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Effect of different Gamma radiation doses on the growing of the Achmrar local fig variety *Ficus carica L.* in Morocco

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Abstract*—This research was carried out in order to determine GR_{50} dose which reduces the growing of 50% as compared to control and give rises to mutation at the fig tree which were irradiated with five different Gamma doses (20, 40, 60, 80, and 100 Gy). The bud cutting irradiated with different doses were prepared and then rooted in greenhouse for three months. Results showed that chlorophyll leaf content decreased with increasing radiation doses, 44, 60 mg.g-^{1} to 24,53 mg.g-^{1} for control and 100 Gy doses respectively. Is was also found that average leaf area and stomatal conductance values deceased compared to the control its varied for the leaf area 65,75 cm^2 for control to 23,95 for the 100 Gy doses, and for stomatal conductance to 557,68 mmol/m^{2}s control to 75 mmol/m^{2}s for 100 Gy doses. As a result, GR 50, dose was found as 62 Gy for fig variety.*

***Keywords*— fig variety, Gamma radiation, GR $_{50}$ dose, chlorophyll, stomatal conductance.**

I. INTRODUCTION

The common fig is an emblematic and characteristic fruit species of the Mediteranean region. Is domestication may have been cotemporary to cereal crops (Poaceae) suggesting very early cultivation (9000 to 12,000 BCE) (Kislev et al., 2006). Fig diversity studies using morphological and molecular markers show that Morocco contains a great genetic diversity of the fig tree with geographic specificities (Oukabli et al., 2003; El oualkadi, 2004; Ater & al., 2008; Achtak et al., 2010). This fruit crop is widespread in the Mediterranean basin countries since it is well adapted either to different soils or climates (Mars, 2003). The fig tree has not been subjected to intensive breeding programs; therefore fig tree populations exhibit a rich genetic biodiversity. Fig propagation is usually carried out by stem-cuttings and this procedure has contributed to synonymy and homonymy, because missing identification and somaclonal variations are common events in sexually propagated species such as fig (do Val et al., 2013). In Morocco, the fig tree is the species where the greatest number of local varieties was listed (Tayou, 1985; El Oualkadi, 2004; Hmimsa, 2004). According to 2018 statistical data, 57.000 tons of fresh fig were produced in 46.000 hectares (ha) of fig plantations in Morocco (DPA Al Hoceima, 2016). Al Hoceima region, located at northwest part of Morocco, was classified in third rank in terms of national fig production on after Taounate-Chefchaouen and Tetouan region, with a surface of 4520 ha and a production of 2800 tons of figs (DPA Al Hoceima, 2016). Achmrar fig variety is a variety wich is of great importance in the annual production of the fresh fig varieties in the Al Hoceima region. It's considered as very old variety, the age of these trees date more than 80 years (DPA Al Hoceima, 2016). The most profitable production is obtained from the table fig varieties in the late growing season of the province. Limited number of fig varieties having some characteristics such as seedless, last season production and resistant to conservation and transportation restricts the profitability of fig culture in both the province and whole country. Therefore, it is thought that development of new fig variety using different breeding methods will contribute to national economy. The improvement of the varieties of crop plants is fundamental for the agricultural production and the horticulture. The use of model species, such as Arabidopsis (Phillips & al, 2008), is also leading to the more rapid development of new mutagenesis techniques. Batista, & al. (2008) reports that Gamma-ray mutagenesis in rice induces extensive transcriptome changes. Gamma and X rays were used to improve different characteristics of plants and to obtain new varieties and species (increasing productivity and quality, resistance to disease and pests and extreme conditions etc.) (Miah & al. 1966; Gokçora, 1973; Demir, 1980). Many researchers have made many studies using different mutagens (physical or chemical) on different plant (Donin, 1978; Yalçin, 1992; Aufhammer & al., 2000; Klu and Haarlent, 2000; Tayyar & al., 2003; El Oualkadi & al., 2018). In other study, it was found that increasing

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radiation dose on M1 generation decreases plant height, and plant numbers alive (Gaul, 1977). Other studies concerning this subject show that the radiation treatments are feasible to be applied on different parts of the plant such as tubers, cutting, seeds and stems (Gaul, 1977; Çoban, 1998). This research was carried out to determine the effects of different Gamma radiation doses on the cutting of Achmrar fig variety and to find out the GR 50 dose. Different doses were applied to bud cutting of Achmrar fig variety.

