The Ecoscan 10(1&2): 397-401, 2016 (Supplement on Rice)
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.com

ESTIMATION OF GENETIC VARIABILITY, DIRECT AND INDIRECT EFFECTS OF YIELD CONTRIBUTING TRAITS ON GRAIN YIELD IN AEROBIC RICE (*Oryaza sativa* L.) GERMPLASM

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ABSTRACT

The experiment was conducted to study genetic variability, correlation coefficients, direct and indirect effects in 30 aerobic rice genotypes during *kharif*, 2012 in Randomized Block Design having three replications. High magnitude of phenotypic and genotypic coefficient of variation were recorded for number of panicles per hill (25.67 and 25.65), seed yield per hill (15.87 and 15.79), harvest index (14.34 and 14.32) and flag leaf length (14.15 and 13.66), suggesting the possibility of yield improvement through selection for these characters. Estimates of heritability ranged from 87.3 % for number of spikelets per panicle to 99.9 % for biological yield. High heritability coupled with genetic advance was observed for harvest index (99.7%) and days to 50% flowering (99.8%), indicating that these characters predominantly governed by additive gene action. The correlation among various yield and yield contributing characters revealed that grain yield per hill was significantly and positively correlated at p= 0.001 (1% level of significance) with harvest index (0.85), biological yield (0.48) and panicle length (0.39) at both phenotypic and genotypic level. The characters like harvest index, biological yield per hill, number of panicles per hill, flag leaf length and plant height exhibited positive direct effect on grain yield per hill at both phenotypic and genotypic paths and direct selection of these characters may be helpful for yield improvement in aerobic rice.

KEY WORDS
Aerobic rice, Heritability
Genetic advance
Correlation and Path coefficient Analysis

Received : 07.01.2016
Revised : 18.04.2016
Accepted : 07.06.2016

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INTRODUCTION

Rice (*Oryza sativa* L.) being the principal food crop to billions of people around the world, it also provides an excellent entry point for mobilization of national and international resources to achieve the millennium goals and the recommendation of the world food summit. According to the FAO (FAO, 2004), the director general has stated "Rice is a symbol of both cultural identity and global unity". Rice provides 75% of the calories and 55% of the protein in the average daily diet of the people (Nandan *et al*., 2010). India occupies the first production which almost tripled its production during the second half of the last century. Global demand for rice is protected to grow at least equal to population growth, thus requiring a 70% (765 million tonnes) increase in supply of rice by the year 2025 (Nandeshwar, 2010). Rice contributes the 43% of total food grain production and 46% of total cereal production. It is a fact that rice being a semi aquatic plant, water requirements far more than the other crops of similar duration. The water requirement of rice varies from 120 to 180 cm. It needs about 5000 liters of water to produce one kilogram of rice.

Water is one of the most vital natural resources of the world. According to United Nations Organization (UNO), water crises are the major threat for mankind in the 21st century. Among 1400 million cubic km of water in the world 97% is salty sea water, 2% is frozen in glaciers only 1% is available as fresh water (Kirloskar, 2003). From the total available water 75% is used for rice cultivation. Irrigated rice requires lot of water about 3000-5000 liters is used to produce 1kg of grain (IRRI, 2001). This high requirement of water for rice cultivation is because rice is generally grown under low land conditions. In lowland rice fields seepage and percolate on accounts for 50-80% of total water outflow from the field (Sharma, 1989). Evaporation makes up about 30% of evapo-transpiration and only 13-33% of total water is consumptive water use by transpiration. Thus it is necessary to develop a better way of growing rice thus uses less water while maintaining high yields. Aerobic rice is a way of growing rice in aerobic soils with intermittent irrigation. It is a system of growing high yielding rice in non puddle and non-flooded aerobic soil (Bouman and Toung, 2001).

Grain yield is a complex polygenic character controlled by many genes interacting with the environment and is the product of many factors called yield components. The selection of parents based on yield alone is often misleading (Selvaraj *et al*., 2011). Knowledge regarding the relative contribution of individual traits to yield may be accomplished by correlation does not provide adequate information about the contribution of each factor towards yield. Therefore a techniques of path coefficient analysis is utilized to have an idea of direct and indirect

contribution of traits on yield. The present paper deals with genetic variability,character association and path analysis in a set of 30 rice genotypes.

