Evolution of induce and physical mutagen on vegetative traits of papaya (*Carica papaya* L.)

ABSTRACT

The experiment was conducted on Horticultural Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, located in Meerut, Uttar Pradesh. The experiment was laid out in RBD design anddata was recorded on different growth trait of papaya. Two variety of papaya Arka surya and Coorg honey dew, the seed of papaya was treated with Gamma and EMS mutagen and sown in field for evolution. The treatment detail of the experiment wasT1, 5 Gy, T2, 10 Gy, T3, 15 Gy, T4, 0.25% EMS, T5, 0.50% EMS, T6, 0.75% EMS, T7, 5 Gy+0.25% EMS, T8, 10 Gy+0.50% EMS, and T9, 15 Gy+0.75% EMS.Finally, on the basis of result recorded that in both year days taken to seed germination and stem girth(cm), 10GR better performance over all treatment, while in number of leaves at flowering and petiole length (cm), 5GR better performance over all treatment. Whereas, In EMS and (Gamma rays + EMS), 0.25% EMS and 5G+0.25EMS perform better result for petiole length and number of leaves at flowering while for days taken to seed germination and stem girth, 0.50EMS and10G+0.50EMS perform better result.

Keys words: Papaya, Gamma rays, EMS, RBD

1. INTRODUCTION

Papaya (*Carica papaya* L.), belonging to the Caricaceae family, is a key economic fruit crop cultivated across the tropical and subtropical regions globally. Originating from Mexico to Panama, this tropical fruit is known for its three sex forms: male, female, and hermaphrodite, making it a polygamous species. It has a relatively small diploid genome, consisting of 372 Mbp/1C and nine pairs of chromosomes (Vincent*et al.,* 2019), The fruit is highly nutritious, rich in vitamin A with 2020 IU per 100 grams is the 2nd highest after mango, and provides significant medicinal benefits such as diuretic and heart stimulant (Singh *et al.,* 2021). Papain, an enzyme extracted from unripe papaya fruits, is utilized in various industries, including meat tenderization, textile processing, and cosmetics manufacturing.

One of the major fruit crops grown in India, papaya (*Carica papaya* L.), is grown across the world's tropical and subtropical zones. One of the main techniques used in plant breeding to develop a variety of crops is mutant breeding. The process of selection benefits from the creation of variability. Crops like grapes have improved greatly as a result of spontaneous mutations. Gamma irradiation is one of the physical mutagenic agents that may be used to boost crossing over frequencies (Celik *et al.,* 2017).

Breeders have long noted that the use of physical mutagens or mutagens may induce variety. Papaya cultivation thrives in countries like India, the USA, Mexico, Peru, Brazil, Jamaica, Nigeria, China, Taiwan, Indonesia, the Philippines, and Thailand.In India, papayais grown across an area of 0.14 million hectares, resulting in a production of 5.74 metric tons per hectare (Anonymous 2021-2022). Mutation breeding has proven effective for enhancing papaya traits, employing both chemical and physical mutagens to introduce genetic variability (Bedo *et al.,*2017). An example of successful mutation breeding is the development of 'Pusa Nanha', previously known as the 'mutant dwarf' variety, by ICAR-IARI in New Delhi.

Mutagenesis is a valuable technique in crop improvement, involving the alteration of the genetic information of an organism to generate variability that can be harnessed for breeding new traits, such as enhanced nutritional qualities, resistance to diseases, or improved agronomic characteristics. In the case of papaya (*Carica papaya* L.), a popular tropical fruit, both qualitative and quantitative traits are significant for its commercial value, consumer preference, and adaptability to different growing conditions(Nishimwe *et al.*, 2019). Mutation breeding helpful for improvement of different qualitative and quantitative traits, in case of qualitative trait, such as fruit colour, shape, and the presence or absence of specific diseases resistance genes governed by one or a few genes, while in quantitative traitsyield, fruit size, sweetness, and overall plant growth vigour and environmental stress tolerance controlled by multiple genes.

2. Materials and methods

The experiment was carried out at the Horticultural Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, located in Meerut, Uttar Pradesh**.** In the experiment, papaya from two cultivars was used, namely Arka Surya and Coorg Honeydew, which were treated with gamma rays at varying levels **(**5, 10, and 15 Krad**).** The seed was treated with Nuclear Research Laboratory, IARI, New Delhi, and different levels of EMS concentrations **(**0**.**25**%**, 0**.**50**%**, and 0**.**75**%)** were treated with a diluted solution of water to achieve the necessary concentrations**.** After treatment, the seed with the mutagenic solution was placed in petri dishes, and the seeds were treated for 2 hours, and then the seed was washed in running water**.** However, the treatment combination of the experiment was T1, 5 Gy, T2, 10 Gy, T3, 15 Gy, T4, 0**.**25**%** EMS, T5, 0**.**50**%** EMS, T6, 0**.**75**%** EMS, T7, 5 Gy**+**0**.**25**%** EMS, T8, 10 Gy**+**0**.**50**%** EMS, and T9, 15 Gy**+**0**.**75**%** EMS**.**The analysis of variance for each character was carried out for the randomized block design as suggested by Panse and Sukhatme, (1985) and with the help of opstat,Sheoran*et al.* **(**1998**)**.

