

MATERIALS AND METHODS

Species selected :-

- | | | |
|---|-----------------|---------------|
| 1) <i>Artocarpus lakoocha</i> Roxb. | (Moraceae) | 760 seedlings |
| 2) <i>Balakata baccata</i> (Roxb.) Ess. | (Euphorbiaceae) | 760 seedlings |
| 3) <i>Horsfieldia thorelii</i> Lec. | (Myristicaceae) | 760 seedlings |

Seedlings were grown in three container types :

- | | |
|---|----------|
| 1) 2.2 x 5.2 in (5.5 x 13 cm) JICA (REX) tray (300 cm ³) | 33 trays |
| 2) 2.5 x 9.0 in (6.25 x 22.5 cm) black plastic bag (800 cm ³) | 760 bags |
| 3) 3.0 x 7.0 in (7.5 x 17.5 cm) black plastic bag (850 cm ³) | 760 bags |

Fertilizers

- | | |
|--|----------|
| 1) "Osmocote", slow releasing (14-14-14) | 1.368 kg |
| 2) soluble fertilizer, granules (15-15-15) | 2.850 kg |

Materials

- | | |
|--|-------------------------|
| 1) forest soil from Doi Suthep-Pui National Park | 741,000 cm ³ |
| 2) coconut husk | 370,500 cm ³ |
| 3) peanut husk | 370,500 cm ³ |
| 4) plastic baskets (32 cm wide x 39 cm long x 9.5 cm high) | |
| 5) grid tables (90 cm wide x 180 cm long x 45 cm high) | |
| 6) oven | |

7) balance

8) Digital Lux meter (model BEHA 93421 IQ 0114SE)

Equipment for collection data

1) venier

2) ruler (cm)

3) pen

4) notebook

5) camera

Experimental Design

A randomized complete block design (RCB) was used. The experiment tested 12 treatments which were replicated in three blocks. Each block represented every treatment, randomly arranged (Figure 14).

Treatment Design

T1: raised – REX tray - “Osmocote”

T2: raised – REX tray – soluble fertilizer

T3: raised – plastic bag (2.5" x 9") - “Osmocote”

T4: raised – plastic bag (2.5" x 9") - soluble fertilizer

T5: raised – plastic bag (3" x 7") - “Osmocote”

T6: raised – plastic bag (3" x 7") - soluble fertilizer

T7: ground – REX tray - “Osmocote”

T8: ground – REX tray – soluble fertilizer

T9: ground – plastic bag (2.5" x 9") - “Osmocote”

T10: ground – plastic bag (2.5" x 9") - soluble fertilizer

T11: ground – plastic bag (3" x 7") - “Osmocote”

T12: ground – plastic bag (3" x 7") – soluble fertilizer

Randomized Complete Block Design

Block 1	Block 2	Block 3
T 3	T 9	T 3
T 5	T 7	T 1
T 1	T 11	T 5
T 4	T 10	T 6
T 2	T 8	T 2
T 6	T 12	T 4
T 9	T 1	T 10
T 11	T 3	T 12
T 7	T 5	T 9
T 10	T 6	T 11
T 8	T 4	T 7
T 12	T 2	T 8

Methods

Seed germination methods

Native tree species, framework species or potential framework species, with a medium to large seeds, used more than 1 year for preparation and low quality in

the nursery such as *Artocarpus lakoocha* Roxb. and *Horsfieldia thorelii* Lec. from Doi Suthep – Pui National Park were studied.

Artocarpus lakoocha Roxb. (Moraceae) is a large deciduous tree, distributed in tropical Himalayas, India, and Thailand (Hooker, 1988). In Thailand occurs in evergreen forest at elevation of between 1,000 to 1,100 m (Maxwell, 2001). The mature trees are about 18 m high. Leaves thinly coriaceous, above glabrous or puberulous and reticulate beneath. Flower – head shortly peduncled, pubescent and oblong seeds (Hooker, 1988). The flowers bloom in September to October, fruiting in January to June (Maxwell, 2001).

