Applied Biological Research 19 (1): 35-40; (2017)
DOI: 10.5958/0974-4517.2017.00005.2

ASSOCIATION ANALYSIS AND SELECTION STRATEGIES FOR VARIOUS YIELD CONTRIBUTING TRAITS IN RICE GENOTYPES

Jitendra Kumar Tiwari

Department of Genetics and Plant Breeding, RMD College of Agriculture and Research Station, Indira Gandhi Agriculture University, Ambikapur - 497 001, Chhattisgarh (India)
*e-mail: *tiwarijk5@gmail.com*

(Received 13 May, 2016; accepted 27 December, 2016)

ABSTRACT

Genetic differences between rice genotypes were analyzed to assess genetic association between grain yield and yield contributing traits as a basis for selection of high yielding rice genotypes. Forty-two rice genotypes were evaluated for 11 quantitative traits to decide selection criteria under sandy loam soil conditions at Northern Hill Zone of Chhattisgarh (India). Results revealed enough variability in genotypes. Genotypic coefficient of variation was highest in grains panicle^{-1} (22.02), followed by spikelet fertility (18.30), spikelets panicle^{-1} (17.11), yield (15.395 kg ha^{-1}). High estimates for heritability was exhibited by spikelet fertility (99.84) followed by days to 50% flowering (98.39), days to maturity (95.75), plant height (79.08). The number of grains panicle^{-1} showed highest positive direct effect (4.88) on grain yield followed by plant height (0.476), spikelet fertility (0.29) and days to 50% flowering (0.21). The characters showing high heritability coupled with high genetic advance and significant correlation with yield contributing traits may be used as selection criteria for grain yield under sandy loam soil conditions.

Key words: Correlation analysis, genetic variability, path analysis, rice

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food all over the world and consumed by more than half of the world population. In Asia, rice supplies 35-60% of total food calories (Khush, 1997). In countries where rice is the major food source, including China, India and Indonesia, the average annual rate of population growth (1.7 %) is higher than 1.2% average growth of rice production (Asia Rice Foundation, 2004). As per FAO estimate, the world population would be around 9.8 billion by 2050 and 75% more food would be required to feed the additional population (United Nation, 2002). Rice is grown under four different cropping environments *viz*., irrigated, rain-fed lowland, rain-fed upland, and deep water (Poehlman and Sleper, 1995).

Soil plays an important role in rice production in terms of water productivity. Soil texture affects the soil available water capacity (AWC). Usually, clay soils contain more organic matter than sandy soil because of greater physical protection attributed to the clay (Six *et al*., 2000). Higher organic matter content generally means greater AWC. Loss of organic matter coupled with soil compaction significantly reduces crop yield (Powers *et al*., 2005). Soil also affects plant root growth, a main organ in water uptake; so soil texture or structure affects root production (Dou *et al*., 2016). Keeping in view the ever-increasing competition for irrigation water from other sectors and other crops, there is an imminent need to find an alternative rice production system with high water productivity (*i.e*., higher grain yield per unit of water used).

The systematic approach for developing superior varieties in any crop depends mainly on the selection of desirable genotypes and parents for development of crosses. The scope of rice improvement is mainly based on the extent of genotypic and phenotypic variability in the gene pool material. Selection based on phenotypes would be difficult for polygenic traits. Correlation in grouping with path analysis would give a better insight into cause-effect relation between different pairs of characters (Jayasudha and Sharma, 2010). Knowledge of correlation between yield and its contributing characters are basic and foremost endeavor to find out the guidelines for plant selection. Partitioning of total correlation into direct and indirect effects by path coefficient analysis helps in making the selection more effective (Priya and Joel, 2009). Knowledge about the nature and magnitude of associations of yield with various component characters is a prerequisite to bring improvement in desired direction. No work done on this aspect has been conducted in Northern Hill Zone of Chhattisgarh. The region is characterized by high rainfall (1200-1500 mm), acidic soil condition and low water retention capacity. Therefore, the present study was aimed to assess the genetic association between grain yield and yield contributing traits as a basis for selecting high yielding rice genotypes raised on sandy loam soil in Northern Hill Zone of Chhattisgarh (India).

