J Krishi Vigyan 2022, 11 (1) : 386-393 DOI : 10.5958/2349-4433.2022.00164.7

Variability, Heritability and Genetic Advance Estimates of Rice Varieties After Mutagenesis

Jyothilekshmi S*, Dijee Bastian , Rose Mary Francies and Lekshmi S L

Onattukara Regional Agricultural Research Station, Kayamkulam,
Alappuzha COA, Kerala Agricultural University Thrissur (Kerala)

ABSTRACT

The present study was conducted for assessing the variability, heritability and genetic advance estimates of upland rice varieties *viz.,* Swarnaprabha and Vaisakh having susceptibility to lodging after treating with gamma rays of dose 375 - 550 Gy. The germination percentage, shoot and root length were inversely related to increase in radiation dose. Correlation studies pointed out that yield is having strong positive correlation with panicle length, panicles per plant, days to maturity and harvest index and direct selection for these independent characters can enhance the yield.

Keyword :

INTRODUCTION

Mutation breeding is one of the plant breeding approaches by which the limiting trait can be corrected either by physical or chemical mutagenesis so that the existing variety can be upgraded either for quality parameters or for yield. The application of mutation techniques by gamma rays and other physical and chemical mutagens has generated a vast amount of genetic variability and is having significance in plant breeding experiments (Hajos,2009). For carrying out mutagenesis lethal dose LD_{50} has to be fixed and the variety meant to be upgraded will be subjected to radiation. Mutation induces variability and the variability can be used for further breeding programmes. The variability generated can be transferred to the progenies and it is expressed as heritability. According to Rangare *et al* (2012) estimates of heritability are more advantageous when expressed in terms of genetic advance. Yield being a dependent trait can be enhanced by improvement of other independent traits by character association. Natural and induced mutations in gene for gibberellin 20 oxidase enabled the production of semi dwarf varieties which revolutionized the grain production through green revolution (Ashikari *et al*, 2012).

MATERIALS AND METHOD

Swarnaparbha (PTB 43) and Vaisakh(PTB 60) suited for upland cultivation but having lodging susceptibility were used as the material for the study. Field experiments were laid out at the upland rice fields of College of Agriculture, Kerala Agricultural University. Cobalt 60 from gamma chamber facility of Tamil nadu Agricultural University was used as the source for gamma rays and seeds before treating were checked for the germination percentage. 50 g seeds each of both the varieties with 12-13 per cent moisture content were packed in paper covers after removing the impurities. The radiation dose was fixed at an interval of 25 Gy starting from 375 Gy upto 550 Gy.

Based on germination test, LD_{50} was fixed for each variety using probit analysis (Cheema and Atta, 2003). Based on probit analysis two effective doses were selected for each variety viz. 400 Gy and 450 Gy for Swarna Prabha and for Vaishak 375 Gy and 450 Gy. M_1 generation was raised using the effective doses and observations were recorded on the fourteenth day for shoot and root growth. Data for various biometrical characters like panicle length (cm), panicles per plant, plant height (cm),

Corresponding Author's Email: jyothilekshmi.s@kau.in

days to maturity, harvest index and yield per plant (gm) were noted and seeds from each plant collected separately for raising M_2 generation.

All the cultural practices and plant protection activities were done as per the Package of Practices r ecommended by Kerala Agricultural University. From the computed analysis of variance, the mean square expectations were calculated. Different estimates of variance were worked out. The phenotypic and genotypic coefficient of variation were calculated (Burton and Devane, 1952). Heritability in broad sense was estimated as per Lush(1940). Heritability is high if the percentage is more than 60%, moderate if it is between 30-60% and low if it is less than 30%. Genetic advance was estimated following the method suggested by Johnson *et al* (1955) and it is low if values are from 0-10%, moderate if it is 10-20% and high if it is 20% and above.

RESULTS AND DISCUSSIONS

Germination study

Study on germination of seeds after treatment was recorded and LD_{50} was estimated. From the germination study it was noted that the germination per cent decreased with increase in radiation dose for both varieties and is depicted in Table 1. As radiation dose increased significant reduction was noticed compared to the control and is presented in Fig 1 and Fig 2. Average shoot and root length decreased with increase in the dose of radiation and the same is in conformity with the results obtained by Amirikhah *et al*.(2021) and the result is given in Table 2. Chlorophyll variants and albinos were noted on leaves and culm at 400 Gy dose for Swarna Prabha and at 450 Gy for Vaishak.

