

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% 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, Udipi District, Karnataka the results showed 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 *percent* 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.

Keywords: Mutants, Correlation, Association, Grain yield, Selection

INTRODUCTION

Rice (*Oryza sativa* L.) is an annual C_3 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. 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-Jibouriet *al.* (1958).

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MATERIAL AND METHODS

48 Induced mutants were grown in the field during *Kharif 2022* at the Zonal Agricultural and
49 Horticultural Research Station, Brahmavar, Udupi District, Karnataka. The experiment was carried out in
50 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
51 located at the latitude 13° 25' North and 75°45' East longitude.

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

58 Plant to progeny method was followed to forward the individual plants from M₁ to M₂. Plants with
59 semi-dwarf, earliness, and medium bold red grain type that were primarily selected and forwarded to
60 M₃ from each treatment (15, 25, 35 and 45kR) and mutants showing severe diseases incidence like
61 false smut, blast, brown leaf spot, lodging type were rejected. Healthy plants attributing good agronomic
62 traits compared with parent were selected and forwarded to the M₄ generation. The material for the
63 present study consists of 25, 11, 21 and 2 lines from the 15kR, 25kR, 35kR and 45kR gamma
64 treatments respectively, total of 59 M₅ mutant lines with one untreated parent check (IRGA-318-11-6-9-
65 2B) were grown in the *Kharif 2022*.

66 The experiment was laid out in a Randomized Complete Block Design (RCBD) with two replications. A
67 total of 59 mutant lines (25, 11, 21 and 2) from each treatment and one untreated parent check were
68 randomized and sown in each replication. The spacing was maintained with the plant-to-plant spacing of
69 15 cm within a row and row-to-row spacing of 20cm in 5 square meter area.

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

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RESULTS AND DISCUSSION

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

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

82 Grain yield per plant (g) exhibited positive and significant association with the traits like flag leaf
83 length ($r = 0.2754$), flag leaf width ($r = 0.2531$), number of productive tillers per plant ($r = 0.6473$), number
84 of grains per panicle ($r = 0.3184$), number of filled grains per panicle ($r = 0.4762$), spikelet fertility ($r =$
85 0.4112), panicle length ($r = 0.3655$) and panicle weight ($r = 0.5007$). These results are in accordance with
86 Ekka *et al.* (2015) for panicle length, Reddy *et al.* (2018) for flag leaf length and flag leaf width, Lakshmi
87 *et al.* (2021) for number of productive tillers per plant and number of grains per panicle, Fentie *et al.*
88 (2021) for number of filled grains per panicle, Kulsum *et al.* (2022) for panicle weight and Kiran *et al.*
89 (2023) for spikelet fertility.

90 For grain yield per plant the traits like, test weight ($r = 0.1138$), grain length ($r = 0.0596$), grain
91 breadth ($r = 0.1374$) exhibited positive and non-significant association, days to fifty *per cent* flowering ($r =$
92 -0.1453) and days to maturity ($r = -0.1107$) exhibited non-significant and negative association. Plant
93 height ($r = -0.1932$) exhibited significant and negative association. These findings were analogous to the

94 works of, Gangashetty *et al.* (2013) for days to fifty *per cent* flowering, days to maturity, plant height, Allam
95 *et al.* (2015) for grain length, Sameera *et al.* (2016) for test weight and Priyanka (2021) for grain breadth.

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

101 Out of fourteen characters, phenotypic path, nine characters had a positive and direct effect on
102 grain yield through days to maturity (0.47175), flag leaf length (0.11801), plant height (0.03055), panicle
103 weight (5.32089), number of productive tillers per plant (0.78001), number of grains per panicle
104 (0.04676), spikelet fertility (0.21734) and grain length (0.12409) This indicated the effectiveness of direct
105 selection for these traits in improvement of grain yield per plant. The traits such as, days to fifty *per cent*
106 flowering (-0.57250), flag leaf width (-0.03980), panicle length (-0.06850), number of filled grains per
107 panicle (-4.83880), test weight (-1.03440) and grain breadth (-0.00020) had negative direct effects on
108 grain yield. These results were similar to the results depicted by Edukondalu *et al.* (2017) for number of
109 filled grains per panicle, test weight, grain breadth, Archana *et al.* (2018) for plant height, Bagudam *et al.*
110 (2018) for number of productive tillers per plant, Dhavaleshvar *et al.* (2019) for days to maturity, Sari *et al.*
111 (2019) for flag leaf length and spikelet fertility, Deepthi *et al.* (2022) for days to fifty *per cent* flowering, test
112 weight, panicle length and Kulsum *et al.* (2022) for panicle weight and number of grains per panicle.

