Forest Ecology and Management, 16 (1986) 403-410
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

Performance of *Pinus halepensis/brutia* Group Pines in Southern New Mexico

JAMES T. FISHER[1], ROBERT W. NEUMANN[2] and JOHN G. MEXAL[1]

[1]*Department of Horticulture, New Mexico State University, Las Cruces, NM 88003 (U.S.A.)*
[2]*Mora Research Center, Box 359, Mora, NM 87732 (U.S.A.)*

New Mexico Agricultural Experiment Station Scientific Paper No. 249

(Accepted 11 March 1986)

ABSTRACT

Fisher, J.T., Neumann, R.W. and Mexal, J.G., 1986. Performance of *Pinus halepensis/brutia* group pines in southern New Mexico. *For. Ecol Manage.*, 16: 403-410.

An international provenance trial of *Pinus eldarica, P. brutia* and *P. halepensis* was established the southern Rio Grande Valley of New Mexico in 1978. The test was planted in a randomized complete block with 10-tree row plots. *Pinus eldarica, P. brutia* and *P.halepensis* were represented by seven, seven and nine seed sources, respectively. After five growing seasons, *P. eldarica* height, diameter at breast height (DBH) and stem volume were, respectively, 1.6, 2.0 and 5.0 times greater than the other two species, and eldarica pine was least variable across all parameters. *Pinus brutia* showed good survival, but growth variation among provenances was high. Survival among *P. halepensis* provenances varied greatly because of winter injury. The potential value of *P. eldarica* for multipurpose plantings in arid and semiarid zones is discussed.

INTRODUCTION

Pinus halepensis Mill., *P. brutia* Ten. and *P. eldarica* Medw. are among the few pine species adapted to calcareous soils having moderate alkalinity. They are planted extensively in semiarid to arid regions lacking sufficient moisture to leach soluble salts below the root zone. In recent decades, extensive forestation efforts have relied heavily on these pines to restore denuded land and establish field protective plantings. *Pinus halepensis* has been widely planted in Israel, Greece and Spain. *Pinus brutia* receives considerable emphasis in Turkey and Iraq, and *P. eldarica* has been planted extensively in Iran, Pakistan, Afghanistan and southern U.S.S.R. (Guseinov and Guseinova, 1976).

In the United States, *Pinus halepensis/brutia* group pines received minor attention until *P. eldarica* was introduced to the Southwest from Afghanistan in 1961 (Fisher and Widmoyer, 1978). The biology and potential uses of *P.*

0378-1127/86/$03.50

eldarica are increasingly being explored because the tree grows rapidly and provides multiple products and benefits under frugal irrigation (Fisher and Widmoyer, 1978). The purpose of the research reported here was to compare the survival and growth potential of eldarica pine and its close taxonomic affinities, and to better understand the differences among species and seed sources.

Species distribution and taxonomy

Pinus halepensis is widely distributed in the western Mediterranean region. In the northeastern part of the region, it is replaced by *P. brutia*. In northeastern Greece, *P. halepensis* and *P. brutia* hybridize where their distributions overlap. *Pinus eldarica* occurs naturally is a semiarid region in the southern U.S.S.R. where it is confined to a single mountain southeast of Tbilisi, Georgia, Transcaucasia. Considered an Oligocene relic, it grows along the eastern extremity of the Choban-Dagh Range, along the south side of the Iori River. It is found at 200 to 600 m elevation and covers only 550 ha (Tutajuk, 1959; Zimina, 1978).

Because taxonomic relationships among these and closely related species are not fully understood, several classification schemes have been reported. For this reason, FAO's Committee for Mediterranean Forest Research refers to *Pinus halepensis/brutia* group pines. The complex belongs to the subgenus *Pinus*, section *Pinus* and subsection *Sylvestres* (Critchfield and Little, 1966).

At present, it seems clear that *P. halepensis* and *P. brutia* are separate species as recognized by Mirov (1955) and Nahal (1962). The identity of *P. eldarica* is unclear. Debazac and Tomassone (1965) and Allegri (1974) concluded that *P. eldarica, P. pithyusa* and *P. stankewiczii* should be regarded as varieties of geographical subspecies of *P. brutia*. However, Kolesnikov (1963) considers all four valid species. This paper refers to *P. eldarica* with the understanding that *P. brutia* subsp. *eldarica* is a legitimate synonym.

