

Association studies in red rice mutant lines of IRGA-318-11-6-9-2B

ABSTRACT

Rice is the important cereal food crop. It provides 20 per cent of the world's dietary energy and predominant dietary energy source. It is estimated that the demand for rice will be 137.30 million tonnes by 2050. In order to achieve this, the production per unit area needs to be increased by mutation in turn creating variation. Induced mutants were grown in the field during *Kharif* 2022 at the Zonal Agricultural and Horticultural Research Station, Brahmavar, Udupi District, Karnataka. The experiment was carried out in acidic soil with pH of 5.27, EC of 0.053 dS m⁻¹, Fe of 14.16 mg, kg⁻¹, and Zn of 1.93 mg kg⁻¹ which is located at the latitude 13° 25' North and 75°45' East longitude. Grain yield had positive correlations with several traits including number of productive tillers, number of grains per panicle, panicle weight, spikelet fertility, flag leaf length and width but negative correlations with days to fifty per cent flowering, days to maturity, and plant height. Days to maturity, flag leaf length, plant height, panicle weight, number of productive tillers per plant per plant, number of grains per panicle, spikelet fertility and grain length showed a direct positive effect on grain yield. This indicated the effectiveness of direct selection for these traits in improvement of grain yield per plant. Days to fifty per cent flowering, flag leaf width, panicle length, test weight, number of filled grains per panicle, panicle length, and grain breadth had negative direct effects on grain yield per plant. **The abstract has a similarity index of these authors (A. Srijan*, S. Sudheer Kumar, Ch. Damodar Raju, R. Jagadeeshwar(2016). Character association and path coefficient analysis for grain yield of parents and hybrids in rice (*Oryza sativa* L.) Journal of Applied and Natural Science. Vol. 8 (1) : 167 –172 as shown below.**

Keywords: BARC, RCBD

Grain yield per plant had significant positive correlation with productivity per day (0.97), panicle weight (0.71), number of filled grains per panicle (0.57), panicle length (0.46), number of productive tillers per plant (0.34), days to 50 per cent flowering (0.23) and plant height (0.16). Path analysis revealed that productivity/ day (0.91) was the major contributor for grain yield followed by, days to 50 per cent flowering (0.19), grain length (0.05), number of productive tillers per plant (0.04), panicle weight (0.04) and number of filled grains per panicle (0.04). **similarity index**

INTRODUCTION

Rice (*Oryza sativa* L.) is an annual C₃ cereal crop with a diploid chromosome number of 2n = 2x = 24, classified under the genus *Oryza* and the family *Poaceae*. It is most popular and important staple food for nearly half of the world's population and in general is consumed widely as polished white rice after milling. Rice with a red bran layer is called as red rice. **(citation is needed to remove plagiarism)** Though, the colour is confined to the bran layer, a tinge of red remains even after milling and unmilled red rice has a higher nutrient content than polished white rice (Hossain, 2004). Traditional red rice varieties are grown in India and many other rice growing countries since ancient times. However, have disappeared from commercial cultivation in early nineties and remained confined to few areas.

Crop improvement through mutagenesis helps to obtain superior mutants for different traits. The purpose of mutation induction is to enhance the mutation rate in a short duration for developing new variants. Spontaneous mutation sometimes is not able to provide genetic variability rapidly and

accurately, therefore inducing mutations artificially is an important tool to improve and increase the productivity of crop plants (Ahloowalia and Maluszynsky, 2001).

To determine the degree of association of characters with yield and also among the yield components, the correlation coefficients were calculated. Phenotypic correlation coefficient helps in determining selection index which may be useful for overall improvement of yield. It is the magnitude of relationship between various plant characters that determines the component characters on which selection can be made for further improvement in yield and quality parameters. It may be either due to pleiotropic action of genes or linkage. If the correlation between yield and a character is due to the direct effect of the character, it reflects a true relationship between them and selection can be practiced for such characters in order to ameliorate yield. But, if the correlation is mainly due to indirect effect of the character through another component trait, the breeder has to select for the trait through which the indirect effect is expected. A great yield response is obtained when the character for which indirect selection is practiced which intern, has a high heritability and positive correlation with yield. Phenotypic coefficient of correlation between two characters are determined by using the variance and covariance components as suggested by Al-Jibouri *et al.* (1958).

