



## Effect of seed treatment by gamma rays on growth, flowering and yield of papaya (*Carica papaya* L.)

Mahesh Kumar<sup>\*1</sup>, Mukesh Kumar<sup>1</sup>, Satya Prakash<sup>1</sup>, Yogesh Prasad<sup>1</sup>, M.K. Singh<sup>1</sup> and Pooran chand<sup>2</sup>

<sup>1</sup>Dept. of Horticulture, <sup>2</sup>Dept. of Genetics and Plant Breeding, S.V.P. University of Agriculture & Technology, Meerut-250110, India

\*e-mail: mkrao477@gmail.com

(Received: August 14, 2015; Revised received: April 16, 2016; Accepted: April 18, 2016)

**Abstract:** In the present study, the papaya seeds of cv. Pusa Dwarf were treated with different doses of gamma rays viz, 05, 10, 15 and 20 krad to observe the influence of treatment on growth, flowering and yield of papaya. The results revealed that fruiting attributes of papaya were significantly influenced with 10 krad gamma rays. For instance, earliest sprouting, maximum germination, survival and stem girth were observed with this treatment. The vegetative growth of plants was effectively reduced by seed treatment with gamma rays than untreated (control) plants which had maximum height, number of leaves per plant, leaf and petiole length. The plants obtained from the seeds treated with 10 krad gamma rays had significantly maximum fruit length, number of fruits per plant and fruit yield during both the years of study. Latest flowering was however, observed in plants obtained from untreated seeds.

**Key words :** Gamma irradiation, Seed germination, Growth, Yield, Papaya

### Introduction

Owing to unique characteristics, papaya cultivation has become very popular among the fruit growers. Being short duration, early maturing, quick growing and dwarf in nature, it is grown very successfully as intercrop in the orchards of major fruit crops (Chattopadhyay, 2012). Due to nutritional and medicinal values, it fetches very good price in the market (Irulappan, 1992). It ranks 4<sup>th</sup> position in production (5382000 MT), 1<sup>st</sup> position in productivity (40.7MT/HA) from 132000 ha area among the fruits in India (Anonymous, 2013). Mutation through gamma irradiation is used in many horticultural crops for yield and quality improvement (Aney, 2013; Goldenberg, 2014; Seth and Joshi, 1986 and 1988). When seeds are irradiated through gamma-rays, the genetic structure of plants is influenced (Bankapur and Habib, 1979). Dwarfness and earliness in flowering are important criteria for high density planting system in papaya (Ram and Majumdar 1981, 1988a). Keeping in view of above facts, a mutation breeding study using gamma irradiation was initiated.

### Materials and Methods

A study of seed treatment by gamma irradiation was carried out at Horticultural Research Centre at SVP University of Agriculture and technology, during the year 2012-13 and 2013-14. The experiment was laid out in randomized block design with five treatments and three replication. Papaya seeds of cv. Pusa Dwarf obtained from IARI, Regional Station Pusa, Samastipur (Bihar) were treated with different doses of gamma rays (Jadhav *et al.*, 2012 and Hassan *et al.*, 2009). For seed treatment, one hundred healthy seeds of uniform size were used. These seeds were kept in 0.1 mm thick polythene bags (size 15 x 22 cm). The sealed bags were exposed to different doses of gamma irradiation (05, 10, 15

and 20 krad) at Nuclear Research Laboratory, IARI, New Delhi as per the procedure described by above researchers. The gamma source was Co<sup>60</sup>. The gamma irradiated and non-irradiated seeds (control) were sown in polyhouse (Jadhav *et al.*, 2012). Data on germination and growth parameters were recorded seven days after sowing under ambient conditions. Two and half months old papaya seedlings which had 6-8 leaves per plant and attained a height of 15-20 cm were used for transplanting in the experimental field. Five healthy and mature plants were selected for each treatment for recording various morphological and yield attributing parameters (Hang and Chau, 2010 and Kushwah *et al.*, 2010).

### Results and Discussion

The data pertaining to days to seed germination, germination percentage and survival percentage of papaya, as influenced by different levels of gamma irradiation are presented in table-1. Significant differences were found among all the treatments in terms of germination percentage. Maximum germination (73.01 and 75.64) and survival percentage (69.64 and 71.79) was recorded from the plants obtained from 10 krad gamma rays seed treatment. However, the minimum germination percentage (66.50 and 67.73) and survival percentage (59.46 and 63.28) was recorded with 20 krad dose of gamma irradiation seed treatment during both the year of experiment. The germination of the treated seeds had shown a sharp dose rate relationship, which decreased with increase in dose of mutagenic treatments. Percentage reduction/ stimulation in seed germination might have been due to the effect of mutagens on meristematic tissue of the seed. The decrease in seed germination at higher dose of the mutagens may be attributed to disturbances at cellular level caused either at physiological or physical level. Kumar and Mishra (2004) also reported lower germination percentage in

okra with increasing dose of gamma rays and EMS. These results are also in close conformity with the findings of Bankapur and Habib (1979), Hafiz *et al.* (2005), Muralee *et al.* (2008) and Kushwaha *et al.* (2010).

