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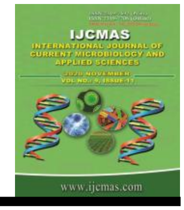

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Genetic Variability, Heritability, Genetic Advance Studies in Rice (*Oryza sativa* L.) for Spikelet Sterility and Pollen Viability

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A B S T R A C T

The investigation carried out at Indian Institute of Rice Research Farm, ICRISAT, Patencheru, Hyderabad, Telangana, India, during Rabi, 2015-16 in order to estimate genetic variability, heritability and genetic advance in 154 genotypes of rice for pollen viability and spikelet fertility. Phenotypic coefficient of variation in general were higher than genotypic coefficient of variation for traits like pollen viability, spikelet sterility indicating high environmental effect on the expression of these traits except days to 50 % flowering and Number of grains per panicle which were less affected by environment for expression. Thus, selection based on phenotypic performance for days to flowering, Number of grains per panicle would be effective to bring about considerable genetic improvement. 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.

Keywords

Variability, Hertiability, Pollen Viability, Spikelet Sterility

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Introduction

Rice (*Oryza sativa* L.) is one of the most important human staple food crop in the world that feeds about 60% of the population in the world and had become the cheap source of energy. By its origin, it is native to Southeast Asia with two cultivated species *Oryza sativa* (Asiatic rice) and *Oryza glaberima* (African rice) also with Twenty two wild species. Rice is cultivated in wide span of agro-ecological situations and agro climatic zones. Though it is widely acclimatisable in different condition it is also most sensitive to extreme temperatures. Worldwide, it is grown in an area 162.67 m ha with a production of 503.17 m tonnes annually and having a productivity of 4556 Kg ha^{-1}. India holds first rank in terms of area with 43.79 m Ha whereas China holds first in production (FAO, 2019). In India Rice is produced with a yield of 112.91m tonnes annually and mean average productivity is 2578 Kg Ha^{-1}. In Andhra Pradesh, it covers an area of 2.16 m Ha with yield of 8.18 m tonnes and 3792 Kg/ha of average productivity (India stat, 2018-19).

The food production always increase in arithmetic leap whereas the population increases in geometric leap whose outcome is the reduced food availability per capita. It is the only crop that had to feed more number of people for larger number of people for a longer periods than any crop. Rice is spectacularly diverse and unique and thus can be grows be grown in extreme range of environments across the world. On the other face of the coin extremities in the climate contributed by climate change had a significant effect on the production of rice. Over a bygone century, average temperature has increased by 1°C and would tend to rise at a speedy note by the end of 21st century at a rate of 1.4 to 5.8°C (IPCC 2018). As extreme high temperatures recur and likely increase surface temperatures by 1.4 to 5.8°C by 2100. There can be serve impact of these high temperature on yields of crops. There will be more effect of these on the tropical region than temperate once during the next half of the century (IPCC, AR5, 2014). The cultivation of Rice now especially in country like us had already made to the optimum at their production. The extreme heat waves would be more frequent and hit with more intensity in the future which can put the rice growing areas at risk by reducing the overall yield by affecting them during most sensitive stages. Instead of rice being a crop originated in tropics it is very sensitive to temperature beyond 35°C particularly at flowering stage where pollen viability and spikelet sterility which would seriously reduce the yield. Hence, study of pollen viability and spikelet fertility at flowering stage would help to screen high temperature tolerance (Prasad *et al.*, 2006). Genetic variability plays an very important role in formulating a successful breeding scheme and thus conserves the attention of the plant breeders and occupies its 1st place in any crop improvement programme. Along with genetic variability the study of heritability, Genetic advance is also important as these parameters would signify the breeder in measuring the extent of likeness among the parents and offspring's (or) within the parents. Whose immensity signifies the selection of a particular genotype by its phenotypic expression and by exercising necessary selection pressure.

