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Rajendra Singh
SVPUAT, Rice Research Station, Nagina, Bijnor, Uttar Pradesh, India

Vivek Yadav
SVPUAT, Rice Research Station, Nagina, Bijnor, Uttar Pradesh, India

DN Mishra
SVPUAT, Rice Research Station, Nagina, Bijnor, Uttar Pradesh, India

Akhilesh Yadav
NDAUT, KVK Faizabad, Uttar Pradesh, India

Correspondence
Rajendra Singh
SVPUAT, Rice Research Station, Nagina, Bijnor, Uttar Pradesh, India

Correlation and Path Analysis Studies in Rice (*Oryza sativa* L.)

Rajendra Singh, Vivek Yadav, DN Mishra and Akhilesh Yadav

Abstract
The present investigation is carried out to study the correlation and path analysis in eighty four (including Check) rice (*Oryza sativa* L.) varieties. Biological yield per plant, harvest index, 1000-grain weight, panicle bearing tillers/plant and panicle length showed positive and significant correlation with grain yield per plant to emerge as most important associates of grain yield in rice. Path analysis identified biological yield per plant followed by harvest index as most important direct as well as indirect yield. Contributing traits or components which merit due consideration at time of devising selection strategy aimed at developing high yielding varieties in rice. In contrary to most of the previous reports in rice, comparatively small proportion of direct and indirect effects of different characters attained high order value in the present study. This may be attributing to presence of very high genetic variability and diversity in the fairly large number of germplasm lines.

Keywords: Rice, Correlation, Path analysis

Introduction
Frontline Rice (Oryza sativa L.) occupies a pivotal place in Indian agriculture, as it forms the staple food for two-thirds of the population, provides 43 per cent calories requirement and 20-25% agriculture income. More than 90 per cent of the world's rice is grown and consumed in Asia, known as rice bowl of the world, where 60 per cent of the earth's people and two third of world's poor live (Khush and Virk, 2000). Information on association of characters, direct and indirect
effects contributed by each character towards yield will be an added advantage in aiding the selection process. Correlation and path analysis establish the extent of association between yield and its components and also bring out relative importance of their direct and indirect effects, thus giving an obvious understanding of their association with grain yield. Ultimately, this kind of analysis could help the breeder to design his selection strategies to improve grain yield. In the light of the above scenario, the present investigation is carried out with the objective of studying the character associations in rice for yield improvement.

Materials and methods
The present experiment was carried out at Experimental Farm of Rice Research Station, Nagina, Bijnor. The list of 80 germplasm is presented in Table 1. The 80 germplasm lines along with four checks were evaluated in augmented design. The experimental plot was sub-divided in to 4 blocks of 24 plots each. The four checks were allocated randomly to four plots in each block, while remaining 20 plots in a block were used for accommodating the unreplicated test genotypes. Twenty seven days old seedlings were transplanted 20cm apart between rows and
15cm within the row. All necessary precautions were taken to maintain uniform plant population in each treatment per replication. All the recommended package of practices was followed along with necessary prophylactic plant protection measures to raise a good crop. Observations were recorded and the data was subjected to statistical analysis. Statistical analyses for the above characters were done following Singh and Chaudhary (1995) for correlation coefficient and Dewey and Lu (1959) for path analysis.

