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Effect of Gamma Irradiation on Germination and Survival of Seedlings in Papaya Cv. Arka Prabhath

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ABSTRACT

Fruit quality improvement is one of the aims to reach in papaya breeding. In the present investigation the papaya cv. Arka Prabhath an advanced generation gynodioecious cultvar developed at IIHR-Bengaluru was subjected for gamma irradiation with different doses *viz.,* 0 Gy, 50 Gy, 100 Gy, 150 Gy and 250 Gy to study treatment influence mainly on shelf life parameter of fruits. Germination percentage of check variety was recorded as 89.75 per cent in red lady and 81.25 per cent in control Arka Prabhath followed by gamma treated M_1 progenies 74.37 per cent (100 Gy), 63.75 per cent (150 Gy) and 50.62 per cent (50 Gy) where, least percentage recorded by 250 Gy treated seeds (5.625%). Survival percentage in nursery was 88 per cent in red lady, 75.63 per cent in control Arka Prabhath followed by 47.5 per cent (100 Gy), 45 per cent (50 Gy), 36.87 per cent (150 Gy) and 3.75 per cent (250 Gy). Survival percentage in the field was 62 per cent in check variety red lady, control Arka Prabhath (75%), followed by 46.25 per cent (100 Gy), 43.75 per cent (50 Gy) and 31.87 per cent (150 Gy) whereas, 250 Gy treated seeds did not survive. Along with the M_1 population, M_3 population of selected 20 (19 + 1 control) mutant lines with prominent characters from M_2 population were also carried forward for the experiment. M_3 population occupied 179 plants in the field. Seed viability was also checked using Tz (tetrazolium test) for irradiated seeds.

Keywords : Gamma irradiation, Germination, Papaya

The 'fruit of the angels', adored by an early adopter Christopher Columbus, apparently translated the Carib name 'ababi' (Anonymous, 2021). A 'common man's fruit', papaya is also known as melon tree or papita (Roshan, 2021) gives insight into exquisite features. Papaya (*Carica papaya* L.) belongs to the family Caricaceae, is one of the most economically important fruit crops due to its high nutritive value and productivity, varied medicinal and industrial uses. Unripe green papaya is also used as vegetable, it contain all other nutrients except carotene (Vijayalakshmi and Nagaraju, 2017). Fiber-rich fruit has its origins in South Mexico and/or in Central America (Ming and Moore, 2014) and it has great capacity of adaptation to the conditions of subtropical and tropical regions of the world.

It is a diploid species with a small genome of 372 Mbp/1C (Arumuganathan and Earle, 1991) and nine pairs of chromosomes (Bennett and Leitch, 2005). Papaya is also the main source of papain, a cysteine protease, enzyme widely used in meat industry for tenderization of tough meat.

Papaya production and productivity has several obstacles like, diseases, pests and post harvest losses. Among them diseases like, anthracnose, powdery mildew, black spot, brown spot and papaya ring spot (Shantamma and Mantur, 2014) are more severe reasons.

Fruit shelf life improvement is one of the aims to reach in papaya breeding besides good yield, tolerance or resistance for PRSV. Mutation breeding has been an alternative technique preferred by breeders as it allows the possibility to form characteristics that do not exist in the nature or lost throughout the evolution. Mutation breeding can be enhanced by genetic selection for novel alleles. Present investigation has an objective to reach such as, to develop Mx (M_1, M_3) TILLING populations of papaya Cv. Arka Prabhath. Therefore analysis of germination percentages and survival percentages are crucial.

To develop Mx population we preferred gamma irradiation instead of EMS treatment due to its high penetration and capacity to create a permanent gene expression for a stress (Ramazan and Mustafa, 2017). In this study variations regard to shelf life has to track by finding mutations occurred related to ripening pathways, among them most important is ethylene pathways. Therefore here we are more interested on ethylene pathways and genes involved in this. Genes such as ACC-Synthase and ACC-Oxidase are concerned in this investigation.

