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Assessment of Lethal Dose of Gamma Radiations and EMS in Papaya (*Carica papaya* L.) Cultivars

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Abstract

An experiment was conducted for assessment of lethal dose of gamma radiations and EMS in Papaya (*Carica papaya* L.) cultivars at Department of Horticulture, Chaudhary Charan Singh Haryana Agriculture University, Hisar, Haryana. The experiment was laid out in Completely Randomized Design (CRD) comprising of twelve treatments. The seeds of papaya subjected to different doses of gamma radiation (100 Gy, 200 Gy, 300 Gy, 400 Gy, 500 Gy and 600 Gy) and EMS treatment (0.2%, 0.4%, 0.6%, 0.8% and 1%). All treatments exhibited significant variations in their parameters. Generally, germination percentage, days taken for germination and chlorophyll content of papaya decreased with increase in the doses of both gamma rays and EMS. Lower doses of mutagens generate little stimulation effect but, higher doses induced lethality. Based on probit analysis, LD50 (lethal dose) for Arka Prabhat was fixed at 316 Gy gamma radiations and 0.4% EMS and for Red lady, it was fixed at 323 Gy gamma radiations and 0.42 % EMS.

Key words : *EMS, gamma rays, LD50, papaya.*

Introduction

Papaya (*Carica papaya* L.) stands as an important fruit crop of ttropical and subtropical regions of the world. Owing to its distinctive and advantageous attributes, papaya cultivation has garnered immense popularity among horticulture farmers. Being short duration, precocious maturity, quick growing and dwarf in nature, it can be ideal crop for intercropping with major fruit crops (1). Moreover, its exceptional nutritional and medicinal properties, it fetches very good price in the indian market. India is the largest producer of papaya in the world, followed by Brazil and Mexico with 1.32 lakh ha area with 56.67 lakh metric tons (MT) production. In plant breeding, Mutation induction has been emerged as a preferred alternative method among fruit breeders, as it provides the potential to introduce traits that may not naturally exist or might be lost throughout the evolution. However, induced mutations have frequently fallen short of producing desirable outcomes in various fruit crops. Numerous induced mutations have resulted in chimeras in fruit crops, with intrasomatic selections reversing the mutant effects. Mutation directly alters the genetic architecture of plants. Dwarfism and early flowering are crucial traits for high-density planting. Consequently, this study aims to investigate the impact of ethyl methane sulphonate seed treatment on the growth, flowering, and yield of papaya.

Materials and Methods

The present study was conducted at Precision Farming Development Centre, Department of Horticulture, CCS Haryana Agricultural University, Hisar. The experiment was laid out in completely Randomized Design with twelve treatments and three replications. Healty and uniform sized Papaya seeds of cultivars Arka Prabhat and Red Lady were irradiated with six doses of gamma radiations (100 Gy, 200 Gy, 300 Gy, 400 Gy, 500 Gy and 600 Gy) and five concentration of EMS (0.2%, 0.4%, 0.6%, 0.8% and 1%). One hundred seeds of each sample of treated along with non-treated (control) were sown in nursery trays in nethouse. Three months old papaya seedling were transplanted to the main field. Data on germination percentage, days to germination, survival percentage were recorded from randomly selected plants from each treatment along with control.

Probit analysis : LD50 values of gamma rays and EMS was determined as per the finney's method (1978). Probit analysis was carried out in MS excel.

Statistical analysis : The experiment was carried out under Completely Randomized Design with factorial arrangements. The data recorded were analyzed by using Analysis of Variance (ANOVA). The statistical analysis was carried out by using OPSTAT statistical software.

Results and Discussion

Germination percentage : It is clear from the data that different doses of gamma radiation and EMS significantly influenced the germination percentage (Table-1). Maximum germination percentage was observed in control (89.83%) followed by T2-100 Gy (73.33) and T8-0.2% (72.00%), whereas, no germination was

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Table-1 : Effect of gamma radiation and EMS on germination and days taken for germination of papaya cultivars in M_1 generation.