Table 1

S. NO.	*Genotypes*	*S. No.*	*Genotypes*
1.	NDRK-5033	28.	Pokali
2.	NDRK-50002	29.	Sahbhagi Dhan
3.	Pant Dhan-12	30.	NDRK-5006
4.	IR-64	31.	NDRK-5014
5.	NDRK-5088	32.	Narendra Usar-3
6.	Pant Dhan-10	33.	NDRK-5008
7.	CSR-27	34.	NDRK-50012
8.	Pusa Sungandha-3	35.	Narendra-1
9.	Basmati-370	36.	NDR-2064
10.	Nagina-22	37.	T-1
11.	CSR-36	38.	CSAR 839-3
12.	T-3	39.	NDRK-5026
13.	NDR-2031	40.	NDRK-50015
14.	Kasturi	41.	NDR-2026
15.	Pusa Sugandha-4	42.	CSR-13
16.	Panth Dhan-4	43.	Narendra-118
17.	Saket-4	44.	Ram Raj
18.	Swarna	45.	PS-1460
19.	CSR-10	46.	T-23
20.	NDRK-5005	47.	PS-5
21.	Narendra-80	48.	PR-106
22.	TR-2005-041	49.	Badshah bhog
23.	FL-478	50.	IR-72
24.	NDRK-5007	51.	Narendra Lalmati
25.	Sambha Maluri	52.	NDRK-5097
26.	Narendra Usar-2	53.	IR-50
27.	NDR-3026	54.	Pakistan Basmati
55.	Taraori Basmati	68	WAS 197-B-6-3-4
56.	Narendra-97	69.	IR-77512-2-1-2-2
57.	Kalanamak	70.	NDRK 50016
58.	Hans Raj	71.	ICSR-2K-242
59.	Ram Bhog	72.	Dubraj
60.	Vishnu Parag	73.	IR 59418-7B-21-3
61.	IR-7736-54-3-1-2	74.	AURC 02-05-1
62.	IR-77736-54-3-1-2	75.	Anjali
63.	WAB 99-84	76.	Ratna
64.	WAS 169-B-B-4-2-9	77.	IR 82571-544-2-3
65.	WAS 197-B-6-3-16	78.	IR 79218-63-2-3-1
66.	WAS 197-B-6-3-16	79.	Swarna Sub-1
67.	WAS 197-B-5-2-16	80.	IR 79495-9-3-2-2

Check variety

1. C1 - Sarjoo-52
2. C2 - NDR-359
3. C3 - Pusa Basmati-1
4. C4 - CSR-30

Results and Discussion

Phenotypic correlation coefficients

In general, the magnitude of the phenotypic correlations was higher than those of the phenotypic correlation coefficients. The grain yield per plant exhibited highly significant and positive correlation with Biological yield per plant (0.7062) followed by Harvest index (%) (0.6794), Panicle bearing tillers/plant, Test weight (g) (0.4230), Spikelet fertility (%) (0.4210) and Spikelet/panicle (0.3775); while negative and significant correlation was observed with L/B ratio and Grain chalkiness. The strong positive association of grain yield with the

Characters mentioned above has also being reported in rice by earlier workers (Qamar *et al.* 2005; Ram Krishan *et al.* 2006).

Days to 50% flowering was showed positive and significant correlation with plant bearing tillers per plant, while it expressed negative and significant with kernel length and grain chalkiness. Plant height demonstrated positive and highly significant association with and panicle length and

kernel breadth and significant with kernel elongation ratio, while negative and Significant with kernel length. Similar trends of results were also reported by Kishore *et al.* 2007. Panicle bearing tillers per plant was showed positive and highly significant correlation with test weight and biological yield per plant and positive and significant with Kernel breadth; while highly significant and negative with Grain Chalkiness and negative and only significant with L/B ratio and Kernel length after Cooking. Panicle length expressed positive and significant correlate with Kernel length after Cooking. Spike lets per plant was showed positive and highly significant association with spike fertility and kernel breadth while Kernel elongation ratio had only positive and significant relationship with spike lets per panicle. Spikelet fertility showed positive and highly significant correlation with Test weight and positive and highly significant association with Kernel breadth while it had negative and highly significant association with L/B ratio. These positive association between these characters have also been reported by Chand *et al.* 2007, Borbora *et al.* 2005.

Test Weight was showed positive and highly significant correlation with Kernel breadth and positive and significant with L/B ratio. Biological yield per plant (g) was showed positive and highly significant correlation with Kernel breadth and positive & significant with L/B ratio. Kernel length (mm) was showed positive and highly significant correlation with Kernel breadth and Kernel length after cooking while negative and significant with Kernel elongation ratio. Kernel length after cooking had only positive and highly significant relationship with Kernel elongation ratio.

