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Study of Coefficient of Variation, Heritability and Genetic Advance for Different Traits of Rice Genotypes Grown under Aerobic Condition

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Conflict of interests: The authors have declared that no conflict of interest exists.

Abstract

The field experiments with thirty genotypes were conducted during June to October month of *kharif,* 2018 and *kharif,* 2019, to assess extent of variability under aerobic condition. The genotypes were sown under dry direct seeded condition using randomized block design (RBD) with three replications. Each genotype was sown in single row of 5 m length with spacing of 20 cm between rows and 15 cm between plants. Data recorded for 22 characters including different morphological and quality traits from 5 randomly selected plants of each replication and mean data used for analysis. ANOVA revealed that the mean sum of squares were highly significant difference for most of the traits. The value of PCV was higher than GCV for all the twenty-two characters. However, maximum GCV and PCV were observed for root dry weight plant^{-1} (31.44% and 32.17%) followed grain yield plant^{-1} (29.97% and 31.03%), root volume (28.62% and 29.20%), root fresh weight plant^{-1} (28.51% and 29.08%), biological yield plant^{-1} (21.86% 22.50%) and number of grains panicle^{-1} (20.55% and 21.37%). Rest of the traits showed moderate and low GCV and PCV. High heritability and genetic advance were recorded for the traits viz., leaf length, number of tillers plant^{-1}, number of grains panicle^{-1}, 1000 seed weight, root length, root volume, root fresh weight plant^{-1}, root dry weight plant^{-1}, kernel length-breadth ratio, grain yield plant^{-1}, biological yield plant^{-1} and harvest index. The information regarding different variability will provide direction to select high yielding genotypes under aerobic condition.

Keywords: Aerobic rice, genetic advance, GCV, heritability, PCV

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important staple food crops as it helps to sustain two thirds of the world's population (Kahani and Hittalmani, 2015). It is semi-aquatic annual crop in nature. It is generally cultivated under submerged soil condition and requires much water compared to other crops. For producing one kg rice, it requires 3000 to 5000 liters of water, much higher than requirement of wheat and maize (Anonymous, 2009; Sunil and Shankaraingappa, 2014). Rice fields are kept flooded for long period of time which enhances seepage, percolation, transpiration and evaporation. In Asia, rice is largest user of fresh water, accounting for more than half of irrigation water (Akinbile et al., 2011). Water become one of the most precious natural resources due to over-exploitation of ground water and failure of rains. It is expected that nearly

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half of global population may face water scarcity by 2030 due to climate change and unpredictable rainfall. According to Tuong and Bouman (2003), 15 million ha irrigated rice areas of Asia may experience-Physical water scarcity and 22 million ha may face-economic water scarcity. At present India is facing a drought in 42% of land area, while 76.02% of Haryana's land area is drought-resilient (Sharma and Goyal, 2018). However, due to increasing global population, around 50% more food will be needed by 2030, with double that being needed by 2050 (Banwart, 2011). The reducing water availability threatens the sustainability of irrigated rice production in all the rice producing countries.

"Aerobic rice technology" is new concept given by International Rice Research Institute (IRRI) to cope up with water crisis. In aerobic cultivation, seeds were directly sown in non-puddled condition without standing water and soils are kept aerobic throughout the growing season (Kato and Katsura 2014). It can save 50% of irrigation water as compared to lowland rice (Parthasarathi et al., 2012). In this method, seed requirement is very low, 6–8 kg ha^{-1} as compared to 62.5 kg ha^{-1} in low land rice. It is environment friendly approach as it reduced greenhouse gas (methane) emission. Aerobic rice cultivar also should be responsive to high input, tolerance for moisture stress, weed competitiveness and lodging tolerance (Anandan et al., 2016). Combining input-responsive specialized rice cultivars and complementary management practices, this water saving approach has yield potentiality at least 4-6 t ha^{-1}.

