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Association and path analysis of yield attributes and physiological parameters in rice (*Oryza sativa* L.) under problematic soil conditions

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Abstract
The present investigation were assessed to work out the association of different grain yield attributes and physiological parameters, direct and indirect effects of their various traits on grain yields. Observations were recorded for yield its contributing traits and physiological parameters. The grain yield having positive and strong correlation with chlorophyll content (0.871), harvest index (0.864), grains per panicle (0.632), spikelet per panicle (0.555), leaf temperature (0.553), and panicle length (0.513) and 1000-grain weight (0.493) showed positive and strong significant association with grain yield per plant at phenotypic level where as plant height and days to 50% flowering possessed significant negative correlation with grain yield per plant. Spikelet per panicle (0.580), biological yield per plant (0.570), harvest index (0.331), flag leaf area (0.164), protein content (0.142), days to maturity (0.129), chlorophyll content (0.107), spikelet fertility (0.098) and leaf temperature (0.045) exhibited direct effect on grain yield. Considering the correlation and path analysis flag leaf area, grains per panicle, 1000-grain weight and harvest index are important characters be considered for yield improvement.

Keywords: Rice, character association, path analysis, physiological parameters, grain yield

Introduction
Rice (*Oryza sativa* L.) is the most important staple food crop of the world because of being the major source of calories of more than half of the total global population. The importance of rice is not only as a fundamental commodity and primary food source for more than half of the world's population, but also influences issues of global concern such as food security and development. More than 90 per cent of the world's rice is grown and consumed in Asia, known as rice bowl of the world, where 60 per cent of the earth's people and two third of world's poor live. Rice being the staple food for more than 70 per cent of our national population and source of livelihood for 120450 million rural households is backbone to the Indian Agriculture.

Rice (*Oryza sativa* L.) is a semi-aquatic annual grass plant belongs to the genus *Oryza*, tribe Oryzeae and family Poaceae. It is the second largest principal food crop in the world after wheat and is one of the main staple food crop in India. Besides being the staple food crop, it has been the cornerstone of food and culture for our people. Among seven billion people on the earth, more than half of them depend on this crop for principal source of energy in their daily diet. Rice is distributed over a wider range of latitude from 50 0 N to 40 ° S and is being grown up to an altitude of 2500 meters. It evolved in humid tropics as a semi aquatic plant and it has got unique adaptive nature to hot humid environment, which is not seen in any other major cereal crop.

Rice yield in India fluctuate greatly in time and space on account of its cultivation under diverse weather, ecological and socio-economic conditions. Out of the total 43.86 million ha. Under rice, 20 million ha. Area is irrigated and the remaining 23.86 million ha. Area is cultivated in rainfed conditions. Rice can be grown under different agro-ecological environments.

Protein content of milled rice is 6-7 per cent, rice however, compares favorably with other cereals in amino acid content. The biological value of protein is high, the fat content of rice is low (2.0-2.5%) and much of the fat is lost during milling. Rice grain contains as much B group vitamin as wheat. Milled rice losses valuable proteins, vitamins and minerals in the milling process during which embryo and aleurone layer are removed and much of the loss of nutrients can avoided through parboiling process. The by-products of rice milling are used for a variety of purposes. Rice bran is used as cattle and poultry feed. Rice hull can be used in manufacture

of insulation materials, cement and cardboard as well as a litter in poultry keeping. Rice straw can be used as cattle feed as well as litter during winter. Rice is grown almost throughout the year in hot and humid reasons of eastern and southern parts of India where two or three crops in a year is uncommon. Rice being the staple food for more than 70 percent of our national population along with the source of livelihood for 120-150 million rural household. It is a backbone to the Indian agriculture.

