

## **Pinus halepensis - Pinus brutia french comparative provenance tests**

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***Pinus halepensis - Pinus brutia***  
**French comparative provenance tests**

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## Summary

*Pinus halepensis* and *Pinus brutia* provenances (and progeny) trials were planted in South eastern France in order to evaluate genetic diversity within and among species. Two plantations were settled in 1976 and 1978 within the FAO/SCM/CRFM/4bis project. More recently 5 new plantations, mainly with *P. brutia* provenances were settled in 1996 and 1997 within the MPC and FORADAPT European project. Variability of growth and survival was analyzed.

## Introduction

*Pinus halepensis* Mill. (Aleppo pine) and *P. brutia* Ten. (Brutia pine or Turkish red pine) play a major role in low elevation Mediterranean forests, covering around 7 millions ha in the western and eastern part of the Mediterranean Basin. Due to their good adaptation to dry summer conditions and their ability to rapidly colonized abandoned lands from agriculture or burned areas, these species not only constitute ecologically valuable natural stands but also permits afforestation in dry conditions for production or protection purposes. In 2000, Schiller reviewed the inter- and intra-specific genetic diversity of these Mediterranean pine species. Diversity among species and provenances within species was generally assessed by morphological markers (seeds, cotyledons, needles...) or biochemical traits (terpenes, isozymes, DNA markers). The genetic diversity of adaptive traits (survival, growth, drought or frost tolerance..) or of shape and branch characteristics was more rarely reported.

We present here a short synthesis of the French field experiments were these two species were planted. The manuscript is mainly based on previous reports of European or national projects.

## Material and Method

### ✓ The "Old" *P. halepensis* *P. brutia* provenance tests

A two-site comparative trial with provenances of the *halepensis-brutia* complex were planted in south-eastern France in 1976 (Ceyreste plantation) and 1978 (Vitrolles plantation) within the international FAO trial (FAO/SCM/CRFM/4bis). Names and origins of the 27 provenances tested in this trial (12 *P. halepensis* provenances, 12 *P. brutia* provenances and 3 *P. eldarica* provenances) are given in Table 1.

Table 1 : List of the *Pinus* provenances tested in Vitrolles and Ceyreste plantations

| species   | FAO code | provenance         | country | Lat.  | Long. | Elev. | site | species   | FAO code | provenance     | country | Lat.  | Lon.  | Elev. | site |
|-----------|----------|--------------------|---------|-------|-------|-------|------|-----------|----------|----------------|---------|-------|-------|-------|------|
| P. halep. | A2       | Elea               | Greece  | 37°46 | 21°32 | 200   | C, V | P. brutia | B1       | Chania         | Greece  | 23°57 | 35°17 | 850   | C,V  |
| P. halep. | A4       | Chalkidique        | Greece  | 40°11 | 23°21 | 125   | C, V | P. brutia | B3       | Lassithiou     | Greece  | 25°32 | 35°06 | 1100  | C,V  |
| P. halep. | A8       | Sakiet Sidiyoussef | Tunisia | 36°15 | 8°25  | 700   | C, V | P. brutia | B4       | Alexandropolis | Greece  | 26°13 | 41°08 | 200   | C,V  |
| P. halep. | A12      | Zaouia Ifrane      | Morocco | 33°15 | -5°23 | 1250  | C, V | P. brutia | B6       | Marmaris       | Turkey  | 28°18 | 37°00 | 175   | C,V  |
| P. halep. | A14      | Ouardane Bouksane  | Morocco | 35°03 | -5°08 | 900   | C, V | P. brutia | B7       | Isparta        | Turkey  | 29°32 | 38°04 | 1043  | C,V  |
| P. halep. | A16      | Soportujar         | Spain   | 37°10 | -3°15 | 800   | C, V | P. brutia | B8       | Düzlerçani     | Turkey  | 30°25 | 37°03 | 250   | C,V  |
| P. halep. | A19      | Cehegin            | Spain   | 38°05 | -1°55 | 850   | C, V | P. brutia | B9       | Pamuçak        | Turkey  | 30°41 | 37°40 | 780   | C,V  |
| P. halep. | A21      | Serra              | Spain   | 39°50 | -0°28 | 600   | C, V | P. brutia | B10      | Bozburun       | Turkey  | 30°45 | 37°21 | 520   | C,V  |
| P. halep. | A23      | Tarrasa            | Spain   | 41°28 | 2°06  | 250   | C, V | P. brutia | B11      | Bakara         | Turkey  | 32°43 | 36°09 | 300   | C,V  |
| P. halep. | A24      | Gemenos            | France  | 43°25 | 5°40  | 150   | C, V | P. brutia | B12      | Silifke        | Turkey  | 33°43 | 36°13 | 100   | C,V  |
| P. halep. | A26      | Otricoli           | Italy   | 42°24 | 12°32 | 400   | C, V | P. brutia | B13      | Camgözü        | Turkey  | 35°20 | 41°50 | 70    | C,V  |
| P. halep. | A27      | Vico del Gargano   | Italy   | 41°54 | 16°00 | 225   | C, V | P. brutia | B14      | Baspinar       | Turkey  | 35°15 | 37°48 | 700   | C    |
|           |          |                    |         |       |       |       |      | P. brutia | B15      | Kisildag       | Turkey  | 35°58 | 36°21 | 370   | C,V  |