MATERIAL AND METHODS

Induced mutants were grown in the field during *Kharif* 2022 at the Zonal Agricultural and Horticultural Research Station, Brahmavar, Udupi District, Karnataka. The experiment was carried out in acidic soil with pH of 5.27, EC of 0.053 dS m⁻¹, Fe of 14.16 mg, kg⁻¹, and Zn of 1.93 mg kg⁻¹ which is located at the latitude 13° 25' North and 75°45' East longitude.

IRGA-318-11-6-9-2B line, International Network for Genetic Evaluation of Rice, (INGER), International Rainfed Lowland Rice Observational Nursery, Module 2 from IRRI, Philippines is a mid-duration (130-135 days) variety with long slender red seeds, erect flag leaf, 95 cm tall, submergence tolerance up to 8-10 days, non-lodging and is resistant to gall midge. Initially, 200 seeds of this variety were exposed to 15kR, 25kR, 35kR and 45kR gamma ray treatment from Cobalt 60 at BARC Mumbai.

Plant to progeny method was followed to forward the individual plants from M₁ to M₂. Plants with semi-dwarf, earliness, and medium bold red grain type that were primarily selected and forwarded to M₃ from each treatment (15, 25, 35 and 45kR) and mutants showing severe diseases incidence like false smut, blast, brown leaf spot, lodging type were rejected. Healthy plants attributing good agronomic traits compared with parent were selected and forwarded to the M₄ generation. The material for the present study consists of 25, 11, 21 and 2 lines from the 15kR, 25kR, 35kR and 45kR gamma treatments respectively, total of 59 M₅ mutant lines with one untreated parent check (IRGA-318-11-6-9-2B) were grown in the *Kharif* 2022.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with two replications. A total of 59 mutant lines (25, 11, 21 and 2) from each treatment and one untreated parent check were randomized and sown in each replication. The spacing was maintained with the plant-to-plant spacing of 15 cm within a row and row-to-row spacing of 20cm in 5 square meter area.

Correlation coefficient and Path analysis was carried out using RStudio software, *Version* 4.3.1 by using packages, '*metan*' and '*variability*'.

RESULTS AND DISCUSSION

The analysis of variance of all mutant lines and one untreated parent check in the M₆ generation with respect to fifteen quantitative traits revealed that the mutant lines exhibited highly significant mean sum of squares for all the traits studied indicating the presence of genetic variability. The analysis of variance for yield and yield related traits are presented in Table 1.

Correlation is an amount of degree and direction of association of one variable with other variables and governs how these aspects vary together or whether there is any relationship between any two such characters. In order to find the nature of association present within the characters, phenotypic correlation was evaluated among the fifteen characters. The results of correlation coefficient are presented in Table 2.

Grain yield per plant (g) exhibited positive and significant association with the traits like flag leaf length ($r = 0.2754$), flag leaf width ($r = 0.2531$), number of productive tillers per plant ($r = 0.6473$), number of grains per panicle ($r = 0.3184$), number of filled grains per panicle ($r = 0.4762$), spikelet fertility ($r = 0.4112$), panicle length ($r = 0.3655$) and panicle weight ($r = 0.5007$). These results are in accordance with Ekka *et al.* (2015) for panicle length, Reddy *et al.* (2018) for flag leaf length and flag leaf width, Lakshmi *et al.* (2021) for number of productive tillers per plant and number of grains per panicle, Fentie *et al.* (2021) for number of filled grains per panicle, Kulsum *et al.* (2022) for panicle weight and Kiran *et al.* (2023) for spikelet fertility.

For grain yield per plant the traits like, test weight ($r = 0.1138$), grain length ($r = 0.0596$), grain breadth ($r = 0.1374$) exhibited positive and non-significant association, days to fifty *per cent* flowering ($r = -0.1453$) and days to maturity ($r = -0.1107$) exhibited non-significant and negative association. Plant height ($r = -0.1932$) exhibited significant and negative association. These findings were analogous to the works of, Gangashetty *et al.* (2013) for days to fifty *per cent* flowering, days to maturity, plant height, Allam *et al.* (2015) for grain length, Sameera *et al.* (2016) for test weight and Priyanka (2021) for grain breadth.

