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Direct and Indirect Effects of Yield Contributing Characters on Grain Yield in Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

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.

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1. 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 [1-5].

Rice is a self-pollinated crop with a short-day length. Throughout its life cycle, the crop demands a hot and humid climate with average temperatures ranging from 2 to 370 C. Rice is primarily a Kharif crop in India, and it is widely farmed in rain fed areas with high annual rainfall. It is also grown with irrigation in locations where rainfall is scarce. Rice is a staple cuisine in India's eastern and southern regions [6-10].

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 (Santha et al., 2016).

In India, rice is staple food of 65% of the total population. It constitutes about 42% of the total food grain production and 45% of total cereal production. In India, rice is grown in 44.78 million ha, the production level is 115.65 million tons and the productivity is about 2.7 tons/ha during 2018-19 (NRRI-2019).

Genetic variability refers to the presence of difference among the individuals of the plant population. The large spectrum of genetic variability in segregating population depends on the amount of the genetic variability among genotypes and offer better scope for selection. Yield is a complex character, which is influenced by several quantitative traits and is governed by polygenes. Application of biometrical techniques in plant breeding has led to the greater understanding of genetics of quantitative characters and proved to be extremely useful to the plant breeder for systematic genetic analysis [11-18].

Heritability and genetic advance are important selection parameters. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. High heritability should be accompanied with high genetic advance to arrive more reliable conclusion. Expected genetic advance as per cent of mean indicates the mode of gene action in the expression of a trait, which helps in choosing an appropriate breeding method (Kumar et al., 2014).

Correlation is the measure of the mutual relationship between two variables. The study of correlations may help the plant breeder to know how the improvement of one character will bring simultaneous improvement in other characters. Path coefficient analysis is a standardized regression coefficient and measures the direct influence of one variable upon the other. Direct selection for yield is not a reliable approach since it is influenced by the environment. Therefore, it is essential to identify the component characters through which yield can be improved. Selection would be more effective for the trait, which has got high genetic advance and high correlation with grain yield. The use of correlation coefficient is to establish extent of association between yield and yield component and other character, which are having decisive role in influencing the yield (Singh, 2009).

However, it is only genetic variation which is heritable and hence important in any selection programme.

1.1 Objectives

1. To asses genetic variability among 23 rice genotypes for grain yield characters.
2. To estimate the association among grain yield characters among rice genotypes.
3. To study direct and indirect effects of grain yield component characters.

2. MATERIALS AND METHODS

The experimental material for present investigation consists of twenty-three genotypes including one check variety (NDR-359) obtained

Table 1. Analysis of variance for 13 quantitative characters of 30 rice genotypes during 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*