To determine successful crop improvement strategies, assessment of variability in available genotypes for grain yield and yield contributing characters is essential. Among different genetic variability parameters, Genotypic Coefficient of Variability (GCV) and Phenotypic Coefficient of Variability (PCV) are major concern for any plant breeder. Heritability and genetic advance are important parameters of selection. Heritability (broad sense) is defined as the proportion of phenotypic variance comprising the sum of additive, dominance, and epistatic effects (Nyquist, 1991; Falconer and Mackay, 1996). Heritability is important parameter in quantitative genetics to determine the response to selection (Piepho and Mohring, 2007). It helps to determine the degree of transmissibility of selected characters of interest to progenies during the breeding process (Sabesan et al., 2009). There is a strong relationship between heritability and genetic advance. Genetic advance describes the degree of gain acquired in a trait under a particular selection pressure (Ogunniyan and Olakojo, 2014). High genetic advance along with high heritability offers the most effective condition for selection of a specific traits (Islam et al., 2016). Keeping in view the present scenario of aerobic rice breeding, the investigation was undertaken to assess variability among the available genotypes for improving the genetic architecture of rice under aerobic condition.

2. Materials and Methods

The experiments were conducted at Rice Research Station, CCSHAU, Kaul, Haryana (29.85° N, 76.66° E) during June to October month of *kharif,* 2018 and *kharif,* 2019. Thirty (30) rice genotypes collected from same Rice Research Station and sown under dry direct seeded condition using randomized block design (RBD) with three replications. Each genotype was sown in single row of 5 m length with spacing of 20 cm between rows and 15 cm between plants. Field was irrigated immediately after sowing to ensure proper germination and subsequently irrigation was given once at 5–7 days interval. To maintain aerobic condition, the plots were kept without standing water throughout crop season. Recommended cultural operations and plant protection measures were taken to ensure uniform and healthy crop stand. Data was recorded on 5 randomly selected plants of each genotype from every replication on 22 morphological and quality parameters viz., days to 50% flowering, plant height (cm), leaf length (cm), leaf width (cm), number of tillers plant^{-1}, panicle length (cm), number of grains panicle^{-1}, grain yield (g) plant^{-1}, days to maturity, biological yield (g) plant^{-1}, 1000 seed weight (g), harvest index (%), root length (cm), root volume (ml), root fresh weight (g) plant^{-1}, root dry weight (g) plant^{-1}, kernel length (mm), kernel breadth (mm), kernel length -breadth ratio, brown rice (%), milled rice (%) and head rice recovery (%). Statistical analysis for genotypic and phenotypic coefficients of variation were calculated by the equation of Burton (1953); heritability (broad sense) was calculated by the formula suggested by Lush (1949) and genetic advance was estimated by using the formula of Johnson et al. (1955).

3. Results and Discussion

In this study, analysis of variance for 22 yield and quality parameters revealed that the mean sum of squares were highly significant difference for all the traits except leaf width, kernel length, kernel breath and kernel length-breath ratio (Table 1). It indicates presence of considerable variation among rice genotypes used in this study.

The PCV and GCV provide a measure to compare variability present in yield and quality parameters. The PCV was slightly higher than GCV for all the traits. It indicated that environmental factors influenced their expression to some extent and presence of high genetic variability for the characters, which may be helpful in selection of yield contributing characters (Yadav, 2000). High (>20%) GCV and PCV were observed for root dry weight plant^{-1} (31.44% and 32.17%); grain yield plant^{-1} (29.97% and 31.03%); root volume (28.62% and 29.20%); root fresh weight plant^{-1} (28.51% and 29.08%); biological yield plant^{-1} (21.86% 22.50%) and number of grains panicle^{-1} (20.55% and 21.37%). While traits like number of tillers plant^{-1} (16.71% and 18.14%); harvest index (16.27%, 17.12%); 1000 seed weight (13.52% and 13.77%); root length (13.36% and 14.26%); leaf length (11.77% and 12.30%) and kernel length-breadth ratio (11.28% and 11.34%) exhibited moderate (10–20%) GCV and PCV. Rest of the characters showed low (<10%) GCV and PCV (Table 2). The