113 CONCLUSION

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

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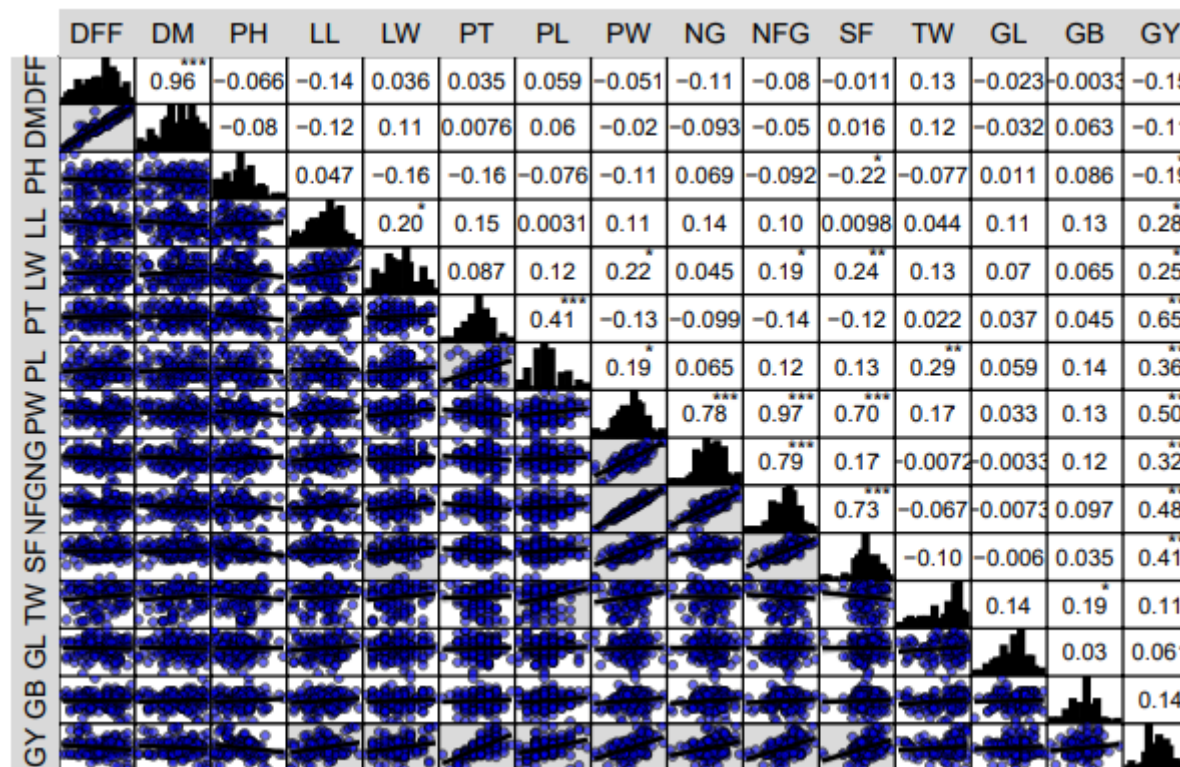
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85 **Table2: Estimates of phenotypic correlation for fifteen yield and yield attributing traits in the mutant lines of M₆ generation of red rice IRRI line IRGA-**
 86 **318-11-6-9-2B**



99 Where,
 00 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)
 01 GL- Grain length (cm) SF- Spikelet fertility (%) LL- Flag leaf length (cm) PT- Number of productive tillers per plant
 02 TW- Test weight (g) LW- Flag leaf width PL- Panicle length (cm) GY- Grain yield per plant (g)
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 04

Table 1: 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 PH- Plant height (cm) NG- Number of grains per panicle DM- Days to maturity NFG- Number of filled grains per panicle
 GL- Grain length (cm) SF- Spikelet fertility (%) GB- Grain breadth (cm) PT- Number of productive tillers per plant
 TW- Test weight (g) LL- Flag leaf length (cm) LW- Flag leaf width PL- Panicle length (cm)