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Genetic Parameters and Selection Indices in F_3 Progenies of Hill Rice Genotypes

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Abstract

The F_3 population of eighteen different cross combinations using five local and seven exotic genotypes was used to study the genetic parameters, heritability, correlation and path coefficients for fourteen quantitative characters under temperate conditions. The selected progenies showed highly significant difference for most of the agro-morphological characters. Comparatively high phenotypic coefficients of variation were observed for all the character than genotypic coefficient variation. High heritability (%) was recorded for days to 50% flowering (96%) followed by days to maturity (95%) and grain yield per plant (84%). High genetic advance were observed for grain yield (47%) followed by biological yield/plant (27%) and harvest index (25%). Days to 50% flowering was positively and significantly correlated with days to maturity, grain length with LB ratio flag leaf length with grain breadth and panicle length with grain breadth at genotypic level. Path coefficient analysis revealed that harvest index and biological yield has highest direct effect on yield followed by days to maturity and number of grain per panicle. Biological yield per plant has highest indirect effect on yield via days to flowering followed by grain weight via biological yield per plant, grain breadth via days to 50% flowering and flag leaf length via biological yield per plant. Therefore, information on the genetic parameters such as coefficient of variation, heritability, genetic advance and the influence of environment on the expression of these characters will help the breeder to evolve suitable cultivars within a short time for hill ecologies.

Keywords: correlation coefficients, early generation, heritability, path analysis, rice, temperate conditions

Introduction

Rice (*Oryza sativa* L.) is an important cereal crop and staple food of Kashmir. Its demand is increasing day by day with the increase in human population. It is grown in both temperate and sub temperate zones of valley within an altitude of 1650 m to 2200 m a.s.l. (above mean sea level) representing temperate region of the country (Ahmad *et al*., 1999). The rice crop in valley is frequently challenged by various biotic and abiotic stresses throughout the growing season. Though during past two and half decades, a few high yielding rice varieties have been released, rice productivity in the valley has reached a plateau in the recent years and chances of further yield enhancement are scanty due to low genetic variability in hill rice cultivars (Sanghera and Wani, 2008). The diversity in agro-climate, coupled with farmers' preferences, give rise to wide range of grain preference from bold and coarse to fine grains in temperate regions. In Kashmir valley, rice occupies an area of 0.141 million ha with annual production of 0.34 million tons and average productivity 2.5 t/ha (Anonymous, 2010).

In Kashmir, breeding programs in this crop has reached to a point of diminishing returns and it is feared that unless new diversity is infused into the breeding germplasm, humanity face catastrophic reductions in productivity if the climate turns adverse (Sanghera and Rather, 2011). Armed with the understanding of specific adaptation, the local constraints to production in the context of climate change and the changing consumer requirements of different geographic areas for new cultivars. It is worthwhile to highlight that hybridization between diverse germplasm followed by selection may result in cultivars with improved stress tolerance, better adaptation, quality traits and yield. Knowledge on genetic variability is the basic requirement in any crop improvement program.

Yield characters are a complex entity and inheritance of yield depends on a number of characters which are often polygenic in nature and are highly affected by environmental factors (Nadarajan and Gunasekaran, 2005). Selection of promising genotypes, in a breeding program, is based on various criteria, most importantly final crop yield and its quality (Kozak *et al.,* 2008). Relationships between yield and yield contributing traits also play an important role in plant breeding. To detect traits, having an influence on a final traits e.g. yield, path analysis is commonly applied (Kozak and Kang, 2006; Shipley, 2002). The path coefficient analysis provides information on internal relation among the investigated characteristics, as well as their effect on certain traits. The traits influencing yield may directly or indirectly affect each other and for the purpose of breeding programs, they should be subject to separate analysis. The relationship between yield and its

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main economic components, in segregating populations of rice, has been studied by several researchers (Kumar *et al.,* 2009; Surek and Beser, 2005; Yogameenakshi and Vivekanandan, 2010). The information on relative direct and indirect contribution of each component character toward yield will help breeders to formulate the effective criteria in selecting desirable genotypes in early segregating populations.