3. RESULTS AND DISCUSSION

3.1. Vegetative traits

3.1.1.Days taken to seed germination

Days to first germination in papaya *cv.* Coorg Honey Dew and Arka Surya presented Table-1 and Figure-1 showed that the significant difference in all treatment for days taken germination in 2022-23, in Gamma rays 10GR (16.67, 16.50) take minimum days for germination followed by 5GR (18.83, 18.00), and the maximum days taken for germination 15GR (19.33, 19.17), while the in EMS reported that 0.50 EMS (17.33, 16.17) take minimum days for seed germination over 0.25 EMS (17.50, 17.50) and the maximum days taken by 0.75 EMS (19.67, 18.33). Whereas in both (Gamma rays + EMS) recorded that 10G+0.50EMS (19.50, 18.50) was taken as the minimum day for germination, followed by 5G+0.25EMS (19.67, 18.67) and 15G+0.75EMS (20.83, 20.50) were taken as the maximum days for germination, while in the case of the control taken as (18, 17.17) days for seed germination. However, in the case of all mutagens recorded, 10GR took a minimum of days for germination, similar finding reported by Pujra*et al.,*(2019) and Shailendra *et al.,* (2010).

During 2023-24 recorded that significant differences in all treatment for days taken for germination, Gamma rays 10GR (17.77, 17.30) take minimum days for germination followed by 5GR (18.01, 17.50), and the maximum days taken for germination 15GR (18.55, 18.48), while the in EMS reported that 0.50 EMS (18.00, 17.40) take minimum days for seed germination over 0.25 EMS (18.30, 18.17) and the maximum days taken by 0.75 EMS (18.65, 18.58). Whereas in both (Gamma rays + EMS) recorded that 10G+0.50EMS (18.36, 18.15) was taken as the minimum day for germination, followed by 5G+0.25EMS (19.15, 18.36) and 15G+0.75EMS (19.51, 18.56) were taken as the maximum days for germination, while in the case of the control taken as (17.45, 17.62) days for seed germination. However, in the case of all mutagens recorded, 10GR took a minimum of days for germination, as presented in Table 1 and Figure 1, result was conformed with smith *et al.,* (2022) and Santosh *et al.,* (2010).

However, the average of both years reported that Gamma rays 10GR (17.22, 16.90) take minimum days for germination, followed by 5GR (18.42, 17.75), and the maximum days taken for germination 15GR (18.94, 18.82), while the EMS reported that 0.50 EMS (17.67, 16.79) take minimum days for seed germination over 0.25 EMS (17.90, 17.84) and the maximum days taken by 0.75 EMS (18.66, 18.46). Whereas in both (Gamma rays + EMS) recorded that 10G+0.50EMS (18.93. 18.33) was taken as the minimum day for germination, followed by 5G+0.25EMS (19.41, 18.51) and 15G+0.75EMS (20.17, 19.53) were taken as the maximum days for germination, while in the case of the control taken as (17.72, 17.39) days for seed germination. However, in the case of all mutagens recorded, 10GR took a minimum of days for germination, as presented in Table 1 and Figure 1, closed result conformed with Nishimwe *et al.,* (2019) and Jayshree*et al.,* (2022).

3.1.2 No. of leaves at flowering

Data presented Table-1 and Figure 2 showed significant differences in all treatment during 2022-23 in papaya cv Coorg honey dew and Arka Surya, in gamma rays 5GR (34.50, 29.33) had maximum number of leaves followed by 10GR (31.33, 26.17) and minimum number of leaves at 15GR (30.67, 25.00), while the EMS reported that 0.25 EMS (28.50, 23.33) had maximum number of leaves followed by 0.50 EMS (27.83, 22.17) and minimum number of leaves observed at 0.75 EMS (26.67, 21.67), whereas in both (Gamma rays + EMS) recorded that 5G+0.25EMS (25.67, 20.33) had maximum number of leaves over 10G+0.50EMS (24.83, 19.17) and minimum number of leaves observed in 15G+0.75EMS (21.50, 16.00), while in the case of the control taken as (20.83, 15.17) number of leaves. However, in the case of all mutagens recorded, 5GR hadmaximum number of leaves at flowering, results conform with smith *et al.,* (2022) and Santhosh et al., (2010).

