Available online at www.jpsscientificpublications.com
Volume – 1; Issue - 3; Year – 2015; Page: 265– 272

Indo – Asian Journal of Multidisciplinary Research (IAJMR)
ISSN: 2454-1370

EFFECT OF INDUCED MUTAGENESIS ON QUANTITATIVE CHARACTERISTICS OF CHILLI *Capsicum annuum* (L). var- K_1 IN M_2 GENERATION

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Abstract

Induced mutation by gamma irradiation and EMS has been found to be a very useful technique for crop improvement. Apart from this, the proper use of induced mutation in plant breeding has become a profitable approach. For the present study, the seeds of Chilli var K_1 were subjected to different doses (20 kR, 30 kR, 40 kR, 50 kR, 60 kR and 70 kR) of gamma rays are and different concentration (10 Mm, 20 Mm, 30 Mm, 40 Mm, 50 Mm and 70 Mm) of EMS. This investigation was carried out to determine the effect of gamma rays and EMS on plant height, number leaves per plant, primary branches per plant, secondary branches per plant, days to first flowering, total number of fruits per plant, fruit length , fruit girth average dry fruit weight, hundred seed weight. All parameters evaluated and showed a significant differences among the different dose /concentration of mutagenic treatments. EMS was found to be quite effective in inducing genetic variability in M_2 generation than gamma rays. The results revealed significant difference in all the traits studied. The study further revealed that the use of EMS is an effective approach for creating improved varieties in chilli.

Key words: Physical mutagens, Chemical mutagens, Chilli and Morphological mutation, PCV and GCV

1. Introduction

Chillies are the fruits or berries of plants belonging to the genus *Capsicum* belongs to the family Solanaceae. The genus *Capsicum* consists of about 25 wild and 5 domesticated species. The five domesticated species are *Capsicum annuum* L., *Capsicum frutescens* L., *Capsicum chinense* Jacq., *Capsicum baccatum* L. and *Capsicum pubescens* (IBPGR, 1983). Of the domesticated species, *C. annuum* is the most economically important and includes both mild and pungent fruit types. Chillies contain numerous chemicals including steam -volatile oil, fatty oils, capsaicinoids, carotenoids, vitamins, protein, fibre and mineral elements (Bosland and Votava, 2000) and are variously used for different purposes because of their nutritional value, flavour, aroma, texture, pungency and colour in a wide assortment of foods, drugs, and cosmetics, while some are cultivated ornamentally, especially for their brightly glossy fruits with a wide range of colours, shapes and sizes (De, 2003).

Mutations are the ultimate source of variability in organisms. It can be used for plant breeding in many different ways. The direct use of mutations is valuable supplementary approach to plant breeding, particularly when it is desired to improve one or two easily identifiable characters in an otherwise well adapted variety. Induced

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Received: 20.03.2015; *Revised*: 10.07.2015;
Accepted: 10.08.2015.

mutation is the eventual source of all the genetic variability in crop plants that may be difficult to bring through cross breeding and other breeding procedures, since mutations gives rise to non-existing variations (Khan and Tyagi, 2010).

2. Materials and Methods

Chilli (*Capsicum annuum* L.) var.K_1 was irradiated with 20 kR, 30 kR, 40 kR, 50 kR, 60 kR and 70 kR of gamma rays at Sugarcane Breeding Institute, TNAU, Coimbatore, India. Another quantity of 5 gram seeds were presoaked for 12 hrs in distilled water, blotted dry and were treated with 10 mM, 20 mM, 30 mM, 40 mM, 50 mM and 60 mM of freshly prepared solutions of ethyl methane sulfonate for 4 hrs with intermittent shaking. After treatment, seeds were thoroughly washed in running water to leach out the residual of chemicals. The treated seeds were sown in seed beds along with control. After 45 days, old seedlings were transplanted to experimental field in Completely Randomized Block Designs with three replicates to raise M_1 population. The M_1 generation (produced directly from mutagen treated seeds) was grown in the pot culture experiment at the Botanical Garden, Department of Botany, Annamalai University. All the recommended cultural practices were carried out during the plant growth period. The M2 generation (produced directly from M_1 seeds) was grown in the field experiment. All the recommended cultural practices were carried out during the plant growth period. All surviving M2 plants were self and harvested to find out the mean performance of quantitative traits.