\* C : Ceyreste ; V : Vitrolles

The main characteristics of the 2 plantations are the followings:

|                          | Ceyreste (1976)       | Vitrolles (1978) |
|--------------------------|-----------------------|------------------|
| nb prov per block        | 5                     | 6                |
| nb trees per unit plot   | 20 (2rows x 10 trees) | 8                |
| total nb trees (surface) | 3300 (1,2 ha)         | 2500 (1,9 ha)    |
| nb of prov.              | 12 PH + 13 PB + 3 PE  | 12 PH + 12 PB    |
| elevation                | 470 m                 | 200 m            |
| longitude (gr E)         | 3.71                  | 3.26             |
| latitude (gr N)          | 48.40                 | 48.32            |
| soil                     | sandstone             | limestone        |
| rainfall                 | 790 mm                | 570 mm           |

In summer 2004 the Vitrolles plantation was destroyed by a forest fire.

Variability of survival and total height was analyzed using respectively a generalized linear model and a linear model (ANOVA) respectively. Prior to ANOVA, height growth was adjusted to environmental effects (mainly soil conditions) with an spatial approach (Iterated Papadakis method).

### ✓ **The "new" *P. brutia* provenance tests**

In order to evaluate provenance variability of *P. brutia* in less dry conditions (deeper soils or higher elevation) than those of the "old" provenances plantations, a "new" five-site comparative trials was settled within the Mediterranean Pine and Cedar (MPC) European project and the FORADAPT INCO project (Table 2). These plantations share some provenances with tests established, in the same project, by Moroccan and Tunisian partners.

18 *Pinus brutia* provenances and 3 *P. halepensis* as control were tested (Table 3). Seven other *P. brutia* provenances evaluated by the French forest service were also included in Bousquet d'Orb and Naucadery plantations. The experimental plantations consist of randomized incomplete blocks, 30 trees per block (15 prov. x 2 trees). Survival and total height were analyzed using a generalized linear model and a linear model (ANOVA) respectively.

Table 2 : list of the "new" *P. brutia* provenance plantations

| site              | Year plant. | altitude | Surface (ha) | soil      | Number of Prov |
|-------------------|-------------|----------|--------------|-----------|----------------|
| Bousquet d'Orb    | F 1995      | 580      | 2            | limestone | 28             |
| Naucadery (Laure) | S 1996      | 150      | 1.5          | limestone | 27             |
| Toulourenc forest | F 1996      | 600      | 2            | limestone | 22             |
| Bedoin forest     | S 1997      | 600      | 2            | limestone | 25             |

Table 3 : list of the provenances tested in the "new" 5-site trial

| Species          | provenance       | country | Species              | provenance             | country |
|------------------|------------------|---------|----------------------|------------------------|---------|
| <i>P. brutia</i> | 050 Karsanti     | Turkey  | <i>P. brutia</i>     | 120 Karabucak          | Turkey  |
| <i>P. brutia</i> | 071 Kiyra        | Turkey  | <i>P. brutia</i>     | 121 Güzelcluk          | Turkey  |
| <i>P. brutia</i> | 073 Suçati       | Turkey  | <i>P. brutia</i>     | 122 Bigadic            | Turkey  |
| <i>P. brutia</i> | 076 Guzelbag     | Turkey  | <i>P. brutia</i>     | 124 Camkonagi          | Turkey  |
| <i>P. brutia</i> | 079 Pinargözü    | Turkey  | <i>P. brutia</i>     | 125 Göktepe            | Turkey  |
| <i>P. brutia</i> | 100 Karadag      | Turkey  | <i>P. brutia</i>     | 129 Koças              | Turkey  |
| <i>P. brutia</i> | 109 Gökçesu      | Turkey  |                      |                        |         |
| <i>P. brutia</i> | 110 Findikpinari | Turkey  | <i>P. halepensis</i> | 001 St Etienne du Grès | France  |
| <i>P. brutia</i> | 113 Melli        | Turkey  | <i>P. halepensis</i> | 002 Port-Cros          | France  |
| <i>P. brutia</i> | 114 Merkez       | Turkey  | <i>P. halepensis</i> | 003 Mejjou             | Morocco |
| <i>P. brutia</i> | 115 Karaçay      | Turkey  | <i>P. halepensis</i> | 011 Vilmorin           | France  |
| <i>P. brutia</i> | 116 Eskibag      | Turkey  | <i>P. halepensis</i> | 015 Gémenos            | France  |

## Result

### ✓ **The "Old" *P. halepensis* *P. brutia* provenance tests**

Present analysis of survival and growth of twenty years old trees, completes preliminary results published in 1992 (Bariteau).

