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Correlation and path coefficient analysis for grain yield, yield components and nutritional traits in rice (*Oryza sativa* L.)

RS Archana, M Sudha Rani, KM Vishnu Vardhan and G Fareeda

Abstract
Character association and path coefficient analysis among grain yield, yield components and nutritional traits were studied in 38 genotypes of rice. Analysis of variance revealed the existence of significant differences among genotypes for all the 17 characters studied. Grain yield per plant was positively and significantly associated with harvest index, panicle weight, number of productive tillers per plant, panicle length, number of filled spikelets per panicle, kernel length, SPAD chlorophyll meter reading, kernel L/B ratio and 1000 grain weight indicating that simultaneous improvement of all the characters is possible. Path coefficient analysis indicated that highest direct effects on grain yield in the traits *viz*., days to 50 per cent flowering, 1000 grain weight, kernel L/B ratio, number of filled spikelets per panicle, harvest index, plant height, kernel breadth, SCMR, iron and protein content. Hence emphasis can be laid out on these traits during selection for further improvement in grain yield in rice.

Keywords: Correlation, path coefficient analysis, yield components, *Oryza sativa* L.

Introduction
Rice (*Oryza sativa* L.) is a monocotyledonous plant belonging to the family Poaceae and sub family Oryzoidea. It is the staple food crop for more than 2.7 billions of people across the world, providing 21 per cent of global human per capita energy and 15 per cent of per capita protein, vitamins, essential fatty acids and micronutrients for the poor and vulnerable society of the world (Bitew, 2016) [11]. About 90 per cent of the world's rice is grown and consumed in Asia, known as "Rice bowl of the World", where it accounts for 50 to 80 per cent of daily calorific intake (Pratap *et al.,* 2012) [28]. Rice is being planted on approximately 11 per cent of earth's cultivated land area and ranks second in production after wheat (Anis *et al.*, 2016) [5].
Producing enough food energy to maintain the world's population is not enough. Till today, billions of people are malnourished. Micronutrient deficiency is a global health problem contributing to high rate of children and women's mortality mostly in developing countries. In general iron (Fe) deficiency has profound negative effect on human health and development, including limited learning capacity in childhood and impaired immune function. To achieve iron balance, adult men need to take about 6-8 mg/day and adult menstruating women about 8-18 mg/day, although this is highly variable. Towards the end of pregnancy, the absorption of 23-27 mg/day is necessary (Suma *et al.* 2014) [35]. Zinc deficiency is characterized by diarrhea, pneumonia, weight loss, growth retardation & delayed puberty in adolescents, poor appetite, delayed wound healing and it is fatal if untreated. The daily recommended dietary allowance (Cakmak *et al.,* 2010) [12] for Zn is around 15mg per day. Besides micronutrients, protein deficiency is also affecting human health. Protein functions as enzymes, hormones, antibodies, transport and structural components as well. Proteins are mostly concentrated in the bran fraction of rice, but milling procedure losses most of the protein content (Chowdhury *et al*., 2016) [14]. For the poor, micronutrient dense rice is the affordable source and developing rice varieties that load high amounts of iron, zinc and protein into their seed is a wise breeding strategy as the consumption rates of rice is high.
Therefore, to meet the demand of high grain yield and also to identify rice genotypes with high nutritional content, the present investigation was undertaken with the objective to ascertain the extent of character association that could identify the relative importance of independent characters that may be useful as indicators for one or more characters.

Similarly, path coefficient analysis partitions the genetic correlation between yield and its components into direct and indirect effects to provide basis for selection and yield improvement.

