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# Assessment of Vegetative Growth of Twelve Pistachio (*Pistacia vera*) Cultivars Grown in Northeast Iran

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## ABSTRACT

Khorasan Province has over 35,000 ha of pistachio orchards. Pistachio cultivation has increased considerably in the last two decades and pistachio growers have introduced many new genotypes to this region. This research was carried out in order to investigate the changes in vegetative characters of twelve pistachio cultivars ('Badami-sefid', 'Pesteh-gharmez', 'Pesteh-garmeh', 'Barg-seyah', 'Daneshmandy', 'Momtaz', 'Kale-ghochi', 'Akbari', 'Owhadi', 'Shahpasand', 'Abas-Ali' and 'Khanjari') in the Faizabad area, Khorasan Province, Iran over three years (2003-2005) following grafting onto 'Badami-sefid' rootstock. The first five cultivars are native to Khorasan Province while the others are native to Kerman and Semnan Provinces. Significant differences ($P<0.01$) were found in several vegetative characters: yearly shoot length, shoot diameter, tree width, graft length, the number of lateral shoots, leaf size and false growth. Shoot elongation was greatest in 'Owhadi' and 'Kale-ghochi', 54 cm and 51 cm, respectively, and least (34 cm) in 'Akbari'. Most lateral shoots formed in 'Abas-ali' and 'Akbari' and fewest in 'Shahpasand'. Leaf area, which was about 135 $cm^2$ and 67 $cm^2$ for 'Akbari' and 'Momtaz' respectively, was significantly different among all cultivars. After three years, total tree length of 'Owhadi', 'Badami-sefid' and 'Kale-ghochi' was 107, 104 and 103 cm, respectively, while 'Daneshmandy' showed the least growth (80 cm). When water salinity in the experimental orchard was more than 6 $dsm^{-1}$ and soil alkalinity was high, leaves started to die back in drought/salt-sensitive cultivars. Three cultivars, 'Owhadi', 'Abas-ali' and 'Akbari' showed the most marginal leaf necrosis, while 'Barg-seyah' had a unique die back pattern in the false growth section. This growth data may prove valuable for Iranian pistachio growers wishing to establish new orchards, but who are unsure of the appropriate choice of cultivar.

**Keywords:** compatibility, genotype, Khorasan, salinity

## INTRODUCTION

Dioecy, open pollination and sexual propagation are the main reasons explaining the creation of new genotypes and varieties in pistachio (*Pistacia vera*) orchards. Incidentally, Iran has the greatest pistachio genotypic diversity in the world (Sheibani 1995). In addition to Iran, three countries, namely the USA, Turkey and Syria are the main centers of pistachio cultivation. In Turkey, 'Uzun' and 'Kirmizi' are the most important cultivars and 'Sirrt' and 'Halebi' are less important. In Iran, four cultivars ('Sefid', 'Owhadi', 'Vahedi', 'Momtaz') have primarily been cultivated and their production has been satisfactory (AK 2001). In Syria there are about 20 female cultivars, three of which ('Ashoury' (Red Aleppo), 'Red Oleimy', 'White Batoury') are very important and whose cultivation area accounts for more than 95% of pistachio orchards in Syria (Hadj-Hassan 2001). Iran has about 400,000 ha of pistachio cultivation, and it is the world's greatest producer and exporter. Khorasan is located in the northeast of Iran and the Pistachio Research Station (Fiez abad) is located between 34° 56' 35" and 34° 57' 45" N and between 58° 44' 33" and 58° 45' 38" E. This area is highly suitable for pistachio cultivation. Although there are many cultivars, three ('Badame-sefid', 'Pesteh-gharmez', 'Pesteh-garmeh') are more important than others. Some pistachio growers have introduced some new cultivars such as 'Kale-ghochi', 'Akbari' and 'Owhadi' and have grafted them onto 'Badame-sefid' and other unknown rootstocks. Within a short period of time, they noticed that some non-native cultivars were graft-incompatible. Some pistachio growers then replaced the incompatible cultivars with native cultivars through grafting, e.g. 'Kale-ghochi', which is gradually being removed from orchards within this area (Sherafati 2005).

