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THE EFFECT OF GAMMA IRRADIATION ON THE GROWTH OF MANGO GRAFTED MATERIAL

Karsinah, N. L. P. Indriyani and Sukartini
Indonesian Agency for Agricultural Research and Development, Indonesian Tropical Fruits Research Institute,
Jl. Raya Solok-Aripan Km. 8 Solok, West Sumatera, Indonesia
E-Mail: k_laladin@yahoo.com

ABSTRACT

Mutation breeding refers to development of new cultivars or germplasm by the deliberate production and selection of new mutations. The objective of this research was to examine the effect of different doses of γ-irradiation on the growth of mango (*Mangifera indica* L.) grafted material. The experiment was conducted at Subang Experimental Field, West Java, from May to December 2009. The research was arranged in a Randomized Complete Block Design with five treatments and three replications, and each treatment consisted of 40 scions. The treatments were doses of γ-rays irradiation, consist of: 0 (non-irradiated as control), 20, 40, 60, and 80 Gy. Mango scions of cv. 'Arumanis' were irradiated with γ-rays at CRDIRT-BATAN Jakarta and then grafted on one year old of mango rootstocks at Subang Experimental Field. The parameters measured were percentage of graft success, time of bud break, shoot length, number of bud that grew on the scion, number of leaves, chlorophyll content, and number of stomata. The results indicated that γ-irradiation doses influence the percentage of graft success, bud break, percentage of grafted material success, shoot length, bud number, total leaf number, and chlorophyll content. Mango grafted materials that can grow were obtained from 0-40 Gy γ-irradiation. Doses of γ-irradiation beyond 60 Gy was lethal to mango cv. 'Arumanis'.

Keywords: mango (*Mangifera indica* L.), γ-rays, scion irradiation, mutation breeding.

INTRODUCTION

Mango (*Mangifera indica* L.) ranks third to banana and citrus i.e., 1.627.997 tonnes or contributes about 10.07% of the national production of fruits in Indonesia (Anonymous, 2008). 'Arumanis-143' is one of the Indonesian mango varieties that can come through to both domestic and world markets. This variety was released in 1984 and had largely been developed in the form of plantation since 1990, so that in five years later 'Arumanis-143' has dominated the transaction of Indonesian mango. The shape of 'Arumanis-143' is elliptic, ± 450 g in weight with smooth, waxy skin, green to yellowish green skin color. The pulp content is 70.76 %, pulp thickness ± 2 cm with yellow color, firm with low fiber, juicy, aromatic and sweet flavor. The stone weight is 54 g with 29.67 g seed weight. The tree is tall reaching 9.2 m; blunt pyramidal crown shape with diameter reached 11.8 m, and has long leaves with a light green color.

Mutation breeding plays a vital role as this gives quicker results than hybridization. Induction mutation on several fruit crops have been successful (Hearn, 1984; Spiegel-Roy *et al*., 1990; Deng, 2000; Ray, 2002; Zamir *et al*., 2009). Some results of mutation studies using γ-rays which aim to produce seedless fruits have been carried out primarily on citrus plants. Majd *et al*. (2009) reported that γ-ray irradiation with a dose of 40 Gy on tangerine bud woods produce plants with seedless fruits. Gulsen *et al*. (2007) resulted that γ-ray irradiation with doses of 0-9 krad on 'Kutdiken' lemon (*Citrus limon* L.) Burm, f.) Clone KT-2A produces seed number varied from 0-34 seeds per fruit. The stable seedless and *mal secco* tolerant plants were obtained from 5 and 7 krad irradiation. Three mutants from 5 krad irradiation gave more lemon-like fruits, while 7 krad caused altered tree morphology and early maturation of fruits. Froneman *et al.* (1996) produced seedless citrus cultivars through bud woods γ-ray irradiation with a dose of 30-75 Gy. The study also indicated that pummelo, mandarin and 'Navel' Orange were very sensitive to high irradiation doses. Gamma irradiation on 'Valencia' Orange and grapefruit produced more seedless fruit on their branches. Hearn (1986) obtained seedless grapefruit from bud woods of 'Foster' (*C. paradisi* Macf.) that irradiated on 5 krad γ-ray.

Chemical induction and γ-irradiation of mutation in mango for breeding purposes have been reported to induced dwarfness, firmer flesh, higher TSS, and better sugar acid blends in a few of the treated plants (Sharma, 1987). Mango cultivars improvement through scion γ-rays irradiation that grafted in situ indicated that doses of γ-irradiation beyond 5 kR are lethal to mango. The LD_{50} for 'Neelum', 'Dashehari', 'Amrapali' and 'Mallika' was 3.9, 2.9, 3.2 and 2.4 kR, respectively. The treatment brought marked changes in leaf characters (Sharma *et al*., 1983). Repeated heading back of the plant obtained from mutagen treated scions resulted in stabilization of characters like small leaves and dwarf habit, and leaves completely different from the cv. 'Dashehari'. This mutant can fit in high density planting (Sharma and Majumder, 1985).

