Electronic Journal of Plant Breeding, 5(3): 531- 537 (Sep 2014)
ISSN 0975-928X

Research Note

Genetic variability and character association studies in rainfed upland rice (*Oryza sativa* L.)

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(Received: 17 Feb 2014; Accepted:25 Jun 2014)

Abstract
A study to obtain information on genetic variability and inter-relationship of grain yield and associated characters under rainfed upland conditions was carried out using 44 diverse genotypes. The analysis of variance revealed the significant differences among the genotypes for all the traits indicating presence of sufficient variability among the genotypes for various traits. High estimate of genotypic and phenotypic coefficient of variation were observed for number of grains per panicle, grain yield per plant, straw yield per plant and harvest index indicated wider genetic variation for these traits.. High value of heritability coupled with high expected genetic advance as per cent of mean were observed for the characters number of grains per panicle, grain yield per plant, straw yield per plant, harvest index, 1000-grain weight, grain L/B ratio and amylose content indicated that selection may be effective for this character. The results of correlation studies indicated that genotypic correlation coefficients were higher in magnitude than their corresponding phenotypic correlation coefficients for most of the traits. Grain yield per plant was found positively and significantly associated with plant height, panicle length, number of total tillers per plant, number of effective tillers per plant, number of grains per panicle, harvest index and 1000-grain weight at both genotypic and phenotypic levels indicating that these traits were main yield attributing traits. Path analysis revealed that straw yield per plant had the highest positive direct effect on grain yield followed by grain length, harvest index, days to maturity, protein content, number of total tillers per plant and number of grain per panicle. For maximizing the grain yield per plant emphasis should be given in selection of characters such as number of grains per panicle, straw yield per plant, harvest index and 1000 grain weight for further improvement of upland rice.

Key words:
Rice, upland, genetic variability, correlation, path analysis.

Rice (*Oryza sativa* L.) is one of the most important food crops in the world, second only to wheat in terms of annual production for human consumption. Rice belongs to family Poaceae and genus Oryza. The rice crop in India accounts for about 22 per cent of the total cropped area under cereals, and about 31 per cent of the total area under food grains (Singhal 2003). Asia is considered to be a "Rice Bowl" of the world and produced more calories and carbohydrates per hectare than any other cereal (Lu and Chang 1980). In India, rice is grown in an area of 42.56 million ha of land with a production of 95.33 million tonnes and productivity of 2240 kg/ha. Rice is grown throught India in all most all the states. In Gujarat, rice occupies about five per cent of gross cropped area of the state and it accounts about 14 per cent of total food grain production. It is grown on an average 6.5 to 7.0 lakh ha of land comprising nearly 45-50% of lowland (transplanted) and 50-55% of upland (drilled) rice. The total production of rice in the state is about 9.0 to 10.5 lakh tonnes with a productivity of 1400 to 1600 kg/ha. (Anon, 2012). The upland rice is one of the most important cereal crops of *kharif* in Panchmahal district of middle Gujarat. The crop is grown under rainfed conditions and the yield potential is very low. Average low yield of paddy in Gujarat as well as in India is due to the poor average productivity of drilled paddy. As the yield of transplanted paddy is reach at its plateau, further improvement can be done only either by heterosis breeding or by improvement of productivity of drilled paddy. At present results of heterosis breeding in rice are not so much enthusiastic. Therefore, there is urgent need to evolve short duration, high yielding and drought resistant genotypes of the rice crop best suited to the region. The information on genetic variability and character association between yield and its components are of utmost importance to initiate the breeding programme to evolve high yielding varieties. Very little work has been done on upland rice and therefore, the present study was undertaken to estimate the extant of genetic variability and character association in a set of 44 highly selected and diverse genotypes of upland rice.

