J. Soils and Crops 27 (1) 95-100, June 2017 **ISSN 0971-2836**

MUTATION INDUCTION BY GAMMA RAYS AND EMS IN MUSTARD (*Brassica juncea*) cv. BIO 902

N. A. Mohurle[1], S. U. Charjan[2], Beena Nair[3]and P. N. Jogdande[4]

ABSTRACT

Seeds of *Brassica juncea* L. cv. BIO 902 were treated with EMS (0.5%) and gamma rays (900-1300 Gy) with the objective to study the variability for qualitative and quantitative traits, to isolate morphological and economical mutants and to elucidate the information on the effectiveness and efficiency of mutagens in M_2 generation. Reduced germination and increased seedling mortality was observed in M_1 and M_2 generation. The variability in treated population was more than control for all the qualitative and quantitative characters. Mutation frequency increased with the increase in doses of gamma rays alone and combination treatment of gamma rays and EMS. Morphological mutants viz., varigated, early and late maturing, branched, appressed, tall and dwarf were identified. These mutants were isolated from all the treatments of gamma rays (900 -1300 Gy) and combination treatment of gamma rays and EMS (0.5%) in BIO 902 variety. In general combination treatment of gamma rays and EMS showed higher mutagenic effectiveness than gamma rays alone in BIO 902 variety. The 1300 Gy gamma rays were found to be most effective and efficient to induce wide range of mutation in mustard.

(Key words: Mutation, gamma rays, EMS)

INTRODUCTION

Indian mustard (*Brassica juncea*) is one of the important oilseed crops in India after groundnut.It is also called 'rai', 'raya', or 'laha'. Indian mustard belongs to family cruciferae *(Syn. Brassicaceae)* and genus *Brassica* with chromosome number 2n=36.Mustard is predominantly grown in India for extraction of oil. Oil content of Indian mustard varies from 38 - 48%.Mustard is grown in more than 50 countries of Asia, Europe, America and Australia covering about 25 million ha area with a total production of about 40 million tonnes.In India, area under mustard cultivation is 60.12 lakh hectares producing about 62.82 lakh tones of seeds with average productivity of 1145 kg ha^{-1} (Anonymous, 2015). Area under mustard cultivation in Maharashtra was 12000 hectares with the production of 4000 tones and average productivity of 310 kg ha^{-1} (Anonymous, 2015a). In Vidarbha, area under cultivation is 685 ha with the production of 335 tones and productivity of 382 kg ha^{-1} (Anonymous, 2015b).

It is well known that improvement of plants through conventional breeding methods is slow, time consuming and labour-intensive. Non conventional genetic improvement programs based on mutation induction, tissue culture and molecular genetics are essential tools of breeding programs.Induced mutations have been accepted as useful tool in a plant-breeding programme.One of the most important role of mutation breeding is the creation of genetic variability in quantitative traits in various crop plants (Shah *et al.*, 1990). The variability, thus created, enhances the chances for selection of new genotypes with desired characteristics.

Mutagenesis provides a unique opportunity for the improvement of oleiferous *Brassica*. Physical and chemical mutagens have been successfully used in rapeseed and mustard to evolve new varieties with improved economic traits. Combination of physical and chemical treatment used in other crops (Rakow and Raney, 2003) has indicated the higher frequency of mutations in combined treatmentsas compared with the separate ones.

The present studies were conducted to compare the relative effectiveness of gammarays alone and in combination of gamma rays and ethyl methane sulphonate to induce genetic variability in the mustard (cv. BIO 902) and to isolate the genotypes with improved characters.

MATERIALS AND METHODS

Dry healthy and genetically pure seeds of *Brassica juncea* cv. BIO 902 were divided into six lots of 300 seeds each for giving the gamma rays treatment separately. These 600 seeds of selected variety were subjected to irradiation with 900,1000,1100,1200 and 1300 Gy (Co^{60} at BARC). The 300 seeds of each treatment were treated with 0.5% aqueous solution of EMS after pre-soaking with sterilized distilled water for 12 hours.

The treated seeds along with one control of dry and another of water soaked were sown in the field to raise M_1 generation in non replicated trial. M_1 generation was screened for different morphological mutants and seeds from

1 and 4. P.G. Students, Botany Section, College of Agriculture, Nagpur
2. Asstt. Professor, Botany Section, College of Agriculture, Nagpur
3. Mustard breeder, AICRP on oilseeds, Nagpur

each M_1 generation were harvested separately.