Improvement of Indonesian mango cv. 'Arumanis' through scion irradiation was preliminary mutation breeding. This mutation breeding was purposed for improvement of agronomic traits such as dwarfness, increasing of fruit quality and pulp content. The present study was conducted to evaluate the effect of different doses of γ-irradiation on the growth of mango grafted material cv. 'Arumanis'.

MATERIALS AND METHODS

The research was conducted at Subang Experimental Field, West Java, from May to December 2009. Mango scions of cv. 'Arumanis' obtained from Cukurgondang Experimental Field, East Java and were irradiated with γ-rays at CRDIRT-BATAN Jakarta. The research was arranged in a Randomized Complete Block Design with five treatments and three replications. The treatments were doses of γ-rays irradiation, consist of: 0 (non-irradiated as control), 20, 40, 60, and 80 Gy. The treated scions were grafted on one year old of mango rootstocks cv. 'Daging'. Each treatment consisted of 40 scions. Observation parameters include:

- Percentage of graft success which was calculated by counting the number of graft success divided by the number of samples. The graft success was observed on 4 weeks after grafting, it was observed by digging a little on base of scion. If this section still looks green, then grafting was successful.
- Time of bud break that was observed by counting the time of samples 50% have bud break.
- Percentage of grafted material success which was calculated by counting the number of grafted material success divided by the number of initial samples.
- Shoot length that was measured from the graft union to apical growth.
- The number of buds that grew on the scions. Growing buds were marked by the development of shoots and leaves on the budwood of scion.
- The number of total leaves per plant that was calculated from the whole leaf that grew on those scions.
- Chlorophyll content that was measured per g leaf sample.
- Number of stomata that was calculated per mm^2.

Observations were carried out on 10, 18, and 26 weeks after grafting, except the chlorophyll content and number of stomata were carried out at the end of the observation. Data were analyzed using one way ANOVA. Means were separated using Least Significant Difference (LSD) at alpha 0.05.

RESULTS AND DISCUSSIONS

Table-1 show that the five doses levels of γ-irradiation affected the percentage of graft success on 4 weeks after grafting. The higher the irradiation level, the lower the percentage of graft success. The highest of graft success percentage was observed in non-irradiated (control i.e., 93.33%), but not significant with 20 Gy (82.50%), 40 Gy (80.00%), and 60 Gy (77.50%). Performances of grafted materials on 4 weeks after grafting were presented in Figure-1.

The time of bud break was 17.7 days after grafting in control and 19 days after grafting in irradiation with 20 Gy, while those with 40 and 60 Gy the sample bud break have not reached 50%. Scion irradiated with 80 Gy caused the bud break did not occur and the grafted materials were not survival. Observation on the percentage of grafted material success on 10, 18, and 26 days after grafting indicated that the highest of grafted material success percentage was observed in non-irradiated (control i.e., 87.50%, 87.50%, and 85.00%), but not significant with 20 Gy i.e., 61.67%, 65.83%, and 65.83% respectively, while those with 40 Gy were 23.33%, 24.17%, and 25.00%, respectively that significantly different with both doses 0 and 20 Gy. Doses of γ-irradiation 60 and 80 Gy caused the gratfed materials were not survival.

Table-1. The effect of γ-irradiation doses on the percentage of graft success, bud break time, and percentage of grafted material success on 10, 18, and 26 weeks after grafting.

γ-rays irradiation (Gy)	**Graft success** (%)	**Bud break time** (days after grafting)	**Grafted material success** (%)		
			Time of observation (weeks after grafting)		
			10	18	26
0	93.33 a	17.7	87.50 a	87.50 a	85.00 a
20	82.50 ab	19.0	61.67 a	65.83 a	65.83 a
40	80.00 ab	- *)	23.33 b	24.17 b	25.00 b
60	77.50 ab	- *)	- **)	- **)	- **)
80	73.33 b	- **)	- **)	- **)	- **)

Note: Letters not followed by the same letter in one column mean that they are significantly different according to LSD at alpha 0.05.
*) The number of sample that have bud break < 50%.
**) Mango grafted materials were not survival.

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Figure-1. Performance of mango grafted materials on 4 weeks after grafting from scion irradiated with 0, 20, 40, 60, and 80 Gy, respectively from left to right.

Table-2 indicated that the growths of mango grafted materials were affected significantly by γ-irradiation doses. The growth of mango grafted material was suppressed by γ-irradiation compared with control. Observation on shoot length on 10, 18, and 26 weeks after grafting in control (non-irradiated) were (21.91, 33.04, and 38.77 cm) that significantly different with 20 Gy (17.30, 25.18, and 30.03 cm), and 40 Gy (15.34, 15,78, 15.78 cm), respectively. Observation on bud number show that the bud number of grafted material irradiated with 20 Gy was higher than control and 40 Gy. While, the total leaf number on 10, 18, and 26 weeks after grafting in control (non-irradiated) were (17.89, 36.07, and 42.74) that significantly different with 20 Gy (9.45, 20.69, and 30.59), and 40 Gy (1.67, 2.05, 2.48), respectively.

