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Correlation and Path Analysis for Yield and Yield Attributes in Maintainer Lines of Rice (*Oryza sativa* L.)

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ABSTRACT

The study was conducted during *kharif* season (June–October) of 2016 at the Regional Agricultural Research Station, Agriculture College, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Jagtial, Telangana, India. Forty (40) maintainer lines of rice (*Oryza sativa* L.) were grown in randomized block design replicated twice to find the relationships between the yield and its components, as well as their direct and indirect effects on the rice grain yield. Observations were recorded for yield, yield attributing characters and quality traits on five randomly selected competitive plants for each entry in each replication for 15 characters. The results revealed that the analysis of variance was significant for all the characters investigated. Grain yield was significantly correlated with its component characters like number of tillers plant^{-1} (0.9191**), panicle length (0.3339**), milling percentage (0.3214**) and hulling percentage (0.2873**) whereas it showed a negligible positive correlation with days to 50% flowering, days to maturity, plant height, panicle length, number of grains per panicle, kernel length, kernel breadth, L/B ratio, test weight, hulling percentage, and head rice recovery percentage. Path coefficient analysis revealed that number of tillers plant^{-1} (0.9439) exerted maximum positive direct effect on plant yield followed by kernel breadth, L/B ratio, panicle length, milling percentage, days to flowering and head rice recovery percentage indicated their importance in determining the complex character and therefore should be kept in mind while practicing selection aimed at improving the grain yield.

KEYWORDS: Hybrid rice, correlation, maintainer lines, quality traits, path analysis

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1. INTRODUCTION

India is the largest producer of rice next to China with 43.78 mha area, production of 118.43 mt and productivity of about 2705 kg ha^{-1} (Anonymous, 2021). Increasing rice production is crucial for ensuring food security and reducing poverty. As they boost yield percentage by about 15–20 (Ma and Yuan, 2015), hybrid rice technology has shown to be one of the most practical and easily adopted techniques to break the yield barrier.

Grain yield is a complex trait which is a result of interaction between various genetic and environmental fluctuation (Wattoo et al., 2010). Breeding programs aim to increase rice production by using more genetic types and applying effective selection methods to increase yield through yield traits. Identifying the relationship between yield and yield traits via correlation analysis is an essential step (Akhtar et al., 2011), but dividing the influence of traits into direct and indirect effects by path analysis is more essential for the selection of yield traits (Ahmadizadeh et al., 2011; Dhavaleshvar et al., 2019). However, it was discovered that genotypic correlations were generally higher than phenotypic values (Nogueira et al., 2012). The coefficient of correlations aids in determining the level of relationship between two separate traits as well as the level at which these traits are mutually variable (Bocanski et al., 2009, Nagabhushan et al., 2011). Examining this relationship between quantitative traits is an important task of assessing the feasibility of a joint selection of two or more traits instead of selecting the secondary traits as genetic gains for primary traits under consideration (Ezeaku and Muhammad, 2006). Association studies confer an idea about relative contribution of different traits exhibited yield and magnitude of correlation between yield component and yield and among themselves (Vennela et al., 2021). Knowing characters that have little or no significance in the selection programme may also be helpful (Singh et al., 2014). Consequently, an insight into interrelationships existing amidst yield components is needed, for selection to be effective. Character association of the yield attributing traits revealed significantly positive association of grain yield with many of the yield attributing traits (Sarwar et al., 2016, Rukmini Devi et al., 2017, Gyawali et al., 2018). A correlation study alone fails to depict the clear picture with respect to the association among traits. The existence of correlation may be attributed to the presence of linkage or pleiotropic effect of genes or physiological and development relationship or environmental effect or in combination of all (Oad et al., 2002). A better understanding of the interrelations between various character pairs would result from the combination of correlation in grouping and path analysis (Jayasudha and Sharma, 2010). Developed initially by Sewell Wright (1921, 1934) to describe a system of correlation coefficients, path analysis is now regarded as one type of the more general statistical technique known as structural equation modeling (SEM). The difference is that path analysis is restricted to observed variables, whereas SEM can handle latent variables as well. Path coefficient analysis helps in the separation of correlation coefficients into direct effects (path coefficient) and indirect effects i.e., other effects as influenced by other variables (Wright, 1921; Azhmadizadeh et al., 2011; Ratna et al., 2016). Present study aimed at understanding the genetic parameters which determine the relationship between rice yield and other traits.

