International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 219-224

Received: 12-09-2019
Accepted: 15-10-2019

MG Patil
Department of Plant Pathology, VNMKV, Parbhani, Maharashtra, India

RV Mali
Department of Plant Pathology, VNMKV, Parbhani, Maharashtra, India

KT Apet
Department of Plant Pathology, VNMKV, Parbhani, Maharashtra, India

CV Ambadkar
Department of Plant Pathology, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
MG Patil
Department of Plant Pathology, VNMKV, Parbhani, Maharashtra, India

Radiation induced mutation for resistance/ tolerance against *Fusarium oxysporum* f. sp. *ciceri* in chickpea (*Cicer arietinum* L.)

MG Patil, RV Mali, KT Apet and CV Ambadkar

DOI: https://doi.org/10.22271/chemi.2019.v7.i6d.8664

Abstract
Chickpea (*Cicer arietinum* L.) is the third most important pulse crop grown throughout the world. *Fusarium oxysporum* f. sp. *ciceri* is a soil-borne as well as seed-borne fungus that is a serious threat, thereby inflicting heavy quantitative as well as qualitative losses in chickpea crop. In India, during 2017-18 Chickpea was cultivated on an area of 105.73 Lakh hectares with a production of 111.58 Lakh tonnes and productivity of 1056 kg/ha (Anonymous, 2018). Wilt of chickpea caused by *Fusarium oxysporum* f. sp. *ciceri* which one of the most prevalent and widely spreading disease in India. The pathogen is facultative saprophytic and it can survive as mycelium and chlamydospores in seed, soil and also on infected crops residues, buried in the soil for up to five to six years. The utilization of mutation breeding is a simple, cost effective and time saving method. Therefore, present investigation on "Radiation induced mutation for resistance against *Fusarium oxysporum* f. sp. *ciceri* (*Cicer arietinum* L.)" was aimed at identification of suitable mutant or a combination of mutants influencing resistance to Fusarium wilt in chickpea. The experimental material was consisted of the population of four selected cultivars of chickpea on the basis of popularity, high yield and disease reaction (JG 62, BDNG 798, JAKI 9218 and Vijay) grown in randomized block design at College of Agriculture Golegaon, during *Rabi* 2018-19. Dry seeds (10-12% moisture content) of JG 62, BDNG 798, JAKI 9218 and Vijay these varieties were irradiated with different doses of gamma rays (20 KR, 30 KR and 40 KR). Another set of presoaked seeds in distilled water (12 hrs.) were treated with ethyl methane sulphonate at different concentration (0.2%, 0.3% and 0.4%) prepared for 6 hrs. A portion of seeds irradiated at 20 KR and 30 KR gamma- ray doses were also treated with 0.2% and 0.3% EMS independently for 6 hrs. Present findings revealed that mutagenic treatments (20 KR, 30 KR, 0.2% EMS, 0.3% EMS, 20 KR+0.2% EMS, 30 KR+0.2% EMS) showed significant impact on various morphological and biological parameters of the plant habit. The effect of different doses of Gamma rays, EMS and combination of these treatments on the number of pods per plant, number of seeds per plant, seed yield per plant and 100 seed weight in M_1 population of chickpea reveals that sufficient variability induced in genotypes for this character across the various treatments.

Keywords: *Fusarium oxysporum*, *Cicer arietinum* L.

Introduction
Chickpea (*Cicer arietinum* L.) is the third most important pulse crop grown throughout the world. About 65 per cent of the global area and 68 per cent of global production of chickpea is contributed by India. Fusarium wilt caused by *Fusarium oxysporum* f. sp. *ciceri* is one of the major disease causes up to 90% losses depending on weather conditions. The incidence is more if the crop is subjected to sudden temperature rise and water stress (Venkataramanamma *et al.*, 2018) [8]. Physical mutagens such as ionising radiations and chemical mutagens that show resistance to pathogen and disease outbreak utilized for the development of elite crop varieties. Mutagenesis enables identification of wild genes or the creation of novel genes that impart disease resistance in cereals, legumes and economically important crops (Raina and Danish 2018) [5]. Different applications of induced mutagenesis have been released numerous cultivars of rice, maize, wheat, cotton, chickpea, rapeseed, mungbean, sesame, apple and durum wheat that are resistant to different bacteria, viruses and pathogens (Oladosu *et al*., 2016) [3].