M_2 generation was raised in *rabi* 2015. Twelve treatments included, different doses of gamma rays alone and combination of gamma rays and EMS along with control of mustard variety BIO 902. 30 M_2 plants were selected at random per treatment to record the observations on yield and yield components. Mean, Standard deviation, variance, coefficient of variation, mutagenic efficiency and effectivenesss were calculated by the formula suggested by Konzak *et al.* (1965).

RESULTS AND DISCUSSION

Data regarding germination % showed that reduced germination % in all the treatment was observed in M_1 generation as compared to control (Table 1). Treatment 1200 Gyrecorded the highest reduction in germination % (21.24%), while it was the lowest in treatment 0.5% EMS + 900 Gy (11.45%). The germination % in control was 80.65% and 81.21% respectively.In M_2 generation, germination decreased in all the treatments except 0.5% EMS + 1200 Gy as compared to control. The data revealed an increase in germination in M_2 as compared to M_1 generation in all the treatments except 0.5% EMS + 1200 Gy. In M_2 reduction in germination percentage was highest in 0.5% EMS + 1200 Gy (25.28%), while the lowest in 900 Gy (1.68%) as compared to control (87.35%, 91.43%).

Data regarding germination indicated that gamma rays alone and combination treatment of gamma rays and EMS reduced the germination % in M_1 generation. The germination % increased in M_2 generation as compared to M_1 in gamma rays alone and combination treatment of gamma rays and EMS. Similar to this result, decrease in percentage of germination with high dose of gamma rays was also reported by Yasin and Aly (2014).

Data regarding mortality showed that in M_1 generation the highest mortality was recorded in 0.5% EMS + 1300 Gy(9.81%), while the lowest was observed in 900 Gy (2.39%) as compared to their controls untreated and water soaked (1.34% and 2.35% respectively). Increase in mortality was found with the increase in concentration of gamma rays in BIO 902 variety except in treatment 0.5% EMS + 1100 Gy.In M_2 generation, maximum mortality was recorded in 1300 Gy(4.87%), while minimum was in 1000 Gy (0.98%). Table 1revealed that the mortality increased in M_2 generation as compared to control. In M_1 generation mortality per cent increased with increase in the doses of gamma rays alone and combination treatment of gamma rays and EMS except in 0.5% EMS + 1100 Gy (8.47). But in M_2 generation there was no specific trend. This indicates the BIO 902 variety responded differently to different concentration of mutagens.Voice *et al.* (2004) observed greater mortality in mustard (*Brassica juncea*), when treated with EMS, DES and gamma rays than control.

Data regarding the mean value for days to maturity was found to decrease in all the treatments of gamma rays alone, but increased in all the combination treatments of gamma rays and EMS except 0.5% EMS + 900 Gy (120.17) and 0.5% EMS + 1200 Gy(120.67) than control (121.50 and121.00). The maximum mean value for the character was observed in 0.5% EMS + 1300 Gy(144.07) and minimum in 1000 Gy(116.23) in BIO 902 variety. Maximum variation was found to be in 0.5% EMS + 1300 Gy (51.61%), while the minimum in 1300 Gy (18.49%).From table 2 it is seen that, treatment with gamma rays resulted in early maturity in 900 Gyto1300 Gy only, while combination treatment of gamma rays and EMS resulted in early maturity in 0.5% EMS + 900 Gy (120.17) and 0.5% EMS + 1200 Gy (120.67) and late maturity in 0.5% EMS + 1000 Gy (124.17), 0.5% EMS + 1100 Gy(121.83) and 0.5% EMS + 1300 Gy (144.07)than control (121.50 and 121.00).Khatri *et al.* (2005) reported early maturity with the increase in dose of EMS and gamma rays.

The data regarding the plant height showed that plant height increased in all the treatments. Maximum plant height was observed in1100 Gy (157.13cm), while the minimum was in0.5% EMS + 900 Gy (128.97cm) of BIO 902 as compared to control (114.00cm and 122.20cm).The coefficient of variation for plant height increased in all the treatments. The maximum variation was in 0.5% EMS + 1200 Gy (51.65%) followed by0.5% EMS + 1300 Gy (51.28%) and minimum in 1300 Gy (23.59) as compared to control (19.26% and11.08%) respectively (Table 3).The mean height in general, increased significantly due to gamma rays alone and gamma rays in combination with EMS.Thagana *et al.*(2006) showed similar result on treatment with gamma rays, which resulted in tall plants, in contrast reduced plant height was reported by Malek *et al.* (2012).

