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RESEARCH ARTICLE :

Genetic parameter analysis in M_1 and M_2 generation of Rathu Heenati rice (*Oryza sativa* L.) variety

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SUMMARY : The present investigation was carried out to study the genetic parameters like phenotypic and genotypic co-efficient of variation (PCV and GCV), broad sense heritability and genetic gain of 167 rice mutants in order to assess the magnitude of variability in photoperiod sensitive rice varieties in M_1 and M_2 generation. The study revealed highly significant differences for all the studied characters, indicating the presence of substantial genetic variability. Comparative study on mean and variance indicated that various quantitative traits observed in M_1 and M_2 generations of Rathu Heenati indicated that considerable shift occurred in the mean for all the traits and increased variability was noticed for all the traits in M_2 generation. The highest heritability was recorded under 300Gy of gamma ray across the treatment. This dose will be serving as effective dose for creating variability in these two varieties. The phenotypic coefficient of variation (PCV) was higher than its corresponding genotypic counterpart (GCV) for all characters studied. Small differences between GCV and PCV were recorded for all the characters studied which indicated less influence of environment on these characters. The highest GCV and PCV were evident in total number of productive tillers per plant and single plant yield and their lowest values for plant height and number of grains per panicle. These characters may serve as effective selection parameter in breeding programme for crop improvement.

KEY WORDS :
Gamma rays, Mutation, Rice genotypes, Variability, Heritability

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BACKGROUND AND OBJECTIVES

Rice is the major staple food for about 65 per cent of the country's population and thus, an important pillar for food security of South Asia. More than 4,000 varieties of rice are grown in India to meet the varied consumer preferences (GAIN, 2011). Among the several resistant sources identified for BPH resistance in rice, rice accession Rathu Heenati remained with durable and broad-spectrum resistance to BPH across rice growing areas. However, these two rice accessions have not been fully exploited to transfer the genes conferring resistance to cultivated rice varieties due to their photoperiod sensitiveness and tall stature. These two parameters remained as the serious impediments in exploiting the worthiness of Rathu Heenati in using them as potential donors in evolving varieties with resistance to BPH. The success of creating mutations and exploiting the right mutants in crop breeding are being exploited for long time. The widespread use of induced mutants in plant breeding programmes throughout the world has led to the official release of more than 2,700 mutant plant varieties. It is noteworthy that a large number of mutant varieties had been developed and widely cultivated in developing countries (Shu, 2009). Among the mutagens employed, gamma (γ) rays remain as the potential mutagen in crop improvement programme. Collection and characterization of this germplasm is not only important for utilizing the appropriate attribute based donors in breeding programmes, but is also essential in the present era for protecting the unique rice. Genetic improvement of any crop is largely dependent on the magnitude of several genetic parameters like phenotypic and genotypic variances, phenotypic and genotypic co-efficient of variation (PCV and GCV), broad sense heritability and genetic gain; on which the breeding methods are formulated for its further improvement. Analysis on genetic variability reveals its presence and is of utmost importance as it provides the basis for effective selection. Hence, to obtain a comprehensive idea, it is necessary to undertake an assessment of quantitative traits. Since heritability is also influenced by environmental factors, the information on heritability alone may not help in pin-pointing characters enforcing selection. However, heritability estimates in conjunction with the predicted genetic gain will be more reliable (Johnson *et al.*, 1955). This study was undertaken to study the effect of induced mutation such as gamma rays in rice varieties and to assess the extent of genetic variation and the magnitude of heritability of several common agro-metrical characters and the maximum possible amount of genetic gain expected to occur in rice genotypes in M_1 and M_2 generation.

RESOURCES AND METHODS

Plant materials :

Rathu Heenati, possessing durable resistance to BPH formed the base material for the present study. Rathu Heenati, a rice accession from Sri Lanka is tall growing with photoperiod sensitiveness and remains as potential donors for BPH resistance in rice.