Table 1: Analysis of variance for different characters in aerobic condition

SV	DF	DFF	PH	LL	LW	TN	PL	GN	DM	TW	RL	RV
Replication	2	54.65	76.78	9.29	0.014	6.83	3.19	10.45	54.65	11.16	1.22	0.36
Treatment	29	133.86**	465.71**	144.29**	0.06	24.32**	14.87**	4631.25**	133.86**	74.29**	34.64**	464.85**
Error	145	11.26	48.00	12.19	0.01	3.68	3.39	350.24	11.26	2.68	4.22	18.13
SV	DF	RFW	RDW	KL	KB	KLBR	BR%	MR%	HRR%	GY	BY	HI
Replication	2	0.05	0.60	0.0001	0.013	0.02	15.24	2.00	1.12	23.80	47.78	26.72
Treatment	29	465.99**	62.24**	1.40	0.13	0.73	9.28**	29.35**	102.31**	267.65**	835.21**	289.37**
Error	145	18.18	2.79	0.01	0.002	0.01	5.33	5.09	5.66	17.95	46.91	28.06

*: Significant at (p=0.05); **: Significant at (p=0.01) level of significance; SV: Sources of variation; DF: Degrees of freedom; DFF: Days to 50% flowering; PH: Plant height; LL: Leaf length; LW: Leaf width; TN: Number of tillers plant^{-1}, PL: Panicle length; GN: Number of grains panicle^{-1}, DM: Days to maturity; TW: 1000 seed weight; RL: Root length; RV: Root volume; RFW: Root fresh weight plant^{-1}, RDW: Root dry weight plant^{-1}; KL: Kernel length; KB: Kernel breadth; KLBR: Kernel length-breadth ratio; BR: Brown rice (%); MR: Milled rice %; HRR: Head rice recovery (%); GY: Grain yield plant^{-1}; BY: Biological yield plant^{-1}; HI: Harvest index

Table 2: Estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense) and genetic advance (GA) for different characters of rice genotypes grown under aerobic condition

Character	Coefficient of variation		Heritability (bs) %	Genetic advance	Genetic advance as % of mean
	GCV	PCV			
Days to 50% flowering	5.02	5.24	91.60	8.91	9.89
Plant height	7.60	8.03	89.70	16.28	14.83
Leaf length	11.77	12.30	91.60	9.25	23.20
Leaf width	8.46	9.34	82.10	0.17	15.80
Number of tillers plant^{-1}	16.71	18.14	84.90	3.52	31.71
Panicle length	5.64	6.41	77.20	2.51	10.20
Number of grains panicle^{-1}	20.55	21.37	92.40	52.90	40.70
Days to maturity	3.76	3.93	91.60	8.91	7.42
1000 seed weight	13.52	13.77	96.40	6.99	27.34
Root length	13.36	14.26	87.80	4.35	25.80
Root volume	28.62	29.20	96.10	17.43	57.80
Root fresh weight plant^{-1}	28.51	29.08	96.10	17.45	57.57
Root dry weight plant^{-1}	31.44	32.17	95.50	6.34	63.29
Kernel length	7.86	7.89	99.30	0.99	16.14
Kernel breadth	7.33	7.40	98.10	0.30	14.96
Kernel length-breadth ratio	11.28	11.34	98.90	0.71	23.10
Brown rice (%)	1.02	1.56	42.50	1.09	1.37
Milled rice %	3.02	3.32	82.70	3.77	5.65
Head rice recovery (%)	6.70	6.90	94.50	8.04	13.42
Grain yield plant^{-1}	29.97	31.03	93.30	12.84	59.63
Biological yield plant^{-1}	21.86	22.50	94.40	22.94	43.74
Harvest index	16.27	17.12	90.30	12.92	31.85

graphical representation of variability parameters is presented in Figure 1 and Figure 2. Similar results were also reported by Ekka et al. (2011) and Kishore et al. (2015) for grain yield plant^{-1}; Khatun et al. (2015) for the number of filled grains panicle^{-1} and grain yield plant^{-1}; Chowdhury et al. (2016) for hulling %, milling % and Head rice recovery (%), Tripathi et al. (2017) for number of grains panicle^{-1}, Akinola et al. (2019) and Tiwari et al. (2019) for grain yield.

