Environment & Ecology 29 (2) : 690—695, 2011
 ISSN 0970-0420

Variation and Association Among Yield and Yield Components in Upland Rice (*Oryza sativa* L.)

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Abstract

A study of genetic variation and interrelationship of grain yield and its component traits in upland direct seeded rice was carried out using 49 advanced breeding lines. High genotypic coefficient of variation was exhibited for grain yield/plant followed by spikelet sterility (%), biological yield/plant, unfilled grains/ panicle, harvest index, plant height and filled grains/panicle characters. Grain yield/plant had significant positive correlation with biological yield, harvest index, panicles/plant, test weight, flag leaf length, plant height and panicle length. Path analysis revealed that the biological yield was the major contributor of grain yield/plant followed by harvest index and spikelets.panicle. For maximizing the grain yield/plant, emphasis should be given for higher biological yield, harvest index and more number of spikelets/ panicle.

Key words : Character associations, Path analysis, Yield components, Upland rice.

Progress in plant breeding requires a continuous supply of genes or gene complexes to meet needs that may or may not be foreseen. Genetic diversity in rice is essential to sustainable levels of high productivity. The systematic breeding program involves the step like creating genetic variability, practicing selection and utilization of selected genotypes to evolve promissing lines. Estimates of heritability and genetic advance will play an important role in exploiting future research for rice improvement. Correlation studies permit only a measure of relationship between two traits. Hence path coefficient analysis becomes necessary as it indicates separation of direct and indirect effects via other related traits by partitioning through correlation coefficient that helps in designing appropriate breeding procedure for evolving high yielding genotypes. The present investigation was conducted aiming to assess the range of variability, heritability and genetic advance and association between yield and yield component traits in upland rice of late sown condition.

Methods

The present experiment was conducted with 49 diverse genotypes under rainfed upland and late sowing condition during *kharif* 2009 at Field Experimentation Center, Department of Genetics and Plant Breeding, SHIATS, Allahabad in randomized complete block design. Each entry was sown in five row plots of 5 m length with 20 cm inter row space. Five plants from each replication were selected at random and observations were recorded on 14 characters viz., plant height (cm), panicle length (cm), flag leaf length (cm), flag leaf width (cm), panicles/plant, spikelets/panicle, filled grains/panicle, unfilled grains/panicle, spikelet sterility (%), test weight (g), yield/plant (g). Days to 50% flowering was computed on plot basis. The mean over replication of each character was subjected to statistical analysis. The phenotypic, genotypic coefficient of variability (PCV, GCV), heritability in broad sense and expected genetic advance at 5% selection internsity were computed by using formulae suggested by Johnson et al. (1). The phenotypic and genotypic correlations were calculated following the method of Singh and Choudhary (2) and path coefficient analysis as per method given by Dewey and Lu (3).

Results and Discussion

Analysis of variance revealed significant differ-

Table 1. Range, mean, phenotypic genotypic coefficients of variation (PCV, GCV), heritability (h^2) and genetic advance (GA) for grain yield and associated characters in upland rice.

	Characters	Range	Mean	PCV (%)	GCV (%)	h^2 (%)	GA
1	Days to 50% flowering	58.33—90.33	77.21	09.26	09.19	98	14.49
2	Plant height (cm)	63.20—96.50	80.00	12.43	12.37	97	20.30
3	Flag leaf length (cm)	17.86—22.17	19.73	06.45	06.20	92	02.42
4	Flag leaf width (cm)	0.89—1.27	01.05	09.36	08.57	84	00.17
5	Panicles/plant	2.90—4.0	03.59	08.49	07.02	68	00.43
6	Panicle length (cm)	17.50—20.80	18.74	04.51	03.79	71	01.23
7	Spikelets/panicle	54.9—81.6	66.89	09.83	09.72	98	13.23
8	Filled grains/panicle	42.43—71.93	56.64	11.37	11.07	95	12.58
9	Unfilled grains/panicles	7.03—15.23	10.29	21.62	19.15	78	03.59
10	Spikelet sterility (%)	10.24—27.60	15.42	22.27	20.02	81	05.72
11	Biological yield/plant	15.77—30.06	21.34	19.81	19.18	94	08.16
12	Harvest index (%)	27.34—48.00	37.86	13.12	12.62	93	09.46
13	Test weight (g)	18.73—26.08	21.40	10.47	10.31	97	04.48
14	Grain yield/plant (g)	4.50—13.56	08.15	27.37	26.69	95	04.37

