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Differential manifestation of micromutations for different quantitative traits in Basmati rice

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ABSTRACT

The quantum of induced polygenic variability for quantitative traits was compared in the M_2 and M_3 generations after treating the seeds of Basmati rice cultivar T- 23 with gamma- rays and ethyl methanesulphonate (EMS). There were mutagenic differences for the release of genetic variability in both the generations. In comparison to EMS, gamma-rays were found to be less effective in generating polygenic variation in terms of coefficient of variability. Moreover, the characters differed in the manifestation of variability in the two generations. High induced variability for panicle length, number of grains panicle^{-1}, plant height, days to flowering and days to maturity was observed in M_2 and for grain yield plant^{-1}, 100-grain weight and effective tillers plant^{-1} in the M_3 generation. Therefore, these generations are most appropriate for improvement of these characters through selection.

Key words: *Genetic advance, heritability, micromutations, selection, variability*

Majority of agronomically important plant characters are quantitatively inherited. These characters display continuous variation and in general are controlled by many genes. The creation of variation for such characters for the selection to act upon is very important in crop improvement and this has long been accomplished through hybridization. However, it has been conclusively established that different kind of mutagens when applied to plant tissues, induce mutations in polygenic characters (Gregory, 1955; Rawlings *et al*., 1958; Swaminathan, 1963; Frey, 1965; Gaul and Aastveit, 1966; Gupta, 1969). The growing emphasis of micromutations as a valuable tool for improvement of cultivated species has assumed greater significance due to the fact that a number of field crop varieties evolved by this method have been released at the global level. However, one of the important problems in such breeding programmes is to determine the generation when the highest degree of induced genetic variation for particular trait under improvement is expected to be generated and the mean stabilized. In the present investigation, therefore, an attempt was made to study the relative quantum and nature of induced phenotypic and genotypic variability, the heritable portion of the induced genetic variability and its response to selection for grain yield and its components in the M_2 and M_3 generations following mutagenesis of *Basmati* rice cultivar T-23 with gamma- rays ethyl methanesulphonate (EMS).

MATERIALS AND METHODS

Two thousand and five hundred (2,500) dry well filled and uniform sized seeds each of late maturing (140 days) locally adapted *Basmati* rice cultivar T-23 were subjected to 25, 30 and 35 kR gamma–rays and 0.8, 1.0 and 1.2% ethyl methane sulphonate (EMS) treatments. In order to satisfy the basic assumptions of genetic analysis for polygenic traits, only morphologically normal looking plants were taken from M_1 and M_2 generations. M_2 and M_3 generations were raised along with control in RBD with two replications. Forty plant progenies per treatment were raised. Each progeny consisted of single row of 2.25 m length with row to row and plant-to-plant spacings of 20 cm and 15cm, respectively. In order to understand quantum of induced variation, data were recorded on five random plants per replication in each of the 40 plant progenies per treatment, thus comprising 400 plants in each treatment

under both M_2 and M_3 generations.

The combined data recorded on grain yield and other polygenic traits of all the treatments of gamma-rays and EMS in the M_2 and M_3 generations were subjected to analysis of variance as suggested by Yonejawa (1979). The phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (H) and the genetic advance (GA) were used as criteria for determining the appropriate generation for selection.

RESULTS AND DISCUSSION

The estimated mean values for various traits in the parental (M_0, M_2 and M_3) generations are presented in Table 1. The mean values of grain yield plant^{-1}, 100-grain weight and effective tillers plant^{-1}were either comparable to the control or increased from M_2 to M_3. Similarly PCV, GCV, H and GA for these traits were more in M_3 than in the corresponding treatments of the M_2 generation (Table 2). Both gamma- rays and EMS treatments caused marked decreases in the grain yield

Table 1. Estimates of parental (M_0, M_2 and M_3) populations mean with respect to various polygenic traits under different doses in T-23