MATERIALS AND METHODS

Thirty aerobic rice genotypes collected from IRRI were sowing in the randomized block design with three replications, at the Experimental Farm of the Department of the Genetics and Plant breeding, Sam Higginbottom Institute of Agriculture technology and Sciences, Allahabad, during *kharif* 2012. In each replication, single seedling was sowed per hill with 20x15 cm spacing. The observations were recorded on five randomly selected plants from each plot for days to 50 per cent flowering, plant height, number of tillers per hill, number of panicles per hill, panicle length, number of spikelets per panicle, flag leaf length, flag leaf width, test weight, days to maturity, biological yield per hill, harvest index and grain yield per hill. The statistical and biometrical analysis of GCV and PCV were calculated by formula given by Burton (1952), heritability in broad sense (h^2) by Burton and de Vane (1953) and genetic advance *i.e.,* the expected genetic gain was calculated using the procedure given by Johnson *et al*., (1955). The correlation coefficient and path coefficient were worked out as for the method recommended by Al-Jibouri *et al*., (1958) and Deway and Lu (1959) respectively, the estimated values were compared with table values of the correlation coefficient to test the significance of the correlation coefficient prescribed by Fisher and Yates (1967).

RESULTS AND DISCUSSION

The extent of variability present in thirty germplasm of aerobic rice was measured in terms of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense), genetic advance, phenotypic and genotypic correlation coefficient analysis and path coefficient analysis. All the genotypes revealed significant differences among the all the characters indicating existence of variability among the genotypes for the characters studied.

The phenotypic coefficient of variation (PCV) were slightly higher than genotypic coefficient of variation (GCV) for 13 different characters were studied which indicate lesser role of environment on the expression of these characters. High magnitude of phenotypic and genotypic coefficient of variation were recorded for number of panicles per hill, seed yield per hill, harvest index and flag leaf length suggest enough variability was present among these 30 rice genotypes. Similar findings were also observed in earlier studies (Akinwala *et al*., 2011). Heritability measures the possibility of joint transmission of two characters in two correlated characters through selection of one character. It has been widely used to assess the degree to which a character may be transmitted from parent to progeny. It also indicates the relative importance of heritability and environment in the expression of character. In the present study traits like biological yield per plant (99.9%), number of panicles per hill (99.8%), test weight (99.8%) , harvest index (99.7%), plant height (99.6%), panicle length (99.2%), seed yield per plant (99%), days to 50% flowering (98.8%), number of tillers per hill (98.5%), days to maturity (98.3%), flag leaf width (93.5%) flag leaf length (93.3%) and number of spikelet per panicle (87.3%) for heritability. Therefore selection from these traits will be valuable for further rice improvement. These results are in accordance with the findings of Khan *et al*. (2009). Estimation of heritability is more advantageous when expressed in terms of genetic advance. Johnson *et al*. (1955) suggested that without genetic advance estimates of heritability would not be of practical value and emphasized the concurrent use of genetic advance along with heritability. In the present study high estimates of heritability coupled with moderate or high value of genetic advance as a percentage of means was observed and this suggested that there was observed and this suggested that there was preponderance of additive gene action for the expression of these characters. Hence, selection of these characters can induce an enhancement of rice production and productivity.

Correlation: The association of grain yield with other characters was estimated by genotypic and phenotypic coefficients (Table 1). Grain yield per plant was correlated positively and significantly with harvest index (0.85 and 0.85), biological yield per hill (0.49 and 0.49), panicle length (0.38 and 0.38), flag leaf width (0.33 and 0.32) at genotypic and phenotypic level and the correlation showed positively and non-significant with no of tiller per plant (0.23 and 0.23), no of spikelets per panicle(0.22 and 0.22), test weight (0.21 and 0.21), no of panicles per hill (0.19 and 0.19) at both level. Likewise,