The experiment was conducted with 44 diverse genotypes under rainfed upland condition during *kharif* -2012 at Agricultural Research Station, Anand Agricultural University, Derol (Gujarat). The material was grown in a randomized complete block design with three replications. Each entry was sown in a double row of three meter length with inter and intra row spacing of 30 cm and 15

cm respectively. Normal crop raised following all recommended cultural practices and plant protection measures. Two irrigations were given during crop period to save the crop. Five plants from each replication were selected at random and observations were recorded on 16 characters viz., days to 50% flowering, days to maturity, plant height (cm), panicle length (cm), number of total tillers per plant, number of effective tillers per plant, number of grains per panicle, grain yield per plant (g), straw yield per plant (g), harvest index (%), 1000-grain weight (g), grain length (mm), grain breath (mm), grain L/B ratio, amylose content (%), protein content (%).

The observations on days to 50% flowering and days to maturity were recorded on plot basis. The mean over replication of each character was subjected to statistical analysis. The estimates of genotypic and phenotypic coefficient of variation was calculated according to Burton (1952), heritability in broad sense and expected genetic advance as per the procedure of Allard (1960). The genotypic and phenotypic correlation were calculated following the method of Singh and Chaudhary (1985) whereas the path coefficient analysis as per method given by Dewey and Lu (1959).

Variability, Heritability and Genetic Advance: The results obtained under the present investigation are presented in Table 1 to 4. Analysis of variance revealed significant differences among the genotypes for all the characters. A wide range of variability was exhibited by most of the traits under study (Table 1). The wide range of variation noticed in all the characters would offer scope of selection for improvement of desirable types. The highest genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was observed for grain yield per plant followed by number of grains per panicle, straw yield per plant and harvest index while it was moderate for 1000-grain weight, grain L/B ratio and amylose content. Remaining characters showed low GCV (Table 2). The presence of high GCV for grain yield per plant, number of grains per panicle, straw yield per plant and harvest index suggested the possibility of improving and fixing these characters through affecting selection. High GCV for grain yield per plant and number of grains per panicle was also reported by Pathak and Patel (1989), Amirthadevarathinam (1990), Singh *et al.* (2000) and Seyoum *et al.* (2012) whereas Chauhan *et al.* (1993) and Sravan *et al.* (2012) observed high GCV for straw yield per plant and harvest index respectively. Amylose content showed highest heritability (99.40) followed by number of grains per panicle (94.08), grain length (91.83), straw yield per plant (85.40), protein content (84.87), harvest index (84.80), grain L/B ratio (83.80), 1000-grain weight (81.72), plant height (80.62), grain yield per plant (79.40), days to 50% flowering, (76.45), days to maturity (75.73) and grain breadth (71.43). High heritability observed for these characters is because of the fact that these characters are less influenced by environmental factors. The characters *viz.*, panicle length, number of total tillers per plant and number of effective tillers per plant showed moderate heritability. High heritability coupled with high genetic advance as percentage of mean was observed for number of grains per panicle, grain yield per plant, straw yield per plant, harvest index, 1000-grain weight, Grain L/B ratio and amylose content indicating additive gene action controlling these traits. Hence phenotypic selection may be effective for improving these characters. The characters like days to 50% flowering, days to maturity, plant height, grain length, grain breadth and protein content showed moderate genetic advance coupled with high heritability which indicating presence of both additive and non-additive gene action and improvement in this population through cyclic selection method is possible. Johnson *et al.* (1955) have also suggested that characters with high heritability coupled with high genetic advance would respond better to selection than those with high heritability and low genetic advance. Pathak and Patel (1989), Amirthadevarathinam (1990) and Chauhan *et al.* (1993) also observed high heritability and genetic advance for these traits.

