Provenance Variation in *Pinus muricata* on Two Sites in Northern Greece

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Abstract

Height, diameter at breast height, survival and stemform at the 7th year, were assessed for 9 provenances of *Pinus muricata* D. DON on 2 sites in northern Greece. Differences between *P. muricata* provenances in height and diameter have shown the Medocino coastal, north of Fort Bragg, to be the best provenance, while the Hubolt, Trinidad Head, was the worst. For diameter, the schist site was better. Survival and stemform do not differ between provenances or sites but site-provenance interactions were found to be important for the survival.

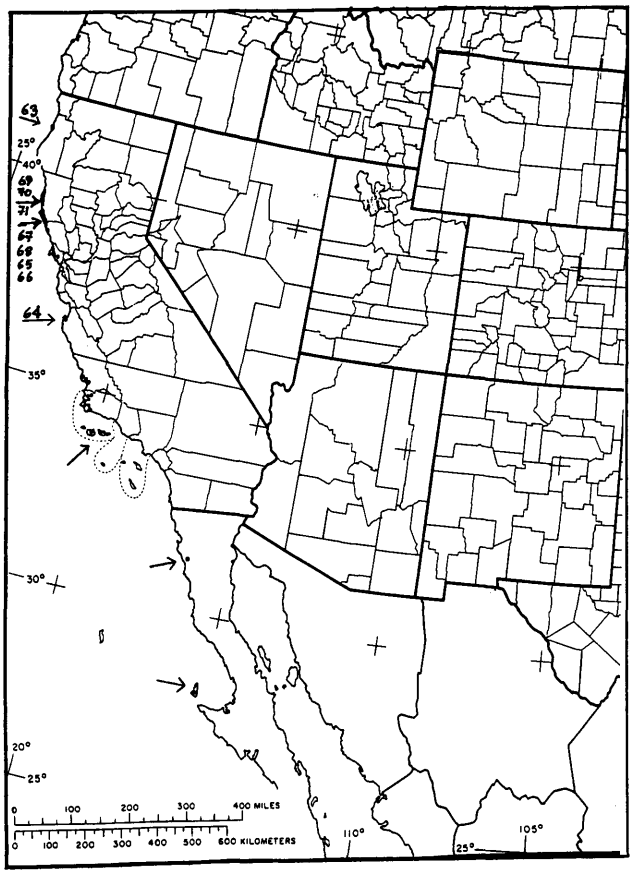
Key words: Pinus muricata, provenance.

FDC: 232.12; 165.5; 174.7 *Pinus muricata;* (495).

Introduction

Pinus muricata D. DON is related to *Pinus radiata* D. DON and *Pinus attenuata* LAMM. of the same natural distribution, along California's coast (*Fig. 1*). The species is regarded highly polymorphic in inter and intra population variability (MILLAR and CRITCHFIELD, 1988) with 3 distinct populations of which the southern is more related to *P. radiata*. It seems that diversity in growth and certain characters between *P. muricata* provenances is well established. Differences were also identified in morphological and chemical characteristics in a smaller area in northern California (Ft. Bragg to Ft. Ross) between "blue", "green" and mixed stands of *P. muricata* (MILLAR, 1983).

Figure 1. – Geographical distribution of *Pinus muricata* in California USA (after Atlas of USA Trees, 1971) and location of the seed origins tested in Greece.



P. muricata has not been used as an exotic to the same extent as the rather similar *P. radiata,* but the available evidence suggests that, some provenances at least, have yields and wood properties similar to those of *P. radiata.* It has been reported (SHELBOURNE, 1974) that the *P. muricata* blue form tolerates lower ambient temperatures and frost better than *P. radiata* in New Zealand. It is also regarded as more tolerant of infertile and poorly drained soils.

In Greece *P. muricata* has not been tried before. *P. radiata* has mainly been planted in small scale in selected sites within other conifer plantations; it has also been used in species and provenance trials. Low temperature and frost was a limitation of extending successfully the planting of *P. radiata.* If the reported (SHELBOURNE, 1974) better tolerance of *P. muricata* to low temperature, hold good for certain provenances in Greece, the species might be most useful for selected sites in conifer plantations as an alternative to *P. radiata* where the latter grows poorly.

P. muricata seed (9 origins) and *P. radiata* seed (13 origins) of a range-wide collection made in California USA, was obtained from CSIRO, Australia. The *P. muricata* provenance seed collection was mostly limited to the northern "blue" strain of muricata pine, the "green" strain from the central and southern coast of California having been considered as less valuable (ELDRIDGE, 1979). The received seed was used for the adjusted *P. muricata* and *P. radiata* provenance trials on 2 different sites, in Nigrita pilot plantation in northern Greece.