Table 1: Estimates of components of variance and genetic parameters for 13 characters in aerobic rice during *Kharif* 2012

S.N.	Characters	VG	VP	GCV%	PCV%	h^2(bs)%	GA 5%	GA as %of mean 5%
1	Days to 50% Flowering	24.5052	24.8052	6.227	6.265	98.8	10.136	12.749
2	Plant height	21.1841	21.2654	4.118	4.126	99.6	9.463	8.468
3	Flag leaf length	23.8513	25.5750	13.666	14.151	93.3	9.716	27.187
4	Flag leaf width	0.0160	0.0171	9.840	10.178	93.5	0.252	19.596
5	No of tiller/plant	1.5263	1.5496	13.889	13.994	98.5	2.526	28.395
6	Panicle length	4.2763	4.3097	8.576	8.609	99.2	4.243	17.598
7	Days to maturity	19.5632	19.8966	4.052	4.086	98.3	9.035	8.276
8	No of spikelets / panicle	38.8386	44.4893	5.589	5.981	87.3	11.995	10.757
9	No of panicles/ hill	7.3956	7.4117	25.650	25.678	99.8	5.596	52.782
10	Biological yield	6.7139	6.7198	8.154	8.158	99.9	5.335	16.796
11	Harvest index	36.2075	36.3095	14.321	14.341	99.7	12.378	29.460
12	Test weight	5.2098	5.2180	9.622	9.629	99.8	4.698	19.806
13	Seed yield / plant	4.4591	4.5055	15.790	15.872	99.0	4.328	32.359

VG = Genotypic Variance, VP = Phenotypic Variance, GCV = Genotypic Coefficient of Variation, PCV = Phenotypic Coefficient of Variation, h^2(bs) = Heritability(broad sense), GA = Genetic Advance

Table 2: Estimates of Phenotypic and Genotypic Correlation Coefficient for different quantitative characters in Aerobic rice

Characters	r	Days to 50% flowering	Plant height	Flag leaf length	Flag leaf width	Tiller/ plant	Panicle length	Days to maturity	No of spikelets /panicle	No of panicles / hill	Biological Yield	Harvest Index	Test Weight	Seed yield / plant
Days to 50% flowering	rg	1.00	-0.44**	-0.19	0.25	0.51**	0.21	0.90**	0.03	0.80**	-0.04	0.22	0.09	0.18
	rp		-0.45**	-0.20	0.26	0.52**	0.21	0.90**	0.03	0.81**	-0.04	0.23	0.09	0.18
Plant height	rg		1.00	0.41**	-0.20	-0.22	0.14	-0.49	-0.07	-0.49**	0.09	-0.08	-0.18	-0.04
	rp			0.42**	-0.21	-0.23	0.14	-0.50**	-0.08	-0.49**	0.09	-0.08	-0.18	-0.04
Flag leaf length	rg			1.00	0.24	0.16	0.02	-0.17	-0.17	-0.33*	0.28*	-0.02	-0.04	0.12
	rp				0.25	0.18	0.03	-0.17	-0.17	-0.34*	0.29*	-0.02	-0.04	0.13
Flag leaf width	rg				1.00	0.22	0.28*	0.29*	-0.08	0.20	0.19	0.27*	0.09	0.32*
	rp					0.22	0.28*	0.30*	-0.10	0.21	0.20	0.27*	0.09	0.33*
Tiller/plant	rg					1.00	-0.04	0.44**	0.30*	0.64**	0.12	0.21	-0.87	0.23
	rp						-0.05	0.45**	0.30*	0.64**	0.12	0.21	-0.09	0.23
Panicle length	rg						1.00	0.10	-0.19	0.21	0.41**	0.19	0.22	0.38**
	rp							0.11	-0.20	0.21	0.41**	0.19	0.22	0.38**
Days to maturity	rg							1.00	0.10	0.73	0.00	0.02	0.09	0.02
	rp								0.11	0.74	0.00	0.02	0.09	0.02
No of spikelets/panicles	rg								1.00	0.17	0.11	0.20	0.08	0.23
	rp									0.18	0.12	0.21	0.09	0.23
No of panicles/hill	rg									1.00	-0.04	0.24	0.12	0.19
	rp										-0.04	0.24	0.12	0.19
Biological Yield	rg										1.00	-0.04	0.14	0.49**
	rp											-0.04	0.14	0.49**
Harvest Index	rg											1.00	0.16	0.85**
	rp												0.16	0.85**
Test Weight	rg												1.00	0.21
	rp													0.21

*and** Significant at 5% and 1% level of significance respectively, rp: Phenotypic correlation coefficient, rg: Genotypic correlation coefficient.