Among the common names given *P. eldarica* are eldarica pine, Eldar pine, Quetta pine and Afghanistan pine. We refer to eldarica pine, as this accords with the Russian scientists responsible for documenting the location and ecology of the meagre natural stands that, indirectly, gave rise to all introductions. *Pinus halepensis* is refered to as Aleppo pine.

MATERIALS AND METHODS

Seed collections were coordinated by R. Morandini of the Instituto Sperimentale per la Selvicoltura in Italy, on behalf of FAO's Committee for Mediterranean Forest Research. Field collections were carried out by forestry institutes in a number of different countries. Provenances included in the study are listed in Table 1. *Pinus halepensis* and *P. brutia* seed sources are mapped in Fig. 1.

TABLE 1

Pinus halepensis/brutia group provenances planted October 1978 in Las Cruces, NM

Code[1]	Country	Provenance	Code[1]	Country	Provenance
A-2	Greece	Elea	B-10	Turkey	Bozburum
A-7	Israel	Elkosh	B-11	Turkey	Bakara
A-8	Tunisia	Sakiet Sidi Y	B-12	Turkey	Silifke
A-12	Morocco	Zaouia Iframe	B-15	Turkey	Kisildag
A-14	Morocco	Ouardane Bouksane	E-1	Iran	—
A-17	Spain	Guadalmedina	E-2	Iran	—
A-18	Spain	Maria	E-3	Iran	—
A-19	Spain	Cehegin	E-4	Iran	Karaj
A-32	Algeria	Ouarsensis	E-5	Pakistan	Quetta
B-3	Greece	Lassithiou	E-6	Pakistan	—
B-6	Turkey	Marmaris	E-7	U.S.S.R.	Azerbaijan
B-8	Turkey	Duzlercani			

[1]A = *P. halepensis*, B = *P. brutia*, E = *P. eldarica*.

The study site is in the Rio Grande Valley of southern New Mexico at an elevation of 1158 m. Annual precipitation and temperature range from 200 to 250 mm and from −23° to 43°C, respectively. The alkaline soils (pH 7.8 to 8.0) were formed in alluvial parent material derived from noncalcareous rocks; calcareous dust is virtually the sole source of pedogenic carbonate (Gile, 1970). Soils have loamy surface layers, and subsoils are clay loams at depths of 20 to 150 cm.

Twenty-four-week-old seedlings grown in 160-cm^3 Ray Leach tubes were auger-planted on 2.5×2.5 m spacing the first week of October 1978. Weeds

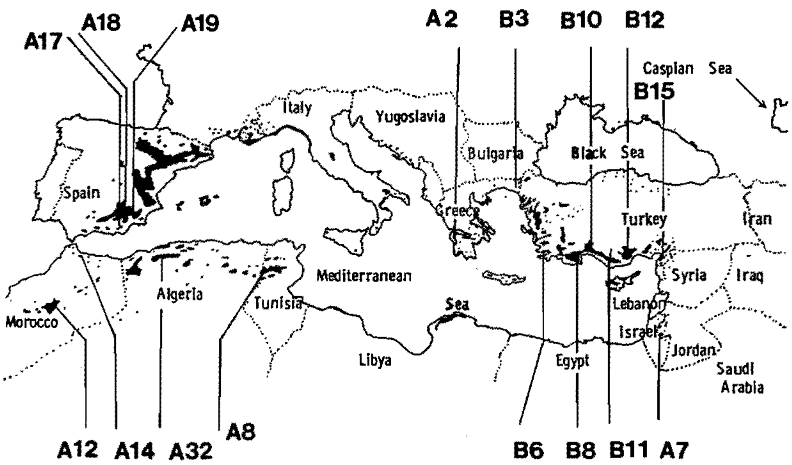

Fig. 1. Locations of *Pinus brutia* and *P. halepensis* provenances

TABLE 2

Survival, height, DBH, volume and branch whorls per year for *P. eldarica*, *P. brutia* and *P. halepensis* after five growing seasons. Values with the same letter are not significantly different ($P<0.05$)

Species	Survival (%)	Height (m)	DBH (cm)	Volume ($cm^3 \times 10^4$)	Whorls/y
P. eldarica	97.4	5.9 A	10.3 A	2.86 A	6.0 A
P. brutia	96.4	3.7 B	4.8 B	0.57 B	4.2 B
P. halepensis	66.0	3.6 B	4.6 B	0.48 B	3.9 C

were controlled by periodic cultivation between and within rows. Trees were flood irrigated five times from March through October and received 8 to 10 cm with each treatment. Natural precipitation was 200 mm.