MATERIALS AND METHODS

A field experiment was conducted at Research Farm, RMD College of Agriculture &Research Station, Ambikapur (Chhattisgarh) during *kharif*, 2015. Forty two genotypes (UPR-3831-10-1-1, TRC2014-3/IR83377-B-B-123-1, BIO-650 (hybrid), RP5586-92-28-15-3-2-2-1, Pusa 2004-09-80-315-483, Bio-453 (hybrid), BRR2005, PR-14101 (hybrid), RP 5445-102-23-3-2, RH-12N0083 (hybrid), TM 12522, PR-14104 (hybrid), PAU -2K10-23-451-2-164-127-0-0, OR 2512-2, MTU 1175 (MTU 2203-15-1-2, CRR 484-2-1-1-1-1, CR 3549-6-1-1-3-1-1, NP-9807, MTU 1176 (MTU II 365-34-1-1, R 1702-3677-1-4734-1, KPH-468 (hybrid), NDR 2110-7-1, AAGP 9772, KPH 473 (hybrid), WGL-505, PAU 5185, JNPT-81, AD 08138, HKR 09-189, , RCPR-10-IR83383-B-B-129-4, YNP-9761, GNV-12-10- (BP 10620F-BB4-12-B-B8-30, RP 5879-HUANGHUAZHAN, PR-14105 (hybrid), IR 64, PR 14107 (hybrid), NLR 3241 along with five checks {NDR359 (NC), IGKV R-1 (local check), US 312 (HC) MTU 1010 (NC), HRI 174 (HC)}, procured from the Indian Institute of Rice Research, Hyderabad (India), were used in the study. The experiment was laid out in a randomized block design with three replications at a plant spacing of 20 cm x 15 cm. A plot size of 5 m x 3 m was used for each genotype and all the recommended package of practices for the region were followed to raise a good crop (Tiwari *et al*., 2013). All the plants in each genotype from each replication were used for recording various plant characters *viz*., days to 50% flowering, plant height, panicle m^{-2}, panicle length, number of panicle $plant^{-1}$, spikelets $panicle^{-1}$, grains $panicle^{-1}$, sterility percentage, days to maturity, test $weight^{-1}$ and grain yield. The data was analyzed as per Singh and Chowdhary (1985). The genotypic, phenotypic and environmental coefficients of variations and heritability were estimated as per the method of Burton and De Vane (1953). The expected genetic advance was assessed as per Johnson *et al.* (1955). Coefficients of correlation were calculated as suggested by Al-Jibouri*et al.* (1958) and path coefficients of different traits with seed yield $plant^{-1}$ were estimated as per the method of Dewey and Lu (1959).

RESULTS AND DISCUSSION

Forty-two rice genotypes, evaluated under sandy loam soil conditions, showed maximum variation for grain yield (3250-7583 kg ha^{-1}), followed by the number of grain $spanicles^{-1}$ (82.5-193.5) and spikelets $panicle^{-1}$ (109.7-228.1) [Table 1]. In general, phenotypic coefficient of variation was higher

Table 1: Genetic parameters of yield and yield attributes of rice genotypes grown under sandy loam soil condition

Characters	Mean	Range		Coefficient of variation		Heritability (h^2 %)	Genetic advance as % of mean
		Minimum	Maximum	Phenotypic	Genotypic		
Days to 50% flowering	63.17	48.00	83.00	12.309	12.209	98.386	15.758
Days to maturity	93.40	81.00	107.00	5.111	5.001	95.755	9.416
Panicle m^{-2}	187.05	144.23	235.63	15.141	8.805	33.817	19.729
plant height (cm)	106.61	89.20	127.00	8.572	7.623	79.078	14.887
Panicle length (cm)	24.07	20.53	27.33	8.555	7.196	70.75	3.001
No. of panicle $plant^{-1}$	7.59	5.87	10.47	17.773	11.669	43.107	1.198
Spikelets $panicle^{-1}$	168.58	109.67	228.13	23.064	17.114	55.055	44.096
Grains $panicle^{-1}$ (No.)	131.04	82.47	193.47	25.781	22.024	72.975	50.787
Test weight (g)	77.95	58.72	91.68	12.787	9.048	50.072	10.281
Sterility percentage	26.25	14.83	40.03	18.317	18.303	99.844	9.89
Yield (kg ha^{-1})	5564.48	3250.00	7583.33	20.068	15.395	58.851	1,353.80