Data showing Table-1 and Figure 2 exposed significant differences in all treatment during 2023-24 in papaya cv. Coorg honey dew and Arka Surya, in gamma rays 0.5GR (36.63, 31.50) had maximum number of leaves followed by 10GR (34.67, 28.67) and 15GR (33.00, 27.67) had minimum number of leaves at flowering, while the EMS reported that0.25 EMS (31.83, 25.50) had maximum number of leaves followed by 0.50 EMS (29.67, 24.67) and minimum number of leaves observed 0.75 EMS (29.50, 24.33), whereas in both (Gamma rays + EMS) recorded that 5G+0.25EMS (27.83, 22.50) had maximum number of leaves over 10G+0.50EMS (26.33, 21.67) and 15G+0.75EMS (23.67, 18.33) had minimum number of leaves, while in the case of the control taken as (22.83, 17.67) number of leaves at flowering. However, in the case of all mutagens recorded, 5GR had maximum of number of leaves at flowering, finding similar to Sing *et al.,* (2008) and Kumar *et al.,* (2016).

Number of leaves at flowering present Table-1 and Figure 2 exposed significant differences in all treatment in both of year average, in gamma rays 0.5GR (35.67, 30.42) had maximum number of leaves at flowering followed by 10GR (33.00, 27.2) and 15GR (31.83, 26.33) minimum number of leaves at flowering, while the EMS reported that 0.25 EMS (30.17, 24.42) had maximum number of leaves at flowering followed by 0.50 EMS (28.75, 23.42) and minimum number of leaves observed 0.75 EMS (28.08, 23.00), whereas in both (Gamma rays + EMS) recorded that 5G+0.25EMS (26.75, 21.42) had maximum number of leaves over 10G+0.50EMS (25.58, 20.42) and 15G+0.75EMS (22.58, 17.42) had minimum number of leaves at flowering, while in the case of the control taken as (21.83, 16.42) had number of leaves at flowering. However, in the case of all mutagens recorded, 5GR hadmaximum number of leaves at flowering, closed result with Jayshree *et al.,* (2022) and Kumar *et al.,* (2016).

3.1.3. Stem girth (cm)

Data presented in Table-1 and Figure-3 exhibited significant differences in all treatment during 2022-23 on papaya cv Coorg honey dew and Arka Surya, in gamma rays, 10GR (39.43, 44.77) had maximum stem girth, followed by 5GR (38.18, 41.72), and the minimum stem girth were 15GR (36.38, 40.82), while the in EMS reported that 0.50 EMS (37.13, 41.97) had maximum stem girth over 0.25 EMS (36.33, 41.67) and the minimum stem girth observed by 0.75 EMS (35.42, 40.13). Whereas in both (Gamma rays + EMS) recorded that 10G+0.50EMS (32.83, 38.17) had maximum stem girth, followed by 5G+0.25EMS (30.20, 32.63) and 15G+0.75EMS (29.03, 30.63) were taken as the minimum stem girth, while in the case of the control taken as (27.93, 29.45) had stem girth. However, in the case of all mutagens recorded, 10GR had the maximum stem girth, result conformed with Singh *et al.,* (2008) and Santosh *et al.,* (2010).

The data showed in Table 1 and Figure 3 revealed significant differences in all treatment during 2023-24 in two papaya *cv.* Coorg honey dew and Arka Surya, gamma rays 10GR (41.32, 45.67) had maximum stem girth, followed by 5GR (40.23, 42.62), and the minimum stem girth were 15GR (38.13, 40.12), while the in EMS reported that 0.50 EMS (38.58, 43.37) had maximum stem girth over 0.25 EMS (38.32, 42.90) and the minimum stem girth observed by 0.75 EMS (37.13, 41.63). Whereas in both (Gamma rays + EMS) recorded that 10G+0.50EMS (34.62, 39.06) had maximum stem girth, followed by 5G+0.25EMS (32.23, 34.85) and 15G+0.75EMS (30.68, 33.77) were taken as the minimum stem girth, while in the case of the control taken as (30.07, 32.02) had stem girth. However, in the case of all mutagens recorded, 10GR had the maximum stem girth, result similar with Kumar *et al.,* (2016) and Pujari *et al.,* (2019).

In average of both years reported that Gamma ray's gamma rays 10GR (40.38, 43.49) had maximum stem girth, followed by 5GR (39.21, 41.43), and the minimum stem girth were 15GR (37.26, 39.13), while the in EMS reported that 0.50 EMS (37.86, 40.84) had maximum stem girth over 0.25 EMS (37.33, 40.74) and the minimum stem girth observed by 0.75 EMS (36.28, 39.38). Whereas in both (Gamma rays + EMS) recorded that 10G+0.50EMS (33.73, 36.84) had maximum stem girth, followed by 5G+0.25EMS (31.22, 33.54) and 15G+0.75EMS (29.86, 32.23) were taken as the minimum stem girth, while in the case of the control taken as (29.00, 31.04) had stem girth. However, in the case of all mutagens recorded, 10GR had the maximum stem girth, as presented in Table 2 and Figure 3, result conformed with Shailendra *et al.,* (2010) and Kumar *et al.,* (2016).