Gamma ray irradiation :

Seeds of Rathu Heenati obtained from the Department of Rice, Centre for Plant Breeding and Genetics (CPBG), Tamil Nadu Agricultural University (TNAU), Coimbatore were irradiated with different doses of gamma rays from Cobalt - 60 (^{60}Co) using the Gamma Chamber Model GC 1200 installed at CPBG, TNAU, Coimbatore. The different doses of gamma rays used for treating the seeds of Rathu Heenati are as follows: 100Gy, 150Gy, 200Gy, 250Gy, 300Gy and 350Gy. A set of 100 well filled and uniform seeds with 12 per cent moisture content of the variety was selected for irradiating them with each of the above mentioned doses. The irradiated seeds were sown on the same day in raised bed nursery established at the Paddy Breeding Station, Department of Rice, CPBG, TNAU. The LD_{50} values for both the genotypes were determined based on the probit analysis (Fienny, 1971 and 1978).

Evaluation of M_1 generation :

Twenty days old seedlings from each of the treatments of Rathu Heenati was transplanted with the spacing of 20 x 20cm in plots of 2.4 x 1.2m. A spacing of 30cm was maintained between plots. The experiment was conducted during *Rabi* 2009-2010. Three replications were maintained for all the treatments including control. Systematic randomization was carried out for all the treatments. Visually recognizable off-type plants, if any, were removed from time to time during the period of experimentation. Normal package of practices were followed during evaluation. A total five plants were observed for establishing the effect of different doses of gamma irradiation in each replication.

Evaluation of M_2 generation :

A total of 167 M_2 families of Rathu Heenati was constituted on individual panicle basis and were evaluated during *Rabi* 2010-2011. A total of 20 seedlings were transplanted in the field for each of the families. The seedlings of Rathu Heenati (not-irradiated) were transplanted for every 20 M_2 families to serve as controls. Normal package of practices were followed during evaluation. Quantitative traits were observed in both M_1 and M_2 generations. Traits *viz.*, plant height, number of productive tillers per plant, panicle length, number of grains per panicle, spikelet sterility and single plant yield were observed in M_1 and M_2 generations.

Data analysis :

The data from the various traits observed of the above two experiments were analyzed for getting basic statistics and ANOVA using the MINITAB software version 15 (2006). The estimates of variability parameters were worked out according to the method suggested by Lush (1940). Phenotypic and genotypic coefficients of variation were calculated based on the method advocated by Burton (1952). Both the PCV and GCV with a value of >20 %, 15-20 % and < 15 % were classified as high, moderate and low, respectively. Heritability in broad sense was estimated (Allard, 1960) and expressed in percentage. Genetic advance was estimated by the method suggested by Johnson *et al.* (1955).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

LD_{50} dose :

In carrying out studies on induced mutations determining the correct doses decide the nature of mutations. The doses can be determined by establishing the LD_{50} value for the mutagen to be used. Since the LD_{50} value is genotype dependent, the value has to be decided for each of the genotypes to be mutagenised. Moreover, this value varies with biological materials, nature of treatment and subsequent environmental conditions (Singh, 1994). In the present investigation, the LD_{50} value for Rathu Heenati was determined based on the survival of seedlings from the seeds treated with different doses of gamma rays adopting probit analysis. The arrived LD_{50} values of Rathu Heenati was 271.1 (Table 1).

Performance of Rathu Heenati in M_1 generation :

The mean, range, phenotypic and genotypic coefficient of variation, heritability and genetic advance of the M_1 generations of Rathu Heenati were listed in Table 2. For plant height, the values in each treatment ranged from 145.00 to 176.00 cm. The maximum plant height was recorded in plants derived from 100Gy (165.50 cm). The reduction in plant height was observed with the increase in dose of gamma rays. The mean plant height observed with the plants derived from 350Gy was found to be the lowest (155.30 cm). For plant height, the highest PCV, GCV, heritability and genetic advance was recorded under 300 Gy of gamma ray of 1.087, 0.895, 67.78 and 1.765 respectively. The number of productive tillers ranged from 7 to 20 and the maximum mean value of 15.20 was observed with plants derived at 350Gy. The mean value for the productive tillers ranged from 11.67 to 15.20 across the treatments. The highest PCV, GCV, heritability and genetic advance was recorded under 350Gy of gamma ray of 2.134, 9.470, 60.91 and 20.13, respectively. The mean panicle length of plants derived from different doses of gamma rays ranged from 14.60 cm (300Gy) to 30.87 cm (100Gy). There was a drastic reduction in panicle length when there was increase in gamma rays dose. Estimates of PCV, GCV for panicle length the highest value was recorded under the 350Gy of gamma ray of 12.134, 9.470, 60.91 and 20.13, respectively. The yield reduction was found to be