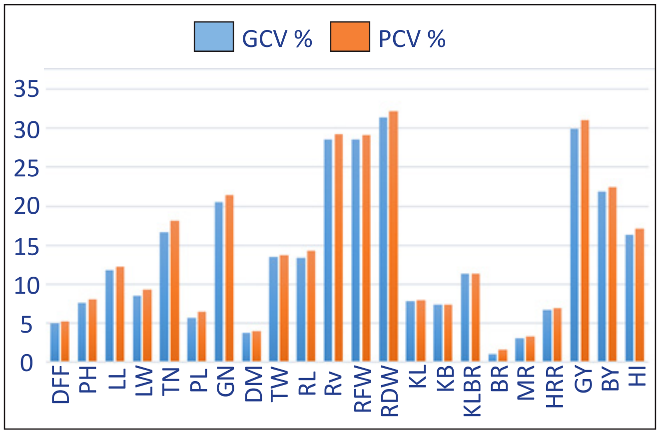

Figure 1: Graphical representation of PCV and GCV; DFF: Days to 50% flowering; PH: Plant height; LL: Leaf length; LW: Leaf width; TN: Number of tillers plant^{-1}; PL: Panicle length; GN: Number of grains panicle^{-1}; DM: Days to maturity; TW: 1000 seed weight; RL: Root length; RV: Root volume; RFW: Root fresh weight plant^{-1}; RDW: Root dry weight plant^{-1}; KL: Kernel length; KB: Kernel breadth; KLBR: Kernel length-breadth ratio; BR: Brown rice (%); MR: Milled rice %; HRR: Head rice recovery (%); GY: Grain yield plant^{-1}; BY: Biological yield plant^{-1}; HI: Harvest index

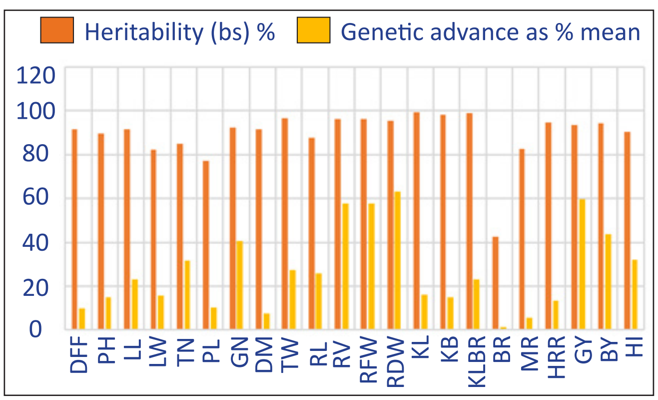

Figure 2: Graphical representation of heritability and genetic advance as % of mean; DFF: Days to 50% flowering; PH: Plant height; LL: Leaf length; LW: Leaf width; TN: Number of tillers plant^{-1}; PL: Panicle length; GN: Number of grains panicle^{-1}; DM: Days to maturity; TW: 1000 seed weight; RL: Root length; RV: Root volume; RFW: Root fresh weight plant^{-1}; RDW: Root dry weight plant^{-1}; KL: Kernel length; KB: Kernel breadth; KLBR: Kernel length-breadth ratio; BR: Brown rice (%); MR: Milled rice %; HRR: Head rice recovery (%); GY: Grain yield plant^{-1}; BY: Biological yield plant^{-1}; HI: Harvest index

