A PROGRAMME FOR THE PROCUREMENT OF IMPROVED FOREST TREE SEEDS IN BANGLADESH

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The paper outlines a programme for the establishment of seed sources of forest trees in Bangladesh. Five species, Garjan, '*Dipterocarpus turbinatus*', Gamar, '*Gmelina arborea*' Sal, '*Shorea robusta*' Jam *Syzygium grandes*' and Teak '*Tectona grandis*' were given the highest priority. Progress in the selection of seed stands, selection of Provisional Plus Trees (PPT), mapping the natural distribution of the four indigenous species and the establishment of clonal orchards of Gamar and Teak is outlined.

INTRODUCTION

Bangladesh is a young country but its forestry traditions date back to the mid-nineteenth century. According to the Government two year (1978-80) approach plan, the area of state owned forest managed by the Forest Department is 1.32 million ha (3.25 million acres). There is also 0.906 million ha (2.4 million acres) of unstocked hill forest under the administration of the district authority of Chittagong Hill Tracts, most of which is only usable for raising forest crops. The major objectives of the approach plan, and indeed of plans for future years, are the accelerated exploitation coupled with the establishment of plantations.

Tree planting in Bangladesh is scheduled for the eastern hill forests which are being exploited, the coastal lands for protection and possibly for inducing acretion and the homestead areas. An estimate of current annual requirements of planting stock for the country is 30 million in the hill forest (Eastern and Central Circles), 13 million in

the Coastal areas (Plantation Circle) and 10 million in the homestead areas (Extension Circle).

A programme to provide improved seed sources for raising seedlings of such a quantity of various species requires careful planning and application of the up-to-date information.

METHODS OF ESTABLISHING IMPROVED SEED SOURCES

There are a number of excellent references which described basic methodology and technology for establishing sources of improved and quality seeds. These include the 'Proceedings of the Symposium on Selection and Breeding to Improve some Tropical Conifers' (Burley and Nikles 1972) ; the report on the FAO/DANIDA Training Course on Forest Seed Collection and Handling (Anon 1975) ; 'Introduction to Forest Genetics' (Wright 1976) ; 'Seed Orchard–Concept and Design' (Nikles 1975) and the selected reference papers from an International Training Course in Forest Tree Breeding organised by the Australian Development Assistance Agency (Anon. 1977). The recommended basic pattern, is the formation of improved interim sources by selecting individual trees or up-grading outstanding plantations and harvesting the seeds *in situ* , centralising and proliferating selected trees vegetatively to collect potentially good genotypes (outstanding phenotypes) in accessible sites as intermediate improved sources. The outstanding phenotypes are tested to assess their breeding qualities so that ultimately clonal or seedling orchards can be established from the best possible parent stock.

Interim improved seed sources are seed stands or seed trees and their location depends on the natural distribution or planting history of the species concerned. Large areas of mature plantations can be assessed for growth and quality and the best trees be retained to form seed stands by culling undesirable ones. As maturity is the ability to set good quantities of viable seed, preference is given to plantations of 25 years of age and older, though younger plantations may also be considered if especially warranted by their source identification, i.e if they originate from a homogenous breeding population. Scattered individuals of good form can be selected as seed trees if the species is not widely established in plantations and pure stocked areas are limited or of poor quality. Special care should be taken to protect and possibly improve the health of such trees. However, the volume gain from such sources was estimated by Shelbourne (1969) to the order of 12 percent.

Intermediate and long term sources of improved seeds are established on suitable accessible areas by utilising vegetative propagation techniques to bring trees of outstanding characters together. Natural forests and plantations are scoured for outstanding phenotypes, and grafting or budding methods are used to establish clone banks. The clones are proliferated and planted in orchards without further testing to produce first stage Clonal Seed Orchards which are

intermediate sources of improved seeds. This strategy is important particularly when little is known about the phenology and breeding character of the species.

Before the establishment of longer term clonal or seedling orchards made up of individuals with proven breeding potentials the quality of the genotype must be assessed. This task requires carefully planned experiments, as well as, time. Controlled pollination methods and techniques for the early assessment of distinctive characters must be developed.