3. Results

3.1. Plant height (cm/plant)

A gradual increase of mean for plant height was noticed with increasing dose/concentration of mutagens in M_2 generation than control. Among them higher mean for plant height was observed at 30 mM EMS (72.70 cm) followed by 40 kR Gamma Rays (72.20 cm). This was significantly increased than other concentration and control (Table - 1). Among the various quantitative traits, plant height showed high PCV and GCV 30 mM EMS (22.49, 18.22) and 40 kR (20.59, 17.31) respectively. While high dose/concentrations showed moderate and low level of PCV and GCV values. The maximum values of heritability (84.83, 78.44), genetic advance (14.61, 11.68) were observed at 30mM of EMS and 40kR of gamma rays respectively. Whereas moderate values also observed at lower concentration. Similarly, higher genetic advance as % of mean was observed at all the mutagenic treatments (Table-2).

3.2. Number of leaves per plant

Among the various dose/concentration of mutagens, 30 mM EMS (76.20) showed more number of leaves followed by 40kR of gamma rays (74.40). Above mentioned mean performance was slightly increased than control (66.25) plant (Table - 1). Among the mutagens, higher PCV and GCV were observed at 30 mM EMS (15.23, 5.97) followed by 40 kR of gamma rays (12.88, 5.74) respectively. Heritability showed high in 30 mM EMS (62.77) and 40 kR (59.82) of gamma rays. Whereas, high genetic advance and genetic advance as per cent of mean recorded at 30 mM EMS (8.00, 12.72) and 40 kR of gamma rays (7.80, 11.26) (Table - 2).

3.3. Number of primary branches per plant

The mean for primary branches was showed a gradual increase in LD_{50} concentration than control. It was higher at 30 mM EMS (4.50) followed by 40 kR (4.45) of gamma rays when compared to control (4.00) values in M_2 generation (Table - 1).

PCV and GCV were high in 30 mM EMS (25.00, 19.30) followed by 40 kR (19.78, 16.80) of gamma rays respectively. Whereas, low values recorded at higher dose/concentration of mutagens.

Among the concentrations, 30 mM EMS (67.52) and 40 kR (61.82) of gamma rays showed more variability. While genetic advance as per cent of mean was also higher at all the concentration of mutagens. Whereas, high genetic advance and genetic advance as per cent of mean

recorded at 30 mM EMS (9.31, 16.78) and 40 kR of gamma rays (6.82, 12.82).

3.4. Number of secondary branches per plant

There was an enhanced level of mean for number of secondary branches in M_2 generation was observed. A gradual increase of mean was observed in the mutagen at lowest and LD_{50} concentration. The higher mean performance was observed at 30 mM EMS (4.00) and 40 kR (3.91) of gamma rays, whereas it was 3.35 in control (Table - 1).

PCV and GCV were high in 30 mM EMS (15.94, 6.26) followed by 40 kR (11.40, 6.79) of gamma rays respectively. Whereas, low values recorded at higher doses/concentration of mutagens.

Heritability showed high in all the mutagenic treatments. Among the concentrations, 30 mM EMS (62.82) and 40 kR (60.60) of gamma rays showed more variability. Whereas, high genetic advance and genetic advance as per cent of mean recorded at 30 mM EMS (15.08, 33.76) and 40 kR of gamma rays (12.29, 20.67) (Table - 2).

3.5. Days to first flowering

Different mutagens with various concentration of M_2 generation showed slight level of decreasing in number of days for first flowering. Among them, 30 mM EMS (86.90) showed elimination of days followed by 40kR of gamma rays (89.25). These mean performances showed lesser number of days was taken for blooming than the control plant (102.10) (Table - 1).