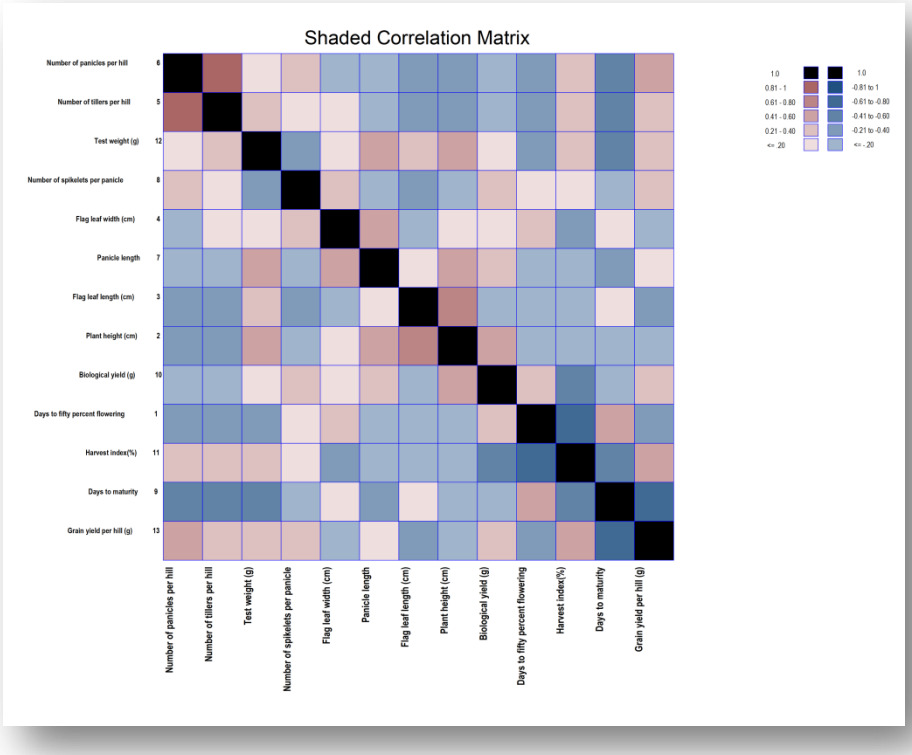

Fig. 1. Genotypical correlation matrix

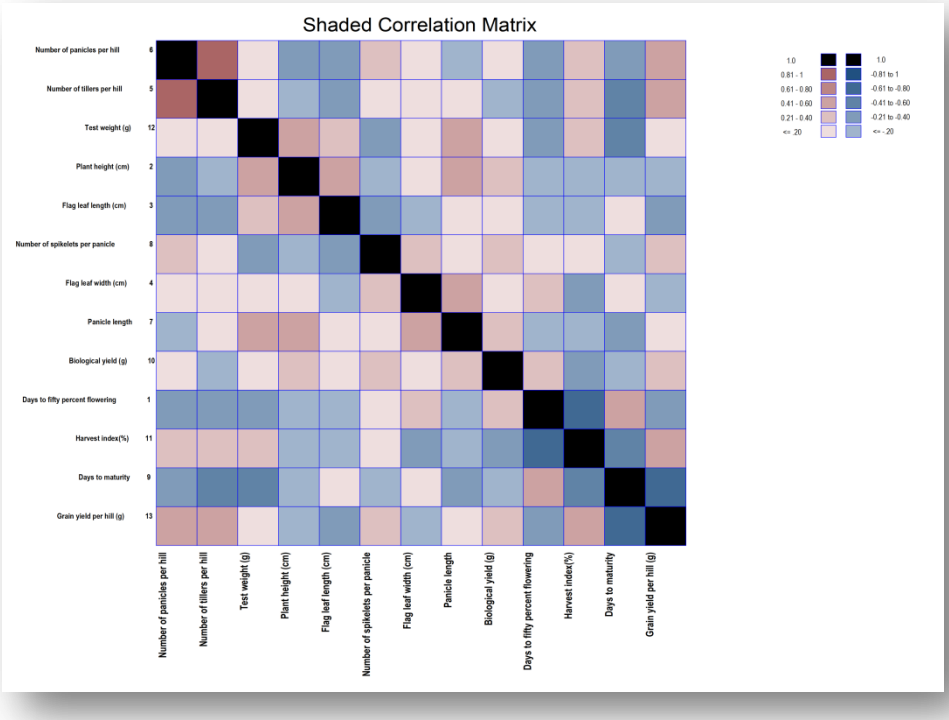

Fig. 2. Phenotypical correlation matrix

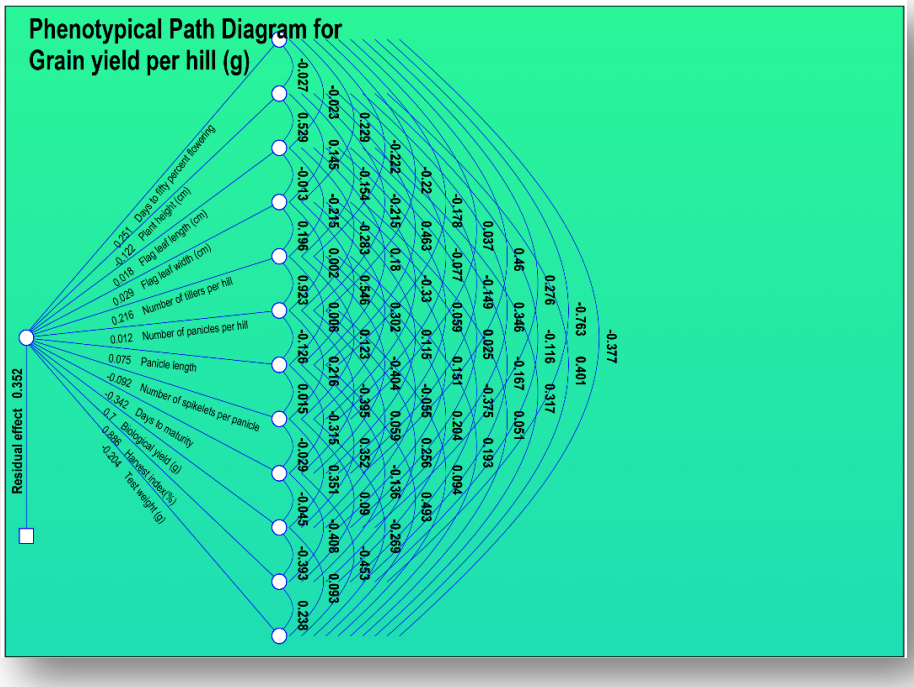