3.1.4. Petiole length (cm)

Data existing in Table- 2 and Figure-4 exhibited significant differences in all treatment during 2022-23 on papaya cv Coorg honey dew and Arka Surya, in gamma rays, 5GR (40.32, 36.58) had maximum petiole length, followed by 10GR (38.38, 33.73), and the minimum petiole length were 15GR (38.23, 33.52), while the in EMS reported that 0.25 EMS (34.95, 31.78) had maximum petiole length over 0.50 EMS (35.88, 31.23) and the minimum petiole length observed by 0.75 EMS (34.95, 30.57). Whereas in both (Gamma rays + EMS) recorded that 5G+0.25EMS (34.18, 29.53) had maximum petiole length, followed by 10G+0.50EMS (32.45, 27.70) and 15G+0.75EMS (31.68, 27.03) were taken as the minimum petiole length, while in the case of the control taken as (42.43, 37.17) had petiole length. However, in the case of all mutagens recorded, 5GR had the maximum petiole length, result conformed with Singh *et al.,* (2008).

The data showed in Table 2 and Figure 4 revealed significant differences in all treatment during 2023-24 in two papaya *cv.* Coorg honey dew and Arka Surya, in gamma rays, 5GR (39.88, 37.05) had maximum petiole length, followed by 10GR (37.67, 35.22), and the minimum petiole length were 15GR (36.88, 35.07), while the in EMS reported that 0.25 EMS (35.87, 33.18) had maximum petiole length over 0.50 EMS (34.85, 32.72) and the minimum petiole length observed by 0.75 EMS (33.93, 32.07). Whereas in both (Gamma rays + EMS) recorded that 5G+0.25EMS (32.83, 31.02) had maximum petiole length, followed by 10G+0.50EMS (31.13, 28.67) and 15G+0.75EMS (30.50, 27.82) were taken as the minimum petiole length, while in the case of the control taken as (41.13, 36.73) had petiole length. However, in the case of all mutagens recorded, 5GR had the maximum petiole length, finding conform with Kumar *et al.*, (2016) and Bakry *et al.,* (2002).

In average of both years reported that in gamma rays, 5GR (40.10, 36.82) had maximum petiole length, followed by 10GR (38.03, 34.48), and the minimum petiole length were 15GR (37.56, 34.29), while the in EMS reported that 0.25 EMS (36.15, 32.48) had maximum petiole length over 0.50 EMS (35.37, 31.98) and the minimum petiole length observed by 0.75 EMS (34.44, 31.32). Whereas in both (Gamma rays + EMS) recorded that 5G+0.25EMS (33.51, 30.28) had maximum petiole length, followed by 10G+0.50EMS (31.79, 28.18) and 15G+0.75EMS (31.09, 27.43) were taken as the minimum petiole length, while in the case of the control taken as (41.78, 36.95) had petiole length. However, in the case of all mutagens recorded, 5GR had the maximum petiole length, as presented in Table 2 and Figure 4, closed result with Kumar *et al.,* (2016) and Singh *et al.,* (2008).

4. CONCLUSION

Finally, on the basis of result concluded that in both year days taken to seed germination and stem girth(cm), 10GR better performance over all treatment, while in number of leaves at flowering and petiole length (cm), 5GR better performance over all treatment. Whereas, In EMS and (Gamma rays + EMS),0.25%EMS and 5G+0.25EMS perform better result for petiole length and number of leaves at flowering while for days taken to seed germination and stem girth, 0.50EMS and 10G+0.50EMS perform better result.

