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Mutagenic sensitivity of scions and seed kernels of polyembryonic mango cultivars Peach and Bappakai to gamma irradiation

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Abstract
In the present study, seed kernels and scions of mango polyembryonic cvs. Peach and Bappakai were treated with different doses (10, 20, 30, 40, 50, 60, and 70 Gy) of gamma irradiation and compared with control. Results suggest that there was gradual decrease in germination percentage of seed kernels and graft success rate with an increase in the dose of gamma irradiation. There was a complete inhibition of germination of seed kernels and success of grafting was observed in the treatments having more than 50 Gy dose. Based on the probit analysis, it was observed that LD_{50} of gamma rays for the seed kernels of Peach and Bappakai were 27.54 Gy and 23.44 Gy, respectively. However, LD_{50} of gamma rays for scions of Peach and Bappakai were 19.95 Gy and 21.37, respectively.

Keywords: LD_{50}, Mango, gamma irradiation

Introduction

Mango has originated from the South East Asian or Indo-Myanmar region having 69 recognized species including the edible fruits to forest trees with fibrous and resinous fruits Kostermans and Bompard (1993) [7]. Although, it is commercially grown in more than 100 countries of the world but no where it is as extensively cultivated as in India, where it occupies about 2.26 million ha area with an annual production of 20.71 million tonnes and accounts 35.02% of area and 21.82% of total production of all fruits in the country (NHB, 2017-18, 1st estimates) [9]. India is the largest producer of mango accounting for almost 40% of the world production (APEDA, 2011-12) [1]. In India, about 30 mango cultivars are being grown commercially. Majority of them posses narrow adaptability and show eco-geographical preferences for growth and yield Yadav and Rajan, (1993) [14]. The ideal cultivar in mango should have characteristics like dwarf tree stature, precocity and regularity in bearing, attractive and good quality fruits, high productivity and resistance to major diseases and pests.

Mango is considered to be a difficult plant species to handle in breeding programme due to certain inherent characteristics including long juvenile phase, high level of heterozygosity, heavy fruit drop. Mango improvement has been a challenge for many years. The success in mango improvement primarily depends on the nature and magnitude of variation present in the population. Polyembryonic mango varieties are known to have narrower genetic base. As these are mainly concentrated in the Western Ghat region of south-western and the north-eastern regions of India, there is a need to create more variability so that desirable recombinants could be developed. Mutation as a tool for creating variability has been widely used by fruit breeders. In mutation breeding both physical and chemical mutagens are being used based on the breeding objective. Among the physical mutagens, X-rays, 60Co γ-rays or thermal neutrons are usually employed. The success of mutation breeding is influenced by the two factors, *viz.*, the rate of mutation and the mutation efficiency. The rate of mutation is affected by the dose of the mutagen applied and can be altered by both physical and biological factors. Mutation with higher doses would be lethal to plant parts and retains only a few plants for selection which in turn limits the success of mutation breeding (Surakshitha *et al.*, 2017) [12]. Therefore, the first step in mutation breeding is optimization of radiation dose, which helps in the choosing of the ideal dose depending on the plant materials and desired outcome. The response of plants to mutagens is species specific and differs among genotypes of the same species (Kwon and Im, 1973) [8].

Polyembryonic cv. Peach has excellent peel colour and the variety Bappakai has good fruit quality with firm pulp and high TSS. These two polyembryonic mango varieties are considered important in mango improvement programmes. The present study was undertaken to find out the LD_{50} of gamma radiation in mango polymebryonic cv. 'Peach' and 'Bappakai'.