Table 3: Estimates of direct and indirect effects of yield component traits on seed yield in 30 aerobic rice genotypes at phenotypic level

Character	Days to 50% flowering	Plant height	Flag leaf length	Flag leaf width	Tillers /plant	Panicle length	Days to maturity	No of spikelets /panicle	No of panicle /hill	Biological Yield	Harvest Index	Test Weight	Seed Yield /Plant
Days to 50% flowering	0.0058	-0.0026	-0.0011	0.0015	0.0030	0.0012	0.0052	0.0002	0.0046	-0.0002	0.0013	0.0005	0.0011
Plant height	0.0055	-0.0124	-0.0050	0.0024	0.0027	-0.0017	0.0060	0.0008	0.0061	-0.0011	0.0010	0.0022	0.0004
Flag leaf length	-0.0022	0.0046	0.0113	0.0027	0.0019	0.0002	-0.0019	-0.0019	-0.0037	0.0032	-0.0003	-0.0005	0.0014
Flag leaf width	-0.0044	0.0034	-0.0042	-0.0176	-0.0039	-0.0049	-0.0050	0.0014	-0.0036	-0.0034	-0.0047	-0.0015	-0.0056
Tiller/plant	-0.0127	0.0055	-0.0041	-0.0056	-0.0250	0.0011	-0.0111	-0.0075	-0.0159	-0.0030	-0.0051	0.0022	-0.0058
Panicle length	-0.0017	-0.0012	-0.0002	-0.0023	0.0004	-0.0084	-0.0009	0.0016	-0.0017	-0.0040	-0.0016	-0.0019	-0.0032
Days to maturity	-0.0029	0.0016	0.0005	-0.0009	-0.0014	-0.0003	-0.0032	-0.0003	-0.0023	0.0000	-0.0001	-0.0003	-0.0001
No of spikelets /panicle	-0.0002	0.0006	0.0015	0.0007	-0.0027	0.0017	-0.0009	-0.0090	-0.0016	-0.0010	-0.0018	-0.0007	-0.0021
No of panicle/hill	0.0168	-0.0103	-0.0069	0.0043	0.0133	0.0044	0.0153	0.0037	0.0210	-0.0008	0.0050	0.0024	0.0040
Biological Yield	-0.0195	0.0457	0.1516	0.1027	0.0638	0.2177	0.0022	0.0607	-0.0216	0.5323	-0.0209	0.0764	0.2592
Harvest Index	0.1975	-0.0726	-0.0200	0.2337	0.1808	0.1699	0.0174	0.1797	0.2110	-0.0345	0.8786	0.1387	0.7472
Test Weight	-0.0006	0.0012	0.0003	-0.0006	0.0006	-0.0015	-0.0006	-0.0005	-0.0008	-0.0010	-0.0011	-0.0069	-0.0015

R SQUARE = 0.9951, RESIDUAL EFFECT = SQRT (0.0699)

Table 4: Estimates of direct and indirect effects of yield component traits on seed yield in 30 aerobic rice genotypes at genotypic level

