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Correlation and Path Coefficients Analysis for Yield and its Contributing Traits in Rice (*Oryza sativa* L.) under Sodic Soil

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Abstract

Yield is the complex trait that depends on various attributes. Therefore, the knowledge about the relationship of different attributes to yield is crucial for making efficient selection strategy. The grain yield per plant exhibited highly significant and positive association with biological yield per plant followed by panicle bearing tillers per plant, spikelets per panicle, grains per panicle, chlorophyll content in F_1s at both genotypic and phenotypic level. Highest positive direct effect on grain yield per plant was exerted by biological yield per plant and harvest-index in F_1s at both genotypic and phenotypic level. Therefore, biological yield per plant and harvest index should be utilized in making selection strategy for yield improvement in rice.

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

Introduction

Rice (*Oryza sativa* L.) is the most important staple food crop of the world. Asia is the leader in rice production accounting for about 90% of the world's production. India has the world's largest rice-growing area (45 million hectares) and ranks second in overall production (130.29 million tonnes) after China, with an average yield of 2895 kg/hectare (Anonymous 2021-22).

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 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.

Correlation is a statistical measure, which is used to find out the degree (strength) and direction of relationship between two or more variables or 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. The concept of path analysis was developed by Wright (1921), but the technique was first used for plant selection by Dewey and Lu (1959). Path-coefficient is simply a standardized partial regression

coefficient, which splits the correlation coefficient into the measures of direct and indirect effects. In other words, it measures the direct and indirect contribution of various independent characters on the dependent character like yield. 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.

Materials and Methods

This experiment was carried out at the Main Experimental Station of A.N.D. University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (U. P.) India. The experimental material was based on a line x tester set of 63 hybrids (F_1's) developed by crossing 21 lines (females) with 3 testers (males). An attempt was made to make a sixty three cross combinations during *kharif* season 2017 to generate F_1's. The 63 F_1's along with parents and two checks, Jaya and CSR 43 were evaluated to work out the correlation and path coefficient of their various attributes on grain yield under the sodic soil in Randomized Complete Block Design with three replications during *kharif* 2018. Estimation of correlation coefficients was done as per Searle, 1961 and path-coefficient analysis was done as per Dewey and Lu, 1959.

Results and Discussion

The estimates of simple correlation coefficients at phenotypic and genotypic levels computed between eighteen characters under study are presented in **Table 1** and **2**, respectively. The phenotypic correlation coefficients and genotypic correlation coefficients for 18 traits were analyzed in the F_1s of 63 cross combinations and their 24 parents. Differences in magnitude as well as in direction were observed for different traits. However, both genotypic correlation coefficient and phenotypic correlation coefficient exhibited similar signs with few exceptions. In general, both positive and negative character associations were observed among different traits. Further, it was also observed that the estimates of genotypic correlation coefficient were higher than the corresponding phenotypic correlations.

The grain yield per plant exhibited highly significant and positive association with biological yield per plant (0.9018, 0.8798), followed by panicle bearing tillers per plant (0.6410, 0.6329), spikelets per panicle (0.6210, 0.6166), grains per panicle (0.6136, 0.6096), chlorophyll content (0.4976, 0.4858), panicle length (0.3741, 0.3589), plant height (0.3020, 0.2978), flag leaf area (0.2755, 0.2746) in F_1s at genotypic and phenotypic level respectively. Therefore, these 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, Zahid *et al.,* 2006, Eradasappa *et al.,* 2007b, Petchiammal and Kumar 2007, Kishor *et al.,* 2007, Rahaman *et al.,* 2011, Bhadru *et al.,* 2011, Krishnamurthy and Kumar, 2012, Ahamed *et al.,* 2014, Kumar *et al.,* 2018 and Shrivastav *et al.,* 2020.

Biological yield per plant showed positive and highly significant correlation with grain yield per plant (0.8798), spikelets per panicle (0.6962), grains per panicle (0.6685), panicle bearing tillers per plant (0.5862), chlorophyll content (0.5068), panicle length (0.3942), plant height (0.2611), protein content (0.2506), flag leaf area (0.2278), leaf nitrogen (0.2213), harvest index (0.1849), leaf temperature (0.1792) and amylose content (0.1677),

