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SELECTION CRITERIA, YIELD RELATIONSHIP, CAUSE EFFECT ESTIMATION FOR SOME YIELD CONTRIBUTING TRAITS IN *TROPICAL JAPONICA* AND *INDICA* RICE LINES (*Oryza sativa* L.)

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ABSTRACT

Thirty-six rice lines comprising of sixteen *tropical japonica* and same number of *indica* lines including four checks namely NDR-359, Sarjoo-52, Pusa Basmathi-1 and CSR-36 grown in randomized block design to assess eighteen quantitative traits. Phenotypic coefficient of variability (PCV) was higher than genotypic coefficient of variability (GCV) for all the traits at both of the levels. Higher order of PCV and GCV at both of the levels was observed for all the traits except kernel length, kernel breadth, plant height and days to flowering; indicated greater scope for selection. The high estimates of broad sense heritability coupled with genetic gain was recorded for grains per panicle, spikelets per panicle, biological yield per plant, days to flowering, plant height, spikelet fertility and flag leaf area indicated selection can be practiced for enhancing the mentioned characters. A very strong positive and highly significant correlation between grain yield per plant and biological yield per plant, panicle bearing tillers per plant, grains per panicle, panicle length, spikelet fertility, spikelets per panicle, test weight, harvest index, flag leaf length, flag leaf area and kernel length suggested that can be increased simultaneously through selection. Harvest index, biological yield per plant, panicle bearing tillers per plant and panicle weight exhibited highest direct effect on grain yield per plant at both genotypic as well as phenotypic level.

Key words : *Tropical japonica, indica, Variability, inter-relationship cause and effects*

Rice is the Life line of more than 90 per cent of the world, grown and consumed in Asia (rice bowl of the world), where 60 per cent of the earth's people and two third of world's poor live (1). Rice is not only one of the major foods, main source of nutrition for 50% of the global population and model plant but also a model organism for scientific research. Asian cultivated rice holds a unique position among domesticated crop species in that it is both a critical food staple and the first fully sequenced crop genome. Rice is consumed as a grain all most exclusively by humans, supplying 23% of daily calories for the world population. According to Food and Agriculture Organization (FAO) of United Nations (UN) 80% of the world rice production comes from seven countries only. In year 2009-10 the world rice production was topped by China (32.7%) followed by India (26%) and Indonesia (10.2%). India is the second most populous nation, stands first in area, second in production, followed and preceded by China on these two aspects (2).

In order to step up the production potential, there is an urgent need to launch a dynamic breeding programme to develop *indica* and *japonica* varieties suitable for different agro-climatic regions. It is true that more diverse plants have greater opportunity of obtaining high heterotic crosses and broad variability in segregating generations during genetic improvement. The knowledge of variability present in a crop species has special significance which provides clear-cut identification that selection can be practices to improve desirable characters. In all crops breeders try to adjust the genotype in relation to that environment where experiment is being done to achieve higher grain yield and agronomic cum morphological traits. The prediction of genetic advance is a prerequisite for crop improvement breeding programs especially when large populations are subjected to selection. Facilitated by obtaining phenotypic and genotypic coefficients of variation in the absence of which field evaluation of every genotype would be physically less feasible. Hence there is need to study variability for different

Table-1: Variance analysis of Randomized Block Design for eighteen characters in world mini rice core collections

Characters	Sources of variation				
	Replication (2)	Treatment (35)	Error (70)	SE(d)	CD at 5%
Days to 50% flowering	14.78	671.79**	16.13	3.28	6.53
Plant height (cm)	41.83	626.71**	18.53	3.52	7.01
Panicle bearing tillers/plant	0.89	45.87**	2.83	1.37	2.74
Flag leaf length	5.26	102.12**	4.43	1.72	3.43
Flag leaf width	0.01	0.35**	0.01	0.09	0.18
Flag leaf area	15.67	458.68**	13.25	2.97	5.92
Panicle length (cm)	0.83	75.33**	2.15	1.19	2.39
Panicle weight (g)	0.05	2.19**	0.03	0.14	0.27
Spikelets/panicle	948.61*	3335.64**	298.63	14.11	28.14
Grains/panicle	637.67	4106.25**	226.98	12.30	24.53
Spikelet fertility (%)	80.42	795.18**	98.22	8.09	16.14
1000- grain weight (g)	0.59	108.65**	0.31	0.45	0.90
Kernel length	0.02	2.39**	0.03	0.13	0.27
Kernel breadth	0.01	0.44**	0.01	0.09	0.18
L:B ratio	0.01	1.18**	0.05	0.19	0.38
Biological yield/plant (g)	174.31*	1650.56**	50.91	5.82	11.62
Harvest index	127.50*	239.38**	38.69	5.07	10.13
Grain yield/plant (g)	7.24	136.19**	5.32	1.88	3.75

*, ** Significant at 5% and 1% probability levels, respectively.