Materials and Methods

Thirty eight genotypes of rice were grown in randomized block design with three replications each during *kharif*, 2017 at at the College farm of Agricultural College, Mahanandi of Acharya N.G. Ranga Agricultural University, Andhra Pradesh. Thirty day-old seedlings of each variety were transplanted in three row plots of 5 m length, at a spacing of 20 cm between rows and 15 cm between plants within the row. Observations were recorded on 17 traits *i.e*., days to 50 per cent flowering, days to maturity, plant height, number of productive tillers per plant, panicle length, panicle weight, number of filled spikelets per panicle, kernel length, kernel breadth, kernel L/B ratio, 1000 grain weight, harvest Index, grain yield, protein content, iron content and zinc content and mean values were used for statistical analysis. Further, genotypic and phenotypic correlation coefficients were calculated using the method detailed by Johnson *et al.* (1955) [22], while the direct and indirect contribution of different yield component characters on grain yield per plant was estimated by path coefficient analysis as suggested by Wright (1921) [37].

Results and Discussion

The analysis of variance revealed significant differences among the genotypes for all the characters indicating that there is an inherent genetic difference among the genotypes. Grain yield is a complex character and it is the end product of action and interaction among number of traits, hence it is important to understand the association of different characters with grain yield. Plant breeder has to find simple correlations and the extent of direct and indirect effects of attributes with grain yield that could be useful to predict the superior cross combinations and to identify traits for ideal plant type and aid in indirect selection. The present study revealed that the genotypic correlations were higher than the corresponding phenotypic correlations (Table. 1), which indicated that these traits were inherently associated among themselves. The results of positive association of kernel length and kernel L/B ratio with grain yield is in conformity with the findings of Aditya and Bhartiya (2013) [1] and chakravorty and Ghosh (2014) [13]. The positive association of panicle weight with grain yield is in accordance with earlier findings of Sathisha *et al.* (2015) [32]. Number of productive tillers per plant and number of filled spikelets per panicle were positively associated with grain yield which is in agreement with earlier reports of Biswajit *et al.* (2017) [17]. The positive correlation of panicle length, 1000 grain weight and harvest index with grain yield is in agreement with earlier reports of Kishore *et al.* (2018) [23]. Positive association of SPAD chlorophyll meter reading (SCMR) and protein content with grain yield was observed, which is in consonance with Sathya and Jebaraj (2013) [33] and Chowdhury *et al.* (2016) [14], respectively. On contrary, non significant and positive association was noticed for grain yield with plant height and iron content. similar results were reported by Sanghera *et al.* (2013) [31] and Suma *et al.* (2014) [35].

Studies on inter character associations for yield components revealed significant and positive association of days to 50 per cent flowering with days to maturity, plant height, kernel breadth and zinc content; days to maturity with plant height, kernel breadth and zinc content; plant height with panicle length; number of productive tillers per plant with panicle weight; number of filled spikelets per panicle; kernel length; harvest index and SCMR; panicle length with panicle weight, kernel length, kernel L/B, harvest index, protein, and iron content at genotypic level; panicle weight with number of filled spikelets per panicle, kernel length, kernel L/B ratio, 1000 grain weight, harvest index, SCMR and iron content; number of filled spikelets per pancle with kernel L/B ratio, harvest index and SCMR; kernel length with kernel L/B ratio, 1000 grain weight, harvest index and iron content; kernel breadth with 1000 grain weight; kernel L/B ratio with harvest index, protein, and iron content at genotypic level; harvest index with SCMR and iron content with zinc content indicating a scope for simultaneous improvement of these traits through selection.

Similar findings of above inter character associations were also reported by Akinwale *et al.* (2011) [3] for panicle weight with number of filled spikelets per panicle; Aditya and Bhartiya (2013) [1] for kernel breadth with 1000 grain weight; Gopikannan and Ganesh (2013) [18] for panicle length with protein content and number of filled grains per panicle with SCMR; Nagaraju *et al.* (2013) [25] for kernel L/B ratio with harvest index; Satya and Jebaraj (2013) [33] for harvest index with SCMR; Jambhulkar and Bose (2014) [20] for panicle weight with 1000 grain weight; Allam *et al.* (2015) [4] for kernel length with 1000 grain weight; Bhati *et al.* (2015) [7] for panicle length with harvest index; Das (2015) [15] for panicle weight with harvest index and number of productive tillers with number of filled grains per panicle; Guru *et al.* (2016) [19] for panicle length with panicle weight and Dharwal *et al.* (2017) [17] for iron with zinc. However, significant and negative associations were observed for grain yield with days to 50 per cent flowering, days to maturity and zinc content probably due to competition for a common possibility, such as nutrient supply. Similar results were reported by Nagesh *et al.* (2012) [26] and Bekel *et al.* (2013) [6] for zinc content and Bhuvaneshwari *et al.* (2015) [9] for days to 50 per cent flowering and days to maturity.