Table 1: Probit analysis for determining the LD_{50} value for different doses of gamma rays in Rathu Heenati

Treatments	No .of seeds evaluated	No. of plants killed	Observed mortality (%)	Corrected mortality (%)	Log 10 of doses	Emprical probit unit	Expected probit unit	Working probit	Weighing co-efficient	Weight
Rathu Heenati										
Control	50	2	-	-	-	-	-	-	-	-
100Gy	50	9	18.00	18.00	2.00	4.08	4.10	4.09	0.47	23.55
150Gy	50	15	30.00	30.00	2.18	4.48	4.50	4.48	0.56	27.90
200Gy	50	20	40.00	40.00	2.30	4.75	4.70	4.75	0.62	30.80
250Gy	50	24	48.00	48.00	2.40	4.95	4.90	4.95	0.63	31.35
300Gy	50	26	52.00	52.00	2.48	5.05	5.00	5.06	0.64	31.85
350Gy	50	27	54.00	54.00	2.54	5.10	5.10	5.21	0.01	20.25
400Gy	50	32	64.00	64.00	2.60	5.36	5.40	5.33	0.01	27.90
500Gy	50	34	68.00	68.00	2.70	5.47	5.50	5.47	0.60	30.05
600Gy	50	50	100.00	100.00	2.78	5.50	5.60	6.42	0.56	27.90

drastic with higher doses of gamma rays. The highest values of PCV and GCV were recorded under the 300Gy of gamma ray of 11.85 and 9.364 whereas the highest heritability (91.17) and genetic advance (21.02) was recorded under 250Gy of gamma rays for single plant yield. The mean percentage of spikelet sterility was found to be 81.05 with gamma ray dose of 350Gy derived plants. Reduction in spikelet sterility was observed with lower doses of gamma rays. An estimate of the highest PCV, GCV, heritability and genetic advance was recorded under 150Gy of gamma ray 4.457, 3.416, 58.314 and 5.612, respectively. Drastic reduction in number of grains per panicle was observed in all the categories of plants derived from various doses of gamma rays. The mean number of grains per panicle ranged from 46.08 to 117.60 across the M_1 plants derived from different doses of gamma rays. The mean value for the number of grains per panicle was found to be the maximum with the control. The highest value under 300Gy of gamma rays the values are 6.429, 4.902, 58.13 and 5.169 for PCV, GCV, heritability and genetic advance, respectively.

Performance of Rathu Heenati in M_2 generation :