Character	Days to 50% flowering	Plant height	Flag leaf length	Flag leaf width	Tillers /plant	Panicle length	Days to maturity	No of spikelets /panicle	No of panicles /hill	Biological Yield	Harvest Index	Test Weight	Seed Yield /Plant
Days to 50% flowering	-0.0089	0.0040	0.0018	-0.0023	-0.0046	-0.0019	-0.0080	-0.0003	-0.0072	0.0003	-0.0020	-0.0008	-0.0016
Plant height	0.0043	-0.0095	-0.0040	0.0020	0.0022	-0.0013	0.0047	0.0007	0.0047	-0.0008	0.0008	0.0017	0.0003
Flag leaf length	-0.0016	0.0034	0.0081	0.0020	0.0014	0.0002	-0.0013	-0.0014	-0.0027	0.0024	-0.0002	-0.0004	0.0010
Flag leaf width	-0.0064	0.0050	-0.0062	-0.0245	-0.0054	-0.0069	-0.0073	0.0026	-0.0052	-0.0048	-0.0067	-0.0022	-0.0080
Tiller/plant	-0.0104	0.0046	-0.0036	-0.0045	-0.0203	0.0009	-0.0091	-0.0061	-0.0130	-0.0024	-0.0042	0.0018	-0.0047
Panicle length	-0.0027	-0.0018	-0.0003	-0.0036	0.0006	-0.0129	-0.0014	0.0026	-0.0027	-0.0053	-0.0025	-0.0029	-0.0049
Days to maturity	0.0105	-0.0058	-0.0020	0.0035	0.0052	0.0013	0.0117	0.0013	0.0086	0.0001	0.0002	0.0010	0.0003
No of spikelets/panicle	-0.0009	0.0021	0.0048	0.0029	-0.0082	0.0055	-0.0031	-0.0273	-0.0049	-0.0032	-0.0057	-0.0024	-0.0062
No of panicle/hill	0.0185	-0.0114	-0.0077	0.0049	0.0147	0.0048	0.0169	0.0041	0.0230	-0.0009	0.0055	0.0027	0.0044
Biological Yield	-0.0195	0.0465	0.1587	0.1054	0.0645	0.2248	0.0026	0.0629	-0.0219	0.5388	-0.0214	0.0773	0.2630
Harvest Index	0.2022	-0.0740	-0.0198	0.2416	0.1827	0.1730	0.0185	0.1868	0.2132	-0.0354	0.8889	0.1406	0.7573
Test Weight	-0.0004	0.0008	0.0002	-0.0004	0.0004	-0.0010	-0.0004	-0.0004	-0.0005	-0.0007	-0.0007	-0.0046	-0.0010

RSQUARE = 0.999, RESIDUALEFFECT = 0.007

Monalisa *et al.* (2006) reported that grain yield was positively & significant correlation with harvest index, biological yield, panicle length and number of tillers per plant. The results presented above are in agreement with the findings of Nandan *et al.*, (2010). Similar findings were also evident in Bidhan *et al.*, (2001). Information on the inter association of yield components showed the nature and extent of their relationship with each other. This will help in the simultaneous improvement of different characters along with yield in breeding programmes.

Path coefficient analysis permits a thorough understanding of the contribution of various characters by portioning the correlation coefficient into components of direct and indirect effects at both genotypic and phenotypic level (Table 3&4). The different yield contributing traits like harvest index (0.7573 and 0.7472), biological yield (0.2630 and 0.2592), number of panicle per hill (0.0230 and 0.0210),flag leaf length (0.0010 and 0.0014) and plant height (0.0003 and 0.0004) had high direct effect on grain yield per plant while flag leaf width (-0.0080 and -0.0056), number of spikelets per panicle (-0.0062 and -0.0021), panicle length (-0.0049 and -0.0032) and test weight (-0.0010 and -0.0015) had negative direct effect on grain yield per plant on genotypic and phenotypic level. Rekand Beper (2003) reported that biological yield and harvest index had the highest positive direct effect on grain yield per plant and Kumar *et al.,* (2006) reported highest positive direct effect on grain yield fallowed by biological yield and harvest index. Chakraborty *et al.* (2010) reported that harvest index showed positive and direct effect on seed yield at genotypic level. In the present experiment the overall results indicated that the selection of higher biological yield per plant, harvest index and number of panicle per plant were relevant characters.

The present study thus suggests that harvest index, biological yield, number of panicles per hill, flag leaf length and plant height should be major traits to be taken into consideration for selection of desirable genotypes in rice breeding programme for developing high yielding cultivars.

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