Int.J.Curr.Microbiol.App.Sci (2018) *7*(7): 3542-3551

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 7 Number 07 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.707.411

Radiation Induced Mutation for Resistance against Dry Root Rot in Chickpea (*Cicer arietinum* Linn.)

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Keywords

Rhizoctonia bataticola, Gamma-ray, EMS, *Cicer arietinum* L

Article Info

Accepted:
26 June 2018
Available Online:
10 July 2018

A B S T R A C T

Chickpea (*Cicer arietinum* L.) is an important cool-season food legume grown extensively by the poor farmers throughout the Indian subcontinent. In India chickpea is being grown in 8.32 million hectare with production of 9.8 million tones and 925 - kg/ha productivity (Project coordinators report, 2014-15). The Dry root rot (DRR) of chickpea caused by necrotropic fungus *Rhizoctonia bataticola*. During the past few decades, modern techniques such as mutation breeding by radiation and chemical mutagens and genetic engineering methodology have been tried to develop resistant cultivars of many crop plants. The utilization of mutation breeding is a simple, less cost full and time saving method. Present investigation entitled "Radiation induced mutation for resistance against *Rhizoctonia bataticola* in chickpea (*Cicer arietinum* Linn.)" was aimed at identification of suitable mutant or a combination of mutants influencing resistance to dry root rot in chickpea. The experimental material was consisted of the population of three selected cultivars of chickpea (JG 63, JG 74, and JG 130) grown in randomized complete block design in the Seed Breeding Farm, Department of Plant Breeding and Genetics, College of Agriculture, Jabalpur (M.P) under AICRP on chickpea project during *Rabi* 2014-15. Dry seeds (10-12% moisture content) of these varieties were irradiated with different doses of gamma rays (150Gy, 200Gy and 400 GY). Another set of presoaked seeds in distilled water (12hrs.) were treated with ethyl methane sulphonate at different concentration (0.3, 0.4 and 0.5%) prepared for 6 hrs. A portion of seeds irradiated at 150 and 200 GY gamma-ray doses were also treated with 0.3% and 0.4% EMS independently for 6 hrs. present findings revealed that JG 63, JG 74, JG 130 showed significant reaction for mutagenic treatments *i.e*, 200Gy, 400Gy, 0.3% EMS, 0.4% EMS, 150Gy+0.3% EMS, 200Gy+0.3% EMS. Among 11 treatments, 7 have shown effect on biological traits of experimental genotypes *i.e*. change in seedling height, decrease in germination percentage and decrease in plant height as compared to control.

Introduction

Chickpea is a cool season pulse crop and is grown in several countries worldwide as a food source. Chickpea is the third most important food legume crop and India is the largest producer contributing to 65% of world's chickpea production. The improvement of chickpea using conventional breeding approaches has been hampered due

to lack of sufficient genetic variability. Mutagenesis is a common and efficient tool to create new desirable genetic variability in chickpea [1]. The use of ionizing radiation such as, x-rays, gamma rays, and neutrons and chemical mutagens for inducing variation is well established. Induced mutation have been used to improve major crop which are seed propagated. Mutation can be linked to changes in DNA sequences for some plant traits and to establish molecular maps in structural and functional genomics of crop plants. These in turn would lead to a rapid enhancement of crop yields and quality [2].