The test was a randomized complete block with 10-tree row plots and five replications. Survival, height, diameter at breast height (DBH) and number of branch whorls were recorded yearly. Tree volume was calculated by the following equation:

$$V=1041+0.3974\,D^2H,$$

where $V=$ volume (cm^3), $D=$ diameter at 1.4 m (cm) and $H=$ total height (cm) (Perry and Roberts, 1964). Data were analyzed for source differences via analyses of variance and least-squares means separations (Ray, 1982).

RESULTS

Significant differences occurred among and within species for each characteristic evaluated (Table 2 and 3). Survival was uniformly high across *P. eldarica* and *P. brutia* provenances. Survival among *P. halepensis* sources was comparatively less and varied greatly among sources. No pest- or disease-related injury was observed for any species over the course of the study.

Pinus eldarica plots could be easily identified because foliage was deep green throughout the year and a central main stem was obvious. Aleppo and brutia

TABLE 3

Coefficients of variation (%) within species for survival and growth parameters

Species	Survival	Height	DBH	Volume	Whorls/y
P. eldarica	2.8	3.2	8.3	15.4	1.6
P. brutia	4.1	14.7	27.4	37.4	6.4
P. halepensis	34.4	9.5	11.2	18.4	9.1

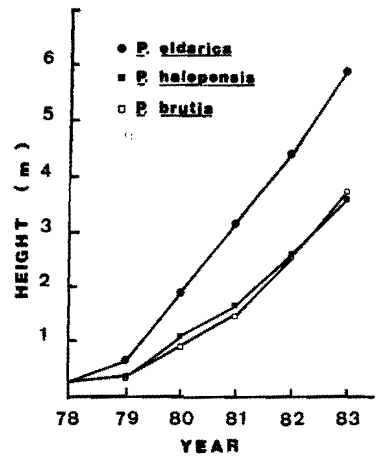

Fig. 2. Height growth for *Pinus eldarica, P. brutia* and *P. halepensis.*

pine foliage color tended to fade during winter, and the expression of apical dominance varied by source.

Eldarica pine was superior across all growth parameters (Table 2) and consistently produced more yearly height growth (Fig. 2). Height growth rate was similar for *P. brutia* and *P. halepensis.* After five years, average tree volume was five times greater for eldarica pine than for the other species. Species differed in the number of branch whorls produced each year (Table 2). Growth parameters were least variable among eldarica pine sources (Tables 2 and 4). Differences were significant (0.05 level) for only two Iranian sources (E-2 and E-3).

Growth parameters were most variable among *P. brutia* sources (Table 3

TABLE 4

Survival and mean separation for height, DBH, volume and branch whorls per year of *P. eldarica* sources after five growing seasons. Values with the same letter are not siginificantly different ($P<0.05$)

Source	Survival (%)	Height (m)	DBH (cm)	Volume ($cm^3 \times 10^4$)	Whorls/y
E-3	100	6.1 A	11.7 A	3.67 A	6.1 A
E-6	96	6.1 A	10.2 AB	2.86 AB	6.0 A
E-7	100	6.0 A	10.1 AB	2.75 AB	6.0 A
E-1	98	5.9 A	9.8 AB	2.71 AB	5.9 A
E-5	94	5.9 A	10.9 AB	3.12 AB	6.1 A
E-4	94	5.8 A	10.1 AB	2.66 AB	6.0 A
E-2	100	5.6 A	9.0 B	2.25 B	5.9 A

TABLE 5

Survival and mean separation for height, DBH, volume and branch whorls per year of *P. brutia* sources after five growing seasons. Values with the same letter are not significantly different ($P<0.05$)

