Direct and indirect effects of yield contributing characters on grain yield in Rice (*Oryza sativa* L.)

sABSTRACT

The present study consists of 23 rice genotypes including one check variety were evaluated at Field Experimentation Centre of the Department of Genetics and Plant Breeding, Direct and indirect effects of yield contributing characters on grain yield in Rice (*Oryza sativa* L.) for 13 quantitative characters. The experiment was conducted by using Randomized Block Design with three replications during *Kharif, 2021*. MTU-1224 (54.85gm) to be high yielding followed by, RNR-1446 (41.4gm), SHIVA 555 (39.267gm), MTU-1121 (39.2gm), MTU-1272 (38gm) showed higher yield over the NDR359 (check). High to moderate estimates of GCV and PCV were recorded for Number of tillers/hill followed by Grain yield per hill, Test weight, Number of spikelet's/hill, Biological yield, Harvest index, Number of panicles/hill, Flag leaf width, Flag leaf length and Plant height. Grain yield indicated significant positive correlation with Harvest index followed by Number of panicles/hill, Number of tillers/hill, Number of spikelet's/Panicles and Biological yield at both phenotypic level and genotypic level. Positive significant direct effects on grain yield per hill were exhibited by harvest index, biological yield and days to 50% flowering at genotypic level and phenotypic level. Thus, these traits are identified as the efficient and potential for indirect selection for the improvement of rice productivity in the present experimental materials.

Comment [P1]: add analysis method

Keywords: Rice, GCV, PCV, Variability, Heritability, Correlation, Path analysis.

Comment [P2]: keywords do not enter words that are in the abstract

Introduction

One of the most significant cereal food crops in the world is rice (*Oryza sativa* L.), which is a member of the genus Oryza and family Graminae. There are 24 species in the genus, 22 of which are wild, and only two, Oryza sativa and Oryza glaberimma, are domesticated. The species of Oryza sativa has 12 basic chromosomes, or 2n=24. Oryza sativa cultivars can be divided into three subspecies: Indica, Japonica, and Javanica. The tropical and subtropical regions support the cultivation of indica rice cultivars. While Javanica types are mostly planted in some regions of Indonesia, Japonica cultivars are grown across the temperate zone.

Rice (*Oryza sativa* L.), one of the primary cereal crops, meets the majority of the carbohydrate requirements of about half of the world's population. It meets the caloric demands of 50% of the population and gives 160 million rurally disadvantaged people a way of surviving. In 2016 (Santha et al.).

Comment [P3]: adjust to international standard quotation

Rice, which has been domesticated for 10,000 years, is possibly the first grain (Kovach *et al.*, 2007). The International Year of Rice was established in 2004 to recognise the importance of rice, which is a staple food for 2.7 billion people worldwide. It takes up 9% of the arable land in the planet. 15 percent of the world's protein and 21 percent of the calories consumed by humans each year comes from rice (IRRI, Rice Almanac, 4th Edition). Currently, rice is grown on 164.19 million hectares around the world, with an average productivity of 4.25 tonnes/ha and an annual production of about 513.02 million tonnes (USDA-2021). More than 90% of the world's rice is produced and consumed in Asia, which is known as the "rice bowl" of the globe.

For the breeding process and the selection of desired features, genetic variation among the characters is crucial. Heritability estimations that are combined with genetic progress are typically more accurate at predicting the gain subject to selection. On the other hand, research into correlations may assist plant breeders in understanding how the development of one character will result in the simultaneous development of other characters. Path coefficient analysis, which assesses the direct impact of one variable on the other, is a standardised regression coefficient. Since the environment has an impact on direct selection for yield, it is not a trustworthy method. Therefore, it is crucial to pinpoint the individual qualities that can boost yield.

Comment [P4]: input previous research

Materials and Methods

Comment [P5]: method requires a reference. Give a clear reason if this is new or any other reason

The experimental material for present investigation consists of twenty three genotypes including one check variety (NDR-359) obtained from Department of Genetics and Plant Breeding, Naini Agricultural Institute, SHUATS, Prayagraj Uttar Pradesh, was carried out at the Field Experimentation Centre of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, U.P. during Rabi 2021 - 2022. The land was prepared by two harrowing followed by puddling. The experiment was conducted in Randomized Block Design (RBD) with three replications. The genotypes were sown on raised bed on 30thJune, 2021. Plant spacing between row to row and plant to plant is 20 cm × 15 cm.

In each replication and in each plot, selection of five plants are done randomly and tagged except the border plants to minimize border effects. All the 13 characters studied and recorded on five randomly selected plants except days to flowering and days to maturity. Seed weight of the grains were recorded with the help of physical balance.