The high PCV and GCV were recorded at 30 mM EMS (22.36, 17.08) and 40 kR (21.51, 15.44) gamma rays. Whereas, other doses/concentration showed moderate to low PCV and GCV values.

Among the various concentrations of mutagens, high heritability was recorded at 30 mM EMS (66.67) followed by 40 kR of gamma rays (62.33) treated plants. While, higher heritability was recorded at all the concentration of mutagens Whereas, high genetic advance and genetic advance as per cent of mean recorded at 30 mM EMS (11.05, 19.71) and 40 kR of gamma rays (10.13, 15.29) (Table - 2).

3.6. Total number of fruits per plant

It was higher in 30 mM EMS (65.25) followed by 40 kR (61.40) of gamma rays than control (53.60) plants. Besides, other concentrations, particularly, the LD_{50} concentration showed slight increase in number of fruits. Whereas, high concentrations showed reduced number of fruits than control (Table - 1).

PCV and GCV were high in 30 mM EMS (17.44, 16.68) followed by 40 kR (16.09, 10.82) of gamma rays respectively. Whereas, low values recorded at higher doses/concentration of mutagens.

Heritability showed high in all the mutagenic treatments. Among the concentrations, 30 mM EMS (59.15) and 40 kR (57.32) of gamma rays showed more variability. Whereas, high genetic advance and genetic advance as per cent of mean recorded at 30 mM EMS (9.70, 16.65) and 40 kR of gamma rays (7.59, 15.03) (Table - 2).

3.7. Fruit length (cm)

Among the various concentrations of mutagens, the fruit length maximum in 30 mM EMS (10.92) followed by 40 kR of gamma rays (10.00) treated chilli plants. Above mentioned mean performance was slightly increased than control (9.55) plants (Table - 1).

Among the different mutagenic concentration, moderate PCV and GCV were observed at 30 mM EMS (10.82, 6.49) followed by 40 kR of gamma rays (10.61, 5.66) respectively. While, high concentrations showed low level of PCV and GCV.

Heritability was high at 30 mM EMS (64.70) followed by 40 kR of gamma rays (63.60). Whereas, high genetic advance and genetic advance as per cent of mean recorded at 30 mM EMS (8.43, 18.42) and 40 kR of gamma rays (5.16, 15.16) (Table - 2).

3.8. Fruit girth (cm)

A gradual increase of mean for fruit girth was noticed with increasing concentration of mutagens up to a certain level. Among them, higher mean for fruit girth was observed at 30 mM EMS (1.41) followed by 40 kR (1.28) of gamma rays. This was significantly increased than other concentration and control (1.04 cm) (Table - 1).

PCV and GCV showed only moderate values among the different concentration of mutagens. The maximum PCV and GCV were observed in 30 mM EMS (24.98, 20.44) and 40 kR (23.03, 19.52) of gamma rays.

Heritability showed high at all the mutagenic concentration. The highest percentage of heritability in 30 mM EMS (80.62) and 40 kR (78.11) of gamma rays. Whereas, high genetic advance and genetic advance as per cent of mean recorded at 30 mM EMS (9.28, 20.58) and 40 kR of gamma rays (7.15, 14.09) (Table - 2).

3.9. Average dry fruit weight (g)

Among the mutagenic treatments, average dry fruit weight gradually increased in 30 mM EMS (1.16) and 40 kR gamma rays (1.13) when compared to control (1.07) (Table - 1).

Variability was more in average dry fruit weight at all the mutagenic treatments. Among them, 30 mM (33.38, 27.51) EMS and 40 kR gamma rays (31.11, 23.02) showed high PCV and GCV.

Heritability was high at 30 mM EMS (67.72) and 40 kR (60.72). Whereas, high genetic advance and genetic advance as per cent of mean recorded at 30 mM EMS (10.81, 18.61) and 40 kR of gamma rays (7.36, 16.55) (Table - 2).

3.10. Hundred Seed weight (g)

A gradual increase of mean for fruit girth was noticed with increasing concentration of mutagens up to certain level. Among them, higher mean for fruit girth was observed at 30 mM EMS (0.616) followed by 40 kR (0.598) of gamma rays. This was significantly increased than other concentration and control (0.474) (Table - 1).