Heritability is an important parameter for the inheritance of characters in plant breeding. The high heritability of any trait indicates that the trait is least influenced by environmental factor. All the morphological traits and 5 quality parameters showed high heritability (>60%). Morphological characters like 1000 seed weight (96.40%), root fresh weight plant^{-1} (96.10%), root volume (96.10%), root dry weight plant^{-1} (95.50%), biological yield plant^{-1} (94.40%), grain yield plant^{-1} (93.30%), number of grains panicle^{1} (92.40%), days to 50% flowering (91.60%), leaf length (91.60%), days to maturity (91.60%), harvest index (90.30%), plant height (89.7%), root length (87.80%), number of tillers plant^{-1} (84.90%), leaf width (82.10%) and panicle length (77.20%) exhibited high heritability. Quality parameters like kernel length (99.30%), kernel length-breadth ratio (98.90%), kernel breadth (98.10%), head rice recovery (94.50%) and milled rice (82.70%) also showed high heritability. While brown rice % showed moderate heritability (42.50%). Heritability component alone is not much useful for the selection of the best individual, as it includes the effect of both additive and non-additive genes. High genetic advance occurs mainly due to additive gene action (Panse and Sukhatme, 1957). Hence for the selection of best individual, estimation of heritability along with the genetic advance would be more useful than heritability alone (Kishor et al., 2008). Along with high heritability, traits which also showed high genetic advance as % of mean (>20%) were root dry weight plant^{-1} (63.29%), grain yield plant^{-1} (59.63%), root volume (57.80%), root fresh weight plant^{-1} (57.57%), biological yield plant^{-1} (43.74%), number of grains panicle^{-1} (40.70%), harvest index (31.85%), number of tillers plant^{-1} (31.71%), 1000 seed weight (27.34%), root length (25.8%), leaf length (23.20%) and kernel length-breadth ratio (23.10%). Similar findings were reported by Alam et al. (2014) for grains number panicle^{-1}; Bagudam et al., 2018 for tiller number, grain number, single plant yield, harvest index, biomass, test weight, grain yield plant^{-1} and biomass of plant after harvest; Tiwari et al. (2019) for grain yield and 1000-grain weight.

4. Conclusion

High genetic variability in the genotypes was observed. The broad sense heritability and genetic advance as percentage of mean identified 12 important traits viz., grain yield plant^{-1}, biological yield plant^{-1}, harvest index, leaf length, number of tillers plant^{-1}, number of grains panicle^{-1}, test weight, root length, root volume, root fresh weight plant^{-1}, root dry weight plant^{-1} and kernel length-breadth ratio. Selection based on these traits would be effective for rice improvement under aerobic condition.

5. References

Akinbile, C.O., El-Latif, K.M.A., Abdullah, R., Yusoff, M.S., 2011. Rice production and water use efficiency for self- sufficiency in Malaysia: A review. Trends in Applied Science Research 6(10), 1127–1140.

Akinola, T.F., Odiyi, A.C., Fayeun, L.S., Ohunakin, A.O., 2019. Genetic variability and genetic diversity of 13 upland rice genotypes for agronomic traits and nutritional qualities. Journal of Agricultural Science and Botany 3(1), 6–11.

Alam, M.S., Hassan, L., Islam, M.M., Begum, S.N., Islam, S.N., 2014. Evaluation of habitual rice (*Oryza sativa* L.) landraces of Bangladesh through different genetic parameters. International Journal of Innovation and Scientific Research 11(2), 494–502.

Anandan, A., Pradhan, S.K., Mohapatra, S.D., Saha, S., Panneerselvam, P., Singh, O.N., 2016. High yielding and water saving NRRI Aerobic rice varieties. NRRI Technology Bulletin 121, 1–4.

Bagudam, R., Eswari, K.B., Jyothi Badri, J., Rao, P.R., 2018. Variability, heritability and genetic advance for yield and its component traits in NPT core set of rice (*Oryza sativa* L.). Electronic Journal of Plant Breeding 9(4), 1545–1551.

Banwart, S., 2011. Save our soils. Nature 474, 151–152.

Burton, G.W., Devane, E.W., 1953. Estimating heritability in tall Fescue (*Festuca arundinacea*) from replicated clonal material. Agronomy Journal 45, 478–481.

Chowdhury, B.D., Nath, A., Dasgupta, T., 2016. Characterization and variability analysis of rice genotypes with reference to cooking quality parameters. IOSR Journal of Agriculture and Veterinary Science 9(4), 08–12.

Ekka, R.E., Sarawgi, A.K., Kanwar, R.R., 2011. Correlation and path analysis in traditional rice accessions of Chhattisgarh. Journal of Rice Research 4(1&2), 11–18.

Falconer, D.S., Mackay, T.F.C., 1996. An Introduction to Quantitative Genetics, Ed. 4. Prentice Hall, London.