Survival rates were significantly different among provenances (Figure 1). In both sites (Ceyreste and Vitrolles), the highest mortality rates were observed for some *P. halepensis* provenances from Greece (Elea), Italy (Vico del Gargano and Otricoli) and Morocco (Ouardane Bouksane). Provenances from France, Spain and north-eastern Greece exhibited high survival rates, but no clear geographic pattern was observed. The highest survival rates were observed for some *Pinus brutia* provenances specially those originating from eastern Taurus (Kisildag and Baspinar).



“Mejjou” provenance exhibited a limited growth. Within *P. brutia*, the site x provenance interaction was moderate as compared to the effect of the 2 main factors (Figure 4). Growth at Bousquet d’Orb is negatively correlated ( $r = -0,63$ ) to the elevation of the stand where seeds were collected. The 5 best performing provenances are the following: Mersin-Findikpinari (east Taurus), Antalya, and 3 provenances from north-western part of *P. brutia* range: M.K.Pasa-Camkonagi, Orhaneli-Göktepe from Turkey and Alexandropolis from Greece.

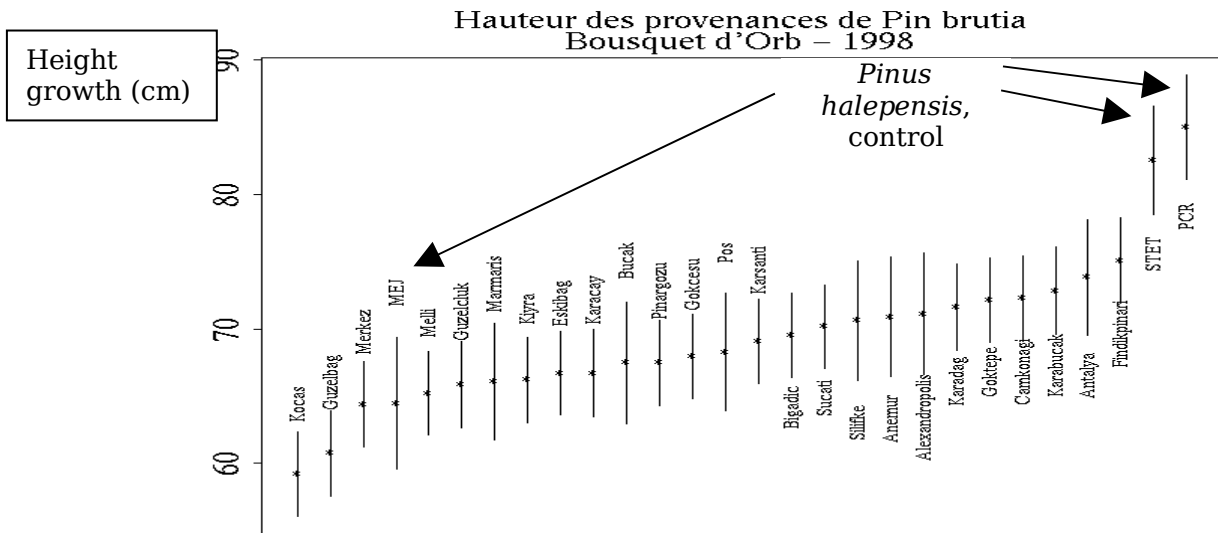


Figure 3 : comparison of growth among 3 years old *Pinus brutia* provenances (Bousquet d’Orb Plantation)