Materials and Methods

The present investigation was conducted during Kharif, 2017, 2018 and 2019 at Student's Instructional Farm of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224229 (U.P.), India. Six genetically diverse genotypes viz., NDRK 5004, NUD 3, Pant 10, IR 28, CSR 10, Sushk samrat were inter crossed in generation mean analysis fashion were evaluated in Randomized Block Design with three replication during Kharif 2019 each plot was consisting of a double row of 3 meter long beds with intra row spacing spaced 20 cm apart. Seed to seed distance within a row will be kept 15 cm. Similar planting distance will be maintained for P1, P2, F1's, F2's, and B1 and B2.The desired observation will be recorded on five randomly selected plants for parents, 10 plants for F1's, 15 plants for B1, B2 and 20 plants for F2 generation. The soil type of the experimental site was sandy loam, low in organic carbon, nitrogen, and phosphorus and rich in potash (EC-3.2dSm-1; ESP-45% and pH-9.2).Data were collected on days to 50% flowering, day to maturity, chlorophyll content, leaf nitrogen, leaf temperature, flag leaf area (cm2), plant height (cm), panicle bearing tillers/plant, panicle length (cm), spikelet per panicle, grains per panicle, spikelet fertility (%), biological yield per plant, harvest index (%), 1000-grain weight (g), protein content (%) and grain yield per plant (g). Genotypic and phenotypic correlation coefficients were carried out using formula suggested by Searle (1961). The correlation coefficient was further partitioned into components of direct and indirect effects by path coefficient analysis developed by Wright (1934) [12] and later described by Dewey and Lu (1959) [2].

Results and Discussion

The analysis of variance showed that the mean squares for the genotypes were highly significant for all traits measured except leaf nitrogen and panicle length (Table 1). Correlation analysis among grain yield and yield contributing characters (Table 2) exhibited that the genotypic correlation coefficient in most cases was higher than their corresponding phenotypic correlation coefficients indicating the association is largely due to genetic cause. Chaubey and Singh (1994) [1] and Ojo *et al*. (2006) [8] reported the similar result. Phenotypic correlations among yield and yield traits with grain yield e.g., days to 50% flowering, day to maturity, chlorophyll content, leaf nitrogen, leaf temperature, flag leaf area (cm2), plant height (cm), panicle bearing tillers/plant, panicle length (cm), spikelet per panicle, grains per panicle, spikelet fertility (%), biological yield per plant, harvest index (%), 1000-grain weight (g), protein content (%) and grain yield per plant (g) were calculated individually for upland rice genotypes. In the current study, grain yield presented highly significant and positive correlation with 7 yield and yield contributing traits from the 17 phenological traits namely chlorophyll content (0.871), harvest index (0.864), grains per panicle (0.632), spikelet per panicle (0.555), leaf temperature (0.553), panicle length (0.513) and 1000-grain weight (0.493). On the other hand, strong association with negative correlation only for plant height (-0.664) and days to 50% flowering (-0.511). The result showed estimation of phenotypic correlation coefficients overall maximum for many phenological traits under field experiment. It suggested directs strong inherent association among the traits. Clearly if the panicle length, spikelet per panicle, grains per panicle, harvest index and 1,000 seed weight were improved, grain yield per genotype would be increased. All the findings were presented in the Table 2. The significant correlation with grain yield had similar findings with Janardhanam *et al*. (2001) [6], Hariprasanna *et al*. (2006) [5] and Yogameenakshi *et al*. (2004) [13] for plant height; Panwar *et al*. (1989) [9] for 1,000 seed weight; Nandan *et al*. (2010) [7] and Ekka *et al*. (2011) [3] reported that panicle length showed positive correlation with grain yield. Seyoum *et al*. (2012) [10] and Sravan *et al*. (2012) [11] reported that grain yield was positively correlated with panicle length and spikelet per panicle. Days to 50% flowering showed positive and highly significant correlation with plant height (0.676). Significant and negative correlation was recorded with harvest index (-0.635), grains per panicle (-0.566), spikelet fertility (-0.513), grain yield per plant (-0.511). Days to maturity showed positive and highly significant correlation with leaf temperature (0.691) and spikelet fertility (0.503). Chlorophyll content showed positive and highly significant correlation with grain yield per plant (0.871), harvest index (0.778), grains per panicle, panicle length (0.604), 1000-gran weight (0.553), leaf temperature and grains per panicle (0.534). Leaf nitrogen showed positive and significant correlation with panicle length (0.470). Leaf temperature showed positive and highly significant correlation with spikelet per panicle (0.883), grains per panicle (0.879), days to maturity (0.691) and chlorophyll content (0.534). Flag leaf area showed positive and highly significant correlation with panicle bearing tillers per (0.661), protein content (0.594) and panicle length (0.518). Plant height showed positive and significant correlation with days to 50% flowering (0.676), spikelet fertility (0.560), while negative and highly significant correlation with harvest index (-0.883), 1000- grain weight (-0.728) and grain yield per plant (-0.664). Panicle bearing tillers per plant showed positive and highly significant correlation with panicle length (0.785) and flag leaf area (0.661). Panicle length showed positive and highly significant correlation with panicle bearing tillers per plant (0.785), 1000- grain weight (0.710) and chlorophyll content (0.604). Spikelet per panicle showed positive and highly significant correlation with grains per panicle (0.949) and leaf temperature (0.883). Grains per panicle showed positive and highly significant correlation with spikelet fertility (0.949), leaf temperature (0.879), chlorophyll content (0.604) and grain yield per plant (0.632). Spikelet fertility showed positive and highly significant correlation with biological yield per plant (0.843), spikelet per panicle (0.514) and plant height (0.560). Biological yield per plant showed positive and highly significant correlation with spikelet fertility (0.843) and spikelet per panicle (0.514). Harvest index showed positive and highly significant correlation with grain yield per plant (0.864), 1000-grain weight, chlorophyll content (0.778) and panicle length (0.585). Thousand grain weight showed positive and highly significant correlation with harvest index (0.778), panicle length (0.710). Protein content showed positive and highly significant correlation with flag leaf area (0.594). All these findings suggested that

