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Research Article

Interrelationships among yield and its contributing traits in rice (*Oryza sativa* L.) under sodic soil

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Abstract
The experiment was conducted to work out the correlation and path coefficient effects of their various attributes on grain yield in rice with 110 genotypes (aromatic and non-aromatic rice) along with three check varieties *viz.,* Sarjoo 52, FL 478 and CSR 10 of rice. The grain yield per plant exhibited a highly significant and positive correlation with biological yield per plant (0.8993), followed by spikelets per panicle (0.5563), grains per panicle (0.5522), panicle length (0.4187), flag leaf area(0.3844) and leaf nitrogen (0.3187), while significant and positive correlation was recorded with spikelets fertility (0.1765). The highest positive direct effect on grain yield per plant was exerted by biological yield per plant (1.1186) followed by the harvest index (0.4738). Therefore, these characters emerged as most important interrelationships of grain yield in rice.

Keywords
Rice (*Oryza sativa* L.), correlation, path, grain yield and sodic soil

INTRODUCTION

Rice is the most important staple food crop of the world and major source of calories for more than half of the global population. Rice, being the staple food for more than 70 per cent of our national population and source of livelihood for 120-150 million rural households, is backbone to the Indian Agriculture.

Thus, the development of improved high yielding pure line and hybrid rice varieties suitable for adverse condition (salt affected soil) would be an important strategy to meet this challenge in context of production and productivity in sodic soil. Utter Pradesh inland salinity areas are mainly concentrated in Raibareilly, Azamgarh, Sultanpur, Ayodhya, Lucknow, Unnao and Pratapgarh districts.

The knowledge of factors responsible for high yields has been rendered difficult since yield is a complex character that manifests through multiplicative interactions of other characters known as yield components (Grafius, 1959). For rational approach in breeding for higher yield, several workers emphasized the use of component approach for successful breeding programme (Moll *et al*., 1962, Bhatt, 1970). Therefore, the identification of important yield contributing characters, out of numerous plant traits, is necessary because it would be impossible and impractical to concentrate and work on improving many characters at a time. The correlation and path coefficient analysis help us in identification of important yield contributing characters. The coefficient of correlation expresses association between two variables, but tells us nothing about the causal relations of variables, *i.e*., which variable is dependent and which is independent. Therefore, the study of path-coefficients is necessary. Path-coefficient is simply a standardized partial regression coefficient, which splits the correlation coefficient into the measures of direct and indirect effects. It also estimates residual effects. Path analysis clearly indicates the relative importance of different yield components so that one may identify the most important yield components.

Salt affected areas have increased day by day because of excessive use of irrigation water with improper drainage coupled with the poor quality irrigation water. The salt

tolerant rice varieties are sparse and for the development of high yielding pure line and hybrid varieties in rice, the information on various genetic aspects in respect to important plant characters is essential for planning and execution of a successful breeding programme. The understanding of genetic architecture and direct and indirect selection parameters of agronomically important traits helps in deciding the type of variety to be developed and the breeding methodology to be followed in a particular growing situation. In order to develop high yield pure line rice varieties, it is essential to screen germplasm lines for gene action, combining ability and nature and magnitude of heterosis for different characters which is prerequisite for identification of potential rice varieties for the adverse soil conditionsAlthough, the information on the above aspects in rice is available, but most of these studies are based on irrigated and normal soil conditions and literature based on salinity conditions are meagre.

MATERIALS AND METHOD

The study was designed to work out the status of association for different grain yield traits on grain yield per plant among 110 genotypes of rice incuding non-aromatic varieties along with three check varieties ., Sarjoo 52, FL 478 and CSR 10. Field experiment was conducted during *Kharif,* 2018 at the Main Experimental Station of A.N.D. University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya, India.. The experiment was laid out in augmented design. The observation were recorded on sixteen different grain yield traits *viz*., days to 50% flowering, chlorophyll content, leaf nitrogen, leaf temperature, flag leaf area (cm), plant height (cm), panicle bearing tillers per plant, panicle length(cm), spikelets per panicle, grains per panicle, spikelet fertility (%), biological yield per plant (g), harvest-index (%),L:B ratio, 1000-grain weight (g) and grain yield per plant (g). Correlation coefficients were estimated as suggested by Searle, 1961 and path-coefficient analysis by Dewey and Lu, 1959.