Correlation: The results on correlation coefficients revealed that both genotypic and phenotypic correlations followed the same trend but the genotypic correlations were generally higher than the phenotypic correlations indicating that the phenotypic expression of correlations is reduced under the influence of environment (Table 3). It was observed that grain yield per plant had positive and significant correlation with plant height (rg = 0.477 and rp = 0.399), panicle length (rg = 0.659 and rp = 0.464), number of total tillers per plant (rg = 0.320 and rp = 0.259), number of effective tillers per plant (rg = 0.520 and rp = 0.409), number of grains per panicle (rg = 0.436 and rp = 0.370), harvest index (rg = 0.604 and rp = 0.600) and 1000-grain weight (rg = 0.328 and rp = 0.241) at both genotypic and phenotypic levels while positively and significantly correlated with straw yield (rp = 0.229) and grain length (rp = 0.255) at phenotypic level only (Table 3). Straw yield per plant and harvest index showed negative correlation among themselves. The harvest index showed significant positive correlation with grain yield per plant, while it was negatively correlated with plant height and total tillers per plant. Straw yield showed positive significant association with plant height, whereas, grain length was found positively associated with 1000-grain weight and grain L/B ratio. Other characters, grain length, protein content, straw yield per plant, grain L/B ratio, grain breadth, days to maturity and days to

50% flowering contributed positive association towards yield in respective order of magnitude. The amylose content was found negatively associated with grain yield. The strong positive correlations of plant height, panicle length, number of total tillers per plant, number of effective tillers per plant, number of grains per panicle, harvest index and 1000-grain weight with grain yield per plant indicated that these characters might be utilized as selection criteria for improving grain yield in upland rice. The observed positive correlation of grain yield with various traits was supported by earlier workers *viz*., Pathak and Patel (1989), Chandra *et al*. (2008), Ekka *et al.* (2011) and Sravan *et al.* (2012) for plant height, panicle length and 1000-grain weight; Amirthadevarathinam (1990) and Chandra *et al.* (2008) for number of total tillers per plant and number of effective tillers per plant; Deosarkar *et al.* (1989) and Chandra *et al.* (2008) for number of grains per panicle; Chauhan *et al.* (1993), Singh *et al.* (2000) and Sravan *et al*. (2012) for harvest index. However, Amirthadevarathinam (1983) reported negative association of plant height with grain yield which is controversy to the present results.

Path coefficient analysis: In the present study path coefficient analysis has been conducted taking grain yield per plant as dependent variable. The persual of the results revealed that straw yield per plant had highest direct effect on grain yield per plant followed by grain length, harvest index, days to maturity, protein content, number of total tillers per plant and number of grains per panicle (Table 4). This may indicate that direct selection of these characters is likely to be effective in increasing grain yield. Plant height and panicle length has high indirect effect via straw yield per plant and grain length while high indirect effect of grain breadth via grain L/B ratio. Harvest index was also highly contributed indirectly via grain L/B ratio and days to 50% flowering. These indirect effects had not only supported the low magnitude direct effect but also resulted in high significant positive correlation with grain yield. Grain L/B ratio, panicle length, grain breadth, 1000-grain weight and days to 50% flowering exhibited higher negative direct effects on grain yield. The observed positive direct effect of various traits on grain yield was also supported by earlier workers *viz*., Amirthadevarathinam (1990) and Chandra *et al.* (2008) for number of total tillers per plant; Chandra *et al.* (2008) for number of grains per panicle; Malini *et al.* (2007) for straw yield; Singh *et al.* (2000) and Sravan *et al.* (2012) for harvest index; Ekka *et al.* (2011) for grain length. However in contrarary to the present findings, Ekka *et al.* (2011) and Sravan *et al.* (2012) revealed that days to 50% flowering had positive direct effect on grain yield while Singh *et al.* (2000) obtained negative direct effect of number of grains per panicle on grain yield.

From the present study, it is evident that genotypes studied may provide good source of material for further breeding program. Therefore, information on the genetic parameters such as coefficient of variation, heritability, genetic advance, genetic correlation coefficient and path coefficient analysis can help the breeder to evolve suitable cultivars within a short time. On the basis of results as summarized above, it is concluded that the great deal of variability for the important characters studied even in highly selected lines under the present investigation. High heritability with high genetic advance for number of grains per panicle, straw yield per plant, harvest index, their strong and positive correlation and the positive direct effect on grain yield indicated their due importance as the indicator characters and their manipulation through selection. These characters can be utilized as selection criteria for the development of high yielding upland rice varieties.