Materials and Methods

The experiment was carried out under AICRP-Chickpea, at seed breeding farm, Adhartal, JNKVV, Jabalpur (M.P.) during rabi 2014-15. Temperature extremes vary between minimum temperature of 2^{o}C in December and January months to maximum temperature of 45^{o}C in May and June months. The average annual rainfall mostly received between mid - June to first week of October with occasional showers in limited quantum during the winter months, ranges between 1000-1500 mm. The relative humidity remains minimum 20 to 35% during summer and medium 40 to 60% during winter season, while it attains maximum values of 80 to 95% during rainy season. Chickpea seeds of JG 130, JG 63, and JG 74 entries/ varieties were collected from healthy plants at maturity stage of the crop from AICRP on chickpea located at seed breeding farm J.N.K.V.V., Jabalpur. Gamma irradiation has been performed (Nuclear Research Laboratory IARI, New Delhi) 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 120 seeds pre treatment will be packed in butter paper cover and placed in 100 curie ^{60}Co gamma cells the treatments will be given for various duration depending on the doses required (150Gray, 200Gray and 400 Gray) with the dose rate of say 54.05 rads/sec. Set of presoaked seeds of selected genotypes in distilled water (12 hrs.) were treated with ethyl methane sulphonate at different concentration by using magnetic stirrer (0.3,0.4 and 0.5%) for 6 hrs. with constant intermitted shaking in shaker and after that washed under running tap water. A portion of seeds irradiated at 150 and 200 GY gamma- ray doses were also treated with 0.3 and 0.4 EMS independently for 6 hrs with constant intermitted shaking in shaker and after that washed under running tap water. A total of 11-treatment combinations (including control) were evaluated separately for each variety planted in Randomized Block Design with three replication following biological parameters of observation during Rabi season 2014-15 at Seed Breeding farm, JNKVV Jabalpur.

Results and Discussion

Impact of the mutagenic treatments on seed germination and some morphological parameters on chickpea variety JG 63

Considering the value of control as 100% for all the morphological traits, the data are presented (Table 1).

Germination (%)

The mean seed germination percentage was reported to be 84.36% at 150Gy, 72.14% at 200Gy, 64.50% at 400Gy respectively as compared to control. Similarly, the germination (%) was also reduced by using chemical mutagens. The germination (%) was noted to be 68.70% at 0.2% EMS, 60.31% at 0.3%EMS and 52.67% at 0.4% EMS treatments respectively. Whereas, the mean seed germination percentage in combination of Gamma irradiation and EMS at treatment was reported as 66.41% at 150GY+0.2% EMS

and 54.49 % at 200Gy+0.2%EMS respectively as compared to control.

Plant height

The minimum mean plant height (%) *i.e.* was noted 71.98% at 200Gy, 75.46% in 0.3% EMS and 79.15% in combination treatment 200Gy+0.3% EMS respectively, among the all treatments as compared to control.

Number of pods per plants

The maximum number of pods per plant (%) i.e, 90.20% was noted at 150Gy, followed by 67.00% at 200Gy and 60.82% at 400Gy. Minimum number of pods per plant (%) was also increased using chemical mutagens, the highest pods per plant (%) in EMS treatment was noted at 0.3% EMS (66.49%), whereas in combination treatment highest mean pods per plant (%) was reported to be 75.77% at 150GY+0.2% EMS as compared to control.

Number of seeds per plant

The mean seeds per plant (%) were noted to be 75.61% at 150Gy, 62.61% at 200Gy and 54.46% at 400Gy respectively. Similarly in chemical mutagenic treatments the mean seeds per plant (%) were noted to be 74.80% at 0.2% EMS, 40.98% at 0.3% EMS and 80.49% at 0.4%EMS respectively. In the combination treatment highest number of mean seeds per plant (%) among all the mutagenic treatments was found at 200Gy+0.3% EMS (84.56%) as compared to control.

Seed yield per plant

The mean seed yield per plant (%) was noted to be 85.52% at 200Gy, 63.13% at 150Gy and 60.15% at 400Gy.

Similarly in chemical mutagenic treatments the highest percentage of mean seed yield per plant was 76.12% at 0.2%EMS, whereas in combination treatments (200GY+0.2% EMS) the highest percentage of mean seed yield per plant was noted to be 70.75% respectively.

Seedling height

Mean seedling height (%) after 15 days of sowing was reported to be 47.30% at 150Gy, 43.25% at 200Gy and 22.90% at 400Gy respectively. Similarly in chemical mutagenic treatments the seedling height was 75.56% at 0.2% EMS, 61.68% at 0.3% EMS and 51.66% at 0.4% EMS respectively. Whereas in combination treatments the mean seedling height was noted to be 87.36% at 150Gy+0.2%EMS, 86.58% at 200Gy+0.2%EMS, 75.02% at 150Gy+0.3%EMS and 48.80% at 200Gy+ 0.3%EMS respectively, as compared to control.