in F_1s. These similar result reported by those of Chaudhary and Motiramani, 2003; Ahamed *et al.,* 2014; Kumar *et al.,* 2018. Harvest index showed positive and highly significant correlation with grain yield per plant (0.6131), panicle bearing tillers per plant (0.3711), flag leaf area (0.2173), plant height (0.1897), biological yield per plant (0.1849), L:B ratio (0.1754), grains per panicle (0.1618) and chlorophyll content (0.1605) in F_1s. These finding are accordance with the result of Ahamed *et al.,* 2014; Kumar *et al.,* 2018. Amylose content showed positive and highly significant correlation with 1000-grain weight (0.2856), spikelets per panicle (0.2408), chlorophyll content (0.2269), panicle bearing tillers per plant (0.2212), biological yield per plant (0.1677) and grains per panicle (0.1599) in F_1s. But grain yield per plant (0.1218) shows positive and significant correlation in F_1s. Protein content showed positive and highly significant correlation with biological yield per plant (0.2506), plant height (0.2439), panicle length (0.2038) and grains per panicle (0.1748) in F_1s. But grain yield per plant (0.1269) shows positive and significant correlation in F_1s. The estimates of correlation coefficients obtained in present study are broadly in conformity with previous reports in rice (Sarawgi *et al.,* 1997, Chaudhary and Motiramani, 2003, Qamar *et al.,* 2005, Zahid *et al*., 2006, Kishore *et al*., 2007, Rahman *et al*., 2011, Bhadru *et al.,* 2011, Ahamed *et al.*, 2014, Kumar *et al.*, 2018 and Shrivastav *et al.*, 2020.

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effects of yield components on grain yield. Path analysis provides more clear picture of character associations for formulating efficient selection strategy. Path coefficient analysis differs from simple correlation in that it points out the causes and their relative importance, whereas, the later measures simply the mutual association ignoring the causation. The concept of path coefficient was developed by Wright S. (1921) and technique was first used for plant selection by Dewey and Lu (1959). Path analysis has emerged as a powerful and widely used technique for understanding the direct and indirect contributions of different characters to economic yield in crop plants so that the relative importance of various yield contributing characters can be assessed. The direct and indirect effects of seventeen characters on grain yield per plant estimated by path coefficient analysis using phenotypic and genotypic correlations is depicted in **Table 3** and **4** respectively.

Highest positive direct effect on grain yield per plant was exerted by biological yield per plant (0.7908, 0.7756), followed by harvest-index (0.4598, 0.4669), amylose content (0.0270, 0.0179), L:B ratio (0.0203, 0.0149) in F_1s at genotypic and phenotypic level respectively. Thus, biological yield per plant and harvest-index emerged as most important direct yield components on which emphasis should be given during simultaneous selection aimed at improving grain yield in rice. These characters have also been identified as major direct contributors towards grain yield by Sarawgi *et al.*, (1997), Mishra and Verma (2002), Petchiammal and Kumar (2007), Kishore *et al*., (2007), Amahed *et al.,* (2014), Kumar *et al.,* (2018) and Shrivastav *et al*., (2020).

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.

Table 1 : Estimates of phenotypic correlation coefficients (F_1s) between 18 characters in rice under sodic soil

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)	Amylose content	Protein content (%)	Grain yield/ plant (g)
Days to 50% flowering	1.0000	-0.0890	-0.0426	-0.1428*	-0.1169	-0.1332*	-0.2511**	-0.1200	-0.1163	-0.1586**	-0.1770**	-0.2185**	-0.2122**	0.1243*	-0.1886**	0.3199**	-0.0564	-0.2665**
Chlorophyll content		1.0000	0.4797**	-0.1013	0.0735	0.3982**	0.4386**	0.2136**	0.3765**	0.4122**	0.2424**	0.5068**	0.1605**	0.2001**	0.1584**	0.2269**	0.1242*	0.4858**
Leaf nitrogen			1.0000	-0.3626**	0.1247*	0.3799**	0.2338**	0.1577**	0.2044**	0.2512**	0.2180**	0.2213**	-0.0116	0.2293**	-0.0316	-0.0669	0.1130	0.1683**
Leaf temperature				1.0000	-0.0669	-0.2023**	0.0002	-0.1676**	0.0018	-0.0367	-0.1158	0.1792**	0.0723	0.1778**	0.1067	-0.0138	0.0042	0.1912**
Flag leaf area (cm^2)					1.0000	0.4854**	0.1429*	0.1972**	0.2649**	0.2428**	0.0588	0.2278**	0.2173**	0.3121**	0.1774**	-0.1033	0.0147	0.2746**
Plant height (cm)						1.0000	0.1458*	0.3185**	0.2576**	0.2362**	0.0435	0.2611**	0.1897**	0.0245	0.1011	-0.1463*	0.2439**	0.2978**
Panicle bearing tillers/ plant							1.0000	0.1392*	0.5719**	0.5393**	0.0788	0.5862**	0.3711**	0.3527**	0.1053	0.2212**	-0.1510*	0.6329**
Panicle length (cm)								1.0000	0.3438**	0.3375**	0.0302	0.3942**	0.0931	0.2187**	-0.1311*	-0.0504	0.2038**	0.3589**
Spikelets/ panicle									1.0000	0.9452**	0.1077	0.6962**	0.1306*	0.1405*	-0.0068	0.2408**	0.1539*	0.6166**
Grains/panicle										1.0000	0.4179**	0.6685**	0.1618**	0.2270**	-0.0736	0.1599**	0.1748**	0.6096**
Spikelet fertility (%)											1.0000	0.1431*	0.1386*	0.2921**	-0.1151	-0.1599**	0.1225*	0.1801**
Biological yield/plant (g)												1.0000	0.1849**	0.0809	0.1052	0.1677**	0.2506**	0.8798**
Harvest index (%)													1.0000	0.1754**	0.1368*	-0.0545	-0.1613**	0.6131**
L/B ratio														1.0000	0.0826	0.0821	0.1024	0.1492*
1000-grain weight (g)															1.0000	0.2856**	-0.1437*	0.1543*
Amylose content																1.0000	-0.1984**	0.1218*
Protein content (%)																	1.0000	0.1269*