II. MATERIEL AND METHODS

This research was carried out at the National Institute of Agronomic Research of Tangier (INRA), Morocco. Achmrar fig variety was used as experimental crop in the study. Five lots of 20 buds cutting were irradiated separately by one of the following doses of radiation: 20 Grays, 40 Grays, 60 Grays, 80 Grays and 100 Grays. The control cutting was untreated.

A total of 120 cutting of Achmrar fig variety were cut in December 2018 and stored at 5°C for 2 months (Gerhardt and Cheng- Yung Cheng Schneider, 1971). All cutting were sown under a greenhouse in plastic bags and arrangers in a randomized plot experimental design with four replications. The cutting kept in a greenhouse for 3 months were observed weekly since the date of planting. After irradiation by Gamma radiation source, cutting was planted in each pot.

Necessary data were recorded on the growth, morphological and biochemical parameters. Total leaf area of the plant was measured with automatic electronic leaf area meter (model LI-3000, USA) and with imageJ software. Chlorophyll content of leaf was estimated by manual SPAD-502 Plus. The stomatic conductance was measured with Leaf Porometer. (Ap4; Delta-T, Cambridge, UK). The statistical analysis of variance was carried out by software SPSS ® version 21.0. The mean difference of the studies parameters among the treatments was adjusted by Ducan's Multiple Range Test (Gomez et al, 1984).

III. RESULTS AND DISCUSSION

The cumulative percentage of bud (CPB) followed a logarithmic progression for both control and irradiated buds (fig 1). The control showed a CPB (100%) higher than the irradiated buds. Irradiated buds showed decreasing CPB based on increasing doses of radiation. The lower CPB were noted for the high radiation doses; 55% for the radiation 100 Gy, 60 and 65% for the dose of 80 and 60 Gy respectively, 70 and 90% for the dose of 40 and 20 Gy applied on buds on Achmrar fig variety.

The correlation between radiation dose and cumulative percent of bud was r= -0.92***. The equation of related regression based on radiation dose is Y=77,72-0,42X (Fig. 2). Based on the minimum level of 50% of cuttings surviving compared to control, lead us to locate the optima radiation dose between 60 and 65 Grays for fig cuttings. The yield of cuttings surviving of these treatments was satisfactory since the rate of survival was ranged from 60 to 100%.

As a result, GR 50, dose for the application of mutation breeding of Achmrar fig variety was determined as 62 Gy. El oualkadi & al. (2018); Ponnusswani & al. (1992) found GR50 dose to be 20-25 Gy on woody cutting of grape variety.