Materials and Methods
The experiment was carried out at the College of Agriculture, Golegaon and Department of Plant Pathology, VNMKV, Parbhani (MH) during *Rabi* 2018-2019. Temperature extremes

vary between minimum temperature of 4.1 ºC in December and January months to maximum temperature of 39 ºC in March month. The average annual rainfall is 1011 mm. Chickpea seeds of JG 62, BDNG 798, JAKI 9218 and Vijay Genotype were collected from healthy plants at maturity stage of the crop. Chickpea seeds of different Genotype JG 62 were collected from AICRP on Chickpea, College of Agriculture Sehore, R.V.S.K.V.V., Gwalior (M.P) and remaining three Genotypes from ARS, Badnapur (MH). Gamma irradiation has been performed (Nuclear Research Laboratory RTMNU, Nagpur) in gamma chamber by exposing the seeds to the gamma rays from ^{60}Co source was filled and handpicked uniform sized seeds with moisture content of 10-12% were chosen for irradiation. A sample of 150 seeds per treatment were packed in the butter paper cover and placed in 100 curie ^{60}Co gamma cell. The treatments were given to various duration depending on the doses required (20 KR, 30 KR and 40 KR) with the dose rate of 12.2 KRads/seconds. The seeds were presoaked in water for 12 hours before treated with ethyl methane sulphonate at different concentration by using magnetic stirrer (0.2, 0.3 and 0.4%) for 6 hrs. A portion of seeds irradiated at 20 KR and 30 KR Gamma rays doses were also treated with 0.2 and 0.3% EMS independently for 6 hrs. with constant intermitted shaking in shaker and after that washed under running tap water. The treated seeds were sown in of 11-treatment combinations (including control) were evaluated separately for each Genotype planted in Randomized Block Design with three replication following biological parameters of observation during *Rabi* season 2018-19 at College of Agriculture, Golegaon., VNMKV, Parbhani.

Results and Discussion

Impact of mutagenic treatments on seed germination and some morphological parameters on chickpea genotypes JG-62, BDNG 798, JAKI 9218 and Vijay

The varieties used for this comparative study are selected on the basis of popularity, high yield and disease reaction *viz*., JG 62, BDNG 798, JAKI 9218 and Vijay were selected to study the impact of the mutagenic treatments and all the results are compared on percentile average basis and presented below.

Germination (%)

The mean seed germination percentage in JG 62 was reported to be 83.42% at 20 and 30 KR, 75.78% at 40 KR respectively as compared to control. Similarly, the germination (%) was also reduced by using chemical mutagens. The germination (%) was noted to be 75.92% at 0.2% EMS followed by 57.40% at 0.4% EMS and 53.15% at 0.3% EMS treatments respectively. Whereas, germination (%) in combination of Gamma irradiation and EMS at treatment was reported as 77.94% at 20 KR+0.2% EMS and lowest 67.29% at 30 KR+0.2% EMS as compared to control (83.42%).

The mean seed germination percentage in BDNG 798 was reported to be 78.90% at 20 KR, 68.70% at 30 KR and 61.80% at 40 KR respectively as compared to control. Similarly, the germination (%) in chemical mutagens was noted to be 64.14% at 0.2% EMS followed by 65.20% at 0.4% EMS and 52.32% at 0.3% EMS treatments respectively. Whereas, germination (%) in combination of Gamma irradiation and EMS at treatment was reported as 64.99% at 20 KR+0.2% EMS and lowest 54.74% at 30 KR+0.3% EMS as compared to control (79.82%).

The mean seed germination percentage in JAKI 9218 was reported to be 83.42% at 30 KR, 81.41% at 20 KR, 74.67% at 40 KR, 62.06% at 0.2% EMS, 57.75% at 0.3% EMS and 48.44% at 0.4% EMS treatments, respectively. Whereas, the mean seed germination percentage in combination of Gamma irradiation and EMS at treatment were reported 68.14% at 30 KR+0.3% EMS and lowest germination at 30 KR+0.2% EMS i.e., 51.21% respectively as compared to control (82.54%).

The mean seed germination percentage in Vijay was reported to be 81.41% at 20 KR, 77.94% at 40 KR and 71.24% at 30 KR respectively as compared to control. Similarly, the germination (%) was also reduced by using chemical mutagens was noted to be 69.21% at 0.2% EMS followed by 59.48% at 0.3 and 0.4% EMS treatments respectively. Whereas, germination (%) in combination treatments was reported as 76.66% at 20 KR+0.3% EMS and lowest 52.34% at 30 KR+0.2% EMS as compared to control (83.42%).

