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Bazı incir (*Ficus carica* L.) çeşitlerinin gamma ışınlarına duyarlılığı

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Anahtar Kelimeler
Ficus carica L., lethal doz, gama ışını, mutasyon ıslahı

ÖZET

Yeni incir (*Ficus carica* L.) çeşitlerinin geliştirilmesi incir endüstrisi açısından son derece kritik öneme sahiptir. Bu çalışma beş incir çeşidine ait kalemler üzerine 6 farklı gamma radyasyon (60Co) dozunun etkilerini araştırmak amacıyla yapılmıştır. Altı cobalt (60Co) gamma dozu (0.0, 10.0, 16.9, 25.3, 50.7 ve 67.0 gray) 'Sarılop', 'Sarı Zeybek', 'Bursa Siyahı', 'Beyaz Orak' ve 'Siyah Orak' incir çeşitlerinin kalemlerine uygulanmıştır. M1V1 (mutasyon 1 vejetasyon 1) bitkileri sürgün büyüme hızı ve hayatta kalma oranları bakımından incelenmişlerdir. LD50 değerleri 'Sarılop' için 50.7 Gy, 'Sarı Zeybek' ve 'Bursa Siyahı' için 25.3 Gy, 'Beyaz Orak ve 'Siyah Orak' çeşitleri için 10.0 Gy olarak hesaplanmıştır. Uygulamadan 16 hafta sonra yapılan ölçümlerde çeşitler ve farklı dozlar arasında önemli derecede interaksiyon tespit edilmiştir. 'Sarılop', 'Sarı Zeybek', ve 'Bursa Siyahı' çeşitleri 10.0, 16.9 ve 25.3 Gy dozlarında 'Beyaz Orak' ve 'Siyah Orak' çeşitlerine göre daha fazla büyüme göstermiştir. Bu çalışma beş farklı incir çeşidinin farklı gamma dozlarına farklı tepkiler verdiğini, bu nedenle de incir ıslah programlarında farklı çeşitler için en uygun dozların belirlenmesi gerektiğini ortaya koymuştur.

Gamma radiation sensitivity of five fig (*Ficus carica* L.) cultivars

Keywords
Ficus carica L., lethal dosage, gamma radiation, mutation breeding

ABSTRACT

This research was conducted to assess effects of six dosage levels of gamma irradiation on budsticks of five fig cultivars. Six levels of dosages (0.0, 10.0, 16.9, 25.3, 50.7, and 67.0 Gy) of cobalt (60Co) gamma irradiation were applied to budsticks of 'Sarılop', 'Sarı Zeybek', 'Bursa Siyahı', 'Beyaz Orak', and 'Siyah Orak' fig cultivars. M1V1 (mutation one vegetation one) plants were evaluated for survival ratio and shoot growth. LD50 values were determined as follows: 50.7 gray (Gy) for 'Sarılop', 25.3 Gy for 'Sarı Zeybek', and 'Bursa Siyahı', 10.0 Gy for 'Beyaz Orak' and 'Siyah Orak' cultivars, respectively. Interaction between cultivars and six levels of gamma dosages was observed for shoot growth in 16th week at alpha 0.01 level. 'Sarılop', 'Sarı Zeybek', and 'Bursa Siyahı' had more shoot growth compared to 'Beyaz Orak' and 'Siyah Orak' at 10.0, 16.9 and 25.3 Gy gamma irradiations. This study shows that varying dosages of gamma irradiation differently affect five fig cultivars; and therefore, suitable irradiation dosages for specific genotypes have to be determined for fig breeding program.

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1. Introduction

Fig is one of the oldest known fruits in the world. The common fig (*Ficus carica* L.) belongs to the family of *Moraceae*. The somatic chromosome number is 2n = 2x = 26 [1, 2]. It probably originated in southern Arabia where wild fig and caprifig trees are still found [1, 3, 4]. Jona and Gribaudo [3] discussed that *F. carica* originated in the jungles of the Caspian foreshores, northwest Turkey and probably elsewhere in the surroundings areas. By time, fig was naturalized in many places and was established in a very extensive region of Western Asia, Crimea and Transcaucasia.