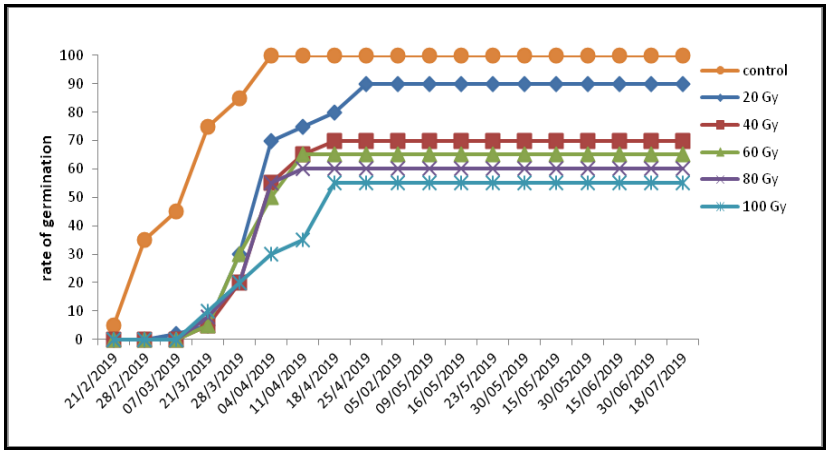

Fig 1. Cumulative rate of growing of Achmrar fig variety and irradiated with increased doses (20-40-60-80 and 100 Grays)

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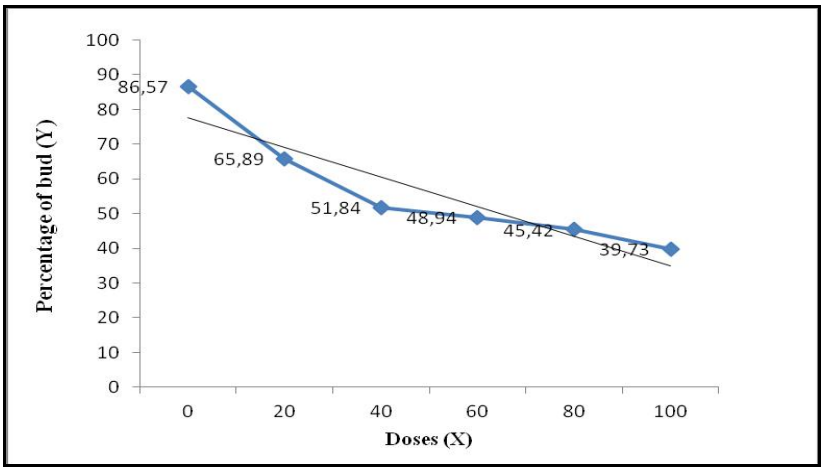

Fig.2: Average of the percentage of growing of the cuttings of the fig variety

Effects of five different Gamma radiation dose applied to the bud cutting of the achmrar fig variety on the average chlorophyll leaf, average leaf area and average stomatal conductance, are shown in table 1.

Table 1: Effects of different Gamma radiation doses on the bud cutting fig variety

Doses (Gy)	Chlorophyl of leaf (mg.g-^{1})	Leaf area (cm^{2})	Stomatal conductance (mmol/m^{2}s)
Control	44,60 *b*	65,75 *c*	557,68 *d*
20	40,76 *ab*	59,26 *bc*	394,30 *cd*
40	34,72 *ab*	56,22 *abc*	307,63 *bc*
60	28,76 *a*	41,26 *abc*	108,63 *ab*
80	26,90 *a*	26,74 *ab*	96,63 *ab*
100	24,53 *a*	23,95 *a*	75,00 *a*
Pα =0.05	*0,002*	*0,025*	*<0,000*

**Significant differences within the same column and means followed by the same letter do not differ at Pα ≤0.05 according to Duncan test.*