Path co-efficient analysis provides an effective means of finding out the direct and indirect causes of association and presents a critical examination of the specific forces acting to produce a given correlation and also measures the relative importance of each causal factor. Hence, the study of direct and indirect effects of yield and nutritional components on grain yield per plant from genotypic correlation was undertaken in the present investigation and the results obtained are presented in Table 2. The results revealed high residual effect for both phenotypic (0.3455) and genotypic (0.2931) path coefficients (Fig. 1&2), indicating that variables studied in the present investigation explained about 64.3 (phenotypic) and 83.7 (genotypic) per cent of the variability in yield and therefore, other attributes besides the characters studied are contributing for grain yield. The results also revealed that days to 50 per cent flowering manifested the maximum positive direct effect on grain yield per plant followed by 1000 grain weight, number of filled grains per panicle, harvest index, plant height, kernel breadth, kernel L/B ratio, grain iron content, SCMR and grain protein content. The results were in agreement with the previous findings of Sameera *et al.* (2016) [30] for days to 50 per cent flowering, 1000 grain weight and plant height; Afrin *et al.* (2017) [2] and Manjunatha *et al.* (2017) [24] for SCMR; Dhakal *et al.* (2017) [16] and Jayaprakash *et al.* (2017) [21] for protein content; Kishore *et al.* (2018) [23] for number of filled grains per panicle and harvest index; Rathod *et al.* (2017) [29] for iron content; Shankar *et al.* (2016) [34] and Tejaswini *et al.* (2018) [36] for kernel breadth and kernel L/B ratio.

Therefore, 1000 grain weight, kernel L/B ratio, number of filled spikelets per panicle, harvest index and SCMR had significant positive association as well as direct effect on grain yield and indirectly influenced *via* various traits. Hence, these traits may be prioritized as an important selection criteria in all rice improvement programmes. Similarly, among the nutritional traits, protein content is identified to be the effective trait for improving grain yield because of its positive significant association and positive direct effect on grain yield per plant. Grain iron content also recorded direct positive effect in addition to positive non-significant association in general with grain yield per plant, indicating the need for adoption of restricted simultaneous selection model to nullify the undesirable indirect effects and make use of the direct effect.

High negative direct effects on grain yield per plant was recorded by panicle length, number of productive tillers per plant, kernel length, panicle weight. However its association with grain yield per plant was observed to be highly significant and positive indicating a major role of indirect effects and hence, a need for simultaneous consideration of indirectly influencing characters for these traits in selection programmes along the traits with negative direct effects. Similar result of direct negative effects on grain yield were reported by Jambhulkar and Bose (2014) [20] for panicle length and panicle weight; Guru *et al.* (2016) [19] for number of productive tillers per plant; Tejaswini *et al.* (2018) [36] for kernel length. In addition, grain zinc content and days to maturity also had high negative direct effects on grain yield per plant. These findings are in conformity with the reports of Pandey *et al.* (2018) [27] for zinc content; Kishore *et al.* (2018) [23] for days to maturity. Association of these traits with grain yield per plant was however, negative and significant indicating that they may not be used as promising criterion for selecting high yielding genotypes.

