Electronic Journal of Plant Breeding, 9 (3) : 1067 - 1076 (Sep 2018) DOI: 10.5958/0975-928X.2018.00133.3
ISSN 0975-928X

Research Article

Genetic studies in F_2 for biometrical traits in Rice (*Oryza sativa.* L)

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(Received:12 Aug 2018; Revised:19 Aug 2018; Accepted:20 Aug 2018)

Abstract
The present investigation was carried out with F_2 plants of three different crosses of rice *viz.,* BPT 2270 x AD09493, AD 08142 x Co (R) 50 and AD09493 x AD 11168. In this experiment, genetic variability, heritability, genetic advance, correlation and path analysis on seven quantitative traits *viz.,* days to fifty per cent flowering, plant height, number of productive tillers, panicle length, thousand grain weight, spikelet fertility per cent and single plant yield were estimated. In all the three crosses, for the traits, days to fifty per cent flowering, plant height, number of productive tillers and thousand grain weight, minimum difference between PCV and GCV was obtained, indicating lesser influence of environment and more genetic control on the expression of these traits. The results of correlation analysis indicated that number of productive tillers had highest significant correlation with single plant yield and hence simultaneous selection for number of productive tillers, along with high spikelet fertility percentage can significantly improve the single plant yield in rice.

Key words
Rice, Single Plant Yield, Heritability, Genetic Advance

Introduction

Rice is the staple food of an estimated 3.5 billion people worldwide, providing up to 50% of the dietary caloric supply and a substantial part of the protein intake for about 520 million people across Asia (Muthayya *et al.,* 2014). It is also the primary source of income and employment for more than 200 million households across the world (Food and Agriculture Organization, 2004). But, the demand for rice is constantly increasing especially in developing countries mainly due to rapid population growth and constraints for crop production such as shrinking land area and increased demand for water.

Knowledge on genetic variability, gene action and heritability of yield contributing traits is a pre-requisite to breed ideal plant type varieties in rice. Estimating the genotypic coefficients of variation (GCV), phenotypic coefficients of variation (PCV), heritability and genetic advance for architectural traits along with the biometrical traits will play an important role in rice breeding programmes. Heritability and genetic advance are other important selection parameters. The estimates of heritability would be rewarding and helpful to the plant breeder in determining the characters to be considered for the selection. The major function of heritability estimates is to provide information on transmission of characters from the parents to the progeny.

Correlation analysis helps in identifying whether the traits in question are positively or negatively related with the yield, so that they could be taken into consideration while breeding for ideal plant type. Correlation combined with path analysis would give better picture of the cause and effect relationship between different pairs of characters (Sharma, 2010).

The nature and relationship between yield and its component traits and also among yield components provide valuable information in practicing selection for improved yield. In general the quantitative traits such as yield (Priya *et al.,* 2013), are governed by polygenes and are considerably influenced by the environment and hence, less predictable. The path coefficient analysis suggested by Dewey and Lu (1959) measures the direct and indirect causes of association and depicts the relative importance of each trait involved in contributing to yield (Immanuel et al., 2011). It also helps in formulating effective breeding methods in the development of superior plant type. Keeping these points in view, genetic correlation among different biometrical traits was studied in the three crosses.

Material and Methods

The present investigation was carried out in the experimental field of Department of Plant Breeding and Genetics, Tamil Nadu Rice Research Institute, Aduthurai. Seeds of F_2 generation of three cross combinations of rice were raised as experimental materials in the present study *viz.,* BPT 2270 x AD09493, AD 08142 x Co (R) 50 and AD09493 x AD 11168. In this study, C_1 denotes AD 09493 x AD11168, C_2 denotes AD08142 x Co (R) 50 and C_3 denotes BPT 2270 x AD 09493. The seeds of F_2 generation of the cross combinations was raised in L_3a field, in Non - Randomized Block Design. All the progenies were sown in the raised bed nursery along with their parents. Thirty days old seedlings were transplanted to the main field with a spacing of 20 cm between rows and 20 cm between plants to facilitate tiller angle observations. The recommended agronomic practices and crop protection measures were followed during the crop growth period. Observations were recorded from randomly selected 300 plants of each of the cross combinations and each of the randomly selected individual plant was tagged before anthesis. Data on all the fourteen characters were subjected to statistical analysis as analysis of variance, genetic variability, correlation coefficient and path coefficient analysis.