Seeds were collected on 15 July 1999 from a single tree at Doi Suthep - Pui National Park headquarters c. 1,050 m, 16 m in height and 148 cm GBH. Ripe compound fruits, were collected from the ground, and the seeds soaked in water overnight. Seeds averaging 10 mm long were sown in plastic baskets on 16 July 1999, at least 1 cm apart, with 250 seeds per basket. The germination rate was 42.5% over 40-60 days. Seedlings were pricked out and transplanted into containers when they had 2 fully expanded leaves or were 6 - 8 cm tall.

Balakata balakata (Roxb.) Ess. (Euphorbiaceae) is a large size evergreen tree, found in primary and disturbed dipterocarp forest, bamboo forest, secondary forest, mixed deciduous forest, also along streams and on hill and slope (Esser, 1999) distributed in Thailand, east Himalayas and north India to Indo-China, southern China, Myanmar, peninsular Malaysia and Sumatra (FORRU, 2000). In

Thailand occurs in mixed evergreen + deciduous, seasonal forest or seasonal evergreen forest, often grown along streams at low elevations, elevation of between 400 to 1,350 m (Maxwell, 2001). The mature trees are about 26 m high with a girth at breast high of up to 60 cm. The bark dirty yellow with deep longitudinal cracks and fissures inner bark fibrous. Leaves are spirally arranged, blades elliptic to oblong, apex acuminate and base acute or obtuse. Inflorescent in terminal whorls and in the axils of few upper most leaves. Two type of inflorescent: purely staminate one, regularly branched with long branches (5-7 cm long) and bisexual ones, hardly branched and with shorter branches (2-3 cm long) (Esser, 1999). Fruit fleshy drupes with white sap. The unripe seed is green and ripens to dark red-purple to black (FORRU, 2000). The flowers bloom in February to August, fruiting in September (December) (Maxwell, 2001).

Seeds from a single tree were collected on 18 September 1999 at Doi Suthep – Pui National Park near the side of the road to Monthathan waterfall, c. 1,050 m, 24 m high and 300 cm GBH. Ripe black were collected from the ground, each contained two black seeds. The seeds were soaked in water overnight to remove the pericarp and the remaining white tissue was scrubbed off by hand. Scarification by hand accelerated germination by accelerating water absorption (care was taken not to remove too much of the testa since this increased risk of fungal infection) and soak in water over night again. Seeds (average length 5 mm) were sow in plastic baskets on 20 September 1999, at least 1 cm apart, with 400 seeds per basket. The germination rate was 75% over 30-45 days. Seedlings were transplanted into containers when they had 2 leaves or were 8 -12 cm tall.

Horsfieldia thorelii Lec. (Myristicaceae) is an uncommon and medium-sized evergreen tree, distributed in central and northern Thailand and Indo-China (FORRU, 2000). In Thailand occurs in bamboo + deciduous, mixed evergreen + deciduous, and evergreen forest, often in disturbed areas at elevation of between 550 to 1,500 m (Maxwell, 2001). The mature trees are about 21 m high with a girth breast at high of about 75 cm. The bark thin and finely lenticellate and becoming thickened and roughly vertically cracked and ridged in older. Leaves are simple and spirally arranged, elliptic – oblong to oblong, broadest at or somewhat above the middle base attenuate, top acute-acuminate. (Wlode, 1984). Flowers are numerous in unisexual inflorescence, male inflorescence 6-21 cm long and female ones with fewer flowers and up to 2 cm long (FORRU, 2000). The flowers bloom in February to April, fruiting in March to May (Maxwell, 2001).