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

Table 2: Estimates of genotypic correlation coefficients (F_1s) between 18 characters in rice under sodic soil

Characters	Days to 50% flowering	Chlorophyll content	Leaf nitrogen	Leaf tem-perature	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)	Amylose content	Protein content (%)	Grain yield/ plant (g)
Days to 50% flowering	1.0000	-0.1260	-0.0800	-0.1867	-0.1431	-0.1751	-0.3274*	-0.1611	-0.1483	-0.1976*	-0.2238*	-0.2798**	-0.2585**	0.1517	-0.2420*	0.3953**	-0.0678	-0.3278**
Chlorophyll content		1.0000	0.5008**	-0.1101	0.0752	0.4143**	0.4575**	0.2438*	0.3839**	0.4256**	0.2735**	0.5244**	0.1890	0.2073*	0.1617	0.2329*	0.1278	0.4976**
Leaf nitrogen			1.0000	-0.3831	0.1319	0.4009**	0.2478*	0.1836	0.2106*	0.2710**	0.2691**	0.2264*	0.0053	0.2537**	-0.0395	-0.0702	0.1153	0.1755
Leaf temperature				1.0000	-0.0710	-0.2064*	-0.0034	-0.1730	0.0012	-0.0387	-0.1254	0.1763	0.0982	0.1876	0.1091	-0.0141	0.0051	0.1947*
Flag leaf area (cm^2)					1.0000	0.4893**	0.1446	0.2033*	0.2660**	0.2443*	0.0624	0.2339*	0.2351*	0.3206**	0.1831	-0.1034	0.0149	0.2755**
Plant height (cm)						1.0000	0.1464	0.3225**	0.2593**	0.2397*	0.0506	0.2697**	0.2051*	0.0232	0.1035	-0.1473	0.2457*	0.3020**
Panicle bearing tillers/plant							1.0000	0.1427	0.5790**	0.5463**	0.0825	0.6056**	0.4087**	0.3654**	0.1053	0.2234*	-0.1544	0.6410**
Panicle length (cm)								1.0000	0.3565**	0.3489**	0.0279	0.4199**	0.1075	0.2300*	-0.1442	-0.0520	0.2097*	0.3741**
Spikelets/ panicle									1.0000	0.9507**	0.1232	0.7129**	0.1458	0.1459	-0.0073	0.2413*	0.1540	0.6210**
Grains/ panicle										1.0000	0.4184**	0.6866**	0.1758	0.2315*	-0.0760	0.1604	0.1752	0.6136**
Spikelet fertility (%)											1.0000	0.1556	0.1492	0.3078**	-0.1214	-0.1688	0.1287	0.1869*
Biological yield/plant (g)												1.0000	0.2659**	0.0845	0.1051	0.1714	0.2601*	0.9018**
Harvest index (%)													1.0000	0.1952*	0.1593	-0.0585	-0.1781	0.6560**
L/B ratio														1.0000	0.0831	0.0839	0.1057	0.1525
1000-grain weight (g)															1.0000	0.2920**	-0.1480	0.1569
Amylose content																1.0000	-0.1991*	0.1222
Protein content (%)																	1.0000	0.1278

Table 3: Estimates of phenotypic direct and indirect (F_1s) effect of 17 characters on grain yield per plant in rice under sodic soil