Results and Discussion

The estimates of genotypic and phenotypic coefficient of variation are necessary to understand the role of environmental influence on different traits. The magnitude of environmental influence on any character is indicated by the magnitude of the differences between the genotypic and the phenotypic coefficient of variation (Akinwale *et al.*, 2011). The PCV and GCV values of the traits of three crosses are given in Table 1.

Moderate estimates of phenotypic and genotypic coefficient of variation were observed for tiller angle, while moderate PCV and low GCV estimates for thousand grain weight and panicle length was observed, indicating the possibilities for direct phenotypic selection under sodicity. Similar results were reported by Abebe *et al.* (2017) for panicle length and for thousand grain weight, by Mallimar *et al.* (2015).

Low estimates of phenotypic and genotypic coefficient of variation were observed for the traits *viz.*, days to fifty per cent flowering, plant height and spikelet fertility percentage due to the presence of low variability in these traits. Similar results were reported by Seyoum *et al.* (2012), Aditya and Bhartiya (2013), Savitha (2015), Rao *et al.* (2014), Devi *et al.* (2016) , Konate *et al.* (2016), Mallimar *et al.* (2015) and Prasad et al. (2017) for days to fifty per cent flowering, Ogunbayo *et al.* (2014), Seyoum *et al.* (2012), Aditya and Bhartiya (2013), Rao *et al.* (2014), Savitha and Ushakumari (2015), Anis *et al.* (2016), Konate *et al.* (2016), Badri *et al.* (2016), Hefena *et al.* (2016) and Sala and Shanthi (2016) for plant height; and Badri *et al.* (2016), Bagati *et al.* (2016), Hefena *et al.* (2016) and Konate *et al.* (2016) for spikelet fertility percentage. Lower genotypic and phenotypic coefficient of variation obtained indicate the presence of narrow genetic base for these traits and hence for their improvement, their genetic base must be widened.

Estimates of genotypic coefficients of variation alone is not sufficient to assess the heritable variation. For more reliable results, estimates of heritability and genetic gain should be considered together during selection of component traits in improving yield (Johnson *et al.*, 1955). The estimates of heritability help the plant breeder in selection of elite genotypes from diverse genetic population, hence prior knowledge about the heritability of the traits is a prerequisite for the selection programme (Singh *et al.*, 2011) which is represented in Table 1.

In C_1 and C_2, high heritability estimates were observed for all the traits except for panicle length which showed moderate heritability while in C_3, all the traits studied showed high heritability, of which, the traits days to fifty per cent flowering, plant height, thousand grain weight, panicle length, spikelet fertility percentage, tiller angle and single plant yield showed high heritability with low genetic advance which indicated that, these traits are governed by non-additive gene action hence mere phenotypic selection in one particular season or location will be ineffective. Rao *et al.* (2014) , Kumar et al. (2015) Savitha and Ushakumari (2015), Badri *et al.* (2016), Seyoum *et al.* (2012) and Ogunbayo *et al.* (2014) have also reported similar results for these characters.

Considering the results of heritability and genetic advance of all the three crosses, the trait *viz.*, number of productive tillers had high heritability coupled with high genetic advance, hence simple selection procedures like pedigree selection can be used for the improvement of these traits.

Correlation coefficient analysis measures the mutual relationship between various plant attributes and

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ISSN 0975-928X

determines the component traits on which selection can be based for genetic improvement in yield. Grain yield is the complex trait which is influenced by the interaction of a number of contributing characters. The estimates of the inter relationship between grain yield and other yield attributes and among the yield attributing traits would facilitate effective selection schemes to improve the yield.