The data presented on plant height in table-2 revealed that the increasing irradiation doses caused gradual decrease in plant height. Lower doses showed slight reduction, but this parameter was significantly affected at higher doses. The maximum plant height at maturity stage ( 130.57 and 130.29 cm ) was recorded in untreated plant (control), while minimum plant height ( 119.39 and 118.01 cm ) was obtained from the plants produced from the seed treated with 20 krad doses of gamma rays under both the year of experiment. It might due to gamma rays induced reduction in plant height by destruction or damage to apical meristem ( Patel and Saha, 1974). Number of leaves per plant was also significantly influenced by different level of gamma irradiation. The maximum number of leaves per plant ( 32.58 and 30.69 ) were recorded in control (untreated) whereas, the seeds treated with 20 krad doses of gamma rays

produced minimum number of leaves per plant (25.30 and 25.27). Stem girth also significantly influenced by gamma irradiation and the maximum stem girth (33.98 and 35.65 cm) was recorded in plants obtained from 10 krad seed treatments, whereas minimum stem girth (29.29 and 27.66 cm) was observed from the plants developed from seed treated with 20 krad dose of gamma rays during both the year of experiment. Petiole length (39.75 and 39.31 cm) and leaf length (33.31 and 30.97 cm) showed the maximum growth in control (untreated ) and minimum petiole length (33.34 and 32.33 cm) and leaf length (27.31 and 25.70 cm) was observed from the plants obtained from the seeds treated with 20 krad dose of gamma rays, which decreased linearly with increasing dose/ concentration of mutagenic. These results confirmed the finding of Hafiz *et al.* (2005), Muralee *et al.* (2008), Kushwaha *et al.* (2010), Hang and Chau (2010), Bankapur and Habib (1979), Sharma *et al.* (2013), Kukimura and Takimata (1975) and Singh *et al.* (2010).

The data given in table-3 clearly indicates that the minimum days to first flowering (221.91 and 219.54 days) and plant height at first flowering (40.26 and 39.26 cm) was observed in plants obtained from seeds treated with 20 krad as compared to control and other treatment of gamma rays. The result also revealed that the plant obtained from untreated seeds took the maximum duration of papaya. A similar trend was also observed for fruiting length (45.44 and 47.93 cm) was observed on the plants produced from the seeds treated with 10 krad doses of gamma rays followed by, (43.36 and 44.70 cm) on the plants produced from 5 krad seed treatment and minimum fruiting length (39.73 and 43.32 cm) was observed on the plants produced with 20 krad seed treatment of gamma rays under both the year of experiment. Gamma rays at a lower concentration induce hormones responsible for flowering and fruit maturity. Early flowering and fruit maturity may be due to the physiological changes caused by gamma irradiation. The mutagens at higher dose caused

**Table-1:** Effect of gamma irradiation on days to seeds germination, germination and survival percentage in papaya

	Days to seeds germination		Germination percentage		Survival percentage	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Control	16.147	15.743	69.693	71.703	64.877	66.277
5 krad	15.820	14.603	70.560	73.157	66.903	68.093
10 krad	14.507	13.720	73.017	75.640	69.647	71.797
15 krad	19.133	18.820	68.193	69.787	63.480	65.483
20 krad	21.567	21.013	66.507	67.730	59.463	63.283
Gen. Mean	17.435	16.780	69.594	71.603	64.874	66.987
S.E.M.	0.269	0.266	0.785	0.565	0.863	0.343
C.D. 5%	0.877	0.868	2.561	1.841	2.814	1.117

**Table-2:** Effect of gamma irradiation on growth parameters of papaya

Treatment	Plant height (cm)		No. of leaf/Plant		Stem girth (cm)		Leaf length (cm)		Petiole length (cm)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Control	130.573	130.293	32.583	30.690	30.033	30.777	33.310	30.973	39.757	39.313
5 krad	127.813	126.260	30.690	29.300	30.773	31.620	30.113	29.480	38.673	36.977
10 krad	124.737	122.773	30.040	28.560	33.987	35.650	30.203	28.273	36.490	33.697
15 krad	121.393	120.007	27.367	26.570	30.500	31.077	29.057	26.843	34.710	32.823
20 krad	119.393	118.013	25.303	25.273	29.290	27.663	27.317	25.703	33.340	32.337
Gen. Mean	124.782	123.469	29.197	28.479	30.917	31.357	30.000	28.255	36.594	35.029
SEM	0.901	0.598	0.659	0.609	0.288	0.249	0.407	0.323	0.615	0.342
C.D at 5%	2.937	1.950	2.148	1.986	0.940	0.813	1.328	1.053	2.007	1.114

