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Effect of gamma rays, ethyl methane sulphonate and sodium azide on seedling traits, fertility and varietal sensitivity in Mungbean (*Vigna radiata* (L.) Wilczek)

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Abstract
Seeds of two mungbean varieties *viz*., WGG-42 and LGG-460 were treated with various dose/concentrations of gamma radiation (200, 300, 400, 500 and 600 Gy) and ethyl methane sulphonate (0.2%, 0.3%, 0.4%, 0.5% and 0.6%) and sodium azide (1 mM, 2 mM and 3 mM) for studying the effect of the mutagens on seedling emergence (%), seedling survival (%), seedling height (cm), pollen fertility (%) and seed fertility (%) in M_1 generation. The increasing dose/concentration of mutagens, decreased seedling emergence (%), seedling survival (%), seedling height (cm) and pollen fertility (%) in both the varieties of mungbean. The reductions in all these traits were observed to be more prominent in SA treatments followed by EMS and gamma rays treatments. The variety WGG-42 was found highly sensitive to various mutagens when compared with LGG-460.

Keywords: Gamma rays, EMS, SA, M_1 generation, mungbean

Introduction
Mungbean (*Vigna radiate* (L.) Wilczek) is a self-pollinated grain legume crop having the diploid chromosome number 2n=2x=22. It is one of the important pulse crops grown in India and ranks third after chickpea and pigeon pea. It is a cheap and rich source of vegetable protein and therefore, commonly used as a supplement to the normal diet of many people. It is grown as *kharif* and summer crop. Among the wide array of pulses cultivation in India, mungbean holds key position as it has established itself as highly valuable short duration crop having many desirable characters like high protein content (22-28%), carbohydrates (60-65%) and rich in aminoacids particularly with lysine, minerals and vitamins. This crop has wider adoptability, low input requirement, ability to restore the soil fertility through symbiotic nitrogen fixation and can be well suited to different cropping systems. Therefore, development of suitable plant types for different niches is highly demanding in order to increase the production and productivity of this crop. However, the major concern to fulfil this demand is due to its narrow genetic base. Among various options available to increase the genetic base in a crop species, mutation breeding has proven its potentiality in various crops especially for self-pollinated crops with narrow genetic base. Induced mutation, using physical and chemical mutagenic agents cause genes to mutate at rates above the spontaneous base line, thus producing a range of novel traits and broadening of the genetic diversity of plants (Lagoda, 2007) [8]. Hence, understanding about the effect of various mutagens on biological material is a pre requisite. In mutation breeding experiments, evaluation of the effect of the mutagens on M_1 generation would help to decide the choice of mutagen and its optimum concentration as the sensitivity of the different varieties to the mutagens is determined by the extent of M_1 effects such as lethality, injury and sterility *etc.* (Gaul, 1970) [3]. Keeping the above facts in view, the present experiment was conducted with an objective to study the effect of gamma rays, EMS and SA on seedling emergence (%), seedling survival (%), seedling height (cm), pollen fertility (%) and seed fertility (%) in M_1 generation, which is highly helpful for further mutation breeding programmes in mungbean.

Material and Methods

Two mungbean genotypes *viz.*, WGG-42 and LGG-460 were subjected to gamma irradiation at the doses of 200, 300, 400, 500 and 600 Gy; ethyl methane sulphonate (EMS) treatments of 0.2%, 0.3%, 0.4%, 0.5% and 0.6% and sodium azide (SA) treatments of 1 mM, 2 mM and 3 mM. Seeds were pre-soaked for 6 hr in water initially. Then, the seeds were immersed for 6 h in the requisite concentration of EMS and SA with intermittent shaking. To ensure a uniform absorption of the mutagen, the volume of mutagen solution was maintained at 10 times proportion to that of the seed volume. The whole treatment was carried out at a room temperature of 28±1°C for 4 hr after washing in running water and untreated seeds were used as control. A total of 750 seeds were sown in each treatment. The treated seeds of gamma rays, EMS, SA and control seeds were immediately sown in the field in a Randomized Block Design (RBD) with three replications to raise M_1 generation during *kharif*, 2017 at Sri Venkateswara Agricultural College, dry land farm, Tirupati. Each treatment consists of five rows of 5 m length per replication, in which 50 seeds per row were sown with 30 × 10 cm distance between rows and plants, respectively. Observations were recorded on seedling emergence (%), seedling survival (%), seedling height (cm), pollen fertility (%) and seed fertility (%). Emergence of hypocotyls from the soil surface was considered as the standard for seedling emergence (%). Seedling emergence (%) were recorded starting from 3rd day of sowing and continued up to 7th day and expressed as percentage of germinated seedlings to the total seeds sown after moderating the germination percentage of control.