RESULTS AND DISCUSSION

The estimates of simple correlation coefficients computed between sixteen characters under study are presented in **Table 1 and 2**.

The grain yield per plant exhibited a highly significant and positive correlation with biological yield per plant (0.8993), followed by spikelets per panicle (0.5563), grains per panicle (0.5522), panicle length (0.4187), flag leaf area(0.3844) and leaf nitrogen (0.3187), while significant and positive correlation was recorded with spikelets fertility (0.1765). Positive correlation was also recorded between grain yield per plant and leaf temperature (0.2719), chlorophyll content (0.1375), 1000-grain weight (0.0995), harvest index (0.0875) L/B ratio (0.0702) and panicle bearing tillers per plant (0.0527). On the other hand, negative correlation was recorded between grain yield per plant and plant height (-0.1696). Therefore, these (biological yield per plant, spikelets per panicle, grains per panicle, panicle length, flag leaf area, and leaf nitrogen) characters emerged as most important associates of grain yield in rice. The strong positive association of grain yield with the characters mentioned above has also being reported in rice by earlier workers (Sarawgi *et al.,* 1997; Chaudhary and Motiramani, 2003; Qamar *et al.,* 2005; Ramkrishnan *et al*., 2006; Kishore *et al*., 2007; Babar *et al.* 2009; Jayasudha and Sharma 2010; Rahman *et al*. 2011; Bhadru *et al.* 2011; Maji and Shaibu 2012; Ahamed *et al.* 2014; Sakina *et al.* 2015; Sritama *et al.,* 2015; Kumar *et al.* 2018; Prakash *et al.* 2018).

Days to 50% flowering showed positive and highly significant correlation with spikelets per panicle (0.2627), plant height (0.2552), leaf temperature (0.2533), flag leaf area (0.2409) and grains per panicle (0.2191), while positive and significant association with grain yield per plant (0.2045) and panicle length (0.1877). Significant and negative correlation was recorded with chlorophyll content (-0.2089).

Highly significant and negative correlation was recorded with flag leaf area (-0.2623), while significant and negative correlation was recorded with days to 50% flowering (-0.2089). Panicle bearing tillers per plant showed positive correlation with panicle length (0.1250), chlorophyll content (0.0948), spikelet fertility (0.0542), grain yield per plant (0.0527), grains per panicle (0.0524).

Panicle length showed a positive and highly significant correlation with flag leaf area (0.5519), spikelets per panicle (0.5324), biological yield per plant (0.5059), grains per panicle (0.4916), grains yield per plant (0.4187), leaf nitrogen (3509), harvest index (0.3143) and positive and significant association with days to 50% flowering (0.1877), while negative correlation was recorded with chlorophyll content (-0.0885).

Spikelets per panicle showed positive and highly significant correlation with grains per panicle (0.9770), biological yield per plant (0.6074), grain yield per plant (0.5563), panicle length (0.5324), flag leaf area (0.4749), harvest index (0.3127), days to 50% flowering (0.2627), while positive and significant association with spikelet fertility (0.2023 and 1000- grain weight (0.1985). Negative correlation was recorded with plant height (-0.0392). Grains per panicle showed positive and highly significant correlation with spikelets per panicle (0.9770), biological yield per plant (0.6040), grain yield per plant (0.5522), panicle length (0.4916), flag leaf area (0.4469), spikelet fertility (3992), leaf nitrogen (0.3898), harvest index (0.3080), days to 50% flowering (0.2191). Highly significant and negative correlation was recorded with plant height (-0.0168).

