Received: 07 Jun 2022 | Revised: 23 Jun 2022 | Accepted: 26 Jun 2022

Electronic Journal of Plant Breeding

Research Article

Estimation of genetic parameters and character association for yield and quality traits in BC_1F_2 population of rice (*Oryza sativa* L.)

R. Prathiksha[1], R. Pushpam[1*], K. Amudha[1] and M. Raveendran[2]

[1]Department of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, India.
[2]Department of Biotechnology, Centre for Plant Molecular Biology and Biotechnology, Tamil Nadu Agricultural University, Coimbatore, India
***E-Mail:**pushpamtnau@gmail.com

Abstract
Two BC_1F_2 populations derived from the cross CO 52 x 3-11-11-2 were evaluated in the present study for fifteen yields, yield contributing characters and quality characters to assess genetic variability, correlation coefficient and path coefficient analyses. Single plant yield, number of productive tillers per plant and alkali spreading value all had higher estimates of PCV and GCV. The high heritability coupled with high genetic advance as a percentage of mean was observed for traits *viz*., volume expansion ratio, single plant yield and plant height. In both the backcross population, a high positive correlation was observed between single plant yield and the traits such as the number of productive tillers and days to first flowering. In the case of direct effects, the number of productive tillers and kernel length after cooking played almost higher positive effects in the backcross population I, while in the population II, the number of productive tillers, kernel breadth before cooking, kernel length after cooking and breadthwise elongation ratio ensured the highest direct effect over the single plant yield. Thus, the number of productive tillers per plant can be considered as a key trait in the selection process and can be strategically used for yield improvement programmes.

Keywords: Genetic parameters, correlation, path analysis, rice

INTRODUCTION

Rice is the most important food crop for more than half of the world's population (Singh *et al.,* 2020). India is the second-largest producer of rice in the world with 117.5 MMT production in the year 2019-20 (Chand *et al.,* 2022). Grain yield has become the ideal criteria for increasing productivity, yet selection for grain yield alone would be futile since it is complicated and linked to multiple traits both directly and indirectly (Soujanya *et al*., 2020). The primary goal of the plant breeder is to generate high yielding varieties of major food crops in light of the rising population. Consumer preference for rice is based on grain length, shape, size, and cooking quality. In India, a wide difference exists among the consumers with respect to the grain size of milled and cooked rice. Consumers favour varieties with a medium alkali spreading value (Muthu *et al.,* 2020). For a successful improvement in rice production and productivity, analysing the variability of yield and yield contributing traits is essential. Analysing the amount of variability can be effected by genetic parameters such as phenotypic and genotypic coefficient of variation. Understanding the potential of a plant material used in a breeding programme can be done by evaluating the extent of heritable variation of traits. In a breeding programme, genetic variability and other genetic factors are significant and heritability combined with genetic progress can help forecast selection efficacy (Parimala *et al*., 2019). Knowledge of correlation studies among the yield and yield contributing traits along with direct and indirect causes of the traits are crucial for grain yield. CO 52 is a popular rice variety with a medium duration (130-135 days) and good cooking quality. Also, it exhibits moderate resistance to hoppers, sheath rot and blast. Despite this, it is susceptible to abiotic stresses like drought and salinity (Robin *et al.,* 2019). There is a need to focus on improving the drought and salinity tolerant nature of CO 52. Thus, the donor parent (3-11-11-2) was selected in such a way that it had QTLs for drought and salinity *viz., $qDTY_{1.1}$* and *$qDTY_{2.1}$* (Drought) and *Saltol* (Salinity). The present investigation was undertaken in this context to elucidate the information on genetic variability, heritability, genetic advance, correlation and path association coefficient in the BC_1F_2 population of CO 52 and 3-11-11-2.