Table 1: Effect of mutagenic treatments on seed germination percentage in M_1 generation

Treatment	Doses	Variety*			
		JG 62	BDNG 798	JAKI 9218	VIJAY
Gamma rays (KR)	20 KR	98.00 (83.42)	93.33 (78.90)	96.67 (81.41)	96.67 (81.41)
	30 KR	98.00 (83.42)	86.67 (68.70)	98.00 (83.42)	89.33 (71.24)
	40 KR	93.33 (75.78)	77.33 (61.80)	92.00 (74.67)	95.33 (77.94)
Ethyl Methane sulphonate (%)	0.2% EMS	94.00 (75.92)	80.67 (64.14)	78.00 (62.06)	87.33 (69.21)
	0.3% EMS	64.00 (53.15)	62.67 (52.32)	71.33 (57.75)	74.00 (59.48)
	0.4% EMS	70.67 (57.40)	82.00 (65.20)	56.00 (48.44)	74.00 (59.42)
Gamma rays + Ethyl methane sulphonate	20 KR+0.2% EMS	95.33 (77.94)	81.33 (64.99)	81.33 (64.90)	78.00 (62.54)
	30 KR+0.2% EMS	84.67 (67.29)	72.67 (58.54)	60.67 (51.21)	62.67 (52.34)
	20 KR+0.3% EMS	92.67 (74.50)	79.33 (63.11)	76.67 (61.27)	94.00 (76.66)
	30 KR+0.3% EMS	88.00 (70.25)	66.67 (54.74)	86.00 (68.14)	74.67 (59.89)
Untreated	Control	98.00 (83.42)	96.67 (79.82)	97.33 (82.54)	98.00 (83.42)
Mean		88.78	79.93	81.27	84.00
	CV	6.15	8.52	7.95	7.00
	CD 5%	9.31	11.62	11.02	10.03
	S.Em+	3.15	3.93	3.73	3.39
	F. cal	13.30	6.76	15.15	12.18

* Mean of three replications

Figures in parenthesis are angular arc sine transformation

Seedling height (cm)

In genotype JG 62 results revealed that mean seedling height (cm) after 14 days of sowing was reported to be in Gamma rays dose 30 KR i.e., 11.67 cm followed by 11.47 cm at 20 KR and 11.32 cm at 40 KR. Similarly in chemical mutagenic treatments the seedling height was 9.87 cm at 0.2% EMS,

9.27 cm at 0.3% EMS and 9.00 cm at 0.4% EMS respectively. Whereas in combination treatments the mean seedling height was noted to be 11.00 cm at 30KR+0.2%EMS followed by 10.20 cm at 20KR+0.2% EMS, 10.00 cm at 30KR+0.3%EMS and 9.47 cm at 20KR+ 0.3%EMS respectively, as compared to control.

Mean seedling height (cm) in BDNG 798 after 14 days of sowing was reported to be 11.20 cm at 20 KR, 11.00 cm at30 KR and 10.63 cm at 40 KR. Similarly in chemical mutagenic treatments the seedling height was 9.50 cm at 0.2% EMS followed by 98.67 cm at 0.4% EMS and 8.30 cm at 0.3% EMS respectively. Whereas in combination treatments the mean seedling height was noted to be 10.40 cm at 20KR+0.2%EMS and lowest 9.20 cm at 20KR+0.3%EMS respectively, as compared to control.

Mean seedling height (cm) in JAKI 9218 after 14 days of sowing was reported to be 11.47 cm at 40 KR, 11.43 cm at 20 KR, 11.20 cm at 20 KR, 10.00 cm at 0.2% EMS, 8.50 cm at 0.3% EMS and 8.00 cm at 0.4% EMS respectively. Whereas in combination treatments the mean seedling height was noted to be 11.30 cm at 20KR+0.3%EMS and lowest 9.50 cm at 30KR+0.2%EMS respectively, as compared to control.

In genotype Vijay results revealed that mean seedling height (cm) after 14 days of sowing was reported to be in Gamma rays dose 30 KR i.e., 12.50 cm followed by 12.00 cm at 20 KR and 11.70 cm at 40 KR. Similarly in chemical mutagenic treatments the seedling height was 10.60 cm at 0.2% EMS, 10.50 cm at 0.3% EMS and 9.33 cm at 0.4% EMS respectively. Whereas in combination treatments the mean seedling height was noted to be 11.17 cm at 30KR+0.2%EMS followed by 10.93 cm at 20KR+0.2%EMS, 10.87 cm at 20KR+0.3%EMS and 10.30 cm at 30KR+ 0.3%EMS respectively, as compared to control.