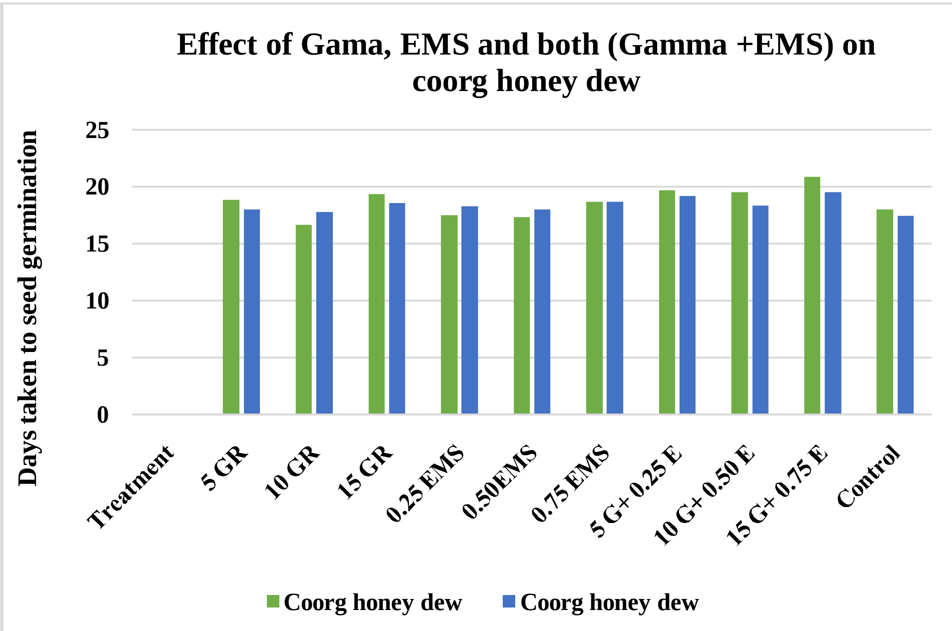
Table-1. Effect of Gama rays, EMS and both of them (Gamma+EMS) on days taken to seed germination percentage and number of leavesat first flowering of papaya cv. Coorg honey dew and Arka Surya.

		Days taken to germination						Number of leaves at first flowering					
		Coorg honey dew			Arka Surya			Coorg honey dew			Arka Surya		
		2022-23	2023-24	Average mean	2022-23	2023-24	Average Mean	2022-23	2023-24	Average mean	2022-23	2023-24	Average mean
	Treatment	Y_1	Y_2		Y_1	Y_2		Y_1	Y_2				
T1	5 GR	18.83	18.01	18.42	18.00	17.50	17.75	34.50	36.83	35.67	29.33	31.50	30.42
T2	10 GR	16.67	17.77	17.22	16.50	17.30	16.90	31.33	34.67	33.00	26.17	28.67	27.42
T3	15 GR	19.33	18.55	18.94	19.17	18.48	18.82	30.67	33.00	31.83	25.00	27.67	26.33
T4	0.25 EMS	17.50	18.30	17.90	17.50	18.17	17.84	28.50	31.83	30.17	23.33	25.50	24.42
T5	0.50EMS	17.33	18.00	17.67	16.17	17.40	16.79	27.83	29.67	28.75	22.17	24.67	23.42
T6	0.75 EMS	18.67	18.65	18.66	18.33	18.58	18.46	26.67	29.50	28.08	21.67	24.33	23.00
T7	5 G+ 0.25 E	19.67	19.15	19.41	18.67	18.36	18.51	25.67	27.83	26.75	20.33	22.50	21.42
T8	10 G+ 0.50 E	19.50	18.36	18.93	18.50	18.15	18.33	24.83	26.33	25.58	19.17	21.67	20.42
T9	15 G+ 0.75 E	20.83	19.51	20.17	20.50	18.56	19.53	21.50	23.67	22.58	16.00	18.83	17.42
Control	Control	18.00	17.45	17.72	17.17	17.62	17.39	20.83	22.83	21.83	15.17	17.67	16.42
SE(m±)		**0.58**	**0.31**		**0.53**	**0.22**		**0.85**	**0.87**		**0.69**	**0.72**	
C.D. at 5%		**1.73**	**0.91**		**1.58**	**0.64**		**2.55**	**2.61**		**2.06**	**2.15**	

Table-2. Effect of Gama rays, EMS and both of them (Gamma+EMS) on stem girth (cm) and petiole length (cm) of papaya cv. Coorg honey dew and Arka Surya.

	Stem girth (cm)							Petiole length (cm)					
		Coorg honey dew			Arka Surya			Coorg honey dew			Arka Surya		
		2022-23	2023-24	Average mean	2022-23	2023-24	Average mean	2022-23	2023-24	Average mean	2022-23	2023-24	Average mean
	Treatment	Y_1	Y_2		Y_1	Y_2		Y_1	Y_2				
T1	5 GR	38.18	40.23	39.21	40.23	42.62	41.43	40.32	39.88	40.10	36.58	37.05	36.82
T2	10 GR	39.43	41.32	40.38	41.32	45.67	43.49	38.38	37.67	38.03	33.73	35.22	34.48
T3	15 GR	36.38	38.13	37.26	38.13	40.12	39.13	38.23	36.88	37.56	33.52	35.07	34.29
T4	0.25 EMS	36.33	38.32	37.33	38.58	42.90	40.74	36.43	35.87	36.15	31.78	33.18	32.48
T5	0.50EMS	37.13	38.58	37.86	38.32	43.37	40.84	35.88	34.85	35.37	31.23	32.72	31.98
T6	0.75 EMS	35.42	37.13	36.28	37.13	41.63	39.38	34.95	33.93	34.44	30.57	32.07	31.32
T7	5 G+ 0.25 E	30.20	32.23	31.22	32.23	34.85	33.54	34.18	32.83	33.51	29.53	31.02	30.28
T8	10 G+ 0.50 E	32.83	34.62	33.73	34.62	39.06	36.84	32.45	31.13	31.79	27.70	28.67	28.18
T9	15 G+ 0.75 E	29.03	30.68	29.86	30.68	33.77	32.23	31.68	30.50	31.09	27.03	27.82	27.43
Control	Control	27.93	30.07	29.00	30.07	32.02	31.04	42.43	41.13	41.78	37.17	36.73	36.95
SE(m±)		1.07	1.21		1.19	1.15		1.22	1.04		1.46	3.05	
C.D. at 5%		3.20	3.61		3.58	3.45		3.67	3.10		4.37	1.02	

