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Full Length Research Paper

Gamma irradiation influences on some biological traits in two almond (*Prunus amygdalus*, L) cultivars

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Mutation by ionizing radiations such as gamma-rays is being employed as one of the mutation breeding approaches to obtain the desirable mutant cultivars and genotypes in plants. Almond cultivars 'A200' and 'Sahand' are self-incompatible following pollination and fertilization problems. Therefore, obtaining their late-flowering and self-fertile mutants with good biological traits, by means of mutation, will be very bounteous for breeders and producers. This study was conducted to evaluate the effects of different exposition times to gamma-radiation on some biological traits of two late-blooming cultivars 'A200' and 'Sahand'. Current shoots of 'A200' and 'Sahand' were exposed to 36 µC gamma-radiation for 0, 5, 10, 30 and 150 min from the Cobalt 60. The factorial experiment was carried out on 4-year old irradiated trees based on completely-randomized design (CRD) and some biological traits such as: resistance to diseases agents, partial fungus and pests (aphid, mite, etc.), blooming date, leaf bud break date, bearing type, leaf area (LA) and flower density were investigated in all irradiated plants. Results showed that long exposition times have significant positive effects on resistance to disease agents such as: "*polystigma occharaceum*", mite, LA and flower density, but did not have significant effect on bearing type, resistance to aphids, blooming and leaf bud break dates in spring. Effects of cultivars were significant on resistance to pests (aphid, mite and other main destructive pests) and diseases agents and bearing type, while no significance was seen on blooming, leaf bud break dates, LA and flower density. Interaction effect between cultivars and exposition time was significant on resistance to diseases, mite and flowering date, but was not significant on LA, flower density, resistance to aphid and leaf bud break date. However, the maximum resistance to diseases agents, aphid and mite was observed in plants irradiated 150 min in both cultivars.

Key words: Almond, breeding, mutants, gamma-irradiation, biological traits.

INTRODUCTION

Mutation of plants with different methods such as irradiation and chemical substances has been used by many researchers in biotechnology and tissue culture breeding techniques. Almond (*Prunus amygdalus L.,*) is one of the most important nut fruits produced in Iran, and currently, it ranks 5th among almond producing countries (FAO, 2007). The most important almond breeding program in Iran is obtaining cultivars with the following traits: late-blooming, frost resistance, self-fertility, resistance to diseases and pests, high yielding and good growth habit. Mutation by physical agents such as α, β, x and gamma rays have been applied for tree fruit breeding too (Veiliev, 1979). However, some new mutated cultivars with new favorable traits are obtained by means of irradiation in apple (Lapins, 1970), cherry (Lapins, 1964), peach (Terraciana, 1968) and almond (Monastra et al., 1988; Garcia et al., 1992). Lapins (1970) obtained a new gamma irradiated induced mutant of 'McIntosh' with resistance to "*Podospharea leucotricha*" and "*Venturia inaqaulis*", while Monastra et al. (1983) irradiated the scions of 'Fascionello' almond cultivar by 3 kr

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Table 1. Analysis of variance for the studied biological traits in two almond cultivars. Traits are respectively, flower blooming date (FBD), leaf bud break date (LBD), bearing type (BT), leaf area (LA), flower density (FD), resistance to polystigma occharaceum (R.P) , resistance to aphid (R.A) and resistance to mite (R.M).

SOV	DF	FBD	LBD	BT	LA	FD	R.P	R.A	R.M
DGRT	4	1.1ns	75.4ns	0.4 ns	472090.6 *	1.1**	2.1ns	0.7ns	112.5**
Cultivar	1	0.04ns	38.9ns	36.9**	1182977.5*	1.24*	1010.3**	9.6**	78.7*
DGRT	4	4.6**	107.2ns	0.43 ns	300299.4ns	0.1ns	1.2ns	1.2 ns	69.1**
Error	257	1.2	88.5	0.20	194564.9	0.2	1.1	0.9	19.4
CV (%)		20.0	15.5	17.84	12.1	35.0	30.9	35.1	103.2

** and *: Significant at P<0.01 and P<0.05% levels, respectively; ns: Non significant.

Table 2. Comparison of means for different gamma radiation times (DGRT) in the studied biological traits in two almond cultivars. Traits are respectively, flower blooming date (FBD), leaf bud break date (LBD), bearing type (BT), leaf area (LA), resistance to polystigma occharaceum (R.P) , resistance to aphid (R.A) and resistance to mite (R.M).