The mean, range, phenotypic and genotypic co-efficient of variation, heritability and genetic advance of the M_2 mutant generations of Rathu Heenati were listed in Table 3. The mean plant height of 142.40, 142.00 and 152.00 cm were observed in families of 300Gy and 350Gy and non-irradiated Rathu Heenati, respectively. The highest PCV, GCV, heritability and genetic advance was recorded under 300Gy of gamma ray of 1.548, 1.159, 55.985 and 1.620, respectively. Reduction in mean number of productive tillers was observed with all the families derived with gamma ray irradiation. The mean values ranged from 6.54 (250Gy) to 8.87 (200Gy). The mean value for non-irradiated Rathu Heenati was found to be 15.20. The highest PCV, GCV and genetic advance was recorded under 350Gy of gamma ray of 21.375, 16.2 and 35.82, respectively whereas the highest heritability was recorded under 150Gy of gamma ray (65.190). Estimates of PCV, GCV and genetic advance for panicle length the highest value was recorded under the 150Gy of gamma ray of 5.354, 3.965 and 7.652, respectively. The highest mean value (18.86 g) was recorded for single plant yield in 250Gy of gamma ray irradiation. The highest values of PCV, GCV and genetic advance as per cent of mean was recorded under the 150Gy of gamma ray of 13.32, 10.66 and 18.16 whereas the highest heritability (66.04) was recorded under 350Gy of gamma rays. In case of spikelet sterility the maximum percentage was 31.62 at 300Gy of gamma ray. Spikelet sterility percentage was found to be higher in all the families derived from gamma ray irradiation. Estimates of PCV, GCV and genetic advance were recorded under 250Gy of gamma ray 9.560, 7.330 and 9.644, respectively. The mean number of grains per panicle was found to be 146.20 with families derived from 350Gy irradiation of gamma rays. It ranged from 28.00-245.00 in individuals observed across the M_2 families of Rathu Heenati. The highest value under 300Gy of gamma rays the values are 2.548, 2.077, 66.416 and 2.164 for PCV, GCV, heritability and genetic advance, respectively for this trait.

Mutagenesis is considered an effective and potential method to create genetic variation especially in crop plants (Hussain *et al*., 1982 and Auld *et al*., 2000). To attain maximum useful mutation density per unit genome and comparative effectiveness of γ-rays, optimal dose for treatment is the key to success. It was observed that the treating of seeds with high doses of gamma rays showed reduced germination with a corresponding decline in growth of seedlings. No germination was observed when the doses of gamma rays were 600Gy and above. The variation in LD_{50} values for different genotypes of the same species is a common observation in mutation studies depending upon the biological materials, their size, maturity, hardness, and moisture content at the time of treatment (Babaei *et al*., 2010; Soriano, 1961 and Tabasum *et al*., 2011). The percentage of germination of seeds treated with various doses of mutagen is used as an index to know the mutation effect. Soriano (1961) observed that there was no significant reduction in germination on exposure to 200, 250 and 300Gy gamma radiations. However, the reduction in germination rate with increasing radiation dose was reported (Cheema and Atta, 2003 and Wootton, 1988). Tabasum *et al*. (2011) reported that, the germination percentage remained almost unaffected by increasing gamma radiation doses although the highest germination of 96.44 per cent was recorded at 200Gy. It was observed that the treating of seeds with high doses of gamma rays showed reduced germination with a corresponding decline in growth of seedlings. These findings were corroborative with Aslam *et al*. (2013). The comparative analysis made on the means and variances for these traits in M_1 and M_2