Table 2: Effect of mutagenic treatments on seedling height (cm) per plant in M_1 generation

Treatment	Doses	Variety*			
		JG 62	BDNG 798	JAKI 9218	VIJAY
Gamma	20 KR	11.47	11.20	11.43	12.00
rays (KR)	30 KR	11.67	11.00	11.20	12.50
	40 KR	11.32	10.63	11.47	11.70
Ethyl	0.2% EMS	9.87	9.50	10.00	10.60
methane	0.3% EMS	9.27	8.30	8.50	10.50
Sulphonate (%)	0.4% EMS	9.00	8.67	8.00	9.33
Gamma rays	20 KR+0.2% EMS	10.20	10.40	9.70	10.93
+ Ethyl methane	30 KR+0.2% EMS	11.00	9.70	9.50	11.17
sulphonate	20 KR+0.3% EMS	9.47	9.20	11.30	10.87
	30 KR+0.3% EMS	10.00	9.50	10.37	10.30
Untreated	Control	13.33	11.27	12.60	14.00
Mean		10.60	9.94	10.37	11.26
	CV	7.66	6.42	7.20	8.08
	CD 5%	1.39	1.09	1.27	1.55
	S.Em+	0.47	0.37	0.43	0.53
	F. cal	7.60	7.70	10.39	5.69

*Mean of three replications

Plant height (cm)

The maximum mean plant height (cm) in genotype JG 62 was noted to be 36.47 cm at 30 KR, 36.43 cm in 0.2% EMS and 35.00 cm in combination treatment 30 KR+0.2% EMS respectively, among the all treatments as compared to control.

The mean plant height (cm) was noted in genotype BDNG 798 *i.e.,* 41.67 cm at 20 KR, 39.00 cm in 0.2% EMS and 42.20 cm in combination treatment 20 KR+0.2% EMS respectively, which was maximum among all the treatments as compared to control.

The maximum mean plant height (cm) was noted to be in JAKI 9218 *i.e.,* 35.60 cm at 30 KR, 35.00 cm in 0.2% EMS and 38.37 cm in combination treatment 20 KR+0.2% EMS respectively, among the all treatments as compared to control.

The mean plant height (cm) was noted in genotype Vijay *i.e.,* 35.00 cm at 30 KR, 34.50 cm in 0.2% EMS and 35.73 cm in combination treatment 30 KR+0.2% EMS respectively, which was maximum among all the treatments as compared to control.

Table 3: Effect of mutagenic treatments on plant height (cm) in M_1 generation

Treatment	Doses	Variety*			
		JG 62	BDNG 798	JAKI 9218	VIJAY
Gamma	20 KR	34.67	41.67	34.13	34.33
rays (KR)	30 KR	36.47	41.00	35.60	35.00
	40 KR	32.33	39.00	33.50	32.33
Ethyl	0.2% EMS	36.43	39.00	35.00	34.50
Methane	0.3% EMS	34.20	36.00	31.50	33.00
Sulphonate (%)	0.4% EMS	31.67	37.57	31.00	31.17
Gamma rays	20 KR+0.2% EMS	34.57	42.20	38.37	33.53
+ Ethyl methane	30 KR+0.2% EMS	35.00	40.13	34.00	35.73
Sulphonate	20 KR+0.3% EMS	33.87	35.40	32.17	32.00
	30 KR+0.3% EMS	34.00	38.00	33.53	29.83
Untreated	Control	37.00	43.00	39.00	37.20
Mean		34.56	39.36	34.35	33.51
	CV	4.53	5.97	6.99	5.99
	CD 5%	2.67	4.01	4.09	3.42
	S.Em+	0.90	1.36	1.39	1.16
	F. cal	3.38	3.38	3.41	3.38

* Mean of three replications

Number of pods/plants

The highest number of mean pods per plants in JG 62 i.e., 94.07 was noted at 30 KR, followed by 92.40 at 40 KR and 90.90 at 20 KR. Minimum number of pods per plants was also increased using chemical mutagens, the highest pods per plant in EMS treatment was noted at 0.2% EMS (91.50), whereas in combination treatment highest mean pods per plants was reported to be 90.13 at 30KR+0.2% EMS as compared to control.

The number of pods per plants in genotype BDNG 798 was reported to be to be 69.30 at 40 KR, followed by 65.67 at 20 KR, 63.17 at 30 KR and in chemical mutagens 75.20 at 0.4% EMS. Whereas, in the combination treatment highest mean pods per plants was reported to be 71.97 at 20KR+0.2% EMS as compared to control.

In genotype JAKI 9218 the maximum number of mean pods per plants was reported to be 91.87 at 30 KR and 90.97 at 20 KR respectively. Similarly, in chemical mutagens maximum number of mean pods per plants was noted to be 89.37 at 0.2% EMS. Whereas in combination treatment highest mean pods per plant percentage was reported to be 81.27 at 20KR+0.2% EMS as compared to control.