Table-2: Estimates of general mean, variability parameters for eighteen characters in world mini rice core collections

Characters	Range		Grand mean	Coefficient of variation (%)			h^2b (%)	Ga (%)
	Minimum	Maximum		PCV	GCV	ECV		
Days to 50% flowering	64.00	119.67	102.69	14.92	14.40	3.91	93.00	29.39
Plant height (cm)	68.05	130.47	95.94	15.50	14.84	4.49	92.00	28.08
Panicle bearing tillers/plant	2.88	18.02	9.52	43.53	39.78	17.67	84.00	7.13
Flag leaf length	18.67	43.74	27.70	21.96	20.60	7.60	88.00	11.03
Flag leaf width	0.84	2.45	1.46	24.21	22.94	7.73	90.00	0.65
Flag leaf area	11.70	70.31	31.28	40.65	38.95	11.63	92.00	24.05
Panicle length (cm)	17.33	34.15	24.37	21.14	20.27	6.01	92.00	9.75
Panicle weight (g)	0.96	4.52	2.43	35.63	34.95	6.92	96.00	1.72
Spikelets/panicle	49.43	191.03	124.09	29.18	25.64	13.93	77.00	57.60
Grains/panicle	28.00	175.00	93.54	41.68	38.44	16.11	85.00	68.32
Spikelet fertility (%)	42.80	92.29	73.74	24.66	20.67	13.44	70.00	26.32
1000- grain weight (g)	18.05	39.17	26.32	22.93	22.83	2.11	99.00	12.33
Kernel length	5.07	8.73	6.63	13.60	13.37	2.48	97.00	1.80
Kernel breadth	1.30	2.87	2.21	17.84	17.12	5.01	92.00	0.75
L:B ratio	2.14	4.90	3.03	21.31	19.89	7.65	87.00	1.18
Biological yield/plant (g)	19.86	115.00	46.90	51.53	49.24	15.22	91.00	45.45
Harvest index	10.24	47.42	32.82	31.31	24.92	18.95	63.00	13.41
Grain yield/plant (g)	4.54	30.22	14.91	46.92	44.30	15.47	89.00	12.84

Table 3: Genotypic and Phenotypic correlation coefficients for eighteen characters in world mini rice core collections