2. MATERIALS AND METHODS

The experiment was conducted at the Regional Agricultural Research Station, Jagtial, Telangana, India during *kharif*, 2016 (June–October). 40 genotypes were laid in Randomized Block Design (RBD) with two replications and a spacing of 20×15 cm^2. Twenty-eight days old seedlings were transplanted in the main field and all the necessary package of practices were followed to raise a healthy crop. Observations were recorded for yield, yield attributing characters and quality traits on five randomly selected competitive plants for each entry in each replication for 15 characters *viz*., days to 50% flowering (DFF), days to maturity (DM), plant height (PH), number of tillers $plant^{-1}$ (NTPP), panicle length (PL), number of grains $panicle^{-1}$(NGPP), kernel length (KL), kernel breadth (KB) L/B ratio (L/B), 1000 grain weight (TW), hulling percentage (HL), milling percentage (ML), head rice recovery percentage (HRR), grain yield $plant^{-1}$ (GYP), bran oil percentage (BO). The analysis was done as per Singh and Chaudhary (1985) for correlation coefficient and Dewey and Lu (1959) for path analysis which were standard procedures used till today (Table 1).

Table 1: List of rice genotypes (Maintainer lines) utilized for the study

Sl. No.	Genotype	Source
1.	B1	RARS, Jagtial
2.	B2	RARS, Jagtial
3.	B3	RARS, Jagtial
4.	B4	RARS, Jagtial
5.	B5	RARS, Jagtial
6.	B6	RARS, Jagtial
7.	B7	RARS, Jagtial
8.	B8	RARS, Jagtial
9.	B9	RARS, Jagtial

Sl. No.	Genotype	Source
10.	B11	RARS, Jagtial
11.	B12	RARS, Jagtial
12.	B13	RARS, Jagtial
13.	B15	RARS, Jagtial
14.	B16	RARS, Jagtial
15.	B17	RARS, Jagtial
16.	B18	RARS, Jagtial
17.	B19	RARS, Jagtial
18.	B20	RARS, Jagtial
19.	B22	RARS, Jagtial
20.	B23	RARS, Jagtial
21.	B24	RARS, Jagtial
22.	B35	RARS, Jagtial
23.	B42	RARS, Jagtial
24.	B86	RARS, Jagtial
25.	B88	RARS, Jagtial
26.	JMS11B	RARS, Jagtial
27.	JMS13B	RARS, Jagtial
28.	JMS14B	RARS, Jagtial
29.	JMS17B	RARS, Jagtial
30.	JMS18B	RARS, Jagtial
31.	JMS19B	RARS, Jagtial
32.	JMS20B	RARS, Jagtial
33.	JMS21B	RARS, Jagtial
34.	CMS11B	IRRI, Philippines
35.	CMS14B	IRRI, Philippines
36.	CMS23B	IRRI, Philippines
37.	CMS46B	IRRI, Philippines
38.	CMS52B	IRRI, Philippines
39.	CMS59B	IRRI, Philippines
40.	CMS64B	IRRI, Philippines

3. RESULTS AND DISCUSSION

3.1. Association between the yield and yield related traits

The study of the association between grain yield and its component traits helps to reveal their importance in rice breeding programs (Table 2).

GYPP showed a highly significant correlation with NTPP (0.9649**), PL (0.3384**), ML percentage (0.3254**) and HL percentage (0.2873**). It was a significantly negative connection with BO percentage (-0.2787**) but insignificant negative correlation with KB. The traits DFF, DM, PH, PL, NGPP, KL, KB, L/B ratio, TW and HRR percentage was negligible positive correlation with GYPP. Similar results were supported by Bhargava et al. *(*2021) for productive tiller number and panicle length, Snehi et al.(2022) for filled grain panicle^{-1} (0.37**), effective tillers plant^{-1} (0.32**), panicle length (0.31**), Devi et al. (2022), Devi et al. (2017) and Krishnaveni et al. (2013).