Materials and Methods

Uniform seed kernels and scions of 'Peach 'and 'Bappakkai' polyembryonic genotypes were treated with different gamma irradiation doses (10, 20, 30, 40, 50, 60 and 70 Gy) and a set of untreated seed kernels and scions was taken as control. The gamma irradiation was given by using Gamma chamber 5000 in compact self-shielded cobalt-60 (^{60}Co) based irradiator (Board of Radiation and Isotope Technology, Department of Atomic Energy, Government of India, Mumbai) at the ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka. After the irradiation, scions were grafted on one-year-old uniform rootstocks. After irradiation, the treated seed kernels (50 seed kernels per replication) were sown in polybags of 9" h × 7" dia. filled with red earth, farm yard manure (FYM) and sand (2:1:1) along with untreated seed kernels as control. For seed germination, the polybags were maintained in the mist chamber (Temperature- 28-30˚C, Relative humidity- 80-85%) for 25-30 days, after that the seedlings were shifted to 50% shade-house for further observations. Seed kernel germination percentage was calculated 4 weeks after sowing. Graft success percentage was calculated at 4, 8, 12 and 16 weeks after grafting. Time taken for germination of seed kernels and time taken for bud break was also recorded.

Present experiment was conducted in Completely Randomized Design (CRD) with three replicates and conducted for the period of sixteen weeks. The LD_{50} value was calculated based on probit analysis (Finney, 1978)[4] using the survival of treated seed kernels and scions to that under control.

Results and Discussion

In the present experiment, there was a gradual decrease in germination of seed kernels and graft success of scions with increase in the dose of gamma irradiation was observed. Complete inhibition in germination and graft success was noted at the more than 50 Gy dose in both seed kernels and scions of cv. Peach and Bappakai.

The LD_{50} for gamma irradiation was calculated on the basis of survival and mortality percentage (Fig.2) of seed kernels and scions after treatment with different doses of gamma irradiation and comparing with untreated control. Probit analysis was carried out to fix the LD_{50} for gamma irradiation in both the materials and varieties (Table 1).

Table 1: Probit analysis for calculating LD_{50} for gamma irradiation in seed kernels and scions of mango polyembryonic cv. Peach and Bappakai

Dose (Gy)	Log $_{10}$ of doses	Mortality (%)	Empirical probit unit	LD_{50} value
Peach seed kernel				
0	0.00	5	3.36	27.54
10	1.00	20	4.16	
20	1.30	35	4.61	
30	1.48	48	4.95	
40	1.60	59	5.23	
50	1.70	80	5.84	
60	1.78	100	-	
70	1.85	100	-	
Bappakai seed kernel				
0	0.00	2	2.95	23.44
10	1.00	25	4.33	
20	1.30	40	4.75	
30	1.48	55	5.13	
40	1.60	65	5.39	
50	1.70	82	5.92	
60	1.78	100	-	
70	1.85	100	-	
Peach scion				
0	0.00	4	3.25	19.95
10	1.00	30	4.48	
20	1.30	45	4.87	
30	1.48	60	5.25	
40	1.60	69	5.5	
50	1.70	85	6.04	
60	1.78	100		
70	1.85	100		
Bappakai scion				
0	0.00	2	2.95	21.37
10	1.00	32	4.53	
20	1.30	43	4.82	
30	1.48	59	5.23	
40	1.60	62	5.31	
50	1.70	82	5.92	
60	1.78	100		
70	1.85	100		

In peach, the LD_{50} value for gamma irradiation for seed kernels was 27.54 Gy and for scions it was 19.95 Gy. In Bappakai, the LD_{50} value for gamma irradiation for seed kernels and scions were 23.44 and 21.37 Gy respectively (Fig. 1).