In view of this, hybridization programme was initiated using five local and seven exotic genotypes having desirable characters to diversifying the narrow genetic variability and determine genetic parameters and selection indices in rice to have a variety which is high yielding combined with other desirable economic characters under temperate Kashmir conditions. The knowledge of mode of inheritance, variability and association studies is essential to have effective selection programme for isolation of superior genotypes. The present study, reports the extent of genetic variability, interrelationships and path coefficient for yield and yield contributing traits in rice from F_3 generation of eighteen crosses evaluated under temperate conditions. The information reported will help in predicting of the effectiveness of selection in early generation selection.

Materials and methods

In the present study, F_3 generation material obtained from five local and seven exotic genotypes having desirable characters crosses (Tab. 1) was chosen and evaluated at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Mountain Research Centre for Field Crops, Khudwani, Anantnag, at an elevation of 1560 m a.s.l. (above mean sea level) representing temperate area of J&K, India in Kharif 2011.

Tab. 1. Cross combination of F_3 progenies of hill rice used as experimental material

S. No	Cross Combinations
1	Vivek Dhan-82 x SKAU-382
2	Vivek Dhan-82 x Jehlum
3	VL Dhan-62 x c
4	VL Dhan-62 x China-1039
5	VL Dhan-62 x SKAU-382
6	VL Dhan-86 x Jehlum
7	VL Dhan-86 x SKAU-5
8	VL Dhan-86 x SKAU-382
9	VL Dhan-154 x Jehlum
10	VL Dhan-154 X China 1039
11	VL Dhan-206 X China 1039
12	VL Dhan-207/SKAU-341
13	VL Dhan-207 X SKAU-382
14	VL Dhan-209 X SKAU-382
15	Jehlum x Vivek Dhan-82
16	SKAU-5 x VL Dhan-62
17	SR-1 x VL Dhan-62
18	SKAU-5 x VL Dhan-65

The 30 days old seedlings of selected F_3 progenies of aforementioned crosses along with two checks Jhelum and Shalimar Rice-1 were transplanted in the experimental field with inter-row and intra-row spacing of 20 cm and 15 cm, respectively. The experimental plot size was 3 rows of 6 m with three replications. Observations were taken on ten single plants randomly selected from each of the F_3 population and checks of all the crosses in each replication. Data were recorded for days to 50% flowering, days to maturity, 100 grain wt (g), grain length (mm), grain breadth (mm), L/B ratio, plant height (cm), panicle length (cm), no. of tiller per plant, flag leaf length (cm), biological yield (g/plant), harvest index (%), no. of grains per panicle and grain yield (g/plant). The genetic parameters were estimated based on the method suggested by Al Jibouri *et al.* (1958). The genotypic and phenotypic correlations were estimated following Johnson *et al.* (1955) and path analysis was carried out following Dewey and Lu (1959). All statistical analyses were performed using OPSTAT ONLINE statistical package and interpretations were made accordingly.

Results and discussion

Genetic improvement for quantitative traits can be achieved through a clear understanding of the nature and amount of variability present in the genetic stocks and the extent to which the desirable traits are heritable. In this study, an attempt has been made to diversify the narrow genetic variability in rice under temperate Kashmir conditions by generating eighteen different cross combinations using five local and seven exotic genotypes having desirable characters. The results of variance analysis showed that there were significant differences among lines for all the traits examined. Wide range of variation observed for all the characters provides a large scope for selection on the basis of phenotypic value of the component characters. Estimates for range, mean, phenotypic coefficient of variation (PCV) genotypic coefficient of variation (GCV), heritability, and genetic advance as percentage of mean for selected lines in F_3 populations are presented in Tab. 2. High value of phenotypic coefficient of variation was observed for grain yield per plant followed by harvest index and biological yield per plant, the lowest estimate was recorded for days to maturity. A close proximity between GCV and PCV for all the characters under study indicates less influence of environment on these characters. Similar findings were earlier reported by Singh and Chakraborty (1996), Devi *et al.* (2006), Prajapati *et al.* (2011). In addition, high heritability (bs) (%) was recorded for days to flowering (96%) followed by days to maturity (95%) and grain yield per plant (84%), the lowest was in number of grains per panicle (24%). Similar finding was earlier reported by Verma (2010) and Anandrao *et al.* (2011). Heritability is a good index of transmission of characters from parents to its progeny. The estimates of heritability

Tab. 2. Genetic variability parameters for fourteen agro-morphological characters in F_3 population of hill rice