MATERIALS AND METHODS

The backcross population was developed by crossing CO 52 (recurrent parent) with 3-11-11-2 (donor parent) at the Department of Rice, Tamil Nadu Agricultural University, Coimbatore. Plants with the highest genome recovery (>70%) for all the three QTLs were identified in BC_1F_1. Two backcross plants *viz.,* plant number 33 (Population I) and 32 (Population II) with genome recovery of 80 and 76 per cent, respectively were forwarded to BC_1F_2. Biometrical observations were recorded in populations I & II on 236 and 182 plants, respectively during *Rabi* 2021-2022. Quantitative traits *viz.,* plant height (cm), days to first flowering (days), the number of productive tillers per plant, panicle length (cm), thousand grain weight (g), and single plant yield (g) were observed on single plant basis in BC_1F_2 populations. Similarly, grain quality parameters such as kernel length before cooking (mm), kernel breadth before cooking (mm), kernel length – breadth ratio, kernel length after cooking (mm), kernel breadth after cooking (mm), linear elongation ratio, breadthwise expansion ratio, volume expansion and alkali spreading value were also recorded by taking an observation of five kernels from each plant. GCV, PCV and the genetic advance were carried out by the method suggested by Johnson *et al.* (1955). The correlation was calculated using the formulae suggested by Falconer (1964). Partitioning of the correlation coefficients into direct and indirect effects was worked out using the procedure suggested by Wright (1921) and elaborated by Dewey and Lu (1959). The mean data obtained were subjected to statistical analysis for the estimation of genetic parameters using the Statistical Tool for Agricultural Research (STAR) tool. Correlation and path coefficient analysis was done using TNAU-STAT.

RESULTS AND DISCUSSION

The estimates of genetic parameters obtained in the present study are presented in **Tables 1 and 2**. High PCV and GCV were recorded for single plant yield and volume expansion. This indicates that the trait exhibits a higher degree of variability among the traits and it can be exploited beneficially for the selection process through simple selection methods. Moderate levels of PCV and GCV for plant height and alkali spreading value was reported by Kalaiselvan *et al.* (2019). Moderate PCV coupled with low GCV were observed for the traits *viz.,* length-breadth ratio, kernel breadth before cooking and kernel breadth after cooking. Such traits could be

Table 1. Components of genetic parameters for yield and grain quality traits in backcross population I

Characters	Mean	Range	VP	VG	PCV (%)	GCV (%)	Heritability (%)	GA	GAM
Days to first flowering (days)	103.41	43.00	73.51	53.56	8.29	7.08	72.86	12.87	12.44
Plant height (cm)	80.09	61.50	115.42	104.90	13.41	12.79	90.89	20.11	25.11
Panicle length (cm)	21.22	16.10	6.54	4.70	12.05	10.21	71.79	3.78	17.82
Number of productive tillers	13.66	27.00	15.90	4.75	29.19	15.95	29.87	2.45	17.96
Thousand grain weight (g)	12.60	9.70	1.31	0.99	9.08	7.90	75.57	1.78	14.14
Kernel length before cooking (mm)	4.93	1.40	0.04	0.01	4.06	2.03	25.00	0.10	2.09
Kernel breadth before cooking (mm)	1.82	0.70	0.05	0.01	12.29	5.49	20.00	0.09	5.06
Length – Breadth ratio	2.72	0.97	0.10	0.01	11.63	2.60	5.00	0.03	1.20
Kernel length after cooking (mm)	6.50	3.10	0.18	0.15	6.53	5.96	83.33	0.73	11.20
Kernel breadth after cooking (mm)	2.92	1.16	0.11	0.00	11.36	2.42	4.55	0.03	1.06
Linear expansion ratio	1.32	0.60	0.01	0.01	7.58	7.58	92.41	0.21	15.61
Breadthwise expansion ratio	1.61	0.46	0.01	0.01	6.21	6.21	92.41	0.21	12.80
Volume expansion ratio	1.84	3.00	0.20	0.19	24.31	23.38	92.50	0.85	46.31
Alkali spreading value	2.53	6.00	2.10	0.10	57.28	12.50	4.76	0.14	5.62
Single plant yield (g)	12.53	8.60	40.94	27.84	29.96	24.70	67.99	8.96	41.95

VP – Phenotypic variation, VG – Genotypic variation, PCV – Phenotypic coefficient of variation, GCV - Genotypic coefficient of variation, GA – Genetic Advance, GAM – Genetic Advance as percentage of mean

Table 2. Components of genetic parameters for yield and grain quality traits in backcross population II