LD_{50} fixation

As suggested by Ramchander *et al* (2014) lethal dose of a variety need to be fixed for mutation induction and it varies depending on the biological material used for treatment. The germination percentage of seeds and survival rate of seedlings is inversely proportional to the increase in radiation dose. From the probit data, lethal dose was fixed at 426 Gy for variety Swarna Prabha and at 398 Gy for variety Vaishak and it is presented in Table 3 and 4.

Mean and Range of Different characters

The value of different genetic parameters varied depending on the mutants and is represented in Table 5. Highest panicle length of 27.10 cm was recorded by Vaishak mutant line and the lowest of 12.65 cm was observed in Swarna Prabha mutant line. The mean value was 25.43 cm and almost all Vaishak mutant lines recorded panicle length above the mean value and for most Swarna Prabha mutant lines the value were lower than the population mean. The panicles per plant ranged from 6.15 (Swarna Prabha mutant line) to 8.2 (Vaishak mutant line) while the general mean was 7.23. Most of the Vaishak mutant lines performed better than the parent and for most Swarna Prabha mutant lines panicle numberwas found to be less than the general mean.

The mean plant height in the population was 122.95 cm. Plant height ranged from 115.42 cm (Swarna Prabha mutant line) to 125.08 cm (Vaishak parent). Almost all the Vaishak mutant lines showed plant height above this mean value. Lowest harvest index (0.31) was obtained for Swarna Prabha mutant line and the highest value (0.37) was obtained for Vaishak mutant line . The mean harvest index was 0.34. Most of the mutant lines in both the varieties recorded lower harvest index than the corresponding parents.

Grain yield showed an average value of 7.58 g and Vaisakh mutant line recorded the highest value of 8.31 g. whereas Swarnaprabha mutant line recorded lowest value for grain yield of 6.76 g. Das *et al* (2007) and Bucheyek *et al* (2009) also noted high variability for panicle length while significant differences in panicles per plant was reported by Karthikeyan *et al* (2010). Sasikala and Kalaiyarasi (2010) also reported significant difference in plant height.

Estimation of coefficient of variation

Coefficient of variation was found to be high for plant height but there was no much significant variation observed between lines for different characters.

Heritability and genetic advance

Heritability was maximum for panicles per plant and it ranged between 23.29 for yield per plant to 68.05 for panicle per plant. High heritability for panicles per plant is a good selection criterion for yield enhancement. High heritability with low genetic advance was noticed for panicles per plant and the result was in conformity with the study of Nair and Rosamma (2007). Heritability estimates are good selection criteria for selection of elite genotypes from variable population (Essam and Yehia, 2021). So the selection for panicle per plant can enhance the yield since high heritability was noticed for panicles per plant.

Correlation studies

Correlations at both genotypic and phenotypic levels were calculated from variance and covariance analysis for all possible combinations of six characters. High genotypic correlation coefficients were noted than phenotypic correlation coefficients for the characters studied and there was significant inter correlations as given in Table 6. It indicated the presence of strong association between the characters under study. Significant positive correlations were noted for panicles per plant with panicle length, plant height, days to maturity, and harvest index at both genotypic and phenotypic levels. Panicle length recorded highly significant positive correlation with panicles per plant, plant height, days to maturity and harvest index. Plant height had highly significant positive correlation with panicles per plant, panicle length, days to maturity and harvest index, but had negative correlation with yield per plant. Days to maturity showed highly significant positive correlation with panicles per plant, panicle length, plant height and harvest index.

Highly significant positive correlation of harvest index with panicles per plant, panicle length, plant height and days to maturity were noted. Characters such as panicle length, panicles per plant, days to maturity and harvest index showed positive correlation with yield but negative correlation was recorded for plant height. These results were in agreement with that obtained by Limbani *et al* (2017) for positive correlation of panicle length and panicle number with yield and priya *et al* (2017) for positive correlation of days to maturity and harvest index with yield.