Spikelet fertility showed a positive and highly significant correlation with grains per panicle (0.3992), while positive and significant association with spikelets per panicle (0.2023), biological yield per plant (0.1893) and grain yield per plant (0.0.1765).

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Table 1. Estimates of phenotypic correlation coefficients between 16 characters in rice

Characters	Days to 50% flowering	Chlorophyll content	Leaf Nitrogen	Leaf temperature	Flag leaf area (cm^2)	Plant height (cm)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility (%)	Biological yield/ plant (g)	Harvest index (%)	L/B ratio	1000 grain weight (g)	Grain yield/ plant (g)
Days to 50% flowering	1.0000	-0.2089*	0.0222	0.2533**	0.2409**	0.2552**	-0.0508	0.1877*	0.2627**	0.2191**	-0.1177	0.2072	-0.0635	0.0609	-0.0885	0.2045*
Chlorophyll content		1.0000	0.1621	-0.0682	-0.2623**	0.0361	0.0948	-0.0885	0.0345	0.0573	0.0906	0.0964	0.0302	0.0592	0.0165	0.1375
Leaf Nitrogen			1.0000	-0.0178	0.1898*	-0.0532	-0.0975	0.3509**	0.3788**	0.3898**	0.1631	0.3801**	-0.2313**	-0.0307	0.3082**	0.3187**
Leaf temperature				1.0000	0.2703**	-0.0876	-0.0463	0.1640	0.0697	0.0411	-0.0801	0.2425**	-0.0241	-0.0307	-0.0918	0.2719
Flag leaf area (cm^2)					1.0000	-0.0133	0.0069	0.5519**	0.4749**	0.4469**	0.0295	0.4288**	-0.2358**	-0.1318	0.2163**	0.3844**
. Plant height (cm)						1.0000	-0.0306	0.1456	-0.0392	-0.0168	0.1116	-0.1596	0.0349	0.0284	0.0970	-0.1696
Panicle bearing tillers/plant							1.0000	0.1250	0.0398	0.0524	0.0542	-0.0210	-0.0239	0.0983	0.0059	0.0527
Panicle length (cm)								1.0000	0.5324**	0.4916**	0.0081	0.5059**	0.3143**	0.0739	0.1104	0.4187**
Spikelets/ panicle									1.0000	0.9770**	0.2023*	0.6074**	0.3127**	0.0023	0.1985*	0.5563***
Grains/ panicle										1.0000	0.3992**	0.6040**	0.3080**	0.0078	0.2085*	0.5522**
Spikelet fertility (%)											1.0000	0.1893*	-0.0645	-0.0166	0.0996	0.1765*
Biological yield/plant (g)												1.0000	-0.4980**	-0.0327	0.1282	0.8993**
Harvest index (%)													1.0000	-0.0207	-0.0776	0.0875
. L/B ratio														1.0000	0.0314	0.0702
1000 grain weight (g)															1.0000	0.0995

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

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Table 2. Estimates of genotypic correlation coefficients between 16 characters in rice