Characters	Mean	Range	VP	VG	PCV (%)	GCV %)	Heritability (%)	GA	GAM
Days to first flowering (days)	107.34	58	80.76	60.81	8.37	7.26	75.30	13.94	12.99
Plant height (cm)	83.68	88.4	112.31	101.79	12.66	12.06	90.63	19.79	23.65
Panicle length (cm)	22.46	13.3	5.56	3.72	10.50	8.58	66.82	3.25	14.45
Number of productive tillers	14.77	30	18.61	7.46	29.21	18.49	40.09	3.56	24.12
Thousand grain weight (g)	20.47	37.5	1.20	0.88	8.74	7.49	73.33	1.65	13.21
Kernel length before cooking (mm)	12.53	8.6	0.08	0.05	5.76	4.55	62.50	0.36	7.42
Kernel breadth before cooking (mm)	4.91	1.68	0.05	0.01	12.42	5.56	20.00	0.09	5.12
Length – Breadth ratio	1.80	0.7	0.10	0.01	11.50	2.57	5.00	0.03	1.18
Kernel length after cooking (mm)	2.75	1.21	0.59	0.56	11.53	11.24	94.92	1.50	22.55
Kernel breadth after cooking (mm)	6.66	3.5	0.11	0.00	11.40	2.43	4.55	0.03	1.07
Linear expansion ratio	2.91	1.6	0.03	0.03	12.74	12.74	95.32	0.36	26.24
Breadthwise expansion ratio	1.36	0.77	0.02	0.02	8.73	8.73	95.32	0.29	17.98
Volume expansion ratio	1.62	0.86	0.46	0.45	28.26	27.80	96.74	1.35	56.32
Alkali spreading value	2.40	3.18	2.10	0.10	57.51	12.55	4.76	0.14	5.64
Single plant yield (g)	2.52	6	35.70	22.60	29.19	23.22	63.29	7.79	38.06

VP – Phenotypic variation, VG – Genotypic variation, PCV – Phenotypic coefficient of variation, GCV - Genotypic coefficient of variation, GA – Genetic Advance, GAM – Genetic Advance as percentage of mean

improved through selection in advanced generations. However, low PCV and GCV were recorded for days to first flowering, thousand grain weight, kernel length before cooking and breadthwise elongation ratio which indicates that lower variation may be due to a narrow genetic base. These results were in accordance with Divya *et al.* (2018) and Nikhitha *et al.* (2020) for days to first flowering.

High heritability coupled with high GAM were observed for plant height, volume expansion ratio and single plant yield which indicates that these traits are controlled by additive gene action and have less environmental influence. Therefore, direct phenotypic selection will be effective in improving these traits and similar results have been reported by Nikhitha *et al.* (2020) and Seneega *et al.* (2019). High heritability and moderate genetic advance were found for the traits such as days to first flowering, panicle length, thousand grain weight and breadthwise elongation ratio. This may be due to the fact that these traits are controlled by both additive and non-additive gene action. Hence, selection for these traits can be advanced to a later generation to obtain desirable improvement. These results were in accordance with Kalaiselvan *et al.* (2019). Low heritability and GAM were found in kernel breadth before cooking, length-breadth ratio, kernel breadth after cooking and alkali spreading value which indicates that the expression of these traits is highly influenced by the environment. Similar observations were recorded by Behera *et al.* (2018) and Nikhitha *et al.* (2020) for length-breadth ratio.

Correlation studies give broad information to the breeder about the association of characters towards the grain yield. Thus, a better understanding of their association with single plant yield would make the selection more precise and accurate with the attributing traits as effective indicators of selection. It was observed from the phenotypic correlation assessment of the present study that single plant yield showed a highly significant positive correlation with the number of productive tillers in both the backcross populations. Similarly, days to first flowering exhibited a significant positive correlation with single plant yield. A similar association of these traits with single plant yield was reported by Muthuvijayaragavan and Murugan (2020) and Nikhitha *et al.* (2020). In the backcross population I, plant height and length–breadth ratio were found to have a highly significant and positive relationship with single plant yield **(Table 3 & Fig.1).** Sudeepthi *et al.* (2020) also reported a similar kind of association between plant height and yield whereas, Nirmaladevi *et al.* (2015) reported a positive association between length – breadth ratio and yield. The association of panicle length with single plant yield was found to be highly significant and positive in the backcross population II **(Table 4 & Fig.2)** whereas, it is significant and positive in the backcross population I. Devi *et al.* (2017), Nikhitha *et al.* (2020), and Sudeepthi *et al.* (2020) reported similar results for plant height with single plant yield.