The Path coefficient analysis was computed to estimate the contribution of individual traits to grain yield. It is performed to understand the causes and effects of chain relationships of different yield contributing traits with yield. The path coefficient analysis was conducted using grain yield as dependent variable and all other traits studied as independent variables. In this study, the phenotypic direct and indirect effects of different traits on grain yield are presented in Table 3.

Out of fourteen characters, phenotypic path, nine characters had a positive and direct effect on grain yield through days to maturity (0.47175), flag leaf length (0.11801), plant height (0.03055), panicle weight (5.32089), number of productive tillers per plant (0.78001), number of grains per panicle (0.04676), spikelet fertility (0.21734) and grain length (0.12409) This indicated the effectiveness of direct selection for these traits in improvement of grain yield per plant. The traits such as, days to fifty *per cent* flowering (-0.57250), flag leaf width (-0.03980), panicle length (-0.06850), number of filled grains per panicle (-4.83880), test weight (-1.03440) and grain breadth (-0.00020) had negative direct effects on grain yield. These results were similar to the results depicted by Edukondalu *et al.* (2017) for number of filled grains per panicle, test weight, grain breadth, Archana *et al.* (2018) for plant height, Bagudam *et al.* (2018) for number of productive tillers per plant, Dhavaleshvar *et al.* (2019) for days to maturity, Sari *et al.* (2019) for flag leaf length and spikelet fertility, Deepthi *et al.* (2022) for days to fifty *per cent* flowering, test weight, panicle length and Kulsum *et al.* (2022) for panicle weight and number of grains per panicle.

CONCLUSION

The trait grain yield per plant had significant positive correlation with traits like flag leaf length, flag leaf width, panicle length, panicle weight, number of productive tillers per plant, number of grains per panicle, number of filled grains per panicle and spikelet fertility, indicating that these trait improvements can enhance the grain yield per plant. Very low residual effect of 0.1611 depicted that the traits included in the study explained high percentage of variation in grain yield. Days to maturity, flag leaf length, plant height, panicle weight, number of productive tillers per plant, number of grains per panicle, spikelet fertility and grain length had positive and direct effect on grain yield at phenotypic path analysis. Hence, selection for these traits would be more rewarding for yield improvement strategy.

The grain yield per plant had a significant positive correlation with traits such as flag leaf length, flag leaf width, panicle length, panicle weight, number of productive tillers per plant, number of grains per panicle, number of filled grains per panicle, and spikelet fertility. This indicates that improving these traits

can enhance grain yield per plant. A residual effect of 0.1611 indicates that the traits included in the study explain a high percentage of variation in grain yield. Days to maturity, flag leaf length, plant height, panicle weight, number of productive tillers per plant, grains per panicle, spikelet fertility, and grain length have a positive and direct effect on grain yield according to phenotypic path analysis. Thus, selecting these traits would be more rewarding for a yield improvement strategy.

