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Association analysis of yield and yield contributing traits in traditional varieties of rice (*Oryza sativa* L.)

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Abstract
Rice is integral to the livelihood of billions of individuals over the globe. Perhaps the oldest domesticated grain crop of the world. It is grown in 26 states and 7 Indian territories of India. Yield has been always the main criteria for selection during a breeding programme. So by considering the following aspect the current study was conducted with 100 traditional rice accessions at in randomized block design (RBD) with 2 replications during *Kharif* 2018 with the objective to find out traits that are directly related to yield which can be selected during breeding programme by association analysis. For path and correlation coefficient analysis data was statistically tested to estimate different descriptive statistics Correlation study indicated that "per plant grain yield had positive and significant correlation with grain length, panicle number, thousand seed weight, panicle length, and flag leaf width where as in path coefficient analysis thousand seed weight, grain length, milling%, plant height, panicle number per plant, flag leaf width and panicle length demonstrated direct and positive effect with per plant grain yield.

Keywords: Yield contributing traits, correlation and path analysis

Introduction
From days of antiquity rice has been a staple nourishment of humankind. It is a crop having 5000 years long history. All around, rice is developed over a region of 160.6 million hectares, with a complete production of 738.20 million tons and productivity of 3424.41kg/ha (Anonymous, 2018a) [4]. Rice is additionally the staple sustenance for 65 percentage of individuals live in India. In India, total production is 115.60 million tons with productivity of 2578 kg/ha (Anonymous, 2018b) [2]. Chhattisgarh state has presented to a differentiated rice landraces in this way it is known as "Rice Bowl of India". With a territory around 3.64 million hectares, production of 9.54 million tons and productivity of 1517 kg/ha Chhattisgarh is a main state in regards to production of rice (Anonymous, 2018c) [3].
For an efficient breeding programme, knowledge of association of yield with its component traits, direct and indirect effects on yield, yield contributing components by correlation coefficient and path- coefficient, respectively. Sankar *et al*. (2005) [10] observed positive correlation among traits like grains per, panicle length, panicle tillers per plant with yield while Kumar *et al*. (2011) [6] documented Attributes like length of panicle, area of flag leaf, tillers /plant were significantly correlated with yield While, it was influenced by negative indirect impacts of primary branch, plant tallness and tiller number. Moreover positive and significant genotypic correlation was seen between yield and panicle length. According to Al-Salim *et al*. (2016) [1] plant tallness or plant height was negatively correlated with grain yield where as there is significant positive correlation among the traits like panicle length and grain yield which means the character can be used as a marker for indirect selection of yield.

Materials and Methods
Materials
The experimental materials comprised of 100 accessions of rice including 2 checks the lists of accessions of rice are presented in Table 1. The experimental materials were received from IGKV, Raipur.