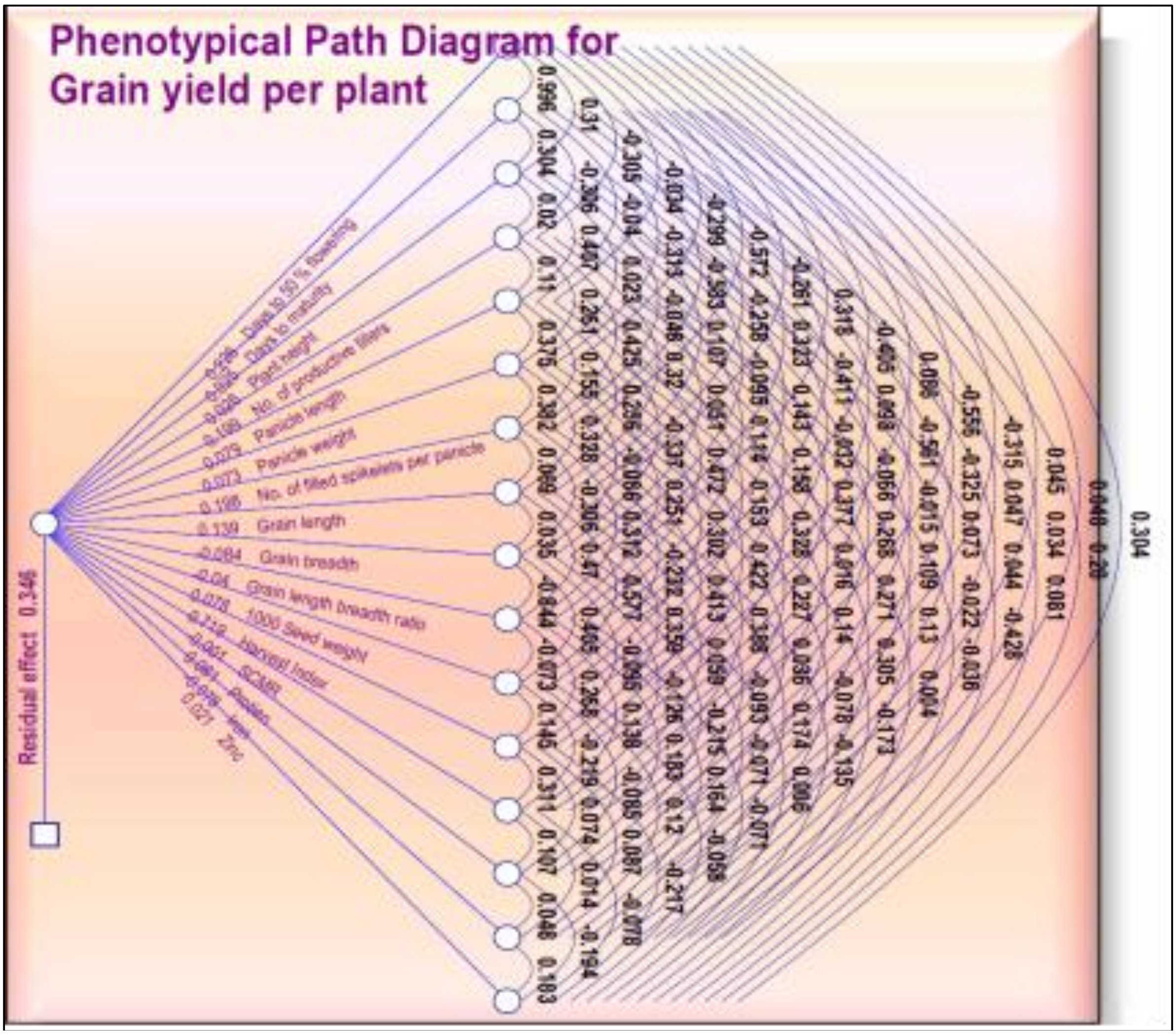

Fig 1: Phenotypic path diagrams for grain yield per plant

Table 1: Phenotypic and genotypic correlations among yield, yield components and nutritional traits among 38 genotypes of rice