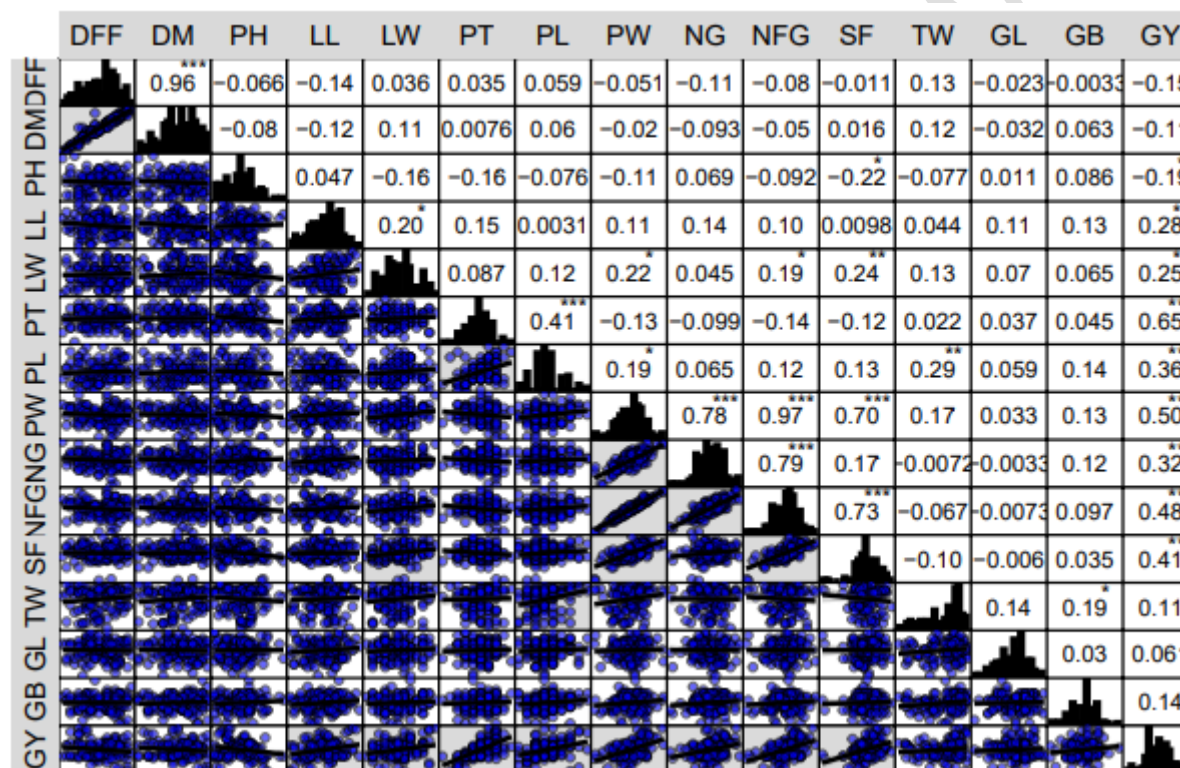
REFERENCES

- Ahloowalia, B. S. and Maluszynski, M., 2001, Induced mutations -A new paradigm in plant breeding. *Euphytica.*, **118**: 167-73.
- Al-Jibouri., 1958, Genetic variability and correlation studies in chillies. *Progressive Horticulture.*, **36**: 113-117.
- Allam, C. R., Jaiswal, H. K. and Qamar, A., 2015, Character association and path analysis studies of yield and quality parameters in basmati rice (*Oryza sativa* L.). *The Bioscan*, **9**(4): 1733-1737.
- Archana, R., Sudha, M., Vishnu, V. and Fareeda, G., 2018, Correlation and path coefficient analysis for grain yield, yield components and nutritional traits in rice (*Oryza sativa* L.). *International Journal of Chemical Studies.*, **6**(4): 189-195.
- Bagudam, R., Eswari, K. B., Badri, J. and Rao, P. R., 2018, Correlation and path analysis for yield and its component traits in NPT core set of rice (*Oryza sativa* L.). *International Journal of Current Microbiology and Applied Sciences.*, **7**(9): 97-108.
- Deepthi, K. P., Mohan, Y. C., Hemalatha, V., Yamini, K. N. and Singh, T. V. J., 2022, Genetic variability and character association studies for yield and yield related, floral and quality traits in maintainer lines of rice (*Oryza sativa* L.). *The Pharma Innovation Journal.*, **11**(2): 191-197.
- Dhavaleshvar, M., Malleshappa, C. and Kumar, D. M. B., 2019, Variability, correlation and path analysis studies of yield and yield attributing traits in advanced breeding lines of rice (*Oryza sativa* L.). *International Journal of Pure and Applied Bioscience.*, **7**: 267-273.
- Edukondalu, B., Reddy, V. R., Rani, T. S., Kumari C. H. A. and Soundharya, B., 2017, Studies on variability, heritability, correlation and path analysis for yield, yield attributes in rice (*Oryza sativa* L.). *International Journal of Current Microbiology and Applied Sciences.*, **6**(10): 2369-2376.
- Ekka, R. E., Sarawgi, A. K. and Kanwar, R. R., 2015, Genetic variability and inter-relationship analysis for various yield attributing and quality traits in traditional germplasm of rice (*Oryza sativa* L.). *Plant Archives*, **15**(2): 637- 645.
- Fentie, D. B., Abera, B. B. and Ali, H. M., 2021, Association of agronomic traits with grain yield of lowland rice (*Oryza sativa* L.) genotypes. *International Journal of Agricultural Science.*, **8**(3): 2348-3997.
- Gangashetty, P., Salimath, P. and Hanamaratti, N., 2013, Genetic variability studies in genetically diverse non-basmati local aromatic genotypes of rice (*Oryza sativa* L.). *RiceGenomics and Genetics.*, **4**(2): 4-8.
- Hossain, M., 2004, FAO rice conference.
- Kiran, A. K., Sharma, D. J., Subbarao, L. V., Gireesh, C. and Agrawal, A. P. 2023., Correlation coefficient and path coefficient analysis for yield, yield attributing traits and nutritional traits in rice genotypes. *The Pharma Innovation Journal.*, **12**(2): 1978-1983.
- Kulsum, U., Sarker, U. and Rasul, M. G., 2022, Genetic variability, heritability and interrelationship in salt-tolerant lines of T. Aman rice. *Genetika*, **54**(2): 761-776.