100 seed weight

The mean 100 seed weight (%) was reported to be 84.74% at 150Gy, 89.78% at 200Gy and 81.10% at 400Gy, respectively. Whereas, in chemical mutagenic treatments it was recorded to be 77.79% at 0.2% EMS, 76.61% at 0.3% EMS and 80.74% at 0.4% EMS also in combination treatments the mean 100 seed weight percentage was noted to be 73.24% at 150Gy+0.2% EMS, 78.15% at 200Gy+0.2% EMS, 78.56% at 150Gy+0.3% EMS and 74.01% at 200Gy+ 0.3% EMS respectively, as compared to control.

Lethality

The highest lethality percentage was recorded in combination treatments, which was 71.93% at 200Gy+0.3%EMS, whereas in physical mutagenic treatment the maximum lethality was recorded to be 53.05% in 400Gy and in chemical mutagenic treatments the maximum lethality percentage was recorded to be 61.66% at 0.4%EMS as compared to control.

Impact of the mutagenic treatments on seed germination and some morphological parameters on chickpea variety JG 74

Considering the value of control 100% for all the morphological traits, the data are presented and discussed (Table 2).

Germination (%)

The mean seed germination percentage was reported to be 84.62% at 150Gy, 64.53% at 200Gy and 53.42 % at 400Gy respectively as compared to control.

Similarly, using chemical mutagens also reduced the germination % and it was found 67.09% at 0.2% EMS, 56.41% at 0.3% EMS and 54.27% at 0.4% EMS treatments respectively.

Whereas, the mean seed germination percentage in combination of Gamma irradiation and EMS at treatment were noted to be 70.09% at 150GY+0.2% EMS and 58.97 % at 200Gy+0.2%EMS respectively as compared to control.

Plant height

The mean plant height (%) was noted to be 59.11% at 200Gy, 90.06% at 0.3% EMS and 79.49% in combination treatment of 200Gy+0.3% EMS respectively, which was minimum among the all treatments as compared to control.

Number of pods per plants

The highest number of mean pods per plant (percentage) were reported to be 90.95% at 150Gy and 56.37% at 200Gy respectively, whereas in combination treatment highest mean pods per plant percentage was reported to be 78.19% at 150GY+0.2% EMS as compared to control.

Number of seeds per plant

The mean seeds per plant percentage were noted to be 89.99% at 150Gy, 74.29% at 200Gy and 40.71% at 400Gy. Similarly in chemical mutagenic treatments the mean seeds per plant percentage were noted to be 97.86% at 0.2% EMS, 36.43% at 0.3% EMS and 63.57% at 0.4%EMS respectively. Whereas the combination treatment showed highest mean seeds per plant percentage among the all mutagenic treatments which was noted to be 89.99% at 200Gy+0.3% EMS as compared to control.

Seed yield per plant

The mean seed yield per plant percentage was noted to be 82.58% at 150Gy, 67.50% at 200Gy, 52.60% at 400Gy and 83.25% at 0.2%EMS, whereas in combination treatments the highest percentage of mean seed yield per plant was noted to be 71.52% at 150Gy+0.2%EMS treatment, followed by 70.35% at 200GY+0.3% EMS respectively.

Seedling height

Mean seedling height percentage after 15 days of sowing was reported to be 77.05% at 150Gy, 96.97% at 200Gy 82.35% at 400Gy, 74.24% at 0.2%EMS, 76.29% at 0.3%EMS and 84.62% at 0.4% EMS, respectively. Whereas, in combination treatments the mean seedling height was noted to be 83.56% at 150Gy+0.2% EMS, 87.12% at 200Gy+0.2% EMS, 92.20% at 150Gy+0.3%EMS and 48.80% at 200Gy+ 0.3% EMS, respectively, as compared to control.