PCV and GCV showed only moderate values among the different concentration of mutagens. The maximum PCV and GCV were observed in 30 mM EMS (21.73, 10.65) and 40 kR (19.32, 9.10) of gamma rays.

Heritability showed high at all the mutagenic concentration. The highest values of heritability in 30 mM EMS (72.03) and 40 kR (64.81) of gamma rays. Whereas, high genetic advance and genetic advance as per cent of mean recorded at 30 mM EMS (12.39, 17.34) and 40 kR of gamma rays (8.26, 13.40) (Table - 2).

4. Discussion

Induced mutagenesis has become an important tool for amending and rectifying specific defects in well adopted varieties or creating new genetic variability in order to utilize economic mutants in crop improvement programme. Genetic variations induced by mutation represent a more efficient source of genetic variability than gene pools conserved by nature. A significant positive shift in mean performance was observed at 30 mM EMS in plant height (72.20 cm), leaves per plant (76.20), primary branches per plant (4.50), secondary branches per plant (4.00), days to first flowering (86.90), total number of fruits per plant (65.25), fruit length (10.92 cm), fruit girth (1.41 cm), average dry fruit weight (1.16 g), hundred seed weight (0.616 g).

Jabeen and Mirza (2002) reported that plant height, number of branches, number of leaves, leaf area, days to first flowering, days to fruiting, number of fruits per plant and chlorophyll content and minimum variances were observed in control and the maximum variance were observed in the treated plants of chilli. These results support an earlier report by Patil *et al.* (1997) and Sri Devi and Mullainathan (2011) *C. annuum.* Seeds of *C. annuum* were treated with 0.1, 0.2 and 0.5% EMS and Dimethyl sulphate for 12 and 18 hours on plant height, number of branches, number of fruits and fruit yield per plant were recorded. Variances for all characters under study were increased in the treated plants.

Table – 1: Effect of physical and chemical mutagen on Plant height(cm), Number of leaves, Primary branches, Secondary branches, Day to first flowering, Number of fruits per plant, Fruit length(cm), Fruit girth(cm), Average dry fruit weight(g), and 100 Seed weight(g). in M_2 Generation

Doses/ Concentrations	Plant height at maturity (cm)	Number of leaves	Number of Primary branches	Number of Secondary branches	Days to first flowering	Number of Fruits per plant	Fruit length (cm)	Fruit Girth (cm)	Average dry fruit weight (g)	100 seed weight (g)
Control	66.95±4.70	66.25±3.62	4.00±0.39	3.35±0.50	102.100±5.51	53.60±2.20	9.55±0.36	1.04±0.15	1.07±0.011	0.474±0.030
30 kR	69.85±3.05	73.20±3.95	4.05±0.64	3.80±0.66	101.55±3.25	58.30±3.41	9.68±0.43	1.05±0.12	1.12±0.004	0.486±0.034
40 kR	72.20±3.91	74.40±2.36	4.45±0.41	4.30±0.47	89.25±5.71	61.40±2.53	10.00±0.40	1.28±0.08	1.13±0.006	0.598±0.022
50 kR	56.00±3.24	57.80±3.13	3.55±0.48	2.80±0.41	110.90±4.19	46.85±2.79	7.84±0.50	0.79±0.13	0.96±0.039	0.410±0.023
20 mM	63.05±1.96	68.90±3.58	4.25±0.56	3.95±0.53	100.60±2.62	59.30±3.25	10.30±0.28	1.09±0.07	1.09±0.019	0.515±0.026
30 mM	72.70±2.76	76.20±4.39	4.50±0.52	4.41±0.49	86.90±4.91	65.25±2.19	10.92±0.50	1.41±0.07	1.16±0.009	0.616±0.015
40 mM	56.25-±3.48	62.00±3.12	3.50±0.45	3.60±0.65	112.90±6.92	51.62±3.21	8.48±0.56	0.66±0.06	0.99±0.041	0.443±0.033