The trait DFF had a positively significant phenotypic correlation with the characters DM (0.8451**) and PL (0.2915**) as well as a negative significant correlation with ML percentage (-0.2684*). Similar findings by Snehi et al. *(*2022) days to 50% of the flowering showed a strong positive connection (0.89**) with days to maturity.

The trait DM recorded positive insignificant correlation with PH (0.1232), NTPP (0.0966), PL (0.0028), NGPP (0.1848), KB (0.0179) and HL percentage (0.0779). The trait PH recorded a positively significant phenotypic correlation with NTPP (0.2653*), KL (0.2368*), PL (0.4355**), KB (0.2858*), HRR (0.2688*) and BO (0.3572**). The trait PH revealed negative insignificant association with L/B ratio (-0.0267) HL percentage (-0.0817) and ML (-0.1469).The number of productive tillers, the length of the panicle, and the plant yield all strongly correlated positively with plant height. It suggests that plant height is important in maximizing rice yield potential. Bhargava et al. (2021) and Panigrahi et al. (2018) reported similar findings.

PL (0.3123**), HL percentage (0.3931**), and ML percentage (0.2932**) all showed positive and significant correlation with the trait NTPP but it showed negative significance with BO percentage. Previous research by Bhargava et al. (2021), Abhilash et al. (2018), and Seneega et al. (2019) found a significant positive correlation between the number of productive tillers and plant yield.

The trait PL showed positive and significant relationship with KL (0.3196**), TW (0.3399**) and HL percentage (0.2242*). Negatively significant association between PL and BO percentage (-0.2674*). According to Bhargava et al. (2021) and Bhadru et al. (2012) found a significant positive correlation between the number of grains panicle^{-1} and the plant yield.

NGPP exhibited a positively significant phenotypic correlation with TW and ML percentage (0.3477**), hence it can be considered as significant component for realizing good yields andit showed negatively significant correlation with kernel length (-0.2283*), and kernel breadth (-0.4613**). Similar results were reported by Snehi et al. (2022) for days toflowering (0.20*), plant height (0.21*), unfilled grain panicle^{-1} (0.41**), filled grain panicle^{-1} (0.74**) and Bhargava et al. (2021) for plant yield, length of panicle and fertility of spikelet.

For the development of new rice cultivars with the greater

Table 2: Phenotypic (P) and Genotypic (G) correlation coefficients of yield and quality traits in rice (*Oryza sativa* L.)

Traits		DF	DM	PTH	No. TPP	PL	No. GPP	KL	KB
DF	G	1.00	0.85	0.30	0.17	0.21	0.19	0.08	-0.04
	P	1.00	0.8451**	0.2951**	0.16	0.19	0.19	0.08	-0.03
DM	G		1.00	0.12	0.10	0.01	0.19	-0.04	0.01
	P		1.00	0.12	0.10	0.00	0.18	-0.04	0.02
PTH	G			1.00	0.28	0.45	-0.02	0.24	0.30
	P			1.00	0.2653*	0.4355**	0.02	0.2368*	0.2858*
No. TPP	G				1.00	0.36	0.10	0.18	-0.18
	P				1.00	0.3123**	0.09	0.18	-0.17
PL	G					1.00	-0.07	0.35	-0.03
	P					1.00	-0.07	0.3196**	-0.03
No. GPP	G						1.00	-0.24	-0.49
	P						1.00	-0.2283*	-0.4613**
KL	G							1.00	0.06
	P							1.00	0.06
KB	G								1.00
	P								1.00

Table 2: Continue...