Characters	Range	Mean	GCV	PCV	GA % of mean	Heritability (%)
Days to 50% flowering	74.66-82.66	79.78	3.64	3.71	7.37	96.56
Days to maturity	126.66-137.66	132.20	2.70	2.76	5.42	95.48
100 grain wt (g)	2.21-3.06	2.60	6.72	12.97	7.16	26.79
Grain length (mm)	3.08-4.35	3.95	5.57	7.24	8.83	59.24
Grain breadth (mm)	1.04-1.25	1.07	4.72	7.13	0.40	66.19
L/B ratio	2.87-4.09	3.69	6.98	8.97	11.19	60.59
Plant height (cm)	118.06-140.04	127.99	3.60	7.00	1.99	51.42
Panicle length (cm)	20.53-26.13	23.68	5.46	7.76	7.92	49.55
No. of tiller per plant	11.53-17.4	14.03	13.73	17.44	22.27	61.97
Flag leaf length (cm)	27.00-38.53	34.25	9.17	12.44	13.91	54.26
Biological yield (g/plant)	320.00-576.66	436.06	19.84	23.02	35.21	74.26
Harvest index (%)	32.40-51.28	42.77	14.52	17.32	25.08	70.31
No. of grain per panicle	155.33-220.66	196.94	7.47	15.25	7.55	24.02
Grain yield (g/plant)	94.33-273.33	186.07	24.87	27.12	47.00	84.14

help the plant breeder in selection of elite genotypes from diverse genetic population. High value of genetic advance (%) was observed for grain yield (47%) followed by biological yield/plant (27%) and harvest index (25%). Therefore, direct selection on the basis of phenotype for these characters will be beneficial. Plant breeder uses selection for improving the architecture of a crop by management of available genetic variability (Gravois and McNew, 1993; Mehetre *et al*., 1994).

Tab. 3. Correlation analysis among fourteen agro-morphological characters in F_3 population of hill rice

Characters	level	DF	DM	100 GW	GL	GB	L:B	PH	PL	NT	FLL	BY	HI	NGP
Days to Maturity	P	0.881^{**}												
	G	0.928^{**}												
100 Grain wt	P	0.116^{NS}	0.089^{NS}											
	G	0.215^{NS}	0.234^{NS}											
Grain Length	P	0.083^{NS}	0.122^{NS}	0.354^{**}										
	G	0.104^{NS}	0.193^{NS}	0.365^{**}										
Grain Breadth	P	-0.130^{NS}	-0.103^{NS}	0.145^{NS}	-0.006^{NS}									
	G	-0.907^{**}	-0.731^{**}	-0.498^{**}	-0.757									
L/B ratio	P	0.114^{NS}	0.125^{NS}	0.197^{NS}	0.821^{**}	-0.570^{**}								
	G	0.160^{NS}	0.203^{NS}	0.316^{*}	0.910^{**}	-0.956								
Plant height	P	0.085^{NS}	0.017^{NS}	0.287^{*}	0.283^{*}	0.110^{NS}	0.165^{NS}							
	G	0.075^{NS}	-0.027^{NS}	0.960^{**}	0.627^{**}	0.573^{**}	0.460^{**}							
Panicle length	P	-0.307^{*}	-0.518^{**}	-0.014^{NS}	-0.054^{NS}	-0.048^{NS}	-0.002^{NS}	0.351^{**}						
	G	-0.476^{**}	-0.715^{**}	0.404^{**}	0.142^{NS}	0.966^{**}	0.023^{NS}	0.890^{**}						
No. of Tillers per Plant	P	-0.068^{NS}	-0.110^{NS}	-0.116^{NS}	0.199^{NS}	-0.065^{NS}	0.207^{NS}	-0.111^{NS}	0.071^{NS}					
	G	-0.116^{NS}	-0.143^{NS}	-0.552^{**}	0.141^{NS}	-0.955	0.291^{*}	-0.341^{*}	0.212^{NS}					
Flag Leaf Length	P	-0.193^{NS}	-0.279^{*}	-0.316^{*}	-0.174^{NS}	0.015^{NS}	-0.151^{NS}	-0.043^{NS}	0.196^{NS}	0.219^{NS}				
	G	-0.271^{*}	-0.374^{**}	-0.733^{**}	-0.145^{NS}	0.975^{**}	-0.260^{NS}	-0.564^{**}	0.243^{NS}	0.552^{**}				
Biological Yield	P	0.410^{**}	0.293^{*}	0.132^{NS}	0.041^{NS}	-0.078^{NS}	0.055^{NS}	0.174^{NS}	0.023^{NS}	0.171^{NS}	0.217^{NS}			
	G	0.455^{**}	0.351^{**}	0.435^{**}	-0.030^{NS}	-0.767^{**}	0.023^{NS}	-0.221^{NS}	-0.160^{NS}	0.173^{NS}	0.405^{**}			
Harvest Index	P	-0.247^{NS}	-0.300^{*}	-0.168^{NS}	0.152^{NS}	-0.265^{NS}	0.290^{*}	-0.010^{NS}	0.205^{NS}	0.114^{NS}	0.136^{NS}	-0.057^{NS}		
	G	-0.276^{*}	-0.354^{**}	-0.285^{*}	0.332^{*}	-0.951	0.430^{**}	0.395^{**}	0.430^{**}	0.191^{NS}	0.180^{NS}	0.113^{NS}		
No. of Grain per Panicle	P	0.194^{NS}	0.117^{NS}	0.053^{NS}	-0.122^{NS}	0.184^{NS}	-0.203^{NS}	-0.197^{NS}	-0.038^{NS}	-0.057^{NS}	-0.205^{NS}	-0.196^{NS}	-0.133^{NS}	
	G	0.359^{**}	0.230^{NS}	-0.171^{NS}	-0.171^{NS}	0.814^{**}	-0.238^{NS}	-0.149^{NS}	0.040^{NS}	0.164^{NS}	-0.214^{NS}	-0.173^{NS}	-0.533^{**}	
Grain Yield	P	0.203^{NS}	0.087^{NS}	0.013^{NS}	0.139^{NS}	-0.205^{NS}	0.220^{NS}	0.122^{NS}	0.127^{NS}	0.218^{NS}	0.271^{*}	0.777^{**}	0.572^{**}	-0.213^{NS}
	G	0.219^{NS}	0.113^{NS}	0.154^{NS}	0.171^{NS}	-0.903	0.253^{NS}	0.082^{NS}	0.113^{NS}	0.247^{NS}	0.405^{**}	0.842^{**}	0.624^{**}	-0.363^{**}