Table – 2: Variability, heritability, genetic advance and genetic advance as per cent of mean in M_2 generation

Mutagens	Plant height (cm/plant)						Number of leaves per plant				
	Treatments Conc. (mM)	PCV	GCV	h^2	GA	GA (%)	PCV	GCV	h^2	GA	GA (%)
Gamma Rays	30	15.14	10.21	73.71	07.63	10.57	11.63	05.19	49.92	03.29	04.77
	40	20.59	17.31	78.44	11.68	15.44	12.88	05.74	59.82	07.80	11.26
	50	13.31	09.87	63.38	05.06	08.67	11.53	04.63	45.82	03.51	05.66
EMS	20	19.05	12.36	72.68	06.63	09.93	11.24	04.53	51.08	04.01	08.17
	30	22.49	18.22	84.83	14.61	20.39	15.23	05.97	62.77	08.00	12.72
	40	13.60	07.14	67.57	04.32	07.73	11.80	03.67	45.69	02.20	03.81

Table – 3: Variability, heritability, genetic advance and genetic advance as per cent of mean in M_2 generation

Mutagens	Primary branches per plant						Secondary branches per plant				
	Treatments Conc. (mM)	PCV	GCV	h^2	GA	GA (%)	PCV	GCV	h^2	GA	GA (%)
Gamma Rays	30	11.26	09.64	58.80	04.98	07.02	10.22	03.67	50.46	05.03	12.74
	40	19.78	16.80	61.82	6.82	12.82	11.40	06.79	60.60	12.29	20.67
	50	15.29	10.62	53.82	03.18	06.81	08.78	03.88	48.82	03.68	10.24
EMS	20	19.23	12.62	55.33	06.91	11.34	10.78	04.80	58.73	07.12	15.27
	30	25.00	19.30	67.52	09.31	16.78	15.94	09.26	62.82	15.08	33.76
	40	09.99	07.93	50.37	02.47	05.47	10.02	04.23	48.07	04.12	10.32

Table – 4: Variability, heritability, genetic advance and genetic advance as per cent of mean in M_2 generation

Mutagens	Days to first flowering						Total number of fruits per plant				
	Treatments Conc. (mM)	PCV	GCV	h^2	GA	GA (%)	PCV	GCV	h^2	GA	GA (%)
Gamma Rays	30	16.60	14.40	54.45	06.44	06.04	12..32	08.11	50.56	05.09	11.50
	40	21.51	15.44	62.33	10.13	15.29	16.09	10.82	57.32	07.59	15.03
	50	12.65	06.09	49.71	04.75	09.40n	11.79	05.59	42.24	04.02	06.22
EMS	20	16.40	12.66	59.71	06.21	14.29	11.34	11.52	57.30	05.92	11.05
	30	24.36	17.08	66.67	11.05	19.71	17.44	16.68	59.15	09.70	16.65
	40	14.97	08.20	50.02	05.45	09.26	13.83	07.80	45.41	02.74	04.14

Table – 5: Variability, heritability, genetic advance and genetic advance as per cent of mean in M_2 generation

Mutagens	Fruit length (cm)						Fruit girth (cm)				
	Treatments Conc. (mM)	PCV	GCV	h^2	GA	GA (%)	PCV	GCV	h^2	GA	GA (%)
Gamma Rays	30	09.00	04.08	62.02	01.18	11.50	21.11	17.49	71.83	05.45	15.06
	40	10.61	05.66	63.60	05.16	15.16	23.03	19.52	78.11	07.15	14.09
	50	07.79	04.06	43.60	03.37	10.76	20.86	10.02	40.01	02.41	10.04
EMS	20	09.93	04.18	47.70	03.51	13.63	17.97	14.02	57.63	03.25	13.30
	30	10.83	06.49	64.70	08.43	18.42	24.98	20.44	80.62	09.28	20.58
	40	06.29	02.29	49.90	01.05	13.42	15.42	05.86	42.46	02.12	09.87

Table – 6: Variability, heritability, genetic advance and genetic advance as per cent of mean in M_2 generation