Figure-1. Effect of Gama rays, EMS and both of them (Gamma+EMS) on days taken to seed germination percentage of papaya cv. Coorg honey dew and Arka Surya.



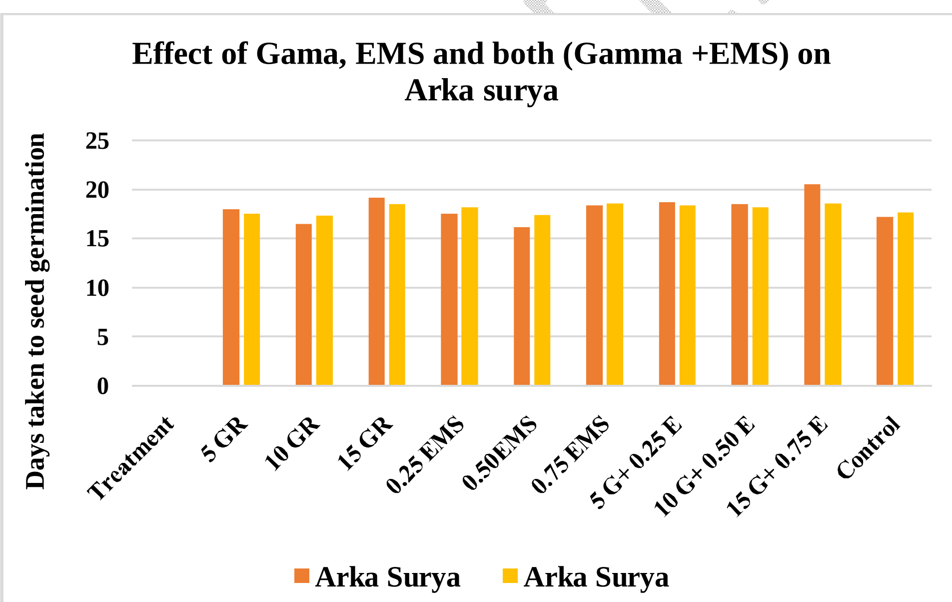
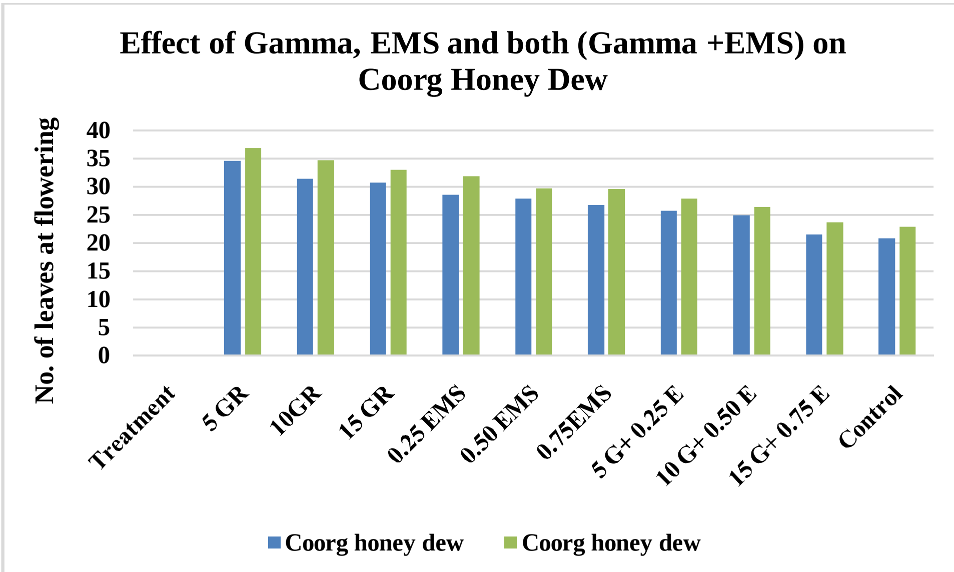


Figure-2. Effect of Gama rays, EMS and both of them (Gamma+EMS) on number of leaves at flowering of papaya cv. Coorg honey dew and Arka Surya.