Table 1: List of Accessions of rice used in the Study

Sl no.	Accessions Name	Sl no.	Accessions Name	Sl no.	Accessions Name
1	Jawa Phool	35	Sarna sel-1	69	Danigauda
2	Raju Dhan	36	Karhani	70	Tendumudi
3	Chudi Dhan	37	Parijat	71	Mudi Davar
4	Luchai Dhan	38	Gouda Kisar	72	Mai Davar
5	Badi Binja	39	Culture Dhan	73	Ras Kadam
6	Culture Desi	40	China Dhan	74	Chrainakhi
7	Sindur Singa	41	Bhiruhall	75	Ayodhya
8	Badi Luchai	42	Safri-1	76	Gadur Sella
9	Gadur Sella	43	Sawanni	77	Lali Bujang
10	Culture Dhan	44	Mohalyan Bako	78	Boer Butta
11	Komal	45	Kanakbas	79	Kali Bhujang
12	Sundarbhujang	46	Longphul	80	Luchai 2
13	Rasi Punam	47	Suraj Phul	81	Ramkalli
14	Culture Dhan	48	Narpatti	82	Ganjikali
15	Jeera Phul-1	49	Bhusu	83	Baisur Dhan
16	Kadam Phul	50	Gulti	84	Sambhogra
17	Karhani-1	51	Byalo	85	Sundarbhujang-1
18	10 10 Dhan -sel	52	Gangti	86	Pili Luchai
19	Kansari	53	Ramdi	87	Desi Dubraj
20	Ranikajar	54	Nandel	88	Karial Dhan
21	Aman Dhan	55	Dhawamudaria	89	Gonda
22	Ras Kadam	56	Khirsar	90	Jhili
23	Jeera Phul-2	57	Pataniajhuli	91	Bhatta Dubraj
24	Chinmauri	58	Kherkokuchi	92	Jhilli Dhan
25	Puniabako	59	Sarojini	93	Sanak Bhujang
26	Raichudi	60	Sonagathi	94	Aassam Chudi
27	Rudra Dhan	61	Kerakhachi	95	Mai Safri
28	Bhaiya Dhan	62	Tumaliabako	96	Pengudi
29	Barhasaal	63	Agyasal	97	Danigauda -1
30	Rattajhikka	64	Nandel	98	Karial Dhan-1
31	Dumar Phul	65	Tendumuri	99	Chandrahasini
32	Jeera Phul-3	66	Ganga Prasad	100	MTU 1010
33	Safri	67	Runia pank		
34	Bagpuchhi	68	Badsahbhog		

Design and Layout

Rice accessions were analysed in field during kharif 2018 at Research Cum Instructional Farm, Deptt. of Genetics & Plant Breeding, College of Agriculture, IGKV, Raipur in Randomised Block Design (RBD) with 2 replications. Total field was divided in to two blocks for two replications and each block is further divided in to five equal parts each having 20 genotypes in random order.

Methods

Association analysis

Correlation coefficients analysis measures the mutual relationship between various characters at genotypic (g), phenotypic (p) and environmental levels with the help of following formula suggested by Miller *et al.* (1958) [8] while Path analysis was originally developed by Wright (1921) and first used for plant selection by Dewey and Lu (1959) [5]. It measures the direct and indirect contribution of independent variables on dependent variable.

Correlation analysis

Correlation is the association between two or more variables which can be estimated in the terms of correlation coefficients which gives the mutual relationship between various characters with the help of formula suggested by Miller *et al.* (1958) [8].

Path coefficient analysis

Path analysis measures the cause of association between two variables. Analysis of path coefficient is based on all possible simple correlations among various characters. It also provides information about direct and indirect effects of independent variables on dependent variable.

Results and Discussion

Correlation analysis

"Association analysis is an important approach in a breeding programme. It gives an idea about relationship among the various characters and determines the component characters, on which selection can be based for genetic improvement in the grain yield. Degree of association also affects the effectiveness of selection process. The degree of association between independent and dependent variables was suggested by Galton 1888, its theory was developed by Pearson (1904) [9] and their mathematical utilization at phenotypic, genotypic and environmental levels was described by Searle (1961) [11]. The association between any two variables is termed as simple correlation or total correlation or zero order correlation coefficient. It is of three types *viz*, phenotypic, genotypic and environmental correlations".

"The correlation coefficient analysis is the index of association between two variables. These have been dealt in all possible combination for important characters at phenotypic and genotypic level and are presented in Table-3

Grain yield per plant showed positive and significant correlation with grain length (.169), 1000 seed weight (.103), flag leaf width (.192), panicle length (.123) and panicle number (.150). Hulling (%) showed positive and significant correlation with milling % (.769) and for all other characters under study it showed non significant correlation. Out of non significant correlation grain length, grain width, decorticated grain kength,1000 seed weight, amylose content, flag leaf width, panicle number, plant height showing positive association while grain yield per plant, flag leaf length, days to 50% flowering, decorticated grain width showed –ve association. Milling % does not possessed positive and significant association with any of the traits. Grain length showed positive and significant association with grain width (.210), decorticated grain length (.758), decorticated grain width (.147), 1000 seed weight (.515) and grain yield per plant (.169). Grain width showed positive and significant association with decorticated grain length (.374), decorticated grain width (.470), 1000 seed weight (.551), flag leaf width (.229) and plant height (.280) while it showed negative and significant correlation with panicle number per plant (0.-.403)".

