Heritability and Character Association Among Yield Component Characters and Grain Yield in Rice (*Oryza sativa* L.)

Abstract:

Rice is the only cereal crop cooked and consumed mainly as whole grains, and quality considerations are more important. Rice has been reported to possess diverse therapeutic properties capable of treating diabetics to neurotic ailments as evidenced by ancient literatures apart from its nutritional importance as a major source of calories for a majority of the world population. The present investigation was taken up to study the total of 31 lines of rice including a check variety were evaluated in randomized block design. On the basis of mean performance MTU-1172 was found to be superior in grain yield per hill followed by MTU-1155, MTU-1224, BPT-3291 and MTU-3626 showed higher yield over the check (NDR-359).

Key words : GCV, PCV, Variability, Heritability, genetic advance, rice(*Oryza sativa* L.)

1. Introduction:

Rice (Oryza sativa L.) is one of the staple cereal food crop in the world and belongs to the genus Oryza of family Graminae (Poaceae). The genus includes 24 species out of which 22 are wild and two viz., Oryza sativa and Oryza glaberimma are cultivated. The basic chromosomes number (n) of the genus Oryza sativa is 12 (2n=24). The cultivated varieties of Oryza sativa grouped in to three sub species, Indica, Japonica, and Javanica. Indica rice varieties are grown throughout the tropical and subtropical regions. Japonica varieties are grown throughout the temperate zone, and Javanica varieties are grown mainly in parts of Indonesia.

"Rice is life‟ was the theme of International year of rice 2004 denoting its overwhelming importance as an item of food and commerce **(Pandey et al., 2010)**. Rice is inseparable from our day-to-day life since time immemorial as evident from its use in almost all rituals of our culture. The crop is grown in a diverse geographical and climatic conditions ranging from below sea level in Kuttanad (Kerala) to high altitude in Kashmir valley. Rice is cultivated in a hydrology range of moisture stress upland condition to waterlogged ecology.

Globally, Globally rice is cultivated now in 162.41 million hectares with annual production of around 728 million tones and average productivity of 4.65 tonnes/ha **(USDA, 2018)**. Asia is considered to be „rice bowl‟ of the world, and it produces and consumes more than 90% of world rice. In World, China, India, Indonesia, Bangladesh, Vietnam and Thailand are the major rice producing countries. China is the largest rice producing country of the world. It has 33% share in the rice production of the world. Thailand is the largest rice exporting country of the world. It has 8% share in the rice export of the world.

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 tones and the productivity is about 2.7 Tonnes/ha durin 2018-19 **(NRRI-2019)**. In India, West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab, Bihar and Orissa are the major rice producing states. Chhattisgarh state is known as „rice bowl" of India. It is grown over an area of 3.7 million hectares with an average productivity of 1.3 tons per hectare in 2017 **(Anonymous, 2018)**.

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 varability among genotypes and offer better scope for selection. The magnitude of heritable variation in the traits studied has immense value in understanding the potential of the genotype for further breeding programme. Varability results due to difference either in the genetic constituation of the individuals of a population or in the environment in which they are grown.

For a successful breeding effort, a full understanding of the nature and extent of genetic diversity as well as the relationship of traits in a crop species is required. The ability to see the direct and indirect effects that each character has on yield will be a huge help in the choosing process. The measure of the mutual relationship between two variables is correlation. The study of correlations may aid plant breeders in understanding how improving one feature leads to improvements in other characters. A path coefficient analysis is a standardized regression coefficient that assesses the direct impact of one variable on another.

As a result, it’s critical to determine the component qualities that might help boost yield. Selection would be more successful for a characteristic with a high genetic progress and a strong link to grain output. The correlation coefficient is used to determine the degree of link between yield and yield components, as well as other characteristics that have a significant impact on yield **(Singh, 2009).**

Heritability and genetic advance are important selection parameters. Heritability estimates along with genetic advance are normally more helpful in predicting the grain under selection than heritability estimates alone. Hence knowledge about genetic advance coupled with heritability is most useful. Character exhibiting high heritability may not necessarily give high genetic advance. High heritability should be accompanied with high genetic advance to arrive more reliable conculsion. Expected genetic advance as percent 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)**.