In all the three crosses, the trait, number of productive tillers had positive and highly significant correlation with single plant yield (Table 2). Hence, this trait could be considered as important yield contributing traits in all the three cross combinations and selection for this trait would ultimately improve the yield. Fiyaz *et al.* (2011), Immanuel *et al.* (2011), Bhadru *et al.* (2012), Kiani and Nematzadeh (2012), Gopikannan and Ganesh (2013), Nagaraju *et al.* (2013), Haradari and Hittalmani (2017) and Priya *et al.* (2017) had also reported positive and significant correlation for number of productive tillers with yield.

In C_1 and C_3 the trait, days to fifty percent flowering showed positive and insignificant correlation with single plant yield. Similar results were reported by Vir and Singh (2006), Yogameenakshi and Vivekanandan (2010), Nandan *et al.* (2010), Savitha and Ushakumari (2015) and Konate *et al.* (2016). This trait showed negative and insignificant correlation with single plant yield in cross $C_{2.}$ In C_1 and C_2, plant height had positive and insignificant correlation with single plant yield Akhi *et al.* (2016), Sameera *et al.* (2016), Konate *et al.* (2016), Vinoth *et al.* (2016), Haradari and Hittalmani (2017) and Rathod *et al.* (2017), but in C_3 this trait showed negative and insignificant correlation with single plant yield which was in accordance with the findings of Moosavi *et al.* (2015). Thousand grain weight showed negative and insignificant correlation with single plant yield in cross C_1 and $C_{2,}$ whereas positive and highly significant correlation in cross C_3. Similar results were reported in earlier studies by Padmaja *et al.* (2015), Immanuel *et al.* (2011), Yadav *et al.* (2011), Rangare *et al.* (2012), Haider and Kaku (2015), Ogunbayo *et al.* (2014), Fiyaz *et al.* (2011), Moosavi *et al.* (2015), Konate *et al.* (2016), Pham *et al.* (2016). Panicle length showed positive and significant correlation with single plant yield in cross $C_{1,}$ while it shows negative and insignificant correlation in cross C_2, positive and highly significant correlation with yield in $C_{3.}$ The results of C_1 and C_3 were in line with Parimala and Devi (2016), Vinoth *et al.* (2016), Haradari and Hittalmani (2017), Priya *et al.* (2017) and Rathod *et al.* (2017), Nandan *et al.* (2010) and Kahani and Hittalmani (2016). The results indicate that increased panicle length increases plant yield.

In C_1 cross, the spikelet fertility percentage showed negative and highly significant correlation. In case of C_2 cross, this trait had negative and insignificant correlation with single plant yield. In C_3 cross, this trait showed positive and highly significant correlation with single plant yield. Similar results were reported by Bagati *et al.* (2016) and Haradari and Hittalmani (2017) for C_3. Higher spikelet fertility, increases number of filled grains per panicle which in turn improves yield.

From the results, the traits *viz.*, number of productive tillers and panicle length should be given due weightage while selection for plants since they have significant influence on yield.

Wright (1921) developed path coefficient analysis, a statistical device which is unique in partitioning the association into direct and indirect effects through other dependent variables. Unlike the correlation coefficient values which measure the extent of relationship, path coefficient (Dewey and Lu, 1959; Wright, 1921) measures the magnitude of direct and indirect effects of characters on complex dependent characters like yield and thus enables the breeders to judge best about the important component characters during selection.

The path analysis showed that in all the three crosses, number of productive tillers showed high positive direct effect on single plant yield which implies that selecting this character for yield improvement may be rewarding, while in $C_{1,}$ the traits *viz.*, days to fifty percent flowering and thousand grain weight expressed positive negligible direct effect (Table 3). The remaining traits showed negative negligible indirect effect on single plant yield. The results were in accordance with the findings of Shanthi *et al.* (2011), Bhadru *et al.* (2012), Gopikannan and Ganesh (2013), Nagaraju *et al.* (2013), Rao *et al.* (2014), Sandhya *et al.* (2014), Sameera *et al.* (2016), Vir and Singh (2006), Padmaja *et al.* (2015), Ekka et al . (2011) and Padmaja *et al.* (2015).