ASSESSMENT OF PRIORITIES

Establishment of improved seed sources is time consuming, as well as, expensive. It is, therefore, essential at the planning stage to limit the scale of the work by carefully assessing the priority of each species for inclusion in the programme in relation to the national planting requirements. In Bangladesh there is a wide range of plantation species both indigenous and exotic, listed in the working plans. Forty five species, which are mentioned in the working plan were carefully examined for priority rating. Importance was given to species which have proved successful in plantation establishment. Species selected by the Forest Department received the highest priority.

Of the three major planting areas mentioned above top priority has been given re-plant the hill forests. This is because people are successfully perpetuating the homestead forests by individual efforts and the silvicultural techniques are being developed for afforesting coastal areas. Further, there are political and economic pressures to exploit the hill forests and there are indications that site-degradation follows if the exploited areas are not immediately re-planted.

The estimated total area of felling coupes of the country based on the working plans is 44515 ha (110,000 acres). Of this, 34398 ha (85,000 acres) is selection felling area in the Sundarbans. So, planting stock is required for the remaining 10117 ha (25,000 acres). Accelerated exploitation required by the two-year approach plan may raise this to 16187 ha (40,000 acres) approximately ; which has been used to calculate the seed requirement. Investigations indicate that five species are likely to be required in far greater quantities than others. These are Garjan, *Dipterocarpus turbinatus* Gaertn., Gamar, *Gmelina arborea* L., Sal, *Shorea robusta* Gaertn, Dhakijam *Syzygium grande* Wt, and Teak, *Tectona grandis* L, and are included in the top priority list. Of these, the first four are indigenous. Though Teak is exotic, a derived provenance has developed from plantations which date back to 1872.

A number of other locally popular species include Moluccana, *Albizzia falcataria* Fosberg, Kadam, *Anthocephalus cadamba* Miq., Champalish or Chum, *Artocarpus chaplasha* Roxb. Champa, *Michelia champaca* L., Mahogany, *Swientenia* spp. etc. Of these, the first two species are relatively new to the forest plantations of Bangladesh though

Moluccana has been used as shade crop in the tea gardens for years. *Albizzia falcataria* and Mahogany are exotic and, to some extent, have formed derived provenances. However, the quantity of seed imported for the early introductions was much less and it is likely that these provenances have a narrow genetic base, and has, therefore, been excluded from the top priority list. These two indigenous species, Champa and Chapalish, though have excellent, attractive timber yet the areas planted each year are limited by seed availability and unreliable establishment. Both are given a priority but second to the five species mentioned above.

Table 1 is an estimate of the annual acreage to be planted with the five selected species to initiate the seed orchard programme for Bangladesh. These estimates are based on the expanded annual plantation programme in the eastern hills and are likely to represent 90 percent of the areas.

Table 1. Estimated areas of the five top priority species under Annual Afforestation Programme

Species	Area in ha (acres)
Teak	6475 (16,000)
Garjan	3237 (8,000)
Gamar	2428 (6,000)
Dhakijam	1619 (4,000)
Sal	809 (2,000)
	Total 14568 (36,000)

SEED REQUIREMENTS

Fruits rather than seeds are harvested for all the five species. Teak and Gamar belong to the family *Verbanaceae* and seeds (0 to 4 in number) develop within a stoney endocarp. The epicarp and mesocarp of Teak are dry and fibrous. The presence of these tissues does not appear to be detrimental to storage. In Gamar the mesocarp is is fleshy and must be removed before storage. Fruits of both the species can be stored for a year under normal atmospheric conditions without serious loss of viability. Garjan and Sal are Dipterocarps and the fruit, usually single seeded, is characterised by the dry extended calyx, developing into wings, which are two in Garjan and three is Sal fruits. Fruits of these species ripen at the end of the dry season and have the reputation of rapid germination at the onset of the monsoon. Dhakijam belongs to *Myrtaceae* and forms large, rounded fruits inside which there is a large round seed. Storage conditions are not known for the Diptero carps or Dhakijam and under normal conditions all three species lose viability rapidly. Currently, plantations of the three species are established by direct sowing. This method is wasteful in terms of seed and might have to be discontinued when improved seeds become available.