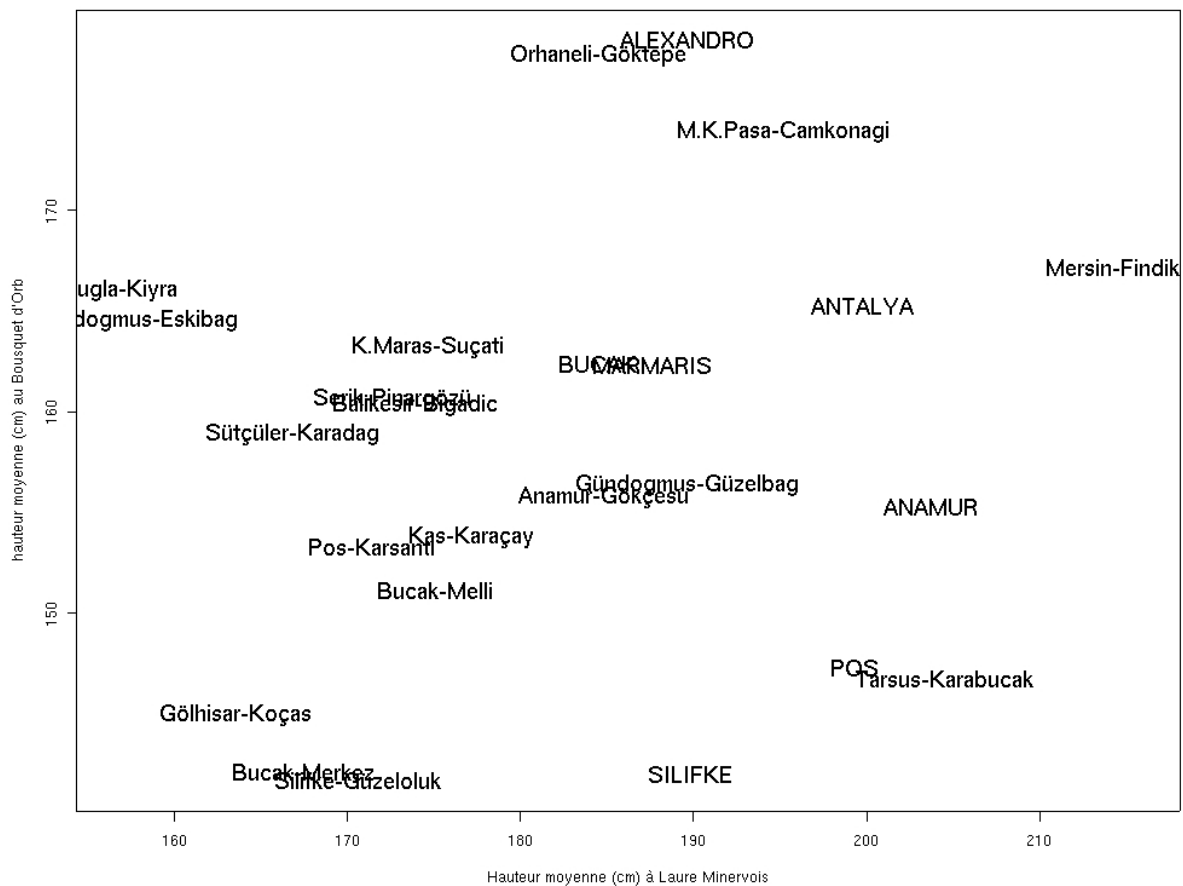


Figure 4: Comparison of *P. brutia* provenance growth (cm) at Bousquet d’Orb and Naucadery

## Conclusion and perspectives

*P. halepensis* is the more drought tolerant Mediterranean pine tree and its environmental and economical importance will undoubtedly increase in the “Earth warming” context. Due to its efficient natural regeneration and colonisation of abandoned land from agriculture, *P. halepensis* is today rarely artificially planted in southern France. However, we recommend to use local seed sources for any new plantations. These provenances are frost resistance and exhibit good growth.

Objective of the new multisite *Pinus brutia* provenance test was to estimate the variability of adaptive traits in less hot and dry conditions than those of the 2 previous provenance trials (1976 and 1978, Ceyreste and Vitrolles). The preliminary results confirm the better adaptation of this species to frost as compared to *Pinus halepensis*. The high susceptibility to frost of the Moroccan *P. halepensis* provenance use as control also confirms the risk of introducing exotic Aleppo pine provenances in Southern France. In 1985, artificial pine forests settled in southern France with Italian seed sources were also seriously damaged by frost.

In the new comparative test, French *P. halepensis* provenances grow faster than *P. brutia* provenances which confirms the highest juvenile growth of *P. halepensis*. When become older, *P. brutia* trees are expected to grow faster and best provenances should overpass *P. halepensis* as observed at Ceyreste plantation.

*Pinus brutia* is undoubtedly a good alternative species for afforestation in southern France, at middle elevation (400-700 m) which generally correspond to the upper limit of *P. halepensis* and the lower limit of *Pinus nigra*. First analysis of growth variability among *P. brutia* provenances indicate good performances of material originating from middle altitude eastern Taurus mountain, such as “Mersin Findikpinari” or from north-western part of *P. brutia* natural area. Provenances from eastern Taurus would also exhibit a high survival rate and a good stem straightness (Figure 5).

Figure 5 : Main characteristics of *P. brutia* provenances tested by FR1/AVIGNON (in the old (\*) and new (o) tests)