1.1 Objectives

1. To estimate the heritability and genetic advance of yield and its components in rice.
2. To study relationship between yield and yield attributing traits on grain yield in rice.
3. To study direct and indirect effects on grain yield in rice.

2. **Materials and Methods:**

The present investigation was carried out in the Field Experimentation Centre of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, U.P during *Kharif*-2021. A randomized block design was adopted with three replications and row to row spacing is 20cm and plant to plant spacing is 15cm with plot size of 5mx2m.

Replication wise data on the basis of five randomly were recorded on following 13 quantitative traits: 1) Days to 50% flowering, 2) Days to maturity, 3) Flag leaf length, 4) Flag leaf width, 5) Number of total tillers per hill, 6) Number of total panicles per hill, 7) Panicle length, 8) Number of spikelets per panicle, 9) Days to maturity, 10) Biological yield, 11) Harvest index, 12) Test weight, 13) Grain yield per hill.

The recorded for all the considered characters were subjected to analysis of variance with the formula suggested by Panse and Sukhatme . Further, different components of variance i.e., phenotypic, genotypic and environmental variance were estimated and genetic parameters like genotypic coefficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability in broad sense, genetic advance as percent of mean and correlation analysis were conducted by following appropriate statistical procedure.

Crop: Rice
Season: *Kharif*-2021

Experimental design: Randomized Block Design
No.of Replications: 3
No.of Genotypes: 30
Gross area: 228 sq.m
Net cultivated area: 220 sq.m
Row to Row distance: 20 cm
Plant to Plant distance : 15 cm
Date of sowing : 28/06/2021
Date of Transplanting: 21/07/2021
Fertilizer dose: N:P:K @ 120:60:60

3. RESULT AND DISCUSSION

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

The abundant scope for improving these characters including grain yield per plant provided the material is subjected to judicious selection programme. Due to diverse source of material taken as well as environmental influence affecting the phenotypes the presence of variability might be large.

ANOVA for different characters is present 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. In Table 2. Which revealed a wide range of variation for all traits studies the mean values, the coefficient of variation for all traits studies the mean values, the coefficient of variation (C.V.), standard error of the mean (SEm±), the critical difference (C.D.) at 5% and 1%, range of 20 genotypes for 13 quantitative characters are presented.

- The varability is classified as low if coefficient of varation (<10%), moderate (10-20%) and high (>20%) by Siva Subramanian and Menon (1973).
- GCV (%) values ranged between least of 4.529 (Days to maturity) to a highest value of 35.089 (grain yield per hill) PCV (%) 7.78 (Panicle length) to a highest value 36.253 (grain yield per hill)

Fig: 1. Histogram depicting GCV, PCV, Genetic advance and H^2 for 13 quantitative chracters of *rice* genotypes

Table:1. Analysis of variance for 13 quantitative traits of *rice* genotypes

Sl.No.	Source	Replication	Treatment	Error
	Degrees of freedom	2	29	58
1	Days to fifty percent flowering	80.0290	488.085**	94.154
2	Days to maturity	59.0780	264.044*	144.997
3	Flag leaf length (cm)	6.1810	120.908**	2.978
4	Flag leaf width (cm)	0.0010	0.095**	0.003
5	Plant height (cm)	9.4240	451.688**	6.478
6	Number of total tillers per hill	0.3450	10.511**	0.619
7	Number of total panicles per hill	0.1340	9.343**	0.617
8	Panicle length (cm)	1.0210	10.881**	0.618
9	Number of spikelets per panicle	271.3120	4207.97**	310.6
10	Test weight (g)	0.5440	46.025**	1.717
11	Biological yield (g)	0.9430	1519.738**	72.135
12	Harvest index (%)	2.1530	384.566**	4.861
13	Grain yield per hill(g)	1.2420	514.73**	11.317