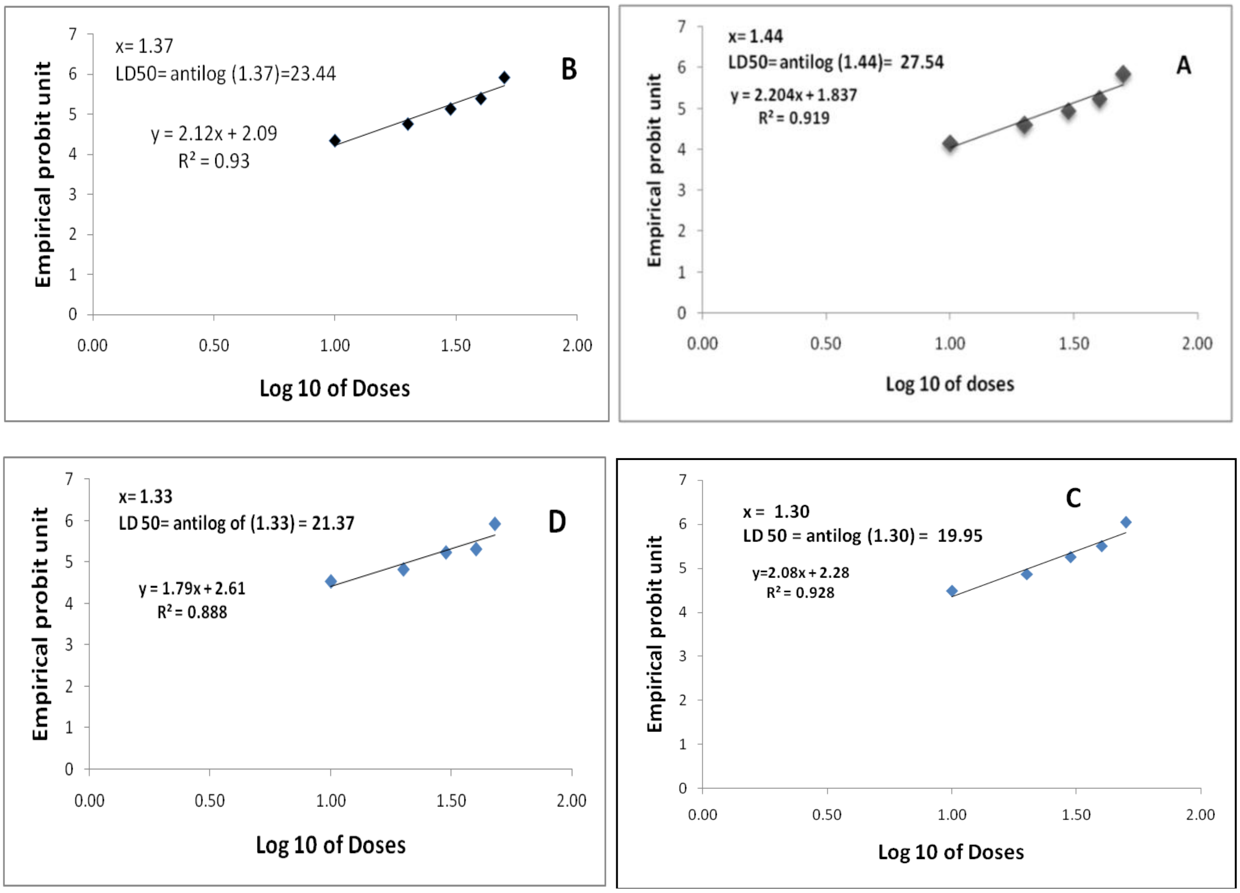

Fig 1: Probit analysis based on the mortality rates of cv. Peach and Bappakai. A) in seed kernels of Peach, B) in seed kernels of Bappakai, C) in scions of Peach and D) in scions of Bappakai