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Table 1. Analysis of variance for sixteen characters in 44 upland rice genotypes

Sr. No.	Characters	Mean squares		
		Replication	Treatment	Error
1	Days to 50% flowering (DFF)	0.280	102.46**	9.54
2	Days to maturity	1.312	102.16**	9.86
3	Plant height (cm)	66.47	205.00**	15.20
4	Panicle length (cm)	3.29	6.56**	1.43
5	Number of total tillers per plant	1.19	2.68**	0.44
6	Number of effective tillers per plant	0.23	0.88**	0.12
7	Number of grain per panicle	113.32	655.88**	13.46
8	Grain yield per plant (g)	46.77	91.08**	7.25
9	Straw yield per plant (g)	1015.50	1444.37**	77.92
10	Harvest index (%)	90.98	62.32**	3.51
11	1000-grain weight (g)	0.011	20.88**	1.45
12	Grain length (mm)	0.006	1.37**	0.042
13	Grain breadth (mm)	0.006	0.12**	0.014
14	Grain L/B ratio	0.030	0.45**	0.027
15	Amylose content (%)	0.050	44.90**	0.093
16	Protein content (%)	0.087	0.73**	0.041

Table 2: The estimates of genotypic ($\hat{\sigma}^2_g$) and phenotypic ($\hat{\sigma}^2_p$) variance and other genetic parameters for sixteen traits in 44 upland rice genotypes

Sr. No	Characters	Mean	$\hat{\sigma}^2_g$	$\hat{\sigma}^2_p$	GCV (%)	PCV (%)	H^2 (b) (%)	GA (% of mean)
1	Days to 50% Flowering (DFF)	65.26	30.97	40.51	8.53	9.75	76.45	15.35
2	Days to Maturity	94.94	30.77	40.63	5.84	6.71	75.73	10.47
3	Plant height (cm)	87.60	63.27	78.47	9.08	10.11	80.62	16.79
4	Panicle length (cm)	15.90	1.71	3.14	8.23	11.14	54.50	12.52
5	Number of total tillers per plant	10.35	0.75	1.19	8.34	10.54	62.60	13.62
6	Number of effective tillers per plant	6.49	0.25	0.37	7.76	9.46	67.57	13.09
7	Number of grains per panicle	60.59	214.14	227.60	23.95	24.69	94.08	47.86
8	Grain yield per plant (g)	21.56	27.95	35.20	24.52	27.52	79.40	44.99
9	Straw yield per plant (g)	93.48	455.48	533.40	22.83	24.71	85.40	43.46
10	Harvest index (%)	19.20	19.60	23.11	23.06	25.04	84.80	43.75
11	1000-grain weight (g)	22.49	6.48	7.93	11.32	12.52	81.72	21.07
12	Grain length (mm)	8.85	0.45	0.49	7.51	7.86	91.83	14.80
13	Grain breadth (mm)	2.70	0.035	0.049	6.93	8.20	71.43	12.22
14	Grain L/ B ratio	3.31	0.141	0.168	11.37	12.41	83.80	21.45
15	Amylose content (%)	26.00	14.94	15.03	14.86	14.91	99.40	30.54
16	Protein content (%)	6.38	0.230	0.271	7.52	8.17	84.87	14.26

Table 3. Genotypic and phenotypic correlation between yield and other traits of upland rice under study