Many studies related to fig breeding were previously reported [5, 6, 7, 8, 9, 10, 11, 12]. Main fig breeding objectives are high eating quality, elimination of caprification, persistence of syconia to ripeness, resistance to pests and diseases, maximum productivity, and hardiness to adverse environmental conditions [1, 2, 13]. Early attempts to create artificial hybrids in fig occurred in the beginning of the 20^{th} century, mainly in USA and ex USSR [1, 13].

Fig breeding using conventional hybridization methods has been limited because of long juvenility periods. Mutation breeding is a valuable tool in altering only few genes while conserving overall genetic background, and an alternative method for the improvement of major crops, ornamental plants and perennial fruit trees [14, 15]. However, reports on fig improvement using this technique are scarce. Akhund-Zade [16] stated that effects of gamma radiation on fig cuttings, seeds and pollen differed by dosage levels from 50 to 100 Gys. In their study, the most frequent finding was decrease in tree vigor and acceleration of fruiting. These studies permitted selection of new cultivars such as ‘Bol’. Effects of different dosages on different fig cultivars were not reported. Mutation breeding led to improved fruit cultivars such as lemon (*Citrus limon* (L.) Burm. f.) [17], avocado (*Persea americana* Mill*)* [18], fig (*Ficus carica* L.) [16], apple (*Malus communis* L.) [19], amla (*Emblica officinalis* Gaertn) [20], Japanese plum (*Prunus salicina* Lindl.) [21], apple (*Malus pumila* Mill.) [22]. In *Brassica napus* or *Sinapsis alba*, Gustafson [23] indicated that dosage levels differentially affect plant cultivars and plant tissues such as seed, cutting, and pollen. Thus, the most suitable irradiation dosages have to be determined for the fig breeding programs.

As in many fruit species such as genus *Citrus* and *Malus*, cultivar improvement mainly relies on clonal variation caused by natural mutations [24, 25, 26]. Fig genetic resources contain many clonally derived cultivars with considerable diversity such as fruit shape, color, and tree vigor [27]. These results indicate that induced mutations may play an important role in fig improvement for important traits such as small ostiol size, large fruit size, fruit flesh quality, and tree productivity.

Determination of LD_{50} value is important for plant breeding for breeding programs. Lethal effect is due to large chromosomal rearrangements such as deletion, translocation, and inversion [28]. LD_{50} value is determined by considering number of surviving plants after exposed to gamma irradiation. If surviving plant number after exposure to gamma irradiation consists of 50% of total grafted plants among different gamma dosages, that dosage is signified as LD_{50} dosage. The most suitable dosage levels is determined to obtain the largest variation for shoot growth of each fig cultivar, because the aim of gamma irradiation is to create variation as much as possible, which may allow us to select desirable individuals. Thus, objectives of this study were to assess effects of different dosages of gamma irradiation and determine the most suitable irradiation dosage levels for fig breeding programs.

2. Materials and Methods

Plant Materials

Budsticks (4-6 mm in diameter and 12-15 cm in length) containing 4-7 buds were obtained from a 7 year-old ‘Sarılop’, ‘Sarı Zeybek’ dried fig and a 15 year-old ‘Bursa Siyahı’, ‘Beyaz Orak’, ‘Siyah Orak’ fresh fig cultivars located at Erbeyli Fig Research Institute, Aydın, Turkey. All cultivars studied were under the same growing conditions.

‘Sarılop’ (*syn*. ‘Calimyrna’) and ‘Sarı Zeybek’ are the most important dried fig cultivars in Turkey [29]. They have superior characteristics such as small ostiol size, seed, and light fruit color. ‘Bursa Siyahı’ is also important cultivar in Turkey’s fresh fig export [30]. All three fig cultivars explained above are cultivars of Smyrna type. ‘Beyaz Orak’ and ‘Siyah Orak’ are fresh fig cultivars, with many agronomically important characteristics and important to the Turkish fig industry. However, these cultivars have some drawbacks. For example, they have relatively mid to large ostiol size, weak tree growth compared to many other fig cultivars. They are susceptible to biotic and abiotic stress factors such as dried fruit beetle *Carpophilus hemipterus* L. (Coleoptera: Nitidulidae) and other *Carpophilus* spp., the vinegar fly *Drosophila* spp. (Diptera: Drosophilidae), and rapidly damaged by excessive heat, cold and wind.