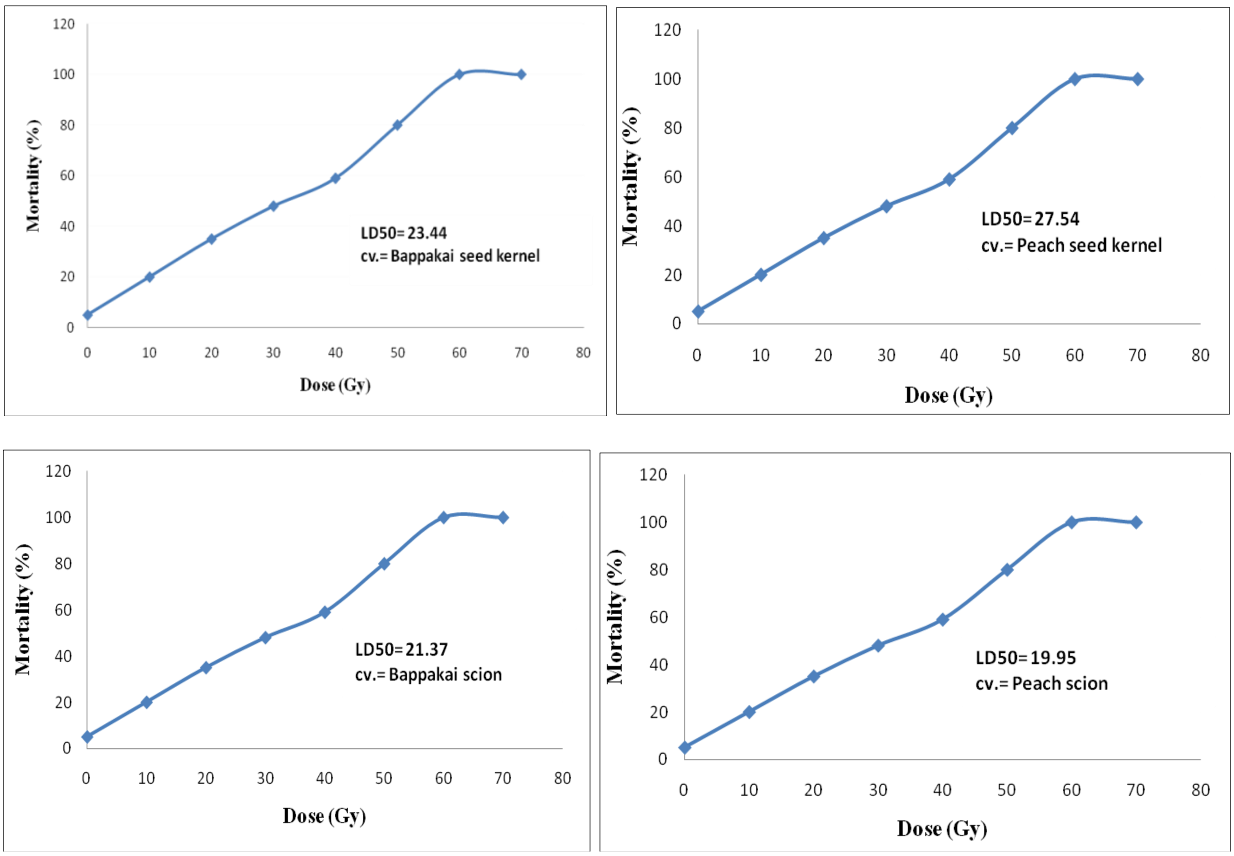

Fig 2: Mortality (%) of seedlings in response to different doses of gamma irradiation

It was observed that germination percentage of seed kernels decreased with the increase in dose of gamma irradiation. In both Peach and Bappakai, the highest percentage of germination of 95 and 98 was observed in control seed kernels, while lowest percentage of 20 and 18 was observed in seed kernels treated with 50 Gy dose. However, no germination was recorded in the seed kernels treated with 60 and 70 Gy of gamma irradiation. The time taken for germination of seed kernels was increased with an increase in dose of irradiation. Minimum time taken for germination (20 days) was noticed in control seed kernels, while maximum time taken for germination (28 days) was observed in seed kernels treated with 50 Gy dose (Table 2).

It was observed, higher the dose of gamma irradiation there was lower graft success (Table 3). In Peach, highest graft success (96%) was observed in non-irradiated scions, while lowest graft success (15%) was noted in scions treated with 50 Gy. In Bappakai, the highest graft success (98%) was recorded in control scions and lowest graft success (18%) was found in scions treated with 50 Gy dose. The maximum time of bud break of 22 days was observed in scions treated with 50 Gy dose, while minimum time of bud break of 15 days in Peach and 16 days in Bappakai genotypes was recorded in non-irradiated scions. However, the bud break was not occurred in the scions irradiated with more than 60 and 70 Gy dose.

