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# Selecting seed trees for a forest restoration program: a case study using *Spondias axillaris* Roxb. (Anacardiaceae)

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## Abstract

*Spondias axillaris* Roxb. (Anacardiaceae) (synonym: *Choerospondias axillaris* (Roxb.) Burt and Hill) is an exceptionally effective framework tree species for restoring seasonal tropical forest ecosystems to degraded sites throughout south and south-east Asia. Criteria were developed to select superior parent seed trees, based on nursery performance and field establishment. Seed progenies were collected from 41 *S. axillaris* parent trees, growing in Doi Suthep-Pui National Park in northern Thailand. Seedlings that survived in the nursery were more likely to have originated from small pyrenes, which germinated rapidly. Seedlings that survived in the field, over the first growing season, tended to be larger at time of planting than those that died. Four standards for selection of superior seed trees were recognised: (i) 70%, or higher, seedling survival in the field, (ii) a sapling height of 100 cm or taller after the first growing season in the field, (iii) 40% or greater germination in the nursery and (iv) 70% or higher seedling survival in the nursery. Twelve of the 41 seed trees met these standards and qualified as superior seed trees for forest restoration.

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**Keywords:** Tropical forest restoration; Germination; Field performance; Seedling development; Framework tree species

## 1. Introduction

Destruction of seasonal tropical forests throughout south and south-east Asia is one of the most serious environmental problems of the region. In Thailand for example, natural forest cover has fallen to less than 20% of the country's land area, despite 15% of the country being designated conservation areas. Large areas of forest within existing national parks and wildlife sanctuaries have been degraded. If these areas

are to fulfill their function of conserving biodiversity, they should be restored by re-establishing the original forest ecosystems as closely as possible (Forest Restoration Research Unit, 1998).

In the past, the most common method of reforestation in northern Thailand was the establishment of commercial plantations of single tree species such as *Pinus* and *Eucalyptus*. These have low value for wildlife conservation and are unsuitable for restoring degraded forest within national parks. Since 1993, various reforestation projects have been implemented to celebrate the Golden Jubilee of His Majesty King Bhumibol Adulyadej. These projects promoted use of a wide range of native forest tree species. However,

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implementing this abrupt change in planting policy has been constrained by a lack of knowledge about which native tree species are most suitable for planting in deforested areas (Forest Restoration Research Unit, 1998).

Since 1997, the Forest Restoration Research Unit (FORRU) of Chiang Mai University has been testing the so-called 'Framework Species Method' of forest restoration to determine its applicability to the ecological and socio-economic conditions of northern Thailand (Forest Restoration Research Unit, 1998, 2000). First pioneered in Queensland, Australia (Goosem and Tucker, 1995; Lamb et al., 1997; Tucker and Murphy, 1997; Tucker, 2000), this method involves planting 20–30 native forest tree species to restore basic forest structure and function. Framework tree species are selected for their capability to survive well, grow fast, shade out herbaceous weeds and attract seed-dispersing wildlife into planted areas with fruit, nectar or nest sites for birds, etc. The attracted wildlife disperses seeds of many other tree species into the planted plots, thus accelerating the recovery of biodiversity. In addition, framework species must be easy to propagate in nurseries.

Initial planting trials tested 37 potential framework tree species in deforested watershed sites within Doi Suthep-Pui National Park. Nine were ranked as excellent (Elliott et al., in preparation), including *Spondias axillaris* Roxb. (Anacardiaceae) (synonym: *Choerospondias axillaris* (Roxb.) Burt and Hill). *S. axillaris* is fairly common in evergreen forests (both with and without pine) (*sensu* Maxwell and Elliott, 2001), often in degraded areas, at elevations of 700–1600 m. It is distributed through northern and eastern Thailand, Nepal, India, Myanmar, Hainan, Lao PDR, Vietnam and Japan (Forest Restoration Research Unit, 2000), and hence could be planted in restoration programs across the region.