Researchers have recognized and collected many cultivars, genotypes and varieties in Iran. About 200 new genotypes and varieties have been recognized (Esmail-pour *et al*. 2005), some of which are very well-known and have been commercialized, and which are now mainly used to produce pistachios for export. Two cultivars, 'Owhadi' and 'Kale-ghochi', have the greatest pistachio cultivation area in Iran, about 60-70% (Esmail-pour *et al*. 2005). 'Owhadi' is a popular cultivar and it is well-known to growers. In some regions, this cultivar has some problems. For example, marginal leaf necrosis was found mostly in these cultivars and growers have to gradually replace them with suitable cultivars. In the Fiezabad area, there are four native cultivars, 'Badami-sefid', 'Pesteh-gharmez', 'Pesteh-garmeh' and 'Barg-seyah', that have special characteristics, such as high yield, large trees and early ripening (Sherafati 2005). Thus, they are recommended for culture in similar areas.

Therefore, we established a pistachio collection in order to gather more information about different Iranian cultivars. In the first three years, following grafting, we studied vegetative growth. The data that was collected will serve as an important data reference for Iranian pistachio growers who would like to establish a new orchard and require some growth characteristics of the main, popular cultivars.

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Short Communication

**Table 1** Characteristics of water used for tree irrigation.

| Description | pH | EC[1] ($dsm^{-1}$) | SAR[2] | Milli equivalents per liter | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | $Na^+$ | $Mg^{++}$ | $Cl^-$ | $Co_3^{--}$ | $HCO_3^-$ | $Ca^{++}$ |
| Water | 7 | 7.6 | 12.1 | 47.8 | 14 | 62.5 | 0.0 | 1.6 | 17 |

1- Electrical conductivity
2- Sodium adsorption ratio ($SAR=Na/(Ca+Mg)^{1/2}$)

## MATERIALS AND METHODS

This study was carried out at the Pistachio Research Station, Fiezabad over three years (2003-2005). A randomized complete block design (RCBD) was used with three replications, each consisting of three trees. Statistical procedures included an analysis of variance (ANOVA) and comparison of means by Duncan's multiple range test. The distance between trees was 6 m × 4 m. The trees were irrigated once in a 12-day period using surface irrigation. Characteristics of the water used for irrigation are shown in **Table 1**.

Cultivars that were used in this study were divided into three groups:

1) Cultivars native to the Fiezabad area: 'Badami-sefid', 'Pesteh-gharmez', 'Pesteh-garmeh', 'Barg-seyah', 'Daneshmandy'.

2) Cultivars transferred from Kerman and Rafsanjan area a few years ago, then planted in gardens: 'Kale-ghochi', 'Akbari', 'Owhadi'.

3) Three important cultivars from Damghan area which were included in the collection: 'Shahpasand', 'Abas-Ali', 'Khanjari'.

Trees were grafted in June 2003 (for each cultivar 80 trees were grafted) after they had been cut from a certain height, ~1 m above the soil level in January 2003. Cv. 'Badami-sefid' was used as the rootstock for all cultivars. Trees were trained to an "open center" form.

The following important characteristics were measured:

1) The diameter of the trunk (mm), about 5 cm below and above the graft point (30 trees were measured).

2) The yearly length of shoots (cm), as the average length of three shoots in different directions. The selected shoot was randomly selected in six trees for each cultivar.

3) The average diameter of three shoots in the middle of each shoot (cm).

4) False growth, which is not desirable, occurs in late June in some cultivars. False growth produces neither flower buds nor vegetative buds.

5) Average number of lateral shoots counted on three shoots that were randomly selected in 6 trees for each cultivar.

6) Ten leaves were taken from each tree; leaf area was measured with a leaf area meter (AM200, ADC Bioscientific, UK);

7) The graft height (m).

8) Tree width (m).

9) Die back and leaf margin scorch were assessed in 10 leaf samples from six selected trees in each cultivar, and compared with healthy leaves in deficiency and toxicity of some elements such as Na, K, Mg, Mn and Ca. Na and K were measured by flame photometry (flame analyzer, Model 343; Digital Flame Photometer Instrumentation Laboratory Inc., Lexington, US). Ca, Mg and Mn were measured by atomic absorption spectroscopy (Model AA-5; Varian Techtron, Melbourne, Australia) according to manufacturer's instructions.