than genotypic coefficient of variation. The highest value of phenotypic coefficient of variation was observed by grains $panicle^{-1}$ (25.78), followed by spikelets $panicle^{-1}$ (23.06), grain yield (20.07 kg ha^{-1}), spikelet fertility (18.32) and panicle $plant^{-1}$ (17.77); whereas lowest phenotypic coefficient of variation was found for days to maturity (5.11). In case of genotypic coefficient of variation, the highest value was observed by the number of grains $panicle^{-1}$ (22.02), followed by the number of spikelet fertility (18.30), spikelets $panicle^{-1}$ (17.11), grain yield (15.39 $kgha^{-1}$); while lowest genotypic coefficient of variation was for days to maturity (5.0). High estimates for heritability was exhibited by spikelet fertility (99.84) followed by days to 50% flowering (98.39), days to maturity (95.75) and plant height (79.08). These characters were least influenced by environmental changes; and the selection based on phenotypic performance would be reliable. Height heritability estimates were observed for quantitative characters such as the number of grains $panicle^{-1}$ and days to 50% flowering. The dependence on phenotypic expression reflects the ability of genotypes to transmit genes to their offspring. Johnson *et al*. (1955) suggested that high heritability, considered along with high genetic advance, is more reliable predictor of desired improvement for 1000-grain weight and grain yield. Further, these characters are amenable to improve selection, especially mass selection. Such values of high heritability and genetic gain may be attributed to the additive effect (Panse, 1957). Hence, selection in segregating generations for such characters would be highly effective.

Correlation and path analysis

Genotypic and phenotypic correlation coefficients for11quantitative traits when analyzed showed no close agreement in most traits studied (Table 3), thereby indicating high environmental influence on the degree of association. Thus, reference was made only to genotypic correlation. In most cases, genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficients. Grain yield was significantly and positively correlated with plant height (0.56), number of grains $panicle^{-1}$ (0.28) and test weight (0.258 g), thereby indicating that these traits have same physiological basis for expression. The association between days to maturity with plant height was genotypically significant. Spikelets $panicle^{-1}$ was positively and significantly associated with plant height and panicle length. Grains $panicle^{-1}$ was significantly associated with plant height, panicle length and spikelets $panicle^{-1}$. However, panicle m^{-2} was negatively associated with yield indicating the importance of these characters for yield improvement. The results are in conformity with earlier reports of Padmaja *et al*. (2011).

The path coefficient analysis splits total correlation coefficient of different characters into direct and indirect effects on fruit yield $plant^{-1}$ in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation (Table 4). The data revealed that the number of grains $panicle^{-1}$ showed highest positive direct effect (4.88) on grain yield, followed by plant height (0.476), Spikelet fertility (0.29) and days to 50% flowering (0.21). Spikelets $panicle^{-1}$ (-3.94), test weight

Table 2: Mean performance of rice genotypes in terms of yield and yield components under sandy loam soil condition