Table 2 : Mean, range, PCV, GCV, h^2 and GA for Rathu Heenati in M_1 generation

Characters	Mean	Range	PCV	GCV	h^2	GA (%)
Plant height						
Control	166.0	160.0-175.0	-	-	-	-
100 Gy	165.46	155.4-173.0	1.001	0.809	65.290	1.626
150 Gy	161.3	145.0-172.0	0.985	0.777	62.255	1.590
200 Gy	163.1	150.0-176.0	0.974	0.769	62.26	1.573
250 Gy	162.4	150.0-175.0	1.020	0.794	60.56	1.537
300 Gy	158.2	145.0-165.0	1.087	0.895	67.78	1.765
350 Gy	155.3	145.0-170.0	1.018	0.801	61.89	1.642
Number of productive tillers per plant						
Control	14.20	7.00-20.00	-	-	-	-
100 Gy	14.73	9.00-20.00	9.504	7.009	54.39	15.21
150 Gy	11.67	8.00-18.00	10.855	7.220	44.234	15.621
200 Gy	11.87	9.00-16.00	11.29	7.990	50.13	17.40
250 Gy	13.00	7.00-18.00	11.70	8.367	51.18	16.22
300 Gy	11.67	7.00-19.00	11.28	7.847	48.37	17.08
350 Gy	15.20	9.00-16.00	12.134	9.470	60.91	20.13
Panicle length						
Control	29.07	27.00-32.10	-	-	-	-
100 Gy	30.87	28.00-33.00	1.050	4.781	3.319	48.19
150 Gy	29.40	24.00-32.00	0.734	4.641	2.913	39.396
200 Gy	30.24	28.00-32.00	0.679	4.446	2.725	37.57
250 Gy	22.33	23.00-31.50	1.969	8.557	6.282	53.90
300 Gy	14.60	10.00-20.00	1.549	11.21	8.525	57.86
350 Gy	15.20	10.00-20.00	1.095	9.811	6.886	49.26
Single plant yield						
Control	30.60	20.00-49.00	-	-	-	-
100 Gy	30.13	18.00-44.00	5.450	3.340	37.56	5.136
150 Gy	30.33	16.00-47.00	6.636	5.073	58.444	7.938
200 Gy	19.47	9.00-33.00	10.12	7.619	56.64	11.99
250 Gy	17.87	5.00-41.00	5.872	5.606	91.17	21.02
300 Gy	17.87	7.00-40.00	11.85	9.364	62.44	14.40
350 Gy	18.40	9.00-27.00	9.413	6.235	43.87	9.823
Spikelet sterility						
Control	37.55	30.00-46.00	-	-	-	-
100 Gy	36.23	21.00-58.20	4.457	2.867	41.37	4.704
150 Gy	42.81	23.00-65.10	4.474	3.416	58.314	5.612
200 Gy	54.95	31.00-78.00	3.092	2.120	47.02	3.526
250 Gy	65.39	45.00-99.00	3.855	2.484	41.52	2.616
300 Gy	77.97	59.20-86.00	2.246	1.591	50.15	2.650
350 Gy	81.05	67.90-99.10	2.312	1.738	56.47	2.870
Number of grains per panicle						
Control	123.9	70.00-280.00	-	-	-	-
100 Gy	102.6	11.00-217.00	2.814	2.095	55.42	2.226
150 Gy	93.07	14.00-254.00	3.251	2.506	59.41	2.630
200 Gy	89.67	15.00-260.00	3.245	2.431	56.12	2.579
250 Gy	70.27	0.00-217.5	4.069	3.005	54.56	3.199
300 Gy	46.33	0.00-204.0	6.429	4.902	58.13	5.169
350 Gy	72.60	0.00-182.00	3.878	2.827	53.14	3.015