Results and Discussion

Significant differences in genotypes were found for all of the characters after analysis of variance (Table 01). This shows that the current gene pool offers a wide range of genotypes from which to choose for yield and its constituent parts. As a result, it was clear that the material under study had enough variation to be put to use in future breeding initiatives.

Comment [P6]: the results are very good but need more depth in discussing

In Table 02, the genetic variability parameters for variables that attribute yield are estimated. For every character under examination, a higher phenotypic coefficient of variation was discovered than a genotypic one. High GCV and PCV in rice germplasm were observed higher for biological yield, grain yield per plant. The Genotypic coefficient of variation (GCV) ranged from 5.622 to 25.791. High estimates of GCV were recorded for tillers per hill, grain yield per plant, biological yield and harvest index. Moderate estimates of GCV were recorded for and test weight, flag leaf width, panicles per hill, flag leaf length, plant height. The Phenotypic coefficient of variation (PCV) ranged from 6.737 to 26.79. high estimates of PCV were recorded for tillers per hill, grain yield per hill, test weight, spikelets per panicle, biological yield and harvest index. Moderate estimates of PCV were recorded for panicles per hill, flag leaf width, flag leaf length, plant height.

The present investigation, all traits showed the high heritability ranging from 67.082 to 92.678. There is no medium and low heritability values are present. The high heritability values of the considered traits in the present study indicated that those were less influenced by the environment and thus help in effective selection of the traits based on the phenotypic expression by adopting simple selection method and suggested the scope of genetic improvement.

The estimation of Genetic Advance was highest for Number of spikelet's per panicle, Biological yield, Plant height. The lowest Genetic Advance was observed for Test weight, Number of tillers/hill, Panicle length, Number of Panicles/hill, Flag leaf width.

High GAM was observed for Number tillers/hill, Grain yield per hill, Number of spikelets/panicle, Harvest index, Test weight, Flag leaf width, Number of panicles/hill, Flag leaf length. The following characters shows moderate GAM Plant height, Panicle length, Days to 50% flowering.

In the present investigation, Correlation analysis among the yield and its contributing characters revealed that the genotypic correlation coefficients in most cases were higher than their phenotypic correlation coefficients indicating the association was largely due to genetic reason at both phenotypic and genotypic correlation coefficient analysis revealed that Grain yield per hill exhibited positive and significant correlation with Harvest index, Number of panicles/hill, Number of tillers/hill, Number of spikelet's/Panicles, Biological yield.

The results of the path coefficient analysis revealed that at both phenotypic and genotypic level the diagonal values showed Direct, high and Positive effect at harvest index, biological yield, days to 50% flowering with grain yield per hill.

Conclusion

MTU-1224 (54.85gm) and RNR-1446 (41.4gm) genotypes were found to have a higher grain production per hill than the check than the other 23 genotypes (NDR-359). Number of tillers per hill, grain yield per hill, and harvest index all showed high to moderate estimates of GCV, PCV, high heritability, together with high genetic advance as percent mean in the current genotypes, showing a predominance of additive gene impact. Grain yield per hill showed highly significant positive correlation with Harvest index, Number of panicles/hill, and Number of tillers/hill at both the genotypic and phenotypic levels. The diagonal values in the path analysis demonstrated a direct, strong, and positive effect on the harvest index, biological yield, days to 50% blooming, and grain production per hill at both the phenotypic and genotypic levels. These characters provide broad spectrum of variability in segregation and may be used as parents in the future hybridization programme to develop desirable genotypes for grain yield improvement in rice genotypes.

Table 1: Analysis of Variance for 13 quantitative characters of 30 rice genotypesduring *kharif-2021*

Sl.No.	**Source**	**Replication**	**Treatment**	**Error**
	Degrees of freedom	**2**	**22**	**44**
1	**Days to fifty percent flowering**	0.8840	298.813**	29.566
2	**Plant height (cm)**	81.5680	572.228**	57.644
3	**Flag leaf length (cm)**	12.2340	87.718**	4.487
4	**Flag leaf width (cm)**	0.0020	0.146**	0.004
5	**Number of tillers per hill**	0.4630	20.623**	0.529
6	**Number of panicles per hill**	0.5120	8.447**	0.67
7	**Panicle length**	0.2030	12.531**	0.433
8	**Number of spikelets per panicle**	3.4210	7419.237**	376.674
9	**Days to maturity**	1.2170	213.36**	27.081
10	**Biological yield (g)**	26.3390	683.299**	48.042
11	**Harvest index (%)**	1.6080	237.642**	6.544
12	**Test weight (g)**	0.1010	42.325**	5.95
13	**Grain yield per hill (g)**	1.320	192.199**	8.263