Rice genotypes	Days to 50% flowering	Days to maturity	Panicle m^{-2}	Plant height (cm)	Panicle length (cm)	No of panicle $plant^{-1}$	Spikelets $panicle^{-1}$	Grain $panicle^{-1}$ (No.)	Test weight (g)	Sterility (%)	Yield (kg ha^{-1})
UPR-3831-10-1-1	49.00	92.00	150.63	127.00	25.47	5.87	206.13	166.67	81.50	35.42	6666.7
TRC2014-3/IR83377-B-B-123-1	56.00	91.00	219.67	110.47	26.07	7.60	192.33	163.00	84.79	22.88	4791.7
BIO-650 (Hybrid)	57.00	100.00	159.73	115.60	23.53	7.47	228.13	183.80	80.59	40.03	6666.7
RP5586-92-28-15-3-2-2-1	58.00	92.00	184.07	107.13	20.53	7.20	204.07	168.60	82.47	21.35	5833.3
Pusa 2004-09-80-315-483	53.00	92.00	191.57	102.67	27.33	7.67	211.47	179.40	85.93	20.62	5666.7
Bio-453 (hybrid)	68.00	94.00	171.40	118.20	25.13	6.40	206.27	139.40	67.47	28.68	6333.3
BRR2005	83.00	104.00	184.40	116.60	25.33	6.80	205.13	119.60	61.82	19.63	3250.0
PR-14101 (Hybrid)	67.00	92.00	169.87	107.73	24.40	8.33	134.53	114.60	85.21	25.63	7083.3
RP 5445-102-23-3-2	61.00	97.00	178.73	94.87	24.67	7.73	172.13	141.73	82.36	29.08	5375.0
RH-12N0083 (hybrid)	63.00	97.00	172.40	108.80	25.20	6.20	174.27	131.87	75.80	31.03	6375.0
TM 12522	81.00	93.00	184.20	93.27	25.27	6.73	170.80	129.80	76.27	28.38	4708.3
PR-14104 (Hybrid)	66.00	95.00	193.63	110.67	24.67	7.87	177.33	125.67	72.92	28.62	6166.7
NDR359 (NC)	48.00	99.00	209.10	98.67	25.20	8.40	124.00	90.60	73.22	26.32	3791.7
Local Check	61.00	90.00	205.10	108.33	26.93	6.93	173.00	156.40	91.07	26.78	5750.0
PAU -2K10-23-451-2-164-127-0-0	67.00	97.00	192.63	107.93	24.87	7.13	211.60	146.47	69.36	25.22	5583.3
OR 2512-2	67.00	88.00	211.07	109.80	23.47	8.47	109.67	87.13	79.37	30.30	5833.3
MTU 1175 (MTU 2203-15-1-2	63.00	96.00	235.63	115.20	21.67	6.60	146.33	103.33	71.00	30.35	5250.0
CRR 484-2-1-1-1-1	64.00	95.00	177.93	111.33	21.40	9.20	114.47	99.33	87.34	25.45	5958.3
CR 3549-6-1-1-3-1-1	58.00	96.00	163.67	115.80	21.53	9.53	124.33	86.93	69.52	19.25	6166.7
NP-9807	69.00	81.00	203.33	102.60	21.53	8.27	126.00	94.73	76.30	25.38	5833.3
MTU 1176 (MTU II 365-34-1-1	73.00	88.00	185.30	90.53	25.47	10.47	158.87	112.47	74.53	28.13	4625.0