Whilst there have been many tree improvement programs for commercial production, we know of none which have attempted to select parent trees for a natural forest restoration program. We have developed criteria for the selection of parent trees of framework species, which fall into three categories: nursery performance; field establishment (survival and growth); and the ability to accelerate biodiversity recovery (attractiveness to wildlife, etc.). In the paper presented here, we report on nursery performance and

early establishment of *S. axillaris* seedlings in the field, to select superior parent seed trees for natural forest restoration.

## 2. Materials and methods

### 2.1. Species description

*S. axillaris* is a light-demanding, medium-sized, deciduous tree, which grows up to 25 m tall and has a diameter at breast height of up to 50 cm. The bark is thin, dark brown or dark grey, vertically cracked, often flaking. The inner bark is pale pink cream. The spirally arranged leaves are 23–28 cm × 31–35 cm. The leaflets are arranged in three to five opposite pairs, plus the terminal segments. Leaflet blades are thin, ovate to oblong-ovate with an acuminate apex and an obliquely acute base. The margin is mostly entire, less often serrate. The inflorescence is axillary and panicate with many flowers. The flowers are dull maroon. The fruit is a fleshy, ovoid drupe, usually one per infructescence. It is grey-green in colour, turning yellow when ripe. The mean dimensions of the fruit are 25.3 mm × 22.4 mm × 22.6 mm (Pakkad, 1997). The mesocarp is pulpy. Each drupe contains a solitary, obovoid pyrene with four to five depressions, each containing a single, oblong, flattened, brown seed (Pakkad, 1997). The wood is soft, light and used for interior finishes, drawers, crates, carvings, turnery, plywood and pulp. The leaves are used as fodder and are edible by people when boiled. The fruit can be eaten fresh or made into a variety of sweetmeats and chutney (Jackson, 1987).

### 2.2. Study site

Trees were propagated in a nursery at 1000 m elevation, near the headquarters of Doi Suthep-Pui National Park, north-west of Chiang Mai. The experimental plots were in a degraded watershed (18°52'N, 98°51'E), at 1207–1310 m elevation. Originally, the plots had been covered in evergreen forest, which was cleared between 1960 and 1970. Subsequently, the area was cultivated for vegetables and further degraded by frequent fires. Although a few scattered mature trees remain, the area is now dominated by weedy herbaceous vegetation including *Pteridium*

*aquilinum* (L.) Kuhn (Dennstaedtiaceae), *Bidens pilosa* L. var. *minor* (Bl.) Sherf, *Ageratum conyzoides* L., *Eupatorium odoratum* L. and *E. adenophorum* Spreng. (all Compositae), *Commelina diffusa* Burm. F. (Commelinaceae), and *Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E. Hubb. ex Hubb. and Vaugh. and *Thysanolaena latifolia* (Roxb. ex Horn.) Honda (both Gramineae). Consequently, planted trees must be able to survive intense heat and drought, particularly in the late dry season, and compete with rank, weedy vegetation.

### 2.3. Plant material and propagation

Forty-one batches of ripe yellow fruits were collected in September 1999 from 41 individuals trees, situated at least 100 m apart in Doi Suthep-Pui National Park. The pyrenes were soaked in water to aid removal of the fruit pulp, and then exposed to air until their surface was dry. Seventy-two pyrenes were randomly selected and their mass and dimensions recorded. Within 2–3 days after collection, the pyrenes were sown into modular plastic trays, onto the surface of a medium of forest soil, coconut husk and peanut husk (2:1:1). The germination trays were then placed on top of concrete benches, partially shaded under a transparent plastic roof (approximately 40% full sunlight, similar to the light intensity in partially regenerating gaps). Germination, defined as the percent of pyrenes with at least one seedling emerging, was monitored three times per week. The dates of the first and last seeds to germinate in the whole seedlot were recorded, and the median length of dormancy (MLD) calculated from the germination times of all seeds which germinated. Once the first pair of leaves of all the germinated seedlings had fully expanded, the seedlings were pricked out and transplanted into black plastic bags (6.5 cm × 23 cm), containing the medium described above. Seedlings were shaded inside the nursery under a plastic roof (approximately 20% full sunlight) for 2 weeks. After this time, seedlings were placed outside, under black shade netting (slan, approximately 50% of full sunlight). Ten granules of Osmocote slow-release fertiliser (15–15–15) were applied every 3 months. Seedling height and root collar diameter were measured every 3 months. Final measurements were taken on 9 June 2000, 25 weeks after pricking out.