100 seed weight

The mean 100 seed weight (%) was reported to be 78.74 at 150Gy, 82.52% at 200Gy 75.19% at 400Gy, 76.96% at 0.2%EMS, 90.55% at 0.3%EMS and 89.60% at

0.4%EMS, respectively. In combination treatments the mean 100 seed weight percentage was noted to be 92.73% at 150Gy+0.2%EMS, 81.69% at 200Gy+0.2%EMS, 77.20% at 150Gy+0.3%EMS and 81.10% at 200Gy+ 0.3%EMS as compared to control.

Lethality

The highest lethality percentage was recorded in physical mutagenic treatments, which was 55.00% at 150Gy, whereas in chemical mutagenic treatment the maximum lethality was recorded to be 43.61% at 0.2% EMS. Similarly, in combination treatments the maximum lethality percentage was recorded to be 45.56% at 150Gy+0.2% EMS as compared to control.

Impact of the mutagenic treatments on seed germination and some morphological parameters on chickpea variety JG 130

Considering the value of control as100% for all the morphological traits, the data are presented and discussed (Table 3).

Germination (%)

The mean seed germination percentage was reported to be 70.11% at 150Gy, 60.92% at 200Gy, 56.32 % at 400Gy, 58.62% at 0.2% EMS, 49.43% at 0.3%EMS and 43.68% at 0.4% EMS treatments, respectively. Whereas, the mean seed germination percentage in combination of Gamma irradiation and EMS at treatment were reported 58.62% at 150GY+0.2% EMS and 48.28% at 200Gy+0.2%EMS respectively as compared to control.

Plant height

The minimum mean plant height (%) was noted to be 67.10% at 400Gy, 84.01% at 0.4% EMS and 69.73% in combination treatment (200Gy+0.3%) EMS respectively, compared to control.

Number of pods per plants

The number of pods per was reported to be to be 61.57% at 150Gy, 35.57% at 400Gy, 28.19% at 200Gy and 61.57% at 0.4% EMS. Whereas, in the combination treatment highest mean pods per plant (percentage) was reported to be 85.22% at 150GY+0.2% EMS as compared to control.

Number of seeds per plant

The mean seeds per plant (percentage) were noted to be 56.6% at 150Gy, 54.05% at 200Gy 58.57% at 400Gy, 85.59% at 0.2% EMS, 53.16% at 0.3% EMS and 64.14% at 0.4%EMS, respectively. Whereas, the combination treatment (200Gy+0.3% EMS) showed highest mean seeds per plant percentage among the all mutagenic treatments which was noted to be 91.00% as compared to control.

Seed yield per plant

The mean seed yield per plant (percentage) was noted to be 61.93% at 150Gy, 73.65% at 200Gy, 59.00% at 400Gy, and 74.67% at 0.2%EMS.

Whereas in combination treatments the highest percentage of mean seed yield per plant was noted 74.67% at 150Gy+0.3%EMS, and followed by 65.45% at 200GY+0.3% EMS, respectively.

Seedling height

Mean seedling height (percentage) after 15 days of sowing was reported to be 82.27% at 150Gy, 84.58% at 200Gy, 94.60% at 400Gy, 76.56% at 0.2%EMS, 92.75% at 0.3%EMS and 58.37% at 0.4% EMS, respectively.

Table.1 Various biological effects of gamma irradiation, EMS and their combinations in M1 generation