Seeds were collected from a single tree on 23 June 1999 at Anuchon camp opposite Doi Suthep Temple c.1,050 m, Doi Suthep – Pui National Park, 14 m height and 168 cm GBH. Fallen fruits with orange aril on the seeds were collected from the ground. The aril and brown testa were removed by hand and the seeds soaked overnight. Seeds (average length 33 mm) were sown in plastic baskets on 24 June 1999, at least 2 cm from apart, with 150 seeds per basket. The germination rate was 25% over 21-75 days. Seedlings were transplanted into containers when they had 2 leaves or were 10 - 13 cm tall.

The germination medium was forest soil, coconut husk, and peanut husk mixed in the ratio of 2 : 1 : 1.

Experimental methods

All seedlings were transferred into three types of containers: two different sizes of plastic bags 2.5 x 9 in. and 3 x 7 in. and REX tray root trainers. Half of the containers were raised 45 cm off the ground on wire grids, while the rest were placed on the ground. There were three blocks *viz.* open, 100% exposure (light intensity averaged 12,170 to >20,000 lux), medium, 80% exposure (light intensity averaged 7,700 to >20,000 lux) and deep shade, 50% exposure (light intensity averaged 2,400 lux). For the ground treatments roots were pruned every 3 months. Two fertilizer treatments were applied, *viz.* soluble fertilizer (NPK 15-15-15), 1.5 tablespoons of soluble fertilizer in a 15 liters (3 gallon) watering can applied every 15 days and slow release fertilizer "Osmocote" (NPK 14-14-14), about 10 granules placed on the surface of the media in the containers every 3 months. Watering was done by using a rubber hose every day.

Table1. Fertilization and root pruning regimes.

Date	<i>A. lakoocha</i>			<i>B. baccakata</i>			<i>H. thorelii</i>		
	osmocote	soluble	pruning	osmocote	soluble	pruning	osmocote	soluble	pruning
01 Oct 99	+	+	-	-	-	-	+	+	-
15 Oct 99	-	+	-	-	-	-	-	+	-
01 Nov 99	-	+	-	-	-	-	-	+	-
15 Nov 99	-	+	-	-	-	-	-	+	-
01 Dec 99	-	+	-	-	-	-	-	+	-
15 Dec 99	-	+	-	-	-	-	-	+	-
01 Jan 00	+	+	+	+	+	-	+	+	+
15 Jan 00	-	+	-	-	+	-	-	+	-
01 Feb 00	-	+	-	-	+	-	-	+	-
15 Feb 00	-	+	-	-	+	-	-	+	-
01 Mar 00	-	+	-	-	+	-	-	+	-
15 Mar 00	-	+	-	-	+	-	-	+	-
01 Apr 00	+	+	+	+	+	+	+	+	+
15 Apr 00	-	+	-	-	+	-	-	+	-
01 May 00	-	+	-	-	+	-	-	+	-
15 May 00	-	+	-	-	+	-	-	+	-
01 Jun 00	-	+	-	-	+	-	-	+	-
15 Jun 00	-	+	-	-	+	-	-	+	-
01 Jul 00	+	+	+	+	+	+	+	+	+
15 Jul 00	-	+	-	-	+	-	-	+	-
01 Aug 00	-	-	-	-	+	-	-	-	-
01 Aug 00	-	-	-	-	+	-	-	-	-

Remark: + = done / applied
 - = not done / applied

Data collection

Data were collected over the periods :

- *Artocarpus lakoocha* Roxb. October 1999 – July 2000
- *Balakata baccata* (Roxb.) Ess. January 2000 – August 2000
- *Horsfieldia thorelii* Lec. October 1999 – July 2000

Balakata baccata (Roxb.) Ess. seeds were collected late, so data were delay.