Table 3 : Mean, range, PCV, GCV, h^2 and GA for Rathu Heenati in M_2 generation

Characters	Mean	Range	PCV	GCV	h^2	GA (%)
Plant height						
Control	152.0	148.0-162.0	-	-	-	-
100 Gy	142.1	133.2-152.6	1.543	1.150	55.48	1.609
150 Gy	139.2	131.0-149.3	1.482	1.044	49.642	1.470
200 Gy	147.8	139.0-166.2	1.422	1.020	51.483	1.436
250 Gy	147.0	121.0-156.0	1.494	1.115	55.664	1.560
300 Gy	142.4	132.4-160.6	1.548	1.159	55.985	1.620
350 Gy	142.0	130.2-153	1.519	1.117	54.02	1.567
Number of productive tillers per plant						
Control	15.2	14-22	-	-	-	-
100 Gy	8.173	7-9.8	16.38	11.88	52.59	26.51
150 Gy	7.984	6.2-15.8	19.56	15.80	65.190	33.64
200 Gy	8.874	6-14.2	16.49	12.81	60.353	28.02
250 Gy	6.547	4.6-8.6	21.25	15.91	56.113	35.31
300 Gy	6.9	4.4-9.8	20.53	15.59	57.681	34.44
350 Gy	6.610	4.8-9.6	21.375	16.20	57.46	35.82
Panicle length						
Control	29.07	24-33	-	-	-	-
100 Gy	31.87	30.1-33.7	4.612	3.188	47.76	6.175
150 Gy	29.53	24-32.2	5.354	3.965	54.845	7.652
200 Gy	32.50	27-35.3	4.759	3.459	52.821	6.697
250 Gy	31.64	28.4-33.6	4.761	3.376	50.288	6.547
300 Gy	29.94	27.7-31.8	5.125	3.698	52.061	7.165
350 Gy	31.29	26.8-35.4	5.137	3.856	56.33	7.417
Single plant yield						
Control	28.53	20-35	-	-	-	-
100 Gy	14.97	9-25.6	12.52	9.827	61.63	16.96
150 Gy	14.53	6.2-29.6	13.32	10.66	64.020	18.16
200 Gy	16.04	8-29.2	11.50	8.933	60.368	15.50
250 Gy	18.86	8.2-26.4	10.01	7.899	62.217	13.59
300 Gy	15.84	6.8-27.4	11.92	9.397	62.176	16.17
350 Gy	18.55	7.8-34.8	10.740	8.728	66.04	14.67
Spikelet sterility						
Control	16.53	12-23.5	-	-	-	-
100 Gy	30.89	12-65.45	7.951	6.190	60.62	8.085
150 Gy	28.28	10.8-39.1	7.884	5.696	52.195	7.605
200 Gy	27.55	9-59.5	8.914	6.940	60.616	9.064
250 Gy	25.11	10.1-62.6	9.560	7.330	58.787	9.644
300 Gy	31.62	9.1-78.5	7.983	6.322	62.706	8.171
350 Gy	26.3	2-58.4	9.321	7.240	60.34	9.468
Number of grains per panicle						
Control	122	88-240	-	-	-	-
100 Gy	130.9	43-240	2.439	1.978	65.77	2.071
150 Gy	132.4	81-222.7	2.316	1.836	62.885	1.957
200 Gy	132.5	28-245	2.347	1.876	63.923	1.988
250 Gy	143.2	54-224.7	2.182	1.749	64.289	1.849
300 Gy	126.5	61-225	2.548	2.077	66.416	2.164
350 Gy	146.2	75-233.3	2.135	1.711	64.20	1.809

Table 4 : Comparison of mean and variance of various traits observed in M_1 and M_2 generations of Rathu Heenati

Treatments	Mean M_1	Mean M_2	Variance M_1	Variance M_2
Plant height				
Control	166.00	152.00	0.953	2.141
100Gy	165.50	142.10	1.792	2.668
150Gy	161.30	139.20	1.571	2.110
200Gy	163.10	147.80	1.571	2.272
250Gy	162.40	147.00	1.662	2.688
300Gy	158.20	142.40	2.004	2.723
350Gy	155.30	142.00	1.547	2.515
Productive tillers per plant				
Control	14.20	15.20	0.894	0.849
100Gy	14.73	8.17	1.066	0.942
150Gy	11.67	7.98	0.709	1.590
200Gy	11.87	8.87	0.899	1.293
250Gy	13.00	6.54	1.183	1.086
300Gy	11.67	6.90	0.838	1.157
350Gy	15.20	6.61	1.394	1.147
Panicle length				
Control	29.07	29.07	1.128	1.128
100Gy	30.87	31.87	1.050	1.032
150Gy	29.40	29.53	0.734	1.371
200Gy	30.24	32.50	0.679	1.263
250Gy	26.65	31.64	1.916	1.142
300Gy	14.60	29.94	1.549	1.225
350Gy	15.20	31.29	1.095	1.456
Number of grains per panicle				
Control	123.90	152.00	3.720	3.488
100Gy	117.60	130.90	7.010	6.702
150Gy	108.50	132.40	6.850	5.910
200Gy	85.70	132.50	6.770	6.180
250Gy	90.40	143.20	8.230	6.279
300Gy	46.08	126.50	7.470	6.898
350Gy	76.65	146.20	7.500	6.254
Spikelet sterility				
Control	37.55	16.53	1.529	2.376
100Gy	36.23	30.89	1.079	3.656
150Gy	42.81	28.28	2.139	2.594
200Gy	54.95	27.55	1.357	3.656
250Gy	65.39	25.11	2.637	3.389
300Gy	77.97	31.62	1.538	3.995
350Gy	81.05	26.30	1.983	3.614
Single plant yield				
Control	30.60	28.53	1.684	1.348
100Gy	30.13	14.97	1.013	2.165
150Gy	30.33	14.53	2.368	2.399
200Gy	19.47	16.04	2.200	2.054
250Gy	17.87	18.86	1.969	2.220
300Gy	17.87	15.84	1.549	2.216
350Gy	18.40	18.55	1.316	2.622