In both the backcross populations, a significant association was observed between a few quantitative and quality traits. Days to first flowering had a highly positive significant correlation with plant height, panicle length and the number of productive tillers. A similar association was found between panicle length and the number of productive tillers, plant height and panicle length, kernel

Table 3. Phenotypic correlation coefficient analysis for yield and grain quality traits in backcross population I

Characters	DFF	PH	PL	NPT	TGW	KLBC	KBBC	L/B RATIO
DFF	1	0.2277**	0.1613*	0.277**	-0.0426	0.3816**	0.0976	0.1548*
PH		1	0.5182**	0.2774**	-0.0327	0.1367	-0.0253	0.1116
PL			1	0.187**	-0.0069	0.1301	0.042	0.0425
NPT				1	-0.0459	0.1803**	-0.081	0.2018**
TGW					1	0.0159	0.0823	-0.0673
KLBC						1	0.3122**	0.339**
KBBC							1	-0.7844**
L/B RATIO								1
KLAC								
KBAC								
LER								
BER								
VE								
ASV								
SPY								

Table 3. Continued.

Characters	KLAC	KBAC	LER	BER	VE	ASV	SPY
DFF	0.2754**	0.022	0.0218	-0.1031	-0.1519*	-0.1938**	0.172*
PH	0.0394	-0.0483	-0.0503	-0.0392	-0.042	-0.115	0.2339**
PL	-0.0021	0.0237	-0.0944	-0.025	-0.1069	-0.1747*	0.1534*
NPT	0.1121	-0.1106	-0.0018	-0.0698	-0.0544	0.0008	0.8059**
TGW	0.0289	0.0982	0.0225	0.034	-0.0573	-0.0161	-0.1256
KLBC	0.4627**	0.2384**	-0.2025**	-0.0644	-0.4168**	-0.1133	0.1024
KBBC	0.1038	0.7748**	-0.1128	-0.1557*	-0.4528**	-0.159*	-0.1228
L/B RATIO	0.1938**	-0.6058**	-0.0231	0.119	0.1897**	0.0908	0.1907**
KLAC	1	0.0154	0.773**	-0.1339	0.2224**	0.0134	0.0532
KBAC		1	-0.1557**	0.5016**	-0.3891**	-0.1751*	-0.1003
LER			1	-0.0999	0.5499**	0.1016	-0.0131
BER				1	0.0162	-0.0625	0.0059
VE					1	0.2492**	-0.0198
ASV						1	0.0057
SPY							1

DFF -Days to first flowering , KLAC- Kernel Length After Cooking , PH -Plant Height, KBAC-Kernel Breadth After Cooking , PL -Panicle Length , LER-Linear Expansion Ratio, NPT-Number of Productive Tillers, BER-Breadthwise Expansion Ratio, TGW-Thousand grain weight , VE-Volume Expansion ratio, KLBC-Kernel Length Before Cooking, ASV-Alkali Spreading Value, KBBC-Kernel Breadth Before Cooking , SPY-Single Plant Yield, L/B RATIO-Length – Breadth Ratio

** Significance at 1% level, * Significance at 5% level

length before cooking and length–breadth ratio, kernel breadth before cooking and kernel breadth after cooking, kernel length after cooking with linear expansion ratio and volume expansion, kernel breadth before cooking and breadthwise expansion ratio and linear elongation ratio with volume expansion. A highly significant negative association was found among quality traits *viz.,* kernel length before cooking and linear elongation ratio, kernel breadth before cooking and length – breadth ratio, length – breadth ratio and kernel breadth after cooking. The results were in accordance with the findings of Nirmaladevi *et al.* (2015) for kernel length before cooking and linear elongation ratio.

The direct and indirect effects of different characters on single plant yield were computed and are presented in **Tables 5 and 6** for the backcross populations I & II, respectively. Path coefficient analysis helps to find out the association and the cause which produce the given correlation and it is a measure of the relative significance

