Comparative radial growth of *Pinus halepensis* Mill. and *Pinus brutia* in Israel

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Introduction

Pinus halepensis and *P. brutia* are vicarious species; the distribution of the former is western Mediterranean while that of the latter lies to the east (cf. Mirove, 1955).

The annual rhythm of cambial activity of *P. halepensis* shows that this species is well adapted to the Mediterranean climate (Liphschitz *et al.*, 1984; Liphschitz & Lev-Yadun, 1986), and responds clearly to changes in precipitation and temperature (Gindel, 1944; Lev-Yadun *et al.*, 1981). No comparable information is available concerning *P. brutia* (cf. Liphschitz & Lev-Yadun, 1986).

Pines comprise about 70 % of the trees in afforestation in Israel, with most of the plantations consisting of *P. halepensis.* Recent surveys have shown that most aleppo pine stands are infested by the Israeli pine bast scale *Matsucoccus josephi* Bodenh. et Harpaz. About 10 % of the mature stands are severely affected and an additional 20 % display significant damage (Madar *et al.*, 1985). Though *P. halepensis* and *P. brutia* are closely related, *P. brutia* is resistant to *Matsucoccus josephi* (Mendel, 1984), but more susceptible to bark beetle attack than the former (Mendel, unpublished data). In the last decade *P. brutia* is widely planted taking first place over *P. halepensis.*

The objective of this investigation was to compare the patterns of annual width growth of both species in various habitats in Israel and to examine their response to identical environmental conditions on different sites. This information is needed to understand their different susceptibility to bark beetles attacks in different habitats. Correlations between annual increments of unaffected trees will indicate whether *P. brutia* may be used to assess increment losses from *Matsucoccus* of *P. halepensis* associated on the same site.

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Materials and methods

Eight stands in typical afforestation areas in Israel where *P. halepensis* and *P. brutia* grow of the same site, were chosen for this investigation. At each site both species were planted in the same year or during two successive years (Table I). In each stand ten well developed trees of each species were sampled : cross sections taken at the base of the stem or increment cores from a height of 0.5 m above the ground were smoothed, and the width of the annual growth rings was measured.

Master chronologies were built for each species and site based on individual chronologies showing similar patterns. They therefore represent the general growth pattern for each tree population and site (Fig. 1). Correlations between the master chronologies of the two species were calculated for each site.

Results

Master chronologies of radial growth of *P. halepensis* and *P. brutia* at eight sites are shown in Fig. 1.

At Iron, marked between-trees variations were observed in both species. The trees of each population were, therefore, divided into two groups. For this site there are, thus, two master chronologies for each species. At all other sites, all ten trees of each species showed very similar radial growth patterns, the master chronologies were, therefore built from ten trees each.

Highly significant correlation coefficients were obtained at all sites, including Iron, between radial growth increments of *P. halepensis* and *P. brutia* (Table II).

At Kh. Ein al Hayik and Iron, *P. brutia* produced wider rings than *P. halepensis.* At Sifsufa the later produced wider rings than the former only after 1975, probably following thinning. At all other sites annual rings of the two species were of about same width (Fig. 1).

Comparison between the master chronology and annual rainfall curves at the nearest meteorological stations show very similar pattern (Fig. 1).

Study site	Lat. N	Long. E	Altitude m'	Year of planting	Soil	Mean annual precipitation (mm) at nearest meteorological station
Sifsufa	32°59'	35°26'	680	1956/7	Brown rendzina	874
Ein Zaitim	32°59'	35°30'	880	1955/6	Terra rosa	674
Bat Shelomo	32°36'	35°00'	75	1962/3	Light brown rendzina	596
Kh. 'Ein al Hayik	32°41'	35°02'	767	1960	Rendzina	767
Iron	32°30'	35°05'	130	1956/7	Rendzina	536
Eshta'ol	31°47'	35°00'	250	1960	Light brown rendzina	539
Lahav	31°23'	34°52'	440	1972	Light brown loess	303
Yattir	31°14'	34°47'	270	1968	Light brown loess	204

Table I. Study sites.

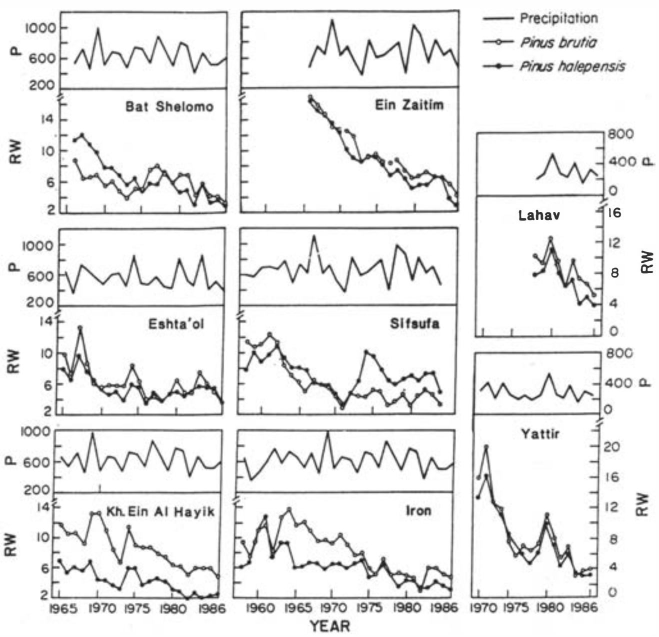

Fig. 1. Radial growth patterns (RW = ring width, mm) (master chronologies) of *P. halepensis* and *P. brutia* in eight mixed stands in Israel, and annual precipitation (P) (mm) at the nearest meteorological stations.

