

THE SIZE OF FINAL CROP TREES OF PLANTATION GROWN *AZADIRACHTA EXCELSA*

Ahmad Zuhaidi Yahya & M. Noor Mahat

Forest Research Institute Malaysia, Kepong, 52109 Kuala Lumpur, Malaysia

One problem in any plantation forest is the determination of an appropriate management regime, which includes the final crop trees for species being grown for the first time. In Malaysia, growth data and management regimes on plantation grown species are only available on a few species, e.g. exotic tree species in the Compensatory Forest Plantation Project (Ahmad Zuhaidi 1993, Ahmad Zuhaidi *et al.* 1996), some indigenous tree species (Ng & Tang 1974, Ahmad Zuhaidi *et al.* 1995) and dipterocarps of the Haurbentes Experimental Forest in Java (Masano *et al.* 1987). *Azadirachta excelsa* (Jack) Jacobs (Meliaceae), an indigenous tree species with multipurpose properties and a fast rate of growth, has been identified as a preferred tree species for large-scale planting. It is a large tree that can attain 50 m in height with an open-crown and terminal bunches of leaves (Mabberly & Pannell 1989). Wyatt-Smith (1952) ranks the tree as an intermediate between the emergent and main canopy in the natural forest. In the humid tropics, it is generally evergreen but may be deciduous for up to three months under a more seasonal climate.

A few research plots of this species exist in the Bukit Lagong Forest Reserve, Selangor, Peninsular Malaysia (3° 14' N, 101° 38' E). One of the plots was measured for both its tree-stand parameters, growth and crown size. The 0.19-ha stand of *A. excelsa* was established at Field 27 in January 1954. Mean daily temperature ranges from 27 to 32 °C. The annual rainfall is between 2000 and 2900 mm. The stand is located at the lower ridges of the Reserve at 100 m above sea-level. Aspects are southerly and westerly. The soil is light reddish loam, shallow with underlying rock and granite. The drainage is good. In the planting trial, 143 seedlings were line-planted at a spacing of 3.6 × 3.6 m (771 trees ha⁻¹). The area was covered with ferns, lallang (*Imperata cylindrica*) and secondary forest prior to establishment. Weedings and climber cuttings were carried out in the first five years after planting. No thinning was carried out.

Measurements were taken for the first time in 1995. Table 1 shows the standing stock of 40-y-old *A. excelsa* stand. As a result of mortality mainly caused by competition, the density had declined to 358 trees ha⁻¹ in 40 years. The results are similar to the estimates given by Ahmad Zuhaidi and Weinland (1995) and for other high quality timber tree species.

Measurements of crown size were taken on 15 standing *A. excelsa* trees as there were no other size class trees greater than 40 cm diameter at breast height. Selected trees were assumed to be representative of a freely growing mature stand. The selection criteria were:

- (a) diameter at breast height of stand average and above
- (b) crown ratio of about 40% (ratio of crown proportion and tree length expressed in percentage)
- (c) bole length 20-25 m
- (d) stand age

Table 1. Standing stock of planted *Azadirachta excelsa* at Bukit Lagong Forest Reserve, Selangor, Peninsular Malaysia (ha⁻¹ values)

| Age | <i>N</i> | h_{dom} (m) | d_{dom} (cm) | $h_{\bar{x}}$ (m) | $d_{\bar{x}}$ (m) | <i>G</i> (m ² ha ⁻¹) | <i>V</i> (m ³ ha ⁻¹) | $V_{m.a.i.}$ (m ³ ha ⁻¹ y ⁻¹) |
|-----|----------|------------------|-------------------|----------------------|----------------------|--|--|--|
| 40 | 358 | 28.9 | 52.9 | 27.5 | 35.3 | 36.22 | 620 | 15.5 |

Note:

- N* : number of trees ha⁻¹
 h_{dom} : dominant stand height (100 biggest trees ha⁻¹)
 d_{dom} : diameter of dominant trees
 $h_{\bar{x}}$: mean height of the stand
 $d_{\bar{x}}$: mean diameter of the stand
G : basal area ha⁻¹
V : volume ha⁻¹
 $V_{m.a.i.}$: mean annual volume increment for standing stock

The maximum crown spread of selected trees was measured using a measuring tape (Suri 1975, Kleine & Weinland 1991). The radii were measured by holding one end of the tape at the middle portion of the trunk and moving away from the base of a tree in a predetermined direction to the fringe of the crown. The reading on the measuring tape was the radius of the crown spread along this direction. Lengths or radii of the crown spread were measured in four directions at right angles to each other. Each radius was then converted into crown projection area measurement (*CPA_i*). These areas were added and divided by four to get the average crown projection area (*ACPA*) in m² (Kleine & Weinland 1991), i.e.

$$ACPA = \Sigma(r_i^2 * 3.142) / 4$$

where r_i = radius in m.