Material and Methods

The study was carried out in the Division of Biotechnology, ICAR - Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru during 2019. The experiment consists of development of M_1 and M_3 populations of papaya. Cobalt 60 source in gamma chamber was used to treat papaya seeds of cv. Arka Prabhath with distinct doses of irradiation *viz.,* 0 Gy, 50 Gy, 100 Gy, 150 Gy and 250 Gy by 'GAMMA CHAMBER 5000'. The Randomized Complete Block Design (RCBD) was followed with four replications for the gamma treated and gamma untreated (Control and Red lady) seeds under poly house condition and recorded germination percentage. Survival percentages were recorded at nursery and field levels. Analysis of variance for germination percentage and survival percentage of papaya seedlings in poly house and field experiment was computed and mean sum of squares for the characters is presented. Seeds of a 19 mutant lines of M_2 population were also used for the germination and survival percentage. All the recommended packages of practice were followed to raise the seedlings. Seed viability was also checked using tetrazolium test (T_Z) for irradiated seeds.

Statistical Analysis

The mean values of germination percentage and survival percentage of check variety, control and mutant seeds (M_1) in each replication were used for Fisher's method of analysis of variance (ANOVA). The analysis of variance for individual character was carried out using the percentage values of replications following the method given by Panse and Sukhatme (1967). The significance of the differences among all the treated lines was tested by F-test using the error variance.

Viability Analysis

Gamma irradiated seeds with distinct doses were collected and pre-moistened by soaking in distilled water for over night and longitudinally cut using blades, but without damaging or separating their parts, to facilitate evaluation. Subsequently, the seeds were placed in 20-mL petri plates and mixed with the 2,3,5-triphenyltetrazolium chloride solution at 1% concentration and allowed for staining times of 6 hrs in dark at room temperature. Seeds were evaluated and classified as viable or unviable, according to the color standard indicated: light pink (healthy tissue), intense red (deteriorating tissue) and without color (dead tissue). Results were expressed in images of viable seeds. Viability test for Gamma irradiated papaya seeds at 150 Gy presented in Plate 1.

Plate 1: Viability test for Gamma irradiated papaya seeds at 150 Gy

Results and Discussion

LD_{50} was found to be 250 Gy for gamma radiations at field survival, above which there was a maximum lethality in var. Arka Prabhath after mutation induction. These results similar with research findings of Ramesh *et al.* (2019) where 500 Gy showed lethality at germination, but showed good percentage of germination with the dose 250 Gy compared to the

TABLE 1

Treatment details of gamma radiation of papaya Cv. Arka Prabhath

T_1	Gamma-ray (Co^{60})	(0.0Gy, Red lady)
T_1	Gamma-ray (Co^{60})	(0.0Gy, control)
T_2	Gamma-ray (Co^{60})	50Gy
T_3	Gamma-ray (Co^{60})	100Gy
T_4	Gamma-ray (Co^{60})	150Gy
T_5	Gamma-ray (Co^{60})	250Gy

records. Treatment details of gamma radiation induction of papaya Cv. Arka Prabhath is presented in Table 1.

The analysis of variance revealed significant differences among the mean of different mutant lines for germination percentage and survival percentage indicating the choice of material for the investigation was appropriate.

Germination Percentage

The data on germination percentage among different doses of gamma radiation revealed significant difference among the treatments. It ranged from 5.625 to 89.75 per cent. Highest germination was recorded in red lady (89.75%) used as check variety compared to other treatments. The treatments T_1, control Arka Prabhath (0 Gy) followed by T_3 (100 Gy), T_4 (150 Gy) and T_2 (50 Gy) showed germination percentage *viz.*, 81.25, 74.37, 63.75 and 50.62 per cent, respectively. The lowest germination was recorded in the treatments $T_{5,}$ 250 Gy (5.63 %). The graph depicting germination percentage of M1 population is presented in Fig.1. Mutagen treated seeds and with increased dose of gamma radiations has resulted in lower germination. Similarly, Nhat Hang and Chau (2010) conducted radio sensitivity test of germinated seeds showed LD_{50} for 30 Gy, and 10, 20 doses were below LD_{50} which were selected for field planting of local papaya variety Dai Loan Tim. This was in contradictory with research findings of Mahadevamma et al. (1997) and Bharathi (2011) where 0.30 per cent of EMS was found to be LD_{50} for var. Arka Prabhath and with respect to gamma dosage LD_{50} was found to be 3Krad for pears (Shin *et al*., 1985).