## RESULTS AND DISCUSSION

There was a significant difference ($P<0.01$) among cultivars in the following characteristics: Yearly length of shoots, shoot diameter, tree width, grafted length, the number of lateral shoots, leaf size and false growth (**Tables 2, 3**). Trees were pruned to an 'open center' shape, except for cvs. 'Owhadi' and 'Kale-ghochi', which had acute apical dominance, and for which this kind of pruning is not suitable, because their main shoots become too long and because they have few lateral shoots. Cvs. 'Akbari', Abas-ali', 'Badami-sefid' and 'Pesteh-garmeh' had greatest leaf areas and density of branches, while the trees had a suitable size and form. Marginal leaf necrosis was found primarily in cvs. 'Owhadi', 'Abas-Ali' and 'Akbari'; analysis of their leaves indicated that the quantity of K, Ca, Mg and Mn was lower than healthy leaves (**Fig. 1, Table 4**). Cv. 'Barg-seyah' suffered

**Table 2** Analysis of variance (ANOVA) of different parameters in 12 pistachio cultivars.

| Sources of change | Degrees of freedom | Grafting height (cm) | False growth (cm) | Tree width (cm) | Diameter above grafting (cm) | Diameter grafting (cm) | Diameter under grafting (cm) | Diameter middle shoot (mm) | Length of shoot (cm) | Leaf area ($cm^2$) | № lateral shoots |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Block | 2 | 63.69 ns | 17.81 ns | 257.48 ns | 13.84 ns | 14.10 ns | 11 ns | 0.70 ns | 13.9 ns | 112.11 ns | 1.75 ns |
| Treatment | 11 | 228 * | 53.41 ** | 458.96 ** | 9.28 ns | 18.17 ns | 27.95 ns | 118 ** | 110.59 ** | 193.61 ** | 4.39 ** |
| Error | 22 | 78.97 | 9.42 | 77.42 | 17.91 | 16.51 | 17.56 | 0.35 | 23 | 27.95 | 0.72 |
| CV | | 9.51 | 48.24 | 9.37 | 13.25 | 10.22 | 11.78 | 5.98 | 11.28 | 0.509 | 2069 |
| SD*** | | 7.28 | 5.65 | 7.21 | 3.46 | 3.31 | 3.46 | 0.47 | 3.84 | 4.35 | 0.69 |

ns, *, ** = Not significant or significant at $P\leq0.05$, $P\leq0.01$ or $P\leq0.001$, respectively.
*** Standard Deviation; Values are means of three replicates

**Table 3** Comparison between different characters in 12 pistachio cultivars.

| Characters / Cultivar | № lateral shoots | False growth (cm) | Grafting height (cm) | Tree width (cm) | Shoot diameter (mm) | Length of shoots (cm) | Leaf area ($cm^2$) |
|---|---|---|---|---|---|---|---|
| Kale-ghochi | 3.30 cde | 1.86 de | 103.73 a | 120.2 a | 11.50 a | 53.9 a | 132.8 |
| Abas-ali | 6.46 a | 3.63 cde | 83.53 c | 77.83 d | 11.16 ab | 39 cde | 133.3 b |
| Badami | 4.5 bc | 4.8 bcde | 104.43 ab | 92.53 bcd | 10.70 abc | 39.8 bcde | 80.8 h |
| Pesteh- gharmez | 3.53 cde | 8.50 abc | 88.33 bc | 88.53 cd | 9.16 d | 44.2 abcd | 78.4 i |
| Shahpasand | 2.20 e | 13.20 a | 96.63 abc | 100.7 bc | 10.50 bc | 46.7 abc | 91.9 f |
| Momtaz | 3.96 cd | 5.56 bcde | 91.20 abc | 85.05 cd | 11.03 ab | 48.2 ab | 67.5 k |
| Khanjari | 4.23 bc | 7.16 bcd | 96.66 abc | 107 ab | 9.83 cd | 39.9 bcde | 72.3 j |
| Daneshmandi | 2.60 de | 3.16 cde | 80.73 c | 86.40 cd | 9.86 cd | 35.8 de | 127.3 c |
| Pesteh-garmeh | 4.66 bc | 5.20 bcde | 90.53 abc | 83.96 cd | 11.15 ab | 37.8 cde | 113.6 d |
| Akbari | 5.73 ab | 0.00 e | 83.3 c | 87.76 ab | 10.93 ab | 34.3 e | 134.9 a |
| Owhadi | 4.06 cd | 13.03 a | 107.6 a | 107.4 cd | 11.30 a | 51.3 a | 90.9 g |
| Barg-seyah | 3.36 cde | 9.96 ab | 94.43 abc | 88.30 cd | 10.73 abc | 39.9 bcde | 101.4 e |

Values within a column (i.e. per character) followed by the same letter(s) are not significantly different according to Duncan's multiple range test ($P<0.01$).