Application of irradiation

Budsticks placed in bags were stored at +4 ^{o}C until the next day, when they are exposed to a cobalt (^{60}Co) source emitting 1.22 kgray/h at the Saraykoy Nuclear Research and Training Center, Kazan, Ankara, Turkey. Irradiation dosages were 0.0 (non-irradiated), 10.0, 16.9, 25.3, 50.7, and 67.0 Gy. The budsticks were then refrigerated until the following day when buds were grafted onto one year old ‘Sarılop’ rootstocks in the semi-controlled greenhouse located at Erbeyli Fig Research Institute where the rest of the study was carried out. We examined all M1V1 buds for survival and, successively, shoot growth at weekly intervals for a period of 10 weeks after grafting, and biweekly for eight additional weeks.

Statistical Analyses

Descriptive statistics such as mean, standard error of mean and factorial variance analysis were performed using SPSS for Windows (SPSS Inc., Chicago, USA). Two-way interaction between fig cultivars and six dosage levels were analyzed for shoot growth differences in M1V1 plants as measured at 16^{th} week.

LD_{50} value was determined by considering number of surviving plant after exposed to gamma irradiation. If surviving plant number after exposed gamma irradiation consisted of 50% of total grafting plants among different gamma dosages, that dosage was signified as LD_{50} dosage.

Standard deviations of means observed at each dosage level were compared for each fig cultivar's shoot growth, and those irradiation levels for each cultivar creating the highest deviation were considered to be the most suitable. Means were separated using Duncan test.

3. Results and Discussion

Distribution and survival ratios of gamma irradiated and control M1V1 plants

A total of 272 buds from 'Sarılop', 257 buds from 'Sarı Zeybek', 351 buds from 'Bursa Siyahı', 279 buds from 'Beyaz Orak', 266 buds from 'Siyah Orak' cultivars were used to obtain M1V1 plants in this study. The distribution of the number of buds to the six dosage levels was shown in Table 1.

Table 1. Distribution of buds to different dosage levels to obtain M1V1 plants

Dose	Sarılop	Sarı Zeybek	Bursa Siyahı	Beyaz Orak	Siyah Orak
Control	54	52	52	52	50
10.0 Gy	41	35	57	55	38
16.9 Gy	44	32	53	38	44
25.3 Gy	43	37	86	42	52
50.7 Gy	34	54	57	41	44
67.0 Gy	56	47	46	38	51
TOTAL	272	257	351	279	266

Survival ratios in 0.0, 10.0, 16.9, 25.3, 50.7, and 67.0 Gy-irradiated 'Sarılop' plants were 76, 85, 75, 63, 56, 2%, respectively. In 67.0 Gy-irradiated plants, only one 'Sarılop' clone survived. Survival ratios in 0.0, 10.0, 16.9, 25.3, 50.7, and 67.0 Gy-irradiated 'Sarı Zeybek' plants were 71, 71, 66, 49, 4, and 0%, respectively. Survival ratios in 0.0, 10.0, 16.9, 25.3, 50.7, and 67.0 Gy-irradiated 'Bursa Siyahı' plants were 63, 77, 83, 62, 12, and 0%, respectively. Survival ratios in 0.0, 10.0, 16.9, 25.3, 50.7, 67.0 Gy-irradiated 'Beyaz Orak' plants were 52, 45, 45, 21, and 0%, respectively. Finally, survival ratios in 0.0, 10.0, 16.9, 25.3, 50.7, and 67.0 Gy-irradiated 'Siyah Orak' plants were 38, 42, 18, 17, 0% respectively (Fig. 1).

Lethal dosages were defined as 50.7 Gy for 'Sarılop', 25.3 Gy for 'Bursa Siyahı' and 'Sarı Zeybek', 10.0 Gy for 'Beyaz Orak' and 'Siyah Orak' cultivars, respectively. Gulsen et al. [17] found similar LD_{50} dosages for lemon (*Citrus limon* (L.) Burm.). However, 40 Gy was lethal in *Prunus avium* L. [31].