grain yield could be enhanced every time if there are an improvement of these phenotypic traits which existed positive and substantial correlation with grain yield.

The direct effects on grain yield of other traits were directly useful for the development of yield. Indirect effects of some traits showed that traits indirectly affected the grain. The highest positive direct effect on grain yield per plant was exerted by spikelet per panicle (0.580) followed by biological yield per plant (0.570), harvest index (0.331), flag leaf area (0.164), protein content (0.142), days to maturity (0.129), chlorophyll content (0.107), spikelet fertility (0.098) and leaf temperature (0.045). The direct effects of remaining thirteen characters were too low to be considered important. The indirect effect of biological yield per plant on grain yield by spikelet per panicle (0.445). Harvest-index positive indirect effect on grain yield per plant by spikelet per panicle (0.198) and biological yield per plant (0.191). Chlorophyll content positive indirect effects on grain yield by biological yield per plant (0.406) and spikelet per panicle (0.293). Leaf nitrogen indirect effects on grain yield by spikelet per panicle (0.076). Leaf temperature positive indirect effect on grain yield by spikelet per panicle (0.213) and biological yield per plant (0.169). Flag leaf area positive indirect effect on grain yield per plant by grains per panicle (0.247) and harvest-index (0.137). Plant height positive indirect effect on grain yield per plant via grains per panicle (0.145), protein content (0.081). Panicle bearing tillers per plant exerted high order indirect effects on grain yield by spikelet per panicle (0.405), biological yield per plant (0.301) and harvest index (0.224). Panicle length positive indirect effect on grain yield per plant via biological yield per plant (0.283) and spikelet per panicle (0.226). Spikelet per panicle exhibited high order of positive indirect effect on grain yield per plant via biological yield per plant (0.437) and harvest index (0.113). Grains per panicle exhibited high order of positive indirect effect on grain yield per plant via spikelet per panicle (0.571), biological yield per plant (0.444) and harvest index (0.126). Spikelet fertility exhibited high order of positive indirect effect on grain yield per plant via spikelet per panicle (0.172) and biological yield per plant (0.107). 1000-grain weight positive indirect effect on grain yield per plant via harvest index (0.260), spikelet per panicle (0.223), biological yield per plant (0.211) and plant height (0.131). Protein content positive indirect effect on grain yield per plant by grains per panicle (0.056).