The number of pods per plants in Vijay genotype was reported to be to be 92.27 at 30 KR followed by 90.80 at 20 KR, 90.27 at 40 KR and highest in chemical mutagens noted to be 85.20 at 0.3% EMS. Whereas, in the combination treatment highest mean pods per plants was reported to be 81.33 at 20KR+0.2% EMS as compared to control.

Table 4: Effect of mutagenic treatments on number of pods per plants in M_1 generation

Treatment	Doses	Variety*			
		JG 62	BDNG 798	JAKI 9218	VIJAY
Gamma	20 KR	90.90	65.67	90.97	90.80
rays (KR)	30 KR	94.07	63.17	91.87	92.27
	40 KR	92.40	69.30	86.10	90.27
Ethyl	0.2% EMS	91.50	65.90	89.37	83.00
Methane	0.3% EMS	88.00	71.97	82.53	85.20
Sulphonate (%)	0.4% EMS	89.43	75.20	78.30	71.33
Gamma rays	20 KR+0.2% EMS	88.33	71.97	81.27	81.33
+Ethyl methane	30 KR+0.2% EMS	90.13	67.98	71.90	70.17
Sulphonate	20 KR+0.3% EMS	82.20	57.28	70.00	71.07
	30 KR+0.3% EMS	75.63	57.80	74.17	59.80
Untreated	Control	93.30	74.60	93.33	90.70
Mean		88.72	67.35	82.71	80.54
	CV	5.16	8.41	7.16	7.05
	CD 5%	7.81	9.66	10.10	9.68
	S.Em+	2.64	3.27	3.42	3.28
	F. cal	4.19	3.52	5.93	11.00

* Mean of three replications

Number of seeds/plant

The mean seeds per plant in genotype JG 62 were noted to be 90.63 at 30 KR followed by 88.33 at 40 KR and 87.33 at 20 KR. Similarly in chemical mutagenic treatments the mean seeds per plant percentage were noted to be 88.00 at 0.2% EMS followed by 86.50 at 0.4% EMS and 85.00 at 0.3% EMS respectively. Whereas the combination treatment showed highest mean seeds per plant percentage among the all mutagenic treatments which was noted to be 86.50 at 30KR+0.2% EMS as compared to control.

In genotype BDNG 798 minimum mean seeds per plant were noted to be 61.10 at 30 KR. Similarly in chemical mutagenic treatments the mean seeds per plant were noted to be 73.20 at 0.4% EMS followed by 70.33 at 0.3% EMS and 63.53 at 0.2%EMS respectively. In the combination treatment highest number of mean seeds per plant among all the mutagenic treatments was found 69.13 at 20KR+0.2% EMS as compared to control.

The highest mean seeds per plant in JAKI 9218 were noted to be 86.07 at 30 KR in gamma rays dose and in chemical mutagens 85.03 at 0.2% EMS, respectively. Whereas, the combination treatment (20 KR+0.2% EMS) showed highest mean seeds per plant percentage among the all mutagenic treatments which was noted to be 77.50 as compared to control.

The mean seeds per plant in genotype Vijay were noted to be maximum 88.37 at 30 KR in Gamma rays respectively. Similarly in chemical mutagenic treatments the highest mean seeds per plant were noted to be 79.00 at 0.3% EMS respectively. In the combination treatment highest number of mean seeds per plant among all the mutagenic treatments was found at 20KR+0.2% EMS (76.27) as compared to control.

Table 5: Effect of mutagenic treatments on number of seeds per plant in M_1 generation

Treatment	Doses	Variety*			
		JG 62	BDNG 798	JAKI 9218	VIJAY
Gamma	20 KR	87.33	62.60	85.67	86.13
rays (KR)	30 KR	90.63	61.10	86.07	88.37
	40 KR	88.33	67.17	80.83	85.93
Ethyl	0.2% EMS	88.00	63.53	85.03	78.50
methane	0.3% EMS	85.00	70.33	78.73	79.00
Sulphonate (%)	0.4% EMS	86.50	73.20	74.83	65.67
Gamma rays	20 KR+0.2% EMS	84.00	69.13	77.50	76.27
+Ethyl methane	30 KR+0.2% EMS	86.50	66.43	68.70	65.30
sulphonate	20 KR+0.3% EMS	78.90	54.33	65.33	67.40
	30 KR+0.3% EMS	72.33	54.60	70.20	55.13
Untreated	Control	90.20	73.30	90.20	88.00
Mean		85.25	65.07	78.46	75.97
	CV	5.93	8.85	8.02	7.96
	CD 5%	8.62	9.82	10.73	10.32
	S. Em+	2.92	3.32	3.63	3.49
	F. cal	3.37	3.92	4.90	10.20

* Mean of three replications

Seed yield/plant (gm)

The mean seed yield per plant (gm) in genotype JG 62 was noted to be 15.02 gm at 30 KR followed by 13.00 gm at 40 KR and 12.99 gm at 20 KR. Similarly in chemical mutagenic treatments the highest mean seed yield per plant (gm) was 14.88 gm at 0.2%EMS, whereas in combination treatments (30 KR+0.2% EMS) the highest of mean seed yield per plant (gm) was noted to be 15.18 gm respectively.

