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PINUS INSULARIS: A PROMISING EXOTIC CONIFER FOR COMMERCIAL PLANTATIONS?

Ahmad Zuhaidi Yahya & Rosdi Koter

Forest Research Institute Malaysia, Kepong 52109 Kuala Lumpur, Malaysia

Pinus insularis Endl. or Benguet pine was first introduced in 1932 into Peninsular Malaysia from the Philippines (Baguio Islands) mainly as an ornamental and roadside tree at the hill stations in Cameron Highlands and Fraser's Hill (Mitchell 1963). A trial plantation was later established in 1932 at Mentigi Forest Reserve, Cameron Highlands, Pahang, at an altitude of 1460 m above sea-level. In 1957 similar plantations were established in the lowland areas including sample plot 6, Compartment 10, in Sungai Buloh and Field 44 and 45 in Bukit Lagong Forest Reserve, Selangor.

The tree reaches up to 30 m in height and 31 cm in diameter at breast height in 21 y (Setten 1952). In Cebu, the Philippines, Claveria (1953) observed a diameter range of 6.4–30.5 cm and a height range of 6.4–15.2 m for a 15-y-old stand. Vincent *et al.* (1965) reported that the tree achieved 11.2 cm diameter at breast height and 14.3 m in height after 5 y. At 30 y at the Cameron Highlands, Peninsular Malaysia, the diameter at breast height was 39.4 cm, the mean dominant height 32 m and clear bole height 12.8 m (Mitchell 1963).

The young seedlings are less hardy than those of other conifers, being particularly susceptible to damping-off. Five-year-old stands were badly damaged by bark-feeding squirrels and had poor resistance to fire. Mature trees are heavily branched, which may mean that a higher stand density may be necessary to maintain tree vigour (Mitchell 1963). The mature wood is of good quality and can be used for general-purpose construction work, paper pulp and veneer (F.R.I. 1959, Peel 1959: cited in Mitchell 1963).

At present, there are only limited growth data available except from sample plot 6 in Block H, Compartment 10, Sungai Buloh Forest Reserve, Selangor, Peninsular Malaysia. The plot is located at 3° 14' N and 101° 38' E, 100–150 m above sea-level. The mean daily temperature ranges from 27 to 30 °C. The annual rainfall is 2000–2500 mm. The soil is of light reddish loam, shallow with underlying rock and granite, and has good drainage. At plantation establishment the area was under a dense regrowth of *Imperata cylindrica*, with mixed *Eupatorium odoratum, Melastoma malabathricum*, and other colonising species, including *Mikania cordata, Passiflora foetida, Derris elliptica* and *Milletia atropurpurea*. The area was slashed over prior to planting. The 0.4-ha plot was planted in September 1957 at a spacing of 3 × 3 m (1111 stems ha^{-1}). Beating-up of 90 trees was carried out in March 1961. Between 1957 and 1963, 14 climber cutting operations were carried out, and pruning was done in October 1964. Treatments with insecticide to repel termites were carried out in September 1963 and October 1964. Thinning was carried out in October 1964 based on the reduction of direct inter-crown competition with the removal of 165 trees ha^{-1} including all trees of poor form and ill health. Results of the survival count, measurements and enumeration during 5.5 y after planting are shown in Table 1.

Table 1. Summary of survival, measurements and enumeration for total height and diameter at breast height of *Pinus insularis* in sample plot 6, Block H, Compartment 10, planted in September 1957, Sungai Buloh Reserve, Selangor, Peninsular Malaysia

	Month/year	12/59	1/61	12/61	3/63
Survival (%)	99	78	78	-	78
Mean height (m)	1.2	-	6.1	7.5	-
Mean diameter (cm)	-	-	-	11.1	12.2

At 5.5 y, the average diameter at breast height was 12.2 cm and the survival rate 78%. The plot was re-measured in 1998 to determine the actual stocking of the stand after 41 years. During the recent measuments, the diameter at breast height was measured at 100 percent enumeration. The total and merchantable tree heights were measured on all trees.

As a comparison, a species trial plot of the same species and of about the same age in Field 44 D, Bukit Lagong Forest Reserve, Selangor (7 km from the Sungai Buloh Forest Reserve) was also measured. Measurements were based on 0.1-ha plots selected at random, using the same technique. One hundred felled trees over the whole range of height-diameter values were used to estimate the standing volume per hectare. The standing stocks of the planted *P. insularis* at both sites are given in Table 2.