Data regarding number of branches plant^{-1} revealed that the highest mean value for the number of branches plant^{-1} was in 1000 Gy (6.40) and the lowest in 0.5% EMS + 1200 Gy (3.40). In general the number of branches plant^{-1} increased in all the treatments of gamma rays alone, but decreased in combination treatment of gamma rays and EMS as compared to their control (4.20 and 5.60). The variability studies showed that the coefficient of variation increases against their control in all the treatments. The highest variation was recorded in 0.5% EMS + 1200 Gy (57.88%). Increase in number of branches plant^{-1} was observed in treatment with physical mutagens than combination of physical and chemical mutagens as compared to control (Table 4). Yaqoob and Ahmed (2003) observed that there was no consistency in the number of branches in response to the increase in radiation dose. Mutant showed significantly more number of branches.

Data on number of siliqua plant^{-1}(Table 5)revealed that the highest mean value for number of siliqua plant^{-1} was in 0.5% EMS + 1100 Gy (91.00) and the lowest in 0.5% EMS + 1000 Gy(59.13). The coefficient of variation for the character increased in all the treatments as compared to the controls. The highest variation was noticed in 1200 Gy (77.27%) and the lowest in 1000 Gy(45.90%). Both gamma rays and EMS proved to be effective in increasing the number of siliqua plant^{-1}. The variations were induced by both the mutagens. Hassan and Haleem (2014) observed

Table 1. Effect of different treatment of EMS and gamma rays on germination and mortality per cent of variety BIO 902 in M_1 and M_2 generation

Treatments	Germination (%)		Mortality (%)	
	M_1	M_2	M_1	M_2
T_1 Control (untreated)	80.65	87.35	1.47	0.78
$T_3$900 Gy	68.58	85.71	2.39	1.18
$T_4$1000Gy	66.39	81.36	3.75	0.98
$T_5$1100 Gy	60.57	77.46	5.98	3.42
$T_6$1200 Gy	59.41	76.10	9.22	3.04
$T_7$1300 Gy	60.46	74.93	9.76	4.87
T_2Control (Water soaked)	81.21	91.43	2.13	0.94
$T_8$0.5 % of EMS+900 Gy	69.76	82.31	7.07	2.39
$T_9$0.5 % of EMS+1000 Gy	64.33	79.75	8.65	1.74
T_{10} 0.5 % of EMS 1100 Gy	65.89.	81.59	8.47	4.10
T_{11}0.5 % of EMS 1200 Gy	66.72	66.05	9.28	3.95
T_{12}0.5 % of EMS 1300 Gy	61.55	78.04	9.81	4.77

Table 2. Effect of different treatments of EMS and gamma rays on days to maturity (days) plant^{-1}of variety BIO 902 in M_2generation

Treatments	Range	Mean	Variance	S D	CV %
T_1 (control Untreated)	7.00	121.50	6.72	2.59	2.13
T_2 (control Water soaked)	7.00	121.00	5.33	2.31	1.91
T_3 (900 Gy)	35.00	121.03	2709.67	52.05	43.01
T_4 (1000 Gy)	15.00	116.23	1998.71	44.71	38.46
T_5 (1100 Gy)	20.00	118.43	2232.08	47.24	39.89
T_6 (1200 Gy)	20.00	119.00	1539.39	39.24	32.97
T_7 (1300 Gy)	25.00	119.27	486.45	22.06	18.49
T_8 (0.5% of EMS and 900 Gy)	10.00	120.17	1549.12	39.36	32.75
T_9 (0.5% of EMS and 1000 Gy)	35.00	124.17	1022.96	31.98	25.76
T_{10} (0.5% of EMS and 1100 Gy)	40.00	121.83	3258.33	57.08	46.85
T_{11} (0.5% of EMS and 1200 Gy)	25.00	120.67	3780.92	61.49	50.96
T_{12} (0.5% of EMS and 1300 Gy)	13.00	119.33	3680.33	60.67	51.61

Table 3. Effect of different treatments of EMS and gamma rays on plant height (cm) of variety BIO 902 in M_2 generation