Genotypic correlation coefficient

The Grain yield per plant was showed highly significant and positive correlation with Biological yield per plant (0.7062) followed by Harvest index (%) (0.6794), Panicle bearing tillers/plant, Test weight (g) (0.4230), Spikelet fertility (%) (0.4210) and Spikelet/panicle (0.3775); while negative and significant correlation was observed with L/B ratio and Grain chalkiness. (Sarawagi *et al.* 1997). Days to 50% flowering was showed positive and significant correlation with plant bearing Tillers per plant, while it expressed negative and significant with Kernel length and Grain chalkiness. Plant height exhibited positive and highly significant association with and Panicle length and Kernel breadth and significant with Kernel elongation ratio, while negative and significant with Kernel length. Panicle bearing tillers per plant was demonstrated positive and highly significant correlation with Test weight and Biological yield per plant and positive and significant with Kernel breadth; while highly significant and negative with Grain Chalkiness and negative and only significant with L/B ratio and Kernel length after Cooking. Panicle length exhibited positive and significant correlate with Kernel length after Cooking. Spike lets per plant was showed positive and highly significant association with Spike fertility and Kernel breadth while Kernel elongation ratio had only positive and significant relationship with spike lets per panicle. Spikelet Fertility showed positive and highly significant correlation with Test weight and positive and highly significant association with Kernel breadth while it had negative and highly significant association with L/B ratio. Test weight was showed positive and highly significant correlation with Kernel breadth and positive and significant with L/B ratio. Biological yield per plant (g) was showed positive and highly significant correlation with Kernel breadth and positive & significant with L/B ratio. Kernel length (mm) was showed positive and highly significant correlation with Kernel breadth and Kernel length after cooking while negative and significant with Kernel elongation ratio. Kernel length after cooking had only positive and highly significant relationship with Kernel elongation ratio. (Mahto *et al.* (2003), Chand *et al.* 2007)

Path-coefficient Analysis

Phenotypic path coefficients

The direct and indirect effect of different characters on Grain yield/plant computed by using phenotypic correlations are presented in Table-3. At phenotypic level, Harvest index (%), (0.6887) and Biological yield/plant (g) (0.6777) exerted very high positive direct effect on grain yield per plant (g). Panicle bearing tillers/plant (0.0858), Kernel length (mm) (0.0588) and Spikelet/panicle (0.0263) also exerted moderate direct effect on Grain yield/plant. The direct effects of other 11 characters were too low to be considered of any consequence. Biological yield per plant (g) (0.2652) and Harvest index (%) (0.1321) were exhibited high positive indirect effects on Grain yield/plant via plant bearing Tillers/plant, which considered indirect positive contribution. Biological yield/plant (g) (0.3687) excreted substantial positive indirect effect on Grain yield/plant (g) via Panicle bearing tillers per plant and Number of spikelet/panicle. However, high order negative indirect contributions on Grain yield/plant via L\B ratio was also shown by Biological yield/plant (g) (-0.2223). Harvest index (%) (-0.1447) was exerted negative indirect affect via Plant height (cm). These results are in conformity to that of Sarawgi *et al.* (1997) and Mishra and Verma (2002).

Genotypic Path coefficient

Path-coefficient computed on the basis of genotypic correlation is given in 4. The highest positive direct contribution on grain yield/plant at genotypic level was expressed by Harvest index (%) (7.210) followed by Biological yield/plant (G) (0.6398), Kernel length (mm) (0.1754), Plant height (cm) (0.1699) and Panicle bearing tillers/plant (0.1206). In addition to very high direct contribution made by these 5 characters, Biological yield/plant also showed considerable positive direct contribution towards Grain yield/plant. In contrast negative direct effect on Grain yield/plant was exerted by Kernel length after cooking (-0.1708) and Kernel breadth (-0.1144). Patil and Sarawgi (2006), Zahid *et al.* (2006), Kishore *et al.* (2007), and Babar *et al.* (2009) The direct effect of rest of the characters on Grain yield/plant was negligible. The high positive indirect effects on Grain yield per plant of Biological yield per plant (0.3636) via Spikelet fertility (%), followed by Number of spikelet/panicle and Harvest index (%), Kernel length (0.1569) and Kernel length after cooking.(Suman *et al.* 2007, Singh *et al.* 2008).