Traits	Level	DF	PH	PBT/P	FLL	FLW	FLA	PL	PW	S/P	G/P	SF	TW	KL	KB	L:B	BY/P	HI	GY/P
DF	rg	1.000	-0.263	-0.142	-0.381	-0.030	-0.178	0.072	0.185	0.114	0.160	0.172	-0.186	-0.100	-0.309	0.224	0.087	0.042	-0.040
	rp	1.000	-0.257	-0.088	-0.334	-0.027	-0.160	0.070	0.170	0.116	0.171	0.169	-0.177	-0.099	-0.286	0.205	0.073	0.036	-0.034
PH	rg		1.000	-0.277	0.351*	0.518	0.498**	-0.193	0.203	-0.114	-0.347	-0.573	0.236	0.254	0.558**	-0.358	0.156	-0.532	-0.164
	rp		1.000	-0.245	0.299*	0.477	0.452**	-0.160	0.192	-0.097	-0.313	-0.475	0.224	0.224	0.504**	-0.307	0.155	-0.400	-0.136
PBT/P	rg			1.000	0.227	0.220	0.237	0.655**	0.010	0.475**	0.667**	0.732**	0.037	0.325*	-0.183	0.408*	0.443**	0.389*	0.699**
	rp			1.000	0.227	0.202	0.234	0.576**	0.007	0.391*	0.594**	0.600**	0.037	0.279*	-0.162	0.340*	0.378*	0.299*	0.607**
FLL	rg				1.000	0.644	0.877**	0.271	0.299*	0.406*	0.229	-0.030	0.595**	0.469**	0.529**	-0.122	0.469**	-0.180	0.401*
	rp				1.000	0.581	0.861**	0.233	0.273	0.325*	0.191	-0.027	0.559**	0.430**	0.482**	-0.118	0.408*	-0.136	0.336*
FLW	rg					1.000	0.920**	0.175	0.482**	0.462**	0.236	-0.104	0.425**	0.467**	0.441**	-0.079	0.576**	-0.325	0.278
	rp					1.000	0.899**	0.149	0.449**	0.385*	0.228	-0.042	0.409**	0.423**	0.419**	-0.098	0.527**	-0.255	0.252
FLA	rg						1.000	0.254	0.467**	0.488**	0.269	-0.064	0.547**	0.516**	0.528**	-0.108	0.610**	-0.299	0.379*
	rp						1.000	0.221	0.438**	0.404*	0.244	-0.033	0.526**	0.478**	0.501**	-0.122	0.557**	-0.237	0.332*
PL	rg							1.000	0.117	0.550**	0.733**	0.697**	0.104	0.424**	-0.186	0.468**	0.565**	0.159	0.643**
	rp							1.000	0.100	0.489**	0.644**	0.517**	0.103	0.407**	-0.176	0.429**	0.513**	0.146	0.581**
PW	rg								1.000	0.464**	0.271	-0.064	0.353*	0.359*	0.460**	-0.185	0.563**	-0.365	0.333*
	rp								1.000	0.397*	0.241	-0.058	0.345*	0.346*	0.440**	-0.174	0.541**	-0.298	0.302*
S/P	rg									1.000	0.904**	0.544**	0.405*	0.565**	0.076	0.327*	0.685**	0.099	0.603**
	rp									1.000	0.851**	0.321*	0.359*	0.496**	0.045	0.298*	0.602**	0.068	0.526**
G/P	rg										1.000	0.843**	0.294*	0.478**	-0.225	0.539**	0.624**	0.313*	0.692**
	rp										1.000	0.759**	0.271	0.428**	-0.204	0.465**	0.558**	0.216	0.619**
SF	rg											1.000	0.079	0.259	-0.525	0.657**	0.352*	0.541**	0.604**
	rp											1.000	0.059	0.193	-0.406	0.488**	0.263	0.332*	0.469**
TW	rg												1.000	0.410**	0.497**	-0.167	0.444**	0.005	0.463**
	rp												1.000	0.399*	0.472**	-0.154	0.420**	0.013	0.439**
KL	rg													1.000	0.253	0.425**	0.488**	-0.209	0.320*
	rp													1.000	0.226	0.426**	0.466**	-0.169	0.297*
KB	rg														1.000	-0.754	0.200	-0.314	0.061
	rp														1.000	-0.765	0.190	-0.234	0.078
L:B	rg															1.000	0.156	0.168	0.182
	rp															1.000	0.142	0.107	0.134
BY/P	rg																1.000	-0.243	0.711**
	rp																1.000	-0.274	0.665**
HI	rg																	1.000	0.437**
	rp																	1.000	0.448**
GY/P	rg																		1.000
	rp																		1.000

*, ** Significant at 5% and 1% probability levels, respectively.

Table 4: Genotypic and Phenotypic path of eighteen characters on grain yield in world mini rice core collections