Treatments	Range	Mean	Variance	S D	CV %
T_1 (control Untreated	65.00	114.00	482.22	21.96	19.26
T_2 (control Water soaked)	47.00	122.20	183.29	13.54	11.08
T_3 (900 Gy)	46.00	141.30	4334.48	65.84	46.59
T_4 (1000 Gy)	75.00	155.20	3250.68	57.01	36.74
T_5 (1100 Gy)	87.00	157.13	4322.75	65.75	41.84
T_6 (1200 Gy)	72.00	151.53	2812.15	53.03	35.00
T_7 (1300 Gy)	106.00	143.80	1150.54	33.92	23.59
T_8 (0.5% of EMS and 900 Gy)	72.00	128.97	2102.65	45.85	35.56
T_9 (0.5% of EMS and 1000 Gy)	65.00	136.30	1362.82	36.92	27.08
T_{10} (0.5% of EMS and 1100 Gy)	85.00	142.53	4688.16	68.47	48.04
T_{11} (0.5% of EMS and 1200 Gy)	75.00	143.67	5506.01	74.20	51.65
T_{12} (0.5% of EMS and 1300 Gy)	45.00	143.13	5386.40	73.39	51.28

Table 4. Effect of different treatments of EMS and gamma rays on number of branches plant^{-1}of variety BIO 902 in M_2generation

Treatments	Range	Mean	Variance	S D	CV %
T_1 (control Untreated	3.00	4.20	1.07	1.03	24.59
T_2 (control Water soaked)	4.00	5.60	1.60	1.26	22.59
T_3 (900 Gy)	5.00	5.07	6.15	2.48	48.93
T_4 (1000 Gy)	5.00	6.40	7.14	2.67	41.75
T_5 (1100 Gy)	4.00	4.57	4.49	2.12	46.41
T_6 (1200 Gy)	6.00	5.03	4.38	2.09	41.56
T_7 (1300 Gy)	6.00	5.43	2.86	1.69	31.15
T_8 (0.5% of EMS and 900 Gy)	6.00	4.93	4.60	2.14	43.47
T_9 (0.5% of EMS and 1000 Gy)	4.00	3.60	1.73	1.31	36.49
T_{10} (0.5% of EMS and 1100 Gy)	5.00	3.57	3.87	1.97	55.19
T_{11} (0.5% of EMS and 1200 Gy)	5.00	3.40	3.87	1.97	57.88
T_{12} (0.5% of EMS and 1300 Gy)	3.00	3.73	3.96	1.99	53.31

Table 5. Effect of different treatments of EMS and gamma rays on number of siliqua plant^{-1}of variety BIO 902 in M_2 generation

Treatments	Range	Mean	Variance	S D	CV %
T_1 (control Untreated	31.00	37.10	82.99	9.11	24.55
T_2 (control Water soaked)	49.00	43.50	278.94	16.70	38.39
T_3 (900 Gy)	128.00	74.43	1820.35	42.67	57.32
T_4 (1000 Gy)	100.00	91.00	1744.59	41.77	45.90
T_5 (1100 Gy)	132.00	89.10	2036.30	45.13	50.65
T_6 (1200 Gy)	280.00	66.83	2667.00	51.64	77.27
T_7 (1300 Gy)	112.00	63.73	1002.96	31.67	49.69
T_8 (0.5% of EMS and 900 Gy)	158.00	74.87	2012.54	44.86	59.92
T_9 (0.5% of EMS and 1000 Gy)	148.00	64.43	1648.70	40.60	63.02
T_{10} (0.5% of EMS and 1100 Gy)	110.00	73.83	1840.21	42.90	58.10
T_{11} (0.5% of EMS and 1200 Gy)	92.00	59.13	1340.81	36.62	61.90
T_{12} (0.5% of EMS and 1300 Gy)	115.00	72.53	1916.76	43.78	60.36

Table 6. Effect of different treatments of EMS and gamma rays on 1000 seed weight (g) plant^{-1} of variety BIO 902 in M_2generation