CONCLUSION

Variability is imperative for breeding programme and mutation breeding is one of the breeding strategies which can create variability. But the optimum dose of mutagen needs to be standardized for treating the seeds. Yield being a dependent trait can be influenced by many independent traits and variability in these independent traits can positively influence the yield.

Correlation studies revealed that yield was having strong positive correlation with panicle length, panicles per plant, days to maturity and harvest index. So yield can be enhanced by selecting genotypes with high performance for these characters. The presence of variability in mutant revealed the fact that mutation can be induced in rice varieties using physical mutagen. Coefficient of variation was found to be high for plant height in M_2 generation and it is expected to be a good source of selection in the next segregating generations. The variability thus generated can be directly selected or can be used for future breeding programmes.

Table 1.Germination percentage for control and irradiated seeds of Swarna prabha and Vaisakh

Radiation Dose	Number of seeds	Swarna Prabha	Vaishak	Percentage over control for Swarnaprabha	Percentage over control for Vaisakh
375	100	65	52.5	78.79	61.55
400	100	50	60	60.61	70.34
425	100	52.5	30	63.64	35.17
450	100	67.5	45	81.82	52.75
475	100	45	37.5	54.55	43.96
500	100	17.5	30	21.21	35.17
525	100	28	22.5	33.94	26.38
550	100	27.5	32.5	33.33	38.10
Control	100	82.5	85.3		

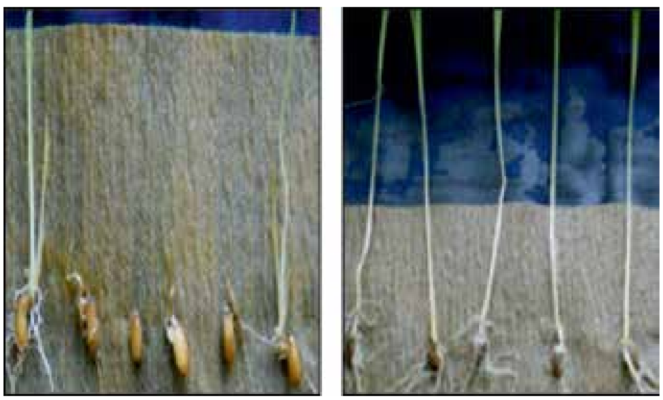

Fig 1. Comparative germination of irradiated and untreated seeds

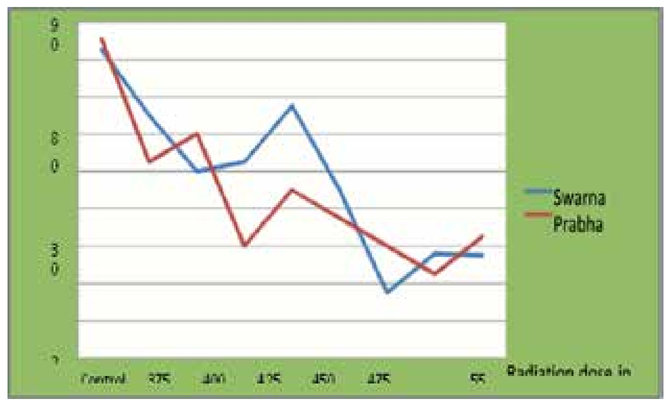

Fig 2. Germination per cent of irradiated seeds of Swarnaprabha and Vaishak

Table 2. Shoot and Root length of non irradiated and irradiated seeds of Swarnaprabha and Vaisakh

	Swarnaprabha		Vaisakh	
Radiation dose	**Shoot length (cm)**	**Root length (cm)**	**Shoot length (cm)**	**Root length (cm)**
Control	18.7	11.9	16.3	9.73
375 Gy	4.5	6.63	2.15	5.55
400 Gy	2.5	3.45	3.5	5.08
425 Gy	1.7	4.43	1.53	3.93
450 Gy	3.45	5.43	5.25	4.65
475 Gy	1.55	3.67	1.34	2.88
500 Gy	0.88	3.75	0.88	1.75
525 Gy	1.07	3.85	0.88	3.9
550 Gy	1.09	2.68	0.83	4.4