### 2.4. Planting out

One month before planting, the experimental field plots were cleared of weeds using handtools. Approximately 1 week later, a single dose of a non-residual herbicide, glyphosate, was applied. One hundred grams of fertiliser (NPK 15–15–15) was mixed in with loose soil at the bottom of each planting hole. *S. axillaris* saplings were hardened off in full sunlight 4 weeks before being dispatched for planting in mid June 2000. Between 5 and 37 saplings from each seed tree were randomly assigned to nine plots (each plot up to 0.5 km apart) and planted on 16 June 2000. Variability in numbers reflected availability of seedlings after mortality during nursery production. Height and root collar diameter of the planted saplings were measured on 27 June 2000 and 6 months thereafter. Weeds were cut around the seedlings three to four times as required during the rainy season and 50–100 g of fertilizer was applied after 5, 11 and 17 weeks, respectively.

### 2.5. Data analysis

Percent seed germination, mean time to germination, MLD, germination period and percentage of seedling survival in the nursery and in the experimental plots were calculated for each seed progeny/seedlings from each seed tree. The percent relative growth rate per year of each seedling in the nursery and in the experimental plots was calculated using the following equation:

Relative growth rate of root collar diameter

$$\begin{aligned} & (\text{RGR of RCD})(\% \text{ per year}) \\ &= \frac{[\ln(\text{RCD}_2) - \ln(\text{RCD}_1)]}{(T_2 - T_1)} \times 100 \times 365 \end{aligned}$$

where  $\text{RCD}_2$  is the RCD at time  $T_2$  (at the end of measurement);  $\text{RCD}_1$  the RCD at time  $T_1$  (at the beginning of measurement);  $T_2 - T_1$  the number of days between the beginning ( $T_1$ ) and the end ( $T_2$ ) time of measurement.

Relative growth rate of height (RGR of height)

$$(\% \text{ per year}) = \frac{[\ln(H_2) - \ln(H_1)]}{(T_2 - T_1)} \times 100 \times 365$$

where  $H_2$  is the height at time  $T_2$  (at the end of measurement);  $H_1$  the height at time  $T_1$  (at the beginning of measurement);  $T_2 - T_1$  the number of days between the beginning ( $T_1$ ) and the end ( $T_2$ ) time of measurement.

### 3. Results

#### 3.1. Pyrene characteristics

Following extraction from the fruit, the fresh mass and dimensions of all pyrenes were measured, and found to differ significantly amongst the progenies ( $P < 0.0001$ ; ANOVA). Across all pyrenes, a mean fresh mass of  $3.1 \pm 0.6$  g (S.D.) was recorded. The mean pyrene mass for the progeny of individual trees ranged from  $2.2 \pm 0.3$  g (S.D.) to  $3.9 \pm 0.5$  g (S.D.). The mean length of pyrenes amongst the seed trees ranged from  $16.6 \pm 1.1$  mm (S.D.) to  $20.2 \pm 1.2$  mm (S.D.), and the mean width ranged from  $12.7 \pm 0.87$  mm (S.D.) to  $16.2 \pm 1.5$  mm (S.D.).

#### 3.2. Germination

The germination percentage ranged considerably, from just 8.3 to 91.7% amongst the progenies (Table 1). The mean germination percentage, however, was  $42.3 \pm 22.3\%$  (S.D.). Fifty-four percent of progenies had a germination percentage of 40% or greater, which we consider to be the minimum acceptable standard for efficient nursery production. The length of the germination period and the MLD also showed considerable variation within, and amongst

the progenies (Fig. 1). The germination period ranged from 13 to 183 days among the progenies, with a mean of  $134.8 \pm 34.9$  days. The MLD ranged from 23 to 169 days, with a mean of  $98.7 \pm 47.2$  days (S.D.).