Treatment	Range	Mean	Variance	S D	CV %
T_1 (control Untreated	2.00	2.98	0.35	0.50	19.81
T_2 (control Water soaked)	1.70	3.21	0.42	0.65	20.27
T_3 (900 Gy)	1.80	3.55	2.49	1.58	44.41
T_4 (1000 Gy)	2.00	3.32	1.74	1.32	39.70
T_5 (1100 Gy)	2.30	3.47	2.26	1.50	43.29
T_6 (1200 Gy)	1.80	3.43	1.49	1.22	35.59
T_7 (1300 Gy)	2.50	3.27	0.70	0.83	25.51
T_8 (0.5% of EMS and 900 Gy)	1.90	3.39	1.88	1.37	40.43
T_9 (0.5% of EMS and 1000 Gy)	2.50	3.51	1.29	1.14	32.40
T_{10} (0.5% of EMS and 1100 Gy)	2.50	3.37	2.79	1.67	49.58
T_{11} (0.5% of EMS and 1200 Gy)	1.70	3.85	4.01	2.00	51.98
T_{12} (0.5% of EMS and 1300 Gy)	2.40	3.01	2.53	1.59	52.92

Table 7. Effect of different treatments of EMS and gamma rays on seed yield plant^{-1} of variety BIO 902 in M_2 generation.

Treatment	Range	Mean	Variance	S.D	CV %
T_1 (control Untreated)	1.93	3.14	0.42	0.65	20.72
T_2 (control Water soaked)	3.17	3.45	1.15	1.07	31.08
T_3 (900 Gy)	10.20	5.90	13.35	3.65	61.98
T_4 (1000 Gy)	8.48	7.29	13.36	3.66	50.15
T_5 (1100 Gy)	12.32	6.95	15.05	3.88	55.78
T_6 (1200 Gy)	21.26	5.17	16.38	4.05	78.35
T_7 (1300 Gy)	9.20	4.95	7.25	2.69	54.37
T_8 (0.5% of EMS and 900 Gy)	15.00	5.80	17.21	4.15	71.48
T_9 (0.5% of EMS and 1000 Gy)	14.01	5.12	14.33	3.79	73.93
T_{10} (0.5% of EMS and 1100 Gy)	10.07	5.57	11.36	3.37	60.51
T_{11} (0.5% of EMS and 1200 Gy)	6.41	4.41	6.90	2.63	59.48
T_{12} (0.5% of EMS and 1300 Gy)	10.39	5.69	12.74	3.57	62.72

Table 8. Frequency of induced mutants in different treatments of EMS and gamma rays in M_2 generation

Sr. no	Type of mutation	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	Total
1	Varigated	0.65	2.03	-	-	0.96	-	-	0.74	0.12	-	4.50
2	Dwarf	-	-	-	-	-	1.86	0.67		-	-	2.53
3	Tall	0.47	0.68	1.78	1.51	0.87	-	-	1.03	-	1.62	7.96
4	Late flowering	-	-	-	-	-	-	1.64	0.90	-	1.82	4.36
5	Early maturing	0.54	0.61	1.91	0.65	0.73	0.58	-	-	1.33	-	6.35
6	Late maturing	-	-	-	-	0.28		0.63	1.20		0.77	2.88
7	High yielding	0.15	0.65	0.47	-	0.19	0.36	0.14	0.29	1.03	1.26	4.54
8	More branch	-	1.08	-	0.42	0.75	-	-	0.10	-	0.56	2.91
9	Long silliqua	-	-	0.55	-	0.74	-	0.22	0.70	-	0.46	2.67
10	Bold seeded	0.44	1.10	0.69	-	-	0.51	0.37	-	0.81	-	3.92
11	Aphid tolerant	0.36	0.52	0.87	0.43	0.28	0.54	1.10	0.92	0.45	0.37	5.84
12	Powdery mildew tolerant	0.22	-	0.36	-	0.14	-	-	-	-	-	0.72
13	Apprased	0.29	0.26	0.47	0.39	0.55	0.60	0.43	0.84	0.27	0.63	4.73
14	Short silliqua	-	-	-	0.35	0.52	0.42	0.39	0.44	0.32	0.18	2.62
Total		3.12	6.93	7.10	3.75	6.01	4.87	5.59	7.16	4.33	7.67	56.53

Table 9. Mutagenic efficiency and effectiveness of different treatments of EMS and gamma rays in *Brassica juncea* L. cv. BIO 902