To estimate the amount of annual requirement, and thereby the area of orchards (or seed stands) to be established, the planting requirements of the orchards must be assessed in terms of tree biology. Available biological data of the selected five species

and the requirements of trees and area of orchards (stands) are calculated and provided in Table 2.

A stocking of 27 and 40 trees per 0.41 ha (1 acre) is maintained for orchards and seed stands respectively. The former is based on experience gained at the Teak Improvement Centre in Thailand as reported by Hedegart *et al* (see Faulkner 1975). Rather, more stock is retained in the seed stands than planted in orchards, partly because the genetic quality is more variable and partly because a heavier culling might result due to wind blow.

Table 2. Estimate of clonal orchard/seed stand requirements

Species	Fruits		Plant %	Seed requirement*		No of seed trees*	Area in ha (acre)	
	per 454 g (per lb)	kg/tree (lb/tree)		million	kg(lb)		clonal orchard	seed stand
Dhakijam	60	13.60(30)	70	1.57	1189(26217)	874	55 (135)	36 (90)
Gamar	400	6.35(14)	70	1.57	1784(3933)	281	28 (70)	18 (45)
Garjan	160	6.35(14)	60	1.69	4803(10588)	756	91 (225)	63 (155)
Sal	550	4.50(10)	60	1.69	1397(3080)	308	10 (25)	8 (20)
Teak	800	4.63(8)	25	4.84	2744(6050)	756	182 (450)	125 (310)

* For 404 ha (1000 acres) of plantations

PROGRESS DURING 1976-1979

Six seed orchard centres have been established. They are at Dulahazara, Hyako, Kaptai and Ukhia in Chittagong and the Chittagong Hill Tracts ; Barshijura in the Sylhet Hills and Salna on the fringe of the Sal forests of central Bangladesh. Each centre has a nursery for raising rootstocks and graftings. The sites have been selected with due consideration of the plantation programme of the Forest Department so that each seed orchard centre can render services to a number of forest ranges.

There are four major steps in the programme :

- Selection of seed stands (or seed trees),
- Selection and centralisation of Provisional Plus Trees (PPT),
- Mapping the distribution of indigenous species, and
- Establishment of clonal seed orchards.

It would be possible to develop a species-wise programme for each centre once the total requirements of seeds for Bangladesh are estimated.

At Kaptai work is mainly concentrated Teak though there are some indigenous hardwood plantations. The Dulahazara Centre is situated near old plantation of Garjan and concentrates work on this species. There are some indigenous hardwood plantations around Ukhia and also excellent groups of natural Dhakijam ; however, the initial work was concentrated on Teak. It may be mentioned that in the southern part of Bangladesh, the growth rate of this species is slow [78.7 cm (31 in) gbh, 12.19 m (40 ft) top height in 26 years compared to 137 cm (54 in) gbh, 22.86 m (75 ft) top height in 41 years in Kaptai]. Such growth rate is, probably, due to the environmental factors and might not influence the genetic quality of the seeds of an interim source. Hyako, the only other centre in the south-eastern hills, is not near to any extensive mature plantation areas, though some older Teak stands occur in the adjoining areas. The Barshijura Centre is surrounded by plantations of Teak and Garjan dating back to the 1940's and also having an attractive 35 year old Sal plantation of good quality nearby. No mature plantations occur in the vicinity of the Salna Centre which is in the natural Sal forests. The Sal forests are being managed by coppicing on a 40-year rotation.

SEED STANDS

Selection of plantation areas for conversion into seed stands was also given top priority. The working plans of the areas under consideration were consulted and the locations of pure or nearly pure plantations of the required species over 4.1 ha (10 acres) were abstracted. All areas which seemed adequately stocked were then revisited and a representative 0.41 ha (one acre) plot was demarcated. Gbh and top height of each tree in the plot were measured. A record of the presence or absence of forking followed by a subjective assessment of bole straightness, spiral grain, fluting (high and low) and branching was also made.