Characters	Days to 50% flowering	Chlorophyll content	Leaf Nitrogen	Leaf temperature	Flag leaf area (cm^2)	Plant height (cm)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility (%)	Biological yield/plant (g)	Harvest index (%)	L/B ratio	1000 grain weight (g)	Grain yield/ plant (g)
Days to 50% flowering	**1.0000**	-0.2114	0.0232	0.2895	0.2548	-0.3158	-0.0527	0.1891	0.2641	0.2215	-0.1161	0.2068	-0.0744	-0.0667	-0.0905	0.2022
Chlorophyll content		**1.0000**	0.1641	-0.1036	-0.2719	0.0905	0.1339	-0.1006	0.0330	0.0549	0.0912	0.1014	0.0381	0.0824	0.0229	0.1398
Leaf Nitrogen			**1.0000**	-0.0681	0.2267	-0.1090	-0.1302	0.3614	0.3945	0.4013	0.1569	0.3921	-0.2386	-0.0467	0.3300	0.3315
Leaf temperature				**1.0000**	0.2900	-0.0528	-0.0200	0.1811	0.0768	0.0442	-0.0834	0.2681	-0.0323	-0.0771	-0.1047	0.3135
Flag leaf area (cm^2)					**1.0000**	0.0037	0.0556	0.5863	0.4984	0.4713	0.0391	0.4508	-0.2660	-0.1704	0.2273	0.3966
. Plant height (cm)						**1.0000**	-0.0280	0.1753	-0.0684	-0.0367	0.1642	-0.1964	0.0783	0.2706	0.1315	-0.1966
Panicle bearing tillers/plant							**1.0000**	0.1118	0.0554	0.0693	0.0575	-0.0123	-0.0292	0.1807	0.0119	0.0664
Panicle length (cm)								**1.0000**	0.5353	0.4923	0.0017	0.5110	0.3247	0.0663	0.1116	0.4214
Spikelets/ panicle									**1.0000**	0.9781	0.2085	0.6093	0.3203	0.0053	0.2003	0.5595
Grains/ panicle										**1.0000**	0.4007	0.6056	0.3123	0.0129	0.2103	0.5561
Spikelet fertility (%)											**1.0000**	0.1911	-0.0526	-0.0161	0.1005	0.1830
Biological yield/plant (g)												**1.0000**	-0.5121	-0.0488	0.1302	0.9026
Harvest index (%)													**1.0000**	-0.0196	-0.0747	0.1047
. L/B ratio														**1.0000**	0.0295	0.0903
1000 grain weight (g)															**1.0000**	0.1026

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

Biological yield per plant showed a positive and highly significant correlation with the grain yield per plant (0.8993), spikelets per panicle (0.0.6074), grains per panicle (0.6040), panicle length (0.5059), flag leaf area (0.4288), leaf nitrogen (0.3801), leaf temperature (0.2425), while positive and significant association with spikelet fertility (0.1893). Significant and negative correlation was recorded with harvest index (-0.4980).

Harvest index showed a positive and highly significant correlation with panicle length (0.3143), spikelets per panicle (0.3127), grains per panicle (0.3080), while negative and highly significant correlation with flag leaf area (-0.2358), leaf nitrogen (-0.2313).

L:B ratio showed a positive correlation with grain yield per plant (0.0702) and panicle bearing tillers per plant (0.0983).

Thousand grain weight showed positive and highly significant correlation with leaf nitrogen (0.3082), flag leaf area (0.2163), while positive and significant association with grains per panicle (0.2085) and spikelets per panicle (0.1985). Positive correlation was recorded with grain yield per plant (0.0995). The similar finding have also been reported by Sarawgi *et al*., 1997; Chaudhary and Motiramani, 2003; Zahid *et al*., 2006; Kishore *et al*., 2007; Babar *et al.* 2009; Jayasudha and Sharma 2010; Rahman *et al*. 2011; Bhadru *et al.* 2011; Maji and Shaibu 2012; Ahamed *et al.* 2014; Sakina *et al.* 2015; Sritama *et al.,* 2015; Kumar *et al.* 2018; Prakash *et al.* 2018).

Days to 50% flowering, plant height, flag leaf area and panicle length had very high positive correlations with each other. This indicated that the taller genotypes possessed a greater flag leaf area and panicle length besides having late flowering. The positive associations between these characters have also been reported by Janardanam *et al.* (2002). Similarly, spikelets per panicle were strongly correlated with plant height and panicle length.

The direct and indirect effects of 16 characters on grain yield per plant estimated by path coefficient analysis using simple correlations are given in **Table 3 and 4.**

The highest positive direct effect on grain yield per plant was exerted by biological yield per plant (1.1186) followed by harvest index (0.4738). The direct effects of remaining thirteen characters were too low to be considered important. These characters have also been identified as major direct contributors towards grain yield by Sarawgi *et al.* (1997) and Mishra and Verma (2002).