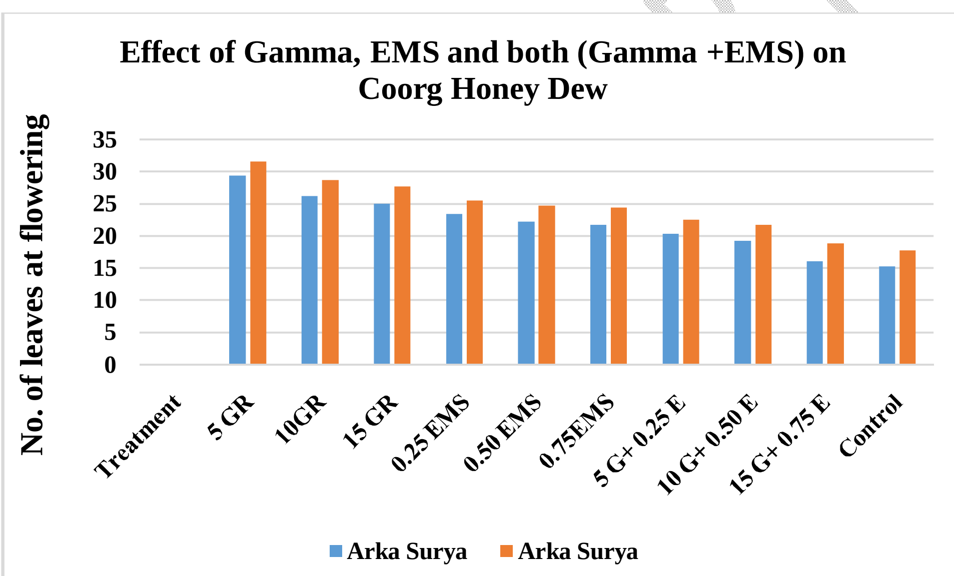
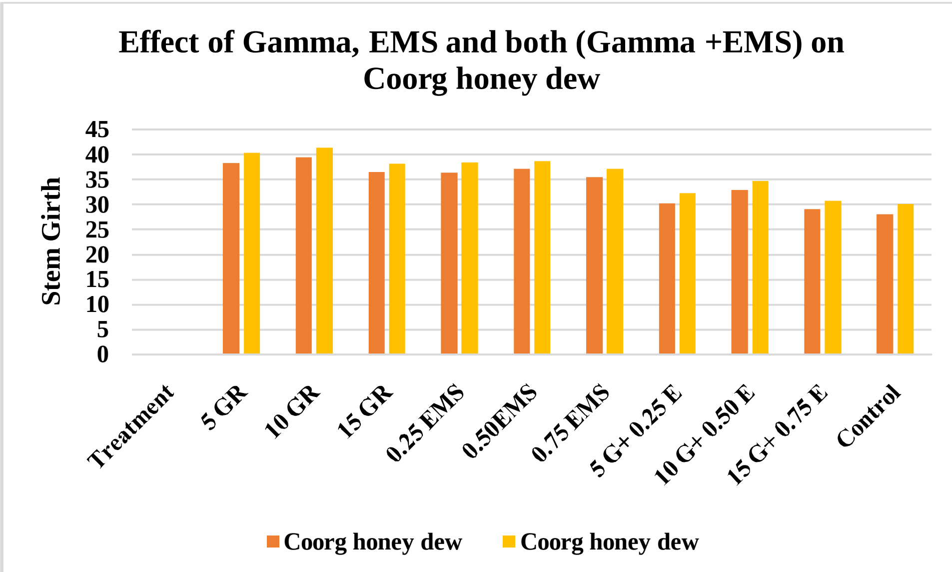


Figure .3. Effect of Gama rays, EMS and both of them (Gamma+EMS) on stem girth of papaya cv. Coorg honey dew and Arka Surya.