where, P=phenotypic, G=genotypic correlation coeficient, DF= days to 50% flowering, DM= days to maturity, 100 GW =100 grain weight, GL=grain length, GB=grain breadth, L:B= grain length breadth ratio, PH= plant height, PL=Panicle length, NT=number of tillers perplant, FLL= flag leaf length, BY=biological yield per plant, HI=Harvest Index, NGP=number of grain per panicle

Tab. 4. Path coefficient analysis for fourteen agro-morphological characters in F_3 population of hill rice

Characters	DF	DM	100 GW	GL	GB	L:B	PH	PL	NT	FLL	BY	HI	NGP
DF	-0.3994	0.4060	0.0057	-0.0050	-0.0296	0.0087	-0.0009	-0.0151	0.0012	-0.0036	0.3783	-0.1917	0.0639
DM	-0.3705	0.4376	0.0062	-0.0093	-0.0239	0.0110	0.0003	-0.0227	0.0015	-0.0050	0.2922	-0.2456	0.0409
100 GW	-0.0860	0.1026	0.0266	-0.0176	-0.0163	0.0172	-0.0146	0.0128	0.0058	-0.0098	0.3615	-0.1978	-0.0303
GL	-0.0414	0.0845	0.0097	-0.0483	-0.0574	0.0550	-0.0073	0.0045	-0.0015	-0.0019	-0.0249	0.2306	-0.0305
GB	0.3621	-0.3198	-0.0133	0.0849	0.0327	-0.0851	-0.0066	0.0339	0.0141	0.0170	-0.6379	-0.7298	0.1447
L:B	-0.0638	0.0886	0.0084	-0.0488	-0.0510	0.0545	-0.0053	0.0007	-0.0030	-0.0035	0.0192	0.2988	-0.0423
PH	-0.0301	-0.0118	0.0336	-0.0303	0.0187	0.0251	-0.0116	0.0283	0.0036	-0.0075	-0.1839	0.2741	-0.0265
PL	0.1903	-0.3129	0.0108	-0.0069	0.0348	0.0013	-0.0103	0.0318	-0.0022	0.0033	-0.1327	0.2986	0.0071
NT	0.0465	-0.0627	-0.0147	-0.0068	-0.0442	0.0158	0.0040	0.0067	-0.0104	0.0074	0.1437	0.1324	0.0291
FL	0.1082	-0.1637	-0.0195	0.0070	0.0416	-0.0142	0.0065	0.0077	-0.0058	0.0134	0.3369	0.1251	-0.0381
BY	-0.1817	0.1538	0.0116	0.0015	-0.0250	0.0013	0.0026	-0.0051	-0.0018	0.0054	0.8316	0.0782	-0.0307
HI	0.1103	-0.1548	-0.0076	-0.0160	-0.0343	0.0235	-0.0046	0.0137	-0.0020	0.0024	0.0937	0.6942	-0.0948
NG	-0.1436	0.1006	-0.0045	0.0083	0.0266	-0.0130	0.0017	0.0013	-0.0017	-0.0029	-0.1435	-0.3700	0.1778

