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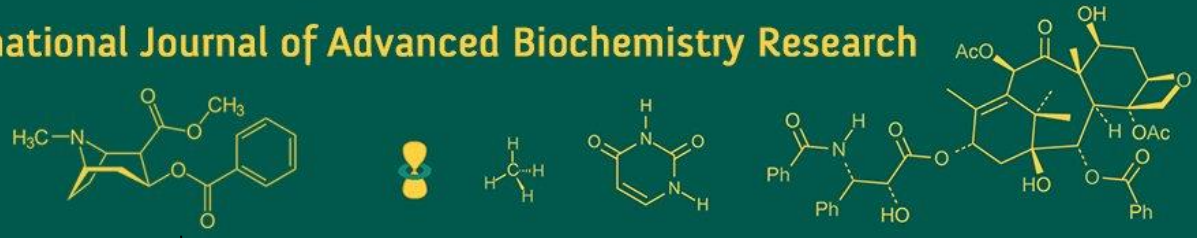

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Association studies for quality traits in advanced breeding lines of rice (*Oryza sativa* L.)

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Abstract
Fifty advanced breeding lines (ABLs) along with five checks were evaluated for quality traits by conducting an experiment during kharif, 2020. Nineteen quality traits data were recorded for performing correlation and path coefficient analysis studies by taking heading head rice recovery % as dependent character. As per correlation studies, head rice recovery % showed highest significant and positive correlation with milling% (0.726) followed by hulling% (0.610), gel consistency (0.404), elongation ratio (0.400), kernel L/B ratio (0.373), cooked rice L/B ratio (0.276) and brown rice L/B ratio (0.273). Highly significant positive correlation and highly significant negative correlation" of gel consistency was noted with alkali spreading value (0.371) and amylose% (-0.858) respectively. Highly significant and positive correlation was obtained between hulling% and milling% (0.715), elongation ratio (0.412), alkali spreading value (0.335) and gel consistency (0.256). As per path studies, brown rice L/B ratio showed highest positive direct effect (2.646) on head rice recovery % followed by cooked rice length (1.648), brown rice breadth (1.408), hulling%, paddy breadth (0.710), kernel breadth (0.378), elongation ratio (0.159) and kernel length (0.148). Rice breadth after cooking showed highest negative direct effect (-3.522) on %, followed by cooked rice L/B ratio (-2.598), brown rice length (-1.496), amylose% (-0.924), gel consistency (-0.543), alkali spreading value (-0.450), kernel L/B ratio (-0.262), paddy length (-0.133), paddy L/B ratio (-0.055) and milling % (-0.025).`

Keywords: Advanced breeding lines (ABLs), quality traits, correlation, path coefficient analysis

Introduction
Following China, India is the second leading rice producer and second leading consumer in the world (Statista, 2024), with 196 million metric tonnes production in the year 2022 and 118 million metric tonnes rice consumption in the year 2023/24 (Statista, 2024). As per the demand projections, by the year 2050, 197 million metric tonnes of rice would be required and if the area under rice remains the same as in 2018-19, then an increase by 1.83 t/ha is required to meet the 2050 rice demand. With the need to meet the global demand, improvement of rice grain quality has also become a priority for the producers and consumers. Being a complex trait, it reflects preference of producers, processing, sellers and consumers in relation to production, processing, marketing and consumption of the grain.

The need to improve rice quality is just as important as increasing yield. Breeding high-yielding rice cultivars with higher quality characteristics is therefore imperative at this time.

There are four quality trait parameters used widely: appearance, cooking quality, milling quality and nutritional value (Yu *et al*. 2008 and 2017) [13, 1]. The important concerns, broken rice yield and the ultimate yield, of both farmers and breeders is determined by milling quality. One of the most important characteristics attracting customers after milling is appearance of kernels. The ease of cooking and the stiffness and stickiness (both of which are linked to its eating qualities) of cooked rice are determined by the cooking quality. Being the most significant staple food in the world, its nutritional worth appeals to consumers as well. In the present study we have concentrated on nineteen quality traits which mainly determines milling, appearance and cooking quality of rice.