Conclusion

The result of analysis of variance clearly showed that adequate genetic variability present in the studied materials for all the traits. The genotypic correlations were generally similar in nature and higher in magnitude with the corresponding phenotypic correlation coefficients. Data in sodic condition revealed that grain yield having positive and strong correlation with chlorophyll content, harvest index, grains per panicle, spikelet per panicle, leaf temperature, panicle length and 1000-grain weight. Spikelet per panicle, biological yield per plant, harvest index, flag leaf area, protein content, days to maturity, chlorophyll content, spikelet fertility and leaf temperature exhibited direct effect on grain yield. Considering the correlation and path analysis flag leaf area, grains per panicle, 1000-grain weight and harvest index are important characters be considered for yield improvement. Therefore, plant breeders should give more attention to these traits during breeding program for developing high yielding rice.

Table-1: Analysis of variance for differences between families (crosses) for 17 metric traits in sodic soil condition

Characters / D.F.	Replications	Families	Error
	2	3	6
Days to 50% flowering	0.87	7.50*	1.00
Days to maturity	4.86	52.22**	3.67
Chlorophyll content	1.15	14.57**	0.25
Leaf Nitrogen	0.00	0.00	0.00
Leaf temperature	2.23*	21.08**	0.36
Flag leaf area (cm2)	2.95	9.16*	1.46
Plant height (cm)	7.27**	484.28**	0.34
Panicle bearing tillers/plant	0.97*	14.75**	0.14
Panicle length (cm)	2.60	3.74	2.24
Spikelet/panicle	0.06	3845.34**	0.62
Grains/panicle	2.43	4795.73**	1.46
Spikelet fertility (%)	0.70	119.65**	2.71
Biological yield/plant (g)	2.32	29.13**	2.38
Harvest index (%)	0.73	76.35**	2.04
1000-grain weight (g)	2.28	16.55**	0.44
Protein content (%)	0.31	2.75**	0.09
Grain yield/plant (g)	3.04*	49.57**	0.42

*, ** significant at 5% and 1% level of probability, respectively.

Table 2: Estimates of phenotypic correlation coefficients among 17 characters in four crosses under sodic soil condition

Traits	Days to maturity	Chlorophyll content	Leaf Nitrogen	Leaf temperature	Flag leaf area (cm2)	Plant height (cm)	Panicle bearing tillers/plant	Panicle length (cm)	Spikelet/panicle	Grains/panicle	Spikelet fertility (%)	Biological yield/plant (g)	Harvest index (%)	1000 grain weight (g)	Protein content (%)	Grain yield/plant (g)
Days to 50% flowering	0.225	-0.371	0.150	-0.205	-0.029	0.676**	0.238	-0.055	-0.513*	-0.566*	0.273	0.074	-0.635**	-0.388	0.177	-0.511*
Days to maturity		0.109	-0.146	0.691**	-0.209	0.288	-0.122	-0.369	0.503*	0.372	0.410	0.432	-0.114	-0.408	0.243	0.235
Chlorophyll content			0.365	0.534*	0.352	-0.583*	0.362	0.604**	0.534*	0.604**	-0.083	0.238	0.778**	0.553*	0.016	0.871**
Leaf Nitrogen				-0.068	-0.230	-0.246	0.112	0.470*	-0.025	-0.103	-0.067	0.118	0.155	0.386	-0.497*	0.102
Leaf temperature					-0.030	0.052	-0.077	-0.112	0.883**	0.879**	0.431	0.448	0.202	-0.083	0.371	0.553*
Flag leaf area (cm2)						-0.115	0.661**	0.518*	-0.161	0.106	-0.184	-0.014	0.431	0.282	0.594**	0.383
Plant height (cm)							-0.121	-0.501*	-0.198	-0.213	0.560*	0.161	-0.883**	-0.728**	0.466	-0.664**
Panicle bearing tillers/plant								0.785**	-0.379	-0.183	-0.461	-0.318	0.317	0.334	0.263	0.376
Panicle length (cm)									-0.228	-0.058	-0.627**	-0.380	0.585*	0.710**	-0.067	0.513*
Spikelet/panicle										0.949**	0.425	0.514*	0.358	0.048	0.139	0.555*
Grains/panicle											0.327	0.413	0.450	0.149	0.322	0.632**
Spikelet fertility (%)												0.843**	-0.427	-0.593**	0.352	-0.189
Biological yield/plant (g)													0.018	-0.295	0.238	0.212
Harvest index (%)														0.778**	-0.092	0.864**
1000-grain weight (g)															-0.174	0.493*
Protein content (%)																0.105