Genotype BDNG 798 showed that the mean seed yield per plant (gm) was recorded to be highest 16.15 gm at 40 KR followed by 15.15 gm at 30 KR doses of Gamma rays treatments. Similarly in chemical mutagenic treatments the highest mean seed yield per plant (gm) was reported to be 16.40 gm at 0.3% EMS followed by 16.36 gm at 0.4% EMS. In combination treatments 20 KR+0.2% EMS the highest mean seed yield per plant was noted to be 17.76 gm followed by 17.69 gm at 30 KR+ 0.2% EMS respectively as compared to control.

The mean seed yield per plant (gm) in JAKI 9218 was noted to be 15.61 gm at 40 KR, 14.86 gm at 30 KR, 13.73 gm at 20 KR and highest 17.27 gm at 0.2%EMS, whereas in combination treatments the highest mean seed yield per plant (gm) was noted to be 16.75 gm at 20 KR+0.2%EMS treatment, followed by 13.67 at 30KR+0.2% EMS respectively.

The mean seed yield per plant (gm) in Vijay was noted to be 14.14 gm at 40 KR followed by 14.06 gm at 20 KR, 13.98 gm at 30 KR and highest 15.81 gm at 0.3%EMS, whereas in combination treatments the highest mean seed yield per plant (gm) was noted to be 15.25 gm at 20 KR+0.2%EMS treatment, followed by 12.44 gm at 30KR+0.2% EMS respectively.

Table 6: Effect of mutagenic treatments on seed yield (gm) per plant in M_1 generation

Treatment	Doses	Variety*			
		JG 62	BDNG 798	JAKI 9218	VIJAY
Gamma	20 KR	12.99	14.60	13.73	14.06
rays (KR)	30 KR	15.02	15.15	14.86	13.98
	40 KR	13.00	16.15	15.61	14.14
Ethyl	0.2% EMS	14.88	13.49	17.27	14.74
methane	0.3% EMS	14.39	16.40	13.38	15.81
sulphonate(%)	0.4% EMS	13.01	16.36	11.75	12.28
Gamma rays	20 KR+0.2% EMS	15.10	17.76	16.75	15.25
+Ethyl methane	30 KR+0.2% EMS	15.18	17.69	13.67	11.21
sulphonate	20 KR+0.3% EMS	14.26	14.33	13.50	12.44
	30 KR+0.3% EMS	11.28	14.28	13.49	10.61
Untreated	Control	13.72	17.36	16.22	15.57
Mean		13.89	15.78	14.57	13.64
	CV	5.99	8.94	8.19	8.05
	CD 5%	1.42	2.40	2.03	1.87
	S.Em+	0.48	0.81	0.69	0.63
	F. cal	6.48	3.37	8.76	7.76

* Mean of three replications

100 seed weight (gm)

The mean 100 seed weight (gm) in JG 62 was reported to be 16.58 gm at 30 KR followed by 14.88 gm at 20 KR and 14.72 gm at 20 KR. Similarly in chemical mutagenic treatments the highest mean 100 seed weight (gm) was 16.93 gm at 0.3%EMS, whereas in combination treatments (20 KR+0.3% EMS) the highest mean of 100 seed weight (gm) was noted to be 18.08 gm respectively as compared to control.

The results showed that the mean 100 seed weight (gm) in genotype BDNG 798 was found to be 24.80 at 30 KR followed by 24.06 gm at 40 KR, 23.36 gm at 20 KR and 23.32 gm at 0.3%EMS followed by 22.36 gm at 0.4%EMS and 21.24 gm at 0.2%EMS, respectively. In combination treatments the mean 100 seed weight (gm) was noted to be 26.64 gm at 30KR+0.2%EMS followed by 26.38 gm at 20KR+0.3%EMS, 26.17 gm at 30KR+0.3%EMS and 25.70 gm at 20KR+ 0.2%EMS as compared to control.

In genotype JAKI 9218 the 100 seed weight (gm) was reported to be 19.32 gm at 40 KR followed by 17.27 gm at 30 KR and 16.03 gm at 20 KR respectively. Whereas highest chemical mutagenic treatments it was recorded to be 20.32 gm at 0.2% EMS also in combination treatments the maximum mean 100 seed weight was noted to be 21.62 gm at 20KR+0.2% EMS, EMS respectively, as compared to control.