Decorticated grain length showed positive and significant association with decorticated grain width (.334), 1000 seed weight (.668) while showed negative but significant correlation within flag leaf length (-.162), panicle length (-.173) and panicle number (-.143). 1000 seed weight possessed positive and significant association with days to 50% flowering (-.160) and plant height (-.183). Days to 50% flowering showed positive and significant association with plant height (.174) while negative and significant correlation with flag leaf length (-.192). Flag leaf length showed positive and significant association with flag leaf width (.211) and plant height (.217). Flag leaf width possessed positive and significant association with grain yield per plant (.192) while showed negative and significant correlation with panicle number per plant (-.221). Panicle length showed positive and significant association with plant height (.396) and grain yield

per plant (.123). Panicle number per plant positive and significant association with grain yield per plant (.150) while showing negative and significant association with plant height (-.359).The association between two variables which can be directly observed is termed as phenotypic correlation and it includes Genotypic and environmental effects therefore, it differs under environmental conditions".

"The inherent or heritable association between two variables is known as genotypic or genetic correlation. This may be either due to pleotropic action of genes or due to linkage or both. The main genetic cause of such association is pleotropy, which refers to manifold effects of a gene (Falconer, 1960). This type of correlation is more stable and is of paramount importance to bring about genetic improvement in one character by selecting the other character of a pair that is genetically correlated".

"In the present investigation grain length, 1000 seed weight, flag leaf width, panicle length and panicle number (150) had positive and highly significant correlation with grain yield per plant. It indicates strong correlation of these traits with grain yield and selection of these traits will be useful in improving grain yield (Table 2 and Figure 1).

Table 2: Summarized data representing the relationship of different traits on grain yield per plant at genotypic level

Traits	Correlation
	Grain yield
Hulling %	-0.078
Milling %	-0.003
Grain Length(mm)	0.169*
Grain Width(mm)	-0.092
Decorticated grain Length(mm)	0.101
Decorticated grain Width(mm)	-0.084
1000 Seed weight(g)	0.103**
Amylose content (%)	-0.066
Days to 50% floweing	-0.066
Flag Leaf Length(cm)	0.053
Flag Leaf Width(cm)	0.192**
Panicle Length(cm)	0.123*
Panicle Number per plant	0.150*
Plant Height (cm)	-0.02

