Effect of Mutagens on Quantitative and Qualitative Characters in M_3 Generation of Rice Variety 'Akshaya' (BPT 2231)

B. Krishna Veni* and M. S. Niveditha

Rice Research Unit, Bapatla, Guntur, Andhra Pradesh

Abstract

The mutagenic effects of gamma rays (10, 20, 30 and 40 kr) and EMS (0.1, 0.2, 0.25 and 0.3%) singly and their combination treatments were studied in rice variety Akshaya (BPT 2231) to find out the effectiveness of these mutagens on various quantitative and qualitative characters, heritability and genetic advance in M_3 generation. Macro mutations such as dwarf and tall plants, early and late flowering along with variation in hull colour and grain type were also observed. Early flowering mutants were isolated from 30 kr + 0.3 per cent EMS combination treatment. Combination treatments of EMS with 40kr and 30 kr doses reduced the plant height considerably. Moderate to high GCV and PCV coupled with high heritability (broad sense) and moderate to high genetic advance as percent of mean were observed for plant height, fertile grains per panicle, grain yield per plant and alkali spreading value. The remaining characters under study manifested low GCV, PCV, high heritability estimates along with low to moderate genetic advance as percent of mean indicating the operation of both additive and non-additive gene action in the inheritance of these traits.

Key words: Macro mutations, quantitative and qualitative traits, heritability, genetic advance.

Mutation breeding has already made significant contribution to crop improvement all over the world. This is amply evident from the fact that more than 2250 varieties of different crops had been released that were derived as direct mutants or from hybridization involving desirable mutants Ahloowalia *et al*. (2004). Induced mutation which increases genetic variability is one of the traditional but still relevant, highly effective, economic and recognized methods for enhancing natural genetic resources and developing improved cultivars of cereals, fruits and other crops Lee *et al.* (2002). Information regarding the effect and efficiency of physical and chemical

*Corresponding author: bkv_lam@yahoo.co.in

mutagens and their combination doses was available in many crops but such information is meager in rice. Hence, an attempt was made in the present to study the effect of single and combination doses of physical and chemical mutagens on rice variety Akshaya (BPT 2231) with an aim to uncover the various mutagenic treatment effects and to estimate the genetic parameters on various quantitative and qualitative characters in M_3 generation.

Material and Methods

The material for the present study comprised of 24 mutagenic treatments along with the control of Akshaya rice variety (BPT 2231) treated with gamma rays (10kr, 20kr, 30kr & 40kr), ethyl methane sulfonate (0.1%, 0.2%, 0.25% & 0.3%) and their combinations. The M_1 and the M_2 generations were grown during *kharif* 2009 and 2010 respectively at Rice Research Unit, Bapatla. Twenty randomly selected plants per treatment in M_2 generation were advanced to M_3. The nursery in M_3 was sown as panicle to row method on raised beds at RRU, Bapatla during *kharif* 2011-12. 25 treatments were grown in a randomized block design with three replications. Thirty day old seedlings were transplanted with a spacing of 20x15 cm between and within the rows respectively. Each progeny consisted of 33 plants/replication and each treatment was represented by 20 rows of 5m length in each replication. Normal recommended cultural practices were followed for raising the crop. Observations were recorded on 10 single plants selected from each progeny at random. Thus, 200 single plants were studied in each treatment for recording observations on yield and yield attributing traits. The quality parameters *viz.*, kernel length, kernel breadth, L/B ratio, amylose content, protein content and alkali spreading value were estimated replication wise on plot basis as per the standard procedures delineated by Murthy and Govinda Swamy (1967), Juliano (1971) and Little *et al.* (1958) and Piper (1966). The mean data was used for analysis of various genetic parameters as per the standard statistical procedures described by Allard (1960) and Burton and Dewane (1952).

Results and Discussion

The spectrum of macro mutations of varying magnitudes recorded in M_3 generation were grouped character wise. These were found to occur at different stages of crop growth in varying frequencies under different treatments. In M_3 generation of Akshaya, eight different types of morphological mutations were observed (Table 1). Among all types of visible morphological mutants, dwarf plant type occupies the major share followed by tall plants and early types. The