		DM	PH	NPT	PL	PW	NFS	KL	KB	LBR	TW	HI	SCMR	Protein	Iron	Zinc	GY
DFF	r_p	0.9964**	0.3099**	-0.3051**	-0.0335	-0.2986**	-0.5718**	-0.2608**	0.3176**	-0.4050**	0.0858	-0.5622**	-0.3152**	0.0448	0.0480	0.3043**	-0.3718**
	r_g	0.9994**	0.4242**	-0.3959**	-0.0121	-0.3631**	-0.5991**	-0.2678**	0.3815**	-0.4421**	0.0951	-0.6259**	-0.4019**	0.0498	0.0430	0.3312**	-0.3991**
DM	r_p		0.3043**	-0.3058**	0.0395	-0.3126**	-0.5834**	-0.2584**	0.3230**	-0.4105**	0.0983	-0.5610**	-0.3255**	0.0473	0.0343	0.2801**	-0.3782**
	r_g		0.4224**	-0.3874**	-0.0227	-0.3782**	-0.6150**	-0.2654**	0.3926**	-0.4524**	0.1039	-0.6287**	-0.4191**	0.0512	0.0269	0.3017**	-0.4046**
PH	r_p			0.0204	0.4072**	0.0233	-0.0475	0.1069	-0.0948	0.1428	-0.0315	-0.0663	-0.0149	0.0734	0.0444	0.0809	0.1039
	r_g			0.1133	0.5185**	0.0328	-0.0610	0.0842	-0.1497	0.1751	-0.0617	-0.0631	-0.1253	0.0813	0.0417	0.1276	0.1430
NPT	r_p				0.1098	0.2612**	0.4253**	0.3198**	0.0513	0.1145	0.1575	0.3773**	0.2683**	0.1092	-0.0221	-0.4279**	0.5550**
	r_g				0.1011	0.4098**	0.5380**	0.4033**	0.0591	0.1483	0.1836	0.4787**	0.4752**	0.1368	-0.0637	-0.5747**	0.6452**
PL	r_p					0.3748**	0.1551	0.2556**	-0.3365**	0.4715**	0.1527	0.3283**	0.0156	0.2706**	0.1302	-0.0359	0.4648**
	r_g					0.4466**	0.1967	0.2930**	-0.4111**	0.5527**	0.1767	0.3870**	0.0328	0.3159**	0.2714**	-0.0699	0.5332**
PW	r_p						0.3816**	0.3276**	-0.0861	0.2508**	0.3022**	0.4225**	0.2265*	0.1401	0.3047**	0.0043	0.5125**
	r_g						0.5686**	0.4635**	-0.1367	0.3515**	0.3889**	0.5965**	0.2960**	0.1861	0.5019**	-0.0851	0.6911**
NFS	r_p							0.0693	-0.3065**	0.3119**	-0.2317*	0.4126**	0.3876**	0.0361	-0.0781	-0.1731	0.4835**
	r_g							0.0843	-0.3827**	0.3561**	-0.2703**	0.4675**	0.5412**	0.0424	-0.0766	-0.1873	0.5310**
KL	r_p								0.0353	0.4701**	0.5772**	0.3587**	0.0590	-0.0925	0.1739**	-0.1349	0.4548**
	r_g								0.0277	0.4965**	0.6634**	0.4449**	0.0661	0.0989	0.2239*	-0.1761	0.5198**
KB	r_p									-0.8436**	0.4053**	-0.0952	-0.1258	-0.2153*	-0.0715	-0.0057	-0.0996
	r_g									-0.8473**	0.5000**	-0.1180	-0.1696	-0.2551**	-0.1380	0.0352	-0.1097
LBR	r_p										-0.0734	0.2678**	0.1377	0.1829*	0.1638	0.0708	0.3252**
	r_g										-0.0708	0.3366**	0.1590	0.1987*	0.2271*	-0.1112	0.3720**
TW	r_p											0.1446	-0.2194*	-0.0854	0.1199	-0.0580	0.2545**
	r_g											0.1747	-0.3263**	-0.0912	0.1665	-0.0839	0.2907**
HI	r_p												0.3114**	0.0740	0.0868	-0.2171*	0.8434**
	r_g												0.3636**	0.0795	0.1511	-0.2564**	0.8720**
SCMR	r_p													0.1075	0.0142	-0.0782	0.2932**
	r_g													0.1440	0.0666	-0.0572	0.4115**
Protein	r_p														0.0477	-0.1942*	0.1918*
	r_g														0.0673	-0.2163*	0.1958*
Iron	r_p															0.1829*	0.0502
	r_g															0.2100*	0.0696
Zinc	r_p																-0.2297*
	r_g																-0.2754**