In case of $C_{3,}$ days to fifty per cent flowering, plant height, thousand grain weight, panicle length and spikelet fertility percentage showed low positive

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direct effect on yield. These results were in line with Vir and Singh (2006), Padmaja *et al.* (2015), Ekka *et al.* (2011), Padmaja *et al.* (2015),

Shanthi *et al.* (2011), Seyoum *et al.* (2012), Gopikannan and Ganesh (2013), Yadav *et al.* (2011) and Kiani and Nematzadeh (2012).

In $C_{1,}$ days to 50 per cent flowering had positive negligible indirect effect through plant height, number of productive tillers and panicle length. In $C_{2,}$ it had positive negligible indirect effect through thousand grain weight and tiller angle, while in $C_{3,}$ through thousand grain weight and spikelet fertility percentage on yield. Plant height contributed indirectly in a positive negligible manner via days to fifty per cent flowering, number of productive tillers, thousand grain weight and panicle length in C_1. In $C_{2,}$ this character showed positive negligible indirect effect through number of productive tillers, thousand grain weight and tiller angle on yield. In case of $C_{3,}$ it showed negative negligible indirect effect through all the traits on yield. In $C_{1,}$ the number of productive tillers had positive negligible indirect effect through plant height and spikelet fertility. In $C_{2,}$ through plant height, thousand grain weight and spikelet fertility percentage. In $C_{3,}$ it had positive negligible indirect effect through thousand grain weight, panicle length and spikelet fertility percentage.

Thousand grain weight had positive negligible indirect effect via panicle length and flag leaf angle on yield in C_1. Similar results were reported by Padmaja *et al.* (2015), Rajamadhan *et al.* (2011), Jambhulkar and Bose (2014) and Sandhya *et al.* (2014). In $C_{2,}$ this trait showed positive indirect effect through days to fifty percent flowering, plant height, panicle length and spikelet fertility percentage. In case of $C_{3,}$ it had positive moderate indirect effect through number of productive tillers, while positive negligible indirect effect through the traits days to 50 per cent flowering, panicle length, spikelet fertility percentage and tiller angle.

In $C_{1,}$ spikelet fertility had positive negligible indirect effect through plant height and thousand grain weight while showing low negative indirect effect through number of productive tillers. Priyanka (2016) and Fiyaz *et al.* (2011) quoted similar results for this trait while the negative indirect effect was previously reported by Renuprasath (2016). In $C_{3,}$ this trait showed positive high indirect effect through days to 50 per cent flowering and thousand grain weight, whereas it had positive low indirect effect through number of productive tillers on yield which were in line with the results of Priyanka (2016), Gopikannan and Ganesh (2013) and Shanthi *et al.* (2011). In all the crosses, positive moderate indirect effect on yield was noticed through the trait number of productive tillers by panicle length. In C_1, positive negligible indirect effect was observed through the traits thousand grain weight and spikelet fertility percentage. In $C_{2,}$ it had positive negligible indirect effect via thousand grain weight and tiller angle and in C_3, through thousand grain weight and spikelet fertility percentage. Sandhya *et al.* (2014), Chandra *et al.* (2015) and Rao *et al.* (2014) also reported positive negligible indirect effects of panicle length through the above said traits.

The results of path coefficient analysis indicated the importance of number of productive tillers through direct effect and thousand grain weight, hence selection through the traits *viz.*, increased number of productive tillers along with high thousand grain weight will be effective for yield improvement.