combination treatments of EMS, particularly with 30kr and 40kr series induced majority of dwarf plant types. The minimum plant height in dwarf mutant was below 90 cm. The maximum frequency of dwarf mutants was observed in 30kr + 0.1% EMS followed by 40kr + 0.25% EMS treatment. Chang *et al.* (1985) also reported similar findings. The combination treatments of EMS with 30kr series showed more number of tall plants compared to dwarf ones. The tallest mutant (155cm) was observed in 0.25 % EMS treatment followed by a mutant with 131 cm in 30kr+0.25% EMS while the parent Akshaya possess 100-110cm height. The results were in accordance with the findings of Satyanarayana *et al.* (1993). The earliest flowering mutant was observed in the treatment of 30kr + 0.3% EMS, which flowered in 84 days. The maximum frequency of late flowering mutants (days to heading was delayed by one week to fifteen days than the parent) were identified from the treatment of 40kr followed by 20kr + 0.3% EMS. Rao and Reddi (1986), Chakraborthy and Kole (2009) also reported late flowering mutants in rice by induced mutation. Mutants possessing long bold grain type were observed in 20kr and 0.25% EMS treatments while from 30kr + 0.25% EMS and 30kr + 0.3% EMS treatments, mutants with long slender grain type were isolated. The hull colour of the seed obtained from three treatments *viz*., 10kr+0.25%EMS, 30kr + 0.30% 0.25% EMS and 40kr + 0.25% EMS was changed to straw colour whereas the untreated control had brown colour hull (Fig. 1& 2). From 30kr+0.3%EMS treatment, mutants possessing dark brown hull colour were also isolated. Domingo *et al.* (2007) and Luzi-Kihupi1 *et al.* (2008) also reported mutants with changed hull color and grain type than their respective parents in rice. Among all treatments studied, 10kr + 0.25% EMS, 30kr+0.3%EMS and 0.25% EMS treatments produced high yielding mutant genotypes with 5-10 per cent yield advantage over the parent Akshaya. The high grain yield recorded in these mutants was not only due to one trait but the cumulative effects of a number of yield attributing traits resulted in the manipulation of high yield. Shashidhar (2001) and Singh and Singh (2003) also reported high yielding mutants in rice through induced mutation.

The analysis of variance for 14 yield components and quality parameters revealed that the mean sum of squares of mutant genotypes were highly significant for all the characters studied indicating the presence of genetic variability among the experimental material. The range, mean and the estimates of genetic parameters for 14 quantitative and qualitative parameters were presented in

Table 2. The results of genetic parameters revealed slight differences between genotypic and phenotypic coefficients of variation values reflecting the minimum environmental influence and consequently greater role of genetic factors on the expression of these traits. High heritability estimates obtained in the present study for all the characters suggest high component of heritable portion of variation that can be exploited by breeders in the selection of superior genotypes on the basis of phenotypic performance. The maximum value for genotypic coefficient of variation and the phenotypic coefficient of variation were observed for alkali spreading value (45.88 and 46.42) respectively followed by grain yield per plant, number of fertile grains per panicle and plant height. Moderate GCV and PCV were manifested for number of productive tillers, days to 50 per cent flowering, test weight, kernel breadth, L/B ratio and protein content while the characters *viz.,* panicle length, kernel length, spikelet fertility and amylose content recorded low estimates. Yusuff Oladosu *et al*. (2014) also reported high GCV and PCV for grain yield/hectare and low GCV and PCV for panicle length in mutant population of MR219 paddy variety by gamma irradiation. Moderate GCV and PCV for days to 50% flowering and test weight Vijaya Lakshmi *et al.* (2008) in upland rice varieties; and low estimates for kernel length and amylose content were reported by Krishna Veni *et al.* (2006) in aromatic parents and hybrids.

All the fourteen characters studied recorded high heritability estimates ranging from 70.3 (L/B ratio) to 99.8 (No. of fertile grains per panicle). Almost similar results for heritability from studies on induced mutants in aromatic rice have been reported for plant height (Hasib and Kole, 2004); days to flower, test weight and grain yield (Kole and Hasib, 2003). Krishna Veni *et al.* (2006) also reported high heritability estimates for kernel length, kernel breadth, L/B ratio, amylose content and alkali spreading value in a study involving 10 parents and 25 hybrids of aromatic rice. The estimates of genetic advance as per cent of mean were high for alkali spreading value followed by grain yield per plant and number of fertile grains per panicle, moderate for plant height, number of productive tillers, days to 50 per cent flowering, test weight and kernel breadth while the remaining traits manifested low estimates of genetic advance. High genetic advance as per cent of mean has been reported by Sharma and Sharma (2007) for No. of fertile grains per panicle and grain yield per plant. Uttamchand *et al.* (2001) and Mamta Singh *et al.* (2007) also reported

moderate estimates for plant height and test weight. Similar findings for kernel breadth and L/B ratio were previously reported by Krishna Veni *et al.* (2006).

The overall results of genetic parameters revealed that moderate to high GCV, PCV coupled with high heritability and moderate to high genetic advance were observed for plant height, fertile grains per panicle, grain yield and alkali spreading value suggesting the predominance of additive type of gene action in controlling these traits. Thus apparently important contribution of additive genetic variance is involved in the expression of these traits. Hence, good response to selection may be attained in early generations in improving these traits. The remaining characters under study *viz.*, No. of productive tillers, days to 50% flowering, spikelet fertility, test weight, panicle length, kernel length, kernel breadth, L/B ratio, amylose content and protein content manifested low GCV, PCV, high heritability estimates along with low to moderate genetic advance indicating the operation of both additive and non-additive action in the inheritance of these traits.