#### 3.3. Seedling growth in the nursery

Most seedlings were ready for planting at the start of the wet season, 25 weeks after pricking out. At this time, the majority of the seedlings had reached a height of 40–60 cm, which is considered suitable for planting (Forest Restoration Research Unit, 1998). The mean height of seedlings amongst the progenies exhibited considerable variation, ranging from  $27.8 \pm 11.2$  cm (S.D.) to  $73.1 \pm 20.4$  cm (S.D.). The mean root collar was similarly variable, ranging from  $1.8 \pm 0.4$  mm (S.D.) to  $4.4 \pm 1.5$  mm (S.D.). This was reflected in the wide ranging growth rates, of both height and root collar diameter (Table 1). Seedling survival in the nursery, measured just prior to planting on 9 June 2000, was high, ranging from 61.9 to 100%, with a mean of  $81.2 \pm 8.8\%$  (S.D.). Thirty-seven trees (90%) had a survival rate of 70% or greater, which was considered to be very good for a framework species.

#### 3.4. Seedling establishment in the field

The number of seedlings of each seed tree transplanted into the plots ranged from 5 to 37, due to variation in nursery mortality and seedling height (Table 1). At the end of the wet season (6 months after planting), seedling survival amongst the progenies ranged from 22.7 to 94.7%, with a mean of

Table 1  
Germination, survival and growth of *S. axillaris* seed progenies collected from 41 parent trees

Parameter	Nursery			Field		
	Mean	S.D.	Range	Mean	S.D.	Range
Percent germination	42.3	22.3	8.3–91.7	–	–	–
Percent seedling survival	81.4	8.8	61.9–100	71.2	14.0	22.7–94.7
Mean size: RCD (mm)	2.9	0.1	1.8–4.4	17.3	2.7	11.4–23.0
Mean size: height (cm)	52.6	11.4	27.8–73.1	103.4	14.3	69.0–143.3
Relative growth rate (percent per year): RCD	267.3	51.6	168–342	463.9	65.1	289.0–607.3
Relative growth rate (percent per year): height	620.3	99.3	408–836	189.3	63.6	41.4–348.2

Growth measurements taken 25 weeks after pricking out in the nursery, and 6 months after planting out in the field. Mean number of seedlings from each parent tree planted out was 18.

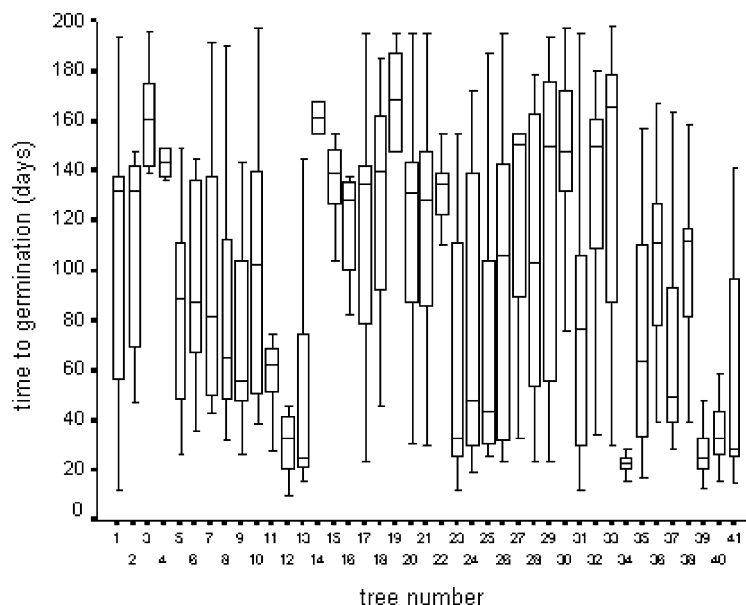


Fig. 1. The germination period and median length of dormancy (MLD) of individual seed trees. Each box contains 50% of the seed germinated, and the line in the box shows the MLD. Vertical lines below and above the boxes represent 0–25%, and 75–100% of seeds which germinated, respectively. Extreme values are at both bounds.

