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Main results from the French Mediterranean Abies comparative field tests

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Summary

Since 1970, INRA Avignon has installed several common garden tests to compare adaptive traits of different Mediterranean Abies species, especially Abies cephalonica from Greece and Abies bornmuelleriana from Turkey.

Abies cephalonica provenance tests identified the patterns of adaptive variability range-wide, using traits such as survival, growth, bud phenology and seed germination under various levels of drought. The best provenances under French conditions are those from the Mainalon and Parnon, in the Peloponnesos. A family seedling seed orchard was planted in 1981 using these provenances.

Abies bornmuelleriana and A. nordmanniana provenance tests were installed in 1978, mostly outside the Mediterranean region. They showed that A. bornmuelleriana could be promising for the Mediterranean region. A new series of tests were installed under Mediterranean conditions in 1994-5. First year mortality results demonstrated a high sensitivity to limestone. Further monitoring in one limestone test showed that A. cilicica (used as reference in the test) could also be interesting for Mediterranean plantation forestry, and that A. cilicica and A. cephalonica were somewhat tolerant to extreme weather events such as the summer heat wave of 2003.

Abies species in the Mediterranean

The genus Abies is represented by 10 species in the Mediterranean (Figure 1). All of them (except Abies alba) are endemics, sometimes with extremely limited distribution areas. Of interest for French (Mediterranean) forestry are A. cephalonica and A. bornmuelleriana. Other species such as A. nordmanniana, A. pinsapo, A. numidica have also been tested under Mediterranean climate in France, and were shown to perform substantially more poorly than the other two.

Abies cephalonica provenance and progeny tests

Figure 1. Distribution of Abies species around the Mediterranean (from Quézel & Médail 2003)

Only Abies alba is native to France, and its marginal populations can be found under Mediterranean climate. Exotic Mediterranean Abies populations can seldom be found in southern France, but although they are small-sized, they grow well and regenerate naturally.
*Abies cephalonica* is distributed in the mountains of Greece, from 1000 to 2000 m (figure 2). *A. cephalonica* provenance tests were installed in the 1970s as part of a program to diversify reforestation material in Mediterranean France. Results from the 3 test sites in this network showed that *A. cephalonica* is indifferent to bedrock type. It has a very slow juvenile growth, up until 15-20 years of age, when annual increments start increasing significantly (up to 50 to 100 cm per year). It performs best at elevations at least 6-700 m, and/or when rainfall is over 800 mm per year. It can withstand a long summer drought period (up to 3 months in France). As bud flushing is relatively early, it is sensitive to late spring frost. (Fady 1991, 1993).

![Figure 2. Natural distribution of A. cephalonica in Greece.](image)

The 3 common garden tests installed in 1970 compared 11 provenances range-wide (Fady 1993). The best provenances in terms of growth and ecological plasticity come from the Mainalon and Parnon mountain ranges in Peloponnesos (figure 3). They are now recommended for use in reforestation programs in France. Although plantation forestry very seldom uses *Abies cephalonica*, a seedling seed orchard was installed in southern France in 1981, comprising 30 families per provenance from Mainalon and Parnon and 4 other provenances, including the drought resistant provenance of Evia (Fady 1992). Seed production should be ready for commercial use in 2010.
The most recent complete evaluation was made in 1989. Additional but partial measurements were made in 1993, and the last ones were made in 1996 (in the seed orchard) to evaluate bud blushing. Earlier evaluations were confirmed.

**Abies bornmuelleriana provenance tests**

Several *A. bornmuelleriana* and *A. nordmanniana* provenance tests were installed in 1978, mostly in the southwest and the northeast of France. However, one site was also planted under Mediterranean conditions (Rouffiac, 500 m elevation, 700 mm annual rainfall). There, 6 *A. nordmanniana*, 5 *A. bornmuelleriana*, 1 *A. equi trojani* and 2 *A. cilicica* provenances. It showed that *A. bornmuelleriana* had interesting adaptive potential (height growth) for southern France. Mean survival at age 20 was 86% (compared to 73% for *A. nordmanniana*), and mean total height at age 20 was 575 cm (compared to 536 cm for *A. nordmanniana*, Table 1). The *A. equi trojani* provenance is also quite remarkable, with a survival rate of 93% and a mean total height of 650 cm at age 20 (Table 1).