Mutagens	Average dry fruit weight (g)						Hundred seed weight (mg)				
	Treatments Conc. (mM)	PCV	GCV	h^2	GA	GA (%)	PCV	GCV	h^2	GA	GA (%)
Gamma rays	30	23.33	15.97	51.16	01.49	04.10	16.65	07.78	59.85	04.98	03.24
	40	31.11	23.02	60.72	07.36	16.55	19.32	09.10	64.81	08.26	13.40
	50	21.76	14.13	38.03	06.12	12.39	15.67	04.59	48.59	03.23	02.77
EMS	20	26.30	19.19	61.02	04.04	08.80	11.73	05.65	56.03	04.24	03.29
	30	33.38	27.51	67.72	10.81	18.69	21.73	10.65	72.03	12.39	17.34
	40	23.61	10.80	53.02	03.02	07.67	17.65	04.60	48.30	03.52	02.57

Similar results have been reported in *Avena sativa* (Krishna Murthy and Vasudevan, 1984) in oats. The observed variation in the treated population was more than that in the control population. This is the expected result because the control plants are supposed to be genetically similar and any kind of differences observed in the control plants is only due to environment.

The results obtained in the present work demonstrated that there were significant differences in most studied yield traits such as fruit length, fruit girth, total no. of fruits per plant, no. of seeds per fruit, seed weight per fruit and hundred seed weight. Similar observations were further confirmed by those obtained in pods per plant, pod length, weight of seeds per plant, seed yield per pod and high seed index (weight of 100 seed) in *Abelmoschus* with the effect of gamma rays (Hegazi and Hamideldin, 2010). The plant height, number of fruit per plant, fruit weight and fruit yield per plant were significantly increased by gamma rays and SA mutagenic treatments. Concerning mutagenic treatments, 2 and 4 kR gamma rays and 0.001 M/L sodium azide enhanced and increased all values of tomato yield traits, while 6 kR gamma rays effect was similar to its respective controls (Mahmoud and Nada Al-Twaty, 2006).

Among the various mutagenic treatments, quantitative and qualitative traits showed high, moderate and low PCV and GCV in M_2 generation. The quantitative and qualitative traits such as, plant height, days to first flowering, fruit length (cm), fruit girth (cm), total no. of fruits per plant, average dry fruit weight (g), no. of seeds per fruit, seed weight per fruit (g), hundred seed weight (g) showed PCV and GCV were significantly higher in EMS than Gamma rays. The other quantitative traits in no. of leaves per plant, no. of primary and secondary branches per plant, chlorophyll content (mg/g fr. wt) were maximum PCV and GCV were observed at 30 mM EMS treatments followed by 40 kR of gamma rays.

High coefficients of phenotypic and genotypic variation were observed for several characters, the highest being for fruits per plant, followed by yield per plant, seeds per fruit and fruit weight. Similar results were also reported by Cherian (2000). The high PCV and GCV observed are evident from their high variability that in turn offers good scope for selection. The lowest PCV and GCV were for days to first flowering, which was in conformity with the findings of Sri Devi and Mullainathan (2012) and Cherian (2000).

Johnson *et al.* (1955) suggested that heritability estimates along with genetic advance is usually more helpful than the heritability value alone in predicting the resultant effect of selecting the best individuals. Genetic advance is indicative of the expected genetic progress for a particular trait under suitable selection procedure (Kaul and Garg, 1982). In the present study, high heritability coupled with high genetic advance was noticed for all the quantitative traits. Genotypic coefficient of variation, heritability and expected genetic advance showed a considerable increase in the treated population.

Genetic advance as per cent of mean under selection in the M_2 populations varied with treatments and characters studied. The study revealed that selection in the treated populations may lead to improvement up to maturity. It also increased in the treatments and it was relatively higher for different quantitative characters studied. Similar differential estimates of genetic advance in different mutagenic treatment populations for

different traits have also been reported by Kalia *et al.* (2001).

Acknowledgment

Authors are thankful to authorities of Annamalai University and University Grants Commission (UGC) for financial assistance.

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