Materials and Methods
The current study was carried out in Kharif 2020 at the Quality Laboratory, Department of Genetics and Plant Breeding, RRL, IGKV, Raipur (C.G.), and at the Research Cum Instructional farm, Department of Genetics and Plant Breeding, College of Agriculture,

IGKV, Raipur (C.G.). The experimental material includes fifty advanced breeding lines of rice in addition to five checks, IGKV R1, IGKV R2, Karma Mahsuri, and IR 64. In Kharif 2020, the experiment was divided into two replications using a Randomized Block Design, with inter- and intra-row spacing kept at 20 × 20 cm.

Results and Discussion

Improvement of a desired characteristic can be done in a realistic breeding project by using indirect selection via other characters. This necessitates a thorough understanding of the relationships between the various characters and the target attribute, as well as between the many characters themselves. The degree of association of head rice recovery % with quality characters was determined using correlation analysis. Simple correlation, on the other hand, does not give enough information on how each trait contributes to yield. As a result, path coefficient analysis is performed for studying the direct and indirect impacts of various independent characters on the dependent character. Head rice recovery % was taken as dependent variable taking other quality characters as independent variables.

Correlation analysis

1. Head rice recovery %

Head rice recovery % showed highest significant and positive correlation with milling% (0.726) followed by hulling% (0.610), gel consistency (0.404), elongation ratio (0.400), kernel L/B ratio (0.373), cooked rice L/B ratio (0.276) and brown rice L/B ratio (0.273). This character showed moderately significant and positive correlation with alkali spreading value.

These results are in line with the findings done by Devi *et al.* (2017) [4] for milling%, hulling% and kernel breadth after cooking and Devi *et al.* (2019) [5] for kernel breadth and Khatun *et al.* (2003) [7] for gel consistency.

2. Hulling %

Highly significant and positive correlation was obtained between hulling% and milling% (0.715), elongation ratio (0.412), alkali spreading value (0.335) and gel consistency (0.256).

These results were similar to one found by Shivani *et al.* (2007) [11] for grain yield and milling%.

3. Milling %

Highly positive significant correlation was seen between milling% and elongation ratio (0.489), cooked rice L/B ratio and gel consistency (0.339) and moderately positive significant correlation with alkali spreading value (0.214).

Similar results were obtained by Devi *et al.* (2015) [3] for kernel breadth after cooking.

4. Paddy length (mm)

Highly positive significant correlation was recorded between paddy length and kernel length (0.872), brown rice length (0.790), kernel length after cooking (0.751), kernel L/B ratio (0.635), paddy L/B ratio (0.598), brown rice L/B ratio (0.550). Paddy length has moderately positive correlation with kernel breadth after cooking (0.218) and cooked rice L/B ratio.

5. Paddy breadth (mm)

Highly positive significant correlation of paddy breadth was recorded with kernel breadth after cooking (0.636), brown rice breadth (0.613), kernel breadth (0.505), alkali spreading value (0.326), elongation ratio (0.257) and kernel length after cooking (0.245).

6. Paddy L/B ratio

Highly positive significant correlation of paddy L/B ratio was obtained with brown rice L/B ratio (0.826), kernel L/B ratio (0.775), brown rice length (0.617), kernel length (0.574), cooked rice L/B ratio (0.474), kernel length after cooking (0.299) and was found moderately significant positive correlation with gel consistency (0.198).

These results are similar to the findings of Kawochar and Begum (2016) [6] for brown rice L/B ratio, kernel L/B ratio and cooked rice L/B ratio.