ences among the genotypes for all the characters. A wide range of variability was exhibited by most of the traits under study (Table 1). Plant height ranged from 63.20 (TRC-87—251) to 96.50 (BAU/GVT437-06). Panicle length varied from 17.50 (Govind) to 20.80 (RR433-1) and showed less phenotypic variation.

Table 2. Phenotypic (rp) and genotypic (rg) correlation between grain yield and some agronomic traits in upland rice. (*) and (**) Significant at 5% and 1% levels of significance, respectively.

Characters		Plant height	Flag Leaf length	Flag Leaf width	Panicles/ plant	Spikelets/ panicle	Panicle length	Filled grains
Days to 50% flowering	G	-0.4272	-0.1070	0.2698	-0.3587	0.0143	-0.0401	-0.1403
	P	-0.4218	-0.1050	0.2365	-0.3006	0.0153	-0.0439	-0.1334
Plant height	G	**1.00**	0.4279	0.0109	0.2828*	0.0141	0.4477**	0.0540
	P	**1.00**	0.4132**	0.0145	0.2454	0.0171	0.3756**	0.0541
Flag leaf length	G		**1.00**	0.6155**	0.1710	0.0914	0.1882	0.1059
	P		**1.00**	0.5632**	0.1419	0.0891	0.1755	0.1046
Flag leaf width	G			**1.00**	-0.0687	-0.0477	0.3879*	-0.0847
	P			**1.00**	-0.0293	-0.0384	0.3009*	-0.0741
Panicles/plant	G				**1.00**	0.1971	0.2090	0.2729*
	P				**1.00**	0.1678	0.1183	0.2145
Spikelets/panicle	G					**1.00**	-0.0325	0.9526**
	P					**1.00**	-0.0396	0.9358**
Panicle length	G						**1.00**	-0.0267
	P						**1.00**	-0.0220
Filled grains	G							**1.00**
	P							**1.00**
Unfilled grains	G							
	P							
Spikelet sterility	G							
	P							
Biological yield/Pl	G							
	P							
Harvest index	G							
	P							
Test weight	G							
	P							

Table 2. Continued.

Characters		Unfilled grains	Spikelet sterility	Biological yield/pl	Harvest index	Test weight	Yield/ plant
Days to 50% flowering	G	0.4984	0.4943**	-0.3648	-0.3018	-0.3923	-0.3944
	P	0.4340**	0.4320**	-0.3533	-0.2890	-0.3774	-0.3847
Plant height	G	-0.1235	-0.1136	0.3402*	0.1056	0.3975**	0.3058*
	P	-0.1097	-0.1035	0.3283*	0.0994	0.3918**	0.2959*
Flag leaf length	G	-0.0809	-0.1387	0.3981**	0.2110	0.2842*	0.4039**
	P	-0.0748	-0.1231	0.3706**	0.2010	0.2740*	0.3825**
Flag leaf width	G	0.0911	0.1102	0.0921	-0.1976	0.1749	-0.0286
	P	0.0731	0.0962	0.0834	-0.1642	0.1518	-0.0203
Panicles/plant	G	-0.2675	-0.3508	0.5194**	0.5114**	0.3266*	0.6065**
	P	-0.1803	-0.2308	0.4168**	0.4123**	0.2694	0.4911**
Spikelets/panicle	G	0.2547	-0.2327	0.0242	0.2424	-0.0421	0.1124
	P	0.2282	-0.2108	0.0197	0.2351	-0.0368	0.1077
Panicle length	G	-0.0455	-0.0167	0.3137*	0.1210	0.2405	0.2758*
	P	-0.0665	-0.0299	0.2792*	0.0811	0.1772	0.2366
Filled grains	G	-0.0516	-0.5156	0.1048	0.3882**	0.0103	0.2351
	P	-0.1212	-0.5254	0.0907	0.3767**	0.0158	0.2244
Unfilled grains	G	**1.00**	0.8769**	-0.2728	-0.4441	-0.2026	-0.3939
	P	**1.00**	0.8820**	-0.2283	-0.3990	-0.1745	-0.3495
Spikelet sterility	G		**1.00**	-0.2947	-0.5449	-0.2022	-0.4489
	P		**1.00**	-0.2489	-0.4828	-0.1810	-0.3971
Biological yield/Pl	G			**1.00**	0.3559**	0.5889**	0.8871**
	P			**1.00**	0.3303*	0.5559**	0.8819**
Harvest index	G				**1.00**	-0.0196	0.7366**
	P				**1.00**	-0.0179	0.7236**
Test weight	G					**1.00**	0.4008**
	P					**100**	0.3821**

