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Studies on variability, heritability and genetic advance for yield contributing characters in rice (*Oryza Sativa* L.)

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Abstract
Rice (*Oryza sativa*, 2n=2x=24) belongs to family Poyeaceae is the major food crop of the world for more than half of the global production. The genetic improvement through plant breeding has been an effective mechanism to improve the yield potential of this crop. *per se* performance largely governs the yield of the crop. The present investigation was carried out at the plant breeding farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University. To study the genetic variability, heritability and genetic advance of mutant generations (M_1, M_2 and M_3) in PY-5 by employing gamma rays in combination with 1% EMS treatments. In the M_2 generation, chlorophyll mutants namely albino and xantha were observed and few viable mutants like grassy leaf, spreading, narrow leaf, pigmented and lax panicle were observed. The results of two generations were revealed that there was a general reduction in characters like plant height and 100 grain weight. There was a general increase in most important economic characters like number of productive tillers per plant and grain yield per plant. Among the treatments studied, 15KR+1 percent EMS treatment was more effective in inducing mutation in M_2 generation when compared to other combination treatments. The genetic variability was found to be wider in M_2 generation and narrowed down and attained homozygosity in M_3 generation. High heritability coupled with high genetic advance as percent of mean was registered in grain yield per plant in both generation. This indicated that the above trait was least influenced by environment and mostly governed by additive gene action. Therefore this trait can be improved through pedigree selection. Among the sibs studied, sib7 was found to be superior for grain yield per plant and productive tillers per plant.

Keywords: genetic variability, heritability and genetic advance

Introduction
Rice (*Oryza sativa*, 2n=2x=24) belongs to family graminae is the major food crop of the world for more than half of the global production. In India rice is grown in 43.86 million hectares, the production level is 104.80 million tonnes and the productivity is about 2390 kg/ha (Agricultural statistics at a glance-2015). The genetic improvement through plant breeding has been an effective mechanism to improve the yield potential of this crop. *per se* performance largely governs the yield of the crop. Hence it should be improved through genetic manipulation. Mutation breeding is nothing but creation of genetic variability, through mutagens, identification of superior lines, multiplication and management of mutant varieties. The induction of wide spectrum of genetic variability with mutagens supplements conventional breeding methods for crop improvement. Induced mutations are being used to a large extent in genetic research and have proven to a valuable diagnostic tool for investigation of metabolic processes in plants. Mutants can be released as new variety or used as one of the parents in future breeding programme. The present investigation was undertaken on high yielding variety of rice, PY-5 with gamma rays and ethyl methyl sulphonate (EMS) to study the effect of mutagens in combination with treatments on various morphological and yield parameters in M_2 generation. To estimate genetic variability, heritability and genetic advance for economic characters in M_2 generation and M_3 generation. To identify the elite genotypes for high productivity with fine grains.

Materials and Methods

A popular rice variety, PY-5 (100-105 days) was used to study the effect of combination of physical and chemical mutagens. PY-5 was high yielding variety developed from Perunthalaivar Kamarajar Krishi Vigyan Kendra, Pondicherry. Parentage of PY-5 is Swarnadhan × NLR 9674 which is released in the year of 1994.

Table 1: The Salient Features of PY-5 (Aravindar)

The Salient Features of PY-5 (Aravindar)	
Parentage	Swarnathan × NLR 9674
Season	Sornavari, Navarai, Kuruvai
Duration	100-105 days
Plant height	90-95 days
1000 Grain Weight	22.65g
Rice grade	Long Slender
Yield	6000 kg/ha
Special features	Resistant to BPH and RTV good milling and cooking qualities.
Year of release	1994

The physical mutagens 5, 10, 15 and 20 KR Gamma rays with 1 percent EMS combination were used for the induction of mutation in rice. Gamma rays treated seeds were presoaked in distilled water for 12 hours and further soaked in freshly prepared aqueous 1.0 percent EMS solution for 3 hours with intermittent shaking. After treatment, seeds were thoroughly washed with tap water for 8 to 10 minutes (Matsuo and Onozawa, 1961) [5]. Untreated seeds are presoaked in distilled water for 12 hours were used as control.