7. Brown rice length (mm)

Brown rice length was found to be highly significant and positively correlated with kernel length (0.858), kernel length after cooking (0.710), brown rice L/B ratio (0.581), kernel L/B ratio (0.460) and was found moderate significant positive correlation with amylose% (0.201) and cooked rice L/B ratio (0.196).

8. Brown rice breadth (mm)

Highest positive significant correlation of brown rice width was recorded with kernel breadth (0.941) followed with kernel breadth after cooking (0.554), amylose% (0.454), kernel breadth after cooking (0.334) and was found moderate significant positive correlation with kernel length (0.194).

9. Brown rice L/B ratio

Brown rice L/B ratio showed highly significant positive correlation with kernel L/B ratio (0.920), kernel length (0.481), cooked rice L/B ratio (0.371) and gel consistency (0.367). A moderate significant positive correlation was recorded between brown rice L/B ratio and kernel breadth after cooking (0.241).

10. Kernel length (mm)

Highly significant positive correlation of kernel length was obtained with kernel length after cooking (0.725) and kernel L/B ratio (0.538). Moderate significant positive correlation was recorded with amylose% (0.231), kernel breadth after cooking (0.194) and cooked rice L/B ratio (0.217).

Similar results were observed by Devi *et al.* (2015) [3] for kernel breadth after cooking and cooked rice L/B ratio, Nandan *et al.*, (2010) [9] and Mathure *et al.*, (2011) [8] for kernel L/B ratio.

11. Kernel breadth (mm)

Highly significant positive correlation of kernel breadth was obtained with amylose% (0.502), kernel breadth after cooking (0.492) and kernel length after cooking (0.308).

Similar results were recorded by Devi *et al.*, (2015) [3] for "kernel breadth after cooking and kernel L/B ratio" Devi *et al.*, (2017) [4] for kernel L/B ratio and Devi *et al.*, (2019) [5] for "kernel breadth after cooking and kernel length after cooking.

12. Kernel L/B ratio
Highly significant positive correlation of kernel L/B ratio was recorded with gel consistency (0.448), cooked rice L/B ratio (0.397) and kernel length after cooking (0.252).
Similar results were recorded by Devi *et al.,* (2015) [3] for kernel length after cooking and Devi *et al.,* (2019) [5] for elongation. Khatun *et al.,* (2003) [7] for gel consistency.

13. Kernel length after cooking (mm)
Highly positive significant correlation of kernel length after cooking was obtained with elongation ratio (0.385), kernel breadth after cooking (0.346), alkali spreading value (0.292) and cooked rice L/B ratio (0.259).
These findings are in line with the results obtained by Devi *et al.,* (2015) [3] for elongation ratio and Devi *et al.,* (2019) [5] for elongation ratio and alkali spreading value.

14. Kernel breadth after cooking (mm)
Kernel breadth after cooking didn't showed any positive correlation with any characters under studied.

15. Cooked rice L/B ratio
Highly significant positive and moderately significant positive correlation of cooked rice L/B ratio was obtained with gel consistency (0.466) and alkali spreading value (0.189) respectively.

16. Elongation ratio
Highly positive significant correlation of elongation ratio was recorded with alkali spreading value (0.412). Moderate significant positive correlation of elongation ratio was obtained with amylose% (0.200).
Similar results were obtained by Thomas *et al*., (2010) [12] for amylose%.

17. Gel consistency
Highly significant positive correlation and highly significant negative correlation of gel consistency was noted with alkali spreading value (0.371) and amylose% (-0.858) respectively.
These results are in line with the findings of Khatun *et al.,* (2003) [7] for amylose%.

18 Alkali spreading value
Alkali spreading value didn't showed any positive correlation with any characters under studied.