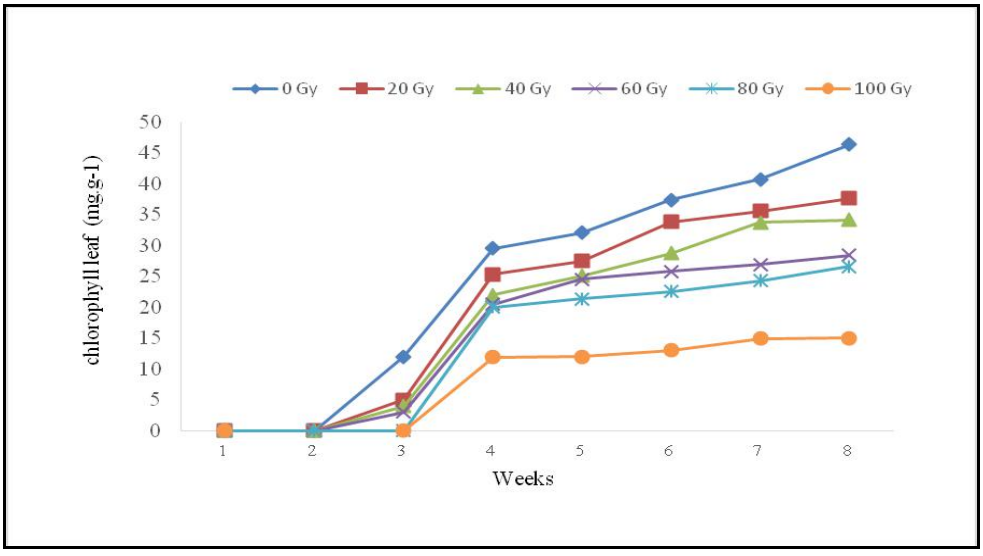

Fig 3: Rate of chlorophyll leaf of fig variety between 1st and 8 weeks

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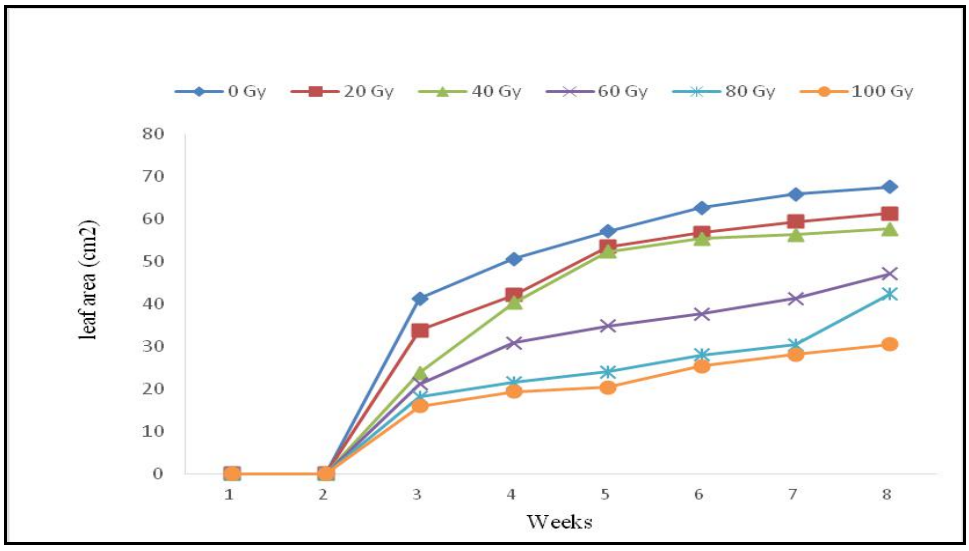