Ten seedlings per treatment per block per species were randomly selected for the following measurements :

1. seedling height ;measured from ground level to the apical bud
2. seedling stem basal diameter

Ten seedlings per treatment per block per species were harvested at the end of the experiment for measurement of the following

1. shoot : root ratio by dry mass
2. root morphology; condition of roots adapted from Mensie's and Wightman scores

score

tap (primary) root condition

- | | |
|---|---|
| 1 | strong, straight, dominant, well developed tap root |
| 2 | tap root severely deformed into two or more fracture zones, but growth still downward |
| 3 | tap root twisted close to the surface of the container |

- 4 tap root twisted upwards, but downward development still present
- 5 tap root straight ascending, but coiled at the bottom
- 6 tap root twisted upward and coiled at the bottom

Statistical analysis

Data on height, basal diameter, shoot : root ratio, and relative growth rate (RGR) for height and basal diameter were tested for differences among blocks and among treatments for each species using ANOVA and LSD test (least significant difference) for divide treatments with less than 10 sample and for more than 10 treatments using SNK test (Student-Newman Keals). Chi-squre test for analysis value data (SPSS for Windows Release 6.0).

Relative Growth Rate (RGR) percent per year

$$\frac{LN H2 - LN H1}{T2 - T1} \times 365 \times 100$$

H1 = first height (cm) or basal diameter (mm)

H2 = final height (cm) or basal diameter (mm)

T1 = start time (day)

T2 = final time (day)

Seedling Quality Index (SQI) = standardized value (of height X basal diameter X root dry weight X shoot /root ratio X root score)

The value of each parameter was divided by the maximum mean recorded to give a standardized value of 0-1 for each characteristic (Zangkum, 1998), for shoot / root ratio divided the minimum mean.

production costs (bath per seedling per season in nursery)

= container price + medium + fertilization + root pruning + labor

The best treatment was identified by balancing seedling performance with production costs using the benefit value which is seedling quality index / production cost



Figure 6. Seeds and seedlings of *Artocarpus lakoocha* Roxb. 1, 3, 5 and 12 days after germination.

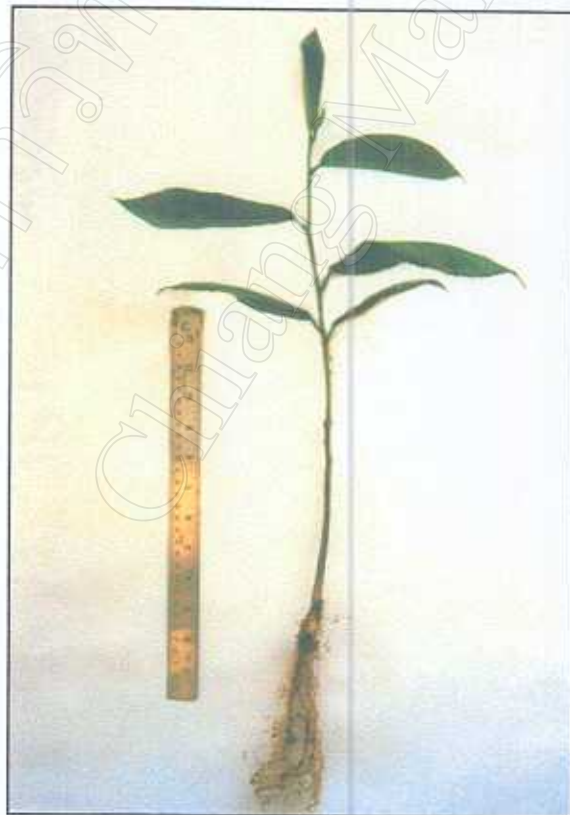


Figure 7. Seedling of *Artocarpus lakoocha* Roxb. 12 months after germination.