Dose EMS treatments		Grain yield plant^{-1} (g)	Panicle length (cm)	Number of grains panicle^{-1}	100-grain weight (g)	Number of effective tillers plant^{-1}	Plant height (cm)	Days to 50% flowering	Days to maturity
0.8%	M_0	6.1 ± 0.30	23.65 ± 0.53	98.80 ± 1.90	2.12 ± 0.04	5.25 ± 0.15	115.27 ± 0.90	115.75 ± 0.48	145.75 ± 0.87
	M_2	6.60* ± 0.36	24.5* ± 0.30	94.70@ ± 2.05	2.10 ± 0.09	5.35* ± 0.22	105.67@ ±2.02	111.54@ ±0. 45	143.40@ ±1.32
	M_3	7.96* ± 0.36	23.99 ± 0.32	85.47@ ± 1.29	2.22* ± 0.07	5.87* ± 0.23	110.60 ± 2.33	114.00@ ± 0.35	143.60@ ± 0.34
1.0%	M_0	5.70 ± 0.37	23.92 ± 0.28	89.00 ± 2.30	2.22 ± 0.08	5.00 ± 0.12	107.77 ± 1.53	170.00 ± 0.57	147.00 ±1.29
	M_2	5.79 ± 0.26	24.14* ± 0.33	92.37* ± 1.76	1.90@ ± 0.07	5.21* ± 0.24	106.44 ± 2.46	111.18@ ± 0.49	141.02@ ± 0.65
	M_3	7.79* ± 0.28	23.72 ± 0.38	81.31@ ± 1.70	2.28 ± 0. 07	5.43* ± 0.16	107.62 ± 2.43	112.92@ ± 0.40	143.45@ ± 0.29
1.2%	M_0	6.90 ± 0.51	23.97 ± 0.33	99.50 ± 1.97	2.17 ±0.06	5.85 ± 0.51	109.80 ± 1.96	115.75 ± 0.85	147.25 ± 1.85
	M_2	6.60 ± 0.19	24.01 ± 0.22	91.04@ ± 1.36	1.98@ ± 0.07	5.39 ± 0.22	107.80 ± 2.17	112.10@ ± 0.42	142.86@ ± 0.50
	M_3	7.53* ± 0.27	23.77 ± 0.42	82.99@ ± 1.86	2.26* ± 0.08	5.82 ± 0.17	108.90 ± 1.58	113.46@ ± 0.39	143.78@ ± 0.35
Gamma-rays									
25 kR	M_0	8.80 ± 0.32	24.27 ± 0.29	104.70 ± 3.15	2.00 ± 0.08	6.40 ± 0.26	114.75 ± 1.53	118.00 ± 0.58	148.75 ± 1.11
	M_2	8.07@ ± 0.25	25.10* ± 0.27	98.90@ ± 2.18	1.86@ ± 0.09	5.62@ ± 0.16	112.99@ ± 1.63	112.27@ ± 0.45	142.18@ ± 0.78
	M_3	8.97* ± 0.36	24.74* ± 0.33	96.48@ ± 1.40	2.18* ± 0.09	5.98@ ± 0.21	115.22 ± 1.55	113.57@ ± 0.39	143.72@ ± 0.42
30 kR	M_0	7.90 ± 0.47	24.00 ± 0.30	97.05 ± 2.65	2.02 ± 0.06	5.15 ± 0.09	112.27 ± 0.97	116.75 ± 1.11	148.50 ± 0.86
	M_2	6.23@ ± 0.27	24.64* ± 0.29	85.52@ ± 1.65	2.11* ± 0.08	5.23* ± 0.21	112.50* ± 1.39	112.90@ ± 1.15	142.30@ ± 2.56
	M_3	8.03 ± 0.29	23.63 ± 0.29	84.96@ ± 1.33	2.25* ± 0.08	5.82* ± 0.19	114.60 ± 2.09	114.69@ ± 0.42	144.40@ ± 0.42
35 kR	M_0	7.25 ± 0.30	24.47 ± 0.53	103.35 ± 1.90	2.15 ± 0.04	5.35 ± 0.15	111.50 ± 0.90	115.75 ± 0.48	146.25 ± 0.87
	M_2	7.27 ± 0.29	25.23* ± 0.19	103.42 ± 0.80	1.98@ ± 0.07	5.53* ± 0.17	109.31* ± 1.91	112.47@ ± 0.46	143.24@ ± 0.51
	M_3	9.08* ± 0.39	23.80 ± 0.21	86.08@ ± 1.04	2.23* ± 0.07	6.14* ± 0.17	115.14@ ± 0.80	113.74@ ± 0.34	143.60@ ± 0.31

* Significant +ve shift in mean @ Significant –ve shift in mean

Table 2. Estimates of parameters of variability for various polygenic traits in M_2 and M_3 generation under different doses in T-23