Variety	Doses	Germination %		Plant height (cm) at maturity		No. of Pods/plant		No. of seeds/plant		Seed yield/ plant (gm)		Seedling height (cm) - 15DAS		100 seed wt. (gm)		Lethality	
		Actual (%)	**% of control**	**Actual (%)**	**% of control**	**Actual %**	**% of control**	**Actual (%)**	**% of control**	**Actual (%)**	**% of control**	**Actual (%)**	**% of control**	**Actual %**	**% of control**	**Actual (%)**	**% of control**
JG 63	**Control**	87.33	100.00	54.33	100.00	64.67	100.00	41.00	100.00	6.70	100.00	12.97	100.00	16.93	100.00	32.67	100.00
	150Gy	73.67	84.36	51.00	93.87	58.33	90.20	31.00	75.61	4.23	63.13	6.20	47.80	14.30	84.47	46.33	38.60
	200Gy	63.00	72.14	39.00	71.78	43.33	67.00	25.67	62.61	5.73	85.52	5.61	43.25	15.20	89.78	57.00	47.49
	400Gy	56.33	64.50	43.67	80.38	39.33	60.82	22.33	54.46	4.03	60.15	2.97	22.90	13.73	81.10	63.67	53.05
	EMS 0.2%	60.00	68.70	45.00	82.83	25.67	39.69	30.67	74.80	5.10	76.12	9.80	75.56	13.17	77.79	60.00	49.99
	EMS 0.3%	52.67	60.31	41.00	75.46	43.00	66.49	16.80	40.98	4.57	68.21	8.00	61.68	12.97	76.61	67.33	56.10
	EMS 0.4%	46.00	52.67	44.00	80.99	32.67	50.52	33.00	80.49	3.67	54.78	6.70	51.66	13.67	80.74	74.00	61.66
	150Gy + 0.2% EMS	58.00	66.41	46.67	85.90	49.00	75.77	21.67	52.85	2.53	37.76	11.33	87.36	12.40	73.24	62.00	51.66
	200Gy + 0.2% EMS	49.33	56.49	45.00	82.83	44.67	69.07	31.17	76.02	4.74	70.75	11.23	86.58	13.23	78.15	70.67	58.88
	150Gy + 0.3% EMS	44.67	51.15	45.33	83.43	38.00	58.76	25.33	61.78	4.43	66.12	9.73	75.02	13.30	78.56	75.33	62.76
	200 Gy + 0.3% EMS	33.67	38.55	43.00	79.15	34.00	52.57	34.67	84.56	4.47	66.72	6.33	48.80	12.53	74.01	86.33	71.93
	CV	**7.75**		**4.30**		**16.72**		**7.17**		**15.24**		**11.83**		**6.20**		**6.96**	
	CD 5%	**7.49**		**3.32**		**12.23**		**3.48**		**1.18**		**2.06**		**1.45**		**7.49**	
	CD 1%	**10.22**		**4.53**		**16.69**		**4.74**		**1.61**		**2.81**		**1.98**		**10.22**	
	S.Em.+	**2.24**		**1.12**		**4.10**		**1.18**		**0.40**		**0.69**		**0.49**		**2.54**	
	F. cal	**33.12**		**14.50**		**7.38**		**33.90**		**7.18**		**7.87**		**7.11**		**33.12**	

Table.2 Various biological effects of gamma irradiation, EMS and their combinations in M1 generation