Table 1. Provenance mean total height (age 20) and rank significance (identical letters indicate non significantly different values) in the Rouffiac Mediterranean *Abies* provenance tests

<table>
<thead>
<tr>
<th>Rank</th>
<th>Provenance</th>
<th>Species</th>
<th>Mean total Height in cm</th>
<th>standard error</th>
<th>significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KAZD</td>
<td><em>A. equi trojani</em></td>
<td>649,771</td>
<td>16,757</td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>ARAC</td>
<td><em>A. bornmuelleriana</em></td>
<td>643,914</td>
<td>14,718</td>
<td>a</td>
</tr>
<tr>
<td>3</td>
<td>CANG</td>
<td><em>A. bornmuelleriana</em></td>
<td>612,562</td>
<td>14,824</td>
<td>ab</td>
</tr>
<tr>
<td>4</td>
<td>AMAN</td>
<td><em>A. nordmanniana</em></td>
<td>592,761</td>
<td>17,076</td>
<td>ab</td>
</tr>
<tr>
<td>5</td>
<td>ALAD</td>
<td><em>A. bornmuelleriana</em></td>
<td>577,311</td>
<td>9,955</td>
<td>bc</td>
</tr>
<tr>
<td>6</td>
<td>COMB</td>
<td><em>A. nordmanniana</em></td>
<td>565,020</td>
<td>30,784</td>
<td>bc</td>
</tr>
<tr>
<td>7</td>
<td>ULUD</td>
<td><em>A. bornmuelleriana</em></td>
<td>559,124</td>
<td>10,226</td>
<td>bc</td>
</tr>
<tr>
<td>8</td>
<td>IGDR</td>
<td><em>A. nordmanniana</em></td>
<td>544,091</td>
<td>11,148</td>
<td>bcd</td>
</tr>
<tr>
<td>9</td>
<td>YASM</td>
<td><em>A. nordmanniana</em></td>
<td>516,912</td>
<td>15,273</td>
<td>cd</td>
</tr>
</tbody>
</table>
To fully evaluate this potential under French Mediterranean ecological conditions, a new series of 4 sites was installed in 1995 in southern France. In addition to *A. bornmuelleriana* provenances, the tests included reference species represented by their best known material: *A. cephalonica*, *A. equi trojani*, *A. cilicica* and *Cedrus atlantica*. *A. bornmuelleriana* provenances were found to be sensitive to soil type. Independently of site elevation, survival was very low on limestone. In Pignan (150 m elevation, 650 mm annual rainfall), for example, total number of seedlings planted in 1997 was 840. In this site, survival was monitored before and after the 2003 heat wave. Overall survival was best in *C. atlantica* (65%) and least in *A. bornmuelleriana* (3%). Survival was 20% in *A. cilicica* and 27% in *A. cephalonica*. However, *C. atlantica* suffered more from extreme heat than *A. cephalonica* et *A. cilicica* as 45% of its mortality is due to the 2003 heat wave against 26% et 32% for *A. cephalonica* et *A. cilicica*, respectively (Bariteau et al. 2007).

Figure 4. Mortality monitored in the *Abies bornmuelleriana* provenance test of Pignan (France). Provenance and reference species codes: Born = *A. bornmuelleriana*, Ceph = *A. cephalonica*, Cili = *A. cilicica*, Equi = *A. equi trojani*, Vent = *C. atlantica*). Provenance composition is identical to that of the other sites of the network.

More than 12 years later, the only remaining site usable for testing out of the 4 initially planted, is on acidic soil and where rainfall is sufficient (Lambert, elevation 600 m, annual rainfall 900 m).

**Conclusion**

Mainalon and Parnon provenances remain the best *A. cephalonica* material for reforestation in southern France. *A. cilicica* seems to have interesting potentials within the same bioclimatic range as *A. cephalonica*. Although interesting for southern France, *A. bornmuelleriana* and *A. equi trojani* should be restricted to acidic, high elevation and high rainfall sites. For conservation purposes, using
exotic Mediterranean Abies species should be avoided where the native marginal populations of A. alba are not present because of risk of hybridization.

Provenance tests constitute valuable guidelines for knowing what are acceptable ecological limits for exotic material. They also are a valuable tool for studying the effect of climate change, and to indicate possible substitutes to current populations under climate change. Provenance tests, where different genotypes of the same species are mixed within the same area, could also be used for studying the relationship between tree species diversity and associated biodiversity.

References