Germination percentage data were statistically analyzed as per RCBD and presented in Table 2. The data showed statistical significant difference among the different treatments of the present experiment.

TABLE 2

Effect of gamma irradiation on Seed germination percentage (%) of M_1 population

Treatment	Seed germination percentage (%)	Survival percentage at nursery	Survival percentage at field
T_1 (RL)	89.75	88	62
T_1	81.25	75.63	75
T_2	50.63	45	43.75
T_3	74.38	47.5	46.25
T_4	63.75	36.88	31.88
T_5	5.625	3.75	0
Mean	60.8958	49.46	43.15
S.E.	3.4113	2.47	3.07
C.D.	11.781	8.904	12.083
SE (m)	3.873	2.927	3.972
SE (d)	5.477	4.140	5.618
C.V.	12.720	11.838	18.414
Significant /Non significant	S	S	S

Survival Percentage

The data on survival percentage of M_1 progenies at nursery and field recorded among the M_1 progenies with control and check variety. Significantly highest survival percentage was recorded in Red lady 88 per cent, 75.63 per cent in control Arka Prabhath followed by 47.5 per cent (100 Gy), 45 per cent (50 Gy), 36.87 per cent (150 Gy) and 3.75 per cent (250 Gy). The graph depicting survival percentage at nursery of M1

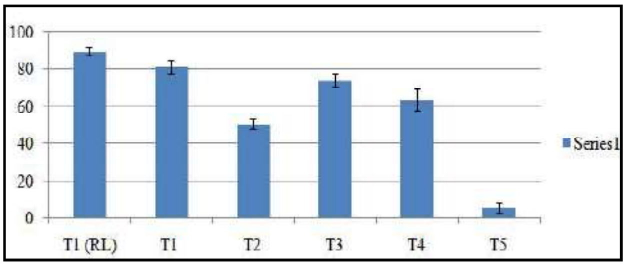

Fig. 1: The graph depicting plant germination percentage of M1 population

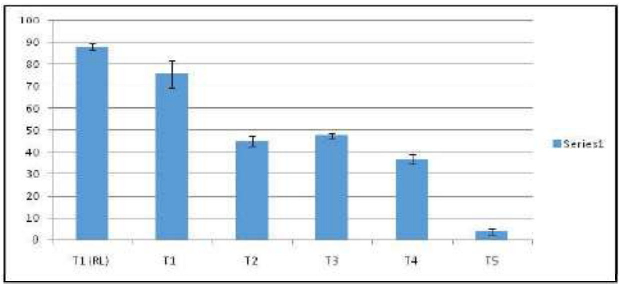

Fig. 2 : The graph depicting plant survival percentage of M1 population in nursery

population is presented in Fig. 2. Survival percentage of progenies at field were also recorded as Red lady with 62 per cent, control Arka Prabhath (75%), followed by 46.25 per cent (100 Gy), 43.75 per cent (50 Gy) and 31.87 per cent (150 Gy) whereas, 250 Gy treated seeds did not survived. The graph depicting plant survival percentage at field of M1 population is presented in Fig. 3.

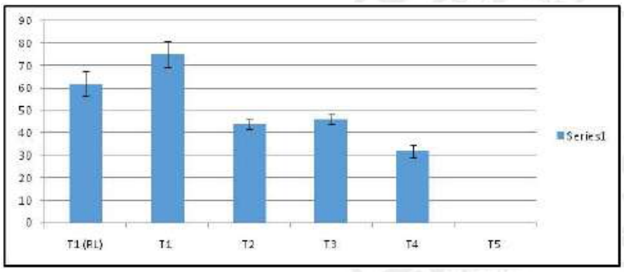

Fig. 3 : The graph depicting plant survival percentage of M1 population in field

Survival percentages at nursery and field data were statistically analyzed as per RCBD and presented in Table 2. The data showed statistical significant difference among the mutant lines of the present experiment.

From the present study, it is evident that, significant variation was observed for germination percentage and survival percentage studied among mutant progenies. To develop Mx TILLING populations of papaya Cv. Arka Prabhath analysis of germination percentages, survival percentages and seed viability are crucial parameters to study. Results showed mutagen treated seeds and with increased dose of gamma radiations has resulted in lower germination compare to the control plants.

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