Anonymous, 2009. Farm data-rice ecosystems, 30: distribution of rice crop area, by environment, 2004-2006. In: IRRI World rice statistics, IRRI (Ed.). International Rice Research Institute, Los Banos, Philippines.

Islam, M., Khalequzzaman, M., Bashar, M., Ivy, N., Haque, M.M., Mian, M.A.K., 2016. Variability assessment of aromatic and fine rice germplasm in Bangladesh based on quantitative traits. The Scientific World Journal, 1–14.

Johnson, H.W., Robinson, H.F., Comstock, R.E., 1955. Estimates of genetic and environmental variability of Soybeans. Agronomy Journal 47, 314–318.

Kahani, F., Hittalmani, S., 2015. Genetic analysis and traits association in F_2 intervarietal populations in rice under aerobic condition. Journal of Rice Research 3(4), 152.

Kato, Y., Katsura, K., 2014. Rice adaptation to aerobic soils: physiological considerations and implications for agronomy. Plant Production Science 17(1), 1–12.

Khatun, T., Hanafi, M.M., Yusop, M.R., Wong, M.Y., Salleh, F.M., Ferdous, J., 2015. Genetic variation, heritability and diversity analysis of upland rice (*Oryza sativa* L.) genotypes based on quantitative traits. BioMed Research International, 1–7.

Kishor, C., Prasad, Y., Haider, Z.A., Kumar, R., Kumar, K., 2008. Quantitative analysis of upland rice. Oryza 45(4), 268–272.

Kishore, N.S., Srinivas, T., Nagabhushanam, U., Pallavi, M., 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.

Lush, L., 1949. Heritability of quantitative characters in farm animals. International Congress Genetics. Hereditas, 356.

Nyquist, W.E., 1991. Estimation of heritability and prediction of selection response in plant populations. Critical Reviews in Plant Sciences 10, 235–322.

Ogunniyan, D.J., Olakojo, S.A., 2014. Genetic variation, heritability, genetic advance and agronomic character association of yellow elite inbred lines of maize (*Zea mays* L.). Nigerian Journal of Genetics 28, 24-28.

Panse, V.G., Sukhatme, P.V., 1957. Genetics and quantitative characters in relation to plant breeding. Indian Journal of Genetics 17, 312–328.

Parthasarathi, T., Vanitha, K., Lakshamanakumar, P., Kalaiyarasi, D., 2012. Aerobic rice mitigating water stress for the future climate change. International Journal of Agronomy and Plant Production 3(7), 241–254.

Piepho, H.P., Mohring, J., 2007. Computing heritability and selection response from unbalanced plant breeding trials. Genetics 177, 1881–1888.

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

Sharma, A., Goyal, M.K., 2018. District-level assessment of the ecohydrological resilience to hydroclimatic disturbances and its controlling factors in India. Journal of Hydrology 564, 1048–1057.

Sunil, C.M., Shankaraingappa, B.C., 2014. Rooting behaviour of aerobic rice under integrated package of agrotechniques. Asian Journal of Agricultural Research 8(2), 105–113.

Tiwari, D.N., Tripathi, S.R., Tripathi, M.P., Khatri, N., Bastola, B.R., 2019. Genetic variability and correlation coefficients of major traits in early maturing rice under rainfed lowland environments of Nepal Advances in Agriculture 2019, 1–9.

Tripathi, A., Kumar, S., Singh, M.K., Kumar, A., Karnwal, M.K., 2017. Phenotypic assessment of rice (*Oryza sativa* L.) genotypes for genetic variability and varietal diversity under direct seeded condition. Journal of Applied and Natural Science 9(1), 6–9.

Tuong, T.P., Bouman, B.A.M., 2003. Rice production in water scarce environment. In: Kijne, J.W., Barker, R., Molden, D. (Eds), Water productivity in agriculture: limits and opportunities for improvement. CAB International, 53–67.

Yadav, R.K., 2000. Studies on genetic variability for some quantitative characters in rice (*Oryza sativa* L.). Advances In Agricultural Research In India 13, 205–207.