19. Amylose %
Amylose % didn't showed any positive correlation with any characters under studied.

Path coefficient analysis
Direct effects
Considering direct effects of quality characters on head rice recover %, brown rice L/B ratio showed highest positive direct effect (2.646) on % followed by cooked rice length (1.648), brown rice breadth (1.408), hulling%, paddy breadth (0.710), "kernel breadth (0.378), elongation ratio" (0.159) and kernel length (0.148). Rice breadth after cooking showed highest negative direct effect (-3.522) on %, followed by "cooked rice L/B ratio (-2.598), brown rice length" (-1.496), amylose% (-0.924), gel consistency (-0.543), alkali spreading value (-0.450), kernel L/B ratio (-0.262), paddy length (-0.133), paddy L/B ratio (-0.055) and milling % (-0.025).
Similar results obtained by Nandan and Singh (2010) [9] for hulling%, Rajamadhan *et al*., (2011) [10] for kernel length and Saravanan and Sabesan (2009) for kernel L/B ratio.

Direct and indirect effects of quality characters on head rice recovery %
1. Hulling %
Hulling% showed positive direct effect on head rice recovery %. This trait showed indirect positive effect on head rice recovery % mainly through amylose% (0.356), brown rice length (0.329) and kernel length after cooking (0.164). However, hulling% had indirect negative effect on head rice recovery % mainly brown rice breadth (-0.387), cooked rice L/B ratio (-0.236) and alkali spreading value (-0.150).

2. Milling %
Milling% had negative direct effect (-0.025) on head rice recovery % however it had indirect positive effect on head rice recovery % mainly through kernel breadth after cooking (0.984), hulling% (0.578) and amylose% (0.387). Milling% had indirect effect on head rice recovery % mainly through cooked rice L/B ratio (-0.888), brown rice breadth (-0.433) and gel consistency (-0.184).

3. Paddy length (mm)
Paddy length showed negative direct effect (-0.133) on head rice recovery % however, this trait had negative indirect effect on head rice recovery % mainly through brown rice L/B ratio (1.456), kernel rice length after cooking (1.237) and kernel length (0.129). Paddy length had negative indirect effect on head rice recovery % mainly through brown rice length (-1.182), kernel breadth after cooking (-0.769) and cooked rice L/B ratio (-0.544).

4. Paddy breadth (mm)
Paddy breadth showed positive direct effect (0.710) on head rice recovery %. This trait indirect positive effect on head rice recovery % mainly through cooked rice L/B ratio (1.115), brown rice breadth (0.863) and brown rice length (0.160). However, it showed indirect negative effect on head rice recovery % mainly through kernel breadth after cooking (-2.241), brown rice L/B ratio (-1.518) and alkali spreading value (-0.146).

5. Paddy L/B ratio
Paddy L/B ratio had negative direct effect (-0.055) on % however, this trait showed positive direct effect on % mainly through brown rice L/B ratio (2.187), kernel breadth after cooking (1.251) and kernel length after cooking (0.492). Paddy L/B ratio had negative indirect effect on head rice recovery % mainly through cooked rice L/B ratio (-1.231), brown rice length (-0.923) and paddy breadth (-0.527).

6. Brown rice length (mm)
Brown rice length showed third highest negative direct effect (-1.496) on head rice recovery % however, this trait had positive indirect effect on head rice recovery % mainly through brown rice L/B ratio (1.538), kernel length after cooking (1.169) and brown rice breadth (0.232). This trait showed negative indirect effect on head rice recovery % mainly through kernel breadth after cooking (-0.654), cooked rice L/B ratio (-0.51) and amylose% (-0.419).

7. Brown rice breadth (mm)
Brown rice breadth showed positive direct effect (1.408) on head rice recovery %. This trait showed indirect positive effect on head rice recovery % mainly via cooked rice L/B (0.848), kernel rice length after cooking (0.550) and paddy breadth (0.435). However, brown rice breadth had negative indirect effect on head rice recovery mainly through kernel breadth after cooking (-1.950), brown rice L/B ratio (-1.839) and amylose% (-0.419).