Where, DF= days to 50% flowering, DM= days to maturity, 100 GW =100 grain weight, GL=grain length, GB=grain breadth, L:B= grain length breadth ratio, PH= plant height, PL=Panicle length, NT=number of tillers per plant, FLL= flag leaf length, BY=biological yield per plant, HI=Harvest Index, NGP=number of grain per panicle

The degree of correlation among yield contributing characters is an important factor, especially regarding economic and complex characters such as yield. Direct selection in such cases is less effective, hence, association analysis was undertaken to determine the direction of selection and number of characters to be considered in improving grain yield. Correlation coefficients of studied traits (Tab. 3) showed that there was a highly significant correlation between grain yield with biological yield per plant (P=0.777, G=0.842), harvest index (P=0.572, G=0.624) and with flag leaf length (P=0.271, G=0.426) and significant negative correlation with number of grain per panicle (P=-0.213, G=-0.363). A strong correlation of grain yield with these traits indicated that, simultaneous improvement of these traits is possible. Previous studies have mentioned similar findings (Abarshahr *et al.,* 2011; Lanceras *et al.,* 2004; Muhammed *et al.,* 2007; Samonte *et al.,* 1998). Days to flowering was positively and significantly correlated with days to maturity (G=0.928, P= 0.881), grain length with LB ratio (G=0.910, P= 0.821), flag leaf length with grain breadth (G=0.975, P=0.175) and panicle length with plant height (G=0.890, P=0.359). It suggests that, priority should be given to these traits while making selection for yield improvement.

Path coefficient analysis of yield components revealed that harvest index and biological yield has highest direct effect on yield followed by days to maturity and Number of grain per panicle (Tab. 4). All direct effect towards grain yield per plant was positive except days to flower, grain length, plant height and number of tiller per plant. Biological yield per plant has highest indirect effect on yield via days to flowering followed by grain weight via biological yield per plant, grain breadth via days to 50 % flowering and flag leaf length via biological yield per plant. Results on importance of direct effect of number grain per panicles were also reported by several researchers (Madhavilatha *et al.,* 2005; Yadav and Bhushan, 2001; Yogameenakshi and Vivekanandan, 2010). The direct effect of days to flowering was negative (-0.3994) but it showed high indirect effect via days to maturity (0.4060). Similarly grain length has negative direct effect on grain yield (-0.0483) but it showed high indirect positive effect on it through the harvest index (0.2306).

The traits (plant height, panicles per plant, 1000-grain weight, grain length, grain width, filled grains per panicle and non-filled grains per panicle) had a direct effect on yield if other traits were kept constant. But the magnitude of direct effect of the panicles per plant was high followed by number of grains per panicle, confirming the results of Kole *et al.* (2008), Kiani and Nematzadeh (2012). Then, appropriate selection indices should be formulated using these traits for yield improvement. The residual effect was 0.504, which indicated that the contribution of component traits on grain yield was 74.60 percent by eight traits studied in path analysis.

In this study genetic improvement for quantitative traits can be achieved through a clear understanding of the nature and amount of variability present in the genetic stocks and the extent to which the desirable traits are heritable. Therefore, information on the genetic parameters such as coefficient of variation, heritability, genetic advance and the influence of environment on the expression of these characters will help the breeder to evolve suitable cultivars within a short time.

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