r_p= Phenotypic correlation; r_g = genotypic correlation; *, ** Significant at 0.05 (0.18-0.24), 0.01 (>0.24) levels, respectively.
DFF-Days to 50% flowering, DM-Days to maturity, PH-Plant height, NPT-Number of productive tillers per plant, PL-Panicle length, PW-Panicle weight, NFS-Number of filled spikelets per panicle, KL-Kernel length, KB-Kernel breadth, LBR-Kernel length breadth ratio, TW-1000 grain weight, GY-Grain yield per plant, HI-Harvest index, SCMR-SPAD chlorophyll meter reading.

Table 2: Phenotypic and genotypic path coefficients for yield, yield components and nutritional traits among 38 rice genotypes

		DFF	DM	PH	NPT	PL	PW	NFS	KL	KB	LBR	TW	HI	SCMR	Protein	Iron	Zinc	GY
DFF	Pp	0.2264	0.2256	0.0701	-0.0691	-0.0076	-0.0676	-0.1294	-0.0590	0.0719	-0.0917	0.0194	-0.1259	-0.0713	0.0101	0.0109	0.0689	-0.3718
	Pg	3.8656	3.8633	1.6398	-1.5304	-0.0469	-1.4036	-2.3158	-1.0351	1.4748	-1.7090	0.3676	-2.4197	-1.5537	0.1925	0.1662	1.2802	-0.3991
DM	Pp	0.0254	0.0255	0.0078	-0.0078	-0.0010	-0.0080	-0.0149	-0.0066	0.0082	0.0105	0.0025	-0.0143	-0.0083	0.0012	0.0009	0.0071	-0.3782
	Pg	-3.6047	-3.6069	-1.5234	1.3972	0.0819	1.3642	2.2183	0.9574	-1.4162	1.6317	-0.3747	2.2675	1.5116	-0.1847	-0.0969	-1.0882	-0.4046
PH	Pp	0.0082	0.0081	0.0265	0.0005	0.0108	0.0006	-0.0013	0.0028	-0.0025	0.0038	-0.0008	-0.0018	-0.0004	0.0019	0.0012	0.0021	0.1039*
	Pg	0.4416	0.4397	1.0411	0.1180	0.5398	0.0341	-0.0635	0.0876	-0.1558	0.1823	-0.0642	-0.0657	-0.1304	0.0846	0.0434	0.1329	0.1430*
NPT	Pp	-0.0607	-0.0609	0.0041	0.1990	0.0219	0.0520	0.0846	0.0636	0.0102	0.0228	0.0313	0.0751	0.0534	0.0217	-0.0044	-0.0851	0.5550**
	Pg	0.3666	0.3587	-0.1049	-0.9259	-0.0936	-0.3794	-0.4981	-0.3734	-0.0548	-0.1373	-0.1700	-0.4432	-0.4400	-0.1267	0.0590	0.5321	0.6452**
PL	Pp	-0.0026	-0.0031	0.0320	0.0086	0.0787	0.0295	0.0122	0.0201	-0.0265	0.0371	0.0120	0.0258	0.0012	0.0213	0.0102	-0.0028	0.4648**
	Pg	0.0112	0.0210	-0.4787	-0.0933	-0.9232	-0.4123	-0.1816	-0.2705	0.3796	0.5103	-0.1631	-0.3573	0.0302	-0.2917	-0.2506	0.0646	0.5332**
PW	Pp	-0.0217	-0.0227	0.0017	0.0190	0.0273	0.0728	0.0278	0.0238	-0.0063	0.0183	0.0220	0.0307	0.0165	0.0102	0.0222	0.0003	0.5125**
	Pg	0.4885	0.5088	-0.0441	-0.5513	-0.6008	-1.3453	-0.7649	-0.6235	0.1840	-0.4729	-0.5232	-0.8024	-0.3981	-0.2503	-0.6752	0.1144	0.6911**
NFS	Pp	-0.1130	-0.1153	-0.0094	0.0840	0.0306	0.0754	0.1976	0.0137	-0.0606	0.0616	-0.0458	0.0815	0.0766	0.0071	-0.0154	-0.0342	0.4835**