The survival percentage was counted on 30th day after sowing by counting the number of plants survived. Seedling height was measured in centimetres from ground level to tip of the plant on 30th day after sowing. Pollen fertility (%) was estimated by staining the pollen grains with 1% acetocarmine solution and considered pollen grains, as fertile which took the stain and had a regular shape whereas the shrunken, empty and unstained ones was considered as sterile. The seed fertility was estimated as the percentage of well-developed seeds to the total number of seeds inclusive of immature, ill developed and shrivelled seeds. The mean values of each dose/concentration and control for these traits were calculated and statistically analysed and percentage over control and per cent on reduction are presented.

Results and Discussion

Effect of different dose/concentration of gamma rays, EMS and SA on seedling emergence, seedling survival, seedling height, pollen fertility and seed fertility among two cultivars *viz.*, WGG-42 and LGG-460 were studied in M_1 generation under field condition and found significant differences among various treatments of mutagens. The results obtained in the present investigation are briefly presented character wise here under.

Seedling Emergence (%)

Table 1: Effect of mutagens on seedling emergence (%) in M_1 generation of WGG-42 and LGG-460 under field condition

Treatments	WGG-42			LGG-460		
	Seedling emergence (%)	**Per cent over control**	**Per cent reduction**	**Seedling emergence (%)**	**Per cent over control**	**Per cent reduction**
			Gamma Rays			
Control	96.27	100.00	-	95.07	100.00	-
200 Gy	75.60	78.53	21.47	86.53	91.02	8.98
300 Gy	59.73	62.04	37.96	78.06	82.11	17.89
400 Gy	48.93	50.83	49.18	75.00	78.89	21.11
500 Gy	31.20	32.41	67.59	68.93	72.50	27.50
600 Gy	19.33	20.08	79.92	59.53	62.61	37.39
Mean	**55.18**			**77.19**		
			Ethyl Methane Sulphonate (EMS)			
Control	96.27	100.00	-	95.07	100.00	-
0.2%	75.47	78.39	23.13	85.20	89.62	10.38
0.3%	74.00	76.87	21.61	70.47	74.12	25.88
0.4%	67.73	70.35	29.65	55.73	58.62	41.38
0.5%	59.53	61.84	38.16	48.83	51.36	48.64
0.6%	33.33	34.62	65.38	34.40	36.18	63.82
Mean	**67.72**			**64.95**		
			Sodium Azide (SA)			
Control	96.27	100.00	-	95.07	100.00	-
1 mM	58.10	60.35	39.65	70.00	73.62	26.37
2 mM	34.20	35.53	64.48	36.93	38.85	61.15
3 mM	18.73	19.46	80.55	22.00	23.14	76.86
Mean	**51.82**			**56.00**		
	SE(m): 1.23			SE(m): 0.78		
	CD(0.05): 3.58			CD(0.05): 2.28		

The data with respect to seedling emergence in both the genotypes are presented in Table 1. The seedling emergence decreased with increase in dose/concentration of all the three mutagenic treatments. In the variety WGG-42 (Table 1), seedling emergence in gamma irradiated population ranged from 19.33 (600 Gy) to 75.60% (200 Gy), whereas in EMS treated population it ranged from 33.33 (0.6%) to 75.47% (0.2%). Similarly, in SA treated population it ranged from 18.73 (3 mM) to 58.10% (1 mM). In case of LGG-460 (Table 1), the seedling emergence was ranged from 59.53 (600 Gy) to 86.53% (200 Gy) in gamma irradiated population and in EMS treated population it ranged from 34.40 (0.6%) to 85.20% (0.2%). Similarly, in SA treated population it ranged from 22.00 (3 mM) to 70.00% (1 mM).