**Table-3:** Effect of gamma irradiation on flowering and yield attributes of papaya

Treatment	Days to first flowering		Plant height in first flowering (cm)		Fruiting length (cm)		Fruits/ Plant		Fruit Yield/ Plant (kg)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Control	225.373	225.207	51.840	49.293	42.983	44.180	33.403	34.353	45.547	48.720
5 krad	225.223	224.957	47.040	45.617	43.360	44.707	34.360	35.830	48.753	52.150
10 krad	223.683	221.597	45.423	42.997	45.447	47.933	36.987	39.307	54.223	59.690
15 krad	222.210	221.377	43.860	40.940	42.097	44.527	32.987	34.680	47.653	50.283
20 krad	221.917	219.543	40.260	39.267	39.737	42.327	31.060	32.773	41.897	45.287
Gen. Mean	223.681	222.536	45.685	43.623	42.725	44.735	33.759	35.389	47.615	51.226
SEM	0.234	0.554	0.569	0.714	0.341	0.272	0.260	0.361	1.323	0.797
C.D at 5%	0.764	1.806	1.856	2.329	1.112	0.886	0.847	1.177	4.314	2.600

a delay flowering and fruiting might be due to their inhibitory effect. The present study coincides with a previous study in linseed by George and Nayar (1973), Hang and Chau (2010). The maximum number of fruits per plant (36.98 and 39.30) was observed on the plants produced from 10 krad seed treated plants, followed by, (34.36 & 35.83 fruits) on the plants produced by 5 krad seed treatment and minimum number of fruits per plants (31.06 and 32.77) was observed on 20 krad gamma rays seed treated plants. Fruit yield per plant was also influenced by different treatments and the maximum fruit yield (54.22 and 59.69 kg/plant) was observed on the plant produced from 10 krad gamma rays seed treated plant followed by, (48.75 and 52.15 kg/plant) on the plant obtained from 5 krad gamma rays seed treated plants and minimum fruit yield per plant (41.89 and 45.28 kg/plant) was observed on the plants obtained from 20 krad seed treated plants by gamma rays during both the year of experiment. The results are reported by Ramchandra *et al.* (2011), Hang and Chau (2010). An increased number of okra fruit per plant and fruit length as a result of gamma irradiation were also recorded by many researchers (Dubey *et al.*, 2007 and Sharma and Mishra, 2007). Obviously, as a result of an increased number of fruits per plant it reflected positively on seed yield. The stimulatory effect at a lower dose is due to the fact that mutagens at lower concentration stimulate the role of enzyme and growth hormone responsible for growth and yield while the inhibitory effect is due to the fact that biological damage increased at a faster rate in higher concentrations of mutagens.

Among the mutagens used in the present study, gamma rays @10 krad were found to be more effective and showed the stimulatory effect as compared to other treatments. However, low dose of gamma rays recorded maximum germination percentage, growth and yield traits. Hence, genetically improved plants for production of high fruit yield in papaya can be achieved through induced mutagenesis by gamma rays @ 10 krad.

#### Acknowledgements

The authors are grateful to S.V.P University of Agriculture and Technology, Meerut (U.P.) for providing necessary facilities carried out this study. The financial support received by the principal author from UGC (RGNF) for research work also acknowledged.