The mean girth, top height and timber height together with the co-efficient of variation were then calculated. Similarly, the mean of 1 to 6 subjective gradings of each of the form-characters were calculated. Table 3 indicates how stands are graded as "Good", "Acceptable", or "Poor" based on the percentage of trees which are average or above average.

Plantations classed as 'Good' are Potential Seed Stands (PSS) and a more intensive sample is taken. As the minimum sample size required is not known therefore in some of the smaller areas a 100 percent evaluation was carried out ; in others 50 percent or 25 percent were assessed.

In 1978, one Dhakijam and two Teak PSS in Kaptai, two Garjan PSS in Dulahazara and three Teak PSS in Ukhia were selected at the onset of the monsoon. A complete assessment was carried out in Dulahazara Garjan Stand during which all trees were numbered in the field. When the final calculation indicated above-average quality, trees to be retained were selected from field sheets. This method of selection was extremely effective. A lower level of

Table 3. General grading rules of seed stand

Feature assessed	Grade		
	Good	Acceptable	Poor
1. Age	over 40 years	39 to 25 years	Under 25 years
Area	over 30 acres	20 to 10 acres	Under 10 acres
Crop constitution	Pure	Mixed/Pure areas	Mixed
Site	Gentle Undulating	Hilly but not steep	Steep
2. Unforked Canopy	Over 50	—	—
Trees/acre	—	—	—
*3. Top height	Over 60	59 to 50	Under 49
Timber height	Over 60	59 to 50	Under 49
Gbh	Over 50	49 to 40	Under 39
*4. Bole straightness	Over 70	69 to 60	Under 59
Straight grain	Over 70	69 to 60	Under 59
Low flutes	Over 50	49 to 40	Under 39
High flutes	Over 60	59 to 50	Under 49
Branching	Over 50	49 to 40	Under 39

*Expressed as percentages of average and above-average trees

sampling was carried out at Kaptai and Ukhia and tree selection was made in the field. It was slow and required more intensive supervision.

A suitable plntation of Gamar could not be found, so the interim source was Selected Seed Trees. However, the survey indicated that the distribution of the trees of this species are very scarce. In fact, due to over-exploitation, Gamar can be considered an endangered species in Bangladesh. It is difficult to find enough naturally-occurring trees ; so groups of trees in plantations were considered.

SELECTON AND CENTRALISATION OF PPT

Empirical and subjective characters of the selected trees are recorded together with those of ten satellite trees. The initial selections were made at the time of seed stand scanning. For the latter the individual tree assessments are not as critical as those for PPT. The result of carrying out both the phases simultaneously has caused recording of unduly lenient descriptions of the selected and the satellite trees although the quality of selection is good. The current chosen trees are considered as "pre-selected" and a more intensive selection level needs to be applied later. A total of 366 pre-selected trees comprised of 33 Dhakijam, 33 Gamar, 118 Garjan, 12 Sal and 170 Teak trees.

Centralisation required reliable vegetative propagation technique and is known only for Gamar and Teak out of the five priority species. A total of 35 clones of Gamar were successfully propagated-3 at Barshijura, 20 at Hyako, 6 at Kaptai and 6 at Ukhia. On the other hand, 51 clones of Teak were centralised, 16 at Barshijura, 10 at Hyako, 23 at Kaptai and 2 at Ukhia. In all the cases either patch or Vorkert budding method proved successful. Experiments are being carried out with other tree species as well, to examine grafting and budding methods. One clone of Garjan has been propagated till to date, but only 2 ramets survived. It is considered that the quality of the rootstock required up-grading and facilities for the after care grafts need to be improved.

DISTRIBUTION MAPPING OF INDIGENOUS SPECIES

Although research work on the above aspects have been carried out in Bangladesh and observations have been taken since the last century, many of the records are not available in the country. All forestry records used to be maintained at Dehra Dun in India, until the partition of India in 1947; and then at Peshawar in Pakistan until the War of Liberation of Bangladesh in 1971. It is therefore, difficult to adjust to this situation; and fundamental observations must be restarted.