In the variety WGG-42, maximum per cent reduction in seedling emergence (%) was 79.92 percent at 600 Gy of gamma rays; 65.38 percent at 0.6% of EMS and 80.55 percent at 3 mM of SA. Sodium azide treatments had more pronounced effect in reducing seedling emergence than gamma rays and EMS treatments. In case of LGG-460, maximum per cent reduction in seedling emergence was 37.39 percent at 600 Gy of gamma rays; 63.82 percent at 0.6% of EMS and 76.86 percent at 3 mM of SA. Reduction in seedling emergence was more in SA treatments as compared to EMS and gamma rays treatments.

The present results revealed that there was a general reduction in seedling emergence with the increasing different doses/concentration of mutagens. The decrease at higher doses may be due to disturbances caused at the physiochemical level of cells and acute chromosomal damage or both. The greater sensitivity at higher doses of mutagens could be attributed to various factors such as changes in metabolic activity of cells and disturbances of balance between promoters and inhibitors of growth regulators (Natarajan and Shivashankar, 1965) [11]. Similar results were also reported by Lavanya *et al.* (2011) [9], Kuldeep and Singh (2013) [7] and Rukesh *et al.* (2017) [12] in mungbean.

Seedling Survival (%)

Observation on the seedling survival of WGG-42 and LGG-460 was presented in Table 2. In general higher reduction in survival percentage was seen at higher doses as compared to lower doses. In the variety WGG-42 (Table 2), the seedling survival percentage ranged from 9.67 (600 Gy) to 68.77% (200 Gy) in gamma irradiated populations and in EMS treated population it ranged from 20.00 (0.6%) to 67.67% (0.2%). Similarly, in SA treated population it ranged from 13.20 (3 mM) to 55.57% (1 mM). In the variety LGG-460 (Table 2), the seedling survival percentage was ranged from 28.73 (600 Gy) to 77.93% (200 Gy) in gamma irradiated populations and in EMS treated population it ranged from 21.97 (0.6%) to 75.20% (0.2%). Similarly, in SA treated population it ranged from 16.93 (3 mM) to 40.43% (1 mM).

In the variety WGG-42, maximum per cent reduction in seedling survival (%) was 89.86 percent at 600 Gy of gamma rays; 79.02 percent at 0.6% of EMS and 86.15 percent at 3 mM of SA. Sodium azide treatments were more drastic in reducing the survival percentage than gamma rays and EMS treatments. In case of LGG-460, maximum per cent reduction in seedling survival (%) was 69.30 percent at 600 Gy of gamma rays; 76.53 percent at 0.6% of EMS and 81.91 percent at 3 mM of SA. Sodium azide treatments were more drastic in reducing the survival percentage than EMS and gamma rays treatments.

Seedling survival decreased in all the treatments of mutagens in both the varieties of mungbean. A direct relationship between the concentration of mutagen applied and survival was observed. These findings are in close agreement with earlier reports of Gajraj *et al.* (1997) [2], Lavanya *et al.* (2011) [9], Kuldeep and Singh (2013) [7] and Rukesh *et al.* (2017) [12] in mungbean. The reduction in survival percentage of the treated population could be due to disturbed physiological processes or chromosome damage leading to mitotic arrest (Sato and Gaul, 1967) [13].