Treatments	Germination %			Days taken for Germination		
	Arka Prabhat	Red lady	Mean	Arka Prabhat	Red lady	Mean
T1 (Control)	87.66	92.00	89.83	16.00	14.33	15.17
T2-100 Gy G R	71.66	75.00	73.33	21.33	18.00	19.67
T3-200 Gy G R	67.00	69.00	68.00	23.66	22.33	23.00
T4-300 Gy G R	51.66	57.66	54.66	25.33	25.00	25.17
T5-400 Gy G R	43.00	45.00	44.00	28.33	27.00	27.67
T6-500 Gy G R	23.00	29.33	26.16	30.00	29.33	30.00
T7-600 Gy G R	0.00	0.00	0.00	0.00	0.00	0.00
T8-0.2% EMS	67.66	76.33	72.00	29.66	27.67	28.67
T9-0.4% EMS	50.00	56.33	53.16	32.66	29.33	31.00
T10-0.6% EMS	33.66	34.66	34.16	36.66	34.00	35.33
T11-0.8% EMS	0.00	0.00	0.00	0.00	0.00	0.00
T12-1% EMS	0.00	0.00	0.00	0.00	0.00	0.00
Mean	41.27	44.60		27.07	25.29	
C.D. at 5%		Treatments : 2.37 Varieties: 0.96 T X V: 3.35			Treatments : 1.47 Varieties: 0.69 T X V: 1.90	

Table-2 : Effect of gamma radiation and EMS on survival (%) 45 days after germination of papaya cultivars in M_1 generation.

	Survial %		
	Arka Prabhat	Red lady	Mean A
T1 (Control)	84.66	91.00	87.83
T2-100 Gy Gamma radiations	67.00	73.33	70.16
T3-200 Gy Gamma radiations	61.00	64.00	62.50
T4-300 Gy Gamma radiations	45.33	52.00	48.66
T5-400 Gy Gamma radiations	30.66	33.33	31.99
T6-500 Gy Gamma radiations	0.00	0.00	0.00
T7-600 Gy Gamma radiations	0.00	0.00	0.00
T8-0.2% EMS	60.66	68.00	64.33
T9-0.4% EMS	42.33	47.33	44.83
T10-0.6% EMS	0.00	0.00	0.00
T11-0.8% EMS	0.00	0.00	0.00
T12-1% EMS	0.00	0.00	0.00
Mean	27.63	35.74	
C.D. at 5%		Treatments : 2.31 Varieties: 0.94 T X V: 3.26	

Table-3 : Probit analysis for cv. Arka Prabhat irridated with gamma radiations.

Doses (gy)	Log value of dose	Observed mortality (%)	Corrected mortality (%)	Empirical value of probit unit	ld50 value
T1 (Control)	0.00	15.34	0.00	0.00	
T2-100 Gy Gamma radiations	2	33.00	20.86	4.19	316.22 Gy
T3-200 Gy Gamma radiations	2.30103	39.00	27.95	4.42	
T4-300 Gy Gamma radiations	2.477121	54.67	46.46	4.9	
T5-400 Gy Gamma radiations	2.60206	69.34	63.78	5.36	
T6-500 Gy Gamma radiations	2.69897	100.00	100.00	0	
T7-600 Gy Gamma radiations	2.778151	100.00	100.00	0	

observed in the seeds treated with 600 Gy gamma radiations and 0.8% and 1% EMS. Likewise treatments, varieties also have significant impact on the germination percentage. Maximum germination percentage was observed in Red lady (44.60%). Germination per cent also significantly influenced by joint effect of varieties and treatments. Maximum germination percentage was observed in untreated seeds of Red Lady (92.00 %) followed by T8- 0.2% EMS (76.33%) and T2- 100 Gy gamma radiations (75%). The results are in line with (2, 3, 4) in papaya, (5)) in mango, (6) in guava and (7). It might be due to the high doses of gamma radiations and EMS altered enzyme activity (8), metabolic disturbances (9), inactivity of plant hormones (10, 11) and chromosomal

Table-4 : Probit analysis for cv. Arka Prabhat treated with EMS.

Doses (%)	Log value of dose	Observed mortality (%)	Corrected mortality (%)	Empirical value of probit unit	Id50 value
T1 (Control)	0.00	15.34	0.00	0.00	
T8-0.2% EMS	0.69897	39.34	28.35	4.42	0.4%
T9-0.4% EMS	0.39794	57.67	50.00	5	
T10-0.6% EMS	0.22185	100.00	100.00	0	
T11-0.8% EMS	0.09691	100.00	100.00	0	
T12-1% EMS	0	100.00	100.00	0	

Table-5 : Probit analysis for cv. Red Lady irridated with gamma radiations.