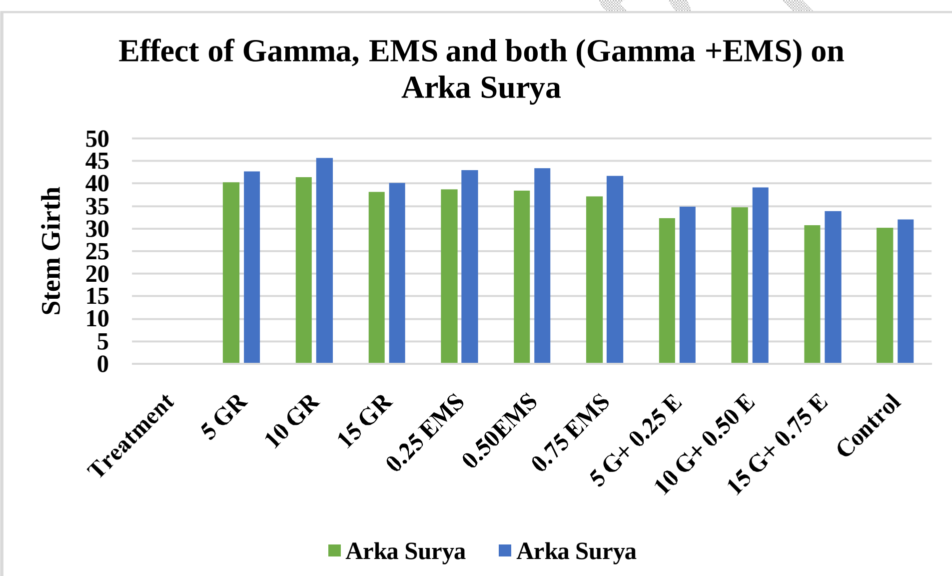
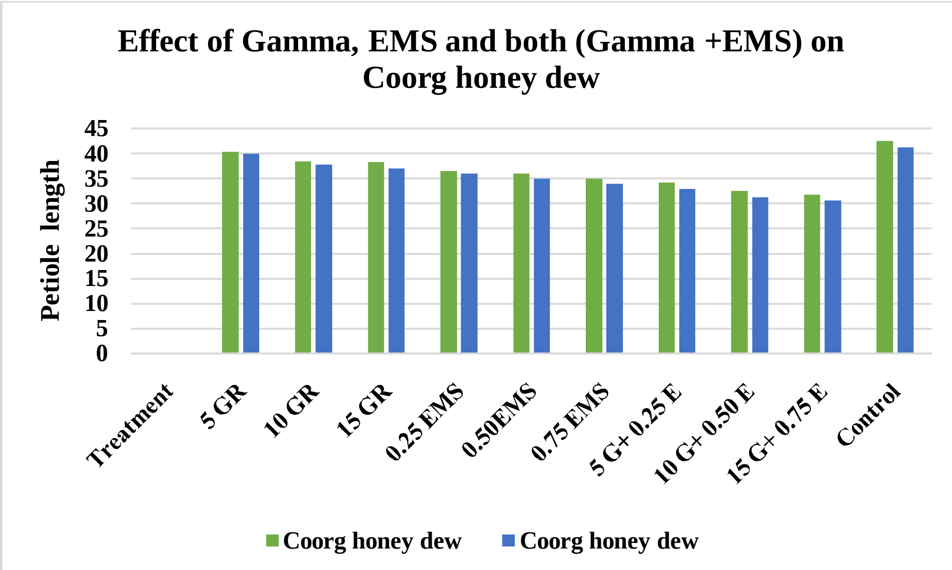
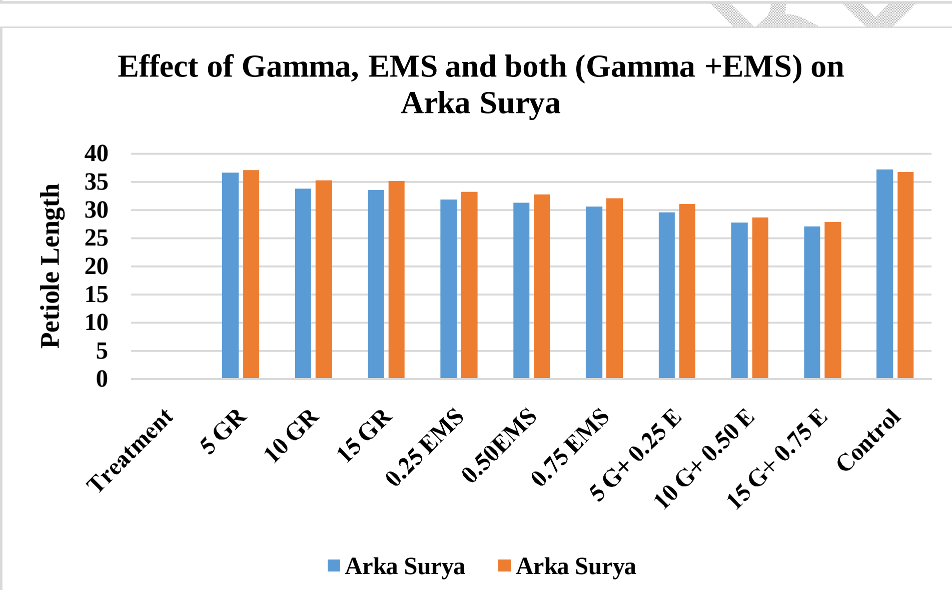


Figure .4. Effect of Gama rays, EMS and both of them (Gamma+EMS) on Petiole length (cm)of papaya cv. Coorg honey dew and Arka Surya.





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