8. Brown rice L/B ratio
Brown L/B ratio showed highest positive direct effect (2.646) on head rice recovery %. This trait showed positive indirect effect on head rice recovery % mainly through kernel breadth after cooking (0.991), kernel length after cooking (0.397) and amylose% (0.205). However, it showed negative indirect effect on head rice recovery % mainly through brown rice breadth (-0.979), cooked rice L/B ratio (-0.964) and brown rice length (-0.870).

9. Kernel length (mm)
Kernel length had positive direct effect on head rice recovery %. This trait showed positive indirect effect on head rice recovery % mainly through brown rice L/B ratio (1.273), kernel length after cooking (1.194) and gel consistency (0.588). However, kernel length had negative effect on head rice recovery % mainly through brown rice length (-1.283), kernel breadth after cooking (-0.681), and cooked rice L/B ratio.

10. Kernel breadth (mm)
Kernel breadth showed positive direct effect (0.378) on head rice recovery %. Kernel breadth had positive indirect effect on head rice recovery % mainly through brown rice breadth (1.325), cooked rice L/B ratio (0.729) and kernel length after cooking (0.507). However, it showed negative indirect effect on head rice recovery % mainly through brown rice L/B ratio (-1.742), kernel breadth after cooking (-1.732) and amylose% (-0.464).

11. Kernel L/B ratio
Negative direct effect (-0.262) of Kernel L/B ratio was obtained on head rice recovery % however, it showed positive indirect effect on head rice recovery % mainly through brown rice L/B ratio (2.434), kernel breadth after cooking (0.996) and kernel length after cooking (0.415). This trait showed negative indirect effect on head rice recovery % mainly through cooked rice L/B ratio (-1.030), brown rice breadth (-0.969) and brown rice length (-0.688).

12. Kernel length after cooking (mm)
Positive direct effect (1.648) on head rice recovery % was obtained by kernel length after cooking. Indirect positive effect of this trait on head rice recovery % were mainly through brown rice L/B ratio (0.637), brown rice breadth (0.470) and paddy breadth (0.174). However, this trait showed negative indirect effect on head rice recovery % mainly through kernel breadth after cooking (-1.218), brown rice length (-1.062) and alkali spreading value (-0.131).

13. Kernel breadth after cooking (mm)
Negative direct effect was shown by kernel breadth after cooking on head rice recovery %. However, it showed positive indirect effect on head rice recovery % mainly through cooked rice L/B ratio (2.095), brown rice breadth (0.779) and kernel length after cooking (0.57). This trait showed indirect negative effect on head rice recovery % mainly through brown rice L/B ratio (-0.744), brown rice length (-0.277) and amylose% (-0.136).

14. Cooked rice L/B ratio
Negative direct effect (-2.598) was shown by cooked rice L/B ratio on head rice recovery % however, it showed positive indirect effect on head rice recovery % mainly through kernel breadth after cooking (2.839), brown rice L/B ratio (0.981) and kernel length after cooking (0.427). This trait showed negative indirect effect on head rice recovery % mainly through brown rice breadth (-0.459), paddy breadth (-0.305) and brown rice length (-0.293).

15. Elongation ratio
Positive direct effect (0.159) of elongation ratio was obtained on HRR. This trait showed indirect positive effect on HRR mainly through hulling% (0.333), brown rice length (0.298) and brown rice breadth (0.225). However, this trait showed negative indirect effect on HRR mainly through brown rice L/B ratio (-0.798), kernel breadth after cooking (-0.464) and cooked rice L/B ratio (-0.328).

16. Gel consistency
Negative direct effect (-0.543) of gel consistency was obtained on head rice recovery % however this trait showed positive indirect effect on head rice recovery % mainly through kernel breadth after cooking (1.738), brown rice L/B ratio (0.971) and amylose% (0.793). This trait showed negative effect on head rice recovery % mainly through cooked rice L/B ratio (-1.21), brown rice breadth (-0.803) and kernel length after cooking (-0.234).