Traits		L/B	1000 GW	HUL	MIL	HRR	B O	GYP
DF	G	0.07	-0.15	0.15	-0.28	-0.06	-0.07	0.18
	P	0.07	-0.14	0.14	-0.2684*	-0.06	-0.07	0.17
DM	G	-0.03	-0.16	0.09	-0.17	-0.07	-0.03	0.12
	P	-0.03	-0.16	0.08	-0.16	-0.06	-0.02	0.12
PTH	G	-0.02	0.08	-0.08	-0.15	0.28	0.37	0.24
	P	-0.03	0.09	-0.08	-0.15	0.2688*	0.3572**	0.24
No. TPP	G	0.21	0.04	0.42	0.29	-0.09	-0.27	0.9649**
	P	0.20	0.03	0.3931**	0.2932**	-0.08	-0.2464*	0.9191**
PL	G	0.19	0.36	0.23	0.10	-0.07	-0.33	0.3384**
	P	0.17	0.3339**	0.2242*	0.08	-0.04	-0.2674*	0.3339**
No. GPP	G	0.16	-0.66	0.03	0.35	0.16	0.20	0.08
	P	0.16	0.6381**	0.03	0.3477**	0.15	0.19	0.08
KL	G	0.72	0.30	0.02	-0.07	-0.06	-0.05	0.14
	P	0.6960**	0.2897**	0.01	-0.07	-0.06	-0.06	0.13
KB	G	-0.63	0.63	-0.18	-0.41	0.07	0.22	-0.18
	P	-0.6542**	0.5686**	-0.18	-0.3827**	0.06	0.19	-0.15
L/B	G	1.00	-0.26	0.09	0.20	-0.06	-0.12	0.18
	P	1.00	-0.2352*	0.09	0.19	-0.06	-0.10	0.15
1000 GW	G		1.00	0.03	-0.15	-0.27	-0.33	0.03
	P		1.00	0.03	-0.16	-0.2573*	-0.3022**	0.03

Table 2: Continue...

Traits		L/B	1000 GW	HUL	MIL	HRR	BO	GYP
HUL	G			1.00	0.11	-0.44	-0.12	0.2873**
	P			1.00	0.10	-0.4062**	-0.10	0.27
MIL	G				1.00	0.02	-0.09	0.3254**
	P				1.00	0.01	-0.09	0.3214**
HRR	G					1.00	0.32	0.00
	P					1.00	0.3042**	0.00
B O	G						1.00	-0.2867**
	P						1.00	-0.2787**

*p=0.05; **: p=0.05; DF: Days to 50% flowering; DM: Days to maturity; PTH: Plant height (cm); No. TPP: Number of tillers plant^{-1}; PL: Panicle length (cm); No.GPP: Number of grains panicle^{-1}; KL: Kernel length (mm); KB: Kernel breadth (mm); L/B: L/B Ratio; 1000 GW: 1000-grain weight; HUL: Hulling %; MIL: Milling %; HRR: Head rice recovery %; BO: Bran oil % GYP: Grain yield plant^{-1} (g)

genetic potential to increase grain yield is the ultimate objective by implementing continuous selection, improving, maintaining, and enhancing other related grain yield components. This shows that the enhancement of these traits may be the cause of the eventual rise in yield. Nayak (2008) and Seneega et al. (2009). Our results suggest that NTPP, PL, ML Percentage and HL percentage are important yield-related traits and could be considered as selection criteria to increase rice grain yield.

3.2. *Attributes direct and indirect effect on plant yield*

Path coefficient analysis divides the correlations for a lucid of the cause-and-effect relationship; correlation only assesses the relationship between two variables. Path coefficient analysis employs other attributes to describe the direct and indirect causes of association (Wright, 1921). The path coefficient analysis estimates for yield and its related traits are shown in (Table 3 and Figure 1).

The trait DFF (0.1736) showed direct positive effect on GYPP. The association was the positive indirect effect of contributed through NTPP (0.1518), PL (0.0236), L/B ratio (0.0088), TW (0.0074) and BO percentage (0.0017). The trait PH showed negative direct effect on GYPP (-0.0980). The association was negative indirect effect of contributed through the traits KL, L/B, TW, ML percentage and BO percentage. The trait NTPP (0.9439) showed positive direct effect on GYPP. The association had positive indirect effect contributed through DFF (0.0134), PL (0.0381) L/B ratio (0.0264), ML percentage (0.0272) and BO percentage (0.0066).The trait PL (0.1222) showed positive direct effect on grain yield plant^{-1}. The association was positive indirect contributed through DFF (0.0160), NTPP (0.2947), NGPP (0.0043), ML percentage (0.0070), L/B ratio (0.0222), and BO percentage (0.0072). The trait NGPP (-0.0628) negative direct effect on grain yield plant^{-1}. The association was indirect effect contributed through PL (-0.01), KB (-0.08) and BO percentage (-0.01). The trait KL (-0.1482) negative direct effect on grain yield plant^{-1}. The association was negative indirect effect contributed through PH, TW and ML percentage. KB (0.1222) showed positive direct effect on grain yield plant^{-1}. The association was positive indirect contributed through the NGPP, KL and HRR. This trait L/B ratio (0.1313) showed