The mean 100 seed weight (gm) in Vijay was reported to be highest 16.46 gm at 40 KR. Similarly in chemical mutagenic treatments the highest mean 100 seed weight (gm) was 20.02 gm at 0.3%EMS, whereas in combination treatments (20 KR+0.2% EMS) the highest mean of 100 seed weight (gm) was noted to be 20.00 gm respectively as compared to control.

Table 7: Effect of mutagenic treatments on 100 seed weight (g) per plant in M_1 generation

Treatment	Doses	Variety*			
		JG 62	BDNG 798	JAKI 9218	VIJAY
Gamma	20 KR	14.88	23.36	16.03	16.33
rays (KR)	30 KR	16.58	24.80	17.27	15.83
	40 KR	14.72	24.06	19.32	16.46
Ethyl	0.2% EMS	16.91	21.24	20.32	18.79
methane	0.3% EMS	16.93	23.32	17.00	20.02
sulphonate(%)	0.4% EMS	15.05	22.36	15.70	18.70
Gamma rays	20 KR+0.2% EMS	17.98	25.70	21.62	20.00
+Ethyl methane	30 KR+0.2% EMS	17.55	26.64	19.90	17.17
sulphonate	20 KR+0.3% EMS	18.08	26.38	20.67	18.46
	30 KR+0.3% EMS	15.60	26.17	19.22	19.25
Untreated	Control	15.22	23.69	17.99	17.70
Mean		16.32	24.34	18.64	18.06
	CV	6.11	5.67	6.32	5.62
	CD 5%	1.70	2.35	2.01	1.73
	S.Em+	0.58	0.80	0.68	0.59
	F. cal	4.87	4.86	8.35	6.28

* Mean of three replications

Lethality

The highest lethality percentage in M_1 generation of genotype JG 62 was recorded in chemical mutagenic treatments, which was 47.33% at 0.4% EMS followed by 46.0% at 0.3% EMS, whereas in physical mutagenic treatment the maximum lethality was recorded to be 24.0% at 20 KR followed by 22.0% at 40 KR doses of Gamma rays treatments. Similarly, in combination treatments the maximum lethality percentage was recorded to be 30.0% at 30 KR+0.3% EMS followed by 29.33% at 20 KR+0.3% EMS as compared to control (23.33%) and in genotype BDNG 798 the highest lethality percentage was noted in combination treatments, which was 41.33% at 30 KR +0.3% EMS, whereas in physical mutagenic treatment the maximum lethality was recorded to be 26.0% in 20 KR and in chemical mutagenic treatments the maximum lethality percentage was recorded to be 38.67% at 0.3% EMS treatment respectively, as compared to control (12.0%). As well as in genotype JAKI 9218 showed the highest lethality

percentage was noted in chemical mutagens treatments, which was 58.67% at 0.4% EMS, whereas in combination treatment the maximum lethality was recorded to be 49.33% in 30 KR+0.2% EMS followed by 28.67% at 20 KR+0.3% EMS treatments and in physical mutagenic treatments the maximum lethality percentage was recorded to be 16.67% at 40 KR dose of Gamma rays treatment as compared to control (19.33%).

The highest lethality percentage of genotype Vijay was recorded in chemical mutagenic treatments, which was 34.0% at 0.4% EMS followed by 31.33% at 0.3% EMS treatments respectively, whereas in physical mutagenic treatment the maximum lethality was recorded to be 24.0% at 30 KR followed by 20.0% at 40 KR doses of Gamma rays treatments. Similarly, in combination treatments the maximum lethality percentage was recorded to be 32.0% at 30 KR+0.3% EMS followed by 26.67% at 20 KR+0.2% EMS as compared to control (17.33%)

Table 8: Effect of mutagenic treatments on lethality (%) in M_1 generation

Treatment	Doses	Variety*			
		JG 62	BDNG 798	JAKI 9218	VIJAY
Gamma	20 KR	24.00	11.33	14.00	13.33
rays (KR)	30 KR	16.00	14.67	14.67	24.00
	40 KR	22.00	26.00	16.67	20.00
Ethyl	0.2% EMS	22.00	20.67	28.67	24.67
Methane	0.3% EMS	46.00	38.67	32.00	31.33
sulphonate(%)	0.4% EMS	47.33	20.00	58.67	34.00
Gamma rays	20 KR+0.2% EMS	24.67	14.00	23.33	26.67
+ Ethyl methane	30 KR+0.2% EMS	28.67	26.67	49.33	23.33
Sulphonate	20 KR+0.3% EMS	29.33	22.00	28.67	20.00
	30 KR+0.3% EMS	30.00	41.33	20.67	32.00
Untreated	Control	23.33	12.00	19.33	17.33
Mean		28.48	22.48	27.82	24.24
	CV	11.61	15.09	16.78	17.30
	CD 5%	5.64	5.79	7.96	7.15
	S.Em+	1.91	1.96	2.69	2.42
	F. cal	26.49	26.68	28.44	7.08