Table-2. The effect of γ-irradiation doses on shoot length, bud number, and total leaf number of mango grafted material on 10, 18, and 26 weeks after grafting.

Parameters	**γ-rays irradiation** (Gy)	**Time of observation** (weeks after grafting)		
		10	**18**	**26**
Shoot length (cm)	0	21.91 a	33.04 a	38.77 a
	20	17.30 b	25.18 b	30.03 b
	40	15.34 c	15.78 c	15.78 c
Bud number	0	2.58 a	2.78 b	2.78 b
	20	2.53 a	3.26 a	3.33 a
	40	1.15 b	1.22 c	1.24 c
Total leaf number	0	17.89 a	36.03 a	42.74 a
	20	9.45 b	20.69 b	30.59 b
	40	1.67 c	2.05 c	2.48 c

Note: Letters not followed by the same letter in one column mean that they are significantly different according to LSD at alpha 0.05.

In primary shoots of mango grafted material originating from irradiated scion with 40 Gy have smaller leaves than those with 20 Gy and control. Those leaves were abnormal which indicated by small leaves and leaf margin was slightly serrated. However, the leaves become normal in secondary shoots (Figure-2).

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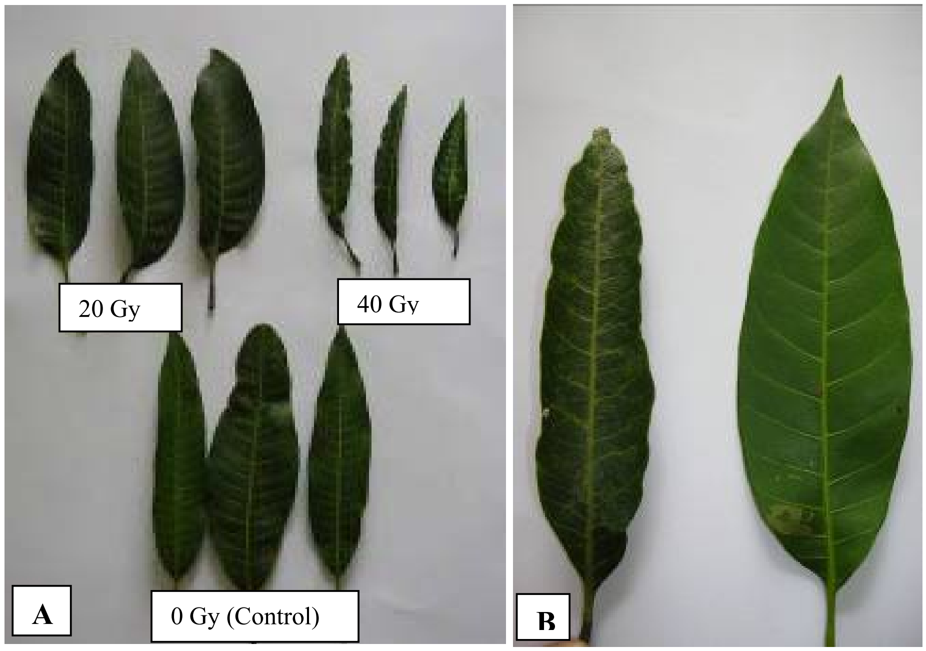

Figure-2. A. Appearance of mango leaves from scions irradiated with three doses of γ-rays. B. Abnormal-shaped leaf from primary shoots (left) and normal-shaped leaf from secondary shoots from scion irradiated with 40 Gy γ-ray (right).

Table-3 showed that there were significant differences of leaves chlorophyll content between irradiation 40 Gy with control and 20 Gy treatments. Mango grafted material irradiated with 40 Gy had higher chlorophyll content (1.51 mg/g) than those of irradiated with 20 Gy (1.43 mg/g) and non-irradiated (1.42 mg/g). However, there were no differences in number of leaves stomata. Number of stomata/mm2 on leaves usually used to determine the amount of ploidy of a plant. In banana, there was negative correlation between the number of ploidy with stomata density (Ganga *et al*., 2002; Vandenhout *et al*., 1995), as well as on *Acacia mearnsii* (de Wild) (Beck *et al*., 2003).

Table- 3. The effect of γ-irradiation doses on chlorophyll content and leaf stomata number of mango grafted material.

γ-rays irradiation (Gy)	**Chlorophyll content** (mg/g)	**Leaf stomata number /mm^2**
0	1.42 a	288.7 ns
20	1.43 a	276.6
40	1.51 b	256.1

Note: ns = not significant.
Letters not followed by the same letter in one column mean that they are significantly different according to LSD at alpha 0.05.

CONCLUSIONS

Study on the effect of γ-irradiation on the growth of mango grafted material cv. 'Arumanis' can be concluded as follows: γ-irradiation doses influence the percentage of graft success, bud break, percentage of grafted material success, shoot length, bud number, total leaf number, and chlorophyll content. Mango grafted materials that could grow were obtained from 0-40 Gy γ-irradiation. Doses of γ-irradiation beyond 60 Gy was lethal to mango cv. 'Arumanis'.

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