****** Significant at 1% level of significance; ***** Significant at 5% level of significance

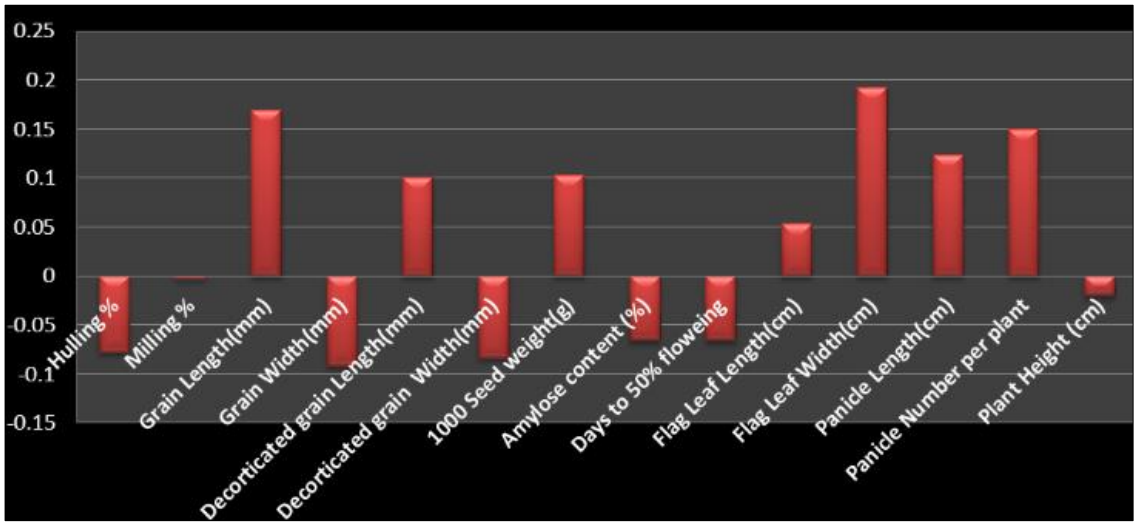

Fig 1: Graph representing significant correlation between grain yield and other traits

Table 3: Association analysis (phenotypic and genotypic) of 15 yield and quality traits of 100 rice accessions

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	P														
	G														
2	P	0.645**													
	G	0.769**													
3	P	0.009	-0.087												
	G	0.011	-0.105												
4	P	0.089	0.057	0.208**											
	G	0.092	0.069	0.210**											
5	P	0.087	-0.004	0.736**	0.369**										
	G	0.089	0.002	0.758**	0.374**										
6	P	-0.042	0.032	0.136	0.454**	0.318**									
	G	-0.038	0.025	0.147*	0.470**	0.334**									
7	P	0.097	0.064	0.479**	0.509**	0.613**	0.439**								
	G	0.111	0.071	0.515**	0.551**	0.668**	0.477**								

8	P	0.021	0.003	-0.037	-0.116	0.024	-0.069	0.11							
	G	0.025	0.01	-0.044	-0.119	0.027	-0.075	0.138							
9	P	-0.093	-0.09	0.107	-0.124	-0.019	-0.048	-0.208**	-0.152*						
	G	-0.095	-0.103	0.108	-0.126	-0.019	-0.048	-0.221**	-0.160*						
10	P	-0.038	-0.006	-0.112	-0.054	-0.158*	0.052	0.01	-0.047	-0.190**					
	G	-0.043	-0.002	-0.117	-0.057	-0.162*	0.056	0.01	-0.045	-0.192**					
11	P	0.023	-0.015	0.036	0.228**	0.093	0.177*	0.218**	0.011	0.018	0.193**				
	G	0.026	-0.031	0.041	0.239**	0.099	0.184**	0.264**	0.001	0.017	0.211**				
12	P	-0.001	-0.015	-0.056	0.220**	-0.159*	-0.124	0.186**	0.043	0.044	-0.044	0.036			
	G	0.003	-0.01	-0.065	0.210**	-0.173*	-0.124	0.193**	0.041	0.048	-0.047	0.041			
13	P	0.023	0.034	-0.087	-0.387**	-0.133	-0.213**	-0.073	0.082	-0.046	-0.061	-0.205**	-0.065		
	G	0.033	0.06	-0.093	-0.403**	-0.143*	-0.223**	-0.074	0.081	-0.047	-0.065	-0.221**	-0.082		
14	P	0.036	0.069	0.041	0.276**	0.094	0.188**	0.03	-0.168*	0.173*	0.214**	0.071	0.388**	-0.350**	
	G	0.034	0.085	0.043	0.280**	0.095	0.194**	0.034	-0.183**	0.174*	0.217**	0.075	0.396**	-0.359**	
15	P	-0.08	0.002	0.164*	-0.095	0.098	-0.084	0.197**	-0.062	-0.063	0.053	0.180*	0.133*	0.142*	-0.019
	G	-0.078	-0.003	0.169*	-0.092	0.101	-0.084	0.103**	-0.066	-0.066	0.053	0.192**	0.123*	0.150*	-0.02

1=Hulling %, 2=Milling %, 3=Grain Length(mm), 4=Grain Width(mm),5= Decorticated grain Length(mm),6= Decorticated grain Width (mm), 7= 1000 Seed weight(g), 8= Amylose content (%), 9=Days to 50% floweing, 10= Flag Leaf Length(cm), 11= Flag Leaf Width(cm), 12=Panicle Length(cm), 13= Panicle Number per plant, 14= Plant Height(cm), 15= Grain yield per plant(g).