Fig. 3. Phenotypical path diagrams for grain yield per hill

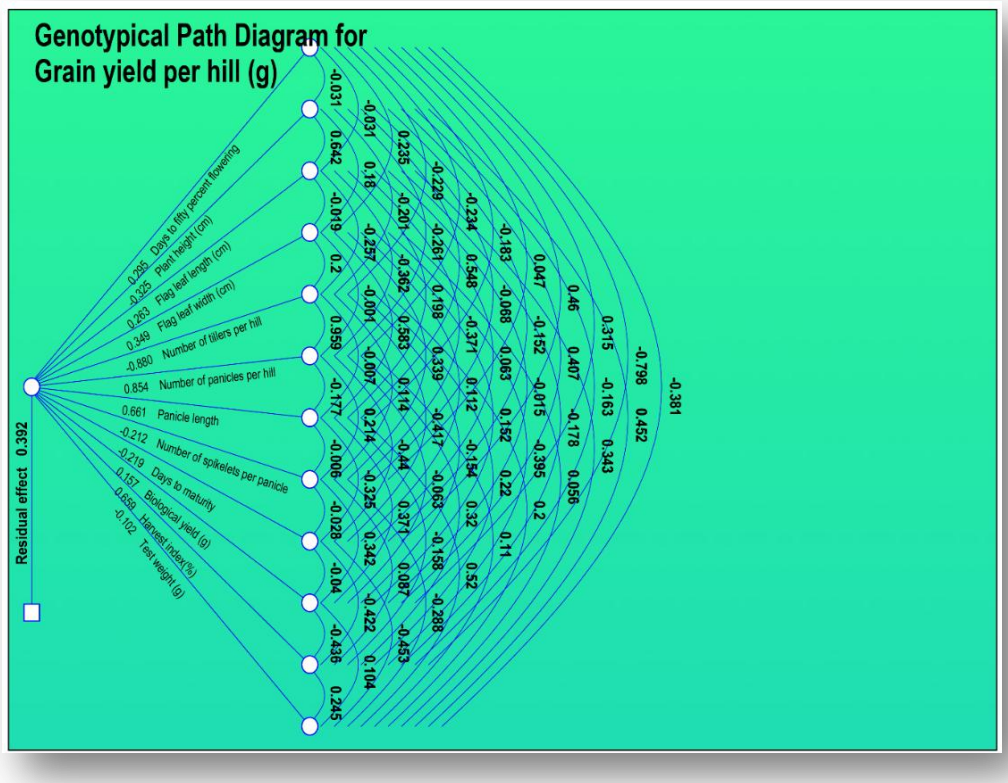

Fig. 4. Genotypical path diagram for grain yield per hill

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.