Table 2: Estimation of genotypes (rg) and phenotypic (rp) correlation coefficient among 16 characters except grain chalkiness in selected rice germplasm

Characters		plant height (cm)	panicle bearing tillers/ plant	panicle length (cm)	spikelets/ panicle	Spikelet fertility (%)	1000 grain weight (g)	biological yield/ plant (g)	harvest index %	kenrnel length (mm)	kernel breadth(mm)	l::b ratio	kernel length after cooking (klac)	kernel elongation ratio	Grain yield/ plant (g)
Days to 50% flowering	g	0.1561	0.2594	0.1448	-0.0561	0.0697	0.1153	0.0418	-0.1762	-0.1502	-0.3182	0.937	-0.0569	-0.0027	-0.0873
	p	**0.1055**	0.2364**	0.1332	-0.0277	-0.0261	0.0560	0.0000	-0.1617	-0.0727	-0.2131*	0.0933	-0.0503	0.1101	-0.929
Plant height (cm)	g		-0.1071	0.4259	0.3359	0.1144	0.0255	0.1797	-0.2164	-0.2344	0.3830	-0.3863**	0.0036	0.4264	-0.0070
	p		**-0.0880**	0.3456**	0.3008	0.0652	0.0655	0.1891	-0.02101	-0.2215*	0.2744**	-0.3633	-0.0147	0.2453*	-0.0149
Panicle bearing tillers / plant	g			-0.1737	0.1767	0.1054	0.4868	0.4032	0.1936	-0.2446	0.2474	-0.2583	-0.2308	0.2183	0.4889
	p			**-0.1604**	0.1683	0.0675	0.4078**	0.3912**	0.1919	-0.2380	0.2059*	-0.2601*	-0.2199*	0.1382	0.4830**
Panicle length (cm)	g				0.1773	-0.0228	0.1287	0.1519	-0.1751	0.2724	-0.0380	0.1168	0.2188	0.0864	-0.0183
	p				**0.1761**	-0.0407	0.0128	0.1411	-0.1473	0.1679	0.0374	0.083	0.2324*	0.0577	-0.0167
Spikelet/panicle	g					0.4615	0.2048	0.5649	-0.0525	-0.1582	0.2599	-0.2826	-0.0165	0.2597	0.3775
	p					**0.2925****	0.1987	0.5440	-0.0611	-0.1625	0.2626**	-0.2729	-0.0219	0.2244*	0.3642**
Spikelet fertility (%)	g						0.4795	0.5683	0.0118	-0.3772	0.3872	-0.3539	-0.2536	0.1810	0.4210
	p						**0.3082****	0.4130	0.0257	-0.1942	0.2104*	-0.2681**	-0.2081*	-0.0304	0.3181**
1000-grain weight (g)	g							0.5168	0.0421	-0.1859	0.4016	-0.3128	-0.1396	0.0942	0.4230
	p							**0.4872**	0.0157	-0.1383	0.2294*	-0.2244*	-0.1289	0.0289	0.3505**
Biological yield/plant (g)	g								-0.0428	0.2724	0.2566	-0.3609	-0.2641	0.1403	0.7062
	p								**-0.0499**	0.2879**	0.2160*	-0.3280	-0.2549*	0.0304	0.6851**
Harvest index (%)	g									0.1411	-0.1380	0.0030	0.1692	0.0794	0.6794
	p									**0.1440**	-0.1378	0.0091	0.1641	0.0522	0.6679**
Kernel length (mm)	g										0.2974	0.8796	0.8945	-0.4764	-0.1037
	p										**0.2864****	-0.8074	0.7875**	-0.2283*	-0.1090
Kernel breadth (mm)	g											-0.8875	-0.2378	0.0680	-0.3006
	p											**0.7484**	0.2488	0.0478	-0.2573*
L:B ratio	g												0.7042	-0.2410	-0.2325
	p												**0.6404**	-0.2058*	-0.2373*
Kernel length after cooking (KLAC)	g													0.3828	-0.1070
	p													**0.3454****	-0.0785
Kernel elongation ratio	g														0.0670
	p														**0.0654**