Traits		EMS						Gamma-rays					
		0.8%		1.0%		1.2%		25 kR		30 kR		35 kR	
		M_2	M_3	M_2	M_3	M_2	M_3	M_2	M_3	M_2	M_3	M_2	M_3
Grain yield plant^{-1} (g)	PCV (%)	32.52	39.74	36.62	42.07	28.63	32.58	24.13	24.97	28.71	26.82	26.11	28.61
	GCV (%)	29.91	38.87	32.74	42.20	27.17	30.92	22.92	24.03	26.10	28.18	22.03	26.31
	H (%)	90.03	95.70	79.91	91.62	90.05	90.07	90.24	92.62	82.64	88.14	71.22	84.59
	GA (%)	42.73	54.34	33.44	51.84	39.76	25.20	46.62	57.98	29.07	59.10	34.56	35.97
Panicle length (cm)	PCV (%)	7.10	6.97	12.20	8.37	9.70	7.65	8.80	8.23	10.10	9.41	11.38	9.28
	GCV (%)	6.70	6.54	11.94	7.98	8.90	6.58	7.70	7.07	9.97	9.29	11.07	8.85
	H (%)	89.19	88.20	95.85	90.88	84.31	73.78	76.79	73.80	97.53	97.26	94.66	90.99
	GA (%)	11.52	1102	16.40	14.11	12.67	11.99	8.41	7.89	18.29	12.44	12.80	9.76
Number of grains panicle^{-1}	PCV (%)	27.03	21.18	30.65	25.91	27.52	23.36	21.32	19.26	26.43	24.62	27.60	21.87
	GCV (%)	26.20	19.86	30.10	25.08	26.27	22.13	20.97	18.86	24.41	22.38	27.20	21.54
	H (%)	93.94	87.89	96.47	93.64	91.10	89.74	96.75	95.85	85.35	62.60	97.26	96.96
	GA (%)	29.94	23.93	32.48	32.15	29.90	28.81	35.86	25.34	37.54	25.14	30.31	29.50
100-grain weight (g)	PCV (%)	17.03	18.57	17.43	22.34	12.73	16.96	12.57	16.85	13.85	16.28	15.08	19.24
	GCV (%)	15.64	17.44	16.58	21.41	11.43	15.71	11.80	16.05	11.06	14.16	13.01	17.21
	H (%)	84.37	88.23	90.50	91.84	80.67	85.81	88.03	90.74	70.16	75..67	74.38	80.02
	GA (%)	16.90	19.86	18.51	18.64	20.11	21.88	25.65	21.13	20.75	23.01	14.94	18.32
Effective tillers plant^{-1}	PCV (%)	21.78	22.52	21.79	24.33	20.63	21.82	17.50	19.61	19.45	33.21	26.34	26.83
	GCV (%)	19.58	20.70	20.52	24.12	19.75	20.85	16.67	18.96	19.05	32.92	19.40	20.34
	H (%)	8085	85.07	97.44	98.28	91.32	91.67	90.70	93.95	95.86	98.24	52.51	59.61
	GA (%)	28.18	27.77	36.93	35.22	30.76	31.35	24.69	34.26	33.08	38.33	19.65	19.73
Plant height (cm)	PCV (%)	7.46	6.30	8.37	2.66	7.08	6.77	6.93	4.76	7.60	5.98	7.28	6.05
	GCV (%)	6.93	5.60	8.17	1.94	6.92	6.61	6.74	4.50	7.10	5.35	6.34	5.00
	H (%)	86.20	79.33	95.31	52.92	95.64	95.14	94.67	89.17	87.23	80.07	75.08	68.28
	GA (%)	8.33	7.03	9.06	8.14	9.51	7.51	10.17	8.34	9.39	8.46	8.03	7.10
Days to 50 % flowering	PCV (%)	3.81	3.80	3.68	3.32	3.22	3.08	3.76	3.02	3.59	3.04	4.78	3.11
	GCV (%)	3.70	3.68	3.12	2.66	3.11	2.96	3.67	2.90	3.44	2.90	4.54	2.72
	H (%)	92.98	92.70	71.65	64.15	90.05	92.55	94.80	92.20	91.90	89.32	89.43	76.72
	GA (%)	5.33	4.14	3.24	3.15	6.00	3.92	5.18	4.95	4.02	2.60	4.37	3.53
Days to maturity	PCV (%)	3.48	2.90	2.96	2.45	2.59	2.55	2.83	1.94	2.59	2.60	3.37	2.98
	GCV (%)	3.12	2.40	2.70	2.13	2.41	2.40	2.57	1.52	2.46	1.59	2.47	1.90
	H (%)	80.35	72.10	83.40	73.50	88.61	88.17	82.44	61.81	65.54	52.51	53.62	40.55
	GA (%)	3.04	2.13	3.22	2.26	3.60	3.52	3.78	2.62	2.93	2.60	1.99	1.57

plant^{-1} in the M_2 generation, indicating both the mutagens had drastic effect, which, however, persisted only in the M_2 generation. The recovery of the damage for this trait in M_3 could be attributed to the selection applied when the normal looking plants in M_2 were taken to raise the M_3 generation. This could have led to the elimination of the plants carrying gross chromosomal abnormalities. Scossiroli *et al*. (1966) also found such an increase in the mean of the quantitative characters in irradiated populations of *Triticum* as a consequence of elimination of "bad" genes. The mean values of panicle length were comparable to control in M_3 generation, whereas these were significantly high in all the treatments of both the mutagens in the M_2 generation. The mean values for number of grains panicle^{-1} in the EMS treated populations were significantly lower in both the generation except under 1.0% EMS dose, where it was significantly high as compared to control in M_2 generation. Unlike EMS, in the gamma irradiated populations, the mean values of this trait were either comparable or significantly lower to the control in the M_2 and M_3 generations. However, the decrease was more in M_3 generation as compared to M_2 generation. In the M_2 generation, the mean values for plant height in EMS treated populations did not differ significantly form the control except under 0.8% where

