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Full Length Research Paper

A study of the influence of different rootstocks on the vegetative growth of almond cultivars

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This study investigated different seed rootstocks (bitter almond, peach seedling and sweet almond seedling), the reactions of these rootstocks with three different almond cultivars (Shahrood cultivars of 15, 12 and 18) and their effect on vegetative growth as well as the effect of the rootstocks on nutrient absorption. The used research design was a split plot in the form of complete randomized block design in three replicates in which the original factor of scion cultivar and sub factor of rootstock type was applied. Features measured during the design included: plant height, trunk diameter, extension width and effect of rootstock on the absorption of nitrogen, phosphorus and potassium. The obtained results indicate that vegetative growth with rootstock of bitter almond, which is mostly used, was less than the other tested rootstocks in the early years and peach rootstock had more vegetative growth. Also, rootstock had a meaningful impact on nutrient absorption so that the greatest amount of nitrogen absorption was obtained by the peach rootstock and the highest amount of potassium absorption was achieved by sweet almond rootstock.

Key words: Almond rootstocks, scion cultivar, vegetative growth, nutrient absorption.

INTRODUCTION

When garden design is going to be determined, the rootstock and scion type should be specified according to its place features to achieve the best and highest amount of the product. Therefore, their advantages and defects should be considered in order to choose the best options. Although the root system through its optimal adaptation to soil conditions is effective in a good production, stable properties are less obvious and thus are less known and most morphological features of scion such as flowering time, pollination needs and habits of growth and fruit quality have been studied from rootstock properties (Felipe et al., 1997). In previous years, the focus has been on the better race for size controller rootstocks (dwarf and semi-dwarf) due to the cost of pruning, spraying, sparse fruit, difficulty of large trees harvest and labor costs (Cummins and Norton, 1974). There are different reports about rootstock effects on flowering time of different species of fruit trees. Also, regarding the increase of fruit in the garden, it is said that rootstock does this work through removing growth balance in favor of reproductive growth (Niki and Sultz, 2004). Seed rootstocks of big almond trees have longevity and deep roots that need deep soil with good drainage. Although these rootstocks more tolerate drought than the rootstocks of peach and plum, their regular irrigation will be completely effective for production of a desired product.

This rootstock in deep soil can better tolerate water stress during harvest than the peach and plum rootstocks but they are considered as most sensitive almond rootstocks against soil moisture conditions and the most tolerant against the limestone which is on top of the soil. Almond rootstock harvest time in comparison with other rootstocks is somehow delayed probably due to slow growth in their early growing years (Grasly, 1977). Due to the difficulty of vegetative production, less amount of uniform and genetic almond rootstock is kept while traditional almond seeds are used for all almond growing

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areas. In this case, bitter almond seeds are preferred because it is believed that they are more resistant to drought and soil pests than grains obtained from sweet almond seeds although desirable mentioned features are not verified; by doing so the bitter almond seeds are also used. These rootstocks like most seed rootstocks show different properties in the garden. In recent years, seeds of selected cultivars are recommended because of complete uniformity and good features represented in the treasury. Almond growing in California under irrigation conditions does not allow almond seeds to be used as rootstock. Therefore, although the problem of different properties is not completely solved, seeds of selected cultivars like Lowell and Namagard have been used (Felipe et al., 1997). Repeated attempts to choose a colony rootstock failed due to difficulty of increased vegetative. Thus, the first rootstock used for almond had different choices than plum that is a kind of species that is mainly increased easily by vegetative increase which has a good compatibility with the heavy soil and fungal problems. Plum rootstocks need high amount of irrigation and are not compatible with conditions without irrigation. These requirements limit their application in the Mediterranean area where most almond growth is available without irrigation. Also, plum rootstocks show some cases of incompatibility with binding to some almond cultivars but some plum colonies of hexaploid have good compatibility with almonds that can be used under irrigation condition (Felipe et al., 1997; Nicotra and Pellegrini, 1989).