Irradiated cultivars, particularly, 'Siyah Orak' and 'Beyaz Orak' indicated low levels of survival ratios. These may be caused by lose of turgor during the treatment and other experimental errors. In addition, irradiated and control 'Bursa Siyahı' buds indicated the similar survival ratios. This may also be due to genetic factors and environmental variations within experiment. Another reason could be graft incompatibility of rootstock 'Sarılop' cultivar with cultivars irradiated.

Shoot growth responses of irradiated and control M1V1 plants

Two-way interaction between five cultivars and six dosage levels was analyzed for shoot growth at 16th week after grafting. To make statistical analysis of post hoc tests, 67.0 Gy-irradiated plants of 'Sarılop' were not included because of insufficient number of surviving M1V1 plants. Therefore, five gamma irradiated fig plants (0.0, 10.0, 16.9, 25.3, and 50.7) were analyzed. On shoot growth recorded at 16th week, cultivars and dosage levels had significant interaction at alpha 0.01 level (Table 2). 'Sarılop', 'Bursa Siyahı' and 'Sarı Zeybek' had more shoot growth than 'Beyaz Orak' and 'Siyah Orak' at 10.0, 16.9 and 25.3 Gy gamma irradiations.

Table 2. Two-way interaction analysis of observed shoot growths at 16th week after grafting

	Shoot growth (16. week)		
	Df	F	*P*
Corrected model	22	10.9	<0.001
Intercept	1	3201.3	<0.001
Cultivar	4	23.9	<0.001
Dosage level	4	12.4	<0.001
Cultivar x dosage level	14	4.7	<0.001
Error	546		
Total	569		
Corrected total	568		

The mean difference is significant at *alpha* 0.01 level.

The five dosage levels had differential effects on shoot growth as measured in five fig cultivars ($p < 0.01$). 'Beyaz Orak' (33 cm) and 'Bursa Siyahı' (30 cm) were in the same group, while 'Sarılop' (28 cm), 'Sarı Zeybek' (25 cm) and 'Siyah Orak' (21 cm) cultivars were different from each other for shoot growth at 16th week after grafting (Table 3).

Studies on development of new fig cultivars are scarce. Several promising cultivars were developed in USA and ex USSR through hybridization breeding. However, incidence of fruit loss or quality deterioration due to endosepsis, smut and other internal diseases is especially high in the 'Calimyrna' cultivar [32]. Hybridization breeding has been not successful enough to obtain intended aims explained above. Thus, the results of this study might be important for breeders.

So far, there have been few reports on other tools aiming fig improvement. The first was polyploidy using colchicines on germinating seeds. Arising plants were weak in tree vigor, had malformed leaf shape, irregular fruit set, and undesirable fruit quality [1]. The second was mutation breeding carried out by Akhund-Zade [16], which 'Bol' fig cultivar was developed.

The most frequent findings were decreased tree vigor and accelerated fruiting. Gamma irradiation causes chromosomal rearrangements that may be related to multiple trait alterations [28]. Irradiated plants also showed variations for fruit maturation time, flowering, branching habit, and thorniness [26]. Therefore, the results of this study may have significant contribution in fig breeding program where only a few studies were reported. Most suitable irradiation dosage for breeding programs may vary among species and cultivars. This was the first report on the effects of different dosage levels of gamma irradiation on different fig cultivars. Two-way interaction analyses indicated that fig cultivars differed in shoot growth in response to five dosage levels.

This is evidence that the most suitable dosage level of each cultivar should be determined for breeding programs. In this study, it appears that 10.0 Gy gamma irradiation caused small modifications while 16.9, 25.3 and 50.7 Gy irradiation caused large alterations in genotypes, perhaps due to chromosomal rearrangements such as deletions, translocations, and inversions.

Survival ratios were lower in higher dosage levels in all fig cultivars. 'Sarılop', 'Sarı Zeybek' and 'Bursa Siyahı' which are cultivars of "Smyrna type" showed more survival ratios than 'Beyaz Orak' and 'Siyah Orak' parthenocarpic fresh fig cultivars, as named "San Pedro" and "Common type", respectively. Caducous cultivars had more performance and resistance against high gamma irradiation dosages.