M_1 generation: The seeds subjected to treatment were sown in the field along with the control in a randomized block design with three replication. A total of 150 seeds were sown under each treatment. All the treatments including the control were transplanted, adopting an uniform spacing of 30 cm between rows and 20 cm between plants. The cultural operations and plant protection measures were carried out during the period of crop growth in the field as standard recommendations.

M_2 generation: The seeds from each treatments of M_1 generation were sown in the field along with the control in a randomized block design with three replication. A total of 250 seedlings were planted at the rate of single seedling per hill for each treatment. All the treatments including the control were transplanted, adopting an uniform spacing of 20 cm between rows and 15 cm between plants. The cultural operations and plant protection measures were carried out during the period of crop growth in the field as standard recommendations.

M_3 generation: Seven high yielding M_2 plants from all treatments were advanced to M_3 generation. They were sown in family rows in a randomized block design, replicating twice with a spacing of 20×15 cm. The cultural operations and plant protection measures were carried out during the period of crop growth in the field as standard recommendations. The observations were recorded on individual plant basis in both M_2 and M_3 generations for plant height, number of productive tillers per plant, boot leaf length, panicle length, 100 grain weight, and grain yield per plant, chlorophyll mutant and viable mutant.

Results and Discussion

Variability, heritability and genetic advance for all the 6 characters are studied in this experiment. For the character plant height, in M2 generation, the high PCV was recorded at 15KR+l per cent EMS (18.05 per cent) followed by 5 KR+l per cent EMS (16.28 per cent). The moderate GCV was recorded at 10KR + l per cent EMS (10.24 per cent). The maximum heritability was recorded at 10 KR+1per cent EMS (54.18 per cent) followed by 15KR+1 per cent EMS (26.63 per cent). Generally all the treatments showed moderate genetic advance as per cent of mean with a maximum of 18.85 per cent at 5KR+1 per cent EMS. In M3 generation, the high PCV was recorded at sib1 (22.38 per cent) and followed by sib 7 (19.18 per cent). The moderate GCV was registered at sib 7 (14.75 per cent). The maximum heritability was recorded at sib 4 (36.70 per cent) followed by moderate at sib 5 (25.58 per cent). Generally all sibs showed low and moderate genetic advance as per cent of mean where sib 7 had high GA as per cent of mean of 23.38 per cent.

Character number of productive tillers per plant recorded highest PCV and GCV values at 5 KR+ 1 per cent EMS (56.61 and 22.76 per cent respectively) followed by 10KR + 1% EMS (42.43 and 23.51 per cent respectively. The heritability values were moderate for all the treatments and maximum was observed at 10 KR+ l per cent EMS (30-70 per cent). Almost all the treatments showed high GA as per cent of mean (26.84 per cent) was expressed at 10 KR+ 1 per cent EMS. In M3 generation, high PCV and GCV values are recorded at sib 2 (20.65 and 13.70 per cent), moderate by sib 6 (19.87 and 12.54 per cent respectively). In M3 generation, the heritability values were Low moderate for almost all the sibs and moderate heritability was observed at sib 6 (39.86 per cent) followed by sib 7 (36.33 per cent). Almost all the sibs showed moderate GA as percent of mean and sib 4 recorded maximum of (20.02 per cent).

In M2 generation the character boot leaf length showed a high PCV was recorded at 5KR+1 per cent EMS (26.36 per cent) followed by at 15KR+1per cent EMS (21.73 per cent). In M2 generation, the treatment 10KR+l per cent EMS recorded high heritability (81.44 per cent) and maximum GA as per cent of mean was recorded (43.16 per cent) at 5KR+1per cent EMS. In M3 generation, a high PCV was recorded at sib 3 (21.57 per cent) followed by sib 4 (21.17 per cent) and moderate GCV also recorded at sib 4 (13.48 per cent) and sib 3 (1107 per cent). In M3 generation, the high heritability was recorded at sib 4 (40.56 per cent) and followed by sib 7 (36.37 per cent). Among the sibs, sib 3 showed moderate and low genetic advance as percent of mean and maximum was observed at sib2 22.54 per cent.

