K and Verulkar, S.B. 2009. Study of heritability, genetic advance and variability for yield contributing characters in rice. *Bangladesh Journal of Agricultural Research*. 34 (2): 175-179.

Burton, G.W. 1952. Quantitative inheritance in grasses. *Proceedings of sixth International GrasslandCongress.* 1: 227-281.

Chakraborty, S and Chaturvedi, H.P. 2014. Genetic variability in upland rice (*Oryzasativa* L.) genotypes of Nagaland. *Indian Research Journal of Genetics and Biotechnology*. 6(2): 374-378.

Fiyaz, A., Ramya, R., Chikkalingaiah, K.T., Ajay, B.C., Gireesh, C and Kulkarni, R.S. 2011. Genetic variability, correlation and path coefficient analysis studies in rice (*Oryza sativa* L.) under alkaline soil condition. *Electronic Journal of Plant Breeding*. 2(4): 531-537.

Garg, P., Pandey, D.P and Singh, D. 2010. Correlation and path analysis for yield and its components in rice (*Oryza sativa* L.). *Crop Improvement*. 37 (1): 46-51.

Gokulkrishnan, J., Sunil Kumar, B and Prakash, M. 2014. Variability studies for some yield and quality traits in rice (*Oryza sativa* L.). *Plant Archives*. 14(1): 533-536.

Harsh, V., Shekhawat, S., Singh, R.P and Yashpal. 2015. Studies on variability, heritability and genetic advance in rice (*Oryza sativa* L.) germplasm lines. *Annals of Agri-Bio Research.* 20 (1): 22-25.

Indiastat, 2015-16. Area, production and productivity of rice in India and Andhra Pradesh. *www.indiastat.com.*

IPCC. Climate change 2014 synthesis report. Fifth assessment report. 2014; http://ar5-syr.ipcc.ch/ipcc/ipcc/resources/pdf/IPCC_SynthesisReport.pdf

Johnson, S.C., 1967. Hierarchical clustering schemes. *Psychometrika*. 32: 241–254.

Ketan, R and Sarkar, G..2014.Studies on variability, heritability, genetic advance and path analysis in some indigenous *Aman r*ice (*OryzasativaL*.) *Journal of Crop and Weed.* 10 (2): 308-315.

Khare, R., Singh, A.K., Eram, S and Singh, P.K. 2014. Genetic variability, association and diversity analysis in upland rice (*Oryza sativa*L). *SAARC Journal of Agriculture.* 12(2): 40-51

Kishore, N.S., Srinivas, T., Nagabhushanam, U., Pallavi, M and Sameera, SK. 2015. Genetic variability, correlation and path analysis for yield and yield components in promising rice (*Oryza sativa*L.) genotypes. *SAARC Journal of Agriculture.* 13(1):99-108.

Konate, A.K., Adama, Z., Honore, K., Ambaliou, S and Alain, A. 2016. Genetic variability and correlation analysis of rice (*Oryzasativa* L.) inbred lines based on agro morphological traits. *African Journal of Agricultural Research.* 11(35): 3340-3346.

Kumar, A and Verma, O.P. 2016. Genetic variability, heritability and genetic advance studies in rice (*Oryza sativa* L.) under sodic soil. *Research in Environment and Life Sciences*. 9 (2): 149-151.

Li, C.M. and Yang, K.C. 1985. Studies on inheritance of quantitative characters for plant type in some inbred lines of maize. *Scientia Agriculture Sinical*. 9: 28-36.

Nandan, R., Sweta and Singh, S.K. 2010. Character Association and path analysis in rice (*Oryza sativa* L.) genotypes. *World Journal of Agricultural Sciences*. 6 (2): 201-206.

Nayak, A. R., Chaudhary, D and Reddy, J. N. 2002. Genetic variability, heritability and genetic advance in scented rice. *Indian Agriculturist*. 46(1&2): 45-47.

Nayudu, K.S.R., Varline, Y.A and Vennila, S. 2007. Studies on variability, heritability and genetic advance for certain yield compounds in rice. *Crop improvement*. 34 (2): 142-144.

Padmaja, D., Radhika, K., Rao, L.V.S and Padma, V. 2008.Studies on variability, heritability and genetic advance for

quantitativecharacters in rice (*Oryzasativa*L.). *Journal of Plant Genetic Resources,* 21 (3): 196-198.

Panse, V.G and Sukhatme, P.V. 1978. *Statistical methods for Agricultural workers*. Indian Council of Agricultural Research Publications, New Delhi. 235-246.

Prasad, K.R., Krishna, K.V.R., Bhave, M.H.V and Rao, L.V.S. 2017.Genetic variability, heritability and genetic advance in boro rice (*Oryza sativa* L.) germplasm International *Journal of Current Microbiology and Applied Sciences*. 6 (4): 1261-1266.

Prasad, P.V.V., Boote, K.J., Allen, L.H., Sheehy, J.E and Thomas, J.M.G. 2006. Species, ecotype and cultivar differences in spikelet fertility and harvest index of rice in response to high temperature stress. *Field Crops Research*. 95: 398-411.

Rashid, M.M., Nuruzzaman, M., Hassan, L and Begum, S.N. 2017. Genetic variability analysis for various yield attributing traits in rice(*Oryzasativa* L.) genotypes. *Journal of Bangladesh Agricultural University*. 15(1): 15-19.

Rohit, Y., Rajpoot, P., Verma, O.P., Singh, P.K., Singh, P and Pathak, V. 2017. Genetic variability, heritability and genetic advance in rice (*Oryza sativa* L.) for grain yield and its contributing attributes under sodic soil. *Journal of Pharmacognosy and Phytochemistry.* 6(5): 1294-1296.

Sabesan, T., Suresh, R. and Saravanan, K. (2009). Genetic variability and correlation for yield and grain quality characters of rice grown in costal saline low land of Tamilnadu. *Electronic Journal of Plant Breeding*. 1: 56-59.

Sharma, A and Koutu, G.K. 2013. Study of heritability, genetic advance and variability for yield attributing characters in exotic germplasm of rice. *Oryza.*50: 404-408.

Srihima, G., Singh, V.J andChakraborti, S.K. 2015. Analysis of variability and genetic parameter for grain quality attributes in high yielding rice (*Oryza sativa* L.) genotypes. *The Ecoscan*. 9 (1&2): 411-414.

Tiwari, G.C.2015.Variability, heritability and genetic advance analysis for grain yield in rice. *International Journal of Engineering Research and Applications* 5 (7):.46-49.

Tiwari, J.K.2017. Association analysis and selection strategies for various yield contributing traits in rice genotypes. *Applied Biological Research.* 19 (1): 35-40.

Umarani, E., Radhika, K., Padma, V and Subbarao, L.V. 2017. Variability, heritability and genetic advance for agro-morphological and grain quality parameters in landraces of rice (*Oryza sativa* L.). *Environment and Ecology*. 35 (3): 1682-1687.

Vuuren, D., M. Meinshausen, G. Plattner, F. Joos, K. Strassmann, S.Smith, M. Wigley, S. Raper, K. Riahi, F. Chesnaye, M. Elzen, J.Fujino, K. Jiang, N. Nakicenovic, S. Paltsev, and J. Reilly. 2008. Temperature increase of 21st century mitigation scenarios. *Proc. Nat Acad. Sci. USA*. 105:15258-15262.

How to cite this article: