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ASSOCIATION ANALYSIS OF GRAIN YIELD AND YIELD-ATTRIBUTING TRAITS IN RICE (*Oryza sativa* L.) GERMPLASM ACCESSIONS

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ABSTRACT

The present investigation was undertaken to assess the association among grain yield and its component traits and to identify the traits contributing directly and indirectly to grain yield in rice (*Oryza sativa* L.). The study was conducted at the Research cum Instructional Farm, College of Agriculture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh during Kharif 2020 using fifty rice germplasm accessions along with seven check varieties in a randomized block design with two replications. Observations were recorded on seventeen yield and yield-attributing traits, and correlation and path coefficient analyses were performed. Grain yield per plant exhibited significant positive correlation with biological yield per plant, paddy length, brown rice length/width ratio, paddy length/width ratio and harvest index, while significant negative correlation was observed with effective tillers per plant and brown rice width. Genotypic correlation coefficients were generally higher than phenotypic correlation coefficients, indicating a strong genetic association among the traits. Path coefficient analysis revealed that biological yield per plant exerted the highest positive direct effect on grain yield, followed by spikelet fertility percentage, number of unfilled grains per panicle, harvest index, paddy length/width ratio, paddy width and brown rice length. The findings indicated that biological yield per plant, spikelet fertility percentage, harvest index and grain-related traits could be considered important attributes in selection for improving grain yield in rice germplasm. The identified associations may assist in formulating effective selection strategies for genetic improvement of rice.

***Key words*:** Rice, germplasm accessions, grain yield, character association, correlation coefficient, path coefficient analysis, yield components, selection.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops worldwide and serves as a major source of dietary energy for a large proportion of the human population, particularly in tropical and subtropical regions. Grain yield is a complex quantitative trait governed by several component characters and their interactions. Therefore, understanding the relationships among yield and its contributing traits is essential for formulating effective selection strategies in rice improvement programmes (Parimala *et al*., 2020; Nirmodh *et al*., 2009). Patterns of character association and trait architecture are pivotal across diverse crop species to dissect yield relationships, as demonstrated in crops such as basil (Sahu *et al*., 2008), oat (Sahu and Tiwari, 2019), cowpea (Sahu, 2021), pigeonpea (Jatav *et al*., 2023; Gupta and Sahu, 2025; Sahu *et al*., 2025) and Indian mustard (Sahu *et al*., 2026).

Association analysis is a technique used to evaluate the association of both morphological characters and genetic variability, further referred to as association mapping or association disequilibrium. Grain yield is a complex character and is correlated with a number of yield components which are correlated to each other. Information on character association and how each trait significantly affects yield provides an added advantage in the selection process. Correlation describes the degree to which yield and its attributes are associated, allowing

for a clear interpretation of their relationship with grain yield. As a result of this analysis, the breeder will be able to prepare preference strategies to improve grain yield (Babu *et al*., 2012). Using path coefficient analysis, knowledge is gained by partitioning the correlation coefficients into direct and indirect effects (Dewey and Lu, 1959; Kumar *et al*., 2014).

In view of the importance of trait associations in improving grain yield, the present study was undertaken to assess the correlation among yield and its component traits and the direct and indirect effects (path analysis) of these traits on grain yield in rice accessions.

Material and Methods

The recent research study was conducted at Research cum Instructional farm, College of Agriculture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh during *Kharif*, 2020. The experimental materials consisted of fifty rice germplasm accessions along with seven checks, namely Dagad Desi, RRF-127, RRF-140, DRR Dhan-42, MTU-1010, Annada and Swarna were used as biological material. These fifty germplasm accessions were selected randomly from five hundred germplasm accession from DBT, New Delhi. The experiment was laid out in a Randomized Block Design with two replications during *Kharif* 2020. The plant materials raised bed nursery was sown on last week of June 2021.

In randomized block design twenty-three days old seedlings were transplanted into the field. The experimental materials were transplanted in two replications and individual replication consisted of fifty-seven genotypes. Each entry was transferred in two rows where row to row spacing was 20 cm and plant to plant spacing was 15 cm. Check varieties were randomized within block. All recommended package of practices were adopted throughout the crop growth period and need based plant protection measures were taken up to raise a healthy crop. Observations were recorded on five randomly selected plants for seventeen yield and yield attributing characters.

Statistical Analysis

Correlation analysis was done to determine relationships among traits using correlation coefficients calculated by using the formula given by Miller *et al*., 1958 and tested with t-test (Fisher and Yates, 1967). Path analysis was done by partitioning correlation into direct and indirect effects to identify key traits influencing grain yield (Dewey and Lu, 1959). Data analysis for path and correlation analysis was conducted by using OPSTAT.

Table 1: List of germplasm accessions included in the experiment.

S. No.	Accession No.	S. No.	Accession No.
1.	IC-386140	26.	IC-463986
2.	IC-216827	27.	IC-283005
3.	IC-121886	28.	IC-126331
4.	IC-461904	29.	IC-518800
5.	IC-217358	30.	IC-458608
6.	IC-206758	31.	IC-125755
7.	IC-516693	32.	IC-386358
8.	IC-458657X	33.	IC-458005
9.	IC-449598	34.	IC-459489
10.	IC-203364	35.	IC-514384
11.	IC-217772	36.	IC-377829
12.	IC-463062	37.	IC-115641
13.	IC-218829	38.	IC-459795
14.	IC-126210	39.	IC-378183
15.	IC-126468	40.	IC-218729
16.	IC-114501	41.	IC-206352
17.	IC-115726	42.	IC-300416
18.	IC-377660	43.	IC-74800X
19.	IC-378252	44.	IC-133944
20	IC-378553	45.	IC-114573
21	IC216830	46.	IC205951
22	IC134905	47.	IC514243
23	IC593995	48.	IC517398
24	IC378408	49.	IC378032
25	IC458406X	50.	IC207460

Result and Discussion

Correlation analysis provides an overview of relationships between characters to determine component traits requiring emphasis when selecting for genetic enhancement in grain yield. Analysis of correlation coefficients assesses reciprocal relationships between traits to guide genetic selection for yield and quality. Knowing the association pattern between yield and component traits is vital for successful selection (Nirmodh *et al*., 2009; Sahu and Sahu, 2017).

Days to 50% flowering (DTF)

Days to 50% flowering showed positive significant genotypic correlation with filled grains per panicle, consistent with Babu *et al*., (2012). It exhibited negative significant correlation with number of effective tillers per plant, 100 seed weight, brown rice width and paddy width. Similar trend associations were observed in potato (Singh *et al*., 2015).

Plant height (PH)

Plant height exhibited positive significant correlation with number of filled grains per panicle, panicle length (Babu *et al*., 2012), and number of unfilled grains per

Table 2: Yield and its attributing traits recorded.

S. No.	Yield Attributing Traits
1.	Days to 50% flowering
2.	Plant height (cm)
3.	Panicle length (cm)
4.	Number of effective tillers per plant
5.	Number of filled grains/panicle
6.	Number of unfilled grains per panicle
7.	Spikelet fertility percentage (%)
8.	Biological yield per plant(g)
9.	Harvest index (%)
10.	100 seed weight (g)
11.	Paddy length (mm)
12.	Paddy width (mm)
13.	Paddy length/width ratio
14.	Brown rice length (mm)
15.	Brown rice width (mm)
16.	Brown rice length/width ratio
17.	Grain yield per plant (g)

panicle. Conversely, negative significant correlation was recorded with effective tillers per plant and harvest index. These findings confirm those of Parimala *et al*., (2020) for panicle length and effective tillers per plant, Das (2015) for filled grains per panicle and harvest index, and Jogi *et al*., (2009) in crop morphology studies.

Panicle length (PL)

Panicle length exhibited positive significant correlation with number of unfilled grains per panicle and number of filled grains per panicle. Negative significant correlation was recorded with 100 seed weight, spikelet fertility percentage and number of effective tillers per plant. Present results align with Singh and Pandey (2012) and Upadhyay *et al.*, (2012) for spikelet fertility percentage and effective tillers.

Number of effective tillers per plant (ETPP)

Number of effective tillers per plant exhibited positive significant correlation with 100 seed weight and negative significant correlation with number of filled grains per panicle and unfilled grains per panicle. These results agree with Mishra *et al*., (2025).

Number of filled grains per panicle (FGPP)

Filled grains per panicle showed significant positive correlation with spikelet fertility percentage, biological yield per plant, and unfilled grains per panicle. Significant negative correlations were observed with 100 seed weight, harvest index and paddy width, conforming with Kumar *et al*., (2016) and Jatav *et al.*, (2023).

Number of unfilled grains per panicle (UFGPP)

Unfilled grains per panicle exhibited strong negative

Table 3: Promising genotypes on the basis of their mean performances of yield characters and superior grain quality.

S. No.	Characters	Promising Genotypes
1	High grain yield with high panicle length	IC-218829, IC-126210 and IC- 115726
2	High grain yield with high 100 seed weight	IC-218829 , IC- 518800, IC-57398, IC121886
3	High brown rice length with high grain yield	IC-121886 and IC-518800

significant correlation with spikelet fertility percentage. Similar findings were reported by Chamar *et al*., (2020) and Kujur and Sahu (2019).

Biological yield per plant (BYPP)

Biological yield per plant showed negative significant correlation with harvest index.

Harvest index (HI)

Harvest index showed strong positive significant correlation with brown rice length, brown rice length/ width ratio and paddy length, while showing positive association with 100 seed weight, as noted by Abede *et al*., (2017).

100 seed weight (100SW)

100 seed weight showed positive significant correlation with brown rice length, paddy length, paddy width and brown rice length/width ratio, confirming Sala and Geetha (2015) and Priya *et al*., (2017).

Grain quality attributes (PaddyL, PW, PL/W, BRL, BRW, BRL/W)

Paddy length exhibited highest positive correlation with brown rice length, paddy length/width ratio and brown rice length/width ratio. Paddy width correlated positively with brown rice width and negatively with paddy length/ width ratio and brown rice length/width ratio (Priya *et al.*, 2017). Brown rice width correlated negatively with brown rice length/width ratio (Das, 2015).

Grain yield per plant (GYPP)

Grain yield per plant exhibited highest positive significant correlation with biological yield per plant, followed by paddy length, brown rice length/width ratio, paddy length/width ratio and harvest index. Negative significant correlation was observed with brown rice width and number of effective tillers per plant. Genotypic correlation coefficients were consistently higher than phenotypic values, indicating strong intrinsic genetic associations. Positive yield correlations with biological yield and harvest index align with findings by Dhurai *et al.*, (2014, 2016), Abede *et al*., (2017), Bhor *et al.*, (2020),

Nandedkar *et al*., (2020), Chamar *et al*., (2021), Gupta and Sahu (2025), and Sahu *et al.*, (2025).

Path coefficient analysis

Path coefficient analysis was carried out using genotypic correlation coefficients with grain yield per plant as the dependent variable to partition correlation into direct and indirect effects.

Direct effects

The highest positive direct effect on grain yield per plant was exhibited by biological yield per plant, followed by spikelet fertility percentage, number of unfilled grains per panicle, harvest index, paddy length/width ratio, paddy width, and brown rice length. These results suggest that direct selection based on these traits will be effective for yield enhancement, agreeing with Katkani *et al*., (2019) and Katiyar *et al.*, (2019) for biological yield per plant; Bhor *et al*., (2020) for spikelet fertility percentage; Dhurai *et al*., (2014, 2016), Bagudam *et al*., (2018), and Katkani *et al.*, (2019) for harvest index and grain dimensions; and Sahu (2019) regarding direct selection pathways. Negative direct effects on grain yield were recorded for number of filled grains per panicle, brown rice width, paddy length, brown rice length/width ratio, effective tillers per plant, plant height, panicle length, and days to 50% flowering, conforming with Dhurai *et al*., (2016) and Katiyar *et al*., (2019).

Indirect effects

- **Days to 50% flowering (DTF):**

Contributed indirectly to yield via biological yield per plant, unfilled grains per panicle, paddy length/width ratio, brown rice width, spikelet fertility percentage, and effective tillers per plant. Negative indirect contributions occurred via filled grains per panicle, brown rice length/ width ratio, harvest index, and plant height (Sala and Geetha, 2015; Dhurai *et al*., 2014).

- **Plant height (PH):**

Positive indirect effects occurred through unfilled grains per panicle, biological yield per plant, brown rice length/width ratio (Priya *et al*., 2017), paddy length, effective tillers per plant, and paddy width. Negative indirect effects occurred via filled grains per panicle, harvest index (Mamun *et al*., 2012; Bagudam *et al*., 2018), paddy length/width ratio, brown rice length, and brown rice width.

- **Panicle length (PL)**

Showed positive indirect contribution through unfilled grains per panicle, biological yield per plant, paddy length, and effective tillers per plant (Srivastava *et al*., 2014; Bhor *et al*., 2020; Parimala *et al*., 2020). Negative indirect contributions were noted via spikelet fertility percentage, filled grains per panicle, harvest index (Das, 2015), paddy width, and brown rice length.

- **Number of effective tillers per plant (ETPP):**

Exerted positive indirect effects through filled grains per panicle, plant height, spikelet fertility percentage, and brown rice width. Negative indirect contributions occurred via biological yield per plant, unfilled grains per panicle, harvest index, and paddy length/width ratio.

- **Number of filled grains per panicle (FGPP):**

Showed positive indirect contribution through spikelet fertility percentage, biological yield per plant (Katiyar *et al.*, 2019), unfilled grains per panicle, brown rice width, paddy length/width ratio, effective tillers per plant, and paddy length. Strong negative indirect effects occurred via harvest index, paddy width, plant height, and brown rice length.

- **Number of unfilled grains per panicle (UFGPP):**

Indirectly enhanced yield *via* biological yield per plant (Parimala *et al*., 2020), paddy length/width ratio (Dhurai *et al*., 2016), brown rice width, and effective tillers per plant. High negative indirect effects occurred *via* spikelet fertility percentage, filled grains per panicle, harvest index, paddy width, paddy length, plant height, and brown rice length/width ratio.

- **Spikelet fertility percentage (SFP):**

Exhibited positive indirect contribution via paddy length, plant height, and brown rice length/width ratio. Negative indirect effects were recorded via unfilled grains per panicle, filled grains per panicle, harvest index, paddy length/width ratio, biological yield per plant, paddy width, and brown rice length.

- **Biological yield per plant (BYPP):**

Indirectly influenced grain yield through unfilled grains per panicle, paddy length/width ratio, brown rice width, and effective tillers per plant (Sala and Geetha, 2015). Negative indirect contributions occurred through filled grains per panicle, harvest index, paddy width, paddy length, brown rice length/width ratio, and spikelet fertility percentage.

- **Harvest index (HI):**

Contributed positively through filled grains per panicle (Chamar *et al.*, 2021), brown rice length, paddy length/ width ratio, paddy width, brown rice width, and plant height. Negative indirect effects occurred via biological yield per plant, paddy length, brown rice length/width ratio,

Table 4: Correlation coefficient analysis of yield traits in fifty-seven genotypes of rice.

		DTF	PH	PL	ETPP	FGPP	UFGPP	SFP	BYPP	HI	100SW	PL	PW	PL/W	BRL	BRW	BRL/W
DTF	G																
	P																
PH	G	0.160															
	P	0.145															
PL	G	-0.048	0.409**														
	P	-0.039	0.371**														
ETPP	G	-0.377**	-0.391**	-0.199*													
	P	-0.256**	-0.325**	-0.190*													
FGPP	G	0.383**	0.434**	0.184*	-0.338**												
	P	0.325**	0.382**	-0.171	-0.190*												
UFGPP	G	0.139	0.312**	0.450**	-0.239*	0.185*											
	P	0.138	0.265**	0.060	-0.171	0.112											
SFP	G	0.066	-0.058	-0.285**	0.037	0.354**	-0.843**										
	P	0.033	-0.043	-0.096	0.060	0.408**	-0.842										
BYPP	G	0.110	0.042	0.081	-0.155	0.219*	0.137	-0.018									
	P	0.089	0.048	0.186*	-0.096	0.185*	0.132	-0.035									
HI	G	-0.060	-0.378**	-0.162	-0.078	-0.498**	-0.098	-0.102	-0.281**								
	P	-0.014	-0.319**	-0.030	-0.017	-0.313**	-0.083	-0.026	-0.254**								
100SW	G	-0.259**	-0.091	-0.311**	0.239*	-0.540**	-0.122	-0.180	-0.077	0.429**							
	P	-0.226*	-0.093	0.019	0.186*	-0.457**	-0.108	-0.128	-0.044	0.291**							
PL	G	0.041	-0.126	-0.078	-0.037	-0.107	0.099	-0.145	0.096	0.379**	0.391**						
	P	0.038	-0.123	-0.030	-0.030	-0.098	0.094	-0.126	0.092	0.315**	0.349**						
PW	G	-0.199*	0.088	-0.089	0.019	-0.248**	-0.116	-0.054	-0.164	0.131	0.383**	-0.104					
	P	-0.197*	0.090	0.019	0.019	-0.223*	-0.099	-0.048	-0.145	0.093	0.343**	-0.101					
PL/W	G	0.144	-0.128	0.017	-0.033	0.087	0.157	-0.078	0.179	0.143	-0.008	0.722**	-0.756**				
	P	0.143	-0.129	-0.032	-0.032	0.077	0.141	-0.067	0.162	0.129	-0.008	0.719**	-0.757**				
BRL	G	0.049	-0.142	-0.066	-0.011	-0.130	-0.017	-0.016	-0.047	0.444**	0.392**	0.758**	-0.107	0.555**			
	P	0.044	-0.136	-0.006	-0.006	-0.113	-0.016	-0.011	-0.041	0.375**	0.355**	0.754**	-0.104	0.549**			
BRW	G	-0.234*	0.081	-0.039	-0.094	-0.153	-0.071	-0.032	-0.162	-0.132	0.188*	-0.199*	0.776**	-0.669**	-0.111		
	P	-0.210*	0.072	-0.013	-0.013	-0.126	-0.053	-0.033	-0.134	-0.116	0.164	-0.195*	0.745**	-0.648**	-0.105		
BRL/W	G	0.164	-0.159	-0.026	0.036	-0.002	0.071	-0.030	0.062	0.393**	0.139	0.648**	-0.586**	0.289**	0.746**	-0.730**	
	P	0.151	-0.149	-0.011	-0.011	-0.007	0.057	-0.021	0.049	0.333**	0.126	0.639**	0.570**	0.813**	0.735**	-0.376**	
GYPP	G	0.075	-0.164	0.015	-0.196*	-0.068	0.098	-0.094	0.850**	0.262**	0.146	0.295**	-0.110	0.266**	0.197	-0.245**	0.287**
	P	0.072	-0.138	-0.105	-0.105	-0.026	0.088	-0.066	0.833**	0.314	0.126	0.267	-0.102	0.241**	0.184	-0.206*	0.252**

Note- DTF= Days to 50% flowering, PH= Plant height (cm), PL= Panicle length (cm) , ETPP= No. of effective tillers per plant, FGPP= No. of filled grains per panicle, UFGPP= No. of unfilled grains per panicle, SFP= Spikelet fertility percentage, BYPP= Biological yield per plant (g), HI= Harvest index (%), 100SW= 100 seed weight (g), PaddyL= Paddy Length (mm), PW= Paddy width= (mm), PL/W= Paddy length/ width ratio, BRL= Brown rice length (mm), BRW= Brown rice width (mm), BRL/W= Brown rice length/width ratio, GYPP= Grain yield per plant. ("G= Genotypic, P= Phenotypic,**Significant at 1% level and *Significant at 5 % level of probability")

Table 5: Path coefficient analysis of yield and yield attributing traits.

	DTF	PH	PL	ETPP	FGPP	UFGPP	SFP	BYPP	HI	100SW	PL	PW	PL/W	BRL	BRW	BRL/W
DTF	**-0.0031**	-0.0105	0.000	0.0261	-0.1469	0.0838	0.0400	0.1063	-0.0242	-0.0022	-0.0089	-0.0609	0.0472	0.0084	0.0551	-0.0351
PH	-0.0005	**-0.0660**	0.0036	0.0270	-0.1663	0.1887	-0.0352	0.0410	-0.1515	-0.0007	0.0279	0.0269	-0.0419	-0.0246	-0.0191	0.0340
PL	0.0001	-0.0270	**-0.0089**	0.0137	-0.0706	0.2718	-0.1733	0.0778	-0.0649	-0.0027	0.0172	-0.0273	0.0056	-0.0114	0.0092	0.0055
ETPP	0.001	0.0258	0.0017	**-0.0692**	0.1294	-0.1447	0.0222	-0.1493	-0.0312	0.0020	0.0083	0.0058	-0.0108	-0.0018	0.0221	-0.0076
FGPP	-0.0012	-0.0286	-0.0016	0.0233	**-0.3835**	0.1117	0.2148	0.2114	-0.1997	-0.0047	0.0237	-0.0758	0.0286	-0.0225	0.0361	0.0004
UFGPP	-0.0004	-0.0206	-0.0040	0.0165	-0.0708	**0.6047**	-0.5120	0.1324	-0.0394	-0.0010	-0.0219	-0.0355	0.0514	-0.0030	0.0168	-0.0150
SFP	-0.0002	0.0038	0.0025	-0.0025	-0.1356	-0.5099	**0.6071**	-0.0177	-0.0410	-0.0015	0.0321	-0.0166	-0.0254	-0.0028	0.0076	0.0065
BYPP	-0.0003	-0.0028	-0.0007	0.0107	-0.0840	0.0830	-0.0111	**0.9651**	-0.1125	-0.0006	-0.0213	-0.0501	0.0584	-0.0081	0.0380	-0.0131
HI	0.0001	0.0249	0.0014	0.0054	0.1910	-0.0594	-0.0621	-0.2710	**0.4009**	0.0037	-0.0839	0.0400	0.0466	0.0770	0.0310	-0.0839
100SW	0.0008	0.0059	0.0027	-0.0165	0.2071	-0.0738	-0.1090	-0.0738	0.1720	**0.0087**	-0.0867	0.1172	-0.0027	0.0679	-0.0443	-0.0296
PL	-0.0001	0.0083	0.000	0.0025	0.0410	0.0598	-0.0879	0.0929	0.1519	0.0034	**-0.2215**	-0.0317	0.2363	0.1314	0.0468	-0.1386
PW	0.0006	-0.0058	0.000	-0.0013	0.0949	-0.0700	-0.033	-0.1581	0.0524	0.0033	0.0229	**0.3063**	-0.2472	-0.0184	-0.1828	0.1252
PL/W	-0.0004	0.0084	-0.0001	0.0022	-0.0335	0.0951	-0.0472	0.1724	0.0572	-0.0000	-0.1600	-0.2314	**0.3272**	0.0961	0.1577	-0.1772
BRL	-0.0001	0.0093	0.0005	0.0007	0.0499	-0.0104	-0.0098	-0.0455	0.1781	0.0034	-0.1679	-0.0326	0.1815	**0.1733**	0.0260	-0.1593
BRW	0.0007	-0.0053	0.0003	0.0065	0.0587	-0.0431	-0.0197	-0.1558	-0.0528	0.0016	0.0440	0.2377	-0.2190	-0.0191	**-0.2356**	0.1560
BRL/W	-0.0005	0.0105	0.0002	-0.0024	0.0007	0.0426	-0.0184	0.0595	0.1574	0.0012	-0.1436	-0.1794	0.2713	0.1292	0.1719	**-0.2137**

spikelet fertility percentage and unfilled grains per panicle.

- **100 seed weight (100SW):**

Indirectly benefited yield via filled grains per panicle, harvest index, paddy width, and brown rice length. Negative indirect effects occurred *via* spikelet fertility percentage, unfilled grains per panicle, biological yield per plant, brown rice width, and brown rice length/width ratio.

- **Paddy length (PL):**

Contributed positive indirect effects via paddy length/ width ratio, harvest index, brown rice length, biological yield per plant, unfilled grains per panicle, brown rice width, and filled grains per panicle. Direct negative indirect effects occurred through spikelet fertility percentage, paddy width and brown rice length/width ratio.

- **Paddy width (PW):**

Indirectly influenced yield via brown rice length/width ratio, filled grains per panicle, harvest index, and paddy length. Negative indirect contribution occurred through paddy length/width ratio, brown rice width, biological yield per plant, unfilled grains per panicle, spikelet fertility percentage and brown rice length.

- **Paddy length/width ratio (PL/W):**

Contributed positive indirect effects via biological yield per plant, brown rice width, brown rice length, unfilled grains per panicle, and harvest index. Negative indirect effects occurred via paddy width, brown rice length/width ratio, paddy length, spikelet fertility percentage and filled grains per panicle.

- **Brown rice length (BRL):**

Showed positive indirect contribution through paddy length/width ratio, harvest index, filled grains per panicle, and brown rice width. Negative indirect effects occurred through paddy length, brown rice length/width ratio, biological yield per plant and unfilled grains per panicle.

- **Brown rice width (BRW):**

Contributed positively through paddy width, brown rice length/width ratio, filled grains per panicle, and paddy length. Negative indirect effects occurred through paddy length/width ratio, biological yield per plant, harvest index, unfilled grains per panicle, spikelet fertility percentage and brown rice length.

- **Brown rice length/width ratio (BRL/W):**

Indirect contribution occurred via paddy length/width ratio, brown rice width, harvest index, brown rice length, biological yield per plant, and unfilled grains per panicle. Negative indirect effects occurred via paddy width, paddy length and spikelet fertility percentage.

Similar complex direct and indirect partitioning patterns in trait association studies have been reported across legumes and other crop systems (Upadhyay *et al*., 2012; Sahu and Sahu, 2017; Sahu and Tiwari, 2019; Kujur and Sahu, 2019; Jatav *et al*., 2023; Mishra *et al*., 2025; Sahu *et al*., 2026).

Conclusion

Results of correlation coefficient study was indicated that grain yield per plant has significant positive correlation with biological yield per plant followed by paddy length, brown rice length/width ratio, paddy length/width ratio and harvest index indicating strong association of these characters with grain yield per plant. Thus, selecting for these traits will be advantageous in terms of increasing grain yield and because there is a positive correlation between the traits, it will help in the simultaneous improved performance of both characters. Negative and significant correlation of grain yield was found with effective tillers per plant and brown rice length direct selection of which will produce undesirable results thus, breaking of these negative associations through appropriate crossing programme may be suggested for further genetic improvement in rice germplasm. On grain yield positive direct effect was exhibited by biological yield per plant followed by spikelet fertility percentage, unfilled grains per panicle, harvest index, paddy length/ width ratio, paddy width and brown rice length suggesting use of these traits for direct selection purpose.

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