- Lakshmi, M. S., Suneetha, Y. and Srinivas, T., 2021, Genetic variability, correlation and path analysis for grain yield and yield components in rice genotypes. *Journal of Pharmacognosy. Phytochemistry.*, **10**(1): 1369-1372.
- Priyanka, K., 2021. Characterization of rice genotypes for morphological, physiological and quality traits. *M.Sc (Ag.) Thesis*. Acharya N.G. Ranga Agricultural University, Guntur, India.
- Reddy, O. R., Lal, G. M. and Lal, S. S., 2018, Genetic variability and correlation studies for yield and quality traits of elite medium duration rice (*Oryza sativa* L.) hybrids. *International Journal of Advanced Research in Biological Sciences.*, **8**(2): 165-173.
- Sameera, S. K., Srinivas, T., Rajesh, A. P., Lakshmi, V. J and Nirmala, P. J., 2016, Variability and path co-efficient for yield and yield components in rice. *Bangladesh Journal of Agricultural Research.*, **41**(2): 259-271
- Sari, W. K., Nualsri, C., Junsawang, N. and Soonsuwon, W., 2019. Path analysis for yield and its components in F₁ upland rice hybrids and their parental lines. *Songklanakarin Journal of Science and Technology.*, **41**(6): 1421-1427.

UNDER PEER REVIEW

Table 1: Estimates of phenotypic correlation for fifteen yield and yield attributing traits in the mutant lines of M₆ generation of red rice IRRI line IRGA-318-11-6-9-2B



Where,
 DFF- Days to fifty *per cent* flowering PH- Plant height (cm) NG- Number of grains per panicle DM- Days to maturity GB- Grain breadth (cm)
 GL- Grain length (cm) SF- Spikelet fertility (%) LL- Flag leaf length (cm) PT- Number of productive tillers per plant
 TW- Test weight (g) LW- Flag leaf width PL- Panicle length (cm) GY- Grain yield per plant (g)

Table 2: Analysis of variance for yield and yield components in the mutant lines of M₆ generation of red rice IRRI line IRGA-318-11-6-9-2B

Source of Variation	Degrees of freedom	Days to 50 %flowering	Days to maturity	Plant height(cm)	Leaf length (cm)	Leaf width (cm)	Panicle length (cm)	Number of productive tillers per plant	Panicle weight (g)
Replication	1	0.075	0.075	17.633	1.408	0.0009	0.300	1.408	0.128
Mutant lines	59	31.85**	23.24**	103.49**	25.14**	0.11**	6.00**	287.09**	0.41**
Error	59	3.74	2.80	10.51	5.65	0.0033	1.32	34.09	0.08
CD (5%)		3.87	3.35	6.49	4.75	0.12	2.30	1.52	0.57
CD (1%)		5.14	4.46	8.63	6.32	0.15	3.05	2.02	0.76
CV (%)		1.90	1.28	3.96	9.47	5.23	6.03	6.95	10.76