Traits	Level	DF	PH	PBT/P	FLL	FLW	FLA	PL	PW	S/P	G/P	SF	TW	KL	KB	L:B	BY/P	HI	Correl. of GY/P
DF	Pg	**0.005**	-0.001	-0.001	-0.002	0.000	-0.001	0.000	0.001	0.001	0.001	0.001	-0.001	-0.001	-0.002	0.001	0.000	0.000	-0.040
	Pp	-0.065	0.016	0.005	0.022	0.002	0.010	-0.005	-0.011	-0.007	-0.011	-0.011	0.011	0.006	0.018	-0.013	-0.005	-0.002	-0.034
PH	Pg	-0.019	**0.073**	-0.020	0.026	0.038	0.036	-0.014	0.015	-0.008	-0.025	-0.042	0.017	0.019	0.041	-0.026	0.011	-0.039	-0.164
	Pp	-0.001	0.017	-0.004	0.005	0.008	0.008	-0.003	0.003	-0.002	-0.005	-0.008	0.004	0.004	0.008	-0.005	0.003	-0.007	-0.136
PBT/P	Pg	-0.085	-0.167	**0.603**	0.137	0.133	0.143	0.395	0.006	0.286	0.402	0.441	0.022	0.196	-0.110	0.246	0.267	0.235	0.699
	Pp	-0.013	-0.037	0.151	0.034	0.031	0.035	0.087	0.001	0.059	0.089	0.091	0.006	0.042	-0025	0.051	0.057	0.045	0.607
FLL	Pg	0.035	-0.032	-0.021	**-0.091**	-0.059	-0.080	-0.025	-0.027	-0.037	-0.021	0.003	-0.054	-0.043	-0.048	0.011	-0.043	0.016	0.401
	Pp	-0.090	0.081	0.062	0.271	0.157	0.233	0.063	0.074	0.088	0.052	-0.007	0.151	0.116	0.131	-0.032	0.110	-0.037	0.336
FLW	Pg	0.019	-0.327	-0.139	-0.406	**-0.630**	-0.580	-0.110	-0.304	-0.291	-0.149	0.066	-0.268	-0.294	-0.278	0.050	-0.363	0.205	0.278
	Pp	-0.003	0.057	0.024	0.069	0.120	0.108	0.018	0.054	0.046	0.027	-0.005	0.048	0.051	0.051	-0.012	0.063	-0.031	0.252
FLA	Pg	-0.070	0.195	0.092	0.343	0.360	**0.391**	0.099	0.183	0.191	0.105	-0.025	0.214	0.202	0.206	-0.042	0.239	-0.117	0.379
	Pp	0.065	-0.182	-0.094	-0.347	-0.362	-0.403	-0.089	-0.176	-0.163	-0.098	0.013	-0.212	-0.192	-0.202	0.049	-0.224	0.095	0.332
PL	Pg	0.036	-0.097	0.331	0.137	0.088	0.128	**0.505**	0.059	0.277	0.370	0.352	0.052	0.214	-0.094	0.236	0.285	0.080	0.643
	Pp	0.005	-0.011	0.038	0.015	0.009	0.015	0.065	0.006	0.032	0.042	0.034	0.007	0.026	-0.012	0.028	0.034	0.009	0.581
PW	Pg	0.064	0.070	0.004	0.104	0.167	0.162	0.041	**0.347**	0.161	0.094	-0.022	0.122	0.125	0.159	-0.064	0.195	-0.127	0.333
	Pp	0.024	0.027	0.001	0.039	0.064	0.063	0.014	0.144	0.057	0.035	-0.008	0.049	0.049	0.063	-0.025	0.077	-0.043	0.302
S/P	Pg	0.162	-0.162	0.673	0.577	0.655	0.693	0.780	0.658	**1.419**	1.282	0.771	0.575	0.801	0.108	0.464	0.972	0.140	0.603
	Pp	-0.039	0.034	-0.134	-0.112	-0.132	-0.138	-0.168	-0.136	-0.343	-0.292	-0.110	-0.123	-0.170	-0.015	-0.099	-0.206	-0.024	0.526
G/P	Pg	-0.358	0.775	-1.490	-0.512	-0.528	-0.602	-1.639	-0.606	-2.020	**-2.235**	-1.883	-0.658	-1.068	0.503	-1.204	-1.395	-0.700	0.692
	Pp	0.067	-0.122	0.2322	0.075	0.089	0.095	0.252	0.094	0.333	0.391	0.297	0.106	0.167	-0.079	0.182	0.218	0.085	0.619
SF	Pg	0.007	-0.025	0.032	-0.001	-0.005	-0.003	0.030	-0.003	0.024	0.037	**0.044**	0.003	0.011	-0.023	0.029	0.015	0.024	0.604
	Pp	-0.032	0.090	-0.114	0.005	0.008	0.006	-0.098	0.011	-0.062	-0.145	-0.191	-0.011	-0.037	0.077	-0.093	-0.050	-0.064	0.469
TW	Pg	-0.082	0.104	0.016	0.262	0.187	0.241	0.046	0.155	0.178	0.130	0.035	**0.440**	0.181	0.219	-0.074	0.195	0.002	0.463
	Pp	-0.016	0.021	0.004	0.052	0.038	0.049	0.009	0.032	0.034	0.025	0.005	0.094	0.037	0.044	-0.014	0.039	0.001	0.439
KL	Pg	-0.051	0.130	0.166	0.239	0.238	0.263	0.216	0.183	0.288	0.244	0.132	0.209	**0.510**	0.129	0.217	0.249	-0.107	0.320
	Pp	0.005	-0.013	-0.015	-0.024	-0.023	-0.026	-0.022	-0.019	-0.027	-0.023	-0.011	-0.022	-0.055	-0.012	-0.023	-0.025	0.009	0.290
KB	Pg	0.404	-0.731	0.240	-0.693	-0.578	-0.691	0.243	-0.602	-0.100	0.294	0.687	-0.650	-0.331	**-1.309**	0.987	-0.262	0.411	0.061
	Pp	-0.011	0.019	-0.006	0.018	0.016	0.019	-0.007	0.017	0.002	-0.007	-0.015	0.018	0.008	0.037	-0.029	0.007	-0.008	0.078
L:B	Pg	-0.195	0.311	-0.355	0.106	0.069	0.094	-0.407	0.161	-0.284	-0.469	-0.572	0.145	-0.370	0.656	**-0.870**	-0.136	-0.146	0.182
	Pp	0.001	-0.001	0.001	-0.001	-0.001	-0.001	0.001	-0.003	0.001	0.001	0.001	-0.001	0.001	-0.002	0.002	0.000	0.001	0.134
BY/P	Pg	0.057	0.102	0.289	0.306	0.376	0.399	0.369	0.368	0.447	0.407	0.230	0.290	0.319	0.130	0.102	**0.653**	-0.159	0.711
	Pp	0.053	0.112	0.274	0.295	0.383	0.404	0.372	0.392	0.437	0.405	0.191	0.305	0.338	0.137	0.103	0.725	-0.198	0.665
HI	Pg	0.030	-0.381	0.270	-0.129	-0.233	-0.214	0.114	-0.261	0.071	0.224	0.387	0.004	-0.150	-0.225	0.120	-0.174	**0.716**	0.437
	Pp	0.022	-0.247	0.184	-0.084	-0.157	-0.146	0.091	-0.184	0.042	0.134	0.205	0.008	-0.104	-0.144	0.066	-0.169	0.617	0.448