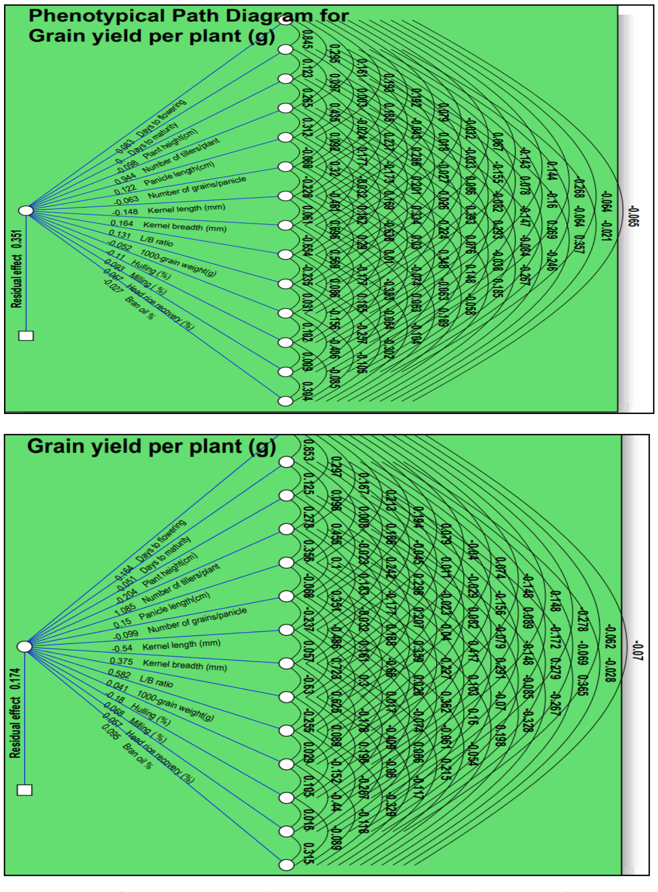

Figure 1: Genotypic and Phenotypic path diagram for grain yield and yield attributes

direct positive phenotypic effect on grain yield plant^{-1}. The association was positive indirect contributed through DFF (0.0056), DM (0.000), PH (0.0026), NTPP (0.1900), PL (0.0206), TW (0.0122), ML percentage (0.0172) and BO percentage (0.0028). The trait 1000-Grain Weight (g) reported direct negative phenotypic effect on grain yield plant^{-1} (-0.0519). The association was negative indirect effect contributed through DFF, PH, KL, L/B, KL, ML and HRR. The trait HL percentage showed direct negative phenotypic effect on grain yield plant^{-1} (-0.1101). The association was negative indirect effect contributed through KB, TW and HRR. The character ML percentage had direct positive phenotypic effect on grain yield plant^{-1} (0.0928), the association was positive indirect contributed through TW (0.0081), L/B ratio (0.0243), KL (0.0109), PL (0.0093), NTPP (0.2768), PH (0.0144), DM (0.0001), HRR (0.0006) and BO percentage (0.0023). The trait HRR percentage had direct positive phenotypic effect on grain yield plant^{-1} (0.0672), The association was positive indirect effect contributed through ML percentage (0.0008), HL percentage (0.0447), TW (0.0133), KB (0.0104), KL (0.0093), DM (0.0000). The trait BO percentage had direct negative phenotypic effect on grain yield plant^{-1} (-0.0269). The association was negative indirect effect contributed through DFF (-0.0054), PH (-0.0350), NTPP (-0.2326), PL (-0.0327), NGPP (-0.116), L/B ratio (-0.0137) and ML percentage.

Table 3: Phenotypic (P) and Genotypic (G) path coefficients of yield and quality traits in rice (*Oryza sativa* L.)