Materials and Methods

The experimental material comprised of 150 germplasm of rice (*Oryza sativa* L.) grown in Augmented RBD at IIRR Farm, ICRISAT, Patencheru, Hyderabad, Telangana, India, during Rabi 15-16. The recommended agronomic and plant protection measures were followed in order to raise a normal crop. Observations on twelve 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, single plant yield and seed vigour were recorded on five randomly selected competitive plants for each genotype 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 and correlation among traits were done by using Genstat 18th edition at 0.05 level of significance. Phenotypic and genotypic coefficients of variation (PCV and GCV) and Heritability (h^2) were computed for all characters. The estimates of genetic advance were obtained and categorized as high, medium and low as suggested by Johnson *et al.,* (1955). Coefficient of genotypic and phenotypic variation were categorized as proposed by Sivasubramanian and Madhavmenon (1973).

Results and Discussion

Analysis of variance for the experiment involving a set of 150 germplasm lines of rice for twelve 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, single plant yield and seed vigour 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.

Variability estimates such as the phenotypic coefficient of variation (PCV), the genotypic coefficient of variation (GCV), broad sense heritability, and genetic advance as percent of means are presented in Table 1. Phenotypic coefficient of variance was found higher than genotypic coefficient of variance for all studied traits indicates the environmental influence on the expression of these traits. Similar results were presented by (Rashid *et al.,* 2017; Gyawali *et al.,* 2018). The extent of the influence of growing environment on observed traits is explained by the magnitude of the differences between GCV and PCV. Large difference between PCV and GCV indicate high environmental influence on the expression of particular traits.

In the present study, phenotypic coefficient of variation in general were higher than genotypic coefficient of variation for traits like pollen viability, spikelet sterility indicating high environmental effect on the expression of these traits except days to 50 % flowering (PCV 6.44, GCV 6.66) and Number of grains per panicle (33.81 PCV, 33.89 GCV) which were less affected by environment for expression. Thus, selection based on phenotypic performance for days to flowering, Number of grains per panicle would be effective to bring about considerable genetic improvement. Similar findings were reported by Umarani *et al.,* (2017), Dhakal *et al.,* (2020). High PCV on grain yield was also reported bySarif *et al.,* (2020), Zakilhasan *et al.,* (2020) which is in agreement with this present study. The greater difference between GCV and PCV were observed in pollen viability and spikelet fertility indicating that these traits were more influenced by growing environment can be improved by providing optimum growing environments Likewise small difference between GCV and PCV were observed on panicle length, plant height, days to flowering and days to maturity indicated that there was very little environmental influence on these traits and cannot be improved by providing favourable environment. In general, high coefficient of variability shows scope of selection in favour of traits of interest and low coefficient of variability indicates the need for creation of variability and selection (Sandeep *et al.,* 2018).

Broad sense heritability estimates ranged from 51.55 percent (pollen viability) to 99.49 percent (number of grains per panicle). The characters like plant height (98.57%), single plant yield (97.93%), number of tillers per hill(93.75 %), days to 50% flowering (93.45 %), days to maturity (89.95%), panicle length (89.74 %), number of paniclesper hill(87.69 %)exhibited high heritability. The results are in accordance with the reports given by Karthikeyan *et al.,* (2010), Chakraborty and Chaturvedi (2014), Chuchert *et al.,* (2018), for days to 50% flowering, days to maturity, plant height, 1000 grain weight and single plant yield; Harsh *et al.,* (2015) and Prasad *et al.,* (2017), Chuchert *et al.,* (2018), Gyawali *et al.,* (2018), Yadav *et al.,* (2018), Tirunch *et al.,* (2019) for panicle length, number of tillers per hill and number of panicles per hill, Umarani *et al.,* (2017) for spikelet sterility.

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 9.84 percent (days to maturity) to 108.48 percent (seed vigour). After seed vigour, spikelet sterility (99.06) recorded highest magnitude of genetic advance as percent of mean followed by single plant yield (77.25%), number of grains per panicle (69.57%), number of tillers per hill (50.83 %), pollen viability (22.95%), number of panicles per hill (35.76 %), plant height (33.71%), 1000grain weight (29.34%) and panicle length (22.44 %).