Table 2: Effect of mutagens on seedling survival (%) in M_1 generation of WGG-42 and LGG-460 under field condition

Treatments	WGG-42			LGG-460		
	Seedling survival (%)	**Per cent over control**	**Per cent reduction**	**Seedling survival (%)**	**Per cent over control**	**Per cent reduction**
Gamma Rays						
Control	95.33	100.00	-	93.60	100.00	-
200 Gy	68.77	72.13	27.87	77.93	83.26	16.74
300 Gy	51.33	53.85	46.15	72.13	77.07	22.93
400 Gy	40.40	42.38	57.62	58.80	62.82	37.18
500 Gy	21.47	22.52	77.48	41.73	44.59	55.41
600 Gy	9.67	10.14	89.86	28.73	30.70	69.30
Mean	**47.83**			**62.15**		
Ethyl Methane Sulphonate (EMS)						
Control	95.33	100.00	-	93.60	100.00	-
0.2%	67.67	70.98	29.02	75.20	80.34	19.66
0.3%	63.20	66.29	33.71	65.47	69.94	30.06
0.4%	53.73	56.36	43.64	49.47	52.85	47.15
0.5%	50.40	52.87	47.13	37.20	39.74	60.26
0.6%	20.00	20.98	79.02	21.97	23.47	76.53
Mean	**58.39**			**57.15**		
Sodium Azide (SA)						
Control	95.33	100.00	-	93.60	100.00	
1 mM	55.57	58.29	41.71	40.43	43.20	56.8
2 mM	25.67	26.92	73.08	21.20	22.65	77.35
3 mM	13.20	13.85	86.15	16.93	18.09	81.91
Mean	**47.44**			**43.04**		
	SE(m): 0.92			SE(m): 0.84		
	CD(0.05): 2.68			CD(0.05): 2.45		

Seedling Height (cm)

Significant reduction in seedling height was observed in both the varieties at different doses/concentration of mutagens (Table 3). In WGG-42, in gamma irradiated population it ranged from 22.35 cm (600 Gy) to 28.21 cm (200 Gy). Similarly, in EMS treatments it ranged from 18.89 cm (0.6%) to 27.53 cm (0.2%). Whereas, in SA treatments it ranged from 19.65 cm (3 mM) to 27.17 cm (1 mM). In LGG-460 (Table 3) mean seedling height ranged from 24.03 cm (600 Gy) to 29.04 cm (200 Gy) in gamma irradiated population. Similarly, in EMS treatments it ranged from 19.35 cm (0.6%) to 28.02 cm (0.2%). Whereas, in SA treatments it ranged from 20.21 cm (3 mM) to 26.32 cm (1 mM).

In WGG-42, per cent reduction in the seedling height ranged from 4.82 (200 Gy) to 24.60 per cent (600 Gy) in gamma irradiated population. Similarly, in EMS treatments it ranged from 7.12 (0.2%) to 36.27 per cent (0.6%). Whereas, in SA treatments it ranged from 8.33 (1 mM) to 33.70 per cent (3 mM). In LGG-460, per cent reduction in the seedling height ranged from 4.05 (200 Gy) to 20.60 per cent (600 Gy) in gamma irradiated population. Similarly, in EMS treatments it ranged from 7.42 (0.2%) to 36.08 per cent (0.6%). Whereas, in SA treatments it ranged from 13.04 (1 mM) to 33.23 per cent (3 mM). In general, EMS treatments were more drastic in reducing the seedling height than SA and gamma rays treatments in both the genotypes.

The seedling height decreased with increasing doses/concentration of mutagens in both the genotypes. Such a decrease in seedling height is likely due to inhibition of cell division, due to auxin destruction, changes in ascorbic acid content and physiological injury in the seeds (Ignacimutu and Babu, 1988) [4]. Similar type of mutagenic sensitivity in mungbean genotypes was also reported earlier by Kuldeep and Singh (2013) [7] and Rukesh *et al.* (2017) [12] in mungbean.

Table 3: Effect of mutagens on seedling height (cm) in M_1 generation of WGG-42 and LGG-460 under field condition