Residual factors: Genotypic= 0.5502 and phenotypic= 0.2957, Bold figures indicates indicate direct effect.

traits in the source population as a prerequisite for crop improvement since all attempts of breeding and selection would be futile unless major portion of variability is heritable.

Correlation coefficient is very important to measure the traits which affect grain yield. A positive correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. These situations are more common in cereals because of yield traits that occur at different growing stages and affect each other, especially where as early occurring traits influence later traits (3).

MATERIALS AND METHODS

A total of thirty-six world mini core rice collections including four checks viz. NDR-359, Sarjoo-52, Pusa Basmathi-1 and CSR-36 were evaluated in Randomized Block Design during *kharif* 2010 at Crop Research Farm, Nawabganj, C.S. Azad University of Agriculture and Technology, Kanpur (UP) India sourced from genetic resource pool and World Mini Core Collections through Rice Improvement Project of the University. Each genotype was grown in three-row of 3 m length following row to row and plant to plant spacing of 20 cm and 15 cm, respectively. Nawabganj is situated between 27.24^{o} N latitude, 77.50 E longitudes and at an altitude of 178 meters above the msl. in the gangetic plain of central Uttar Pradesh. The climate of district Kanpur is semi-arid with hot summer and cold winter. Nearly 80 percent of total rainfall occurs during the monsoon (only up to September) with a few showers in the winter. The recommended dose of fertilizers N:P:K @ 120:60:60 and cultural practices were followed to raise good and healthy crop. Experimental site was sandy loam having EC =0.34 and pH=8.0, rich in potash and low in organic carbon, nitrogen and phosphorus. The observations were taken on ten randomly selected plants per genotype for eighteen traits namely days to 50% flowering, plant height (cm), panicle bearing tillers per plant, flag leaf length (cm), flag leaf width (cm), flag leaf area (cm^2), panicle length (cm), panicle weight (g), spikelets per panicle, grains per panicle, spikelet fertility (%), 1000-grain weight (g), kernel length (mm), kernel breadth (mm), L:B ratio, biological yield per plant (g), harvest index and grain yield per plant (g). Statistical analyses were subjected, for analysis of variance (4), genotypic and Phenotypic coefficients of variation (5), estimate of broad sense heritability (h^2b) (6) and genetic advance as percent of the mean, was computed by the method suggested by (7), character association (8) and path coefficient analysis by (9).