Biological yield per plant exhibited high order of positive indirect effects on grain yield per plant *via* spikelets per panicle (0.6794), grains per panicle (0.6757), panicle length (0.5659), flag leaf area (0.4797), leaf nitrogen (0.4252), leaf temperature (0.2712) and days to 50 % flowering (0.2318). In contrast, high order of negative indirect effects were extended by biological yield per plant on grain yield per plant via harvest index (-0.5570), plant height (-0.1786), L:B ratio (-0.0365) and panicle bearing tiller per plant (-0.0234).

Harvest–index exhibited a high order of positive indirect effect on grain yield per plant *via* panicle length (0.1489), spikelets per panicle (0.1481) and grains per panicle (0.1459). The rest of the estimates of indirect effects obtained in path analysis were negligible. The estimate of residual factors (0.1281) obtained in path analysis was low. Janardanam *et al.* (2002), Mahto *et al.* (2003), Qamar *et al.* (2005), Patil and Sarawgi (2006), Zahid *et al.* (2006), Kishore *et al.* (2007), Babar *et al.* (2009), Jayasudha and Sharma (2010), Rahman *et al*. (2011), Bhadru *et al. (*2011), Maji and Shaibu (2012), Ahamed *et al.* (2014), Sakina *et al. (*2015), Sritama *et al.(* 2015), Kumar *et al.* (2018), Prakash *et al.* (2018) have also identified biological yield and harvest-index as important direct and indirect yield contributing characters. The indirect effects of remaining characters were too low to be considered important.

In the present study, path analysis identified biological yield per plant followed by harvest-index as most important direct as well as indirect yield contributing traits or components which merit due consideration at time of devising selection strategy aimed at developing high yielding varieties in rice.

In contrary to most of the previous reports in rice , comparatively small proportion of direct and indirect effects of different characters attained high order values in the present study. Majority of the estimates of direct and indirect effects were too low. This may be attributed to the presence of very high genetic variability and diversity in the fairly large number of germplasm lines. The existence of different character combinations in diverse germplasm lines might have led to different types of character association in different lines. Thus, the presence of several contrasting types of character associations or inter-relationships might have resulted into cancellation of contrasting associations by each other ultimately leading to lowering of the net impact or effect.

In the present study, majority of the significant estimates of correlations between yield and yield components were positive in nature which represents highly favorable situation because the selection practiced for improving these traits individually or simultaneously would bring improvement in others due to correlated response. This suggested that the selection would be quite efficient in improving the yield and yield components in context of germplasm collections evaluated.

Path analysis identified biological yield per plant followed by harvest-index as most important direct as well as indirect yield contributing trait which merit due consideration at

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Table 3. Estimates of phenotypic direct and indirect effects of 15 characters on grain yield per plant in rice