*, ** Significant at 5% and 1% level of probability, respectively

Table 4.13: Estimates of genotypic correlation coefficients among 17 characters in four crosses under sodic soil condition

Traits	Days to maturity	Chlorophyll content	Leaf Nitrogen	Leaf temperature	Flag leaf area (cm2)	Plant height (cm)	Panicle bearing tillers/plant	Panicle length (cm)	Spikelet/panicle	Grains/panicle	Spikelet fertility (%)	Biological yield/plant (g)	Harvest index (%)	1000 grain weight (g)	Protein content (%)	Grain yield/plant (g)
Days to 50% flowering	-0.545	-1.606	-0.696	-1.084	-0.459	0.905	-0.978	-1.004	-0.922	-1.014	0.263	-0.225	-1.141	-0.970	-0.104	-1.433
Days to maturity		-0.226	-0.875	0.668	-0.529	0.191	-1.080	-0.986	0.661	0.496	0.549	0.602	-0.168	-0.820	0.044	0.145
Chlorophyll content			0.289	0.454	0.257	-0.959	-0.108	0.476	0.709	0.770	-0.227	0.154	0.978	0.897	-0.145	0.902
Leaf Nitrogen				-0.528	-0.743	-0.787	-0.813	0.259	-0.096	-0.259	-0.514	-0.616	0.243	0.592	-1.269	-0.133
Leaf temperature					-0.110	-0.062	-0.763	-0.428	0.994	0.987	0.458	0.494	0.235	-0.188	0.321	0.515
Flag leaf area (cm2)						-0.255	0.934	0.511	-0.107	0.152	-0.260	-0.064	0.523	0.628	0.724	0.400
Plant height (cm)							-0.684	-0.865	-0.197	-0.216	0.594	0.098	-0.942	-0.938	0.460	-0.869
Panicle bearing tillers/plant								0.861	-0.624	-0.310	-1.221	-1.044	0.664	1.025	0.236	0.279
Panicle length (cm)									-0.261	-0.063	-0.990	-0.820	0.752	1.128	-0.234	0.443
Spikelets/panicle										0.955	0.501	0.647	0.352	-0.056	0.174	0.625
Grains/panicle											0.377	0.506	0.444	0.121	0.388	0.699
Spikelet fertility (%)												0.849	-0.442	-0.731	0.364	-0.325

Biological yield/plant (g)													0.051	-0.425	0.244	0.125
Harvest index (%)														0.873	-0.086	0.970
1000-grain weight (g)															-0.247	0.717
Protein content (%)																0.014

Table 4.22: Direct (Diagonal) and indirect effects of 17 characters on grain yield/ plant at phenotypic level of cross under sodic soil condition