DGRT	FBD	LBD	BT	LA	R.P	R.A	R.M
Control	5.5a	5.5 a	2.4 a	321 ab	3.5 b	3.0 a	8.8 b
5 min	5.7 a	5.7 a	2.6 a	231.8 b	4.1 a	2.82 a	4.3 b
10 min	5.4 a	5.4 a	2.5a	334.8 ab	3.2 b	2.75 a	4.2 b
30 min	5.4 a	7.4 a	2.5a	318.6 ab	3.4 b	2.71 a	4.3 b
150 min	5.2 a	5.2 a	2.5 a	488.5 a	3.2 b	2.6 a	3.0 a

Same letters show not difference among different gamma cultivars at DGRT in each column and different letters in columns show significant difference based on Duncan's New Multiple Range Test ($p< 0.05$).

gamma–rays from Co60 and obtained a new mutated cultivar ‘supernova’ with late-flowering, high shelling percentage and self-fertility traits. Moreover, Andrew (1990), with studding gamma irradiation as a quarantine treatment for sweet cherries against Queensland fruit fly, introduced some tolerant mutants, whereas Deocoutye (1967) found russet-free sectors on fruits of "golden delicious" apple trees after gamma irradiation. Sharafi et al., (2005) investigated the effects of different gamma irradiation times on some physiological and morphological characteristics of two of cultivars from P. amygdalus L., and reported very different results on the studied characteristics.

Our purpose was to study the effects of $36^{\mu C}$ (micro cowry) gamma-ray at different times on self-fertility and some biological traits such as flowering date in spring, resistance to diseases and pests in the two late-flower almond cultivars ‘A200’ and ‘Sahand’ for using commercially in producing and breeding programs.

MATERIALS AND METHODS

One-year old shoots of 'A200' and 'Sahand' in 2000 were divided into 5 groups and irradiated by $36^{\mu C}$ gamma–ray at 0, 5, 10, 30 and 150 min from co60 in a nuclear partition of the Faculty of Science, University of Tabriz and were then grafted on 'Azar' seedling. Afterwards, young irradiated trees were maintained for about 1 year at nursery and then 267 trees were transmitted to the main garden in Sahand Horticulture Research Station in Azarshahre, Tabriz. As such, the trees were planted in 4 west-east rows in a sandy-loam soil. All the environmental conditions and horticultural practices (irrigation, nutrition … and etc) for all irradiated trees were equal and as a consequence, biological traits were noted for all genotypes according to the international almond descriptor (Gulcane, 1985). Flower blooming date (FBD) in spring and leaf-buds break date (LBD) were: extremely late, 9; very late, 8; late, 7; medium to late, 6; early, 3 and very early, 2. As such, the leaf area (LA) was measured with the leaf area meter set for 30 mature leaves of all trees. However, bearing type (BT: on spore, 2; on current shoot, 1 and Mixed, 3) resistance to aphid ("*Brachycaudus amygdalinum*": R.A), mite ("panonychus ulmi": R.M) and "polystigma occharaceum" (R.P) were grouped as: very susceptible, 7; medium susceptible, 5 and low susceptible, 3, according to the almond descriptor. In the study, the factorial experiment was carried out by the completely randomized design (CRD), while the statistical analysis was carried out by the SAS software. However, comparisons of means were carried out by Duncan's new multiple range tests.

RESULTS AND DISCUSSION

Analysis of variances (Table 1) showed that leaf area (LA), flower density (FD) and resistance to mite (R.M) were significantly affected by different gamma radiation times (DGRT), but no effect was shown on other traits. Also, significant differences were observed between two cultivars only for bearing type (BT), leaf area, flower density, resistance to “*Polistigma occharaseum*" (R.P), resistance to aphid (R.A) and resistance to mite (R.M), while interaction between cultivars x DGRT was significant only for full blooming date and resistance to mite.