Characters	Days to 50% flowering	Chlorophyll content	Leaf Nitrogen	Leaf tempera -ture	Flag leaf area (cm^2)	Plant height (cm)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility (%)	Biological yield/plant (g)	Harvest index (%)	L/B ratio	1000 grain weight (g)	Correlation coefficient for Grain yield/plant (g)
Days to 50% flowering	-0.0105	0.0022	-0.0002	-0.0027	-0.0025	0.0027	0.0005	-0.0020	-0.0028	-0.0023	0.0012	-0.0022	0.0007	0.0006	0.0009	0.2045
Chlorophyll content	-0.0042	0.0203	0.0033	-0.0014	-0.0053	0.0007	0.0019	-0.0018	0.0007	0.0012	0.0018	0.0020	0.0006	0.0012	0.0003	0.1375
Leaf Nitrogen	-0.0002	-0.0012	-0.0072	0.0001	-0.0014	0.0004	0.0007	-0.0025	-0.0027	-0.0028	-0.0012	-0.0027	0.0017	0.0002	-0.0022	0.3187
Leaf	0.0022	-0.0006	-0.0002	0.0088	0.0024	-0.0008	-0.0004	0.0014	0.0006	0.0004	-0.0007	0.0021	-0.0002	-0.0003	-0.0008	0.2719
Flag leaf area (cm^2)	0.0040	-0.0043	0.0031	0.0045	0.0166	-0.0002	0.0001	0.0092	0.0079	0.0074	0.0005	0.0071	-0.0039	-0.0022	0.0036	0.3844
Plant height (cm)	0.0008	-0.0001	0.0002	0.0003	0.0000	-0.0032	0.0001	-0.0005	0.0001	0.0001	-0.0004	0.0005	-0.0001	-0.0001	-0.0003	-0.1696
Panicle bearing tillers/plant	0.0009	-0.0016	0.0017	0.0008	-0.0001	0.0005	-0.0171	-0.0021	-0.0007	-0.0009	-0.0009	0.0004	0.0004	-0.0017	-0.0001	0.0527
Panicle length (cm)	-0.0037	0.0017	-0.0069	-0.0032	-0.0109	-0.0029	-0.0025	-0.0197	-0.0105	-0.0097	-0.0002	-0.0100	0.0062	0.0015	-0.0022	0.4187
Spikelets/ panicle	-0.0045	-0.0006	-0.0065	-0.0012	-0.0082	0.0007	-0.0007	-0.0091	-0.0172	-0.0168	-0.0035	-0.0104	0.0054	0.0000	-0.0034	0.5563
Grains/ panicle	0.0128	0.0033	0.0227	0.0024	0.0260	-0.0010	0.0030	0.0286	0.0569	0.0582	0.0232	0.0352	-0.0179	0.0005	0.0121	0.5522
Spikelet fertility (%)	0.0028	-0.0022	-0.0039	0.0019	-0.0007	-0.0027	-0.0013	-0.0002	-0.0048	-0.0095	-0.0239	-0.0045	0.0015	0.0004	-0.0024	0.1765
Biological yield/plant (g)	0.2318	0.1078	0.4252	0.2712	0.4797	-0.1786	-0.0234	0.5659	0.6794	0.6757	0.2118	1.1186	-0.5570	-0.0365	0.1434	0.8993
Harvest index (%)	-0.0301	0.0143	-0.1096	-0.0114	-0.1117	0.0165	-0.0113	0.1489	0.1481	0.1459	-0.0306	-0.2359	0.4738	-0.0098	-0.0368	0.0875
. L/B ratio	0.0014	-0.0014	0.0007	0.0007	0.0031	-0.0007	-0.0023	0.0017	-0.0001	-0.0002	0.0004	0.0008	0.0005	-0.0236	-0.0007	0.0702
1000 grain weight (g)	0.0011	-0.0002	-0.0037	0.0011	-0.0026	-0.0012	-0.0001	-0.0013	-0.0024	-0.0025	-0.0012	-0.0015	0.0009	-0.0004	-0.0121	0.0995

Residual factors = 0.1281, Bold figures indicate direct effects.

Table 4. Estimates of genotypic direct and indirect effects of 15 characters on grain yield per plant in rice