R 1702 -3677 -1-4734-1	81.00	91.00	163.30	106.27	22.33	8.33	185.60	158.13	85.23	18.00	6500.0
KPH -468 (Hybrid)	59.00	94.00	179.90	100.40	22.20	8.20	167.60	129.07	77.79	24.18	4708.3
NDR 2110-7-1	58.00	95.00	191.07	112.80	20.93	8.20	150.47	97.00	65.32	30.70	6291.7
AAGP 9772	72.00	93.00	224.97	98.33	24.27	7.80	126.80	88.53	70.05	28.88	3958.3
KPH 473 (Hybrid)	61.00	89.00	183.33	110.13	23.33	6.27	179.13	158.60	88.59	26.05	7583.3
MTU 1010 (NC)	54.00	97.00	198.23	108.87	22.00	6.73	148.87	112.00	75.19	25.15	4583.3
WGL -505	67.00	98.00	184.50	104.07	26.27	8.87	143.27	115.17	80.07	19.40	4625.0
PAU 5185	61.00	94.00	150.97	104.27	24.27	7.40	179.20	135.13	75.32	28.77	5958.3
JNPT -81	61.00	99.00	206.87	92.20	25.00	8.73	175.47	105.27	59.88	25.55	5125.0
AD 08138	64.00	89.00	206.83	89.20	21.60	8.47	157.40	129.73	82.57	23.23	5291.7
HKR 09-189	69.00	92.00	219.10	100.20	22.93	7.20	138.20	102.13	73.34	22.20	4708.3
HRI 174 (HC)	67.00	95.00	169.20	108.67	25.47	5.87	206.67	165.07	79.89	29.57	6125.0
RCPR -10-IR83383-B-B-129-4	66.00	91.00	176.30	111.93	25.87	6.33	206.87	156.47	75.92	29.95	6250.0
YNP -9761	61.00	88.00	144.23	105.53	22.07	8.53	124.53	104.33	83.80	27.52	6541.7
GNV -12-10- (BP 10620F -BB4-12-B-B8-30	61.00	90.00	206.83	102.47	26.20	7.33	189.00	173.13	91.68	27.61	5041.7
NLR 3241	63.00	88.00	152.40	95.93	23.13	8.73	201.13	170.00	84.61	18.70	4041.7
RP 5879 –HUANGHUAZHAN	53.00	94.00	193.37	100.47	26.27	7.27	152.67	131.67	86.22	29.03	4833.3
PR -14105 (Hybrid)	67.00	92.00	185.30	120.67	23.47	6.93	172.07	141.80	82.67	26.63	5958.3
IR 64	53.00	87.67	203.47	101.40	25.07	6.13	138.80	113.07	81.37	31.02	5041.7
PR 14107 (Hybrid)	62.00	90.00	194.60	112.93	21.93	8.47	224.80	193.47	86.68	14.83	5875.0
US 312 (HC)	61.00	107.00	177.40	117.53	26.60	6.27	140.80	82.47	58.72	27.03	6958.3
Mean (x)	63.17	93.40	187.05	106.61	24.07	7.59	168.58	131.04	77.95	26.25	5564.5
CV (%)	1.56	1.05	12.32	3.92	4.63	13.40	15.46	13.40	9.04	0.72	12.87
$CD_{0.05}$	0.95	0.95	22.27	4.04	1.08	0.98	25.19	16.97	6.81	0.18	691.71