	Pg	-0.9190	-0.9434	-0.0936	0.8253	0.3017	0.8721	1.5339	0.1293	-0.5870	0.5462	-0.4146	0.7171	0.8302	0.0651	-0.1175	-0.2873	0.5310**
KL	Pp	-0.0361	-0.0358	0.0148	0.0443	0.0354	0.0454	0.0096	0.1386	0.0049	0.0651	0.0800	0.0497	0.0082	-0.0128	0.0241	-0.0187	0.4548**
	Pg	0.4132	0.4096	-0.1299	-0.6223	-0.4521	-0.7152	-0.1300	-1.5431	-0.0428	-0.7662	-1.0237	-0.6864	-0.1020	0.1526	-0.3455	0.2717	0.5198**
KB	Pp	-0.0267	-0.0271	0.0080	-0.0043	0.0283	0.0072	0.0258	-0.0030	-0.0840	0.0709	-0.0341	0.0080	0.0106	0.0181	0.0060	-0.0005	-0.0996
	Pg	0.3954	0.4069	-0.1551	0.0613	-0.4261	-0.1417	-0.3966	0.0288	1.0365	-0.8782	0.5183	-0.1223	-0.1758	-0.2644	-0.1430	0.0365	-0.1097
LBR	Pp	0.0160	0.0162	-0.0057	-0.0045	-0.0187	-0.0099	-0.0123	-0.0186	0.0334	-0.0396	0.0029	-0.0106	-0.0054	-0.0072	-0.0065	0.0028	0.3252**
	Pg	-0.8209	-0.8400	0.3252	0.2753	1.0263	0.6527	0.6613	0.9220	-1.5734	1.8569	-0.1316	0.6251	0.2953	0.3689	0.4217	-0.2065	0.3720**
TW	Pp	0.0067	0.0077	-0.0025	0.0124	0.0120	0.0237	-0.0182	0.0453	0.0318	-0.0058	0.0785	0.0113	-0.0172	-0.0067	0.0094	-0.0046	0.2545**
	Pg	0.2045	0.2234	-0.1326	0.3949	0.3799	0.8363	-0.5812	1.4266	1.0753	-0.1523	2.1504	0.3757	-0.7017	-0.1961	0.3580	-0.1805	0.2907**
HI	Pp	-0.4001	-0.4035	-0.0477	0.2714	0.2361	0.3039	0.2968	0.2580	-0.0684	0.1926	0.1040	0.7193	0.2240	0.0533	0.0624	-0.1561	0.8434**
	Pg	-0.7991	-0.8026	-0.0806	0.6112	0.4941	0.7615	0.5969	0.5679	-0.1506	0.4298	0.2231	1.2767	0.4642	0.1014	0.1929	-0.3273	0.8720**
SCMR	Pp	0.0002	0.0002	0.0000	-0.0001	0.0000	-0.0001	-0.0002	0.0000	0.0001	-0.0001	0.0001	-0.0002	-0.0005	-0.0001	0.0000	0.0000	0.2932**
	Pg	-0.2696	-0.2811	-0.0840	0.3187	-0.0220	0.1985	0.3630	0.0443	-0.1138	0.1067	-0.2189	0.2439	0.6708	0.0966	0.0447	-0.0384	0.4115**
Protein	Pp	0.0036	0.0038	0.0060	0.0089	0.0220	0.0114	0.0029	-0.0075	-0.0175	0.0149	-0.0070	0.0060	0.0088	0.0814	0.0039	-0.0158	0.1918*
	Pg	0.0138	0.0141	0.0225	0.0378	0.0873	0.0514	0.0117	-0.0273	-0.0705	0.0549	-0.0252	0.0220	0.0398	0.2762	0.0186	-0.0598	0.1958*
Iron	Pp	-0.0038	-0.0027	-0.0035	0.0017	-0.0102	-0.0239	0.0061	-0.0137	0.0056	-0.0129	-0.0094	-0.0068	-0.0011	-0.0037	-0.0785	-0.0144	0.0502
	Pg	0.0226	0.0141	0.0219	-0.0335	0.1428	0.2640	-0.0403	0.1178	-0.0726	0.1195	0.0876	0.0795	0.0351	0.0354	0.5261	0.1105	0.0696
Zinc	Pp	0.0064	0.0059	0.0017	-0.0091	-0.0008	0.0001	-0.0037	-0.0029	0.0001	-0.0015	-0.0012	-0.0046	-0.0017	-0.0041	0.0039	0.0212	-0.2297
	Pg	-0.2087	-0.1902	-0.0804	0.3622	0.0441	0.0536	0.1181	0.1110	-0.0222	0.0701	0.0529	0.1616	0.0361	0.1363	-0.1323	-0.6303	-0.2754