Lethal dosage (LD_{50}) levels also differed among the five fig cultivars. Lethal dosages were 50.7 Gy for 'Sarılop', 25.3 Gy for 'Bursa Siyahı' and 'Sarı Zeybek', 10.0 Gy for 'Beyaz Orak' and 'Siyah Orak' cultivars. These results are concordant with the findings of Uzun et al. [33], which showed that 'Beyaz Orak' was distinct from the other cultivars. Indeed, 'Beyaz Orak' and 'Siyah Orak' parthenocarpic cultivars are quite different from other caducous fig cultivars in tree vig"or and fruit characteristics.

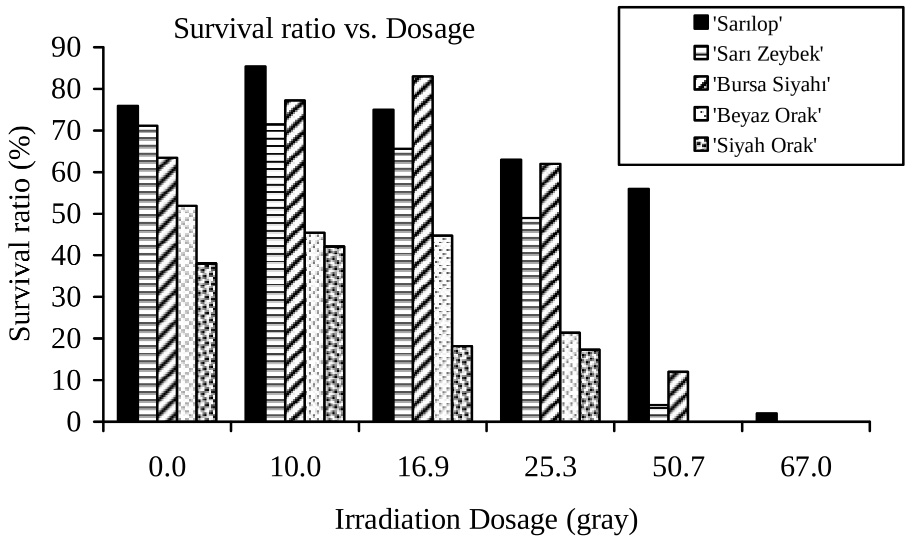

Fig. 1. Survival percentages among the irradiated plants with six different dosages (0.0, 0.0, 16.9, 25.3, 50.7, and 67.0). Experimental units for each treatment are shown in 'Sarılop', 'Sarı Zeybek', Bursa Siyahı', 'Beyaz Orak' and 'Siyah Orak' cultivars, respectively.

Table 3. Shoot growth means at 16th week after grafting on different gamma irradiated fig plants

Cultivars	Dose (Gy) Control	10.0	16.9	25.3	50.7	Mean
	Shoot growth [mean (x) (cm) ± standard error of mean (SEM) (s_x) at 16th week)]					
'Sarılop'	39.3±1.3	30.4±1.6	30.0±1.5	23.3±2.0	19.1±1.4	28.4±1.6 b
'Sarı Zeybek'	30.6±0.9	23.2±1.3	22.8±1.2	25.7±1.6	23.0±3.5	25.1±1.7 c
'Bursa Siyahı'	30.6±1.4	31.7±1.5	36.8±1.5	29.4±1.3	21.2±1.6	29.9±1.5 ab
'Beyaz Orak'*	33.4±1.9	34.5±2.0	34.5±2.5	30.2±2.9	0	33.2±2.3 a
'Siyah Orak'*	22.1±1.9	26.4±2.5	19.5±2.2	15.2±2.5	0	20.8±2.3 d
Mean	31.2±1.5	29.2±1.7	28.7±1.8	24.8±2.1	21.1±2.2	27.5±1.9

*For 'Beyaz Orak' and 'Siyah Orak' cultivars, mean shoot growths were calculated for four gamma irradiation levels (0.0, 10.0, 16.9, and 25.3 Gy, except for 50.7 Gy), because all mutant clones were died in 50.7 Gy gamma dosages in these cultivars. The values followed by the same letter do not show statistically significant differences ($p < 0.01$).