Treatments	% Lethality (L)	% Mutation per 100 M_2 plants (MP)	Mutagenic efficiency (MP/L)	Mutagenic effectiveness (MP/tc)
T_3 (900 Gy)	0.76	1.01	1.33	0.17
T_4 (1000 Gy)	1.25	1.55	1.24	0.06
T_5 (1100 Gy)	1.86	2.32	1.25	0.10
T_6 (1200 Gy)	3.44	2.49	0.72	0.10
T_7 (1300 Gy)	3.59	3.18	0.89	0.13
T_8 (0.5 % of EMS and 900 Gy)	1.91	1.56	0.82	0.07
T_9 (0.5 % of EMS and 1000 Gy)	2.83	3.21	1.13	0.13
T_{10} (0.5 % of EMS and 1100 Gy)	2.87	3.39	1.18	0.14
T_{11} (0.5 % of EMS and 1200 Gy)	3.72	3.63	0.98	0.15
T_{12} (0.5 % of EMS and 1300 Gy)	3.38	4.05	1.20	0.17

that mutants showed significantly more number of siliqua plant^{-1} with 15 Kr of gamma rays.

Data regarding 1000 seed weight (Table 6)revealed that the 1000 seed weight increased in all treatments except 0.5% EMS + 1300 Gy (3.01g) as compared to control untreated (2.98g) and control water soaked (3.21g). The highest mean value for the character was in 0.5% EMS + 1200 Gy (3.85g) and lowest in 0.5% EMS + 1300 Gy (3.01g). The variations for the character were found to be increase in all the treatments. Maximum variation was in 0.5% EMS + 1300 Gy (52.92%) followed by 0.5% EMS + 1200 Gy (51.98%) and the minimum variation in 1300 Gy (25.51%) as compared to controls (19.81% and 20.27%). The mean of 1000-seed weight in general, increased significantly due to gamma rays alone and gamma rays and EMS in combination. Javed *et al.* (2000) reported most of the mutants had higher 1000-grain weight significantly superior to the parent variety. The mutant showed 7- 44% increase over the parent in 1000 grain weight.

Data regarding seed yield plant^{-1} (Table 7) revealed that the maximum seed yield plant^{-1} was observed in 1000 Gy (7.29g) and minimum in 0.5% EMS + 1200 Gy (4.41g). The coefficient of variation increased in all the treatments. Maximum coefficient of variation was noticed in 1200 Gy (78.35%) and the minimum was in 1000 Gy (50.15%). The significant effect of mutagens in the mean seed yield plant^{-1} was noticed in all treatments. Javed *et al.* (2000) reported that five mutants produced significantly higher yield than parents.

Mutation frequency of each visible mutant in M_2 generation was calculated as suggested by Gaul (1958) and is represented in table 8. It revealed that the combination of treatment 0.5% of EMS and 1300 Gy induced the highest mutation frequency (7.67%) followed by 0.5% of EMS and 1100 Gy (7.16%) and the lowest in 900 Gy (3.12%). The frequency of mutation was comparable in all treatments. Increase in frequencies over character with the increase in doses of gamma rays and EMS in combination was observed by Sangsir *et al.* (2005) in mustard.

The efficiency and effectiveness of mutagens were estimated as suggested by Konzak *et al*. (1965) and data are presented in table 9.From the table 9, it was noticed that 900 Gy exhibited the highest mutagenic efficiency (1.33), while 1200 Gy (0.72) showed the lowest. It was observed that in BIO 902 variety, the mutagenic efficiency increased with increase in doses of gamma rays and EMS in combination. Among all the treatments the highest mutagenic effectiveness was observed in 900 Gy (0.17) and 0.5% of EMS and 1300 Gy (0.17), while the lowest in 1000 Gy (0.6). The gamma rays in combination with EMS showed the higher effectiveness than gamma rays alone in BIO 902. Further it was noticed that with the increase in concentration of gamma rays in combination with EMS, there was increase in mutagenic efficiency except 0.5% of EMS and 1200 Gy. This trend was not observed for gamma rays alone in BIO 902.

The present study provided evidence on the induction of genetic variability in various quantitative characters in *Brassica juncea* cv. BIO 902 after treating with gamma rays alone and combination treatment of gamma rays and EMS. Reduced germination and increased seedling mortality was observed in M_1 and M_2 generations.In M_2 generation, it was observed that gamma rays proved to be useful for inducing earliness, while gamma rays in combination with EMS proved to be useful for inducing both earliness and delayed maturity in BIO 902 variety.In treated population, the plant height was significantly increased in BIO 902 variety.1000 Gy gamma rays proved to be effective in increasing the number of branches plant^{-1} in BIO 902 variety.Gamma rays alone and combination treatment of gamma rays and EMS increased significantly the number of siliqua plant^{-1} in M_2 generation.Gamma rays alone and combination treatment of gamma rays and EMS were found effective in increasing the 1000 seed weight in BIO 902.Mean seed yield plant^{-1} increased significantly by gamma rays alone and combination treatment of gamma rays and EMS. The best results were given by 1000 Gy gamma rays in BIO 902 variety.