Table 2: Effect of different doses of gamma irradiation on time taken for germination and germination percentage

Irradiation dose (Gy)	Time taken for Germination(days)	Seed kernel germination (%) (4 weeks after sowing)
Peach seed kernel		
0	20±0.4^{d}	95±2.0^{a}
10	20±0.3^{d}	80±1.6^{b}
20	22±0.4^{c}	65±1.2^{c}
30	22±0.3^{c}	52±0.1^{d}
40	24±0.0^{b}	41±0.2^{e}
50	28±0.6^{a}	20±0.2^{f}
60	++	++
70	++	++
SE (m)	0.4	1.15
CV	3.24	3.54
CD (p = 0.05)	1.31	3.71
CD (p = 0.01)	1.80	5.21
Bappakai seed kernel		
0	20±0.3^{d}	98±1.4^{a}
10	21±0.3^{cd}	75±0.5^{b}
20	22±0.4^{c}	60±0.5^{c}
30	22±0.1^{c}	45±0.3^{d}
40	26±0.4^{b}	35±0.4^{e}
50	29±0.3^{a}	18±0.4^{f}
60	++	++
70	++	++
SE (m)	0.3	0.8
CV	2.58	2.25
CD (p = 0.05)	1.07	2.21
CD (p = 0.01)	1.51	3.10

Table 3: Effect of different doses of gamma irradiation on time taken for sprouting and graft success (%)

Irradiation dose (Gy)	Time taken for sprouting/ bud break (days)	Graft success (%) (4 weeks after grafting/sowing)	Grafted material success (%) @ Time of observation (weeks after grafting/sowing)		
			8	12	16
Peach scion					
0	15±0.2^{e}	96±0.4^{a}	90±0.43^{a}	88±0.09^{a}	80±1.39^{a}
10	16±0.3^{d}	70±0.5^{b}	70±1.16^{b}	65±0.64^{b}	65±0.39^{b}
20	18±0.2^{c}	55±0.4^{c}	55±0.14^{c}	50±0.15^{c}	50±0.12^{c}
30	19±0.0^{b}	40±0.1^{d}	40±0.27^{d}	35±0.30^{d}	35±0.07^{d}
40	22±0.3^{a}	31±0.1^{e}	30±0.09^{e}	25±0.29^{e}	25±0.19^{e}
50	22±0.1^{a}	15±0.0^{f}	15±0.20^{f}	10±0.24^{f}	10±0.15^{f}
60	**	**	**	**	**
70	**	**	**	**	**
SE (m)	0.25	0.3	0.53	0.33	0.60
CV	2.32	1.19	1.84	1.28	3.21
CD (p = 0.05)	0.77	1.08	1.63	1.04	1.85
CD (p = 0.01)	1.08	1.52	2.29	1.46	2.60
Bappakai scion					
0	16±0.1^{e}	98±0.5^{a}	88±1.47^{a}	86±0.23^{a}	82±1.95^{a}
10	17±0.2^{d}	68±0.6^{b}	60±0.99^{b}	60±1.46^{b}	60±0.43^{b}
20	17±0.1^{d}	57±0.1^{c}	50±1.09^{c}	50±0.85^{c}	45±0.70^{c}
30	19±0.2^{c}	41±0.9^{d}	40±0.04^{d}	35±0.08^{d}	35±0.22^{d}
40	21±0.5^{b}	38±0.4^{e}	30±0.57^{e}	25±0.32^{e}	25±0.09^{e}

50	22±0.3[a]	18±0.3[f]	15±0.16[f]	15±0.36[f]	10±0.25[f]
60	**	**	**	**	**
70	**	**	**	**	**
SE (m)	0.33	0.6	0.88	0.73	0.87
CV	2.82	1.90	3.26	2.80	
CD (p = 0.05)	0.93	1.83	2.73	2.25	
CD (p = 0.01)	1.31	2.53	3.84	3.15	

The general criterion used for identifying the promising treatment for gamma irradiation was 40-60% of survival rate (Van Harten, 1998) [13]. The optimum dosage of gamma rays in various materials was calculated by evaluating the various responses such as germination (%), mortality (%), lethality (Sripichtt *et al.*, 1988) [11] and growth (Bottino *et al.*, 1975) [3]. In the present experiment, in Peach, LD_{50} of gamma irradiation was 27.54 Gy in seed kernels and 19.95 Gy in scions. In Bappakai, LD_{50} of gamma irradiation in seed kernels was found to be 23.44 Gy and in scions it was 21.37 Gy. From the results, it was clear that, the LD_{50} of gamma irradiation in seed kernels was little higher than scion material. Similar results were also observed in mango cvs Arumanis (Karsinah *et al.*, 2012) [5], Neelum, Amrapalli, Dashehari and Mallika (Sharma *et al.*, 1983) [10], in grape cvs Red globe and Muscat (Surakshita *et al*., 2017) [12].