$71.2 \pm 14.0\%$  (S.D.) (Table 1). Saplings from 27 seed trees had a survival rate of 70% or greater. After 6 months in the plots, the mean height of all seedlings was  $103.4 \pm 14.3$  cm (S.D.), nearly double the size when planted. Sapling heights ranged from  $69.0 \pm 36.3$  cm (S.D.) to  $143.3 \pm 11.6$  cm (S.D.), exhibiting similar variation to that found in the nursery. The mean root collar diameter of all seedlings was  $17.3 \pm 2.7$  mm (S.D.), more than six times greater than when planted, ranging from  $11.4 \pm 7.2$  mm (S.D.) to  $23.0 \pm 2.7$  mm (S.D.). Consequently, RGRs also showed considerable variation: from  $41.4 \pm 105.9\%$  per year to  $348.2 \pm 296.3\%$  per year for height, and  $289.0 \pm 217.9\%$  per year (S.D.) to  $607.3 \pm 131.5\%$  per year for root collar diameter.

### 3.5. Pyrene mass and survival

In general, smaller or lighter pyrenes yielded better results than larger, heavier ones. For example, the mean fresh mass of pyrenes that successfully germinated was slightly, but significantly lower than that of pyrenes that failed to germinate ( $3.1 \pm 0.6$  g (S.D.) cf.  $3.2 \pm 0.6$  g (S.D.),  $F = 6.72$ ,  $P = 0.009$ ). Seedlings that survived in the nursery germinated from signifi-

cantly smaller and lighter pyrenes than those that died (length  $18.5 \pm 1.6$  mm (S.D.) cf.  $18.8 \pm 1.5$  mm (S.D.),  $F = 5.945$ ,  $P = 0.015$ ; width  $14.3 \pm 1.4$  mm (S.D.) cf.  $14.5 \pm 1.4$  mm (S.D.),  $F = 3.284$ ,  $P = 0.070$ ; fresh mass  $3.1 \pm 0.6$  g (S.D.) cf.  $3.2 \pm 0.6$  (S.D.),  $F = 9.703$ ,  $P = 0.002$ ). In addition, seedlings that survived in the nursery tended to originate from pyrenes that germinated more rapidly compared with those that died. The mean time to germination of seedlings that survived was  $84.8 \pm 52.9$  days (S.D.) whereas for seedlings that died, it was  $99.5 \pm 57.5$  days (S.D.) ( $F = 12.602$ ,  $P < 0.001$ ).

Seedlings that survived in the field over the first growing season tended to be larger at the time of planting than those that subsequently died. The mean height and root collar diameter of surviving seedlings was  $63.1 \pm 24.5$  cm and  $3.3 \pm 1.3$  mm, respectively, whereas for seedlings that died the corresponding values were  $54.0 \pm 25.5$  cm and  $2.8 \pm 1.2$  mm (height:  $F = 16.483$ ,  $P < 0.001$ ; RCD  $F = 17.375$ ,  $P \leq 0.001$ ).

### 3.6. Selection of seed trees

Criteria used to identify superior seed trees of *S. axillaris* were: survival and early growth of saplings

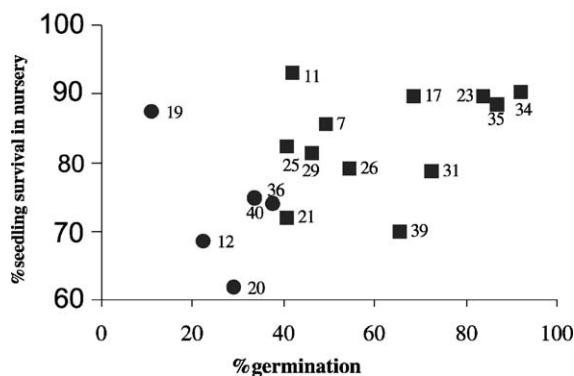


Fig. 2. Percent seedling survival in the nursery plotted against percent germination for all seed trees that produced saplings having a survival rate in the field of higher than 70% and growing taller than 100 cm by the end of the first growing season. Superior seed trees are indicated by squares.