The increased genetical variability in treated population for most of the qualitative and quantitative characters indicated that the superior lines can be isolated from the population.Mutation frequency did not show any specific trend with increase in doses of mutagen. Mutagenic efficiency increased with the increase in doses of gamma rays and it also increased with the increase in doses of gamma rays and EMS in combination in BIO 902 variety. It was highest in 900 Gy treated BIO 902 variety.Mutagenic effectiveness was generally found to be more in combination treatment of gamma rays and EMS than gamma rays alone. There was no specific trend followed in the combination treatments of gamma rays and EMS and gamma rays alone. In the present study 1300 Gy gamma rays alone was found to be induce wide range of mutation in mustard.

REFERENCES

Anonymous, 2015. Proceeding of 22nd AGM of AICRP on rapeseed and mustard, pp.34.

Anonymous. 2015a. Ministry of Agriculture, Govt. of India.

Anonymous. 2015b. Agricultural Statistics at glance.

Gaul, 1958. Present aspects of induced mutation in plant breeding. Euphytica, **7**:275-279.

Hassan,M.S. and S.H.M. Abs-El-Haleem, 2014. Effectiveness of gamma rays to induced genetic variability to improve some agronomic traits of canola (*Brassica napus*). Asian. J. Crop Sci.**94**:78-79.

Javed, M.A., A. Khatri, I.A. Khan, M. Ahmad, M.A. Siddiqui and A.G. Arain, 2000. Utilization of gamma irradiation for the genetics im-provement of oriental mustard (*Brassica juncea* Coss.). Pak.J.Bot.**32**: 77-83.

Khatri,A.I.A.Khan,M.A.Siddiqui,S.Raza and G. S. NIzamani, 2005. Evaluation of high yielding mutant of *Brassica Juncea* cv.S - 9 developed through gamma rays and EMS. Pak.J.Bot. **37**(2):279-284.

Konzak, C.F.,R.A. Nilan,J.Wanger and R.J. Foster, 1965; Efficient chemical mutagenesis. Rad. Bot. **5** (suppl.):49-70.

Malek, M.A., H.A. Begum, M. Begum, M.A. Sattar, M.R. Ismail and M.Y. Raffi, 2012. Development to high yielding mutant varieties of mustard (*Brassica Juncea*) through gamma rays irradiation. AJCS **6**(5):922-927.

Rakow, R. and J.P. Raney, 2003. Present status and future perspectives of breeding for seed quality in brassica oilseed crops.Proc. 11th Inter. Rapseed Cong., Copenhangen, Denmark. pp. 181-185.

Sangsiri, C.W., Sorajjapinun and P. Srinives, 2005**.** Gamma radiation induced mutations in mungbean. Science Asia.,**31:** 251-255.

Shah, S.A., I. Ali and K. Rahman, 1990. Induction and selection of superior genetic variables of oilseed rape *(Brassica napus* L.*).*The Nucleus,**27**(1-4): 37-40.

Thagana, W.M., C.M. Ndirangu; E.O. Omolo, T.C. Riungu and M.G. Kinyua, 2006. Variability in M_2 generations and characteristics of selected advanced mutant lines of rapeseed. 10th KARI Biennial Scientific Conference.**51**: 135-147.

Voice, N., V. Marghity, S. Iilcieevici, E. Bainita and I. Druganescu, 2004. The action of gamma radiation on mustard. Asian.J.Crop Sci., **54**:4-5.

Yaqoob, M. and B. Ahmad, 2003. Induced mutation studies in some mung bean cultivars. Sarhad J. Agric., **19**:301-365.

Yassein,A.A.M and Amina. A.Aly,2014.Effect of gamma radiation on morphological, physiological and molecular traits of *Brassica napus*. Egypt.J.Genet.Cytol., **43**:25-38.

Rec. on 15.05.2016 & Acc. on 04.06.2016