Path coefficient analysis

Correlation coefficients along with path coefficients together provide more reliable information, which can be effectively predicted in crop improvement programme. If the correlation between causal factor and direct effects is more or less of equal magnitude, it explains the true and perfect relationship between then traits and hence, direct selection through these traits will be rewarding. However, if the correlation coefficient is positive and the direct effects are negative or negligible the indirect causal factors are to be considered in simultaneous selection. The path coefficient analysis was carried out by using the correlation coefficient between different quantitative characters to obtain direct and indirect effects of different characters on grain yield per plant (Table 4). 1000 grain weight showed maximum positive direct effect (.9421) followed by panicle number per plant (.6499), flag leaf width (.5865), panicle length (.3045), milling% (.2167), grain length (.2095) and plant height (.0749) with grain yield per plant. As far indirect effect concerned, Hulling % showed positive effect via milling % (.166), grain length (.002), decorticated grain width (.005), 1000 grain weight (.010), days to 50% flowering (.0128), flag leaf length (.001), flag leaf width (.007), panicle number (.005) and plant height (.002). Milling % showed indirect positive effect via decorticated grain length (.005), 1000 seed weight (.006), days to 50% flowering (.013), panicle number (.009) and plant height (.006). Grain width showed indirect positive effect via 1000 seed weight (.048), amylose content (.005), flag leaf length (.003), flag leaf width (.011) and plant height (.003). Grain width showed indirect positive effect via milling % (.014), grain length (.044), 1000 seed weight (.051), amylose content (.014), days to 50% flowering (.016), flag leaf length (.001), flag leaf width (.066) and plant height (.020). Decorticated grain length showed indirect positive effect via milling % (.004), grain length (.15), 1000 seed weight (.062), days to 50% flowering (.002), flag leaf length (.005), flag leaf width (.027) and plant height (.007). Decorticated grain width showed indirect positive effect via hulling% (.010), milling % (.005), grain length (.030), 1000 seed weight (.044), amylose (.008), days to 50% flowering (.006), flag leaf width (.051) and plant height (.014).

1000 seed weight showed indirect positive effect via Milling % (.015), grain length (.060), days to 50% flowering (.029), flag leaf width (.073), panicle length (.275), and plant height (.002). Amylose content showed indirect positive effect via milling % (.002), grain width (.019), decorticated grain width (.010), 1000 seed weight (.012), days to 50% flowering (.021), flag leaf length (.001) and panicle number (.013). Days to 50% flowering showed indirect positive effect via hulling %(.026), grain length (.022), grain width (.020), decorticated grain width (.006), amylose % (.018), flag leaf length (.006), flag leaf width (.004) and plant height (.013). Flag leaf length showed indirect positive effect via grain length (.008), 1000 seed weight (.024), flag leaf width (.277) and plant height (.005). Flag leaf width showed indirect positive effect via hulling % (.011), grain width (.009), amylose % (.005), days to 50% flowering (.025) and plant height (.016).

Panicle length showed indirect positive effect via grain width (.360), decrticated grain width (.017), flag leaf length (.001), flag leaf width (.011) and plant height (.029). Panicle number showed indirect positive effect via milling % (.012), grain width (.668), decorticated grain width (.030), days to 50% flowering (.006) and flag leaf length (.002). Plant height showed indirect positive effect via milling % (.018), grain length (.009), 1000 seed weight (.003), amylose % (.021), flag leaf width (.020) and panicle length (.003). Low residual effect of 0.8153 depicts that number of observed traits in present study is sufficient for the study.