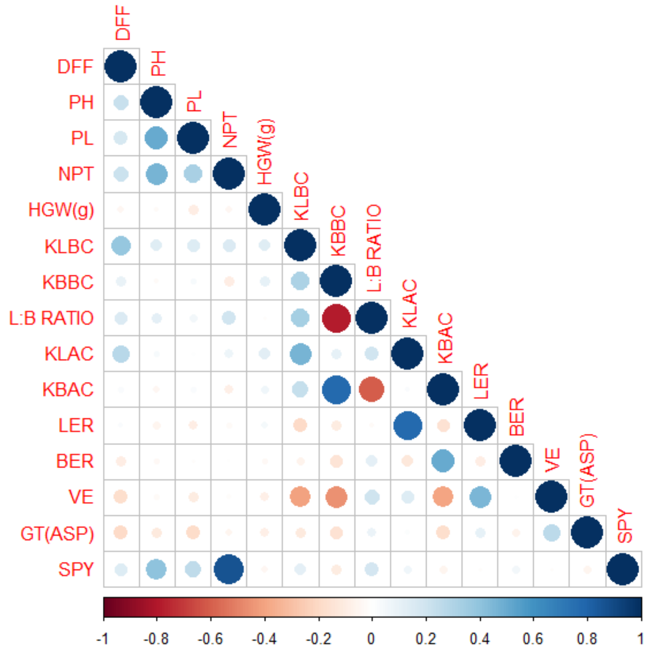

Fig 1. Phenotypic correlation coefficient analysis and Correlogram for yield and quality traits in backcross population I

Table 4. Phenotypic correlation coefficients of yield and grain quality traits backcross population II

Characters	DFF	PH	PL	NPT	TGW	KLBC	KBBC	L/B RATIO	KLAC	KBAC	LER	BER	VE	ASV	SPY
DFF	1	0.31**	0.2906**	0.2321**	0.0977	-0.0176	0.0721	-0.0668	-0.0565	0.1208	-0.0589	0.0735	0.1159	-0.0173	0.195*
PH		1	0.6344**	0.184*	0.0542	0.0091	0.0901	-0.0551	0.0813	0.0782	0.0662	0.0167	-0.0016	-0.2066**	0.1203
PL			1	0.2518**	0.1114	-0.002	0.1371	-0.1088	0.0214	0.0144	0.019	-0.1033	-0.0676	-0.2603**	0.2156**
NPT				1	-0.0304	0.0713	-0.032	0.071	0.0712	0.1134	0.0328	0.1513	0.101	-0.0411	0.7427**
TGW					1	0.2665**	0.0825	0.1116	0.0601	0.0206	-0.066	-0.0425	0.0036	0.0611	-0.0235
KLBC						1	0.0864	0.5926**	0.1777*	0.0504	-0.2988**	-0.0176	-0.1023	0.0129	0.099
KBBC							1	-0.7475**	0.0188	0.4722**	-0.0374	-0.338**	0.0675	-0.0454	-0.0053
L/B RATIO								1	0.1169	-0.3415**	-0.1537	0.2685**	-0.1033	0.0449	0.0722
KLAC									1	-0.0385	0.8836**	-0.0345	0.3487**	0.0782	0.0799
KBAC										1	-0.0744	0.6668**	0.1376	-0.0733	0.0622
LER											1	-0.0264	0.3836**	0.0651	0.0238
BER												1	0.1035	-0.0397	0.0776
VE													1	0.0372	0.1096
ASV														1	-0.0564
SPY															1

DFF -Days to first flowering , KLAC- Kernel Length After Cooking , PH -Plant Height, KBAC-Kernel Breadth After Cooking , PL -Panicle Length , LER-Linear Expansion Ratio, NPT-Number of Productive Tillers, BER-Breadthwise Expansion Ratio, TGW-Thousand grain weight , VE-Volume Expansion ratio, KLBC-Kernel Length Before Cooking, ASV-Alkali Spreading Value, KBBC-Kernel Breadth Before Cooking , SPY-Single Plant Yield, L/B RATIO-Length – Breadth Ratio

** Significance at 1% level, * Significance at 5% leve

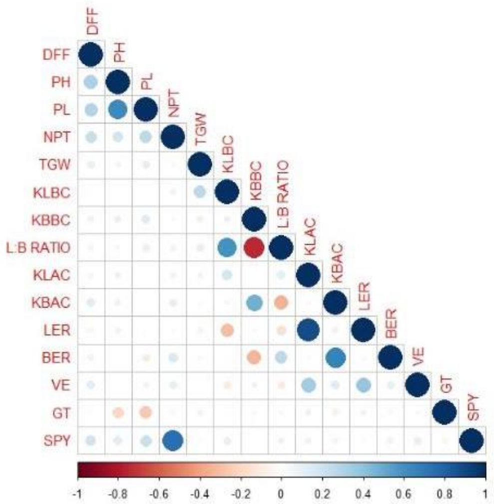

Fig 2. Phenotypic correlation coefficient analysis and Correlogram for yield and quality traits in backcross population II

Table 5. Estimates of direct and indirect effects of yield and grain quality traits in the backcross population I