Characters		DFF	DTM	PLH	PL	NTTP	NETP	NGP	GYP	SYP	HI	TWT	GL	GB	L:B R	AC	PC
DFF	**Rg**	-	1.011	0.463**	0.275	0.486**	0.205	-0.105	0.012	0.306*	-0.202	0.331*	0.218	-0.045	0.158	0.374*	0.210
	Rp	-	0.966**	0.359**	0.162	0.348**	0.156	-0.092	0.041	0.244*	-0.140	0.240*	0.183	-0.064	0.152	0.319**	0.174
DTM	**Rg**			0.439**	0.264	0.464**	0.184	-0.103	0.021	0.290	-0.179	0.319*	0.235	-0.059	0.176	0.369*	0.197
	Rp			0.357**	0.166	0.347**	0.166	-0.090	0.041	0.215*	-0.124	0.229*	0.196	-0.079	0.169	0.312**	0.160
PLH	**Rg**				0.670**	0.458**	0.507**	0.298*	0.477**	0.615**	-0.143	0.251	0.517**	-0.218	0.409*	0.212	0.391**
	Rp				0.530**	0.312**	0.354**	0.262*	0.399**	0.542**	-0.135	0.193	0.439**	-0.184	0.346**	0.190	0.347**
PL	**Rg**					0.512**	0.504**	0.567**	0.659**	0.622**	0.044	0.331*	0.322*	-0.157	0.285	-0.159	0.491**
	Rp					0.325**	0.286**	0.419**	0.464**	0.507**	-0.016	0.249*	0.254*	-0.149	0.259*	-0.118	0.295**
NTTP	**Rg**						0.903**	0.300*	0.320*	0.403**	-0.095	0.003	-0.187	-0.115	-0.072	0.333*	0.385*
	Rp						0.790**	0.225*	0.259*	0.303**	-0.048	0.013	-0.140	-0.058	-0.061	0.266*	0.289**
NETP	**Rg**							0.332*	0.520**	0.280	0.127	-0.121	-0.171	-0.044	-0.115	0.270	0.297
	Rp							0.251*	0.409**	0.225*	0.101	-0.119	-0.163	-0.048	-0.091	0.224*	0.234*
NGP	**Rg**								0.436**	0.270	0.096	-0.121	0.129	-0.221	0.203	-0.086	0.091
	Rp								0.370**	0.237*	0.085	-0.111	0.127	-0.182	0.186	-0.082	0.080
GYP	**Rg**									0.192	0.604**	0.328*	0.288	0.043	0.157	-0.063	0.226
	Rp									0.229*	0.600**	0.241*	0.255*	0.023	0.145	-0.052	0.213
SYP	**Rg**										-0.649**	0.249	0.360*	-0.439**	0.473**	0.290	0.032
	Rp										-0.612**	0.209	0.325*	-0.349**	0.405**	0.261*	0.020
HI	**Rg**											0.115	-0.071	0.419**	-0.273	-0.313*	0.171
	Rp											0.068	-0.063	0.325**	-0.221*	-0.280*	0.180
TWT	**Rg**												0.447**	0.450**	0.037	0.059	0.145
	Rp												0.414**	0.392**	0.009	0.056	0.085
GL	**Rg**													-0.407**	0.852**	-0.045	0.265
	Rp													-0.309**	0.789**	-0.041	0.226*
GB	**Rg**														-0.815**	-0.068	-0.093
	Rp														-0.816**	0.059	-0.076
L:B R	**Rg**															-0.015	0.207
	Rp															-0.011	0.173
AC	**Rg**																-0.112
	Rp																-0.102

* ** Significant at 5% and 1% levels respectively. DFF: Days to 50% flowering, DTM : Days to maturity, PLH: Plant height (cm), PL: Panicle length (cm), NTTP: Number of total tillers per plant, NETP: Number of effective tillers per plant, NGP: Number of grains per panicle, GYP: Grain yield per plant (g), SYP: Straw yield per plant (g), HI: Harvest index(%), TWT: Test weight (g), GL: Grain length (mm), GB: Grain breadth (mm), L:B ratio: Length : Breadth ratio, AC: Amylose content (%), PC: Protein content (%).