in the field and germination percentage and seedling survival in the nursery. Survival in the field is the most important criterion. We considered that a standard of 70% survival over the first growing season was the minimum which would be acceptable for a restoration program. The second criterion applied was growth in the field. An acceptable standard was considered to be a height of 100 cm or more by the end of the first growing season. Parent seed trees which met the first and second criteria were then considered for their nursery performance (Fig. 2). Standards of more than 40% germination and more than 70% survival in the nursery were applied. Twelve of the 41 seed trees satisfied all four of the standards outlined above.

## 4. Discussion

### 4.1. Nursery performance

Low germination percentage appears to limit nursery production of *S. axillaris* seedlings. The overall mean percent germination of only 42% found in this study was remarkably similar to previously reported values in nurseries under very similar conditions (including artificial watering), namely 43% (Forest Restoration Research Unit, 2000) and approximately 50% (Hardwick, 1999). *S. axillaris* seeds have been shown to rapidly lose viability during storage. Hau (1999) conducted germination trials using seed that

had been stored for 5–7 months and obtained a germination percentage of only 16–18.8% in a nursery with supplementary watering, and just 1.7–6.7% in the field, under natural conditions of rainfall. Hardwick (1999) also obtained low germination percentages for seeds sown in a nursery plot with no supplementary watering, under various levels of shade, even though the seeds had not been stored for any length of time. Therefore, frequent watering and maintenance of high levels of soil moisture are clearly essential in achieving even moderate rates (40–50%) of germination. One way to maximize the germination percentage might be to sow smaller pyrenes, since the results showed that pyrenes that germinated had a slight, but significantly lower mass than those which failed to germinate. Water may diffuse into the lighter, smaller pyrenes and stimulate seed germination more easily than into the heavier, larger ones. Therefore, one consideration for the selection of superior parent trees for efficient nursery production of seedlings might be to choose trees that produced slightly smaller pyrenes.

Three seed trees exhibited a very low percent germination. An acceptable germination standard needs to be established and seeds should be collected only from those trees that meet the standard. In this study, we suggest a standard germination percentage of 40 or higher, which we consider to be the minimum acceptable standard for efficient nursery production. Germination period and median length of dormancy varied considerably among seed progenies from different parent trees (Fig. 2), leading to uneven production of non-uniform seedlings. Ideally, a nursery manager would select seed trees that produced seed with short MLDs and which germinated synchronously, for maximum efficiency and uniformity of planting stock.

When MLD was compared with mean seedling size at the time of planting (Table 1 and Fig. 1) it was found that seedlings from five seed progenies with long MLDs were smaller than those derived from seed progenies with shorter MLDs. There were exceptions, however, e.g. seed tree no. 26 had a short MLD, but the resulting seedlings were quite small. In contrast, seed tree no. 32 had a long MLD, but the resulting seedlings were larger than those from tree no. 26.

Growth of seedlings in the nursery was sufficiently rapid to allow plants to attain a size suitable for planting (averaging around 53 cm tall) by the optimal

planting time (i.e. the beginning of the rainy season). Collection of seeds late in the rainy season is adequate to produce a crop of saplings of a size suitable for planting at the optimal time of year, whilst shortening the nursery care period to 9 months and considerably reducing labour required and expenses. However, seedlings from seven seed trees exhibited a slow growth rate, which meant that seedlings would not be ready for planting out in the next rainy season. Most of these trees also had a low percent germination.

The survival rate of *S. axillaris* seedlings in the nursery was high (in general more than 80%), although variable among progenies. Thirty-eight progenies had a seedling survival rate of more than 70%, a figure which we considered acceptable for normal nursery practice. High seedling survival could help to compensate for low germination rates.