Table:2. Genetic parameters for 13 quantitative characters in *rice* genotypes

Genetic Parameters													
Characters	Days to fifty percent flowering	Days to maturity	Flag leaf length (cm)	Flag leaf width (cm)	Plant height (cm)	Number of total tillers per hill	Number of total panicles per hill	Panicle length (cm)	Number of spikelets per panicle	Test weight (g)	Biological yield (g)	Harvest index (%)	Grain yield per hill(g)
GCV	10.245	4.529	16.19	13.461	9.552	18.014	17.119	7.16	15.776	19.821	27.599	24.429	35.089
PCV	13.424	9.771	16.792	14.113	9.758	19.633	18.849	7.78	17.561	20.941	29.59	24.894	36.253
h2 (Broad Sense)	58.24	21.487	92.958	90.972	95.818	84.186	82.489	84.692	80.705	89.586	86.995	96.301	93.682
Genetic Advancement 5%	18.015	6.015	12.453	0.344	24.565	3.432	3.191	3.506	66.702	7.493	42.206	22.743	25.828
Gen.Adv as % of Mean 5%	16.105	4.325	32.156	26.448	19.261	34.048	32.029	13.574	29.196	38.647	53.028	49.384	69.963

Table: 3. Genotypic correlation coefficient between yield and its components traits in *rice*

Genotypical Correlation Matrix													
Characters	**Days to percent flowering**	**Days to maturity**	**Flag leaf length (cm)**	**Flag leaf width (cm)**	**Plant height (cm)**	**Number o tillers hill**	**Number o panicles hill**	**Panicle length (cm)**	**Number o spikelet panicle**	**Test weight (g)**	**Biological yield (g)**	**Harvest index (%)**	**Grain yield per hill**
Days to fifty percent flowerin	1.0000	1.1334	0.1520	0.501**	0.247*	-0.1307	-0.1389	-0.0852	0.1964	-0.450**	0.0470	-0.507**	-0.263*
Days to maturity		1.0000	0.1368	0.646**	0.394**	-0.280*	-0.304*	0.243*	0.0772	-0.303*	0.0585	-0.435**	-0.334*
Flag leaf length (cm)			1.0000	0.263*	0.724**	-0.0238	-0.0284	0.465**	0.0150	0.429**	0.282*	0.1555	0.291*
Flag leaf width (cm)				1.0000	0.357**	-0.640**	-0.609**	0.411**	0.0641	-0.1260	0.340*	-0.499**	-0.1444
Plant height (cm)					1.0000	-0.1465	-0.1516	0.580**	0.0594	0.449**	0.565**	-0.1526	0.229*
Number of total tillers per hi						1.0000	0.995**	-0.240*	0.0404	0.307*	0.1271	0.639**	0.627**
Number of total panicles per h							1.0000	-0.265*	0.0786	0.301*	0.1640	0.629**	0.636**
Panicle length (cm)								1.0000	0.1406	0.382**	0.430**	-0.1405	0.1503
Number of spikelets per panicl									1.0000	-0.1810	0.315*	-0.2052	0.1105
Test weight (g)										1.0000	0.314*	0.639**	0.585**
Biological yield (g)											1.0000	-0.0960	0.640**
Harvest index (%)												1.0000	0.660**
Grain yield per hill													1.0000

Table: 4. Phenotypic correlation coefficient between yield and its components traits in *rice*