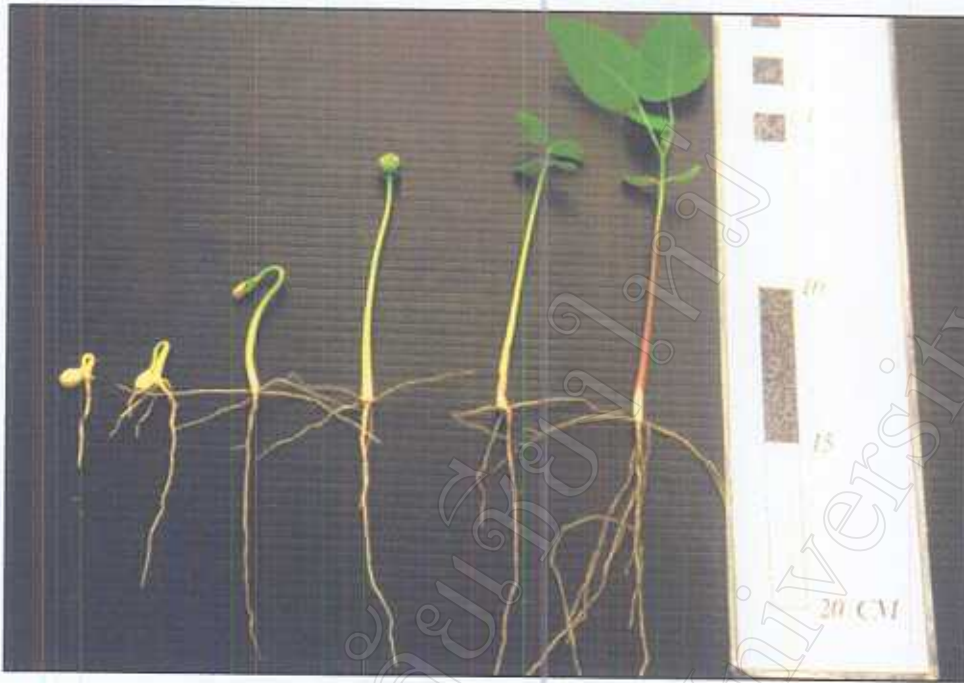


Figure 8. Seeds and seedlings of *Balakata baccata* (Roxb.) Ess. 1, 2, 4, 5, 7 and 10 days after germination.

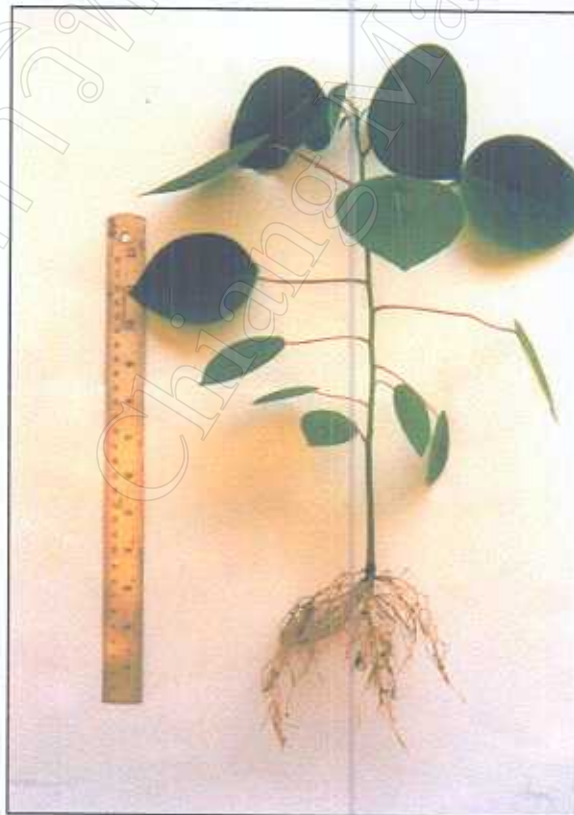


Figure 9. Seedling of *Balakata baccata* (Roxb.) Ess. 2 months after germination.