Table 3. Probit analysis in Swarnaprabha

Dose (Gy)	No(n)	Germination	x	Empirical probit	Expected probit	y	ω	n ω	nωx	nωy	nωx²	nωy²	nωxy
375	100	65	2.574	5.38	5.05	5.378	0.6005	60.05	154.57	322.95	397.87	1736.8	831.29
400	100	50	2.602	5	5.25	4.991	0.6343	63.43	165.04	316.58	429.45	1580.0	823.75
425	100	52.5	2.628	5.07	5.15	5.074	0.6343	63.43	166.71	321.84	438.17	1633.0	845.91
450	100	67.5	2.653	5.47	5.35	5.467	0.5809	58.09	154.14	317.62	408.98	1736.4	842.72
475	100	45	2.676	4.87	4.93	4.874	0.6343	63.43	169.77	309.16	454.43	1506.8	827.50
500	100	17.5	2.698	4.08	4.14	4.085	0.4714	47.14	127.23	192.58	343.39	786.70	519.76
525	100	28	2.720	4.42	4.51	4.419	0.5578	55.78	151.74	246.52	412.77	1089.4	670.57
550	100	27.5	2.740	4.42	4.53	4.417	0.5578	55.78	152.87	246.41	418.92	1088.4	675.25
Total							467.1	1242.1	2273.7	3304.0	11157.8	6036.79	

$x = \frac{\Sigma n\omega x}{\Sigma n\omega} \times 100 = 2.64$, $y = \frac{\Sigma n\omega y}{\Sigma n\omega} \times 100 = 4.86$,

Regression equation, y = y + b (x- x), x = 2.63, antilog 2.63 = 426.5

y- working probit, w- weighting coefficient, n- number of samples, x-log dose

Table 4. Probit analysis in Vaisakh

Dose (Gy)	No.	Germination	x	Empirical probit	Expected probit	y	ω	n ω	nωx	nωy	$nωx^2$	$nωy^2$	nωxy
375	100	52.5	2.574	5.08	5.6	5.013	0.636	63.6	163.708	318.826	421.390	1598.27	820.670
400	100	60	2.602	5.25	5.4	5.25	0.616	61.6	160.286	323.4	417.076	1697.85	841.506
425	100	30	2.628	4.48	5.05	4.496	0.58	58	152.446	260.768	400.688	1172.41	685.399
450	100	45	2.653	4.87	5.1	4.874	0.634	63.4	168.213	309.011	446.306	1506.12	819.873
475	100	37.5	2.676	4.69	5.25	4.676	0.616	61.6	164.884	288.041	441.344	1346.88	770.999
500	100	30	2.698	4.48	5.17	4.486	0.58	58	156.540	260.188	422.497	1167.20	702.239
525	100	22.5	2.720	4.26	4.87	4.32	0.531	53.1	144.440	229.392	392.901	990.973	623.982
550	100	32.5	2.740	4.56	5.2	4.571	0.6	60	164.421	274.26	450.575	1253.64	751.571
Total								479.3	1274.9	2263.88	3392.78	10733.37	6016.24

Ƹnωx   Ƹnωy

x = ———— X 100 =2.6, y = ———— X 100 = 4.73,

Ƹnω   Ƹnω

Regression equation, y = y + b (x- x), x = 2.61, antilog 2.61 = 398

y- working probit, w- weighting coefficient, n- number of samples, x-log dose

Sl. No.	Characters	Mean ± SE	Range	Coefficient of variability		h^2 (Broad sense) (%)	Genetic Advance	GA as per cent of means (%)
1	PL	25.43 ± 0.96	12.65 -27.10	5.37	0.9359	50.25	1.41	5.56
2	PN	7.23 ± 0.24	6.15 - 8.20	5.99	0.1277	68.05	0.607	8.40
3	PH	122.95 ± 0.87	115.42-125.08	1.22	1.4628	65.52	2.02	1.64
4	HI	0.34 ± 0.01	0.31-0.37	3.76	0.0001	45.57	0.012	3.53
5	Y	7.58 ± 0.30	6.76-8.31	3.62	0.0175	23.29	0.132	1.73

Table 6. Phenotypic and genotypic correlation between yield and yield contributing traits in M2 generation of rice