Phenotypical Correlation Matrix													
Characters	**Days to percent flowering**	**Days to maturity**	**Flag leaf length (cm)**	**Flag leaf width (cm)**	**Plant height (cm)**	**Number o tillers hill**	**Number o panicles hill**	**Panicle length (cm)**	**Number of spikelet panicle**	**Test weight (g)**	**Biological yield (g)**	**Harvest index (%)**	**Grain yield per hi**
Days to fifty percent flowerin	1.0000	0.448**	0.1050	0.380**	0.1831	-0.1451	-0.1351	-0.1048	0.1419	-0.319*	0.0292	-0.395**	-0.2026
Days to maturity		1.0000	0.0710	0.280*	0.1766	-0.1992	-0.1989	0.0287	0.0817	-0.0933	-0.0017	-0.220*	-0.1752
Flag leaf length (cm)			1.0000	0.246*	0.708**	-0.0388	-0.0511	0.409**	0.0070	0.403**	0.253*	0.1447	0.270*
Flag leaf width (cm)				1.0000	0.342**	-0.589**	-0.564**	0.388**	0.0392	-0.1074	0.306*	-0.471**	-0.1400
Plant height (cm)					1.0000	-0.1294	-0.1307	0.522**	0.0648	0.417**	0.538**	-0.1469	0.232*
Number of total tillers per hi						1.0000	0.982**	-0.1926	0.0747	0.248*	0.1815	0.584**	0.617**
Number of total panicles per h							1.0000	-0.218*	0.1031	0.242*	0.209*	0.567**	0.615**
Panicle length (cm)								1.0000	0.1521	0.335*	0.402**	-0.1266	0.1549
Number of spikelets per panicl									1.0000	-0.1784	0.337*	-0.1666	0.1529
Test weight (g)										1.0000	0.271*	0.573**	0.514**
Biological yield (g)											1.0000	-0.1029	0.656**
Harvest index (%)												1.0000	0.638**
Grain yield per hi													1.0000

Table: 5. Direct and indirect effects of yield components in grain yield in rice at genotypic level

PATH matrix of Grain yield per hill(g)													
Characters	**Days to percent flowering**	**Days to maturity**	**Flag leaf length (cm)**	**Flag leaf width (cm)**	**Plant height (cm)**	**Number o tillers hill**	**Number o panicles hill**	**Panicle length (cm)**	**Number o spikelet panicle**	**Test weight (g)**	**Biological yield (g)**	**Harvest index (%)**	**Grain yield per hill**
Days to fifty percent flowerin	-0.8178	-0.9269	-0.1243	-0.4096	-0.2021	0.1069	0.1136	0.0697	-0.1606	0.3677	-0.0384	0.4144	-0.263*
Days to maturity	-0.4204	-0.3710	-0.0507	-0.2398	-0.1462	0.1038	0.1126	-0.0901	-0.0286	0.1123	-0.0217	0.1612	-0.334*
Flag leaf length (cm)	-0.0195	-0.0175	-0.1282	-0.0338	-0.0928	0.0030	0.0036	-0.0597	-0.0019	-0.0550	-0.0361	-0.0199	0.291*
Flag leaf width (cm)	0.8176	1.0551	0.4300	1.6323	0.5821	-1.0446	-0.9933	0.6704	0.1047	-0.2056	0.5555	-0.8142	-0.1444
Plant height (cm)	0.1664	0.2653	0.4873	0.2401	0.6734	-0.0986	-0.1021	0.3906	0.0400	0.3025	0.3801	-0.1027	0.229*
Number of total tillers per hi	-1.3004	-2.7837	-0.2366	-6.3686	-1.4577	9.9519	9.8968	-2.3923	0.4025	3.0501	1.2647	6.3550	0.627**
Number of total panicles per h	1.2435	2.7179	0.2544	5.4483	1.3574	-8.9034	-8.9530	2.3736	-0.7037	-2.6945	-1.4684	-5.6339	0.636**
Panicle length (cm)	0.0709	-0.2019	-0.3870	-0.3416	-0.4824	0.1999	0.2205	-0.8317	-0.1169	-0.3174	-0.3578	0.1168	0.1503
Number of spikelets per panicl	0.1003	0.0394	0.0077	0.0327	0.0303	0.0207	0.0401	0.0718	0.5106	-0.0924	0.1607	-0.1048	0.1105
Test weight (g)	0.1544	0.1040	-0.1472	0.0433	-0.1543	-0.1052	-0.1034	-0.1311	0.0622	-0.3434	-0.1080	-0.2195	0.585**
Biological yield (g)	0.0170	0.0211	0.1017	0.1228	0.2037	0.0459	0.0592	0.1552	0.1136	0.1134	0.3609	-0.0346	0.640**
Harvest index (%)	-0.2749	-0.2358	0.0844	-0.2706	-0.0828	0.3464	0.3414	-0.0762	-0.1113	0.3467	-0.0521	0.5425	0.660**
Grain yield per hill	-0.263*	-0.334*	0.291*	-0.1444	0.229*	0.627**	0.636**	0.1503	0.1105	0.585**	0.640**	0.660**	1.0000
Partial R^2	0.2150	0.1239	-0.0373	-0.2358	0.1540	6.2358	-5.6955	-0.1250	0.0564	-0.2007	0.2308	0.3582	