17. Alkali spreading value
Negative direct effect was obtained of alkali spreading value on head rice recovery %, however this trait showed positive indirect effect on head rice recovery % mainly through kernel length after cooking (0.481), amylose% (0.473) and hulling% (0.270). This trait showed negative indirect effect on head rice recovery % mainly through cooked rice L/B ratio (-0.491), gel consistency (-0.201) and brown rice L/B ratio.

18. Amylose %
Negative direct effect of amylose % was obtained on head rice recovery %, however it showed positive indirect effect on head rice recovery % mainly through brown rice breadth (0.639), cooked rice L/B ratio and gel consistency (0.466). This trait showed negative indirect effect on head rice recovery % mainly through brown rice L/B ratio (-0.587), kernel breadth after cooking (-0.518) and hulling% (-0.312).

Table 1: Genotypic and phenotypic correlation coefficients of quality characters

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	G	1	0.715**	-0.046	-0.011	0.013	-0.220*	-0.275**	0.020	-0.180	-0.383**	0.172	0.100	0.005	0.091	0.412**	0.256**	0.335**	-0.386**	0.610**
	P		0.610**	-0.022	0.048	-0.043	-0.156	-0.236*	0.052	-0.208*	-0.283**	0.072	0.022	0.003	0.034	0.269**	0.197*	0.201*	-0.327**	0.520**
2	G		1	-0.164	-0.032	-0.081	-0.178	-0.308**	0.04	-0.246**	-0.322**	0.055	0.059	-0.280**	0.342**	0.489**	0.339**	0.214*	-0.419**	0.726**
	P			-0.143	0.002	-0.087	-0.154	-0.281**	0.055	-0.243*	-0.309*	0.052	0.035	-0.254**	0.286**	0.339**	0.306**	0.169	-0.357**	0.684**
3	G			1	0.086	0.598**	0.790**	0.046	0.550**	0.872**	0.001	0.635**	0.751**	0.218*	0.209*	-0.209*	0.003	0.070	0.009	0.013
	P				0.081	0.560**	0.728**	0.069	0.473**	0.790**	0.003	0.577**	0.596**	0.207*	0.180	-0.141	0.038	0.107	-0.017	0.011
4	G				1	-0.742**	-0.107	0.613**	-0.574**	-0.012	0.505**	-0.458**	0.245**	0.636**	-0.429**	0.257**	-0.249**	0.326**	-0.033	-0.115
	P					-0.760**	-0.103	0.543**	-0.515**	-0.039	0.437**	-0.406**	0.174	0.530**	-0.333**	0.184	-0.211*	0.258**	-0.039	-0.108
5	G					1	0.617**	-0.455**	0.826**	0.574**	-0.400**	0.775**	0.299**	-0.355**	0.474**	-0.335**	0.198*	-0.203*	0.046	0.103
	P						0.545**	-0.383**	0.709**	0.526**	-0.343**	0.684**	0.211*	-0.286**	0.356**	-0.262**	0.192*	-0.128	0.037	0.098
6	G						1	0.165	0.581**	0.858**	0.157	0.460**	0.710**	0.186	0.196*	-0.199*	-0.137	-0.047	0.201*	-0.166
	P							0.165	0.573**	0.788**	0.141	0.429**	0.584**	0.177	0.177	-0.125	-0.116	-0.037	0.184	-0.155
7	G							1	-0.695**	0.189*	0.941**	-0.688**	0.334**	0.554**	-0.326**	0.160	-0.570**	0.053	0.454**	-0.532**
	P								-0.700**	0.199*	0.891**	-0.621**	0.269**	0.518**	-0.283**	0.098	-0.511**	0.070	0.402**	-0.508**
8	G								1	0.481**	-0.658**	0.920**	0.241*	-0.282**	0.371**	-0.302**	0.367**	-0.058	-0.222*	0.273**
	P									0.408**	-0.625**	0.829**	0.191*	-0.266**	0.325**	-0.189*	0.336**	-0.076	-0.200*	0.264**
9	G									1	0.206*	0.538**	0.725**	0.194*	0.217*	-0.349**	-0.108	-0.038	0.231*	-0.200*
	P										0.187	0.556**	0.580**	0.177	0.195*	-0.331**	-0.105	-0.006	0.207*	-0.185
10	G										1	-0.705**	0.308**	0.492**	-0.281**	0.117	-0.558**	0.019	0.502**	-0.624**
	P											-0.697**	0.239*	0.452**	-0.245**	0.081	-0.484	0.009	0.401**	-0.595**
11	G											1	0.252**	-0.283**	0.397**	-0.361**	0.448**	0.014	-0.310**	0.373**
	P												0.220*	-0.252**	0.349**	-0.302**	0.369**	0.045	-0.220*	0.351**
12	G												1	0.346**	0.259**	0.385**	-0.142	0.292**	0.030	0.075
	P													0.287**	0.391**	0.543**	-0.136	0.263**	0.082	0.066
13	G													1	-0.806**	0.132NS	-0.494**	0.038	0.147	-0.221*
	P														-0.754**	0.124	-0.425**	0.056	0.136	-0.204*
14	G														1	0.126	0.466**	0.189*	-0.184	0.276**
	P															0.263**	0.344**	0.160	-0.111	0.238*
15	G															1	-0.068	0.412**	-0.200*	0.400**
	P																-0.093	0.292**	-0.086	0.284**
16	G																1	0.371**	-0.858**	0.404**
	P																	0.289**	-0.773**	0.376**
17	G																	1	-0.512**	0.234*
	P																		-0.350**	0.214*
18	G																		1	-0.522**
	P																			-0.455**
19	G																			1
	P																			