(-1.91), panicle m^{-2} (-0.55) and days to maturity (-0.18) had negative direct effect on grain yield. The panicle m^{-2} had positive indirect effect on grain yield through spikelets $panicle^{-1}$ (1.72), test weight (0.31) and number of panicle $plant^{-1}$ (0.004). The number of panicle $plant^{-1}$ (2.14) showed positive indirect effect on grain yield through days to 50% flowering (0.02) and days to maturity (0.04). Spikelets $panicle^{-1}$ exhibited positive indirect effect on yield via panicle m^{-2} (0.24), plant height (0.11) and grain panicle (4.41). Test weight exhibited positive indirect effect on grain yield through days to maturity (0.12), panicle m^{-2} (0.09), number of panicle $plant^{-1}$ (0.004) and number of grains $panicle^{-1}$ (3.299). The effect of residual factor (0.221) on grain yield ha^{-1} was negligible, thereby suggesting that no other major yield component is left over. Grain $panicle^{-1}$ showed high positive and direct effect

Table 3: Genotypic and phenotypic correlation coefficient between fruit yield and its components in rice

Characters		Days to 50% flowering	Days to maturity	Panicle m^{-2}	plant height (cm)	Panicle length (cm)	Panicle $plant^{-1}$ (No.)	Spikelets $panicle^{-1}$	Grain $panicle^{-1}$ (No.)	Test weight (g)	Sterility (%)	Yield (kg ha^{-1})
		1	2	3	4	5	6	7	8	9	10	11
1	G	1.00										
	P	1.00										
2	G	-0.041	1.00									
	P	-0.030	1.00									
3	G	-0.016	-0.097	1.00								
	P	-0.110	0.248**	1.00								
4	G	-0.133	0.280**	-0.307**	1.00							
	P	-0.029	0.219*	0.047	1.00							
5	G	-0.037	0.257**	0.020	-0.054	1.00						
	P	0.081	-0.157	-0.094	-0.311**	1.00						
6	G	0.123	-0.243**	0.098	-0.540**	-0.362**	1.00					
	P	0.081	-0.157	-0.094	-0.311**	-0.287**	1.00					
7	G	0.019	0.114	-0.436**	0.248**	0.261**	-0.551**	1.00				
	P	0.028	0.074	-0.163	0.187*	0.265**	-0.198*	1.00				
8	G	-0.129	-0.200*	-0.393**	0.144	0.194*	-0.395**	0.904**	1.00			
	P	-0.104	-0.178*	-0.177*	0.123	0.216*	-0.182*	0.857**	1.00			
9	G	-0.240**	-0.679**	-0.163	-0.121	0.011	0.114	0.305**	0.675**	1.00		
	P	-0.177*	-0.475**	-0.079	-0.077	-0.025	-0.009	-0.057	0.452**	1.00		
10	G	-0.239**	0.091	-0.086	0.192*	0.221*	-0.477**	-0.036	-0.080	-0.115	1.00	
	P	-0.238**	0.089	-0.058	0.171	0.187*	-0.314**	-0.030	-0.068	-0.076	1.00	
11	G	-0.147	-0.116	-0.593**	0.560**	-0.161	-0.312**	0.191*	0.278**	0.258**	0.317**	1.00
	P	-0.108	-0.074	-0.339**	0.429**	-0.112	-0.107	0.020	0.074	0.079	0.247**	1.00

*5% level and ** 1% levels of significance

and had significant positive correlation with grain yield. The plants with more numbers of grain $panicle^{-1}$ should be considered in selection criteria for increasing fruit yield. These finding were in line with Oad *et al*. (2002), Borkakati *et al*. (2005), Patil and Sarawgi (2005) and Dhanwani *et al*. (2013). The genetic architecture of grain yield is based on the resultant of various interactions among selected trait for study. Based on the studies on correlation and path analysis it maybe concluded that spikelet $panicle^{-1}$, panicle length, number of panicle $plant^{-1}$ and test weight being easily observable should be given prime importance for selecting genotypes to improve the genetic yield potential of rice.

Table 4: Direct and indirect effect of component character on grain yield in rice

Characters	1	2	3	4	5	6	7	8	9	10
1	0.2149	0.0074	0.0087	0.0630	0.0006	0.0051	-0.0757	-0.6317	0.4585	-0.0715
2	-0.0088	-0.1811	0.0534	0.1330	-0.0044	-0.0100	-0.4486	-0.9766	1.3002	0.0273
3	-0.0034	0.0175	-0.5528	-0.1456	-0.0003	0.0041	1.7217	-1.9209	0.3120	-0.0256
4	-0.0286	-0.0508	0.1696	0.4745	0.0009	-0.0223	-0.9771	0.7046	0.2312	0.0575
5	-0.0080	-0.0465	-0.0113	-0.0255	-0.0170	-0.0150	-1.0293	0.9467	-0.0218	0.0662
6	0.0265	0.0439	-0.0544	-0.2563	0.0062	0.0414	2.1742	-1.9314	-0.2190	-0.1425
7	0.0041	-0.0206	0.2411	0.1175	-0.0044	-0.0228	-3.9471	4.4168	-0.5829	-0.0107
8	-0.0278	0.0362	0.2173	0.0684	-0.0033	-0.0163	-3.5675	4.8868	-1.2919	-0.0239
9	-0.0515	0.1231	0.0901	-0.0573	-0.0002	0.0047	-1.2024	3.2991	-1.9136	-0.0345
10	-0.0514	-0.0165	0.0474	0.0912	-0.0038	-0.0197	0.1413	-0.3914	0.2208	0.2990

1. Days to 50% flowering 2. Days to maturity 3. Panicle m^{-2}4. Plant height (cm) 5. Panicle length (cm.) 6. No. of panicle $plant^{-1}$ 7. Spikelets $panicle^{-1}$ 8. Grain $panicle^{-1}$ (No.) 9. Test weight (g) 10. Sterility (%) 11. Yield (kg ha^{-1}).
Residual = 0.221

REFERENCES

Al-Jibouri, H.A., Millar, P.A. and Robinson, H.F. 1958. Genotypic and environmental variances and covariances in an upland cotton cross of interspecific origin. *Agronomy Journal*, **50**: 632-636.