generations indicated profound influence of the gamma rays on the traits *viz*. number of grains per panicle, spikelet sterility and single plant yield. There was a significant reduction in the number of grains per panicle and single plant yield with the increase in the dose of gamma rays. In the M_1 generation of Rathu Heenati, the number of grains per panicle was high (117.60) at 100Gy and low (76.65) at 350Gy. The single plant yield followed the same trend. It was high (30.13) with low dose and low (18.40) with high dose. The spikelet sterility showed dose dependent response. The sterility increased (81.05%) with high dose (350Gy). The same trend was observed for spikelet sterility and single plant yield in M_2 generation but not with number of grains per panicle. The number of grains per panicle was found to be increased in M_2 generations of all the doses. Similar observations were made by Van Harten (1998); Fu *et al*. (2008) and Babaei *et al*. (2010). Comparison of the means and variances of various quantitative traits observed in M_1 and M_2 generations indicated that considerable shift occurred in the mean for all the traits and increased variability was noticed for all the traits in M_2 generation (Table 4). This could be because of recombination happened in the M_1 plants. The extent of variability was higher in M_2 generation. Invariably, the variability increased significantly in both the varieties, irrespective of increase or decrease in the mean values. Similar results were reported by Amirthadevarathinam *et al*. (1990); Gupta and Sharma (1994); Siddiqui and Sanjeeva (2010) and Aditi and Amitava (2012). Considering mutation and recombination in creating variability, it is expected that recombination creates more genetic variability in all the biological systems (Johnston, 2001). Knowledge on genetic variability of the available population is very essential for any crop improvement programme, as it will positively enhance the efficiency of selection. Genetic variability, which is partitioned from environmental effects, is appreciated. The co-efficient of variation helps to measure the range of diversity available in the character with reference to its mean and provides a means to compare the variability present in the quantitative characters. Gaul (1964) stated that radiation induced variability could be determined in M_2 generation whereas Borojevic and Borojevic (1969) opined that variability increased in wheat upto four times in M_2 and M_3 which decreased in M_4 and stabilized around M_5 generation. In order to know the breeding utility of the variability and selection value of various quantitative traits, it is essential to determine various components and heritable proportion of variability (Gottschalk and Kaul, 1980). The variability for quantitative traits is expressed by the environmental factors and selection would be highly difficult, if the available variability among genotypes is due to the environment. Though the genotypic coefficient of variation reveals the extent of genetic variability persist in the genotypes for the various component characters, it does not indicate whether the variation is to be heritable. In this study difference between PCV and GCV for the studied characters was very less across the treatments indicating low sensitivity to environment and consequently greater role of genetic factors influencing the expression of these characters. This was similar to the results of Bineeta *et al.*, 2012 and Mahmood *et al.*, 2013. Estimation of heritability and genetic advance as per cent of mean in a given population is also needed to assess the extent of genetic gain expected from effective selection. A relative comparison of heritability estimates and expected genetic advance as per cent of mean will give an idea about the nature of gene action governing a particular trait. High value of heritability together with high genetic advance for any character indicates additive gene action and selection will be rewarding for improvement of such traits, whereas high heritability associated with low genetic advance might attribute to the presence of non-additive gene action which indicates epistasis, dominance and genotypic and environmental interaction (Tikka *et al.*, 1977), hence, their response to selection would be poor. A study on heritability estimates of the families indicated that for plant height, panicle length and single plant yield was found to higher in 300Gy of gamma rays with appreciate amount of genetic advance as percent of mean. Therefore selection of families within these treatments would result in the identification of good yielding types. The economic mutants identified from this population will be forwarded through pedigree breeding for getting superior genotypes. These lines will be exploited further for developing line BPH resistance combinations with photoperiod insensitive and higher yield.

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