*, ** significant at 5% and 1% probability levels respectively

Table 3: Direct and indirect effect of different characters except grain chalkiness on growth yield/plant at phenotypic level in selected rice germplasm

Characters	Days to 50% flowering	plant height (cm)	panicle bearing tillers/ plant	panicle length (cm)	spikelets/ panicle	spikelet fertility (%)	1000 grain weight (g)	biological yield/ plant (g)	harvest index %	kenrnel length (mm)	kernel breadth(mm)	l::b ratio	kernel length after cooking (klac)	kernel elongation ratio	Grain yield/ plant (g)
Days to 50% flowering	**-0.0056**	-0.0006	-0.0013	-0.0070	0.0002	0.0001	-0.0003	0.0000	0.0009	0.0004	0.0012	-0.0005	0.0003	-0.0006	-0.0929
Plant height (cm)	0.006	**0.0056**	-0.0005	0.0019	0.0017	0.0004	0.0004	0.0011	-0.0012	-0.0012	0.0015	-0.0020	-0.0001	0.0014	-0.0149
Panicle bearing tillers / plant	0.0203	-0.0076	**0.0858**	-0.0138	0.0144	0.0058	0.0350	0.0336	0.0165	-0.0204	0.0177	-0.0223	-0.0189	0.0119	0.4830
Panicle length (cm)	-0.0002	-0.0005	0.0003	**-0.0016**	-0.0003	0.0001	0.0000	-0.0002	0.0002	-0.0003	-0.0001	-0.0002	-0.0004	-0.0001	-0.0167
Spikelet/panicle	-0.0007	0.0079	0.0044	0.0046	**0.0263**	0.0077	0.0052	0.0143	-0.0016	-0.0043	0.0069	-0.0072	-0.0006	0.0059	0.3642
Spikelet fertility (%)	-0.0002	0.0005	0.0005	-0.0003	0.0022	**0.0076**	0.0024	0.0032	0.0002	-0.0015	0.0016	-0.0020	-0.0016	-0.0002	0.3181
1000-grain weight (g)	-0.0019	-0.0022	-0.0140	-0.0004	-0.0068	-0.0105	**-0.0342**	-0.0167	-0.0005	.0047	-0.0078	0.0077	0.0044	-0.0010	0.3505
Biological yield/plant (g)	0.0000	0.1281	0.2652	0.0956	0.3687	0.2799	0.3302	**0.6777**	0.0338	-0.1951	0.1464	-0.2223	-0.1728	0.0263	0.6851
Harvest index (%)	-0.1114	-0.1447	0.1321	-0.1014	-0.0420	0.0177	0.0108	-0.0344	**0.6887**	0.0992	0.0949	0.0062	0.1130	0.0359	0.6679
Kernel length (mm)	-0.0043	-0.0130	-0.0140	0.0099	-0.0096	-0.0114	-0.0081	-0.0169	0.0085	**0.0588**	-0.0168	0.0475	0.04632	-0.0134	-0.1090
Kernel breadth (mm)	0.0112	-0.0145	-0.0109	-0.0020	-0.0138	-0.0111	-0.0121	-0.0114	-0.0073	0.0151	**-0.0527**	0.0394	0.0131	-0.0025	0.2573
L:B ratio	-0.0076	0.0298	0.0213	-0.0081	0.0224	0.0220	0.0184	.0269	-0.0007	-0.0662	0.0613	**-0.0820**	-0.0525	0.0169	-0.2373
Kernel length after cooking (KLAC)	-0.0001	0.000	-0.0006	0.0006	-0.001	-0.0006	-0.0004	-0.0007	-0.0004	0.0022	-0.0007	0.0018	**0.0027**	0.0009	-0.07854
Kernel elongation ratio	-0.0021	-0.0048	0-.00237	-0.0011	0-.0044	0.0006	-0.0006	-0.0008	-0.0010	0.0044	-0.0009	0.0040	-0.0067	**-0.0194**	