these were significantly lower to the control. The mean values of this trait in the gamma irradiated population were significantly lower under 25 kR and 35 kR in M_2 generation, comparable to control under 30kR in M_2 and 25 KR in the M_3 and significantly high under 30 kR and 35 KR in M_3 generation. The estimates of various genetic parameters for panicle length, number of grain panicle^{-1} and plant height in treated populations were higher in the M_2 generation than corresponding treatment in the M_3 generation (Table2). Both gamma-rays and EMS treatments were found effective in shortening the vegetative stage in the M_2 and M_3 generations. This might be due to the heritable nature of the early flowering mutants induced in the M_2 generation. Since, variety under study was late in flowering and maturity, induced variability in a direction opposite to previous selection history is inevitable as suggested by Brock (1965). The days to flowering and maturity for all the treatments of both the mutagens decreased significantly over the control in $M_2$and M_3 generations. Both the mutagens were effective in inducing variability in both the generations. The parameters such as PCV, GCV, H and GA for days to flowering and days to maturity were almost of the same magnitude in the M_2 and M_3 generations for both mutagens in all the treatments (Table2). The estimates of PCV, GCV, H and GA were high for grain yield plant^{-1}, number of grains panicle^{-1} and effective tillers plant^{-1}, in different treatments of both the mutagens in the M_2 and M_3 generations. High GCV for grain yield plant^{-1}, number of grains panicle^{-1} and effective tillers plant^{-1} in rice through induced mutagenesis has also been reported earlier by Kaul *et al*. (1981), Gupta and Sharma (1994) and Mehtre *et al* .(1996).

Form the foregoing results, it was observed that different quantitative traits responded differently in the manifestation of variability in different generations. The magnitude of the induced variability however, depended upon the mutagens and their treatments. When comparing both the mutagens, gamma- rays were found to be less effective in generating polygenic variation. Gaul (1967) and Joshi and Frey (1967) also reported that chemical mutagens were more effective than physical mutagen in generating polygenic variation for morphological traits. The doses of gamma rays were found to have linear relationship with the magnitude of PCV and GCV, whereas, in EMS treatments these estimates were maximum in 1.0% EMS dose.

Based upon the results obtained, two groups of characters could be identified. Firstly, the characters like panicle length, number of grains panicle^{-1}, plant height, days to flowering and days to maturity, where the maximum variability was induced in M_2 and there was on further increase in the variability in the M_3 generation. In second category of characters, such as grain yield plant^{-1}, 100- grain weight and effective tillers plant^{-1}, substantial variability was generated in M_2, which was further enhanced wherever the material was advanced to M_3 generation. Among the major factors contributing to the release of additional variation in the advance generation is the increased frequency of genetic recombination subsequent to mutational events as well as higher frequency of crossing over at unusual places e.g. near the centromere (Whittinghill, 1951; Lawrence 1961), background of the genotype and duplicate or multiplicate inheritance of the characters (Swaminathan, 1965).

In mutation breeding an important question arises, whether the selection of micromutations should be started in the M_2 or later generations? Although several experiments have been conducted in the past with the aim of inducing micromutations, few studies seem to have been undertaken to assess the extent of induced variability following treatment of plants in different generations. Palenzona (1966), while studying progress of selection for quantitative traits in wheat concluded that selection started in M_3 was more effective that if started in the M_2 generation. Scossiroli (1968), on the other hand did not observe large differences when the selection was started in the M_2 or M_3 generations. Selection for quantitative traits in the M_3 to M_5 generation was found to be more efficient than M_2 generation (Jana and Roy, 1973; Yonejawa *et al.*, 1973; Yonejawa, 1979). Yonejawa and Yamgata (1975) further observed that the efficiency of mutation breeding could be in some cases increased greatly by application of delayed selection methods. In the present investigation, an attempt was made to examine the appropriate generation for selection. The studies revealed that different quantitative traits responded differently in the manifestation of variability in different generations. The selection for a particular trait should be carried out in a particular generation when the highest degree of induced genetic variance is generated and mean is stabilized in favourable direction. Accordingly, in the present material selection for panicle

length, number of grains panicle^{-1}, plant height, days to flowering and days to maturity should be started in M_2, whereas for grain yield plant^{-1}, 100 grain weight and effective tillers plant^{-1} in the M_3 generation.

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