* Mean of three replications

The impact of the mutagenic treatments on seed germination and on some morphological traits

From the present investigation on impact of the mutagenic treatments on seed germination and on some morphological traits it was revealed that the mutagenic treatments *viz*., 20 KR, 30 KR, 0.2% EMS, 0.3% EMS, 20 KR+0.2% EMS and 30 KR+0.2% EMS among 11 treatments have shown some prominent effect on individuals of selected chickpea varieties *viz*., JG 62, BDNG 798, JAKI 9218 and Vijay as compared to other treatments. Reduction in germination in mutagenic treatment has been due to delay or inhibition of physiological and biological processes necessary for germination. It was also evident from the present study that the effectiveness of EMS treatments initially increased with an increase in concentration but decreased at higher concentration.

The present findings are conformity with the findings of Khan *et al.* (2005) [2] observed decrease in plant height, number of primary and secondary branches, pods per plant, seeds per pod and grain yield were significantly affected due to genotypes, treatments and also by their interaction.

The trend of the overall effectiveness of mutagenic treatments on experimental genotypes, JG 62, BDNG 798 and Vijay showed changes in their varietal characteristics which are in agreement with the findings of Shah *et al.* (2008) [6] in case of Pb- 2000 and C-44 with mutagenic treatments. Wani (2009) [9] observed in case of Gamma rays, the lethality increased with an increase in dose from 150 to 400 Gy in var. Pusa-212 and Pusa-372, whereas it decreased beyond the dose of 300 Gy in the var. Pusa-212.It was further confirmed by comparing with similar results were earlier reported by Wani and Anis (2014) [10], Pawar *et al*. (2018) [4], Ugandhar *et al*. (2018) [7].

References

1. Anonymous. Pulses revolution from food to nutritional security. Crops Division, Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare Krishi Bhavan, New Delhi -110 001, 2018. Assessed on 13th sept. 2018.
2. Khan M, Qureshi A, Hussain S, Ibrahim M. Genetic variability induced by gamma irradiation and its modulation with gibberellic acid in M_2 generation of chickpea (*Cicer arietinum* L.). Pak. J. Bot. 2005; 37(2):285- 292.
3. Oladosu Y, Rafii MY, Abdullah N, Hussin G, Ramli A, Rahim A *et al*. Principle and application of plant mutagenesis in crop improvement: a review. Biotechnology & Biotechnological Equipment. 2015; 30(1):1-16.
4. Pawar M, Gupta Om, Chobe D. Radiation Induced Mutation for Resistance against Dry Root Rot in chickpea (*Cicer arietinum* Linn.) Int. J. Curr. Microbiol. App. Sci. 2018; 7(7):3542-3551.
5. Raina A, Danish M. Mutagenesis in Plant Breeding for Disease and Pathogen Resistance. Agri Res & Tech: Open Access J. 2018; 13(1):1.
6. Shah T, Mirza J, Haq MA, Babar MA. Induced genetic variability in chickpea (*Cicer arientinum* L.) and comparative mutagenic effectiveness and efficiency of physical and chemical mutagens. Pak. J Bot. 2008; 40(2): 605-613.
7. Ugandhar T, Prasad BR, Venkateshwarlu M, Odelu G, Parvathi D. Studies on experimental mutagenesis on chickpea (*cicer arietinum* L.) induced by ultraviolet rays and ethyl methane sulphonate. European Journal of Biomedical and Pharmaceutical sciences. 2018; 5(8):506-511.
8. Venkataramanamma K, Bhaskara BV, Reddy R, Jayalakshmi S, Jayalakshmi V, Hari Prasad KV *et al*. Screening of chickpea germplasm/genotypes against Fusarium wilt of chickpea under field and artificial condition. Int. J. Curr. Microbiol. App. Sci. 2018; 7(09):1041-1050.
9. Wani A. Mutagenic Effectiveness and efficiency of Gamma Rays, Ethyl Methane sulphonate and their combination treatment in chickpea (*Cicer arietinum* L.) Asian Journal of Plant Sciences. 2009; 8(4): 318-321.
10. Wani AA, Anis M. Gamma rays and ethyl methane sulfonate induced polygenic variability in *Cicer arietinum* L. var. Pusa-212. Journal of Phytology. 2014; 6:26-32.