Study Site	Regression equation	r*
Sifsufa	Y = 1.034x-0.834	0.73
Ein zaitim	Y = 0.723x+0.282	0.96
Bat Shelomo	Y = 0.336x+1.796	0.61
Iron group A	Y = 0.405x+1.633	0.93
Iron group B	Y = 1.000x+0.916	0.78
Kh. 'Ein al Hayik	Y = 1.356x+1.403	0.83
Eshta'ol	Y = 1.386x-0.775	0.91
Lahav	Y = 0.856x+1.327	0.91
Yattir	Y = 1.145x-0.040	0.95

*Correlation coefficients are significant for P=0.05

Table II. Linear regression equations and correlation coefficients (r) values of the annual growth increments between paired pine populations : *P. halepensis* (x) over *P. brutia* (Y) within sites.

Discussion

At each of the sites examined growth responses of *P. halepensis* and *P. brutia* were similar. The effect of site conditions is decisive, and is expressed by the correlation coefficient between radial growth of both pines. However, as expected, patterns of the width increment differ in the same species between populations growing under different invironmental conditions in different parts of Israel. Parallel radial growth patterns of *P. halepensis* and *P. brutia* are conspicuous both in the young age and in later years. In spite of the fact that during the first years wider rings are produced patterns of width growth of both pines are similar to those of annual rainfall.

Investigations concerning the annual rhythm of cambial activity have shown that *P. halepensis* is well adapted to the Mediterranean climate, with local variations occurring among populations growing in different parts of its range (Liphschitz & Lev-Yadun, 1986). The high correlation coefficients between width growth of *P. halepensis* and *P. brutia* suggest that within reasonable limits the latter will presumably behave in various habitats like *P. halepensis*. Site factors such as soil or precipitation are not expected to cause one species to replace the other through competition. However, Panetsos (1975) suggested that low freezing temperatures might be a strong selective factor favouring *P. brutia*. Although *P. brutia* is more susceptible to drought, fire (Panetsos, 1975) and bark beetle attack (Mendel, unpublished data), its competitive vigour is enhanced by its resistance to *M. josephi* injury.

During the last two decades, a serious deterioration of *P. halepensis* plantations has been observed mainly in the central parts of Israel. Data are missing to quantitatively assess losses caused by the scale. Assessment of damage due to cyclic outbreaks of, or chronic annual injury by the scale is needed for an economic approach to its control. *P. brutia* might be infested by, and some development of *Matsucoccus josephi* can take place (Bodenheimer & Neumark, 1955; Mendel, 1984). However, injury to this species is very rare and not of significance. Identical growth rates of *P. brutia* and *P. halepensis* suggest that the former can serve as a yardstick to evaluate growth losses of *P. halepensis* related to *M. josephi*.

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RÉSUMÉ

*Comparaison de la croissance en diamètre du Pin d'Alep (*Pinus halepensis *Mill.) et du Pin brutia (*Pinus brutia *Ten.) en Israel.*

La croissance en diamètre dans un peuplement mixte d'arbres de Pin d'Alep et de Pin brutia dans huit régions d'Israel a été examinée. La corrélation de la croissance en diamètre entre les deux expèces est statistiquement significative. Les périodes d'activité cambiale reflètent le rôle de l'environnement local, particulièrement les conditions météorologiques. L'accroissement identique des deux espèces suggère que le Pin brutia peut remplacer le Pin d'Alep dans les différentes régions d'Israel. Le Pin brutia peut servir d'indice pour évaluer les dommages au Pin d'Alep causés par Matsucoccus josephi.

SUMMARY

The width of the annual growth rings was measured in eight even-aged mixed or neighbouring stands of Pinus halepensis *and* P. brutia. *Highly significant correlations were found on all sites between radial growth rates of both species. Growth patterns reflect the effect of the site conditions particularly the precipitation. Identical growth rates suggest that* P. brutia *may replace* P. halepensis *in most environments and that the former can serve as a yardstick to assess increment losses of* P. halepensis *caused by the Israeli pine bast scale Matsucoccus josephi.*

RESUMEN

Se examina el crecimiento en diametro en una población forestal mixta de Pino de Alepo y de Pino brutia en ocho regiones de Israel. Es estadísticamente significativa la correlación del crecimiento en diámetro entre las dos espécies. Los períodos de actividad cambial refletan el papel del medio ambiente local, particularmente las condiciones meteorológicas. El crecimiento idéntico de las dos espécies sugiere que el Pino brutia puede substituir el Pino de Alepo en varias regiones de Israel. El Pino brutia puede servir de indice para evaluar las deterioraciones causadas por Matsucoccus josephi *al Pino de Alepo.*