MATERIALS AND METHODS

This study was performed to evaluate the performance of different seed rootstocks and the impact of rootstock on vegetative properties of different almond cultivars in 2005 to 2010 at Semnan Agricultural Research Center (Shahrood). Rootstocks which were used included bitter almond, sweet almond and peaches seed rootstocks. Also, scion cultivars were considered as almonds with cultivars of 15-18-12; among these three cultivars, the 15 and 18 cultivars were made of paper and 12 was made of stone. Also, cultivars of 18 and 12 have the superior property of late flowering and also cultivar 12 in most parts of the country shows a good compatibility. The research design used was split plot in the form of complete randomized block design. For implementation of this design, the related seed rootstocks was prepared and planted at the treasury. In 2006, the related almond cultivars were bonded on rootstocks of seeds that were almost in the same size and growth and in 2008, seeds were transferred to the original location. Vegetative factors considered in this design included: trunk diameter measured from 20 cm above the soil surface, the annual growth rate of seedlings, width or radius of tree expansion, trees height and the absorption rate of high consumption elements of nitrogen, phosphorus and potassium.

RESULTS

Trunk diameter

Variance analysis (Table 1) shows the data obtained for the trunk diameter property and it indicates that in different rootstocks, the trunk diameter size was meaningfully different and also, the scion cultivar had no significant effect on the tested trunk diameter. Also, interaction treatment of rootstock type and scion cultivars had no significant effect on trunk diameter of the tested seedlings.

Also, according to the table which compares the average of these results, it can be observed that peach and sweet almond rootstocks in comparison with bitter almonds had more trunk diameter such that peach trunk diameter (3.463 cm) was more than those of the two other rootstocks. Also, the highest amount of trunk was obtained through combination of peach rootstock and Shahrood 15 cultivar and the lowest one (2.333 cm) was obtained from Shahrood 15 cultivar on bitter almond rootstock.

Annual growth rate

According to the results of recorded data analysis about annual growth rate of seedlings, it was found that although the scion cultivar had no significant impact on annual growth rate, rootstock type and interaction of rootstock type and scion cultivar had significant effect on annual growth rate of the seedlings (Table 1). Investigation of the comparison of averages about this property (Tables 1, 2 and 3) show that the highest amount of growth was related to sweet almond rootstock and the least one was related to the bitter almond rootstock.

Also, in the examination of the effects of interaction treatments, the highest amount of annual growth was based on a combination of Shahrood 18 on sweet almond rootstock (42.17 cm) and the lowest growth was related to sweet almond and Shahrood 15 (23.67 cm).

Extension width

Variance analysis table about extension width attribute of almond seedlings shows that unlike the scion cultivar, the rootstock had no significant effect on this property and interaction of rootstock treatment and scion cultivar had no significant effect on the seedling extension width. The highest amount of seedling extension width (110.30 cm) was related to the peach rootstock and the lowest one was related to bitter almond (77 cm) (Table 4).

Seedling height

Variance analysis table indicates that rootstock has not a meaningful effect on seedling height but scion cultivar and rootstock interaction and scion had significant effect on seedling height. In this case, the tallest seedling was related to peach rootstock (152.7 cm), and the lowest

Table 1. Variance analysis of vegetative properties and the amount of mineral absorption experimental treatments in 2005-2010.

Source of variation	df	Mean square						
		Trunk circumference	Annual growth	Canopy expansion	Height	N uptake	P uptake	K uptake
Replication	2	0.319	153.898	1540.421	1292.429	3.369	0.009	0.191
Scion	2	0.104^{ns}	66.041^{ns}	6.028**	1171.290^{ns}	4.885^{ns}	0.001^{ns}	0.169^{ns}
Main error	4	0.361	39.776	670.799	274.412	1.712	0.002	0.187
Rootstock	2	3.158**	155.741*	189.361*	1629.911*	0.983^{ns}	0.001^{ns}	0.234^{ns}
Rootstock*scion	4	0.167^{ns}	88.444*	102.847^{ns}	664.429^{ns}	3.217*	0.005*	0.192**
Error	12	0.131	35.552	568.229	370.443	0.906	0.001	0.119
Correlation coefficient		11.97	19.75	24.15	13.58	19.63	14.23	18.71

Ns, not significant; * significant in 5% level and ** significant in 1%.