#### 4.2. Field performance

Saplings planted in the field had high survival rates. A standard of 70% survival or higher, was considered the minimum acceptable for our restoration planting program and saplings from twenty-seven seed trees met or exceeded this standard. Hau (1999) also reported exceptionally high survival rates (97.5–100% over 2 years) of *S. axillaris* saplings planted in deforested sites in Hong Kong. Growth rates of saplings in the field were also high, with seedlings nearly doubling in size 6 months after planting out (Table 1). Hau (1999) reported ‘exceptionally high’ growth rates of *S. axillaris* saplings, in comparison with other tree species, planted out on hillsides in Hong Kong, but stem heights 2 years after planting only ranged from 100 to 156 cm. Clearly, conditions on Doi Suthep are more favourable for the growth of *S. axillaris* than those of Hong Kong, since saplings from most progenies approached or exceeded the mean heights reported for Hong Kong within 6 months after planting. Hardwick (1999) reported that natural establishment of *S. axillaris* seedlings in deforested areas is primarily limited by lack of seed dispersal. Therefore, either direct seeding or planting of saplings is necessary to establish this species in deforested areas. In a planting experiment that tested the effects of weeding, Hardwick found that highest mortality of planted *S. axillaris* saplings occurred during the hot-dry season and that removal

of surrounding weeds substantially increased sapling mortality during that season.

#### 4.3. Selection of seed trees

This study aimed to develop criteria to select superior seed trees of *S. axillaris* for forest restoration programs, based on nursery performance and field establishment, whilst minimising the risk of reducing genetic variability within populations of planted saplings. We believe that it is the first study of its kind. Seed traits, including seed size, seed mass, dormancy, germination and dispersal are central components of plant life histories and have pronounced and multiple effects on fitness (Jansen, 1969; Harper, 1977). The choice of seed trees may have profound effects on the efficiency of nursery operations and the ability to achieve production targets (Blakesley et al., 2000). Ideal characteristics of seed trees include high percent seed germination, high seedling survival and rapid growth, both in the nursery and in the field, and high genetic diversity. There is no absolute recommendation for the number of parent trees from which seed should be collected to maintain genetic diversity, although the FAO (1985) Forest Resources Division have suggested that 10–20 individuals are sampled for provenance or progeny trials, which may be increased to 25–50 individuals per population for *ex situ* conservation purposes. In fact, amongst the 41 parent trees trialled in this investigation, we have identified 12 which satisfied all four of our performance requirements. In selecting parent trees to produce *S. axillaris* seedlings for forest restoration, trees that produce smaller than average pyrenes should be selected. Seedlings that grow taller than 60 cm in the nursery by planting time are more likely to perform well after planting out than smaller ones.

We believe that our selection criteria will be generally applicable to other framework species, as they reflect the requirements for rapid and effective capture of degraded plots, and for efficient nursery production of high quality trees. The criteria were not designed specifically for *S. axillaris*. They should also be widely applicable geographically, as similar seasonal tropical forests and species extend across the Indian subcontinent and south-east Asia region.

Long-term studies of field performance of our seedlings are currently underway. Parameters which

are being assessed include long-term growth rates, canopy structure, time to fruiting, fruit yield, and attractiveness to wildlife. Time to fruiting is particularly important, as fruit will attract seed-dispersing wildlife into the plots. Provided canopy closure occurs, actual canopy structure and tree height are of secondary importance. Structural diversity within the regenerating forest canopy is beneficial to forest restoration, since it provides more niche space to seed-dispersing wildlife. These long-term studies will determine the need to modify or expand the selection criteria used in this study.

Compared with most other species tested as framework species, *S. axillaris* shows exceptional promise, due to its high survival and initial growth rates in the field, although further research needs to be carried out to determine the attractiveness of its fruit, in restoration plots, to seed-dispersing wildlife. Flowering and fruiting were not observed within 3 years after planting, but the trees were favoured as perching sites for many bird species. Svasti (2000) mentions the value of this species as food for wildlife. This species is also exceptionally resistant to fire (Kuarak, unpublished data).

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