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)	Amylose content	Protein content (%)	Grain yield/ plant (g)
Days to 50% flowering	0.0043	-0.0004	-0.0002	-0.0006	-0.0005	-0.0006	-0.0011	-0.0005	-0.0005	-0.0007	-0.0008	-0.0009	-0.0009	0.0005	-0.0008	0.0014	-0.0002	-0.2665
Chlorophyll content	-0.0007	0.0084	0.0040	-0.0009	0.0006	0.0033	0.0037	0.0018	0.0032	0.0035	0.0020	0.0043	0.0013	0.0017	0.0013	0.0019	0.0010	0.4858
Leaf nitrogen	-0.0001	0.0011	0.0022	-0.0008	0.0003	0.0008	0.0005	0.0003	0.0004	0.0005	0.0005	0.0005	0.0000	0.0005	-0.0001	-0.0001	0.0002	0.1683
Leaf temperature	-0.0039	-0.0028	-0.0099	0.0274	-0.0018	-0.0055	0.0000	-0.0046	0.0000	-0.0010	-0.0032	0.0049	0.0020	0.0049	0.0029	-0.0004	0.0001	0.1912
Flag leaf area (cm^2)	0.0004	-0.0003	-0.0004	0.0002	-0.0035	-0.0017	-0.0005	-0.0007	-0.0009	-0.0009	-0.0002	-0.0008	-0.0008	0.0011	-0.0006	0.0004	-0.0001	0.2746
Plant height (cm)	-0.0011	0.0032	0.0031	-0.0016	0.0039	0.0081	0.0012	0.0026	0.0021	0.0019	0.0004	0.0021	0.0015	0.0002	0.0008	-0.0012	0.0020	0.2978
Panicle bearing tillers/ plant	0.0039	-0.0069	-0.0037	0.0000	-0.0022	-0.0023	-0.0156	-0.0022	-0.0089	-0.0084	-0.0012	-0.0092	-0.0058	0.0055	-0.0016	-0.0035	0.0024	0.6329
Panicle length (cm)	-0.0018	0.0031	0.0023	-0.0024	0.0029	0.0046	0.0020	0.0146	0.0050	0.0049	0.0004	0.0058	0.0014	0.0032	-0.0019	-0.0007	0.0030	0.3589
Spikelets/panicle	0.0001	-0.0002	-0.0001	0.0000	-0.0001	-0.0001	-0.0003	-0.0002	-0.0005	-0.0005	-0.0001	-0.0003	-0.0001	0.0001	0.0000	-0.0001	-0.0001	0.6166
Grains/panicle	-0.0015	0.0040	0.0024	-0.0004	0.0023	0.0023	0.0052	0.0032	0.0091	0.0096	0.0040	0.0064	0.0016	0.0022	-0.0007	0.0015	0.0017	0.6096
Spikelet fertility (%)	-0.0003	0.0004	0.0003	-0.0002	0.0001	0.0001	0.0001	0.0000	0.0002	0.0007	0.0016	0.0002	0.0002	0.0005	-0.0002	-0.0003	0.0002	0.1801
Biological yield/plant (g)	-0.1694	0.3931	0.1716	0.1390	0.1767	0.2025	0.4547	0.3058	0.5400	0.5185	0.1110	0.7756	0.1434	0.0628	0.0816	0.1301	0.1944	0.8798
Harvest index (%)	-0.0991	0.0749	-0.0054	0.0337	0.1015	0.0886	0.1733	0.0435	0.0610	0.0755	0.0647	0.0863	0.4669	0.0819	0.0639	-0.0255	-0.0753	0.6131
L/B ratio	0.0018	0.0030	0.0034	-0.0026	0.0046	-0.0004	0.0052	-0.0033	0.0021	0.0034	0.0043	0.0012	0.0026	0.0149	0.0012	0.0012	0.0015	0.1492
1000-grain weight (g)	-0.0011	0.0009	-0.0002	0.0006	0.0011	0.0006	0.0006	-0.0008	0.0000	-0.0004	-0.0007	0.0006	0.0008	0.0005	0.0059	0.0017	-0.0009	0.1543
Amylose content	0.0057	0.0041	-0.0012	-0.0002	-0.0018	-0.0026	0.0040	-0.0009	0.0043	0.0029	-0.0029	0.0030	-0.0010	0.0015	0.0051	0.0179	-0.0036	0.1218
Protein content (%)	0.0000	0.0001	0.0001	0.0000	0.0000	0.0001	-0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-0.0001	0.0001	-0.0001	-0.0001	0.0005	0.1269

Residual factors = 0.1217, Bold figures indicate direct effects

Table 4: Estimates of genotypic direct and indirect (F_1s) effect of 17 characters on grain yield per plant in rice under sodic soil