Characters	DFF	PH	PL	NPT	TGW	KLBC	KBBC	L/B RATIO	KLAC	KBAC	LER	BER	VE	ASV	SPY
DFF	**-0.0555**	0.0047	0.0003	0.2263	0.0037	-0.158	-0.0153	-0.0144	0.1967	0.0008	-0.0143	-0.0035	-0.0002	0.0005	0.172
PH	-0.0126	**0.0208**	0.001	0.2266	0.0028	-0.0566	0.004	-0.0104	0.0281	-0.0017	0.0329	-0.0013	-0.0001	0.0003	0.2339
PL	-0.009	0.0108	**0.002**	0.1528	0.0006	-0.0539	-0.0066	-0.0039	-0.0015	0.0008	0.0618	-0.0008	-0.0001	0.0005	0.1534
NPT	-0.0154	0.0058	0.0004	**0.8169**	0.004	-0.0747	0.0127	-0.0187	0.0801	-0.0039	0.0012	-0.0023	-0.0001	0	0.8059
TGW	0.0024	-0.0007	0	-0.0375	**-0.087**	-0.0066	-0.0129	0.0063	0.0207	0.0034	-0.0147	0.0011	-0.0001	0	-0.1256
KLBC	-0.0212	0.0028	0.0003	0.1473	-0.0014	**-0.414**	-0.049	-0.0315	0.3305	0.0083	0.1326	-0.0022	-0.0005	0.0003	0.1024
KBBC	-0.0054	-0.0005	0.0001	-0.0662	-0.0072	-0.1293	**-0.1568**	0.0728	0.0741	0.027	0.0738	-0.0052	-0.0006	0.0005	-0.1228
L/B RATIO	-0.0086	0.0023	0.0001	0.1648	0.0059	-0.1404	0.123	**-0.0929**	0.1384	-0.0211	0.0152	0.004	0.0002	-0.0003	0.1907
KLAC	-0.0153	0.0008	0	0.0916	-0.0025	-0.1916	-0.0163	-0.018	**0.7144**	0.0005	-0.5062	-0.0045	0.0003	0	0.0532
KBAC	-0.0012	-0.001	0	-0.0904	-0.0085	-0.0987	-0.1215	0.0563	0.011	**0.0349**	0.102	0.0169	-0.0005	0.0005	-0.1003
LER	-0.0012	-0.001	-0.0002	-0.0014	-0.002	0.0838	0.0177	0.0021	0.5522	-0.0054	**-0.6548**	-0.0034	0.0007	-0.0003	-0.0131
BER	0.0057	-0.0008	0	-0.057	-0.003	0.0267	0.0244	-0.0111	-0.0957	0.0175	0.0654	**0.0336**	0	0.0002	0.0059
VE	0.0084	-0.0009	-0.0002	-0.0444	0.005	0.1726	0.071	-0.0176	0.1588	-0.0136	-0.3601	0.0005	**0.0013**	-0.0007	-0.0198
ASV	0.0108	-0.0024	-0.0003	0.0006	0.0014	0.0469	0.0249	-0.0084	0.0095	-0.0061	-0.0665	-0.0021	0.0003	**-0.0028**	0.0057

Residual effect: 0.4918

of each factor which causes the impact over yield. A high positive effect was exerted by the number of productive tillers over a single plant yield. Similar findings were noted by Muthuvijayaragavan and Murugan (2020), Soujanya *et al*. (2020) and Sudeepthi *et al.* (2020). This signifies that this trait might be considered an important criterion for selection in crop improvement programmes. A low direct positive effect was exerted by days to first flowering on a single plant yield. A high level of negative effect was shown by kernel length before cooking over the single plant yield.

The direct effect of kernel length after cooking over a single plant yield was found to be very high in the backcross population II whereas, high in the backcross population I. A very high and a high negative direct effect was exerted

Table 6. Estimates of direct and indirect effects of yield and grain quality traits in the backcross population II