Table 2. Effect of different rootstocks, scion cultivars and its interaction on trunk diameter.

Rootstock/cultivar	Shahrood 12	Shahrood 15	Shahrood 18	Different rootstock
Bitter almond	3.683 a	2.353 a	2.993 ab	2.348 b
Sweet almond	3.567 a	2.333 a	3.500 a	3.251 a
Peach	3.140 a	2.357 b	3.260 a	3.463 a
Scion cultivars	3.919 a	3.010 a	3.133 a	

Numbers in each column with common letters statistically have no significant difference.

Table 3. Effect of different rootstocks, scion cultivars and its interaction on annual growth.

Rootstock/cultivar	Shahrood 12	Shahrood 15	Shahrood 18	Different rootstock
Bitter almond	28 b	25.33 b	28.67 b	26.44 b
Sweet almond	25.70 b	23.67 b	42.17 a	34.67 a
Peach	34.67 ab	30.33 b	33.17 ab	29.46 ab
Scion cultivars	32.72 a	27.33 a	30.51 a	

Numbers in each column with common letters statistically have no significant difference.

Table 4. Effect of different rootstocks, scion cultivars and its interaction on canopy expansion.

Rootstock/cultivar	Shahrood 12	Shahrood 15	Shahrood 18	Different rootstock
Bitter almond	116 a	78.67 a	102.8 a	77 b
Sweet almond	110.7 a	74 a	113 a	108.9 a
Peach	104.2 a	78.33 a	110.8 a	110.3 a
Scion cultivars	97.78 a	17.99 a	22.99 a	

Numbers in each column with common letters statistically have no significant difference.

seedling was obtained from bitter almond rootstock (126.7 cm). Also, in an investigation of averages obtained from the effect of rootstock interaction and scion, the highest seedling (171.3 cm) was a combination of Shahrood 18 on almond rootstock Shahrood 12 on bitter almond rootstock and the shortest one was related to a combination of shahrood 15 cultivar on sweet almond rootstock (115.7 cm) (Table 5).

Absorption rates

Variance analysis table about effect of rootstock and scion cultivar on high consumption elements absorption shows that the related used rootstocks had no meaningful effect on absorption of nitrogen and phosphorus while interaction of rootstock type and scion cultivar had significant effect on the absorption rate of the

Table 5. Effect of different rootstocks, scion cultivars and its interaction on height.

Rootstock/cultivar	Shahrood 12	Shahrood 15	Shahrood 18	Different rootstock
Bitter almond	171.3 a	136 abcd	155abc	126.7 b
Sweet almond	163.2 ab	115.7d	138.8 abcd	145.7 ab
Peach	123.4 cd	128.3 bcd	143.3 abcd	152.7 a
Scion cultivars	131.7 b	154.1 a	139.2 ab	

Numbers in each column with common letters statistically have no significant difference.

Table 6. Effect of different rootstocks, scion cultivars and its interaction on N uptake.

Rootstock/cultivar	Shahrood 12	Shahrood 15	Shahrood 18	Different rootstock
Bitter almond	4.663 ab	2.777 c	4.763 ab	4.068 a
Sweet almond	5.607 ab	5.100 ab	4.140 bc	4.949 a
Peach	4.713 ab	5.537 ab	6.343 a	5.531 a
Scion cultivars	4.994 a	4.471 a	5.082 a	

Numbers in each column with common letters statistically have no significant difference.

Table 7. Effect of different rootstocks, scion cultivars and its interaction on P uptake.