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)	Amylose content	Protein content (%)	Grain yield/ plant (g)
Days to 50% flowering	**-0.0095**	0.0012	0.0008	0.0018	0.0014	0.0017	0.0031	0.0015	0.0014	0.0019	0.0021	0.0027	0.0025	0.0014	0.0023	-0.0038	0.0006	-0.3278
Chlorophyll content	-0.0003	**0.0027**	0.0014	-0.0003	0.0002	0.0011	0.0012	0.0007	0.0010	0.0011	0.0007	0.0014	0.0005	0.0026	0.0004	0.0006	0.0003	0.4976
Leaf nitrogen	-0.0004	0.0027	**0.0053**	-0.0020	0.0007	0.0021	0.0013	0.0010	0.0011	0.0014	0.0014	0.0012	0.0000	0.0013	-0.0002	-0.0004	0.0006	0.1755
Leaf temperature	-0.0026	-0.0016	-0.0054	**0.0141**	-0.0010	-0.0029	0.0000	-0.0024	0.0000	-0.0005	-0.0018	0.0025	0.0014	0.0056	0.0015	-0.0002	0.0001	0.1947
Flag leaf area (cm^2)	0.0016	-0.0009	-0.0015	0.0008	**-0.0114**	-0.0056	-0.0016	-0.0023	-0.0030	-0.0028	-0.0007	-0.0027	-0.0027	0.0036	-0.0021	0.0012	-0.0002	0.2755
Plant height (cm)	-0.0015	0.0035	0.0033	-0.0017	0.0041	**0.0083**	0.0012	0.0027	0.0022	0.0020	0.0004	0.0022	0.0017	0.0005	0.0009	-0.0012	0.0020	0.3020
Panicle bearing tillers/plant	0.0145	-0.0203	-0.0110	0.0002	-0.0064	-0.0065	**-0.0443**	-0.0063	-0.0257	-0.0242	-0.0037	-0.0269	-0.0181	0.0162	-0.0047	-0.0099	0.0068	0.6410
Panicle length (cm)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0001**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0042	0.0000	0.0000	0.0000	0.3741
Spikelets/panicle	-0.0076	0.0196	0.0107	0.0001	0.0136	0.0132	0.0295	0.0182	**0.0510**	0.0484	0.0063	0.0363	0.0074	0.0074	-0.0004	0.0123	0.0078	0.6210
Grains/panicle	0.0097	-0.0209	-0.0133	0.0019	-0.0120	-0.0118	-0.0269	-0.0172	-0.0468	**-0.0492**	-0.0206	-0.0338	-0.0086	0.0114	0.0037	-0.0079	-0.0086	0.6136
Spikelet fertility (%)	-0.0027	0.0032	0.0032	-0.0015	0.0007	0.0006	0.0010	0.0003	0.0015	0.0050	**0.0119**	0.0018	0.0018	0.0037	-0.0014	-0.0020	0.0015	0.1869
Biological yield/ plant (g)	-0.2212	0.4147	0.1791	0.1394	0.1850	0.2133	0.4789	0.3321	0.5638	0.5430	0.1231	**0.7908**	0.2103	0.0668	0.0831	0.1356	0.2057	0.9018
Harvest index (%)	-0.1189	0.0869	0.0024	0.0452	0.1081	0.0943	0.1880	0.0495	0.0670	0.0808	0.0686	0.1223	**0.4598**	0.0898	0.0733	-0.0269	-0.0819	0.6560
L/B ratio	0.0016	0.0021	0.0026	0.0019	0.0033	0.0008	0.0038	0.0024	0.0015	0.0024	0.0032	0.0009	0.0020	**0.0203**	0.0069	0.0019	0.0011	0.1555
1000-grain weight (g)	0.0017	-0.0012	0.0003	-0.0008	-0.0013	-0.0007	-0.0008	0.0010	0.0001	0.0005	0.0009	-0.0008	-0.0011	0.0006	**-0.0072**	-0.0021	0.0011	0.1569
Amylose content	0.0107	0.0063	-0.0019	-0.0004	-0.0028	-0.0040	0.0060	-0.0014	0.0065	0.0043	-0.0046	0.0046	-0.0016	0.0023	0.0079	**0.0270**	-0.0054	0.1222
Protein content (%)	0.0003	-0.0005	-0.0005	0.0000	-0.0001	-0.0010	0.0006	-0.0008	-0.0006	-0.0007	-0.0005	-0.0010	0.0007	0.0004	0.0006	0.0008	**-0.0039**	0.1278

Residual factors =0.03, Bold figures indicate direct effects

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