The largest variation of shoot growth was from 25.3 Gy for 'Sarılop' (23 ± 10), 25.3 Gy for 'Sarı Zeybek' (25 ± 7), 16.9 Gy for 'Bursa Siyahi' (31 ± 10), 10.0 Gy for 'Beyaz Orak' (34 ± 10), and 'Siyah Orak' (26 ± 10) cultivars. Thus, these dosages can be recommended for fig breeding programs thorough gamma irradiation.

These results were consistent with our field observations. 'Sarılop', 'Bursa Siyahı', and 'Sarı Zeybek' cultivars are caducous and have strong tree growth habit; thus their M1V1 plants are shown stronger development than other fig cultivars as reported by Yalcinkaya and Kaynas [34]. Sahin and Balci [35] reported that both 'Beyaz Orak' and 'Siyah Orak' have weak apical dominancy. In conclusion, these two cultivars tolerate less dosage levels than 'Sarılop', 'Sarı Zeybek', and 'Bursa Siyahı', which should be considered in fig breeding programs.

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References

1. Storey. W.B., Figs. In: Advances in Fruit Breeding (Janick, J. and J. Moore Eds.) pp. 568-589. Purdue Univ. Press. Indiana, USA, 1975.
2. Jona, B., Gribaudo, I., Ficus spp. Biotechnology in Agriculture and Forestry, 16: 76-93, 1991.
3. Condit, I.J., The Fig. Waltham, Chronica Botanica, 1947.
4. Zukowskij, P.M., Ficus. In: Cultivated plants and their wild relatives. State Publishing House Soviet Science, pp. 58-59, 1950.
5. Petrova, E. F., Voronova, O. G., Biological characteristics of figs in Abkhazia. Naucho Tekhnicheskii Byulleten 141: 163-166, 1984.
6. Aksoy, U., Present status and future prospects of underutilized fruit production in Turkey. Cah Options Mediter 13: 97-107, 1995.
7. Grassi, G., Il fico: Acquisizioni scientifiche italiane dell'ultimo trentennio. Fruitticoltura 44: 7-16, 1998.
8. Grassi, G., Santonastaso, M., The fig growing in Italy: The present state and problems. In: Proceedings of the 1st International Symposium on Fig (Aksoy, U., L. Ferguson & S. Hepaksoy Eds.), pp. 31-36. Acta Hortic. 480, Izmir, Turkey, 1998.
9. Mars, M. et al., Multivariate analysis of fig (Ficus carica L.) germplasm in southern Tunisia. In: Proceedings of the 1st International Symposium on Fig (Aksoy, U., L. Ferguson and S. Hepaksoy Eds.) pp. 75-81. Acta Hortic. 480, Izmir, Turkey, 1998.
10. Kuden, A.B., Tanriver, E., Plant genetic resources and selection studies on fig in the East Mediterranean and South East Anatolia Regions. In: Proceedings of the 1st International Symposium on Fig (Aksoy, U., L. Ferguson and S. Hepaksoy Eds.) pp. 49-54. Acta Hortic. 480, Izmir, Turkey, 1998.
11. Kutlu, E., Aksoy, U., Further evaluation of selected 'Sarilop' (Calimyrna) clones. In: Proceedings of the 1st International Symposium on Fig (Aksoy, U., L. Ferguson and S. Hepaksoy Eds.) pp. 265-270. Acta Hortic. 480, Izmir, Turkey, 1998.
12. Caliskan, O., Polat, A.A., Fruit characteristics of fig cultivars and genotypes grown in Turkey. Scient Hortic 115: 360-367, 2008.
13. IBPGR, *Ficus carica*. Genetic resources of tropical and sub-tropical fruits and nuts, pp. 63-69, 1986.
14. Maluszynski, M., et al., Officially released mutant varieties. The FAO/IAEA database. Mutation Breeding Review 12: 1-84, 2000.
15. Gulsen, O., Roose, M.L., Lemons: diversity and relationships with selected citrus genotypes as measured with nuclear genome markers. J Amer Soc Hort Sci 126: 309-317, 2001.
16. Akhund-Zade, I.M., Radiation mutagenesis in subtropical crops. L-ya Vses onf. Po Prikl. Radiobiol 50-51, 1981.
17. Gulsen, O., et al., Development of seedless and Mal Secco tolerant mutant lemons through budwood irradiation. Scient Hort 112: 184-190, 2007.
18. Fuentes, J.L., et al., Mutation induction in zygotic embryos of avocado (Persea americana Mill). Biotechnologia Aplicada 21: 82-84, 2004.
19. Yao, J.L., et al., Parthenocarpic apple fruit production conferred by transposan insertion mutations in a MADS-box transcription factor. PNAS 98: 1306-1311, 2001.
20. Selvi, B.S., et al, Genetic variability studies in gamma ray induced amla (Emblica Officinalis Gaertn.) grafts. J Applied Science Research 3:1929-1932, 2007.
21. Pridieri, S., Gatti, E., Effects of gamma radiation on plum (*Prunus salicina* Lindl.) 'Shiro'. Adv Hort Sci 14: 215-223, 2000.
22. Pridieri, S., Fasolo, F., High-frequency shoot regeneration from leaves of the apple rootstock M26 (Malus pumila Mill.). Plant Cell Tiss Org Cult 17: 133-142, 1989.
23. Gustafson, A., The X-ray resistance of dormant seeds in some agricultural pants. Hereditas 30: 165-178, 1944.
24. Zagaja, S. W. et al., Development of compact mutants in apple and sour cherry. In induced mutations in vegetatively propagated plants. II. Proc. Final Res. Coord. Meet. IAEA, Vienna, 1982.
25. Lacey, C.N., Cambell, D., Selection, stability and propagation of mutant apples, improving vegetatively propagated crops. Botany 11: 197-200, 1987.
26. Davies, F.S., Albrigo, L.G., Citrus. CAB International, Wallingford, Oxon, UK., 1994.
27. Mars, M., Fig (*Ficus carica* L.) genetic resources and breeding. In: Proceedings of the 2nd International Symposium on Fig (Lopez Corrales, M. and M.J. Bernalte