RESULTS AND DISCUSSION

Highly significant variance for all the characters due to treatments were observed under study while the variances due to replication was non-significant for all the traits except for spikelet per panicle (948.61), biological yield per plant (174.31) and harvest index (127.50) (Table-1). The phenotypic coefficient of variability (PCV) was higher than genotypic coefficient of variability (GCV) for all the traits and considerable amount of environmental effect on expression of the some character by total phenotypic variation were also recorded (Table-2). Hence traits exhibited higher variation for GCV and PCV across the environment (10). Higher order of PCV and GCV at both of the levels was observed for all the characters like biological yield per plant (51.53 and 49.24), grain yield per plant (46.92 and 44.30), panicle bearing tillers per plant (43.53 and 39.78), grains per panicle (41.68 and 38.44), flag leaf area (40.65 and 38.95), panicle weight (35.63 and 34.95), harvest index (31.31 and 24.92), spikelets per panicle (29.18 and 25.64), spikelet fertility (24.66 and 20.67), flag leaf width (24.21 and 22.94), flag leaf length (21.96 and 2.60), L:B ratio (21.31 and 19.89), and panicle length (21.14 and 20.27) also renowned by (11). High amount of GCV and PCV at both levels suggested greater scope for selection because of GCV and PCV alone is not helpful in determining the heritable portion. GCV and heritability estimates would give better information about the efficiency of selection. Moderate PCV and GCV at both level chronicled only in case of kernel length (13.60 and 13.37), days to flowering (14.92 and 14.40), plant height (15.50 and 14.84) and kernel breadth (17.84 and 17.12) also convicted by (6).

The high estimates of broad sense heritability coupled with genetic gain was recorded for grains per panicle (68.32), spikelets per panicle (57.60), biological yield per plant (45.45), days to flowering (29.39), plant height (28.08), spikelet fertility (26.32) and flag leaf area (24.05) indicated that selection can be practiced for enhancing the above character. Similar findings were also concluded by (10).

Correlation and path coefficient at both genotypic and phenotypic level are summarized in Tables 3 and 4 respectively. There were strong positive and highly significant correlation (Table-3) between grain yield per plant and biological yield per plant (0.711 and 0.665), panicle bearing tillers per plant (0.699 and 607), grains per panicle (0.692 and 0.619), panicle length (0.643 and 0.581), spikelet fertility (0.604 and 0.469), spikelets per panicle (0.603 and 0.526), test weight (0.463 and 0.439), harvest index (0.437 and 0.448), flag leaf length (0.401 and 0.336), flag leaf area (0.379 and 0.332) and kernel length (0.320 and 0.290) that can be increased simultaneously through selection (11).

Harvest index followed by biological yield per plant, panicle bearing tillers per plant, and panicle weight exhibited highest direct effect on grain yield per plant at both genotypic as well as phenotypic level while panicle length and test weight have highest direct genotypic effect on grain yield, where as its direct phenotypic effect is negligible. The direct effect of spikelets per panicles followed by kernel length and flag leaf area was highest at genotypic level were as phenotypic direct effect recorded negative effect on grain yield per plant which indicated that performance these characters were highly influenced by environmental factors. Therefore we should take more emphasis on the characters like harvest index, biological yield per plant, panicle bearing tillers per plant, panicle weight, kernel length and flag leaf area. The remaining characters also can be taken in the consideration for further amelioration on the basis of their pedigree performance (10).

Indirect effect of kernel breadth (0.411 and -0.008), panicle bearing tillers per plant (0.235 and 0.045), flag leaf width (0.205 and -0.031) and spikelet per panicle (0.140 and -0.024) at both levels were positive or negligible. This result indicated (Table-4) that these characters had a greater effect on grain yield (13).

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