Comparison of means in Table 2 indicated that increasing the gamma radiation time (GRT), increased

Table 3. Comparison of means for the studied biological traits between two almond cultivars. Traits are respectively, flower blooming date (FBD), leaf bud break date (LBD), bearing type (BT), leaf area (LA), flower density (FD), resistance to polystigma occharaceum (R.P) , resistance to aphid (R.A) and resistance to mite (R.M).

Cultivars	FBD	LBD	BT	LA	FD	R.P	R.A	R.M
'Sahand'	5.3 a	5.3 a	3.0 b	262.6b	1.3 a	5.6b	3.0b	5.4 b
'A200'	5.5 a	6.7 a	2.1 a	413.3a	1.1b	1.0a	2.4 a	3.0 a

Same letters show not difference among cultivars in each column and different letters in columns show significant difference based on Duncan's New Multiple Range Test ($p< 0.05$).

Table 4. Comparison of means for interaction between cultivar x DGRT.

Cultivars	DGRT	FBD	R.M
'Sahand'	Control	5.0 a	6.2 d
	5 min	ab	5.7 cd
	10 min	5.45 ab	5.5 cd
	30 min	5.05 b	5.9 d
	150 min	5.43 ab	4.5 bcd
'A200'	Control	5.0 b	11.85e
	5 min	5.88 a	2.33 ab
	10 min	5.45 ab	3.32abc
	30 min	5.93 a	2.51 ab
	150 min	5.13 ab	1.41 a

Same letters show no difference among cultivars X DGRT in each column.

the leaf area and resistance to mite, but did not have any effect on other traits. By raising the GRT, flower density increased especially in 'A200' (data not shown). As such, FBD, LBD, BT, R. P and R.A, in different gamma radiation times (DGRT), were similar to the control. Table 3 showed that except for flower density, all other traits in 'A200' were better than 'Sahand'. Comparison of means of DGRT x cultivars in Table 4 indicated that interaction between DGRT x Cultivar was significant only for resistance to mite and flowering date (Table 4). As a result, increasing GRT, raised resistance to mite in 'A200', but did not affect 'Sahand'. Also, increasing the GRT, promoted the flowering date of 'A200', but did not affect 'Sahand'. In this study, shoots (scions) of 'A200' and 'Sahand' cultivars were irradiated from 36µc gamma-ray at different occasions. Results showed that 150 min gamma–radiation increased resistance to mite especially in 'A200', but not in 'Sahand'. Also, increasing gamma radiation times, accelerated the flowering time both in 'A200' and 'Sahand'. It should be noted that, in this experiment, the maximum resistance to aphid and mite "*polystigma occharaceum*" and the maximum LA for 'A200' were observed in the maximum gamma radiation time, whereas it was not shown in the data analysis. Similar to these results, Lapins (1970), in apple 'McIntosh' cultivar, obtained new mutated cultivar (McIntosh 8f-2-32) with resistance to "*Podosphaera leucotricha*" and "*Venturia inaequalis*".

Also, Zhukou-os (1979) obtained mutants that are resistant to "*Coccomyces hiemalis*" by means of gamma and X-rays in some cherry cultivars. Legava and Garacia (1987; 1992) and Monastra et al. (1988) obtained mutants with very dwarf growth habit and very late flower from irradiation on 'Ferrgnes', 'pizzuta- d' Avola' and 'Fascionello', almond cultivars. In most of the tree fruits breeding programs, many mutant genotypes and cultivars with favorable traits such as dwarfing growth habit, late blooming, colorful fruits, pest and diseases tolerance have been obtained by means of irradiation on the buds, callus, shoots and meristems in different techniques of biotechnology and tissue culture (FAO/ IAEA). In the similar study, Sharafi et al. (2005) irradiated two cultivars of almond with gamma ray for obtaining self-fertile genotypes following evaluation of the effects of gamma on physiological and morphological traits and finally; they reported genotypes with open center, dwarf and high yield mutated genotypes. However, in this research, flowering date of both 'A200' and 'Sahand' was accelerated by gamma radiation.

Conclusion

Incredibly different effects were observed in both cultivars, in that, positive effects were often observed in "A200" and negative effects were observed in "Sahand"

irradiated trees. Moreover, it should be noted that, many genotypes (mutants) with late blooming, dwarf growing habit, pest and diseases tolerance have been found in 10 years study on the irradiated trees and will be introduced for breeding and commercially growing programs as soon as possible.

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