For panicle length, in M2 generation, all the treatments shows low GCV values. The maximum GCV was recorded at 10 KR + 1 per cent EMS (32.05 per cent) and minimum PCV was recorded at 20 KR + 1 per cent EMS (9.87 per cent). The moderate heritability values were observed at 20 KR + l per cent EMS (23.10 per cent. The GA as per cent of mean was low at 5 KR 1per cent EMS (8.73 per cent). In M3 generation, the maximum PCV was recorded at sib 3(24.86 per cent and 24.77 per cent). Moderate GCV were recorded at sib 6(12.77 per cent. The high heritability was recorded at sib 1 (38.90 per cent) and sib 5 (32.4 per cent). Almost all the sibs showed moderate GA as per cent of mean and maximum was observed in sib 7 (19.9 per cent).

Hundred grain weight, in M2 generation, the treatment 15 KR + 1 per cent EMS observed moderate PCV & low GCV values (14.78 & 8.09 per cent respectively). The minimum PCV & GCV values recorded at 10 KR + 1per cent EMS (10.96 and 3.90 per cent respectively). The treatment 5 KR + 1per cent EMS exhibited high heritability (50.99 per cent) and moderate GA as per cent of mean was observed (11.80per cent) at 5 KR+1 per cent EMS. In M3 generation, the sib 3 recorded moderate PCV (10.61 per cent) and the sibs 2 and 3

were recorded low GCV values sibs 2 (6.25) percent and sib 3 (5.07 per cent). The sibs 7 and 2 were recorded maximum heritability (48.15 and 46.87 per cent respectively). All the sibs showed low and moderate genetic advance as per cent of mean.

In M2 generation the character grain yield per plant had highest values of PCV and GCV were recorded at (55.89 and 29.07 per cent respectively). The minimum PCV and GCV were recorded at 20 KR+ 1 per cent EMS (19.52 and 8.76 per cent respectively). The maximum heritability for grain yield was observed at 15 KR+ 1per cent EMS (55.32 per cent). The high GA as per cent of mean was observed at 15 KR+ 1per cent RMS (51.17 per cent). In M3 generation, the maximum values of PCV were observed in sibs 2 and 3 (22.37 and 18.66 per cent reapectively). The moderate GCV values were recorded at sibs 2 and 6 (10.88 and 10.43 per cent respectively). The sib 6 showed maxims heritability of 44.22 per cent. In concerned about GA as percent of mean, all sibs showed low values and sib 6 recorded moderate GA per cent of mean of 14.30 per cent.

Variation in growth parameters is essential to increase the economic products indirectly. In the present investigation, variation has been observed in the mutant population for the growth parameters like total number of productive tillers and grain yield per plant. Thus it was possible to mutants for different characters, which could be identifying mutants for different characters, which could be used in future breeding programmes.

Mutants having significantly superior number of productive tillers, hundred grain weight and grain yield per plant were selected from the plants treated with 15 KR+1 per cent EMS treatments in M2 generation and sib 2 in M3 generation. From these observations, it was evident that it is possible to obtain significant variation through mutagenesis that could be better utilized to increase the productivity (Mugiono, 1998) [7].

Among the various treatments, significant variability was observed for majority of the important economic traits. Significant variation was observed for the economic traits like total number of productive tillers and grain yield per plant in the mutant population of 15KR+1 per cent EMS in M2 generation and sib 2 in M3 generation.

The estimation of genotypic coefficient of variation indicates the amount of genetic variation present for different traits while heritability gives an insight into the proportion of the variation which is inherent. However, heritability estimate itself is an indication of the amount of genetic progress that would result from selecting the best individual. Thus the study of heritability in conjunction with genetic advance was emphasized in predicting the resultant effect for selecting the best individuals (Mehetre *et al*, 1996) [6].