The results from the present study unveiled a substantial level of genetic variability among the tested genotypes, ready to be exploited by the breeders in the future rice improvements. In general, the results of PCV and GCV indicated that each trait varied from other trait with respect to the level of PCV and GCV, hence selection and breeding methods should be different for each character. There is a wide scope for yield improvement by adopting suitable breeding methods and selection procedure, since high PCV and GCV prevailed for grain yield in all the crosses studied. Considering the results of heritability and genetic advance of all the three crosses studied, the trait, number of productive tillers had high heritability coupled with high genetic advance, hence simple selection procedure like pedigree selection can be used for the improvement of this trait. Among all the seven traits studied, the trait, number of productive tillers only showed high heritability coupled with high genetic advance with positive and significant correlation with grain yield in all three crosses indicating the reliability of this trait and also it is suggested to give more weightage to this trait during selection for yield improvement. The trait, thousand grain weight which had moderate to high PCV, GCV, heritability and desirable direct and indirect effect on yield, could also be taken into account while effecting selection. The results of path coefficient analysis also indicated the importance of number of productive tillers through direct effect and thousand grain weight, hence selection through the traits *viz.,* increased number of productive tillers along with high thousand grain weight will be effective for yield improvement.

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Electronic Journal of Plant Breeding, 9 (3) : 1067 - 1076 (Sep 2018) DOI: 10.5958/0975-928X.2018.00133.3
ISSN 0975-928X

Table 1. Variability parameters, Heritability and Genetic Advance of the F_2 population of three crosses

	AD 09493 x AD 11168					AD 08142 x Co (R) 50					BPT 2270 x AD 09493				
Traits	**PCV %**	**GCV %**	**(h^2)**	**(GA)**	**GA as % of mean**	**PCV %**	**GCV %**	**(h^2)**	**(GA)**	**GA as % of mean**	**PCV %**	**GCV %**	**(h^2)**	**(GA)**	**GA as % of mean**
DFT	5.58	5.51	97.5	1.81	1.97	72.91	72.80	79.4	2.32	0.10	3.97	3.54	88.6	2.42	2.53
PH	10.60	10.52	98.4	2.22	2.50	10.38	9.39	91.2	2.52	2.40	5.80	5.54	81.8	3.32	3.78
NPT	26.04	24.88	91.3	1.94	14.01	29.72	26.87	86.1	1.92	12.61	20.65	19.14	81.7	2.24	16.07
TGW	16.21	14.59	80.9	1.85	10.61	16.19	14.45	76.5	1.54	8.17	10.48	9.16	79.6	1.13	10.17
PL	13.07	9.11	48.6	1.51	6.22	13.15	9.94	72.3	1.82	7.53	11.74	9.98	57.1	1.67	7.15
SF %	8.33	7.23	75.3	3.41	4.11	7.00	6.44	83.7	3.16	4.10	7.00	5.89	84.6	3.84	4.32
SPY	48.17	41.64	74.8	3.28	17.52	43.97	39.04	93.2	2.68	9.39	26.20	25.29	67.2	1.82	13.57

PCV – Phenotypic Coefficient of Variation, **GCV –** Genotypic Coefficient of Variation, **h^2** – Heritability, **GA** – Genetic Advance
DFF - Days to 50 % flowering, **PH** - Plant height, **NPT** - Number of productive tillers per plant, **PL** - Panicle length, **TGW** - 1000 grain weight, **SFP** - Spikelet fertility percentage, **SPY** – Single plant yield.

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Table 2. Correlation matrix for the biometrical and architectural traits in F_2 population of three crosses studied