Characters	DFF	PH	PL	NPT	TGW	KLBC	KBBC	L/B RATIO	KLAC	KBAC	LER	BER	VE	ASV	SPY
DFF	0.0133	-0.0289	0.0233	0.1691	-0.0021	0.0155	0.0639	-0.0308	-0.0729	-0.083	0.079	0.0439	0.0043	0.0006	0.195
PH	0.0041	-0.0932	0.0508	0.1341	-0.0012	-0.008	0.0798	-0.0254	0.1049	-0.0537	-0.0888	0.01	-0.0001	0.0071	0.1203
PL	0.0039	-0.0592	0.0801	0.1835	-0.0024	0.0017	0.1213	-0.0503	0.0276	-0.0099	-0.0254	-0.0617	-0.0025	0.0089	0.2156
NPT	0.0031	-0.0172	0.0202	0.7286	0.0007	-0.0625	-0.0284	0.0328	0.0918	-0.078	-0.044	0.0904	0.0037	0.0014	0.7427
TGW	0.0013	-0.0051	0.0089	-0.0222	-0.0219	-0.2336	0.073	0.0516	0.0775	-0.0142	0.0886	-0.0254	0.0001	-0.0021	-0.0235
KLBC	-0.0002	-0.0008	-0.0002	0.0519	-0.0058	-0.8768	0.0765	0.2737	0.2293	-0.0346	0.4007	-0.0105	-0.0037	-0.0004	0.099
KBBC	0.001	-0.0084	0.011	-0.0233	-0.0018	-0.0758	0.8853	-0.3453	0.0243	-0.3246	0.0502	-0.2019	0.0025	0.0016	-0.0053
L/B RATIO	-0.0009	0.0051	-0.0087	0.0517	-0.0025	-0.5196	-0.6618	0.4619	0.1509	0.2348	0.2062	0.1604	-0.0038	-0.0015	0.0722
KLAC	-0.0008	-0.0076	0.0017	0.0519	-0.0013	-0.1558	0.0166	0.054	1.2903	0.0265	-1.1852	-0.0206	0.0128	-0.0027	0.0799
KBAC	0.0016	-0.0073	0.0012	0.0826	-0.0005	-0.0442	0.418	-0.1577	-0.0497	-0.6875	0.0998	0.3983	0.005	0.0025	0.0622
LER	-0.0008	-0.0062	0.0015	0.0239	0.0014	0.262	-0.0331	-0.071	1.1402	0.0511	-1.3413	-0.0158	0.0141	-0.0022	0.0238
BER	0.001	-0.0016	-0.0083	0.1102	0.0009	0.0154	-0.2992	0.124	-0.0445	-0.4585	0.0354	0.5974	0.0038	0.0014	0.0776
VE	0.0015	0.0001	-0.0054	0.0736	-0.0001	0.0897	0.0598	-0.0477	0.4499	-0.0946	-0.5145	0.0618	0.0367	-0.0013	0.1096
ASV	-0.0002	0.0193	-0.0209	-0.03	-0.0013	-0.0113	-0.0402	0.0207	0.1009	0.0504	-0.0873	-0.0237	0.0014	-0.0342	-0.0564

Residual effect: 0.5768

DFF -Days to first flowering , KLAC- Kernel Length After Cooking , PH -Plant Height, KBAC-Kernel Breadth After Cooking , PL -Panicle Length , LER-Linear Expansion Ratio, NPT-Number of Productive Tillers, BER-Breadthwise Expansion Ratio, TGW-Thousand grain weight , VE-Volume Expansion ratio, KLBC-Kernel Length Before Cooking, ASV-Alkali Spreading Value, KBBC-Kernel Breadth Before Cooking , SPY-Single Plant Yield, L/B RATIO-Length – Breadth Ratio

by linear elongation ratio over the plant yield in the backcross population II and I respectively. High levels of positive effect were found in the backcross population II alone by kernel breadth before cooking, length – breadth ratio and breadthwise elongation ratio which makes clear that these traits can be utilized in direct selection for the traits recommended for yield enhancement. Similarly, kernel breadth after cooking enhanced a high negative direct effect over the single plant yield in the same population. A moderate positive effect was shown by plant height and panicle length over single plant yield in the backcross populations I and II, respectively.

The high positive indirect effect was recorded by linear expansion ratio on the single plant yield *via* kernel length after cooking in the backcross population II. Likewise, a high negative indirect effect was recorded by kernel length after cooking *via* linear expansion ratio. Furthermore, kernel length before cooking showed a high direct positive effect on single plant yield *via* length breadth ratio and kernel length after cooking in the same population. Such cases were reported by Singh *et al*. (2018).

From the results observed in PCV, GCV, Heritability, GAM, correlation and path coefficient analysis, it is concluded that the number of productive tillers per plant can be considered as a key trait in the selection process and can be strategically used for yield improvement programmes.