*** and ** indicate Significant at 5% and 1% level of significance.**

Table 2 Estimation of variability and genetic parameters for 13 quantitative characters in rice germplasm for *kharif* 2021

Traits	GCV	PCV	h^2 (Broad Sense) (%)	Genetic Advancement 5%	Gen. Adv as % of Mean 5%
Days to fifty percent flowering	8.448	9.74	75.22	16.926	15.093
Plant height (cm)	10.37	11.986	74.847	23.341	18.481
Flag leaf length (cm)	14.135	15.236	86.079	10.067	27.016
Flag leaf width (cm)	17.408	18.083	92.678	0.432	34.524
Number of tillers per hill	25.791	26.79	92.677	5.132	51.146
Number of panicles per hill	16.621	18.647	79.452	2.956	30.52
Panicle length	7.943	8.358	90.314	3.931	15.55
Number of spikelet's per panicle	21.19	22.827	86.173	92.653	40.522
Days to maturity	5.622	6.737	69.631	13.545	9.663
Biological yield (g)	20.557	22.77	81.508	27.063	38.233
Harvest index(%)	20.211	21.052	92.17	17.358	39.971
Test weight (g)	18.859	23.026	67.082	5.875	31.82
Grain yield per hill (g)	24.674	26.284	88.123	15.142	47.714

h^2 =Heritability, GCV= Genotypic Coefficient of Variation, PCV=Phenotypic Coefficient of Variation

Table-3 Correlation Coefficient Analysis

TRAITS		DF50	PH	FLL	FLW	NTT	NPT	PL	NSP	DM	B.Y	H.I	TW	GYP
DF50	P	1	-0.0265	-0.0233	0.2288	-0.2217	-0.2197	-0.1778	0.0373	0.460**	0.276*	-0.763**	-0.377*	-0.370*
	G	1	-0.0312	-0.0305	0.2348	-0.2293	-0.2343	-0.183	0.0471	0.460**	0.315*	-0.798**	-0.381*	-0.390**
PH	P		**1**	0.529**	0.1452	-0.154	-0.2146	0.463**	-0.0766	-0.1494	0.346*	-0.1159	0.401**	-0.0001
	G		1	0.642**	0.1798	-0.201	-0.261*	0.548**	-0.0678	-0.1523	0.407**	-0.1635	0.452**	-0.0476
FLL	P			**1**	-0.0134	-0.2153	-0.283*	0.1796	-0.330*	0.0591	0.0246	-0.1665	0.317*	-0.273*
	G			1	-0.0187	-0.257*	-0.362*	0.1975	-0.372*	0.0629	-0.0149	-0.1782	0.343*	-0.351*
FLW	P				**1**	0.1964	0.0018	0.546**	0.302*	0.115	0.1514	-0.375*	0.0513	-0.1522
	G				1	0.1998	-0.0015	0.583**	0.339*	0.1125	0.1518	-0.395**	0.0562	-0.1791
NTT	P					**1**	0.923**	0.006	0.1228	-0.404**	-0.0546	0.204	0.1926	0.422**
	G					1	0.959**	-0.0066	0.1144	-0.417**	-0.1541	0.22	0.2005	0.392**
NPT	P						**1**	-0.1262	0.216	-0.395**	0.0587	0.256*	0.0935	0.532**
	G						1	-0.1774	0.2136	-0.440**	-0.0625	0.320*	0.1099	0.522**
PL	P							**1**	0.0151	-0.315*	0.352*	-0.1363	0.493**	0.1245
	G							1	-0.006	-0.325*	0.371*	-0.1578	0.520**	0.1021
NSP	P								**1**	-0.0289	0.352*	0.0898	-0.269*	0.350*
	G								1	-0.0283	0.342*	0.0866	-0.288*	0.350*
DM	P									**1**	-0.0449	-0.408**	-0.453**	-0.617**
	G									1	-0.0395	-0.422**	-0.453**	-0.650**
B.Y	P										**1**	-0.393**	0.0932	0.363*
	G										1	-0.436**	0.1039	0.291*
H.I	P											**1**	0.238*	0.540**
	G											1	0.245*	0.572**
TW	P												**1**	0.1956
	G												1	0.2101