Table 4: Direct and indirect genotypic effect of 15 yield and quality traits of 100 rice accessions

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	-0.27325	0.16664	0.00229	-0.0153	-0.0002	0.00519	0.01049	-0.00301	0.01283	0.00134	0.00725	0.00003	0.00542	0.00251
2	-0.21006	0.21678	-0.02193	-0.01143	0.005	-0.00346	0.00665	-0.00113	0.01391	0.00008	-0.00861	-0.00009	0.00983	0.00636
3	-0.00298	-0.02269	0.2095	-0.03483	-0.0017	-0.02025	0.0485	0.00523	-0.01463	0.00367	0.0114	-0.00058	-0.0153	0.00324
4	-0.0252	0.01494	0.044	-0.16587	-0.00084	-0.06484	0.05193	0.01411	0.01697	0.0018	0.0663	-0.0002	-0.06645	0.02095
5	-0.02424	0.00041	0.15884	-0.06206	-0.00224	-0.04604	0.06289	-0.00326	0.00262	0.00507	0.02746	-0.00156	-0.02355	0.00714
6	0.01027	0.00544	0.03076	-0.078	-0.00075	-0.13789	0.04495	0.00889	0.00652	-0.00176	0.05117	-0.00112	-0.03685	0.01453
7	-0.03043	0.01531	0.60785	-0.09143	-0.0015	-0.0658	0.9421	-0.01632	0.0298	-0.00032	0.07328	0.275	-0.01224	0.00251
8	-0.00692	0.00207	-0.00924	0.01973	-0.00006	0.01034	0.01296	-0.11865	0.02157	0.00142	0.0004	0.00037	0.01344	-0.01368
9	0.02601	-0.02237	0.02273	0.02088	0.00004	0.00667	-0.02083	0.01899	-0.13481	0.00604	0.00472	0.00043	-0.0078	0.01307

10	-0.00715	-0.00673	0.00861	-0.03965	-0.00022	-0.02544	0.02489	-0.00017	-0.00229	-0.00664	0.27736	0.00037	-0.03648	0.00562
11	0.01169	-0.00053	-0.02447	0.00949	0.00036	-0.00774	0.00095	0.00535	0.02592	-0.0314	0.5865	-0.00043	-0.01072	0.0163
12	-0.00079	-0.00211	-0.01353	0.3606	0.00039	0.01703	-0.01821	-0.00491	-0.00641	0.00148	0.01132	0.3045	-0.0135	0.02965
13	-0.00897	0.01292	-0.01942	0.6681	0.00032	0.0308	-0.00699	-0.00966	0.00637	0.00204	-0.06133	-0.00074	0.6499	-0.02691
14	-0.00917	0.01841	0.00907	-0.04638	-0.00021	-0.02674	0.00316	0.02166	-0.02351	-0.00683	0.0208	0.00358	-0.05926	0.07494

1=Hulling %, 2=Milling %, 3=Grain Length(mm), 4=Grain Width(mm),5= Decorticated grain Length(mm),6= Decorticated grain Width(mm),7= 1000 Seed weight(g),8= Amylose content (%), 9=Days to 50% floweing,10= Flag Leaf Length(cm),11= Flag Leaf Width(cm), 12=Panicle Length(cm),13= Panicle Number per plant,14= Plant Height(cm),15= Grain yield per plant(g)

Summary and Conclusions

Grain yield per plant showed positive and significant correlation with grain length, panicle number thousand seed weight, panicle length, and flag leaf width". High genotypic correlation between the concerned character and grain yield per plant describes selection for the concerned character will lead to increase in grain yield per plant.

"Path coefficient analysis showed 1000 grain weight, panicle length, milling%, plant height, panicle number per plant, flag leaf width" and, grain length showed positive direct effect with grain yield per plant.

Conclusions

- Grain length, 1000 seed weight, flag leaf width, panicle length, and panicle number showed significant and positive correlation with grain yield per plant.
- 1000 seed weight, panicle number per plant, flag leaf width, panicle length, milling%, grain length and plant height exhibited positive direct effect on grain yield per plant.

Correlation and Path analysis indicates the traits can be directly selected for yield during breeding programme.

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