1. Hulling %
2. Milling %
3. Paddy length (mm)
4. Paddy breadth (mm)
5. Paddy L/B ratio
6. Brown rice length (mm)
7. Brown rice breadth (mm)
8. Brown rice L/B ratio
9. Kernel length (mm)
10. Kernel breadth (mm)
11. Kernel L/B ratio
12. Kernel length after cooking (mm)
13. Kernel breadth after cooking (mm)
14. Cooked rice L/B ratio
15. Elongation ratio
16. Gel consistency
17. Alkali spreading value
18. Amylose %
19. Head rice recovery %

Table 2: Direct and indirect effects on head rice recovery (%) of other quality characters

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	r_{xy}
1	0.809	-0.018	0.006	-0.007	-0.0007	0.329	-0.387	0.053	-0.026	-0.144	-0.045	0.164	-0.019	-0.236	0.065	-0.139	-0.150	0.356	0.609
2	0.578	-0.025	-0.021	-0.022	0.004	0.266	-0.433	0.129	-0.036	-0.121	-0.014	0.097	0.984	-0.888	0.078	-0.184	-0.096	0.387	0.725
3	-0.037	0.004	-0.133	0.061	-0.033	-1.182	0.065	1.456	0.129	0.0004	-0.166	1.237	-0.769	-0.544	-0.033	-0.001	-0.031	-0.008	0.012
4	-0.008	0.0008	-0.0114	0.710	0.041	0.160	0.863	-1.518	-0.001	0.191	0.120	0.403	-2.241	1.115	0.041	0.135	-0.146	0.030	-0.114
5	0.010	0.002	-0.079	-0.527	-0.055	-0.923	-0.641	2.187	0.085	-0.151	-0.203	0.492	1.251	-1.231	-0.053	-0.107	0.091	-0.042	0.102
6	-0.178	0.004	-0.105	-0.076	-0.034	-1.496	0.232	1.538	0.127	0.059	-0.120	1.169	-0.654	-0.510	-0.031	0.074	0.021	-0.185	-0.165
7	-0.222	0.007	-0.006	0.435	0.025	-0.246	1.408	-1.839	0.028	0.355	0.180	0.550	-1.950	0.848	0.0255	0.310	-0.023	-0.419	-0.531
8	0.016	-0.001	-0.073	-0.407	-0.046	-0.870	-0.979	2.646	0.071	-0.249	-0.241	0.397	0.991	-0.964	-0.048	-0.199	0.026	0.205	0.273
9	-0.145	0.006	-0.116	-0.008	-0.031	-1.283	0.266	1.273	0.148	0.077	-0.141	1.194	-0.681	-0.564	-0.055	0.588	0.017	-0.213	-0.200
10	-0.309	0.008	-0.0001	0.359	0.022	-0.235	1.325	-1.742	0.030	0.378	0.185	0.507	-1.732	0.729	0.018	0.303	-0.008	-0.464	-0.623
11	0.139	-0.001	-0.084	-0.325	-0.043	-0.688	-0.969	2.434	0.079	-0.266	-0.262	0.415	0.996	-1.030	-0.057	-0.243	-0.006	0.286	0.372
12	0.080	-0.001	-0.100	0.174	-0.016	-1.062	0.470	0.637	0.107	0.116	-0.066	1.648	-1.218	-0.061	0.0614	0.077	-0.131	-0.027	0.074