Treatments	WGG-42			LGG-460		
	Seedling height (cm)	**Per cent over control**	**Per cent reduction**	**Seedling height (cm)**	**Per cent over control**	**Per cent reduction**
Gamma Rays						
Control	29.64	100.00	-	30.27	100.00	-
200 Gy	28.21	95.18	4.82	29.04	95.95	4.05
300 Gy	26.46	89.27	10.73	27.09	89.49	10.51
400 Gy	25.72	86.77	13.23	26.59	87.83	12.17
500 Gy	24.27	81.88	18.12	26.01	85.92	14.08
600 Gy	22.35	75.40	24.60	24.03	79.40	20.60
Mean	**26.11**			**27.17**		
Ethyl Methane Sulphonate (EMS)						
Control	29.64	100.00	-	30.27	100.00	-
0.2%	27.53	92.88	7.12	28.02	92.58	7.42
0.3%	25.57	86.27	13.73	26.16	86.43	13.57
0.4%	24.09	81.27	18.72	24.25	80.11	19.89
0.5%	20.82	70.24	29.76	21.66	71.57	28.43
0.6 %	18.89	63.73	36.27	19.35	63.92	36.08
Mean	**24.42**			**24.95**		
Sodium Azide (SA)						
Control	29.64	100.00	-	30.27	100.00	-
1 mM	27.17	91.67	8.33	26.32	86.96	13.04
2 mM	23.14	82.96	21.93	24.21	79.99	20.01
3 mM	19.65	66.30	33.70	20.21	66.77	33.23
Mean	**24.90**			**25.25**		
SE(m): 0.76 CD(0.05): 2.23				SE(m): 0.72 CD(0.05): 2.09		

Pollen Fertility (%)

Table 4: Effect of mutagens on pollen fertility (%) in M_1 generation of WGG-42 and LGG-460 under field condition

Treatments	WGG-42			LGG-460		
	Pollen fertility (%)	**Per cent over control**	**Per cent reduction**	**Pollen fertility (%)**	**Per cent over control**	**Per cent reduction**
Gamma rays						
Control	98.58	100.00	-	97.71	100.00	-
200 Gy	90.64	91.95	8.05	91.13	93.27	6.73
300 Gy	85.69	86.92	13.08	84.36	86.34	13.66
400 Gy	82.62	83.81	16.19	78.22	80.06	19.94
500 Gy	79.01	80.15	19.85	75.01	76.77	23.23
600 Gy	75.34	76.43	23.57	69.52	71.15	28.85
Mean	**85.31**			**82.66**		
Ethyl Methane Sulphonate (EMS)						
Control	98.58	100.00	-	97.71	100.00	-
0.2%	91.76	93.08	6.92	91.72	93.87	6.13
0.3%	85.26	86.49	13.51	87.08	89.12	10.88
0.4%	78.94	80.08	19.92	82.68	84.61	15.39
0.5%	73.37	74.43	25.57	75.82	77.60	22.40
0.6 %	68.75	69.74	30.26	70.33	71.97	28.03
Mean	**82.78**			**84.22**		
Sodium Azide (SA)						
Control	98.58	100.00	-	97.71	100.00	-
1 mM	91.41	92.73	7.27	93.64	95.83	4.17
2 mM	80.22	81.38	18.62	83.29	85.25	14.75
3 mM	72.98	74.03	25.97	75.07	76.83	23.17
Mean	**85.80**			**87.43**		
SE(m): 0.85 CD(0.05): 2.47				SE(m): 0.77 CD(0.05): 2.22		

The pollen fertility decreased with increase in the dose/concentration of all the mutagenic treatments in both the varieties (Table 4). In WGG-42, mean pollen fertility ranged from 75.34% (600 Gy) to 90.64% (200 Gy) in gamma irradiated population. Similarly, in EMS treatments it ranged from 68.75% (0.6%) to 91.76% (0.2%). Whereas, in SA treatments it ranged from 72.98% (3 mM) to 91.41% (1 mM). In LGG-460, mean pollen fertility ranged from 69.52% (600 Gy) to 91.13% (200 Gy) in gamma irradiated population. Similarly, in EMS treatments it ranged from 70.33% (0.6%) to 91.72% (0.2%). Whereas, in SA treatments it ranged from 75.07% (3 mM) to 93.64% (1 mM).