Carcia Eds.) pp. 19-27. Acta Hortic. 605, Caceres, Spain, 2003.

28. Fehr, W.R., Mutation breeding. Theory and Technique. Principles of Cultivar Development, vol.1, Macmillian Publishing Comp., NY, USA, 1993.
29. Kabasakal, A., et al., Pomological studies on 'Sarı Zeybek' fig variety. Final reports of fig researches project. Erbeyli Fig Research Institute, Incirliova, Aydin, Turkey, 1988.
30. Aksoy, U., Some significant results of the research – work in Turkey on fig. In: Proceedings of the 2nd International Symposium on Fig (M. Lopez Corrales & M.J. Bernalte Carcia Eds.), pp. 173-181. Acta Hortic 605, Caceres, Spain, 2003.
31. Yang, H., Schmidt, H., Selection of a mutant from adventitious shoots formed in X ray treated cherry leaves and differentiation of standard and mutant with RAPDs. Euphytica 77, 89-92, 1994.
32. Doyle, J.F., Fig cultivar development and evaluation. In: Proceedings of the 2nd International Symposium on Fig (M. Lopez Corrales & M.J. Bernalte Carcia Eds.), pp. 29-32. Acta Hortic 605, Caceres, Spain, 2003.
33. Uzun, H.I., et al., Molecular identification of Turkish fig cultivars by fruit and leaf isoymes. In: Proceedings of the 2nd International Symposium on Fig (Lopez Corrales, M. and M.J. Bernalte Carcia Eds.) pp. 45-50. Acta Hortic. 605, Caceres, Spain, 2003.
34. Yalcinkaya, E., Kaynas, N., Morphological behaviours of some fig varieties under Yalova conditions. In: Proceedings of the 2nd International Symposium on Fig (Lopez Corrales, M. and M.J. Bernalte Carcia Eds.) pp. 95-96. Acta Hortic. 605, Caceres, Spain, 2003.
35. Sahin, B., Balci, B., Studies on phenological and pomological properties of breba fruit producing fig varieties. In: Proceedings of the 1st International Symposium on Fig (Aksoy, U., L. Ferguson and S. Hepaksoy Eds.) pp. 91-96. Acta Hortic. 480, Izmir, Turkey, 1998