In the present study, phenotypic coefficient of variation (PCV) was higher than genotypic co-efficient of variation (GCV) for all the characters in all the treatments in both generations among the treatments. In M2 generation 5KR+1 per cent EMS showed higher PCV and GCV for number of productive tillers, 5KR+1 per cent EMS showed higher PCV and GCV for boot leaf length and 10 KR+1 per cent EMS showed higher PCV and GCV for grain yield per plant. Wide range between PCV and GCV was observed for characters like number of productive tillers and grain yield per plant. In M3 generation sib 3 recorded wider range for these characters.

In the present investigation, high PCV and GCV were recorded in all sibs in M3 generation compared to M2 generation plant. These results were in conformity with Basak and Ganguli (1996) [1], Rao *et al.,* (1996) [8] and Bharathi *et al.,* (2002) [2]. PCV and GCV values for number of productive tillers in M2 generation was high than M3 generation. These results were parallel with the findings of Rao *et al.,* (1996) [8]. Variability result for boot leaf length was high in M2 generation than M3 generation. Low variability for this trait was recorded by Rao *et al.,* (1996) [8] and Bharathi *et al.,* (2002) [2]. All the treatment showed high PCV and GCV for panicle length in both generations. For the trait of hundred grain weight, PCV and GCV were higher in M2 generation compare to M3 generation. These type of results also reported by Singh and Sanjeev Singh (2001) [9], Basak and Ganguli (1996) [1], Rao *et al.,* (1996) [8] and Bharathi *et al.,* (2002) [2].

In case of grain yield per plant M2 generation recorded higher PCV and GCV compared to M3 generation. Sindhu (1986) reported moderate PCV and GCV values for this character. Singh and Sanjeev Singh (2001) [9], reported low PCV and GCV values for this characters.

Heritability and genetic advance as per cent mean for different characters were found to be more in the treated population. Increase in heritability and genetic advance as per cent of mean for number of productive tillers per cent was recorded at 10KR+1 per cent EMS. For plant height, at 10KR+1 per cent EMS registered highest heritability and genetic advance as per cent of mean respectively. In case of hundred grain weight, maximum heritability and genetic advance as per cent of mean was recorded at 5KR+1 per cent EMS in M2 generation.

In grain yield per plant, showed maximum heritability and genetic advance as per cent of mean was recorded at 15KR+1 per cent EMS, in M2 generation and sib 4 in M3 generation. This enhanced variability in this variety due to mutagenic treatments provided an opportunity to utilize the generated variability for selection and for further crop improvement through those characters. Among the treatments, combination treatment of 15KR+1 per cent EMS and 10KR+1 per cent EMS exhibited maximum mean performance for many characters in the high heritability and genetic advance. Treatment 10KR+1 per cent EMS showed maximum range of variation for yield and yield component characters.

In the present investigation high heritability with high genetic advance as per cent of mean was observed for plant height in M2 generation compared to M3 generation. These type of similar results were recorded by Singh and Sanjeev Singh (2001) [9], Ismaial (1972) [4] and Rao *et al.,* (1996) [8].

High heritability coupled with high GA as per cent of mean were recorded more in M2 generation compared than M3 generation. High heritability coupled with moderate genetic advance as per cent of mean were recorded for panicle length and boot leaf length in both generations. Hundred grain weight showed high heritability coupled with high genetic advance in M2 generation and moderate heritability and GA as per cent of mean in M3 generation. This indicated that both additive as well as dominant gene action might be involved in controlling the above traits in the respective generation. Therefore these traits offer little scope for improvement by selection.

High heritability with high genetic advance as per cent of mean was observed for grain yield per plant in both generations. Hla-Shwe *et al.,* 1993 [3], Mehetre *et al,* (1996) [6] reported similar results.

This indicated that the above trait was least influenced by environment and mostly governed by additive gene action. Therefore this trait can be improved through pedigree selection.