13	0.004	0.007	-0.029	0.452	0.019	-0.277	0.779	-0.744	0.028	0.186	0.074	0.570	-3.522	2.095	0.021	0.268	-0.016	-0.136	-0.220
14	0.073	-0.008	-0.027	-0.305	-0.026	-0.293	-0.459	0.981	0.0322	-0.106	-0.104	0.427	2.839	-2.598	0.020	-0.253	-0.085	0.17	0.275
15	0.333	-0.012	0.027	0.182	0.018	0.298	0.225	-0.798	-0.051	0.044	0.094	0.634	-0.464	-0.328	0.159	0.037	-0.185	0.184	0.400
16	0.207	-0.008	-0.0004	-0.176	-0.011	0.205	-0.803	0.971	-0.016	-0.211	-0.117	-0.234	1.738	-1.210	-0.010	-0.543	-0.167	0.793	0.403
17	0.270	-0.005	-0.009	0.231	0.011	0.070	0.074	-0.153	-0.005	0.007	-0.003	0.481	-0.132	-0.491	0.065	-0.201	-0.450	0.473	0.233
18	-0.312	0.010	-0.001	-0.023	-0.002	-0.300	0.639	-0.587	0.034	0.190	0.081	0.049	-0.518	0.478	-0.031	0.466	0.230	-0.924	-0.522

Residual = 0.34995. The main diagonal (bold) is direct effects.

1 = Hulling %
2 = Milling %
3 = Paddy length (mm)
4 = Paddy breadth (mm)
5 = Paddy L/B ratio
6 = Brown rice length (mm)
7 = Brown rice breadth (mm)
8 = Brown rice L/B ratio
9 = Kernel length (mm)
10 = Kernel breadth (mm)
11 = Kernel L/B ratio
12 = Cooked kernel length (mm)
13 = Cooked kernel breadth (mm)
14 = Cooked rice L/B ratio
15 = Elongation ratio
16 = Gel consistency
17 = Alkali spreading value
18 = Amylose %

Conclusion

Enhancing a desired characteristic like head rice recovery % through a realistic breeding approach involves complex interactions among various traits. The correlation and path coefficient analyses conducted in this study underscored the intricate relationships between head rice recovery % and other quality parameters. While correlation analysis provided insights into the strength and direction of associations among traits, path coefficient analysis further elucidated direct and indirect impacts of independent characters on head rice recovery %. These findings emphasize the importance of considering not only direct influences but also indirect pathways mediated through other traits in breeding programs aimed at improving rice quality. Thus, a comprehensive understanding of these interrelationships is crucial for effective selection strategies in rice breeding projects.

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