Table: 6. Direct and indirect effects of yield components in grain yield in rice at phenotypic level

PATH matrix of Grain yield per hill(g)													
Characters	**Days to percent flowering**	**Days to maturity**	**Flag leaf length (cm)**	**Flag leaf width (cm)**	**Plant height (cm)**	**Number o tillers hill**	**Number o panicles hill**	**Panicle length (cm)**	**Number o spikelet panicle**	**Test weight (g)**	**Biological yield (g)**	**Harvest index (%)**	**Grain yield per hi**
Days to fifty percent flowerin	0.0693	0.0310	0.0073	0.0263	0.0127	-0.0101	-0.0094	-0.0073	0.0098	-0.0221	0.0020	-0.0274	-0.2026
Days to maturity	-0.0121	-0.0269	-0.0019	-0.0075	-0.0048	0.0054	0.0054	-0.0008	-0.0022	0.0025	0.0000	0.0059	-0.1752
Flag leaf length (cm)	0.0060	0.0041	0.0571	0.0141	0.0404	-0.0022	-0.0029	0.0234	0.0004	0.0230	0.0145	0.0083	0.270*
Flag leaf width (cm)	-0.0066	-0.0049	-0.0043	-0.0175	-0.0060	0.0103	0.0099	-0.0068	-0.0007	0.0019	-0.0053	0.0082	-0.1400
Plant height (cm)	-0.0133	-0.0129	-0.0515	-0.0249	-0.0728	0.0094	0.0095	-0.0380	-0.0047	-0.0304	-0.0392	0.0107	0.232*
Number of total tillers per hi	-0.0460	-0.0632	-0.0123	-0.1868	-0.0410	0.3172	0.3114	-0.0611	0.0237	0.0787	0.0576	0.1852	0.617**
Number of total panicles per h	0.0362	0.0533	0.0137	0.1510	0.0350	-0.2629	-0.2678	0.0583	-0.0276	-0.0649	-0.0559	-0.1518	0.615**
Panicle length (cm)	-0.0007	0.0002	0.0026	0.0025	0.0033	-0.0012	-0.0014	0.0064	0.0010	0.0021	0.0026	-0.0008	0.1549
Number of spikelets per panicl	-0.0017	-0.0010	-0.0001	-0.0005	-0.0008	-0.0009	-0.0012	-0.0018	-0.0121	0.0022	-0.0041	0.0020	0.1529
Test weight (g)	0.0400	0.0117	-0.0504	0.0134	-0.0522	-0.0311	-0.0303	-0.0419	0.0223	-0.1252	-0.0339	-0.0718	0.514**
Biological yield (g)	0.0232	-0.0014	0.2015	0.2433	0.4280	0.1443	0.1660	0.3196	0.2681	0.2154	0.7951	-0.0818	0.656**
Harvest index (%)	-0.2968	-0.1652	0.1087	-0.3535	-0.1104	0.4387	0.4257	-0.0951	-0.1252	0.4305	-0.0773	0.7512	0.638**
Grain yield per hi	-0.2026	-0.1752	0.270*	-0.1400	0.232*	0.617**	0.615**	0.1549	0.1529	0.514**	0.656**	0.638**	1.0000
Partial R^2	-0.0140	0.0047	0.0154	0.0024	-0.0169	0.1957	-0.1646	0.0010	-0.0018	-0.0643	0.5217	0.4792	