Cross	Trait	DFF	PH	NPT	TGW	PL	SF%	SPY
AD 09493 x AD 11168	**DFF**	**1.000**	0.030	0.060	-0.030	0.050	0.12 *	0.060
	PH		**1.000**	0.090	0.030	-0.040	0.100	0.090
	NPT			**1.000**	-0.020	0.15 **	-0.16 **	0.89 **
	TGW				**1.000**	0.19 **	0.080	-0.010
	PL					**1.000**	-0.040	0.14 *
	SF%						**1.000**	-0.16 **
	SPY							**1.000**
	Trait	**DFF**	**PH**	**NPT**	**TGW**	**PL**	**SF%**	**SPY**
AD 08142 x Co (R) 50	**DFF**	**1.000**	0.070	-0.080	-0.020	0.070	-0.030	-0.080
	PH		**1.000**	0.050	-0.040	0.030	0.080	0.050
	NPT			**1.000**	-0.040	0.110	-0.010	0.98 **
	TGW				**1.000**	-0.030	0.060	-0.060
	PL					**1.000**	0.050	0.090
	SF%						**1.000**	-0.020
	SPY							**1.000**
	Trait	**DFF**	**PH**	**NPT**	**TGW**	**PL**	**SF%**	**SPY**
BPT 2270 x AD 09493	**DFF**	**1.000**	-0.110	-0.040	0.060	-0.020	0.19 **	0.010
	PH		**1.000**	-0.080	-0.12 *	-0.12 *	-0.35 **	-0.050
	NPT			**1.000**	0.13 *	0.17 **	0.15 **	0.93 **
	TGW				**1.000**	0.030	0.16 **	0.19 **
	PL					**1.000**	0.24 **	0.19 **
	SF%						**1.000**	0.18 **
	SPY							**1.000**

Significant at 5 per cent level
** Significant at 1 per cent level

DFF - Days to 50 % flowering, **PH** - Plant height, **NPT** - Number of productive tillers per plant, **PL** - Panicle length, **TGW** - 1000 grain weight, **SFP** - Spikelet fertility percentage, **SPY** – Single plant yield.

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Table 3. Direct and indirect effects of different traits as partitioned by path analysis in F_2 population of three crosses studied

Cross	Trait	DFF	PH	NPT	TGW	PL	SF%	SPY	Residual effect
AD 09493 x AD 11168	DFF	**0.006**	0.009	0.052	-0.011	0.013	-0.009	0.056	r = 0.452
	PH	0.001	**0.007**	0.080	0.001	0.001	-0.003	0.085	
	NPT	-0.001	0.001	**0.878**	-0.001	-0.001	0.004	0.888 **	
	TGW	-0.001	-0.001	-0.020	**0.007**	0.003	-0.002	-0.013	
	PL	-0.002	-0.002	0.132	0.001	**-0.001**	0.001	0.137 *	
	SF%	-0.003	0.001	-0.138	0.001	0.004	**-0.028**	-0.164 **	
	Trait	**DFF**	**PH**	**NPT**	**TGW**	**PL**	**SF%**	**SPY**	
AD 08142 x Co (R) 50	DFF	**-0.005**	-0.001	-0.076	0.003	-0.002	-0.002	-0.081	r = 0.210
	PH	-0.003	**-0.008**	0.052	0.001	-0.001	-0.003	0.046	
	NPT	0.001	0.003	**0.977**	0.001	-0.003	0.003	0.977 **	
	TGW	0.003	0.003	-0.043	**-0.017**	0.001	0.003	-0.057	
	PL	-0.001	-0.003	0.109	0.001	**-0.028**	-0.003	0.087	
	SF%	-0.003	-0.001	-0.010	-0.001	-0.001	**-0.005**	-0.017	
	Trait	**DFF**	**PH**	**NPT**	**TGW**	**PL**	**SF%**	**SPY**	
BPT 2270 x AD 09493	DFF	**0.045**	-0.005	-0.041	0.004	-0.001	0.004	0.009	r = 0.363
	PH	-0.005	**0.045**	-0.071	-0.008	-0.004	-0.008	-0.054	
	NPT	-0.002	-0.004	**0.911**	0.009	0.005	0.003	0.927 **	
	TGW	0.003	-0.005	0.121	**0.064**	0.001	0.004	0.187 **	
	PL	-0.001	-0.006	0.155	0.002	**0.029**	0.005	0.189 **	
	SF%	0.009	-0.016	0.138	0.010	0.007	**0.022**	0.177 **	

*Significant at 5 per cent level
** Significant at 1 per cent level

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