REFERENCES

Behera, B., Sahu, S., Kar, R.K. and Pandey, R.K. 2018. Studies on genetic variability for some metric traits in slender grain rice genotypes. *Journal of Applied and Natural Science*, **10** (1): 375-378. [Cross Ref]

Chand, R. 2022. Indian Agriculture Towards 2030—Need for a Transformative Vision. *Indian Agriculture Towards 2030*, 1-7. [Cross Ref]

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy J.,* **51** (9) : 515-518. [Cross Ref]

Divya, J., Raju, C.D., Rao, L.S. and Aparna, K. 2018. Genetic variability studies in genetically diverse rice genotypes. *Int. J. Curr. Microbiol. App. Sci,* **7** (4) : 1169-1172. [Cross Ref]

Falconer, D. S. 1 964. . An Introduction of Quantitative Genetics- Second edition. Oliver and Boyd, Edinburgh. 312-324.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.,* **47**: 314-318. [Cross Ref]

Kalaiselvan, S., Subramanian, A., Thirumurugan, T. and Rajanbabu, V. 2019. Genetic variability and association studies in F_2 population of rice under sodicity. *Electronic Journal of Plant Breeding*, **10** (2): 601-613. [Cross Ref]

Muthu, V., Abbai, R., Nallathambi, J., Rahman, H., Ramasamy, S., Kambale, R., ...and Muthurajan, R. 2020. Pyramiding QTLs controlling tolerance against drought, salinity, and submergence in rice through marker assisted breeding. *PloS one*, **15** (1): e0227421. [Cross Ref]

Muthuvijayaragavan, R. and Murugan, E. 2020. Association analysis of F_2 generation in rice (*Oryza sativa* L.) under salinity condition. *Electronic Journal of Plant Breeding*, **11** (1): 283-289. [Cross Ref]

Nikhitha, T. C., Pushpam, R., Raveendran, M. and Manonmani, S. 2020. Genetic variability and frequency distribution studies in F_2 population involving traditional variety mappillai samba. *Electronic Journal of Plant Breeding*, **11** (03): 933-938. [Cross Ref]

Nirmaladevi, G., Padmavathi, G., Kota, S. and Babu, V. R. 2015. Genetic variability, heritability and correlation coefficients of grain quality characters in rice (Oryza sativa L.). *SABRAO journal of Breeding and Genetics*, **47** (4): 424-433.

Parimala, K. and Devi, K. R. 2019. Estimation of variability and genetic parameters in indica and japonica genotypes of rice (*Oryza sativa* L.). *Int. J. Curr. Microbiol. App. Sci*, **8** (3): 1138-1142. [Cross Ref]

Robin, S., Pushpam, R., Rajeswari, S., Amudha, K., Jeyaprakash, P., Manonmani, S., ... and Ganesamurthy, K. 2019. CO 52 (IET 25487): A highly remunerative medium duration fine grain rice variety. *Electronic Journal of Plant Breeding,* **10** (3): 1148-1160. [Cross Ref]

Seneega, T.V., Gnanamalar, R.P., Parameswari, C., Vellaikumar, S. and Priyanka, A.R., 2019. Genetic variability and association studies in F_2 generation of rice (Oryza sativa L.). *Electronic Journal of Plant Breeding,* **10** (2): 512-517. [Cross Ref]

Singh, R., Yadav, V., Mishra, D. N. and Yadav, A. 2018. Correlation and path analysis studies in rice (*Oryza sativa* L.). *Journal of Pharmacognosy and Phytochemistry*, 2084-2090.

Singh, S. K., Habde, S., Singh, D. K., Khaire, A., Mounika, K. and Majhi, P. K. 2020. Studies on character association and path analysis studies for yield, grain quality and nutritional traits in F_2 population of rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*, **11** (03): 969-975. [Cross Ref]

Soujanya, T., Hemalatha, V., Revathi, P., Prasad, M. S. and Yamini, K. 2020. Correlation and path analysis in rice (*Oryza sativa* L.) for grain yield and its components. *PART I: Plant Sciences*, 88

Sudeepthi, K., Srinivas, T. V. S. R., Kumar, B. R., Jyothula, D. P. B. and Umar, S. N. 2020. Assessment of genetic variability, character association and path analysis for yield and yield component traits in rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*, **11** (01): 144-148. [Cross Ref]

Wright S. 1921. Correlation and causation. *J. of Agric. Research.,* **20**: 557-585