Variety	Doses	Germination %		Plant height (cm) at maturity		No. of Pods/plant		No. of seeds/plant		Seed yield/ plant (gm)		Seedling height (cm) - 15DAS		100 seed wt. (gm)		Lethality	
		Actual (%)	**% of control**	**Actual (%)**	**% of control**	**Actual %**	**% of control**	**Actual (%)**	**% of control**	**Actual (%)**	**% of control**	**Actual (%)**	**% of control**	**Actual %**	**% of control**	**Actual (%)**	**% of control**
JG 74	**Control**	78	100.00	53	100	62.67	100	46.67	100	5.97	100	13.2	100	16.93	100	29.33	100
	150Gy	66	84.62	33.33	62.89	57	90.95	42	89.99	4.93	82.58	10.17	77.05	13.33	78.74	66	55.00
	200Gy	50.33	64.53	31.33	59.11	35.33	56.37	34.67	74.29	4.03	67.50	12.8	96.97	13.97	82.52	50.33	41.94
	400Gy	41.67	53.42	34.67	65.42	33.33	53.18	19	40.71	3.14	52.60	10.87	82.35	12.73	75.19	41.67	34.72
	EMS 0.2%	52.33	67.09	48	90.57	25.67	40.96	45.67	97.86	4.97	83.25	9.8	74.24	13.03	76.96	52.33	43.61
	EMS 0.3%	44	56.41	48.33	91.19	34.33	54.78	17	36.43	4.47	74.87	10.07	76.29	15.33	90.55	44	36.66
	EMS 0.4%	42.33	54.27	47.73	90.06	27.33	43.61	29.67	63.57	3.93	65.83	11.17	84.62	15.17	89.60	42.44	35.36
	150Gy + 0.2% EMS	54.67	70.09	43.73	82.51	49	78.19	20	42.85	4.27	71.52	11.03	83.56	15.7	92.73	54.67	45.56
	200Gy + 0.2% EMS	46	58.97	50.33	94.96	40.33	64.35	41.67	89.29	3.8	63.65	11.5	87.12	13.83	81.69	46	38.33
	150Gy + 0.3% EMS	37	47.44	43.2	81.51	34.67	55.32	25.33	54.27	3.63	60.80	12.17	92.20	13.07	77.20	37	30.83
	200 Gy + 0.3% EMS	31	39.74	42.13	79.49	30.67	48.94	42	89.99	4.2	70.35	10.37	78.56	13.73	81.10	31	25.83
	CV	**7.75**		**10.1**		**18.02**		**32.03**		**11.83**		**7.23**		**6.2**		**9.05**	
	CD 5%	**7.49**		**7.44**		**12.01**		**17.63**		**0.87**		**1.37**		**1.45**		**6.93**	
	CD 1%	**10.22**		**10.15**		**16.38**		**24.06**		**1.1**		**1.88**		**1.98**		**9.4**	
	S.Em.+	**2.5**		**2.52**		**4.07**		**5.9**		**0.29**		**0.46**		**0.49**		**2.3**	
	F. cal	**33.22**		**8.32**		**8.78**		**4.03**		**6.78**		**5.83**		**7.11**		**20.66**	

Table.3 Various biological effects of gamma irradiation, EMS and their combinations in M1 generation

Variety	Doses	Germination %		Plant height (cm) at maturity		No. of Pods/plant		No. of Seeds/plant		Seed yield/ plant (gm)		Seedling height (cm) -15DAS		100 Seed wt. (gm)		Lethality	
		Actual (%)	**% of control**	**Actual (%)**	**% of control**	**Actual %**	**% of control**	**Actual (%)**	**% of control**	**Actual (%)**	**% of control**	**Actual (%)**	**% of control**	**Actual %**	**% of control**	**Actual (%)**	**% of control**
JG 130	**Control**	87	100	50.67	100	49.67	100	37	100	6.83	100	12.97	100	18.93	100	33	100
	150Gy	61	70.11	39.67	78.29	30.67	61.75	21.43		4.23	61.93	10.67	82.27	16.87	89.12	59	49.17
	200Gy	53	60.92	34.83	68.74	14	28.19	20	54.05	5.03	73.65	10.97	84.58	15.93	84.15	67	55.83
	400Gy	49	56.32	34	67.10	17.67	35.57	21.67	58.57	4.03	59.00	12.27	94.60	14.47	76.44	70.67	58.89
	EMS 0.2%	51	58.62	42.67	84.21	13.67	27.52	31.67	85.59	5.1	74.67	9.93	76.56	16.8	88.75	69	57.50
	EMS 0.3%	43	49.43	46.97	92.70	27.33	55.02	19.67	53.16	4.57	66.91	12.03	92.75	15.83	83.62	77	64.17
	EMS 0.4%	38	43.68	42.57	84.01	30.67	61.75	23.73	64.14	3.93	57.54	7.57	58.37	14.64	77.34	82	68.33
	150Gy + 0.2% EMS	51	58.62	44.67	88.16	42.33	85.22	25.4	68.65	4.27	62.52	10.1	77.87	16.07	84.89	68.67	57.23
	200Gy + 0.2% EMS	42	48.28	44	86.84	40.67	81.88	26.7	72.16	3.8	55.64	9.89	76.25	15.63	82.57	78	65.00
	150Gy + 0.3% EMS	39	44.83	37.13	73.28	36.33	73.14	19.2	51.89	5.1	74.67	9.73	75.02	14.87	78.55	81	67.50
	200 Gy + 0.3% EMS	29	33.33	35.33	69.73	25.67	51.68	33.67	91.00	4.47	65.45	6.33	48.80	14.63	77.28	91	75.83
	CV	**6.6**		**8.46**		**16.72**		**21.92**		**11.27**		**11.83**		**6.09**		**6.96**	
	CD 5%	**5.52**		**5.93**		**12.23**		**9.4**		**0.89**		**2.06**		**1.64**		**7.49**	
	CD 1%	**7.6**		**8.08**		**16.69**		**12.9**		**1.22**		**2.8**		**2.24**		**10.22**	
	S.Em.+	**1.8**		**2.01**		**4.14**		**3.3**		**0.3**		**0.6**		**0.55**		**2.5**	
	F. cal	**64.76**		**7.23**		**7.38**		**3.37**		**7.9**		**7.87**		**5.56**		**33.2**	