DF50: Days to 50% Flowering, **DM**: Days to Maturity, **PH**: Plant Height, **FLL**: Flag Leaf Length, **FLW**: Flag Leaf Width, **NTT**: Number of Total Tillers, **NPT**: Number of Productive Tillers, **PL**: Panicle Length, **BM**: Biological Yield, **H.I**: Harvest Index, **NGPP**: Number of Grains per Panicle, **TW**: Test Weight, **GYP**: Grain Yield per Plant, **P**: Phenotypic, **G**: Genotypic

*, ** indicates 5% and 1% significant, respectively

Table-4 Path Coefficient Analysis

TRAITS		DF50	PH	FLL	FLW	NTT	NPT	PL	NSP	DM	B.Y	H.I	T.W	G.Y.P
DF50	P	**0.2507**	-0.0067	-0.0058	0.0574	-0.0556	-0.0551	-0.0446	0.0093	0.1154	0.0693	-0.1912	-0.0945	-0.370*
	G	**0.2945**	-0.0092	-0.009	0.0692	-0.0675	-0.069	-0.0539	0.0139	0.1355	0.0926	-0.2352	-0.1121	-0.390**
PH	P	0.0032	**-0.1221**	-0.0646	-0.0177	0.0188	0.0262	-0.0566	0.0094	0.0182	-0.0422	0.0141	-0.0489	-0.0001
	G	0.0101	**-0.3246**	-0.2085	-0.0584	0.0653	0.0846	-0.178	0.022	0.0495	-0.1321	0.0531	-0.1467	-0.0476
FLL	P	-0.0004	0.0097	**0.0184**	-0.0002	-0.004	-0.0052	0.0033	-0.0061	0.0011	0.0005	-0.0031	0.0058	-0.273*
	G	-0.008	0.1691	**0.2632**	-0.0049	-0.0677	-0.0952	0.052	-0.0978	0.0166	-0.0039	-0.0469	0.0903	-0.351*
FLW	P	0.0065	0.0041	-0.0004	**0.0285**	0.0056	0.0001	0.0156	0.0086	0.0033	0.0043	-0.0107	0.0015	-0.1522
	G	0.0819	0.0627	-0.0065	**0.349**	0.0697	-0.0005	0.2035	0.1184	0.0393	0.053	-0.1379	0.0196	-0.1791
NTT	P	-0.0479	-0.0333	-0.0465	0.0424	**0.216**	0.1993	0.0013	0.0265	-0.0872	-0.0118	0.0441	0.0416	0.422**
	G	0.6604	0.5791	0.7406	-0.5755	**-0.8803**	-0.763	0.0189	-0.3296	0.822	0.444	-0.6336	-0.5774	0.392**
NPT	P	-0.0026	-0.0025	-0.0033	0	0.0108	**0.0117**	-0.0015	0.0025	-0.0046	0.0007	0.003	0.0011	0.532**
	G	-0.7595	-0.8449	-0.821	-0.0047	0.9097	**0.854**	-0.5749	0.6923	-0.852	-0.2027	1.0374	0.3564	0.522**
PL	P	-0.0134	0.0349	0.0135	0.0411	0.0004	-0.0095	**0.0753**	0.0011	-0.0237	0.0265	-0.0103	0.0371	0.1245
	G	-0.1209	0.3623	0.1305	0.3852	-0.0043	-0.1172	**0.6607**	-0.004	-0.2149	0.245	-0.1043	0.3439	0.1021
NSP	P	-0.0034	0.007	0.0302	-0.0276	-0.0112	-0.0198	-0.0014	**-0.0915**	0.0026	-0.0322	-0.0082	0.0246	0.350*
	G	-0.01	0.0144	0.0788	-0.072	-0.0243	-0.0453	0.0013	**-0.2122**	0.006	-0.0727	-0.0184	0.061	0.350*
DM	P	-0.1576	0.0511	-0.0202	-0.0394	0.1382	0.1353	0.1077	0.0099	**-0.3424**	0.0154	0.1396	0.155	-0.617**
	G	-0.1007	0.0334	-0.0138	-0.0246	0.0913	0.0963	0.0712	0.0062	**-0.2189**	0.0087	0.0924	0.0992	-0.650**
B.Y	P	0.1933	0.2417	0.0172	0.1059	-0.0382	0.041	0.2464	0.2459	-0.0314	**0.6995**	-0.2746	0.0652	0.363*
	G	0.0495	0.0641	-0.0023	0.0239	-0.0243	-0.0098	0.0584	0.0539	-0.0062	**0.1575**	-0.0687	0.0164	0.291*
H.I	P	-0.6755	-0.1026	-0.1475	-0.3321	0.1807	0.2267	-0.1207	0.0795	-0.3609	-0.3476	**0.8856**	0.2108	0.540**
	G	-0.5264	-0.1078	-0.1175	-0.2606	0.1451	0.211	-0.1041	0.0571	-0.2783	-0.2877	**0.6594**	0.1614	0.572**
T.W	P	0.0768	-0.0816	-0.0645	-0.0105	-0.0392	-0.0191	-0.1004	0.0549	0.0922	-0.019	-0.0485	**-0.2037**	0.1956
	G	0.0388	-0.046	-0.0349	-0.0057	-0.0204	-0.0112	-0.053	0.0293	0.0462	-0.0106	-0.0249	**-0.1019**	0.2101