Table 4 . Path coefficient analysis showing direct and indirect effects of various traits on grain yield per plant in upland rice.

Genotypes	DFF	DTM	PLH	PL	NTTP	NETP	NGP	SYP	HI	TWT	GL	GB	L:B R	AC	PC	'$r_{g'}$ with GYP
DFF	**-1.209**	1.616	-0.366	-0.533	0.303	-0.121	-0.030	1.318	-0.590	-0.442	0.917	0.079	-0.867	0.208	0.145	0.012
DTM	-1.222	**1.599**	-0.347	-0.513	0.289	-0.109	-0.030	1.249	-0.524	-0.425	0.987	0.105	-0.970	-0.205	0.136	0.021
PLH	-0.559	0.702	**-0.790**	-1.301	0.285	-0.299	0.087	2.646	-0.416	-0.335	2.171	0.385	-2.250	-0.118	0.271	0.477**
PL	-0.332	0.422	-0.529	**-1.942**	0.319	-0.298	0.165	2.678	0.129	-0.441	1.352	0.277	-1.569	0.088	0.340	0.659**
NTTP	-0.587	0.742	-0.362	-0.995	**0.623**	-0.533	0.087	1.735	-0.278	-0.004	-0.788	0.203	0.396	-0.185	0.267	0.320*
NETP	-0.247	0.294	-0.401	-0.979	0.562	**-0.591**	0.097	1.207	0.370	0.162	-0.720	0.077	0.634	-0.150	0.206	0.520**
NGP	0.127	-0.164	-0.236	-1.102	0.187	-0.196	**0.291**	1.163	0.281	0.161	0.541	0.390	-1.117	0.048	0.063	0.436**
SYP	-0.370	0.464	-0.486	-1.209	0.251	-0.166	0.079	**4.302**	-1.893	-0.332	1.514	0.775	-2.600	-0.161	0.022	0.192
HI	0.244	-0.287	0.113	-0.086	-0.059	-0.075	0.028	-2.790	**2.918**	-0.154	-0.300	-0.740	1.500	0.174	0.118	0.604**
TWT	-0.401	0.509	-0.198	-0.642	0.002	0.072	-0.035	1.072	0.336	**-1.334**	1.877	-0.794	-0.203	-0.033	0.100	0.328*
GL	-0.264	0.375	-0.408	-0.625	-0.117	0.101	0.037	1.550	-0.209	-0.596	**4.203**	0.719	-4.689	0.025	0.183	0.288
GB	0.054	-0.095	0.172	0.305	-0.071	0.026	-0.064	-1.889	1.222	-0.600	-1.710	**-1.766**	4.486	0.038	-0.065	0.043
L:B R	-0.191	0.282	-0.323	-0.554	-0.045	0.068	0.059	2.033	-0.796	-0.049	3.582	1.440	**-5.502**	0.008	0.143	0.157
AC	-0.452	0.590	-0.168	0.309	0.208	-0.160	-0.025	1.248	-0.912	-0.078	-0.188	0.120	0.081	**-0.556**	-0.078	-0.063
PC	-0.253	0.315	-0.309	-0.954	0.240	-0.176	0.026	0.140	0.498	-0.193	1.112	0.165	-1.139	0.062	**0.692**	0.226

Note: Diagonal values are direct effects

Residual effect = 0.0088, * ** Significant at 5% and 1% levels respectively.

DFF: Days to 50% flowering, DTM : Days to maturity, PLH: Plant height (cm), PL: Panicle length (cm), NTTP: Number of total tillers per plant, NETP: Number of effective tillers per plant, NGP: Number of grains per panicle, SYP: Straw yield per plant (g), HI: Harvest index (%), TWT: Test weight (g), GL: Grain length (mm), GB: Grain breadth (mm), L:B ratio: Grain Length : Breadth ratio, AC: Amylose content (%), PC: Protein content (%), GYP: Grain yield per plant (g).