The software called "R-Language" was used to perform the analysis mentioned above.

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance for Quantitative Characters in Rice (*Oryza sativa* L.)

Analysis of variance for different characters is presented in Table 1. The mean squares due to genotypes showed highly significant differences (α=0.01) for all characters indicating the presence of substantial amount of genetic variability among the rice genotypes. Among 23 genotypes, genotype MTU-1224 (54.85gm), RNR-1446 (41.4gm), SHIVA 555 (39.267gm), MTU-1121 (39.2gm), MTU-1272 (38gm) were found to be superior in grain yield.

In the present study phenotypic coefficient of variation were higher than genotypic coefficient variation indicating that these characters are influenced by the environment for all the characters. Siva Subramanian and Menon (1973) : Classified variability as low if coefficient of variation (<10%), moderate (10-20%) and high (>20%). High PCV and GCV were observed for the Number of tillers/hill (26.79), Grain yield per hill (26.284), Test weight (23.026), Number of spikelet's/hill (22.827), Biological yield (22.77), Harvest index (21.052). Moderate PCV and GCV were observed for the Number of panicles/hill (18.647), Flag leaf width (18.083), Flag leaf length (15.236), Plant height (11.986). Low PCV and GCV were observed for the Days to 50% flowering (9.74), Panicle length (8.358), Days to maturity (6.737).

3.2 Heritability

Johnson et al*.,* (1955) Classified heritability as low (<30%), medium (30-60%), and high (>60%).

The following traits having the higher heritability for Flag leaf width (92.678), Number of tillers/hill (92.677), Harvest index (92.17), Panicle length (90.314), Grain yield/hill (88.123), Number of spikelet's/panicle (86.173), Flag leaf length (86.079), Biological yield (81.508), Number of panicles/hill (79.452), Days to 50% flowering (75.22), Plant height (74.847), Days to maturity (69.631), Test weight (67.082). There is no medium and low heritability values are present.

3.3 Genetic Advance as Percent Mean

The estimation of genetic advance as percent mean is classified as low (<10%), moderate (10 to 20%) and high (>20%) proposed by Johnson et al., 1955.

High GAM was observed for Number tillers/hill (51.146), Grain yield per hill (47.174), Number of spikelet's/panicle (40.522), Harvest index (37.979), Test weight (38.233), Flag leaf width (34.524), Number of panicles/hill (30.52), Flag leaf length (27.016). Moderate GAM Plant height (18.481), Panicle length (15.55), Days to 50% flowering (15.093). Days to maturity (9.663) shows Low GAM.

3.4 Correlation Coefficient of Analysis

In the present investigation, at 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 and also exhibited positive and non significant correlation with Test weight, Panicle length.

Grain yield per hill exhibited negative and significant correlation with Days 50% flowering, Days to maturity, Flag leaf length and also exhibited negative and non significant correlation with Flag leaf width, Plant height.

3.5 Path Analysis

In Path analysis, at both phenotypic and genotypic levels Grain yield per hill exhibited high, Positive and significant at Harvest index, Number of panicles per hill, Numbers tillers per

hill, Number of spikelet's per hill, Biological yield and also exhibited positive and non significant for Test weight, Panicle length.

Grain yield per hill exhibited negative and significant with Days to 50% flowering, Flag leaf length, Days to maturity and also exhibited negative and non significant for Plant height, Flag leaf width.

4. CONCLUSION

Among 23 genotypes MTU-1224 (54.85gm) and RNR-1446 (41.4gm) were found superior over the check (NDR-359). Number of tillers per hill 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 and diagonal values in the path analysis showed a direct, strong, and positive effect with Harvest index at both the genotypic and phenotypic 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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