Rootstock/cultivar	Shahrood 12	Shahrood 15	Shahrood 18	Different rootstock
Bitter almond	0.223 abc	0.278 a	0.228 abc	0.243 a
Sweet almond	0.261 ab	0.21 bc	0.213 bc	0.228 a
Peach	0.268 ab	0.197 c	0.278 a	0.248 a
Scion cultivars	0.251 a	0.228 a	0.24 a	

Numbers in each column with common letters statistically have no significant difference.

Table 8. Effect of different rootstocks, scion cultivars and its interaction on K uptake.

Rootstock/cultivar	Shahrood 12	Shahrood 15	Shahrood 18	Different rootstock
Bitter almond	2.113 bc	1.567 cde	1.37 de	1.683 b
Sweet almond	1.80 bcd	2.317 b	3.063 a	2.393 a
peach	2.103 bc	1.167 de	1.083 e	1.451 b
Scion cultivars	2.01 a	1.683 a	1.839 a	

Numbers in each column with common letters statistically have no significant difference.

three mineral elements. Average comparison table about effect of rootstock effect indicates that most amount of nitrogen and phosphorus absorption was through peach rootstock (Tables 6 and 7) and the highest amount of potassium absorption was through sweet almond rootstock (Table 8). Also, in the investigation of rootstock type and scion cultivar interaction, tables of average comparison indicate that shahrood 18 cultivar on peach rootstock has the highest amount of nitrogen absorption (6.343%) while both shahrood 15 cultivar on bitter almond rootstock and shahrood 18 on peach rootstock have the highest amount of phosphorus absorption (0.278%) and 18 cultivar on sweet almond rootstock had the highest amount of potassium absorption (3.063%).

DISCUSSION

Results of this study show that the rootstock type was effective on all evaluated properties including trunk diameter, the annual growth rate of seedlings and its width extension. Interaction of rootstock treatment type and used scion cultivar was effective only for seedling annual growth rate and this issue focuses on special place of rootstock and very important impact of rootstock on initial seedling growth and therefore its impact on performance and other vegetative properties. According to the performed measurements, in most cases, the hybrid trees on the peach rootstocks had more growth than trees transplanted on almond rootstocks; this shows

that this issue corresponds with other reports on performance of almonds transplanted on peach rootstocks in different conditions and also on product early harvest of these trees (Arshi and Sheraftyan, 2002). Although, it should not be considered that formation rootstocks with more growth does not necessarily lead to the increase of production. Regarding this issue, it is said that selection of rootstocks with average growth and more trees per area in which more trees with higher density are planted are appropriate in order to achieve greater production.

In fact, the secret of achieving better performance is filling of garden with more canopies (Duncan, 2006). Another point about the peach rootstock is that these rootstocks contain a curtain system which is not like almond taproot and therefore in the old garden with peach rootstock, more trees falling will occur (Day, 1953). Although, the using of bitter almond rootstock for many years shows that these rootstocks produce big trees during several years, the harvest time of transplanted trees on almond seed rootstock will be delayed in comparison with other rootstocks. With a little attention to the mentioned issues and according to the results of this investigation about bitter almond growth which is less than other tested rootstocks, it can be concluded that although the transplanted trees on bitter almond rootstock have less growth in the early growing years, they are more resistance to bad environment conditions and some diseases (Stylianidis and Syrgianidis, 1989) and their greater longevity than the peach rootstock as well as system of almond rootstock which has been increased vertically with a good establishment are among the advantages of using this rootstock (Mick et al. 1996). Also, the effect of different rootstocks on the absorption of elements is different, although the importance of rootstock role as the most important factor in water absorption and nutrients is completely clear.

This issue can be attributed to rootstock type, its radiation and genetic factors. Results of this test show that peaches have the highest amount of nitrogen absorption which can be explained by considering rootstock type and its role in more absorption of nutrients. This result corresponds with other results of tests on several almonds rootstocks including peach and plum rootstocks, peach hybrids, almond and plum and almond among where peach rootstocks had the highest amount of nitrogen absorption in comparison with other rootstocks (Duncan, 2006).

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