In the present experiment, it was also observed that the time taken for germination or bud break was significantly higher in seed kernels or scions, which were treated with higher doses of gamma irradiation than control population. This was in accordance with the earlier reports on mango cv. Arumanis (Karsinah *et al.*, 2012) [5]. The germination (%) of seed kernels and graft success (%) of scions was decreased significantly with the increase in dose of gamma irradiation in both the genotypes. The significant decrease in germination (%) was probably due to the effect of gamma irradiation on mersitematic tissues of seed kernel, chromosomal aberrations, inhibition of DNA replication and synthesis of growth regulators, interference of irradiation with the synthesis of enzymes, damage of cell constituents at molecular level and altered enzyme activity (Khan and Goyal, 2009 [6], Asare *et al.*, 2017 [2], Yusuf and Nair, 1974 [15]). In mutation breeding, determination of LD_{50} is an essential pre-requisite, as usage of over dosage may lead to complete lethality of plants. Therefore, this calculation of LD_{50} will assist the breeder to produce more mutant population with useful characteristics.

References

1. Agricultural and Processed Food Products Export Development Authority (APEDA), http://apeda.gov.in/apedawebsite
2. Asare AT, Mensah F, Acheampong S, Bediako EA, Armah J. Effects of Gamma Irradiation on Agromorphological Characteristics of Okra (*Abelmoschus esculentus* L. Moench.), Advances in Agriculture, 2385106:1-7.
3. Bottino PJ, Sparrow AH, Schwemmer SS, Thompson KH. Interrelation o exposure and exposure rate in germinating seeds of barley and its concurrence wit dose – rate theory. Rad. Bot. 1975; 15:17-27.
4. Finney DJ. Statistical Method in Biological Assay. Charles Griffin Co. 1978.
5. Karsinah NLP, Indriyani, Sukartini. The effect of gamma irradiation on the growth of mango grafted material. J Agric Bio Sci., 2012; 7:840-44.
6. Khan S, Goyal S. Improvement of mungbean cultivars through induced mutations. African Journal of Plant Science. 2009; 3:174-80.
7. Kostermans AJGH, Bompard JM. The Mangoes, Their Botany, Nomenclature, Horticulture and Utilization. Academic Press, London, 1993.
8. Kwon SH, Im KH. Studies on radiosensitivity of soyabean varieties. Korean J Breed. 1973; 5(1):5-10.
9. National Horticulture Board (NHB), http://nhb.gov.in/
10. Sharma DK, Majumder PK, Singh RN. Induction of mutation in mango (*Mangifera indica* L.). J of Nuclear Agric. Biol. 1983, 12(1).
11. Sripichtt P, Nawata E, Shigenaga S. The effects of exposure dose and dose rat of gamma radiation on in vitro shoot-forming capacity of cotyledon explants in red pepper. Jpn. J Breed. 1988; 38:27-34.
12. Surakshitha NC, Soorianathasundarama K, Meenakshi ganesan N. Determination of mutagenic sensitivity of hardwood cuttings of grapes ‘Red Globe’ and ‘Muscat’ (*Vitis vinifera* L.) to gamma rays, Scientia Horticulturae. 2017; 226:152-156.
13. Van Harten AM. Mutation Breeding: Theory and Practical Applications. Cambridge University Press, UK, 1998.
14. Yadav IS, Rajan S. Genetic resources of *Mangifera*: Advances in Horticulture., Fruit Crops. Part 1. (Chadha, K. L. and Pareek, O.P., Eds.). Malhotra Publishing House, New Delhi, India. 1993; 1:77-93.
15. Yusuf KK, Nair PM. Effect of gamma irradiation on the indole acetic acid synthesizing system and its significance in sprout inhibition of potatoes. Radiat Bot., 1974; 14:251-56.