Table 2. Standing stocks of planted *P. insularis* in 1998 at (a) sample plot 6, Block H, Sungai Buloh Forest Reserve, and (b) Field 44 D, Bukit Lagong Forest Reserve

Site	N	h_{dom} (m)	d_{dom} (cm)	h_g (m)	d_g (cm)	G (m^2ha^{-1})	V (m^3ha^{-1})	V_{mai} ($m^3ha^{-1}y^{-1}$)
(a) Sungai Buloh	98	24.2	56.3	22.1	42.0	13.45	118.90	2.97
(b) Bukit Lagong	300	22.1	42.1	19.4	29.1	19.95	154.95	3.87

Key:

N : number of trees ha^{-1}
h_{dom} : mean height of 100 biggest trees ha^{-1}
d_{dom} : mean diameter at breast height of 100 biggest trees ha^{-1}
h_g : mean height of the stand
d_g : mean diameter of the stand
G : basal area ha^{-1}
V : volume ha^{-1}
V_{mai} : mean annual volume increment

The results show that diameter growth at Sungai Buloh was distinctly higher than that at Bukit Lagong as indicated by the average size of the dominant trees in both plots in Sungai Buloh and Bukit Lagong Forest Reserve (56.3 and 42.1 cm). The distinct diameter size at Sungai Buloh was probably due to the effect of low thinning treatment in 1964, whereas no silvicultural treatments or tree improvement activities were conducted at Bukit Lagong except line cleaning and climber cuttings. However, the wide diameter ranges (20.1–61.2 and 16.3–55.6) for the two populations are not necessarily disadvantageous as long as the size of the final crop (trees having diameter at breast height greater than 35 cm) is within a relatively narrow range. It was found that 64% of the trees in both plots were having diameter at breast height greater than 35 cm.

A survey on stem quality was also conducted on all trees in the sample plot at Sungai Buloh Forest Reserve, Selangor to determine the quality of all trees. Table 3 gives the results of this survey, showing that (a) few trees had bends and kinks, (b) forking below 6 m was not common, and (c) there were no major diseases and damage.

Table 3. Results of a survey on stem quality and forking of all trees ha^{-1} in a *P. insularis* stand in the sample plot, Sungai Buloh Forest Reserve, 1977

Quality	N	%
Forking		
Forking below 6 m (first log)	3	3
Forking between 6 and 12 m (second log)	40	41
Forking between 12 and 18 m (third log)	45	46
No forking	10	10
Stem quality		
2 logs straight, no bends, kinks	47	48
1 log straight, no bends, kinks	48	49
No log straight	3	3
Diseases	None	None
Total	98	100

When planted on a short rotation (less than 20 y), it is likely that the softwood species could yield a merchantable volume of 20 $m^3 ha^{-1} y^{-1}$. Results from the measurements in 1964 show that the stand in Sungai Buloh had a total yield of 192.30 $m^3 ha^{-1}$ (approximately 32.05 $m^3 ha^{-1} y^{-1}$) at stand age of 6 y for trees above 8 cm at breast height (Vincent *et al.* 1965). However, generalising from the available growth information obtained from small plots, the height growth pattern varies according to site and shows poor performance irrespective of site and spacing. This generalisation is confirmed by the average dominant height of the species at 24.2 and 22.1 m after 41 y. The growth performance recorded was not as encouraging as expected. Vincent *et al.* (1965) confirmed similarly poor crop height and crop stem development age for age at any nominal spacing. High growth rate (21.06 m^3 ha^{-1} y^{-1} after 20 y, Mitchell 1963) for plantation grown *P. insularis* at higher elevation in Cameron Highlands apparently is on highly siliceous granite derived soil with a surface peat layer, high in organic content as compared to the lowland areas in the Sungai Buloh and Bukit Lagong Forest Reserves with clay loam soil derived from degraded granite and under sheet of *I. cylindrica.* The trees planted in the Sungai Buloh and Bukit Lagong Forest Reserves or any low-lying areas do not appear to produce seed prolifically. Cones collected from mature trees rarely yield seed and natural regeneration is comparatively rare (Mitchell 1963). Based on all these, the prospect of *P. insularis* may be limited to small-scale short-rotation plantation, especially at high elevation.

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