The character days to 50% flowering (12.84%) showed moderate magnitude of genetic advance as percent of mean. The trait days to maturity (9.84%) recorded the lowest magnitude of genetic advance as percent of mean. Maximum amount of genetic advance was found for seed vigour, followed by spikelet fertility, single plant yield, number of grains per panicle, number of tillers per hill, number of panicles per hill, plant height, 1000 grain weight, pollen viability, and panicle length. Similar results for high genetic advance were reported by Akshitha *et al.,* (2020) for seed vigour, Tiwari(2015) Umarani *et al.,*(2017), Behera *et al.,* (2018) for spikelet sterility, Tiwari *et al.,* (2015), Konate *et al.,* (2016), Kumar and Verma (2016), Rashid *et al.,* (2017), Rohit *et al.,* (2017), Yadav *et al.,* (2018) and Devi *et al.,* (2020) for single plant yield. Ketan and Sarkar (2014)for number of grains per panicle, Prasad *et al.,* (2017), Chuchert *et al.,* (2018) for number of tillers per hill, Sandeep *et al.,* (2018) for pollen viability, Gyawali *et al.,* (2018), Dhakal *et al.,* (2020) for number of panicles per tiller, Prasad *et al.,* (2017), Chuchert *et al.,* (2018), Dhakal *et al.,* (2020), for 1000 grain weight, Nayudu *et al.,* (2007), Sabesan *et al.,* (2009) for panicle length, Rashid *et al.,* (2017), Rohit *et al.,* (2017) for plant height.

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).

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.

Table.1 Estimation of Variability, Heritability and Genetic advance per cent of mean for 12 characters

S. No.	Character	GCV (%)	PCV (%)	h^2 (%)	GA	GA as% of mean (5 %)
1.	**Days to 50 % Flowering (days)**	6.44	6.66	93.45	13.23	12.84
2.	**Days to maturity (days)**	5.03	5.3	89.95	13.06	9.84
3.	**Plant height (cm)**	16.46	16.58	98.57	32.18	33.71
4.	**number of tillers per hill**	25.45	26.28	93.75	8.29	50.83
5.	**Number of panicles per tiller**	18.51	19.77	87.69	4.42	35.76
6.	**Panicle length (cm)**	11.48	12.12	89.74	5.01	22.44
7.	**Number of grains per panicle**	33.81	33.89	99.49	72.02	69.57
8.	**1000 grain weight (g)**	15.13	16.11	88.31	5.94	29.34
9.	**Single plant yield**	37.84	38.23	97.93	16.17	77.25
10.	**Pollen viability (%)**	15.5	21.58	51.55	17.14	22.95
11.	**Spikelet sterility (%)**	56.74	67.05	71.61	24.27	99.06
12.	**Seed vigour**	53.3	54.03	97.33	1776.76	108.48

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 andKoutu (2013) and Prasad *et al.*, (2017) for number of tillers per hill; and number of productive tillers per hill, Umarani *et al., (2017)* for spikelet fertility; Khare *et al.*,(2014), Srihima *et al.*, (2015), Kumar and Verma (2016) for 1000 grain weight; Nayudu *et al.*, (2007), Anbanandanetal. (2009), Garg *et al.*, (2010), Kishore *et al.*,(2015) and Rohit *et al.*,(2017) for single plant yield.

In the present study, phenotypic coefficient of variation in general were higher than genotypic coefficient of variation for traits like pollen viability, spikelet sterility indicating high environmental effect on the expression of these traits except days to 50 % flowering and Number of grains per panicle which were less affected by environment for expression. Thus, selection based on phenotypic performance for days to flowering, Number of grains per panicle would be effective to bring about considerable genetic improvement. 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.

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