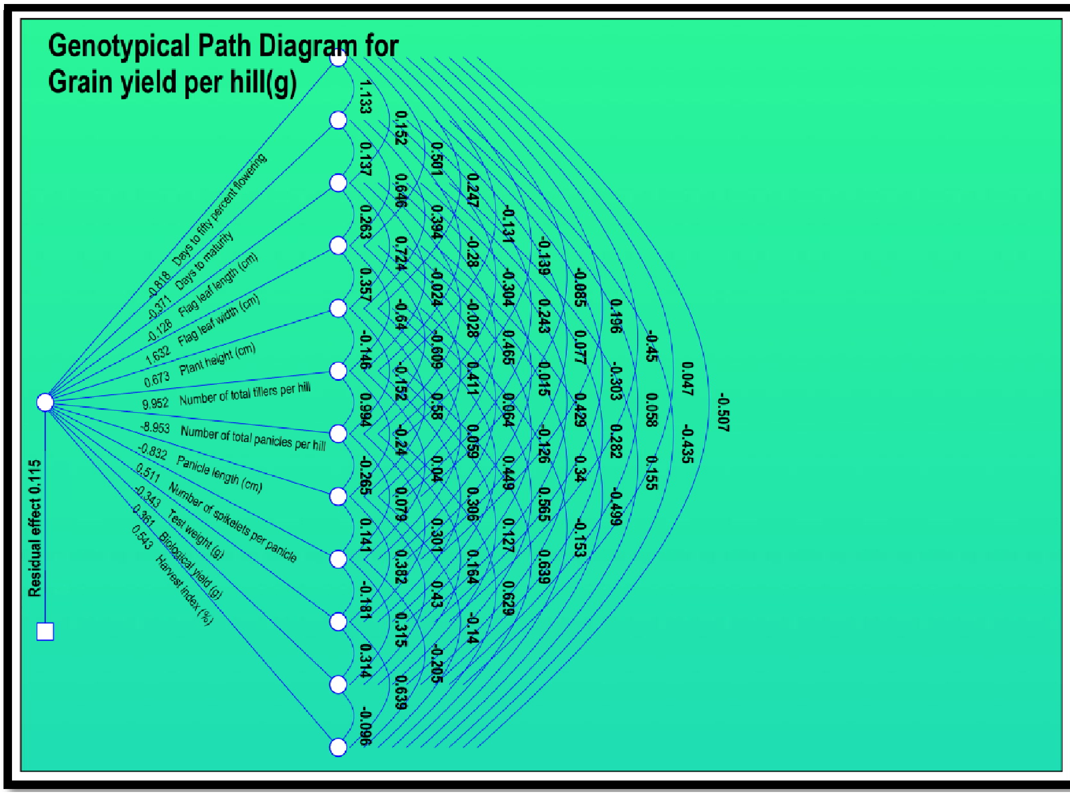

Fig:2 Genotypic path Diagram for grain yield per hill (g)