In WGG-42, per cent reduction in pollen fertility ranged from 8.05 (200 Gy) to 23.57 percent (600 Gy) in gamma irradiated population. Similarly, in EMS treatments it ranged from 6.92 (0.2%) to 30.26 percent (0.6%). Where as in SA treatments ranged from 7.27 (1 mM) to 25.97 percent (3 mM). Of the three mutagens used, EMS appeared to have caused more effect than gamma rays and SA treatments in WGG-42. In LGG-460, per cent reduction in pollen fertility percentage was ranged from 6.73 (200 Gy) to 28.85 percent (600 Gy) in gamma irradiated population. Similarly, in EMS treatments it ranged from 6.13 (0.2%) to 28.03 percent (0.6%). Whereas, in SA treatments ranged from 4.17 (1 mM) to 23.17 percent (3 mM). Gamma rays had more pronounced effect than SA and EMS treatments on pollen fertility.

Pollen fertility decreased with increase in dose/concentration of all the three mutagenic treatments suggesting the relationship with the dose/concentration dependent increase in the frequencies of meiotic chromosomal abnormalities. Such type of chemically induced sterility may be due to gene mutations or invisible deficiencies and cytoplasmic factors (Malinovskii *et al*. 1973). The decrease in the fertility as a consequence of mutagenesis and mutagen induced pollen fertility had also been reported by Khan *et al*. (2004) [6], Khan and Goyal (2009) [5] and Kuldeep and Singh (2013) [7] in mungbean.

Seed Fertility (%)

Data pertaining to seed fertility was presented in Table 5. In WGG-42, seed fertility in gamma irradiated population ranged from 89.79% (500 Gy) to 94.43% (200 Gy) and in EMS treated population it ranged from 88.94% (0.4%) to 95.38% (0.2%). Similarly, in SA treated population it ranged from 91.59% (2 mM) to 94.49% (1 mM). The percent of seed fertility showed irregular trend with increasing doses of mutagens in all the three mutagens. For LGG-460, seed fertility ranged from 93.20% (300 Gy) to 95.68% (200 Gy) in gamma irradiated population. Similarly, in EMS treated population it ranged from 92.84% (0.5%) to 95.23% (0.3%). In SA treated population, the seed fertility ranged from 94.08% (1 mM) to 96.40% (2 mM).

In the variety WGG-42, maximum per cent reduction in seed fertility was 8.78 percent at 500 Gy of gamma rays; 9.64 percent at 0.4% of EMS and 6.95 percent at 2 mM of SA. In case of LGG-460, maximum per cent reduction in seed fertility was 4.39 percent at 300 Gy of gamma rays; 4.77 percent at 0.5% of EMS and 3.49 percent at 1 mM of SA. In general, SA treatments caused more reduction in seed fertility than gamma rays and EMS treatments in both the genotypes. In all the three mutagens, percent of seed fertility showed irregular trend with increasing doses of mutagens. Similar trend was also reported by Gajraj *et al*. (1997) [2], Awnindra and Singh (2007) [1] and Vairam (2014) [14] in mungbean.

Table 5: Effect of mutagens on seed fertility (%) in M_1 generation of WGG-42 and LGG-460

Treatments	WGG-42			LGG-460		
	Seed fertility (%)	Per cent over control	Per cent reduction	Seed fertility (%)	Per cent over control	Per cent reduction
Gamma Rays						
Control	98.43	100	-	97.48	100	-
200 Gy	94.43	95.94	4.06	95.68	98.15	1.85
300 Gy	94.14	95.64	4.36	93.20	95.61	4.39
400 Gy	92.44	93.91	6.09	94.98	97.43	2.57
500 Gy	89.79	91.22	8.78	95.61	98.07	1.93
600 Gy	93.73	95.23	4.77	95.38	97.85	2.15
Mean	**93.83**			**95.39**		
Ethyl Methane Sulphonate (EMS)						
Control	98.43	100	-	97.48	100	-
0.2%	95.38	96.90	3.10	93.64	96.05	3.95
0.3%	95.25	96.77	3.23	95.23	97.69	2.31
0.4%	88.94	90.36	9.64	93.47	95.88	4.12
0.5%	93.15	94.64	5.36	92.84	95.23	4.77
0.6 %	90.38	91.82	8.18	94.12	96.55	3.45
Mean	**93.59**			**94.46**		
Sodium Azide (SA)						
Control	98.43	100	-	97.48	100	-
1 mM	94.49	96.00	4.00	94.08	96.51	3.49
2 mM	91.59	93.05	6.95	96.40	98.89	1.11
3 mM	93.01	94.49	5.51	95.46	97.93	2.07
Mean	**94.38**			**95.86**		
SE(m): 1.36 CD(0.05): 3.95				SE(m): 0.56 CD(0.05): 1.64		