RRU-2840 had the shortest (17.80 cm) flag leaf length whereas RR433 -1 the longest (22.17 cm). Maximum and minimum width of flag leaf was recorded in OR 2084-2 (1.27) and BAU 409-05 (0.89), respectively. Panicles/plant varied from 2.90 (R 1448-35-18-3-1) to 4.0 (PY-84). The genotypes had appreciable range of variation for filled grains (42.43-71.93), unfilled grains (7.03—15.23) and spikelet sterility (%) (10.24—27.60). Biological yield and harvest index exhibited 15.77 (JGL 11097) to 30.06 (R433-1) and 27.34 (R-1829—RF-3) to 48 (BAU/GVT 471-08), respectively. The minimum test weight was observed in BAU/GVT 470-07 (18.73) and maximum in RR-410-79-1-B-D2—B (26.08). A wide range of variation i.e., 58.33 days in Birsa Dhan 108 and 90.33 in R 1829-RF-3 were observed for days to 50% flowering. Grain yield/plant had considerable range of variation, the minimum and maximum were being recorded in R1829-RF-3 (4.50) and BAU/GVT 471-08 (13.56), respectively. Chauhan and Tandon (4), Katch et al. (5) and Ramalingam et al. (6) also reported similar results of a wide range of variability. The GCV was high for grain yield/plant (26.69), spikelet sterility (20.02%), biological yield/plant (19.18) and unfilled grains (19.15) whereas the estimates were low to moderate for the remaining characters (Table 1). The closeness between estimates of PCV and GCV for days to 50% flowering, test weight, biological yield, filled grains, spikelets/panicle, flag leaf length and plant height suggested that these characters might be less influenced by the environmental factors. The findings were in close agreement with those of Chauhan and Tandon (4), Gamathinnayagam (7) and Chauhan et al. (8).

The heritability estimates ranged from 68 (panicles/plant) to 98% (days to 50% flowering and spikelets/panicle). Most of the characters showed high heritability estimates. High heritability estimates with high genetic advance were recorded for 50% flowering, spikelets/panicle, filled grains/panicle and plant height indicating the predominance of additive gene effects in the expression of the traits and easy to phenotypic selection. The findings of the present study

Table 3. Path Coefficient analysis showing direct (diagonal) and indirect effects of yield and other component characters at genotypic and phenotypic level.