Characters	Days to 50% flowering	Days to maturity	Chlorophyll content	Leaf Nitrogen	Leaf temperature	Flag leaf area (cm2)	Plant height (cm)	Panicle bearing tillers/plant	Panicle length (cm)	Spikelet/panicle	Grains/panicle	Spikelet fertility (%)	Biological yield/plant (g)	Harvest index (%)	1000 grain weight (g)	Protein content (%)	Grain yield/plant (g)
Days to 50% flowering	**-0.157**	0.096	-0.018	0.000	-0.006	0.023	-0.047	-0.017	0.002	0.001	0.011	-0.011	-0.126	-0.027	-0.003	-0.007	-0.287
Days to maturity	-0.117	**0.129**	-0.022	0.000	0.006	0.016	-0.080	-0.012	0.000	0.024	-0.009	-0.007	-0.144	-0.006	0.000	-0.007	-0.230
Chlorophyll content	0.027	-0.027	**0.107**	0.000	0.017	-0.017	0.042	-0.047	0.016	0.293	-0.252	0.024	0.406	0.161	-0.015	0.030	0.763
Leaf Nitrogen	-0.008	0.010	0.008	**-0.004**	0.004	-0.042	-0.069	-0.013	0.010	0.076	-0.044	0.012	0.016	-0.051	0.002	0.040	-0.055
Leaf temperature	0.020	0.019	0.041	0.000	**0.045**	-0.066	-0.025	-0.002	0.003	0.213	-0.189	0.003	0.169	-0.010	0.004	0.059	0.283
Flag leaf area (cm2)	-0.022	0.012	-0.011	0.001	-0.018	**0.164**	-0.036	0.000	-0.004	-0.343	0.247	-0.011	-0.221	0.137	-0.010	-0.017	-0.133
Plant height (cm)	-0.025	0.034	-0.015	-0.001	0.004	0.020	**-0.302**	0.040	0.012	-0.187	0.145	-0.013	-0.131	-0.117	0.016	0.081	-0.438
Panicle bearing tillers/plant	-0.026	0.015	0.049	-0.001	0.001	0.001	0.118	**-0.104**	0.010	0.405	-0.301	0.031	0.301	0.224	-0.025	-0.026	0.672
Panicle length (cm)	-0.010	0.002	0.060	-0.001	0.005	-0.023	-0.129	-0.037	**0.029**	0.226	-0.172	0.032	0.283	0.070	-0.009	0.051	0.377
Spikelet/panicle	0.000	0.005	0.054	-0.001	0.016	-0.097	0.098	-0.072	0.011	**0.580**	-0.432	0.029	0.437	0.113	-0.014	-0.022	0.705
Grains/panicle	0.004	0.003	0.062	0.000	0.019	-0.092	0.100	-0.071	0.011	0.571	**-0.439**	0.032	0.444	0.126	-0.014	-0.018	0.739
Spikelet fertility (%)	0.018	-0.009	0.026	-0.001	0.001	-0.019	0.041	-0.033	0.009	0.172	-0.143	**0.098**	0.107	0.101	-0.011	0.000	0.358
Biological yield/plant (g)	0.035	-0.033	0.077	0.000	0.013	-0.063	0.069	-0.055	0.014	0.445	-0.342	0.018	**0.570**	0.111	-0.014	0.003	0.849
Harvest index (%)	0.013	-0.002	0.052	0.001	-0.001	0.068	0.107	-0.070	0.006	0.198	-0.168	0.030	0.191	**0.331**	-0.029	-0.038	0.687
1000-grain weight (g)	-0.011	-0.001	0.044	0.000	-0.004	0.043	0.131	-0.069	0.007	0.223	-0.166	0.029	0.211	0.260	**-0.037**	-0.032	0.627
Protein content (%)	0.008	-0.006	0.023	-0.001	0.019	-0.020	-0.172	0.019	0.010	-0.090	0.056	0.000	0.013	-0.088	0.008	**0.142**	-0.082

Residual factors = 0.0307, Bold figures indicate direct effects.