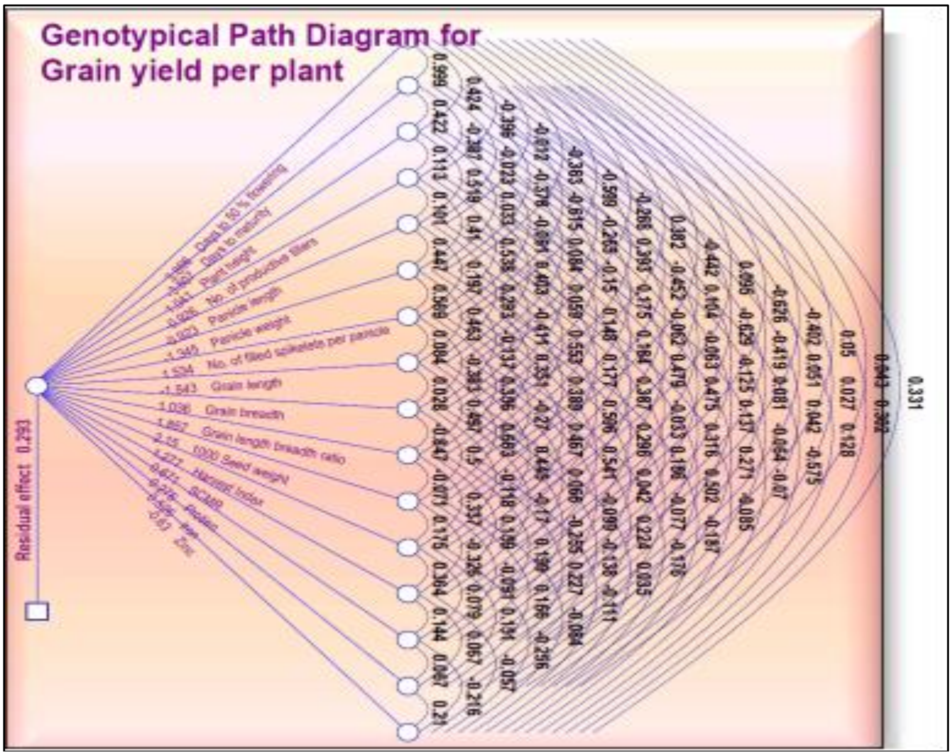

Fig 2: Phenotypic path diagrams for grain yield per plant

Conclusion

A perusal of the results of both correlation and path analysis revealed that most important characters accounting for cause and effect relationship on yield are harvest index, panicle weight, number of productive tillers per plant, number of filled spikelets per panicle, SCMR, kernel L/B ratio and 1000 grain weight. Thus, these traits were identified to be the major yield factors and major emphasis may be given towards selection of these traits for improvement of grain yield in rice. Further, the significant and positive association of protein content with grain yield demonstrated the scope for simultaneous improvement of both the traits. Hence, due emphasis should be given to these traits while formulating selection criteria to bring improvement in yield as well as grain quality.

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