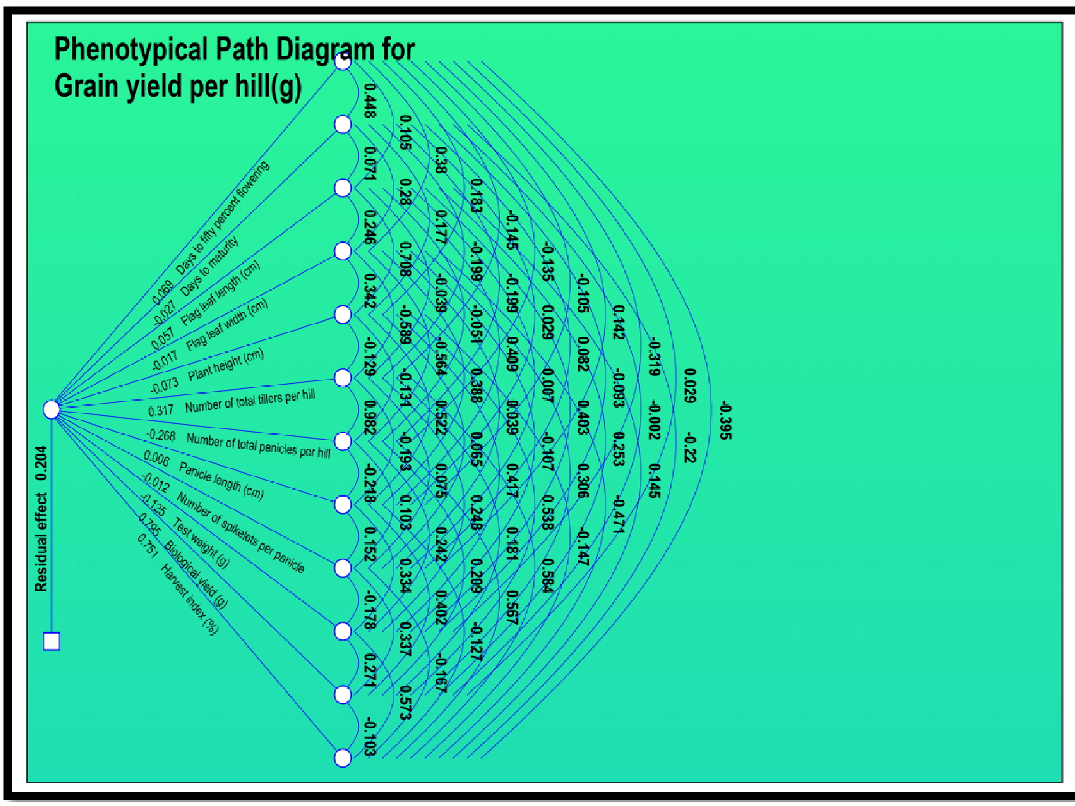

Fig:3 Phenotypic path Diagram for grain yield per hill (g)

Heritability:

The present investigation, all traits showed the high heritability ranging from 21.487 % to 96.301% Plant height (95.818%) showed the highest heritability among all the characters followed by grain yield per hill (93.682%), Flag leaf length (92.958%). Moderate range heritability showed by days to fifty percent flowering (58.24%) and low range heritability has not observed among these characters.

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 genetopic improvement.

Genetic advance as percent mean:

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

In the present investigation all the characters showed highest genetic advance as a percent of mean present in grain yield per hill (69.96%) followed by biological yield (53.02%), harvest index (49.38%), test weight(38.64%), number of tillers per hill (34.04%), flag leaf length (32.15%), number of paniclesper hill (32.02%), number of spikelets per panicle (29.19%).

Moderate estimates of geneticadvance as per cent mean was recorded for plant height (19.26%), days to 50% flowering(16.10%), panicle length(13.57%).

Lowest estimates of genetic advance as percent mean was observed for days to maturity(4.32%).

Correlation analysis:

Correaltion analysis among the yield and its contributing characters revealed that the genotypic correlation coefficients is most cases were higher than their phenotypic correlation coefficients indicating the association was largely due to genetic reason. At the both genotypic and phenotypic levels, significant positive correlations were observed for Number of total tillers per hill, Number of panicles per hill, Test weight, Biological yield, Harvest index.

Path coefficient Analysis:

Path coefficient analysis is an important tool for partitioning the correlation coefficient into direct and indirect effects of an independent variable and dependent variable though correlation gives information about the component traits associated with the charcters, they could not provide an exact picture of relative importance of the direct and indirect contribution of the component charcter. At the both genotypic and phenotypic levels, have high positive direct effect with Flag leaf width, Plant height, Number of total panicles per hill, Panicle length, Number of spikelets per panicle, Test weight, Harvest index.

4. Conclusion:

This study evaluated the genetic variability parameters for yield and its contributing factors in rice genotypes. Genetic variability foremost important breeding tool in order to break yield stagnation and developing high yielding varieties. The study of correlations my aid plant breeders in understanding how improving one feature leads to improvements in other characters.

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