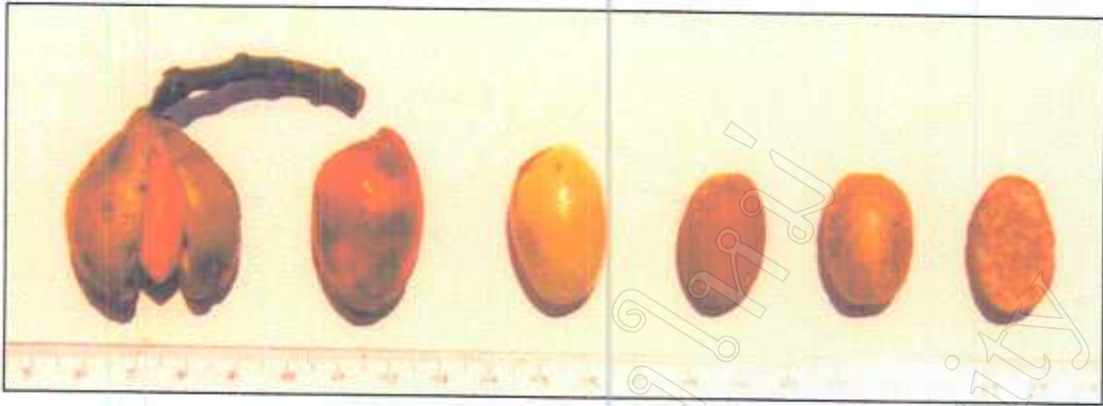


Figure 10. Capsule and seeds of *Horsfieldia thorelii* Lec.



Figure 11. Seedling of *Horsfieldia thorelii* Lec. 12 months after germination.

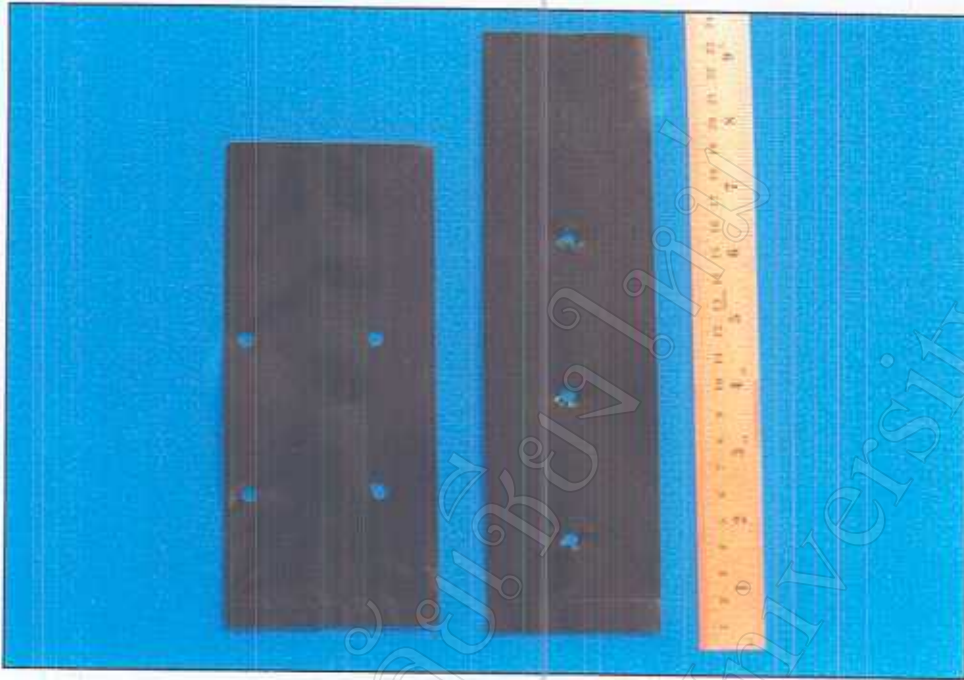


Figure 12. Left: plastic bag 3 × 7 in, right: 2.5 × 9 in



Figure 13. JICA (REX) tray



Figure 14. Experiment design was in randomized blocks in the FORRU nursery on January 2000.