In order to survey the natural distribution of indigenous trees, staff at each centre choose footpaths to walk along and record the position and number of trees seen. Later, attempts are made to plot the trees on maps. This has met with limited success in respect of mapping the distribution, but has set the importance of the conservation of genes. Gamar, once abundant throughout the country, is now scarce due to its increasing popularity as a quality furniture timber. It seems that Chapalish, Champa and other species too will meet the same fate. The current preference in furniture timber is Sil Koroi (*Albizzia procera* Benth.) and it is rapidly disappearing.

ESTABLISHMENT OF CLONAL ORCHARDS

Clonal orchards may be established from PPT prior to the assessment of their heritability. These may be considered as 'Intermediate improved seed sources' and orchards

may be established from tested clones. Gamar and Teak are the only species which can be reliably propagated for clonal orchards. During the later part of the 1978-79 dry season preparation of grafts of these species was started and a total of 50.58 ha (125 acres) of orchards have been established at the Barshijura, Hyako, Kaptai and Dulahazara centres. An additional area which was obtained at Ichamati, 56.3 km (35 miles) north east of Chiattagong, was also planted.

The number of ramets per clone which varied considerably, influenced the size and design of each orchard. A randomised complete block design as described by Giertych (*See* Faulkner 1975) was employed. In every orchard each clone is represented by the same number of ramets as there are clones. Three Teak orchards with 31, 22 and 10 clones each respectively; four Gamar orchards with 23, 20, 16 and 13 clones each respectively, were established. The 20 clone and 13 clone orchards of Gamar are on adjacent sites at Dulahazara.

Grafting for the orchards was successful at only three centres (Barshijura, Hyako and Kaptai) and as a result the ramets had to be transported to other centres. Each ramet in its 22.9 cm x30.5 cm (9 in x 12 in) earthen pot weighed approximately 6.8 kg (15 lbs). The potting mixtures tended to be rather clayey and since the plants were transported during the monsoon some damage to root systems occurred. In general, however, mortality after planting was low, the most serious being 17 percent at Barshijura due to termite attacks. 60 of the 84 dead ramets of this centre were replaced with identical clones and the remaining gaps were filled with clones already represented. So, this centre now has 23 ramets per clone instead of 22. The deaths were considered also due to excess plant debris on the site coupled with sluggish initial growth of the ramets, following transportation. In future graftings will be prepared in the respective centres where the orchards are to be established.

CONCLUSIONS

Throughout the world forest geneticists are proving the value of selected seed for afforestation programmes. In Bangladesh pressure for land is so great that only a limited area will be available for growing essential forst-based raw materials, so it is imperative on the Forest Department to plant only the best possible stock. The programme outlined in this paper may help achieve this goal.

REFERENCES

Anon. 1975. FAO/DANIDA Training Course on Forest Seed Collection and Handling. FAO-FOR : TF-RAS II (DEN), Vol.2, 453 pp.

Anon. 1977. International Training Course in Forest Tree Breeding : Selected Reference Papers. Watson Ferguson and Co., Brisbane : 2nd Ed. 257 pp.

Burley, J. and Nikles, D. G. 1972. Selection and Breeding to Improve Some Tropical Conifers. CFI, Oxford-For Dept., Queensland, Vols. 1 & 2. 417 pp & 466 pp.

Faulkner, R. (Ed.). 1975. Seed Orchards. For. Comm. Bull. No.54, HMSO, London. 149 pp.

Nikles, D. G. 1975. Seed Orchards – Conceptand Design. FAO-FOR : TP-RAS II (Den) Vol.2 ; 212-219

Shelbourne, C.J.A. 1969. Predicted Genetic Improvement from Different Breeding Methods. 2nd World Conf. on For. Tree Breed. Vol.2 : 1023-1029

Wright, J.W. 1976. Introduction to Forest Genetics. Academic Press Inc.,463pp.

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