Table 4.21: Direct (Diagonal) and indirect effects of 17 characters on grain yield/ plant at genotypic level of cross under sodic soil condition

Characters	Days to 50% flowering	Days to maturity	Chlorophyll content	Leaf Nitrogen	Leaf temperature	Flag leaf area (cm2)	Plant height (cm)	Panicle bearing tillers/plant	Panicle length (cm)	Spikelet/panicle	Grains/panicle	Spikelet fertility (%)	Biological yield/plant (g)	Harvest index (%)	1000 grain weight (g)	Protein content (%)	Grain yield/plant (g)
Days to 50% flowering	**0.843**	-0.309	0.160	0.004	-0.555	0.209	-0.411	-0.085	-0.053	-0.015	0.292	0.025	-0.406	-0.076	0.126	-0.198	-0.450
Days to maturity	0.687	**-0.380**	0.113	0.004	0.078	0.152	-0.636	-0.068	-0.062	0.302	-0.132	-0.024	-0.317	-0.025	0.119	-0.101	-0.290
Chlorophyll content	-0.379	0.121	**-0.355**	0.000	0.506	-0.425	0.419	-0.456	0.861	4.315	-4.600	0.345	0.802	0.292	-0.630	0.041	0.857
Leaf Nitrogen	0.050	-0.024	-0.002	**0.061**	0.056	-0.756	-0.628	-0.066	0.532	1.207	-0.853	0.118	-0.015	-0.133	0.164	0.174	-0.114
Leaf temperature	-0.327	-0.021	-0.126	0.002	**1.430**	-1.152	-0.173	0.055	0.100	3.017	-3.340	0.110	0.292	-0.032	0.232	0.198	0.264
Flag leaf area (cm2)	0.078	-0.026	0.067	-0.020	-0.730	**2.257**	-0.278	0.034	-0.285	-4.603	4.137	-0.111	-0.437	0.232	-0.371	-0.100	-0.156
Plant height (cm)	0.146	-0.101	0.062	0.016	0.104	0.264	**-2.382**	0.429	0.632	-2.453	2.375	-0.136	-0.253	-0.202	0.713	0.326	-0.460
Panicle bearing tillers/plant	0.075	-0.027	-0.170	0.004	-0.082	-0.079	1.073	**-0.953**	0.468	5.768	-5.342	0.315	0.566	0.399	-1.042	-0.285	0.686

Panicle length (cm)	-0.033	0.017	-0.220	0.023	0.103	-0.464	-1.086	-0.322	**1.386**	3.205	-3.045	0.285	0.554	0.115	-0.312	0.180	0.386
Spikelet/panicle	-0.002	-0.015	-0.203	0.010	0.571	-1.376	0.774	-0.728	0.588	**7.550**	-7.011	0.272	0.805	0.191	-0.599	-0.104	0.724
Grains/panicle	-0.035	-0.007	-0.229	0.007	0.671	-1.313	0.795	-0.716	0.593	7.441	**-7.113**	0.299	0.816	0.214	-0.581	-0.086	0.758
Spikelet fertility (%)	0.073	0.031	-0.422	0.025	0.539	-0.863	1.114	-1.034	1.360	7.079	-7.332	**0.290**	0.668	0.536	-1.022	-0.026	1.018
Biological yield/plant (g)	-0.333	0.117	-0.276	-0.001	0.405	-0.958	0.585	-0.524	0.746	5.906	-5.642	0.188	**1.029**	0.190	-0.541	-0.024	0.868
Harvest index (%)	-0.116	0.017	-0.188	-0.015	-0.084	0.953	0.875	-0.690	0.289	2.621	-2.764	0.283	0.355	**0.551**	-1.180	-0.211	0.695
1000-grain weight (g)	-0.076	0.032	-0.160	-0.007	-0.237	0.601	1.219	-0.712	0.310	3.243	-2.963	0.213	0.399	0.466	**-1.394**	-0.276	0.655
Protein content (%)	-0.435	0.101	-0.038	0.028	0.741	-0.592	-2.029	0.710	0.651	-2.056	1.602	-0.020	-0.064	-0.303	1.007	**0.383**	-0.316

Residual factors = 0.0307, Bold figures indicate direct effect

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