**Table 4** Analysis of leaf marginal necrosis (LMN).

| Element | Sufficient level | Sample leaf | LMN |
|---|---|---|---|
| Potassium | 1% | 0.49% | Very low |
| Calcium | 1% | 0.55% | Low |
| Magnesium | 0.50% | 0.30% | Almost low |
| Manganese | 25 ppm | 15.7 ppm | Low |
| Sodium | <0.20 ppm | 16.2 ppm | Abundant |

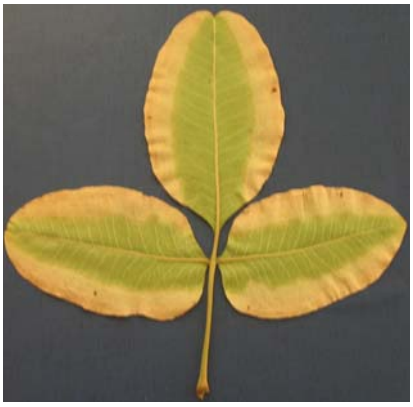

**Fig. 1 Leaf marginal necrosis.**

**Fig. 2 Leaf displaying die-back symptoms.**

severe leaf die back in the part of false growth. False growth does not allow the plant to initiate and induce flowers, and these trees absorb many metabolites without any benefits to growers. As a result, growers have no interest in these shoots. Also the level of Ca, Mn and N was very low and Na was higher than healthy leaves (**Fig. 2, Table 5**). This problem were observed only in cv. 'Barg-seyah' and in the leaves of the central part of false growth. There were no significant differences between healthy leaves and die-back leaves in terms of micro- and macro elements, except for N, K, Ca and Cl.

At present, salinity is the most important problem in many areas of Iran (and around the world). Most nutrient disorders in pistachio trees occur when saline water is used and in alkaline soil (Ferguson *et al*. 2002). Salinity is the main reason for marginal leaf necrosis and die-back (Ranjbar *et al*. 2001; Munns *et al*. 2002). The EC and pH of water and soil increase over time (Sepaskhah and Maftoun 1981; Behboudian *et al*. 1986). Despite reduced yields with increasing salinity, pistachio has been described as salt-tolerant (Sepaskhah and Maftoun 1981; Behboudian *et al*. 1986; Picchioni and Miyamota 1990; Ferguson *et al*. 2002) and is potentially an alternative to salt-sensitive pecan (*Carya illionsis*) or almond (*Prunus amygdalus*). However, symptoms of toxicity in pistachio and cultivar differences in susceptibility to salinity have been previously described (Sepaskhah and Maftoun 1981; Behboudian *et al*. 1986; Picchioni and Miyamota 1990; Ferguson *et al*. 2002). For example, saline stress can cause decreased growth, alter photosynthetic rates and causes morphological changes in the leaves (Behboudian *et al*. 1986; Picchioni and Miyamoto 1990; Ranjbar *et al*. 2001; Munns *et al*. 2002). However, finding ways to prevent the death of trees is one of the main objectives for researchers (and ultimately growers). The selection of a rootstock and cultivar resistant to salinity is the easiest way to prevent the negative effects of salinity. In this study, we noticed a great difference among cultivars in terms of leaf die-back, vegetative growth and marginal leaf necrosis. Four cultivars, 'Owhadi', 'Kale-ghochi', 'Abas-ali' and 'Akbari' were the most salt-sensitive while 'Pesteh-garmeh' did not show any symptoms of nutrient disorders or leaf death. Cv. 'Barg-seyah' showed a unique kind of leaf die-back in which leaves died in the section of false growth. In addition, two cvs. ('Badami-sefid', 'Pesteh-garmeh') had good vegetative growth and almost no problems. 'Badami-sefid' is a commercial cultivar while 'Pesteh-garmeh' is not. Therefore, the latter is considered to be the best cultivar. However, further studies are required to study traits related to flowering and yield.

This study provides basic knowledge about the growth behaviour and morphological traits of several important local Iranian pistachio cultivars and the data obtained through our observations provide a rough, but practical basis for selection of cultivars to be cultured in Iran depending on the region or environmental conditions.

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**Table 5** Analysis of leaves with spotted die-back in cv. 'Barg-seyah'.

| Description | % | | | | | | ppm | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Na | Ca | Cl | Cu | Zn | Mn | Fe |
| Correct leaf | 2.43 | 0.13 | 2.59 | 0.07 | 3.15 | 0.86 | 10 | 18 | 36 | 114 |
| Die back leaf | 1.89 | 0.12 | 1.45 | 0.08 | 1.23 | 1.05 | 8 | 16 | 24 | 121 |