Doses (gy)	Log value of dose	Observed mortality (%)	Corrected mortality (%)	Empirical value of probit unit	Id50 value
T1 (Control)	0.00	9	0.00	0.00	
T2-100 Gy Gamma radiations	2	26.67	19.42	4.12	323.59 Gy
T3-200 Gy Gamma radiations	2.30103	36.00	29.67	4.48	
T4-300 Gy Gamma radiations	2.477121	48.00	42.86	4.82	
T5-400 Gy Gamma radiations	2.60206	66.67	63.37	5.33	
T6-500 Gy Gamma radiations	2.69897	100.00	100.00	0	
T7-600 Gy Gamma radiations	2.778151	100.00	100.00	0	

Table-6 : Probit analysis for cv. Red Lady treated with EMS.

Doses (%)	Log value of dose	Observed mortality (%)	Corrected mortality (%)	Empirical value of probit unit	Id50 value
T1 (Control)	0.00	9	0.00	0.00	
T8-0.2% EMS	32.00	25.27	4.33	32.00	0.42%
T9-0.4% EMS	52.67	47.99	4.95	52.67	
T10-0.6% EMS	100.00	100.00	0	100.00	
T11-0.8% EMS	100.00	100.00	0	100.00	
T12-1% EMS	100.00	100.00	0	100.00	

aberrations (12) that had adverse influence on embryo development.

Days taken for germination : The data on days taken for germination is significantly influenced by varieties, treatments and their interaction (Table 1). Minimum days taken for germination was observed in control (15.16 days) followed by T2-100 Gy (19.66 days) gamma radiations and T3-200 Gy gamma radiations (23 days). Whereas, maximum days was taken by T10-0.6% EMS (35.33 days). In addition to this, Red Lady (25.29 days) cultivar took less days as compared to Arka Prabhat (27.07 days). (2, 4) in papaya and (13) in rough lemon.

Survival per cent : Mutagen treatment have significant impact on the survival per cent (Table-2). Maximum survival per cent was recorded in control (87.83 %) and the lowest was observed in T5-400 Gy gamma radiations (44.00 %), regardless of varieties. However, 100 per cent mortality was observed in the T6-500 Gy gamma radiations, T7-600 Gy gamma radiations, T10-0.6% EMS, T10-0.8% EMS and T10-1.0% EMS. Varieties also impact significantly survival per cent as Red Lady (35.74%) had more survival per cent as compared to Arka Pabhat (27.63%). Survival per cent also significantly affected by interaction of varieties and treatments and maximum survival per cent was observed in Red Lady control (92.00%) and minimum was observed in T5-400 Gy gamma radiation of cv. Arka Prabhat (30.66%). This might be due to killing of cells and ionization in the nuclei. Higher doses of mutagens could inhibit mitosis on cell division as well as elongation, by inactivating or decreasing auxin content, resulting in poor root establishment and survival (14). (15) reported that decrease in survival percentage of seedlings might be due to accumulation some harmful genes or alleles in population caused by mutation, leading to the mortality of mutagen treated seedlings. (2, 4) in papaya and Kaur and Rattanpal (2010) in rough lemon also reported that there was decrease in survival percentage of seedlings with increase in concentration of physical and chemical mutagens.

Determination of LD50 value : LD50 value were determined using probit analysis, based on the survival rate of seeds following exposure to varying doses of gamma radiation and EMS compared with untreated control. Probit curve analysis indicated that LD50 for Arka Prabhat was fixed at 316 Gy gamma radiations (Table-3) and 0.4% EMS (Table-4) and for Red lady, it was fixed at 323 Gy gamma radiations (Table-5) and 0.42 % EMS (Table-6). (3) noted a slight variation in LD50 doses, which ranged from 300 to 350 Gy across three distinct papaya varieties. The lethal dose varies depending on the biological material, nature of the treatment, and

subsequent environmental conditions. (4) noted LD50 value for gamma rays was 186.24 Gy for Arka Prabhat cultivar of papaya. (16) noted LD50 doses for gamma ray and EMS were observed at 7.66Gy and 0.33% respectively in acid lime.

Conclusion

The findings suggest that induced mutations through physical and chemical mutagens is efficient in augmenting variability in papaya. According to the present findings, the LD50 for Arka Prabhat was fixed at 316 Gy gamma radiations and 0.4% EMS and for Red lady, it was fixed at 323 Gy gamma radiations and 0.42% EMS. This data will be instrumental for subsequent mutagenesis experiments aimed at cultivating mutants with desirable characteristics in papaya, as the determination of mutagenic sensitivity is a prerequisite.

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