DF50: Days to 50% Flowering, **DM**: Days to Maturity, **PH**: Plant Height, **FLL**: Flag Leaf Length, **FLW**: Flag Leaf Width, **NTT**: Number of Total Tillers, **NPT**: Number of Productive Tillers, **PL**: Panicle Length, **B.Y:** Biological Yield, **H.I**: Harvest Index, **NGPP**: Number of Grains per Panicle, **TW**: Test Weight, **GYP**: Grain Yield per Plant, **P**: Phenotypic, **G**: Genotypic

*, ** indicates 5% and 1% significant,

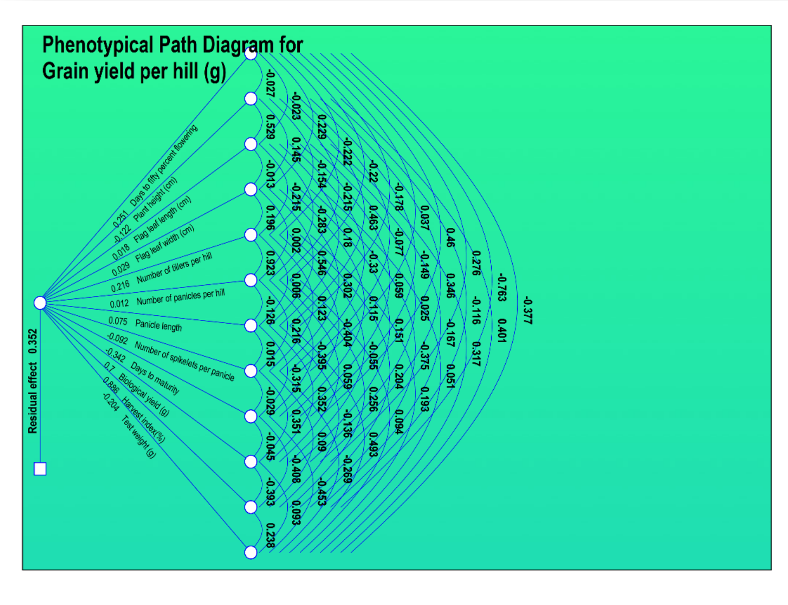

Fig 1 Phenotypical path diagrams for grain yield per hill

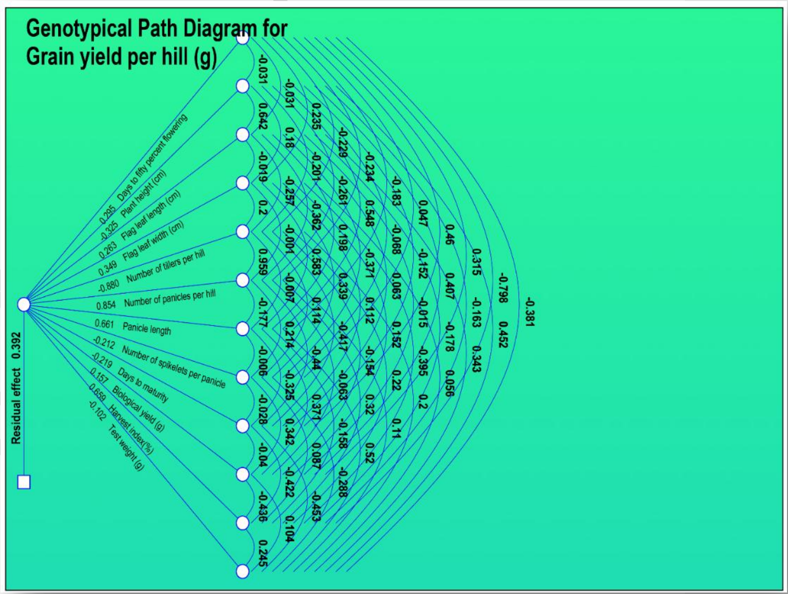

Fig 2 Genotypical path diagram for grain yield per hill

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