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Table 2: Estimates of genetic parameters for yield components and quality traits in M_3 generation of Akshaya variety

S.No.	Character	Mean	Range	PCV	GCV	Heritability (%)	Genetic advance as percent of mean (%)
1	Plant height (cm)	109.81	96.67-155.33	11.50	11.43	98.7	29.98
2	No. of productive tillers	17.52	14.64-20.67	9.8	9.13	86.7	22.44
3	Days to 50% flowering	115.55	84-124.3	7.98	7.96	99.5	20.96
4	No. of fertile grains/panicle	161.44	121.33-244.0	16.63	16.61	99.8	43.82
5	Spikelet fertility (%)	87.2	75.29-95.54	5.35	5.33	99.3	14.02
6	Panicle length (cm)	25.5	23.12-27.92	4.05	3.49	74.2	7.94
7	Test weight (g)	18.96	15.69-23.40	9.81	9.62	96.1	24.88
8	Grain yield/plant(g)	29.64	22.19-38.72	17.85	17.66	97.9	46.11
9	Kernel length (mm)	5.67	5.35-6.03	3.71	3.67	97.5	9.56
10	Kernel breadth (mm)	2.15	1.95-2.25	8.10	7.79	92.5	19.79
11	L/B ratio		2.51-3.01	8.50	7.13	70.3	15.77
12	Amylose content (%)	24.43	22.40-25.44	3.30	2.85	74.5	6.49
13	Protein content (%)	8.4	7.22-9.26	7.86	6.69	72.5	15.04
14	Alkali spreading value	3.93	1.0-6.83	46.42	45.88	97.7	119.74

Table 1: Spectrum and frequency of morphological mutants in M_3 generation of Akshaya (BPT 2231) by different mutagenic treatments

Treatment	Total population	Mutation spectrum								Total morphological mutants	Mutation frequency (%)
		Plant height		Flowering		Hull colour		Grain type			
		Dwarf	Tall	Early flowering	Late flowering	Straw colour	Dark brown	Long slender	Long bold		
Gamma rays											
10kr	1980	-	5	3	-	-	-	-	-	8	0.40
20kr	1980	-	3	-	-	2	-	-	4	9	0.45
30kr	1980	-	2	-	-	-	-	-	-	2	0.10
40kr	1980	-	4	-	12	-	-	-	-	16	0.81
EMS treatments											
0.1%	1980	-	-	-	6	-	-	-	-	6	0.30
0.2%	1980	-	-	-	3	-	-	-	-	3	0.15
0.25%	1980	-	1	-	3	-	-	-	32	36	1.82
0.3%	1980	7	-	-	-	-	-	-	-	7	0.35
Combination treatments											
10kr+0.1%EMS	1980	5	-	-	-	-	-	-	-	5	0.25
10kr+0.2%EMS	1980	5	3	-	-	-	-	-	-	8	0.40
10kr+0.25%EMS	1980	12	5	-	2	35	-	-	-	54	2.73
10kr+0.3%EMS	1972	2	-	-	1	-		-	-	3	0.15
20kr+0.1%EMS	1974	-	-	5	3	-	-	-	-	8	0.41
20kr+0.2%EMS	1980	-	-	-	4	-	-	-	-	4	0.20
20kr+0.25%EMS	1978	3	-	-	7	-	-	-	-	10	0.51
20kr+0.3%EMS	1980	-	-	-	11	-	-	-	-	11	0.56
30kr+0.1%EMS	1980	22	-	-	-	-	-	-	-	22	1.11
30kr+0.2%EMS	1970	-	16	25	-	-	-	-	-	41	2.08
30kr+0.25%EMS	1973	-	26	-	7	-	-	22	-	55	2.79
30kr+0.3%EMS	1980	5	18	35	-	5	3	21	2	89	4.49
40kr+0.1%EMS	1980	13	-	-	-	-	-	-		13	0.66
40kr+0.2%EMS	1980	-	2	-	-	-	-	-		2	0.10
40kr+0.25%EMS	1975	21	-	-	-	15	-	-	-	66	3.34
40kr+0.3%EMS	1980	-	-	-	3	-	-	-	-	3	0.15
Total		**95**	**85**	**68**	**62**	**57**	**3**	**43**	**38**	**451**	

Figure 1: Variation in hull colour and grain shape in Akshaya mutant population

Figure 2: Panicles of Akshaya (left) and Akshaya mutant