	Characters		Days to 50% flowering	Plant height	Flag leaf length	Flag leaf width	Panicles plant	Panicle length	Spikelets/ panicle
1	Days to 50% flowering	G	0.0178	-0.0076	-0.0019	0.0048	-0.0064	-0.0007	0.0003
		P	0.0166	-0.0070	-0.0017	0.0039	-0.0050	-0.0007	0.0003
2	Plant height	G	-0.0181	**0.0425**	0.0182	0.0005	0.0120	0.0190	0.0006
		P	-0.0070	**0.0166**	0.0069	0.0002	0.0041	0.0062	0.0003
3	Flag leaf length	G	-0.0009	0.0037	**0.0085**	0.0053	0.0015	0.0033	0.0008
		P	-0.0035	0.0137	**0.0332**	0.0187	0.0047	0.0100	0.0030
4	Flag leaf width	G	-0.0016	-0.0001	-0.0037	**-0.0060**	0.0004	-0.0011	0.0003
		P	-0.0047	-0.0003	-0.0112	**-0.0199**	0.0006	-0.0035	0.0008
5	Panicles/plant	G	0.0062	-0.0049	-0.0029	0.0012	**-0.0172**	-0.0036	-0.0034
		P	0.0016	-0.0013	-0.0007	0.0002	**-0.0052**	-0.0006	-0.0009
6	Panicle length	G	0.0011	-0.0118	-0.0102	-0.0049	-0.0055	**-0.0263**	0.0009
		P	0.0007	-0.0056	-0.0045	-0.0026	-0.0018	**-0.0150**	0.0006
7	Spikelets/panicle	G	0.0052	0.0051	0.0330	-0.0172	0.0711	-0.0117	**0.3609**
		P	-0.0012	-0.0013	-0.0069	0.0030	-0.0130	0.0031	**-0.0775**
8	Filled grains	G	0.0707	-0.0272	-0.0534	0.0427	-0.1375	0.0135	-0.4800
		P	-0.0052	0.0021	0.0041	-0.0029	0.0084	-0.0009	0.0365
9	Unfilled grains	G	0.0606	-0.0150	-0.0098	0.0111	-0.0325	-0.0055	0.0310
		P	0.0195	-0.0049	-0.0034	0.0033	-0.0081	-0.0030	0.0103
10	Spikelets sterility	G	-0.1241	0.0285	0.0348	-0.0277	0.0881	0.0042	0.0584
		P	-0.0075	0.0018	0.0021	-0.0017	0.0040	0.0005	0.0037
11	Biological yield/Pl	G	-0.2655	0.2476	0.2898	0.0671	0.3780	0.0176	0.2284
		P	-0.2569	0.2387	0.2695	0.0606	0.3030	0.0144	0.2030
12	Harvest index	G	-0.1546	0.0541	0.1081	-0.1013	0.2620	0.0620	0.1242
		P	-0.1424	0.0490	0.0991	-0.0809	0.2032	0.0400	0.1159
13	Test weight	G	0.0090	-0.0091	-0.0065	-0.0040	-0.0075	-0.0055	0.0010
		P	0.0054	-0.0056	-0.0039	-0.0022	-0.0039	-0.0025	0.0005

Table 3. Continued.

	Characters		Filled grains	Unfilled grains	Spikelet sterility	Biological yield	Harvest index	Test weight	Grain yield/ plant
1	Days to 50% flowering	G	-0.0025	0.0089	0.0088	-0.0065	-0.0054	-0.0070	-0.3944
		P	-0.0022	0.0072	0.0072	-0.0058	-0.0048	-0.0062	-0.3847
2	Plant height	G	0.0023	-0.0052	-0.0048	0.0144	0.0045	0.0169	0.3058
		P	0.0009	-0.0018	-0.0017	0.0055	0.0017	0.0065	0.2959
3	Flag leaf length	G	0.0009	-0.0007	-0.0012	0.0034	0.0018	0.0024	0.4039
		P	0.0035	-0.0025	-0.0041	0.0123	0.0067	0.0091	0.3825
4	Flag leaf width	G	0.0005	-0.0005	-0.0007	-0.0006	0.0012	-0.0011	-0.0286
		P	0.0015	-0.0015	-0.0019	-0.0017	0.0033	-0.0030	-0.0203
5	Panicles/plant	G	-0.0047	0.0046	0.0060	-0.0090	-0.0088	-0.0056	0.6065
		P	-0.0011	0.0009	0.0012	-0.0022	-0.0021	-0.0014	0.4911
6	Panicle length	G	0.0007	0.0012	0.0004	-0.0082	-0.0032	-0.0063	0.2758
		P	0.0003	0.0010	0.0004	-0.0042	-0.0012	-0.0027	0.2366
7	Spikelets/panicle	G	0.3437	0.0919	-0.0840	0.0087	0.0875	-0.0152	0.1124
		P	-0.0725	-0.0177	0.0163	-0.0015	-0.0182	0.0029	0.1077
8	Filled grains	G	**-0.5039**	0.0260	0.2598	-0.0528	-0.1956	-0.0052	0.2351
		P	**0.0390**	-0.0047	-0.0205	0.0035	0.0147	0.0006	0.2244
9	Unfilled grains	G	-0.0063	**0.1216**	0.1067	-0.0332	-0.0540	-0.0246	-0.3939
		P	-0.0055	**0.0450**	0.0397	-0.0103	-0.0179	-0.0078	-0.3495
10	Spikelet sterility	G	0.1295	-0.2201	**-0.2510**	0.0740	0.1368	0.0508	-0.4489
		P	0.0091	-0.0153	**-0.0174**	0.0043	0.0084	0.0031	-0.3971