The final stems ha⁻¹ (*N*) for closed canopy conditions are given by

$$N = (10000 / ACPA) * 3.142 / 4$$

We assumed that the canopy at stand maturity was closed and that there were no gaps between crowns. Figures in Table 2 show that the average diameter at breast height of the measured trees was 52.1 cm (41.5 - 80.5 cm) and the average crown projection area was 54.3 m² (47.3 - 99.4 m²). For a completely closed canopy the calculated final crop trees with average diameter at breast height of 52.1 cm was 144 trees ha⁻¹.

Table 2. Results of crown measurement of *Azadirachta excelsa* stand at Bukit Lagong Forest Reserve, Selangor, Peninsular Malaysia, 1995

| No | dbh (cm) | r_1 (m) | CPA_1 (m ²) | r_2 (m) | CPA_2 (m ²) | r_3 (m) | CPA_3 (m ²) | r_4 (m) | CPA (m ²) | $ACPA_4$ (m ²) | d_c (m) |
|----|-------------|--------------|------------------------------|--------------|------------------------------|--------------|------------------------------|--------------|----------------------------|-------------------------------|--------------|
| 1 | 65.4 | 6.18 | 119.9 | 6.13 | 118.0 | 5.65 | 100.3 | 4.35 | 59.4 | 99.4 | 11.3 |
| 2 | 41.5 | 3.60 | 40.7 | 4.85 | 73.9 | 3.68 | 42.5 | 3.20 | 32.2 | 47.3 | 7.8 |
| 3 | 52.7 | 2.72 | 23.2 | 3.12 | 30.6 | 3.20 | 32.2 | 4.87 | 74.5 | 40.1 | 7.1 |
| 4 | 47.0 | 4.95 | 76.9 | 3.12 | 30.6 | 2.14 | 14.4 | 4.45 | 62.2 | 46.0 | 7.6 |
| 5 | 51.8 | 1.50 | 7.1 | 3.44 | 37.2 | 5.52 | 95.7 | 3.57 | 40.0 | 45.0 | 7.6 |
| 6 | 55.0 | 4.52 | 64.2 | 4.60 | 66.4 | 4.15 | 54.1 | 3.16 | 31.4 | 54.0 | 8.3 |
| 7 | 55.3 | 4.74 | 70.6 | 3.53 | 39.1 | 3.43 | 37.0 | 2.25 | 15.9 | 40.6 | 7.2 |
| 8 | 47.5 | 4.45 | 62.2 | 3.12 | 30.6 | 2.40 | 18.1 | 3.59 | 39.8 | 37.7 | 6.9 |
| 9 | 41.9 | 4.95 | 77.0 | 4.87 | 74.5 | 2.56 | 20.6 | 2.60 | 21.2 | 48.3 | 7.8 |
| 10 | 46.9 | 5.23 | 85.9 | 5.96 | 111.6 | 4.15 | 54.1 | 3.32 | 34.6 | 71.5 | 9.5 |
| 11 | 52.9 | 3.24 | 33.0 | 3.85 | 46.6 | 3.64 | 41.6 | 4.46 | 62.5 | 45.9 | 7.6 |
| 12 | 49.1 | 4.25 | 56.7 | 3.55 | 39.6 | 3.45 | 37.4 | 5.12 | 82.3 | 54.0 | 8.3 |
| 13 | 46.7 | 3.82 | 45.8 | 3.55 | 39.6 | 3.24 | 33.0 | 2.74 | 23.6 | 35.5 | 6.7 |
| 14 | 47.7 | 6.85 | 147.4 | 6.34 | 126.3 | 5.60 | 98.5 | 1.54 | 7.5 | 94.9 | 10.9 |
| 15 | 80.5 | 4.25 | 56.7 | 2.15 | 14.5 | 3.67 | 42.3 | 5.76 | 104.2 | 54.4 | 8.3 |
| Av | 52.1 | | | | | | | | | 54.3 | |

r_1, \dots, r_4 : crown radii
 $ACPA$: average crown projection area for completely closed canopy
 d_c : calculated crown diameter
 CPA_1, \dots, CPA_4 : areas of crown

The assessment shows that plantation grown mature dominant and co-dominant trees will have attained a crown projection area of 54.3 m² during a growth period of 40 years. Based on the assumption of a completely closed canopy stand this would be equivalent to a possible stocking of final crop trees of 145 ha⁻¹. It is presently not known as to how many trees need to be planted under regulated plantation management (with thinning, etc.), in order to achieve this final stocking. The results, however, provide some guide to formulating realistic production targets, but they have to be judged with caution, since they were obtained from an unreplicated trial with a limited number of trees. They may be refined by conducting more of these comparatively simple studies on existing plantation plots taking into consideration different site conditions and, if carried out, stand treatments.

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