Characters	Days to 50% flowering	Chlorophyll content	Leaf Nitrogen	Leaf temperature	Flag leaf area (cm^2)	Plant height (cm)	Panicle bearing tillers/ plant	Panicle length (cm)	Spikelets/ panicle	Grains/ panicle	Spikelet fertility (%)	Biological yield/plant (g)	Harvest index (%)	L/B ratio	1000 grain weight (g)	Correlation coefficient for Grain yield/plant (g)
Days to 50% flowering	**-0.0171**	0.0036	-0.0004	-0.0049	-0.0043	0.0054	0.0009	-0.0032	-0.0045	-0.0038	0.0020	-0.0035	0.0013	0.0011	0.0015	0.2022
Chlorophyll content	-0.0034	**0.0159**	0.0026	-0.0016	-0.0043	0.0014	0.0021	-0.0016	0.0005	0.0009	0.0014	0.0016	0.0006	0.0013	0.0004	0.1398
Leaf Nitrogen	-0.0003	-0.0018	**-0.0109**	0.0007	-0.0025	0.0012	0.0014	-0.0039	-0.0043	-0.0044	-0.0017	-0.0043	0.0026	0.0005	-0.0036	0.3315
Leaf temperature	0.0079	-0.0028	-0.0019	**0.0272**	0.0079	-0.0014	-0.0005	0.0049	0.0021	0.0012	-0.0023	0.0073	-0.0009	-0.0021	-0.0028	0.3135
Flag leaf area (cm^2)	0.0026	-0.0027	0.0023	0.0029	**0.0101**	0.0000	0.0006	0.0059	0.0050	0.0047	0.0004	0.0045	-0.0027	-0.0017	0.0023	0.3966
. Plant height (cm)	0.0014	-0.0004	0.0005	0.0002	0.0000	**-0.0046**	0.0001	-0.0008	0.0003	0.0002	-0.0007	0.0009	-0.0004	-0.0012	-0.0006	-0.1966
Panicle bearing tillers/plant	0.0021	-0.0054	0.0052	0.0008	-0.0022	0.0011	**-0.0402**	-0.0045	-0.0022	-0.0028	-0.0023	0.0005	0.0012	-0.0073	-0.0005	0.0664
Panicle length (cm)	-0.0033	0.0018	-0.0064	-0.0032	-0.0103	-0.0031	-0.0020	**-0.0176**	-0.0094	-0.0087	0.0000	-0.0090	0.0057	0.0012	-0.0020	0.4214
Spikelets/ panicle	-0.0335	-0.0042	-0.0500	-0.0097	-0.0632	0.0087	-0.0070	-0.0678	**-0.1267**	-0.1240	-0.0264	-0.0772	0.0406	-0.0007	-0.0254	0.5595
Grains/panicle	0.0404	0.0100	0.0732	0.0081	0.0860	-0.0067	0.0127	0.0898	0.1785	**0.1825**	0.0731	0.1105	-0.0570	0.0023	0.0384	0.5561
Spikelet fertility (%)	0.0058	-0.0045	-0.0078	0.0041	-0.0019	-0.0082	-0.0029	-0.0001	-0.0104	-0.0199	**-0.0496**	-0.0095	0.0026	0.0008	-0.0050	0.1830
Biological yield/ plant (g)	0.2327	0.1141	0.4412	0.3016	0.5073	-0.2210	-0.0139	0.5750	0.6855	0.6815	0.2150	**1.1252**	-0.5762	-0.0549	0.1465	0.9026
Harvest index (%)	-0.0355	0.0182	-0.1137	-0.0154	-0.1268	0.0373	-0.0139	0.1548	0.1527	0.1489	-0.0251	-0.2441	**0.4766**	-0.0093	-0.0356	0.1047
. L/B ratio	0.0013	-0.0017	0.0009	0.0016	0.0034	-0.0054	-0.0036	0.0013	-0.0001	-0.0003	0.0003	0.0010	0.0004	**-0.0201**	-0.0006	0.0903
1000 grain weight (g)	0.0009	-0.0002	-0.0034	0.0011	-0.0024	-0.0014	-0.0001	-0.0012	-0.0021	-0.0022	-0.0010	-0.0014	0.0008	-0.0003	**-0.0104**	0.1026

Residual factors = 0.0910, Bold figures indicate direct effects.

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time of devising selection strategy aimed at developing high yielding varieties in rice in both experiments. Thus, the presence of several contrasting types of character associations or inter-relationships might have resulted into cancellation of contrasting associations by each other ultimately leading to lowering of the net impact or effect.

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