#### References

- Aney, A.: Effect of gamma irradiation on yield attributing characters in two varieties of pea (*Pisum sativum* L.) *Int. J. Life Sci.*, **1**: 241-247 (2013).
- Anonymous: National Horticulture Board. Horticulture Database (2013).
- Bankapur, V.M. and Habib, A.F.: Mutation breeding in papaya (*Carica papaya* L.) *Mysore J. Agri. Sci.*, **13**: 113-116 (1979).
- Chattopadhyay, T.K.: Papaya In; A textbook on pomology. Kalyani Publishers, New Delhi-11002 page No. 107-129 (2012).
- Dubey, A.K., Yadav, J.R. and Singh, B.: Studies on induced mutations by gamma irradiation in okra (*Abelmoschus esculentus* (L.) Monch.). *Progressive Agric.*, **7**: 46-48 (2007).
- George, G.P. and Nayar, G.G.: Early dwarf mutant in linseed induced by gamma rays. *Current Science.*, **42**: 137-138 (1973).
- Goldenberg, L., Yaniv, Y., Porat, R. and Carmi, N.: Effect of gamma irradiation mutagenesis for induction of seedlessness, on the quality of Mandarin fruit. *Food and Nutrition Sci.*, **5**: 943-952 (2014).
- Hafiz, I.A., Naveed Anwar, Abbasi, N.A. and Asi, A.A.: Effect of various doses of gamma radiation on the seed germination and seedling growth of mango. *Sarhad J. of Agricul.*, **21**: 563-567 (2005).
- Hang, N.T.N. and Chau, N.M.: Radiation induced mutation for improving papaya variety in Vietnam. *Acta Horticulturae*, **851**: 77-80 (2010).
- Hassan, Amro B., Osman, Gammaa A.M., Rushdi, Mohamed A.H., Eltayeb, Mohamed M. and Diab, E.E.: Effect of gamma irradiation on the nutritional quality of maize cultivars (*Zea mays*) and sorghum (*Sorghum bicolor*) grains. *Pakistan J. of Nutrition*, **8**: 167-171 (2009).
- Irulappan, I.: Papaya, a fruit of the tropics. *Indian Horticulture*, **37**: 33-34 (1992).
- Jadhav, P.A., Kalpande, H.V., Kathale, M.N. and Dahale, G.P.: Effect of gamma rays and ethyl methane sulphonate on germination, pollen viability and survival of Okra. *J. of Crop and Weed*, **8**: 130-131 (2012).
- Kukimura, H. and Takemata, T.: Induced quantitative variation by gamma rays and ethyleneimine in tuber bearing plant. *Gamma Field Symp.*, **14**: 25 (1975).
- Kumar, A. and Mishra, M.N.: Effect of gamma-rays, EMS and NMU on germination, seedling vigour, pollen viability and plant survival in M1 and M2 generation of okra (*Abelmoschus esculentus* (L.) Monch.) *Advances in Plant Science*, **17**: 295-297 (2004).
- Kushwah, M.S., Yadav, M., Singh, D.B., Roshan, R.K. and Pebam, N.: Effect of gamma -irradiation on germination, growth, sensitivity and survivability of papaya cv. Kesar King. *Acta Horticulturae*, **851**: 93-98 (2010).
- Patel, J.D. and Saha, J.J.: Effect of gamma irradiation on seed germination and organization of shoot apex in *Solanum melongena* and *Capsicum annum*. *Phytomorphology*, **25**: 174-180 (1974).
- Ram, M. and Majumdar, P.K.: Dwarf mutant of papaya (*Carica papaya* L.) induced by gamma rays. *J. Nuclear Agric. Biol.*, **10**: 72-74 (1981).
- Ram, M. and Majumdar, P.K.: High density orcharding in papaya. *J. Inst. Agril. Anim. Sci.*, **9**: 115-117 (1988).
- Ramachandra, K.M., Narayanpur, V.B. and Farooqi, A.A.: Effect of gamma irradiation on growth, yield and composition of oil in patchouli (*Pogostemon patchouli* Pellet.). *Environ. Ecol.*, **29**: 1149-1151 (2011).
- Seth, J.N. and Joshi, R.R.: The effect of ionizing radiation on the growth and production of compact apple mutant II. Fruiting behaviour of induces mutant of early Shanburry. *Progressive Horticulture*, **18**: 163-166 (1986).
- Seth, J.N. and Joshi, R.R.: Chaubattia Agrim, a promising very early apple cultivars. *Progressive Horticulture*, **19**: 183-184 (1988).
- Sharma, B.K. and Mishra, M.N.: Micro- mutation for fruit number, fruit length and fruit yield characters in gamma irradiated generation of ANKUR-40 variety of okra (*Abelmoschus esculentus* (L.) Monch.) *Int. J. Plant Sci.*, **2**: 208-211 (2007).
- Sharma, L.K., Kaushal, M., Gill, M.I.S. and Bali, S.K.: Germination and survival of Citrus jambhiri seeds and epicotyls after treating with different mutagens under in vitro conditions. *Middle East Journal of Scientific Research*, **16**: 250-255 (2013).
- Singh, S.V., Singh, D.B., Yadav, M., Roshan, R.K. and Pebam, N.: Effect of EMS on germination, growth and sensitivity of papaya (*Carica papaya* L.) cv. farm selection-1. *Acta Horticulturae*, **851**: 113-116 (2010).
- Yadav, M., Kushwah, M.S., Singh, D.B., Roshan, R.K. and Nongallei, P.: Effect of gamma -irradiation on germination, growth, sensitivity and survivability of papaya cv. Kesar King. *J. of Horticult. Sci.*, **3**: 68-71 (2008).