Materials and Methods

Sites

Nigrita *P. pinaster* plantation in Serres district northern Greece (Long. E 23 30' to 34', Lat. N 40 49' to 52', Alt. 420 m to 660 m) was established on hilly land in an extensive oak coppice area with dispersed openings of variable size grazed and grassy. It is in a winter rainfall area with mean annual precipitation 600 mm and mean annual temperature 12 °C. The soils range from relatively heavy to friable depending on the parent material which is mainly schist but with ultrabasic igneous rocks extensively represented (NAKOS, 1982). The *P. muricata* and the adjusted *P. radiata* provenance trials were established on the 2 major soil types (*Table 1*).

Provenances

P. muricata seed (9 origins) of a range-wide collection made in California USA, was obtained from CSIRO, Australia. The plants were raised in polyethylene bags, at the experimental nursery of Forest Research Institute of Thessaloniki and were

Table 1. – Site characteristics.

Charact.	Site 1	Site 2
Lithology	Ultabasic igneous	Biotite gneisses, mica schist and muskovite
Aspect	South-Southeast	South-Southwest
Alititude (m)	500	470
Slope (%)	20	10
Soil depth (cm)	60-120	30-60
Soil texture	loam/clayloam-clay	sandyloam-loam/clayloam
Soil acidity(pH)	5.0/5.7-6.3	5.1/4.7
Soil Ca:Mg ratio	0.45/0.05-0.08	4.4/1.6
FAO-UNESCO unit	Chromic Luvisol(Lc)	Orthic Acrisol (Ao)

planted on the 2 sites in November of the same year. The provenances are shown in the *table 2*.

Experimental layout

The *P. muricata* trial was of randomized blocks design with 3 replications per site. There are 10 trees per plot in 2 rows of 5 trees. Spacing is 3 m x 2 m. There are no internal border rows, but a double border of the same species surrounds all external plot edges. In total, 540 trees were measured.

Assessments and data analysis

Measurements of survival and tree height were carried out from the 2nd year, while measurements of diameter at breast height (DBH) were initiated at the 6th year. Frost damage was observed followed usually by insect attack to the leading shoot that were replaced by a top lateral one. The stem form was expressed as percentage of the straight stems (never damaged) to the total stems per plot. Thus data of the 7th year after planting, for survival (%), tree height (cm), diameter (cm) and stem form (%) as it has been defined above, were used for the subsequent statistical analysis.

Prior to statistical analysis the percentages were transformed with angular (arcsin) transformation. An analysis of variance across the 2 sites has been calculated for each trend (survival, height, diameter and stem form). The broad sense heritability (HHbs) and the expected genetic gain (GGp) was calculated per site for all the traits, in order to allow provenance selection based on their average (NANSON, 1970).

Results and Discussion

Pinus muricata growth rates at the 7th year (mean height 3.6 m, diameter 5.0 cm) were lower to those of the adjusted *Pinus radiata* trial (mean height 4.0 m, diameter 7.3 cm) on the 2 sites, while the survival and stem form were similar. This is in line with early observations (COOLING and VARELIDES, 1986) and reports on the 2 species performance (FALKENHAGEN, 1991a; BARROS and ROJAS, 1986; SIMSEK and TULUKCU, 1983).

The provenances

In contrast to *P. radiata*, where significant differences in growth between provenances were hardly identified in provenance trials (FALKENHAGEN, 1991b; COOLING and VARELIDES, 1986; SIMSEK and TULUKCU, 1983; MATZIRIS, 1979a and b; VARELIDES, 1977), the *P. muricata* provenance differences appear significant and accounted for 64% of the observed variation of the tree height and 51% for the diameter variation. In both cases the 69 Medocino provenance proved the best with mean height 4.0 m and diameter 7.6 cm, while 63 Huboldt provenance proved the worst with mean height 2.2 m and diameter 3.0 cm. The other *P. muricata* provenances, with no differences between them in diameter and slight differences in height, rank between the 2 mentioned above as can be seen in the *table 3*. These results verify an early evaluation (COOLING and VARELIDES, 1986) that had shown 69 Medocino provenance well ahead of the group of the others.

It seems that diversity in growth and certain characters between *P. muricata* provenances is well established, while for *P. radiata* the opposite is true. In a *P. muricata* provenance trial in NSW Australia (ADES et al., 1992), including provenances from Humboldt, Medocino and Sonoma, where the susceptibility to Dothistoma needle blight was tested, the Medocino provenance is suggested as an alternative to *P. radiata* on high risk sites not only for its resistance, but also for the high growth rates and wood properties. Sonoma "green" and Medocino "blue" provenances were found to be the best growing in a series of *P. muricata* trials in New Zealand (SHELBOURNE et al., 1982). The Sonoma provenance of "green strain" was the best for growth and stemform in the *P. muricata* provenance trial in South Africa cited above (FALKENHAGEN, 1991a). This Sonoma coastal provenance, (65 in our numbering) and the other Sonoma provenances (66 and 67) did not show surperiority in growth at Nigrita trial, being superior only to the last in rank (Huboldt, 63).