Table 2: Variability, Heritability and Genetic advance in M_2 generation

Treatment	Plant height				Productive tillers				Boot leaf length			
	PCV (%)	GCV (%)	h^2	GA as% of mean	PCV (%)	GCV (%)	h^2	GA as% of mean	PCV (%)	GCV (%)	h^2	GA as% of mean
Control	-	-	-	-	-	-	-	-	-	-	-	-
5KR+1%EMS	16.78	7.18	16.17	18.85	56.61	22.76	16.17	18.85	26.36	23.50	79.47	43.16
10KR+1%EMS	13.92	10.24	54.18	15.53	42.43	23.51	30.70	26.84	20.97	18.92	81.44	35.17
15KR+1%EMS	18.05	9.31	26.63	9.90	37.02	18.15	24.04	18.33	21.73	8.51	13.94	6.24
20KR+1%EMS	10.19	6.32	38.48	8.07	22.02	11.82	28.81	13.07	13.10	1.56	1.42	0.38
Treatment	**Panicle length**				**Grain weight**				**Grain yield per plant**			
	PCV (%)	GCV (%)	h^2	GA as% of mean	PCV (%)	GCV (%)	h^2	GA as% of mean	PCV (%)	GCV (%)	h^2	GA as% of mean
Control	-	-	-	-	-	-	-	-	-	-	-	-
5KR+1%EMS	23.39	9.95	18.11	8.73	11.23	8.02	50.99	11.80	55.11	35.80	42.19	47.90
10KR+1%EMS	32.05	9.79	9.34	6.16	10.96	3.90	12.68	2.86	55.89	29.07	27.06	31.15
15KR+1%EMS	17.32	.02	21.46	7.66	14.78	8.09	30.00	9.13	44.90	33.39	55.32	51.17
20KR+1%EMS	9.87	4.74	23.10	4.70	10.87	2.04	3.52	0.78	19.52	8.76	20.15	8.10

Table 3: Variability, Heritability and Genetic advance in M_3 generation

Sibs	Plant height				Productive tillers				Boot leaf length			
	PCV%	GCV%	h^2	GA as% of mean	PCV%	GCV%	h^2	GA as% of mean	PCV%	GCV%	h^2	GA as% of mean
1	22.38	6.67	8.88	5.24	21.05	4.70	5.58	2.41	16.93	8.95	27.95	9.74
2	14.02	4.83	11.89	4.40	20.65	13.70	4.41	18.72	16.36	12.02	10.60	22.54
3	16.44	2.12	16.7	4.645	19.42	10.44	28.91	11.56	21.57	11.07	26.35	11.70
4	16.90	10.24	36.70	16.37	18.56	1.34	25.2	20.20	21.17	13.48	40.56	17.68
5	18.98	9.60	25.58	10.00	23.26	9.02	15.06	7.21	19.25	7.50	15.18	6.02
6	12.79	2.9	5.33	1.40	19.87	12.54	39.86	16.31	24.40	9.18	14.16	7.11
7	19.18	14.75	25.91	23.38	20.42	12.30	36.33	15.28	23.32	14.06	36.37	17.47
Sibs	**Panicle length**				**100 Grain weight**				**Grain yield per plant**			
	PCV%	GCV%	h^2	GA as% of mean	PCV%	GCV%	h^2	GA as% of mean	PCV%	GCV%	h^2	GA as% of mean
1	21.10	4.36	38.90	17.70	8.91	4.55	26.14	4.80	15.66	6.40	18.07	5.60
2	24.77	6.80	7.54	3.84	9.13	6.25	46.87	8.82	22.37	10.88	23.67	10.91
3	24.83	11.54	21.59	11.04	10.61	5.07	22.88	5.00	18.66	6.49	12.10	4.65
4	14.75	8.94	23.67	11.16	6.24	3.30	28.04	3.60	16.88	9.04	28.67	9.97
5	17.70	10.09	32.4	11.84	7.13	4.19	34.53	5.07	13.89	4.85	12.37	3.54
6	19.66	12.35	3.95	16.00	8.96	4.24	22.41	4.13	15.69	10.43	44.22	14.30
7	24.45	4.59	14.45	19.90	6.76	4.69	48.13	6.70	13.78	4.42	10.31	29.20

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