Asia Rice Foundation. 2004. Last update September 23, 2004, *http://www.asiarice.org/sections/science.html.*

Borkakati R.P., Chowdhari, R.K. and Kurmi, K. 2005. Studies on genetic variability and correlation in some rice hybrids. *National Journal of Plant Improvement*, **7**: 119-121.

Burton, G.W. and Vane De, E.H. 1953. Estimating heritability in tall fescue (*Festucaarun dinaceae*) from replicated clonal material. *Agronomy Journal,* **54**: 478-481.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path analysis of components of crested wheat-grass seed production. *Agronomy Journal,* **51**: 515-518.

Dhanwani, R.K., Tiwari, J.K. and Sarawgi, A.K. 2013. Correlation and path coefficient analysis for yield and quality traits in rice. *Journal of Interacadmicia*, **17**: 604-613.

Dou, F., Soriano, J., Tabien, R.E., Chen, K. 2016. Soil texture and cultivar effects on rice (*Oryza sativa*, L.) grain yield, yield components and water productivity in three water regimes. *PLoS ONE,* **11**(3): *e0150549.doi:10.1371/journal.pone.0150549*.

Jayasudha, S. and Sharma, D. 2010. Genetic parameters of variability, correlation and path-coefficient for grain yield and physiological traits in rice (*Oryza sativa* L.) under shallow lowland situation. *Electronic Journal of Plant Breeding,* **1**(5): 33-38.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Genotypic and phenotypic correlations in soybean and their implications in selection. *Agronomy Journal,* **47**(7): 314-318.

Khush, G.S. 1997. Origin, dispersal, cultivation and variation of rice. *Plant Molecular Biology*, **35**: 25-34.

Oad, F.C., Samo, M.A., Hassan, Z.U., Pompe, S.C. and Oad, N.L. 2002. Correlation and path analysis of quantitative characters of rice ratoon cultivars and advance lines. *International Journal of Agriculture & Biology*, **4**: 204-207.

Padmaja, D., Radhika, K., Subba Rao, L.V. and Padma V. 2011. Correlation and path analysis in rice germplasm. *Oryza*, **48**: 67-72.

Panse, V.G. 1957. Genetics of quantitative characters in relation to plant breeding. *Indian Journal of Genetics and Plant Breeding,* **17**: 318-328.

Patil and Sarawgi A.K. 2005. Studies on genetic variability, correlation and path analysis in traditional aromatic rice accessions. *Annals of Plant Physiology*, **19**: 92-95.

Poehlman, J.M. and Sleper, D.A. 1995. *Breeding Field Crops* (4thedn.). Iowa State Press, Iowa, USA.

Powers, R.F., Scott, D.A., Sanchez, F.G., Voldseth, R.A., Page-Dumroese, D., Elioff, J.D. and Stone, D.M. 2005. The North American long-term soil productivity experiment, Findings from the first decade of research. *Forest Ecology Management*, **220**: 31-50.

Priya, A.A. and Joel, A.J. 2009. Grain yield response of rice cultivars under upland condition, *Electronic Journal of Plant Breeding,* **1**: 6-11.

Six, J., Paustian, K., Elloitt, E.T. and Combrink, C. 2000. Soil structure and soil organic matter, I. distribution of aggregate size classes and aggregate associated carbon. *Soil Science Society of America Journal*, **64**: 681-689.

Singh, R.K. and Chaudhary, B.D. 1985. *Biometrical Methods in Quantitative Genetic Analysis.* Kalyani Publishers, New Delhi, India.

Tiwari, J.K., Rastogi, N.K., Chandrakar, P.K., Sarawgi, A.K. and Verulkar, S.B. 2013. Identification of four rice varieties from Chhattisgarh through DUS characterization. *Indian Journal Plant Genetic Resources,* **26**: 238-240.