Conclusion

From the present study, it can be concluded that all the three mutagens showed inhibitory effect on seedling emergence (%), seedling survival (%), seedling height (cm), pollen fertility (%) and seed fertility (%) in M_1 generation. The increasing dose/concentration of mutagens decreased seedling emergence (%), seedling survival (%), seedling height (cm) and pollen fertility (%) in both the varieties of mungbean. The present results also revealed, more reduction was observed at higher doses compared to lower doses for all the characters studied in M_1 generation. The reductions in all these characters were found to be more prominent in SA treatments followed by EMS and gamma rays treatments. Thus it was proved that mungbean is more sensitive to SA, as compared to EMS and gamma rays treatments. Considering the genotypes, the variety WGG-42 was found more sensitive to various mutagens when compared with LGG-460. Hence, in the present investigation it could be concluded that, knowledge on effectiveness of various mutagens and genotypes would help to save time and resources and better planning to exploit maximum benefit of selections.

References

1. Awnindra KS, Singh RM. Gamma rays and EMS induced chlorophyll mutations in mungbean [*Vigna radiate* (L.) Wilczek]. Indian Journal of Crop Science. 2007; 2(2):355-359.
2. Gajraj S, Sareen PK, Saharan RP. Mutation studies in mungbean (*Vigna radiate* (L.) Wilczek). Journal of Nuclear Agriculture and Biology. 1997; 26(4):227-231.
3. Gaul H. Mutagens effects observable in the first generation, plant injury, lethality, cytological effects and sterility. Manual on mutation breeding. IAEA, Vienna, 1970; 119:85-89.
4. Ignacimutu S, Babu CR. Radio sensitivity of the wild and cultivated urd and mung beans. Indian Journal of Genetics and Plant Breeding. 1988; 48(3):331-342.
5. Khan S, Goyal S. Improvement of mungbean varieties through induced mutations. African Journal of Plant Sciences. 2009; 3:174-180.
6. Khan S, Wani MR, Parveen K. Induced genetic variability for quantitative traits in mungbean (*Vigna radiate* (L.) Wilczek.). Pakistan Journal Botany. 2004; 36(4):845-850.
7. Kuldeep S, Singh MN. Effectiveness and efficiency of gamma rays and ethyl methane sulphonate (EMS) in mungbean. 2013; 26(3&4):25-28.
8. Lagoda PJL. Effects of mutagenic agents on the DNA sequence in plants. Plant Breeding and Genetics Newsletter. 2007; 19:13-14.
9. Lavanya GR, Leena Y, Suresh Babu G, Paul PJ. Sodium azide mutagenic effect on biological parameters and induced genetic variability in mungbean. Journal of Food Legumes. 2011; 24(1):46-49.
10. Malinoveskii BN, Zoz NM, Kitaev AI. Induction of cytoplasmic male sterility in sorgum by chemical mutgens. Genetica. 1973; 9:19-27.
11. Natarajan AT, Shivashankar G. Studies on modification of mutation responses of barley seeds to ethyl methane sulphonate. *Z.* Vererburgstehre. 1965; 96:13-21.
12. Rukesh AG, Rahuman MA, Christine SL, Packiaraj D. Impact of gamma irradiation induced mutation on morphological and yield contributing traits of two genotypes of greengram (*Vigna radiate* (L.) Wilczek). Journal of Pharmacognosy and Phytochemistry. 2017; 6(6):1229-1234.
13. Sato M, Gaul H. Effect of EMS on fertility in barley. Radiation Botany. 1967; 7:7-10.
14. Vairam N. Mutation studies for the improvement of elite unexplored traits in greengram (*Vigna radiate* (L.) Wilczek). Ph.D. Thesis. AC and RI. Madurai, 2014.