Impact of osmotic drought stress on carbon isotope discrimination and growth parameters in three pistachio rootstocks

(*Pistacia* spp., Anacardiaceae)

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The most important pistachio producer countries in the world
Introduction

- In Iran, pistachios are usually cultivated under dry and saline conditions (Sheibani, 1995), as they have a high tolerance to drought and salinity.

- Still, water deficit and salinity can cause a reduction in plant growth, yield and nut quality.

- Drought stress adversely affects growth, dry mass accumulation, and productivity of plants (Anjum et al., 2011) and causes a higher rate of impairment than any other environmental factors (Shao et al., 2009).

- Higher drought tolerance of wild pistachio species could be related to a deep taproot, high water conservation ability by stomatal adjustment, stomatal features, leaf characteristics, and leaf shedding.
Therefore, these wild species are very often used as rootstock (Gijon et al. 2010; Ferguson et al. 2005; Ranjbar et al. 2001; Hokmabadi et al. 2005).

Carbon isotope discrimination (Δ) decreases with increasing salinity in pistachio seedlings. However, there were no significant difference in Δ between *P. vera* rootstocks (Hokmabadi et al. 2005).

There are three pistachio species in Iran which are grown under different environmental conditions.

*Pistacia vera* L. is the most common rootstock. Yet, physiological responses of this pistachio rootstock to drought stress and comparison to other recommended rootstocks have not been studied enough.

The aim of this study was to evaluate the effects of osmotic drought stress on carbon isotope discrimination and plant biomass, leaf area, elongation rate and root/shoot ratio of *P. vera* cv. Badami, *P. vera* cv. Sarakhs (native), and *P. terebinthus* rootstocks (used in Turkey).
Materials and methods

- Certified seeds of Badami and Sarakhs were obtained from IPRI (30° 39' N, 55° 94' E), Rafsanjan, Iran. *P. terebinthous* seeds obtained from Turkey.

- Seedlings were grown in a glasshouse at Ghent University (51°3' N, 3°42' E), Ghent, Belgium.

- Temperature and relative humidity ranged between 27/21 °C and 49/71 % RH.

- **Drought stress treatments were:**
  - $\Psi_s = -0.10$ MPa, as control
  - $\Psi_s = -0.5$ MPa,
  - $\Psi_s = -1.0$ MPa
  - $\Psi_s = -1.5$ MPa using PEG 6000.
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Ohadi
Measurements:

- **Carbon isotope discrimination**
  Dried leaf samples were ground by a grinder.
  
  Five mg subsamples of ground plant material were packed in tin capsules and analyzed for natural abundance of C\(^ {13}\) by combustion to CO\(_2\) in the present of O\(_2\) by an elemental analyzer (EA) coupled to an isotope ratio mass spectrometer (IRMS) to measure \(\delta^{13}C\).

- **Plant Growth Parameters**
  
  Fresh weight of leaves, shoots, and roots was determined with an electronic balance. Dry weight of the plant fractions was determined after drying at 85°C for 72 hours.
  
  Plant height was measured with a ruler at the beginning and end of the experiment.
  
  The experiment was designed as a randomized complete design (RCD).
  
  All analyses were performed in SPSS 22.
Results:

Effects of drought stress treatments on Carbon Isotope Discrimination
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Results:

Effects of drought stress treatments on Plant Dry Weight
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Results:

Effects of drought stress treatments on Root/ Shoot Ratio
### Impact of osmotic drought stress on carbon isotope discrimination and growth parameters in three Pistachio rootstocks

<table>
<thead>
<tr>
<th>Treatments</th>
<th>PFV</th>
<th>SDW</th>
<th>LDW</th>
<th>RDW</th>
<th>LA</th>
<th>EI</th>
<th>Shed</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.1</td>
<td>52.9 a</td>
<td>11.7 a</td>
<td>6.1 a</td>
<td>6.6 a</td>
<td>22.8 a</td>
<td>16.2 a</td>
<td>0.030 a</td>
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<td>-0.5</td>
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<td>6.9 b</td>
<td>3.2 b</td>
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<td>18.7 a</td>
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<td>-1</td>
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<td>5.6 b</td>
<td>2.5 b</td>
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<td>0.9 b</td>
<td>0.174 a</td>
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<td>-1.5</td>
<td>24.5 b</td>
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<td>2.5 b</td>
<td>5.0 a</td>
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<td>2.3 b</td>
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<thead>
<tr>
<th>Rootstocks</th>
<th>Badami</th>
<th>Sarakhs</th>
<th>Terbatus</th>
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<tr>
<td>PFV</td>
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<td>SDW</td>
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<tr>
<td>RDW</td>
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<tr>
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<td>13.9 b</td>
<td>31.4 a</td>
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<tr>
<td>EI</td>
<td>5.7 ab</td>
<td>2.0 b</td>
<td>7.7 a</td>
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<tr>
<td>Shed</td>
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<td>0.05 a</td>
<td>0.06 b</td>
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<thead>
<tr>
<th>Anova</th>
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<th>Treatment</th>
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<tr>
<td>F</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>Prob</td>
<td>ns</td>
<td>ns</td>
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</tbody>
</table>

*ns = not significant*
Conclusion:

- Under control conditions, Terbinthus maintained the highest PDW compared to both other rootstocks but this rootstock showed the largest decrease for this parameter in reaction to severe drought stress.

- Reduction rates were 42.4%, 33.1% and 47.1% for Badami, Sarakhs and Terbinthus, respectively.

- Therefore, Sarakhs kept the lowest PDW reduction values among the other rootstocks in this study.
Conclusion:

- Pistachio trees are considered drought tolerant, yet the applied osmotic drought stress induced significant reductions in leaf carbon isotope discrimination.

- There were negative significant relationship between $\Delta^{13}C$ with PDW value. Based on the correlation, we evidenced $\Delta^{13}C$ would seem to be a good indicator of drought stress effects that significantly influence biomass factors of pistachio plants in water deficit conditions.

- In conclusion, Sarakhs better tolerated the applied drought stress as shown by the growth reduction performance in the severest drought condition as compared with Badami and Terbinthus.

- However, further research in field conditions is needed to confirm this survey’s research results.
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Thank you very much for your attention
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