Character		DF	DM	PTH	No.TPP	PL	No.GPP	KL	KB	L/B
DFF	G	0.1639	-0.0438	-0.0606	0.1807	0.0319	-0.0191	-0.0426	-0.0151	0.0432
	P	0.0834	-0.0003	-0.0289	0.1518	0.0236	-0.0121	-0.0117	-0.0052	0.0088
DM	G	0.1398	-0.0514	-0.0254	0.1068	0.0011	-0.0184	0.0243	0.0042	-0.0167
	P	0.0704	-0.0004	-0.0121	0.0912	0.0003	-0.0116	0.0063	0.0029	-0.0043
PTH	G	0.0487	-0.0064	-0.2039	0.3010	0.0682	0.0023	-0.1309	0.1120	-0.0134
	P	0.0246	0.0000	-0.0980	0.2505	0.0532	0.0015	-0.0351	0.0468	-0.0035
No.TPP	G	0.0273	-0.0051	-0.0566	1.0847	0.0534	-0.0098	-0.0992	-0.0664	0.1203
	P	0.0134	0.0000	-0.0260	0.9439	0.0381	-0.0058	-0.0262	-0.0283	0.0264
PL	G	0.0349	-0.0004	-0.0927	0.3863	0.1500	0.0067	-0.1897	-0.0121	0.1095
	P	0.0161	0.0000	-0.0427	0.2947	0.1222	0.0043	-0.0474	-0.0052	0.0222
No.GPP	G	0.0318	-0.0096	0.0047	0.1080	-0.0102	-0.0987	0.1280	-0.1825	0.0937
	P	0.0160	-0.0001	0.0023	0.0867	-0.0084	-0.0628	0.0338	-0.0755	0.0213
KL	G	0.0129	0.0023	-0.0494	0.1990	0.0526	0.0234	-0.5405	0.0215	0.4207
	P	0.0066	0.0000	-0.0232	0.1672	0.0390	0.0143	-0.1482	0.0099	0.0914
KB	G	-0.0066	-0.0006	-0.0609	-0.1920	-0.0048	0.0480	-0.0310	0.3752	-0.3663
	P	-0.0026	0.0000	-0.0280	-0.1631	-0.0039	0.0290	-0.0090	0.1636	-0.0859
L/B	G	0.0122	0.0015	0.0047	0.2243	0.0282	-0.0159	-0.3909	-0.2362	0.5818
	P	0.0056	0.0000	0.0026	0.1900	0.0206	-0.0102	-0.1031	-0.1070	0.1313
1000 GW	G	-0.0243	0.0080	-0.0168	0.0430	0.0538	0.0652	-0.1619	0.2345	-0.1486
	P	-0.0119	0.0001	-0.0084	0.0245	0.0408	0.0401	-0.0429	0.0930	-0.0309
HUL	G	0.0242	-0.0046	0.0162	0.4524	0.0340	-0.0028	-0.0089	-0.0669	0.0516
	P	0.0120	0.0000	0.0080	0.3710	0.0274	-0.0019	-0.0015	-0.0290	0.0113
MIL	G	-0.0455	0.0088	0.0303	0.3152	0.0154	-0.0348	0.0402	-0.1535	0.1139
	P	-0.0224	0.0001	0.0144	0.2768	0.0093	-0.0218	0.0109	-0.0626	0.0243
HRR	G	-0.0101	0.0035	-0.0570	-0.0922	-0.0105	-0.0158	0.0330	0.0246	-0.0349
	P	-0.0053	0.0000	-0.0263	-0.0797	-0.0047	-0.0093	0.0093	0.0104	-0.0084
B O	G	-0.0115	0.0014	-0.0745	-0.2892	-0.0493	-0.0195	0.0291	0.0808	-0.0682
	P	-0.0054	0.0000	-0.0350	-0.2326	-0.0327	-0.0116	0.0086	0.0308	-0.0137

Table 3: Continue...