Fig 4 : Rate of leaf area of fig variety between 1 st and 8 weeks

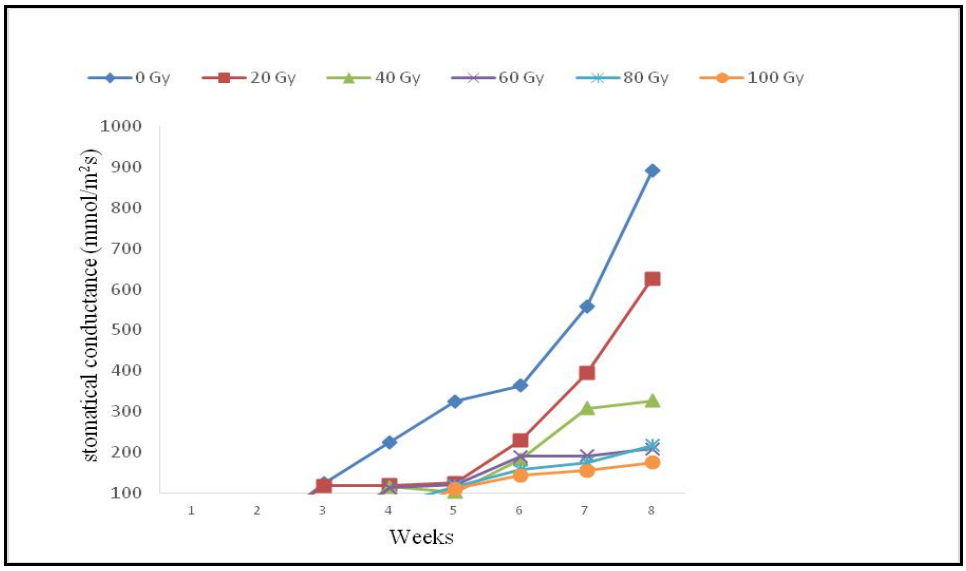

Fig 5: Rate of stomatical conductance (mmol m-^{2} s-1) of fig variety between 1st and 8 weeks

Effects of various Gamma radiation doses applied to Achmrar variety on the chlorophyll leaf, leaf area and stomatal conductance at the end of 6 weeks later are presented in Fig. 3; 4 and Fig 5.

Doses of 80 and 100 Gy Gamma radiation dose decreased the chlorophyll leaf, leaf area and stomatal conductance of the bud cutting significantly. All of the radiation dose increased chlorophyll leaf, leaf area and stomatal conductance period of the bud cutting compared to control (Fig.3, 4 and 5).

The effects of the cutting of Achmrar fig variety irradiated with different Gamma radiation on the bud cutting were determined. The control recorded a chlorophyll leaf content of 44 mg.g-1, while chlorophyll leaf at the 20, 40, 60, 80 and 100 Gy radiation dose decreased to 40.76, 34.72, 28.76, 26.90 and 24.53 mg.g-1, respectively. Depending on increasing radiation dose, leaf area values also decreased compared to control 65.75 cm2 and found to be 59.26, 56.22, 41.26, 26.74 and 13.95, respectively (Table 1).

Because of increasing radiation dose, the stomatal conductance in bud cutting of Achmrar fig variety decreased as well. The average stomatal conductance of control was 555.68 mmol/m2s, whereas it was 394.30, 307.63, 108.63, 95.63 and 75 mmol/m2s at 20,40, 60, 80 and 100 Gy, respectively (table 1). Leaf morphology and area are the main characters which are directly influenced by any mutagenic treatment. Lower doses were found to be stimulating on processes like nutrient uptake and photosynthetic activities (Al-Qudat, 1990; Antonov, 1985). Appearance of more number of smaller leaves with reduction in leaf area is also common (Sheppard and

Evenden. 1986). This effect may also cause compactness resulting in dwarf plants (Shin et al., 1988).

According to statistical analyses, various radiation dose treatments applied on Achmrar fig variety were highly significant for all the parameters as seen in Table 1 (P< 0,01).The results obtained from this research were in accordance with a study indicating that shooting delayed with increasing radiation dose in a round seedless grape variety (Çoban, 1988). We aslo found that shooting delayed with increasing radiation doses affected the development of shooting of the scions at different levels (Tayyar, 2003). These results were also in line with other various studies (Enset and Pratt, 1975; Donini, 1978; Donini, 1993; Hadju et al., 1995; Korosi et al, 1995; Lima de Silva and Daozon, 1995).

IV. CONCLUSION

It was evident from the results that different Gamma radiation doses applied had significant effects on the vegetative development parameters of the bud cutting. Increased Gamma radiation treatments resulted in decrease on vegetative development of bud cutting. It was determined that 62Gy Gamma radiation doses are suitable for Achmrar fig variety whereas 80 and 100 Gy radiation dose have many negative effects on the plants. These results give some information in determining appropriate dose levels on mutations breeding studies in other fig varieties.

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