Traits	Panicles per plant	Panicle length	Plant height	Days to maturity	Harvest index	Grain yield
Panicles per plant	1	0.9636**	0.5831**	0.9665**	0.8658**	0.0369
Panicle length	0.6066**	1	0.6583**	0.8851**	0.7109**	0.1041
Plant height	0.3850**	0.4397**	1	0.6459**	0.5906**	-0.0619
Days to maturity	0.7540**	0.5696**	0.4751**	1	0.9206**	0.0224
Harvest index	0.5212**	0.4035**	0.3484**	0.5787**	1	0.0003
Grain yield	0.2663**	0.2246*	-0.1256	0.1499	0.0242	1

REFERENCES

Amrikhah Rahim, Nematollah Etemadi, Mohammad R S, Ali Nikbakht and Ali Eskandari (2021). Gamma radiation negatively impacted seed germination, seedling growth and antioxidant enzymes activities in tall fescue infected with *Epichloe* endophyte. *Ecotoxicol and Environm Safety* 112-169.

Ashikari M, Sasaki A and Eunuch-Tanaka M (2012). Loss-of-function of a rice gibberellin biosynthetic gene, GA20 oxidase (GA20ox-2), led to the rice green revolution. *Breed Sci* **52**:143–150

Bucheyek T L, Gwanama C, Mgonja M, Chisi M, Folkertsma R and Mutegi R (2009). Genetic variability characterisation of Tanzania sorghum landraces based on simple sequence repeats (SSRs) molecular and morphological markers . *African Crop Sci J* **17**(2):71-86.

Burton G W and Devane E H (1952). Estimating heritability in tall fescue (*Festuca arundinaceae*) from replicated clonal material. *Agron J* **45**: 478-481.

Cheema A A and Atta B M (2003). Radiosensitivity studies in Basmati rice. *Pakistan J Botany* **35** (2):197-207.

Das S, Subudhi H N and Reddy J N (2007). Genetic variability in grain quality characteristics and yield in lowland rice genotypes. *Oryza* **44**(4): 343-346.

Essam el-Hashash and Yehia W M B (2021).Estimation of heritability, gene number and multivariate analysis usimg non-seggregation and segregation generations in two cotton crosses. *Asian J Biochem, Genetics and Molecular biology* **9** (3):45-62.

Hajos N M (2009). Results of mutation induction in corn, pea and soybean . *Bulletin of Szent Istvan University* 50-57.

Johnson H W, Robinson H F and Comstock R I (1955). Estimates of genetic and environmental variability in soybeans. *Agron J* **47**: 314-318.

Karthikeyan P, Anbuselvam Y, Elangaimannan R and Venkatesan M (2010). Variability and heritability studies in rice (*Oryza sativa* L.) under coastal salinity. *Electronic J Pl Breed* **1**:196-198.

Limbani P L, Gangani M K and Pandya M M (2017).Genetic variability, heritability and genetic advance in rice(*Oryza sativa*).2017. *Int J Pure and Appl Biosci* **5**(6): 1364-1371

Lush J L (1940). Intrasine correlation and regression of offspring on dams as a method of estimating heritability of character. *Proceedings of Am Soc of Anim Nutri* **32**: 293-301

Priya S, Suneetha Y, Babu D R and Rao V S (2017).Inter-relationship and path analysis for yield and quality characters in rice (*Oryza sativa* L.). *Int J Sci*, *Environ and Technol* **6**(1): 381-390

Ramchander S, Arumugam Pillai M and Ushakumari R (2014). Determination of Lethal Dose and Effect of Ethyl Methane Sulphonate in Rice Varieties. *Trends in Biosci* **7**(11): 1151-1156

Rangare N R, Krupakar A, Ravichandra K, Shukla A K and Mishra A K (2012). Estimation of character association and direct and indirect effects of yield contributing traits on grain yield in exotic and Indian rice (*Oryza sativa* L.) germplasm. *Int J Agri Sci* **2**(1): 54-61.

Sasikala and Kalaiyarasi (2010). Sensitivity of rice varieties to gamma irradiation. *Electronic J Pl Breed* **1**(4) 885-889.

Nair A S and Rosamma C A (2007). Evaluation of rice genotypes for ratoon performance. *Oryza* 44(1): 71-73

Received on 13/2/2022 *Accepted on 12/8/2022*