Provenance selection

It has been found, so far, that 69 Medocino coastal provenance of *P. muricata* is the best growing in Nigrita plantation and no other provenance has shown superiority in survival or stemform. By selecting this provenance, the expected genotypic gain over the mean per site at the 7th year, based in the broad sense heritabilty and expressed as percent of the mean, is between 29% to 61% for height, 43% to 48% for DBH, 5% to 14% for stemform and negligible for survival as it can be seen in the *table 4*.

In the South Africa trial (FALKENHAGEN, 1991a), where 6 of the same provenances were used, the expected genetic gains at 8 years on 2 sites were more or less the same in absolute terms but considerably lower as percentage of the mean. This was due to higher differentiation between the provenances in Nigrita case.

The sites

Significant site differences appeared for diameter and accounted for 24% of the total variation of this trend; 61% of

Table 2. – *Pinus muricata* provenances (California USA).

Greek stock number	Australian stock number	Location	Race	Latitude N.degrees hundredth	Longitude E.degrees hundredth	Altitude metres	Number of trees bulked
63	S12602 10	Huboldt Co., Trinidad Head	Blue	41.10	124.12	275	41
64	S12876 07	Monterey, Huckleberry Hill	Green	36.58	121.92	135	30
65	S12604 08/1	Sonoma Co., coastal: Stewart Point	Green	38.63	123.38	50	30
66	S13041 08/2	Sonoma Co., inland	Green	38.60	123.30	100	50
67	S12598 09/1	Sonoma Co., coastal: south, Pt. Arena	Blue	38.88	123.62	55	24
68	S12603 09/2	Sonoma Co., inland: south, Pt. Arena	Blue	38.83	123.58	275	25
69	S12600 09/3	Medocino Co., coastal: north, Fort Bragg	Blue	39.33	123.77	65	21
70	S12599 09/4	Medocino Co., inland: north, Fort Bragg	Blue	39.25	123.72	250	30
71	S12601 09/5	Medocino Co., Albion Ridge,	Blue	39.23	123.72	160	20

Table 3. – Components of variance per source, as percentages of the total variance, for 4 traits at the 7th year.

Source	df	Survival	Height	Diameter	Stemform	t
1.Sites	1	2	2	24**	4	2
2.Reps in sites	4	4	4	5	45****	5
3.Provenances	8	34	64****	51****	6	4
4.Proven.XSites	8	31***	3	4	9	5
5.Residual	32	29	27	16	36	
Total	53	100	100	100	100	

Note: a) Level of significance **** p = 0.001, *** p = 0.01 and ** p = 0.025.
b) t is the numerical indication of the source against which the Mean Square of the source in the same line is tested for significance in the analysis of variance.
c) df is the abbreviation for degrees of freedom.

P.muricata provenance means

Height (cm)		Diameter (cm)	
69	399	69	7.57
64	313	66	5.27
66	301	64	5.24
71	290	65	5.14
68	288	68	5.05
65	287	71	4.72
70	278	70	4.63
67	264	67	4.60
63	221	63	2.98

site means

Diameter (cm)	
schist	5.79
ultrabas.	4.27

overall means	
survival (%):	95.6
height (cm):	360
diameter(cm):	5.03
stemform (%):	71.5

Note: Means connected with a line do not differ at p 5%.

Table 4. – Heritability (HH) in the broad sense applicable to provenance selection and expected genotypic gain in absolute (GG) and as a percentage of the mean (%%) per trait and site, for selecting provenance 69.

Traits	Schist HH	Schist GG	Schist %%	Ultrabasic HH	Ultrabasic GG	Ultrabasic %%
Height (m)	0.95	1.04	61	0.82	0.83	29
DBH (cm)	0.95	2.77	48	0.85	1.83	43
Survival (%)	0.82	3.85	4	0.90	1.98	2
Stemform (%)	0.57	9.01	14	0.51	5.00	6
" (*)		10.43	16		7.70	10

Note: The second (*) stemform figures, are for selecting the higher ranking provenance per site (68 in Schist and 67 in ultrabasic) for this trait.

the diameter variation is attributed to provenance differences as has already been mentioned. The schist site, with mean diameter 5.8 cm, is superior to the ultrabasic with mean diameter 4.3 cm. Variation within sites was found important for stem form; the schist site replications are well distinguished regarding this trend.

The site differences in diameter where the schist site with shallower sandy and less fertile soil proved better, might reflect the tolerance of the "blue" provenances to infertile soils. It has been reported (MILLAR, 1989) that in Sonoma County where the 2 races meet in a narrow contact zone near the sea level, stands of the "blue" *P. muricata* were observed at higher altitude on patches of infertile"pygmy-forest" soil while the "green" grew on fertile soils half a kilometre away from that infertile zone. The majority of *P. muricata* tested in Nigrita, 6 out of 9 provenances, were "blue".

The site-provenance interaction

The survival of *P. muricata* has shown significant site provenance interactions accounting for 31% of the total survival variation. The size of the interactions makes the provenance differences insignificant (random model, provenance SS tested against interaction SS) although for the two sites differences do appear (fixed model, provenance SS against residual SS) with provenance 67 clearly the worst for the 2 sites in terms of survival.

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