Source of variation	Degrees of freedom	Number of grains per panicle	Number of filled grains per panicle	Spikelet fertility (%)	Test weight (g)	Grain length (cm)	Grain breadth (cm)	Grain yield per plant (g)
Replication	1	53.33	200.21	6.88	0.0096	0.00012	0.00000083	5.80
Mutant lines	59	578.02**	711.39**	92.00**	0.86**	0.0013**	0.00045**	59.17**
Error	59	111.59	140.67	22.94	0.13	0.00041	0.00011	17.09
CD (5%)		21.14	23.73	9.58	0.73	0.04	0.02	8.27
CD (1%)		28.12	31.57	12.75	0.97	0.05	0.03	11.00
CV (%)		8.11	11.14	5.90	1.53	2.86	3.42	15.53

Table 3: Estimates of phenotypic path coefficient analysis for fifteen yield and yield attributing traits in the mutant lines of M₆ generation of red rice IRR1 line IRGA-318-11-6-9-2B

	DFF	DM	PH	LL	LW	PT	PL	PW	NG	NFG	SF	TW	GL	GB	r Values
DFF	-0.57250	0.45085	-0.00201	-0.01630	-0.00140	0.02691	-0.00403	-0.27315	-0.00514	0.38662	-0.00239	-0.13017	-0.00265	0.00009	-0.14530
DM	-0.54722	0.47175	-0.00245	-0.01460	-0.00435	0.00632	-0.00410	-0.10798	-0.00437	0.24146	0.00348	-0.12251	-0.00309	-0.02302	-0.11068
PH	0.03773	-0.03778	0.03055	0.00561	0.00631	-0.12605	0.00521	-0.56181	0.00320	0.44517	-0.04736	0.07974	0.00104	-0.03476	-0.19320*
LL	0.07907	-0.05835	0.00145	0.11801	-0.00808	0.11521	-0.00028	0.59869	0.00646	-0.49694	0.00191	-0.04567	0.01245	-0.04853	0.27540**
LW	-0.02004	0.05123	-0.00481	0.02379	-0.03980	0.06607	-0.00851	1.19632	0.00211	-0.92953	0.05312	-0.13711	0.00012	0.00016	0.25310**
PT	-0.01975	0.00380	-0.00494	0.01740	-0.00339	0.78001	-0.02816	-0.68850	-0.00454	0.66146	-0.02630	-0.02413	0.00451	-0.02013	0.64734**
PL	-0.03366	0.02825	-0.00232	0.00048	-0.00498	0.32066	-0.06850	1.03863	0.00300	-0.59082	0.02821	-0.30291	0.00638	-0.05693	0.36549**
PW	0.02926	-0.00953	-0.00321	0.01322	-0.00897	-0.10047	-0.01331	5.32089	0.03443	-4.68684	0.15251	-0.17885	0.00201	-0.05043	0.50071**
NG	0.06298	-0.04410	0.00209	0.01631	-0.00181	-0.07574	-0.00440	4.16467	0.04676	-3.84732	0.03827	0.00777	-0.00032	-0.04675	0.31841**
NFG	0.04575	-0.02354	-0.00281	0.01212	-0.00770	-0.10663	-0.00836	5.17763	0.03718	-4.83880	0.15974	0.06908	-0.00083	-0.03665	0.47620**
SF	0.00630	0.00755	-0.00666	0.00104	-0.00979	-0.09438	-0.00889	3.75092	0.00823	-3.55651	0.21734	0.10718	-0.00059	-0.01055	0.41119**
TW	-0.07197	0.05575	-0.00235	0.00520	-0.00530	0.01817	-0.02004	0.92316	-0.00035	0.32333	-0.02249	-1.03440	0.01588	-0.07085	0.11379
GL	0.01357	-0.01307	0.00028	0.01326	0.00001	0.03151	-0.00391	0.00050	-0.00014	0.03581	-0.00115	-0.14726	0.12409	0.00610	0.05960
GB	-0.00120	0.02925	0.00286	0.01542	-0.00230	0.04228	-0.01050	0.72592	0.00589	-0.47759	0.00617	-0.19759	-0.00099	-0.00020	0.13741

Residual effect (P) = 0.1611

Where,

DFF- Days to fifty *per cent* flowering
 GL- Grain length (cm)
 TW- Test weight (g)

PH- Plant height (cm)
 SF- Spikelet fertility (%)
 LL- Flag leaf length (cm)

NG- Number of grains per panicle
 GB- Grain breadth (cm)
 LW- Flag leaf width

DM- Days to maturity
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 PT- Number of productive tillers per plant
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