Source	Survival (%)	Height (m)	DBH (cm)	Volume ($cm^3 \times 10^4$)	Whorls/y
B-12	89	4.2 A	5.8 A	0.75 A	4.7 A
B-11	100	4.2 A	6.3 A	0.84 A	4.4 AB
B-6	100	4.1 A	5.1 A	0.59 A	4.4 AB
B-10	98	4.1 A	5.6 A	0.70 A	4.2 AB
B-15	98	3.6 AB	4.3 AB	0.50 A	4.0 B
B-8	96	3.3 AB	3.9 B	0.43 A	3.9 B
B-3	94	2.7 B	2.5 B	0.21 A	4.3 AB

and 5). On the basis of mean separations, more than half the brutia pine sources were superior to B-3 (height and DBH) and B-8 (DBH).

Mortality among *P. halepensis* provenances was attributed to winter injury. Survival was highest for two upland Spain sources, and was generally lower among coastal North African sources (Table 6). No significant differences (0.05 level) were detected among sources for height, DBH and volume.

DISCUSSION AND CONCLUSIONS

Eldarica pine growth was clearly superior under the conditions imposed in this study. In western Australia, where a similar study was conducted without supplemental irrigation, growth differences between eldarica and brutia pine sources were less pronounced (Palmberg, 1975). With less moisture (about

TABLE 6

Mean separation for height, DBH, volume and branch whorls per year of *P. halepensis* sources after five growing seasons. Values with the same letter are not statistically different ($P<0.05$)

Source	Survival (%)	Height (m)	DBH (cm)	Volume ($cm^3 \times 10^4$)	Whorls/y
A-8	82	4.0 A	5.1 A	0.60 A	4.4 AB
A-7	54	4.0 A	4.8 A	0.44 A	3.5 C
A-2	67	3.9 A	4.9 A	0.57 A	4.4 A
A-14	34	3.8 A	4.9 A	0.49 A	4.1 ABC
A-19	98	3.7 A	5.1 A	0.56 A	3.7 BC
A-17	68	3.7 A	4.6 A	0.47 A	3.5 C
A-18	94	3.3 A	3.9 A	0.37 A	3.5 C
A-32	37	3.2 A	4.3 A	0.44 A	3.8 ABC
A-12	60	3.1 A	3.7 A	0.35 A	3.8 ABC

400 mm), eldarica was superior to most, but not all, brutia sources. The accelerated aldarica pine growth suggests it may be more responsive to intensive culture through its ability to produce more growth flushes per growing season. *Pinus eldarica* consistently produced roughly six growth flushes per growing season, regardless of source. Faster growth may also be the result of eldarica pine's ability to maintain higher tissue nutrient concentrations than Aleppo or brutia pines (Chan et al., 1982).

The variations detected among species and sources point to several opportunities for applying genetic selection to establish fast growing conifers in southern New Mexico. The selection of eldarica pine over Aleppo and brutia pines is clearly justified. Although growth was rather uniform across eldarica sources, differences between two sources are large enough to justify further tree improvement efforts. By choosing Iranian source E-3 over E-2, volume production would be increased 60%. Growth variation across brutia sources suggests proper selection will result in faster growing trees. Among Aleppo pine sources, improper selection can lead to low survival caused by winter injury. This study and numerous others have failed to detect patterns of systematic variation, determined by source latitude and longitude. The observed variation patterns have been attributed to the intervention of man, particularly where stands are most accessible, and to genetic drift within the small, fairly isolated populations escaping exploitation.

This study clearly demonstrates that eldarica pine can produce short-rotation wood and fuelwood crops. The spacing used in this study (1600 trees per ha) allowed full crown exposure over five growing seasons. Data reported here suggest eldarica pine can produce about 46 m^3 ha^{-1} of bole wood in five years. Using data drawn from a limited number of trees, Fisher and McCrae (unpublished) estimated dry matter production to be 108 tons ha^{-1} for irrigated trees stocked at 1372 trees per ha and harvested six years after planting.

Based on the limited amount of work done in the United States, it seems probable that eldarica pine will be used to manufacture particle board and paper, and to provide energy and extractives. Wood appears unsuitable for building construction because of low bending strength.

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