Character		1000 GW	HUL	MIL	HRR	BO	GYP
DFF	G	-0.0062	-0.0266	-0.0189	-0.0035	-0.0066	0.1767
	P	0.0074	-0.0158	-0.0249	-0.0043	0.0017	0.1736
DM	G	-0.0065	-0.0160	-0.0117	-0.0039	-0.0026	0.1237
	P	0.0081	-0.0086	-0.0146	-0.0043	0.0006	0.1238
PTH	G	0.0034	0.0143	-0.0101	0.0159	0.0346	0.2357
	P	-0.0045	0.0090	-0.0136	0.0181	-0.0096	0.2393
No.TPP	G	0.0016	-0.0751	0.0198	-0.0048	-0.0252	0.9649**
	P	-0.0013	-0.0433	0.0272	-0.0057	0.0066	0.9191**
PL	G	0.0149	-0.0408	0.0070	-0.0040	-0.0311	0.3384**
	P	-0.0173	-0.0247	0.0070	-0.0026	0.0072	0.3339**
No.GPP	G	-0.0274	-0.0051	0.0240	0.0091	0.0187	0.0845
	P	0.0331	-0.0033	0.0323	0.0099	-0.0050	0.0805
KL	G	0.0124	-0.0030	-0.0051	-0.0035	-0.0051	0.1385
	P	-0.0150	-0.0011	-0.0068	-0.0042	0.0016	0.1314
KB	G	0.0259	0.0321	-0.0279	0.0037	0.0204	-0.1847
	P	-0.0295	0.0195	-0.0355	0.0043	-0.0051	-0.1462
L/B	G	-0.0106	-0.0160	0.0133	-0.0034	-0.0111	0.1819
	P	0.0122	-0.0095	0.0172	-0.0043	0.0028	0.1481
1000 GW	G	0.0415	-0.0053	-0.0103	-0.0552	-0.0311	0.0324
	P	-0.0519	-0.0034	-0.0145	-0.0173	0.0081	0.0254
HUL	G	0.0012	-0.1801	0.0072	-0.0250	-0.0112	0.2873**
	P	-0.0016	-0.1101	0.0095	-0.0273	0.0028	0.2707
MIL	G	-0.0063	-0.0190	0.0681	0.0009	-0.0084	0.3254**
	P	0.0081	-0.0112	0.0928	0.0006	0.0023	0.3214**
HRR	G	-0.0111	0.0792	0.0011	0.0568	0.0299	-0.0035
	P	0.0133	0.0447	0.0008	0.0672	-0.0082	0.0040
B O	G	-0.0136	0.0213	-0.0061	0.0179	0.0947	-0.2867**
	P	0.0157	0.0115	-0.0079	0.0204	-0.0269	-0.2787**

Genotypic Residual effect: 0.1739; Phenotypic Residual effect: 0.3510; Bold values are direct effects; DF: Days to 50% flowering; DM: Days to maturity; PTH: Plant height (cm); No.TPP: No. of tillers plant^{-1}; PL: Panicle length (cm); No.GPP: Number of grains panicle^{-1}, KL: Kernel length (mm); KB: Kernel breadth (mm), L/B: L/B Ratio, 1000 GW: 1000-grain weight; HUL: Hulling %; MIL: Milling %; HRR: Head rice recovery %; BO: Bran oil % GYP: Grain yield plant^{-1} (g)

Table 3 depicts the path coefficient analysis estimates for yield and its related traits. NTPP (0.9439) exerted maximum positive direct effect on plant yield followed by KB, LB, PL, ML, DF and HRR indicates yield improvement is directly associated with these traits. Similar results of direct positive effect on plant yield were reported by Bhargava et al. (2021), Rajasekar et al. (2021), Nandeshwar et al. (2010) and Kalaiselvan et al. (2019).

Negative direct effects on plant yield were observed by DM, PH, NGPP, KL, TW, HL percentage, and BO percentage in contrast to positive direct effects. Similar results were also reported by Rajasekar et al. (2021) for plant height, Gawal et al. (2006), Jayasudha and Sharma (2010), Hossain et al. (2020) and Devi et al. (2022) for panicle length, test weight, panicle density, days to 50% flowering, hulling, percent and filled grains panicle^{-1} expressed negative direct effect on grain yield plant. The trait NTPP showed highest positive direct effect among all the yield traits. Thus, it can be regarded as a key factor in plant yield.

4. CONCLUSION

The characters, NTPP (0.9191**), PL (0.3339**), ML percentage (0.3214**) and HL percentage (0.2873**) were found significantly positive and NTPP (0.9439) exerted maximum positive direct effect on plant yield followed by KB, L/B, PL, ML percentage, DFF and HRR percentage.

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