Table 3. Continued.

	Characters		Filled grains	Unfilled grains	Spikelet sterility	Biological yield	Harvest Index	Test Weight	Grain yield/ plant
11	Biological yield/Pl	G	0.0763	-0.1986	-0.2145	**0.7279**	0.2591	0.4286	0.8871
		P	0.0660	-0.1660	-0.1810	**0.7271**	0.2402	0.4042	0.8819
12	Harvest index	G	0.1989	-0.2275	-0.2792	0.1824	**0.5124**	-0.0101	0.7366
		P	0.1856	-0.1966	-0.2380	0.1628	**0.4928**	-0.0088	0.7236
13	Test weight	G	-0.0002	0.0046	0.0046	-0.0135	0.0004	**-0.0228**	0.4008
		P	-0.0002	0.0025	0.0026	-0.0080	0.0003	**-0.0143**	0.3821

are in agreement with Singh et al. (9) and Chauhan et al. (8). High heritability estimates with low genetic advance as exhibited by grain yield/plant, test weight, unfilled grains and spikelet sterility (%) indicating that this could be due to non-additive gene effects and the rxpression might be influenced largely by non-genetic factors. Gamathinnayagan et al. (7) also reported similar trends in direct seeded rainfed rice. The magnitude of genotypic correlation is higher than the phenotypic correlation indicating that elimination of environmental effects led to strengthen genetic association (Table 2).

Significant and positive correlation of grain yield with plant height (*rg*=0.3058*, *rp*=0.2959*), panicle length (*rg*=0.2758*, *rp*=0.2366*), flag leaf length (*rg*=0.4039*, *rp*=0.3825**), panicles/plant (*rg*=0.6065**, *rp*=0.4911**), biological yield (*rg*=0.8871**, *rp*=0.8819**), harvest index (*rg*=0.7366**, *rp*=0.7236**) and test weight (*rg*=0.4008**, *rp*=0.3821**) was observed. Several other workers viz., Chauhan et al. (8), Chaturvedi et al. (10) and Reddy et al. (11) have also observed positive and significant association between biological yield, harvest index, flag leaf length and plant height with grain yield. Plant height had positively significant correlation with panicle length, flag leaf length, panicles/plant, biological yield/plant and test weight. The character, filled grains was positively and significantly correlated with harvest index. Unfilled grain and spikelet sterility (%) were also positively and significantly correlated with days to 50% flowering.

The variable grain yield is a result of interaction between component characters, which are either positively or negatively associated with each other. The path coefficient analysis revealed that biological yield had the maximum direct effect on grain yield, followed by harvest index and spikelets/panicle (Table 3). Similar results were also observed by Chaturvedi et al. (10). The direct contribution of plant height, flag leaf length, unfilled grains and days to 50% flowering was positive but of low magnitude. The direct contribution of biological yield to grain yield was supported by indirect effects of test weight, panicles/plant, flag leaf length, harvest index, plant height and panicle length. Similarly harvest index also contributed to higher grain yield via panicles/plant, filled grains, biological yield and spikelets/panicle. Based on result of present study on correlation and path analysis, the characters namely, biological yield/plant, harvest index, unfilled grains, plant height and days to 50% flowering influenced the grain yield/plant either directly or indirectly for higher grain yield potential these characters should be included in the breeding programme of upland rice.

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