Phenotypic residual effect (P) = 0.1655
Bold figure denotes the direct effect

Table 4: Direct and indirect effect of different characters except grain chalkiness on growth yield/plant at genotypic level in selected rice germplasm

Characters	Days to 50% flowering	plant height (cm)	panicle bearing tillers/ plant	panicle length (cm)	spikelets/ panicle	spikelet fertility (%)	1000 grain weight (g)	biological yield/ plant (g)	harvest index %	kenrnel length (mm)	kernel breadth(mm)	l::b ratio	kernel length after cooking (klac)	kernel elongation ratio	Grain yield/ plant (g)
Days to 50% flowering	**-0.0760**	-0.0119	-0.0197	-0.0116	0.0043	-0.0053	-0.0088	-0.0032	0.0134	0.0114	0.0242	-0.0071	0.0043	0.0002	-0.0873
Plant height (cm)	0.0265	**0.1699**	-0.0182	0.0724	0.0571	0.0194	0.0043	0.0305	-0.0368	0.0398	0.0651	-0.0656	0.0006	0.0724	-0.0070
Panicle bearing tillers / plant	0.0313	-0.0129	**0.1206**	-0.0210	0.0213	0.0127	0.0587	0.0486	0.0234	0.0295	0.0298	-0.0312	-0.0278	0.0263	0.4889
Panicle length (cm)	-0.0064	-0.0190	0.0077	**-0.0445**	-0.0079	0.0010	-0.0057	-0.0068	0.0078	0.0121	0.0017	-0.0052	-0.0097	0.0038	-0.0183
Spikelet/panicle	-0.0001	0.0005	0.0002	0.0003	**0.0014**	0.0007	.0003	0.0008	-0.0001	0.002	0.0004	-0.0004	0.0000	0.0004	0.3775
Spikelet fertility (%)	0.0045	0.0074	0.0068	-0.0015	0.0300	**0.0649**	0.0311	0.0369	0.0008	0.0245	0.0251	-0.0230	-0.0165	0.0117	0.4210
1000-grain weight (g)	0.0042	0.0009	0.0177	0.0047	0.0074	0.0174	**0.0363**	0.0188	0.0015	0.0067	0.0146	-0.0113	-0.0051	0.0035	0.4230
Biological yield/plant (g)	0.0268	0.1150	0.2580	0.0972	0.3614	0.3636	0.33078	**0.6398**	-0.0274	0.1743	0.1641	-0.2309	-0.1690	0.0897	0.7062
Harvest index (%)	-0.1271	-0.1560	0.1396	-0.1263	-0.0378	0.0085	0.0303	-0.0300	**7.210**	0.1017	0.0995	0.0021	0.1220	0.0573	0.6794
Kernel length (mm)	-0.0264	-0.0411	-0.0429	0.0478	-0.0278	-0.0662	-0.0326	-0.0778	0.0248	**0.1754**	-0.0522	0.1543	0.1569	0.0836	0.1037
Kernel breadth (mm)	0.0364	-0.0438	-0.0238	0.0043	-0.0297	-0.0443	-0.0459	-0.0293	-0.0158	0.0340	**-0.1144**	0.1015	0.0272	0.0078	0.3006
L:B ratio	0.0000	-0.0002	-0.0001	0.0001	-0.0001	-0.0002	-0.002	-0.0002	0.0000	0.0004	-0.0004	**0.0005**	0.0003	-0.0001	-0.2323
Kernel length after cooking (KLAC)	0.0097	-0.0006	0.0394	-0.0374	0.0028	0.0437	0.0238	0.0451	-0.0289	0.1528	0.0406	-0.1203	**-0.1708**	-0.0654	-0.1070
Kernel elongation ratio	0.0001	-0.0163	-0.0084	-0.0033	-0.0099	-0.0069	-0.0037	-0.0054	-0.0030	0.0182	-0.0026	0.0092	-0.0147	**-0.0383**	0.0670

Bold figure denotes the direct effect

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