Whereas, in combination treatments the mean seedling height was noted to be 77.87% at 150Gy+0.2% EMS, 76.25% at 200Gy+0.2% EMS, 75.02% at 150Gy+0.3% EMS and 48.80% at 200Gy+ 0.3%EMS respectively, as compared to control.

100 seed weight

The mean 100 seed weight percentage was reported to be 89.12% at 150 Gy, 84.15% at 200Gy and 76.44% at 400Gy respectively. Whereas in chemical mutagenic treatments it was recorded to be 88.75% at 0.2% EMS, 83.62% at 0.3% EMS and 77.34% at 0.4% EMS also in combination treatments the mean 100 seed weight percentage was noted to be 84.89 at 150 Gy+0.2% EMS, 82.57% at 200 Gy+0.2% EMS, 78.55% at 150 Gy+0.3% EMS and 77.28% at 200 Gy+ 0.3% EMS respectively, as compared to control.

Lethality

The highest lethality percentage was recorded in physical mutagenic treatments, which was 58.89% at 400Gy, whereas in chemical mutagenic treatment it was 68.33% at 0.4% EMS. Similarly in combination treatments the maximum lethality percentage was recorded to be 75.83% in 200Gy+0.3% EMS as compared to control.

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

From the present investigation it was revealed that the mutagenic treatments *viz*., 200Gy, 400Gy, 0.3% EMS, 0.4%EMS, 150Gy+0.3%EMS and 200Gy+0.3%EMS has found to shown some prominent effect on individuals of selected chickpea varieties viz., JG 63, JG 74 and JG 130 as compared to other treatments. There is a change in terms of decrease in seedling height, germination percentage, plant height, number of pods per plant, number of seeds per plant and seed yield per plant as compared to control. Whereas, similar experiment conducted by [3] against the ICL 6104 and ICL 3279 genotypes. They found the similar changes in some biological parameters like seedling height, germination and plant height. [4] observed decrease in plant height, number of primary and secondary branches, pods per plant, seeds per pod and grain yield in M_2 generation were significantly affected due to genotypes, treatments and also by their interaction. Similar kinds of results were obtained in the present investigation on M_1 generation. [5] Observed reduced germination percentage at higher dosages in all lines, especially in induced mutant lines of ILC 5901.

In the present study, the germination percentage decreases by applying higher doses of chemical and physical mutagens. As discussing about comparative mutagenic effectiveness, it was found that EMS treatments are more efficient than gamma radiation according to the biological and agronimical parameters, as similar with the findings of [6]. 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 combination of 200Gy + 0.3%EMS treatment was found most effective in the populations of all three genotypes. The present findings are conformity with the findings of [7], [8] and [9].

The overall trend of effectiveness of mutagenic treatment on experimental genotypes, JG 63 and JG 74 showed changes in their varietal characteristics are in agreement with the findings of [6] in case of Pb-2000 and C-44 with mutagenic treatments.

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How to cite this article:

Maruti Pawar, O.M. Gupta and Devashish Chobe. 2018. Radiation Induced Mutation for Resistance against Dry Root Rot in Chickpea (*Cicer arietinum* Linn.). *Int.J.Curr.Microbiol.App.Sci.* 7(07): 3542-3551. doi: https://doi.org/10.20546/ijcmas.2018.707.411