MINISTRY OF FORESTRY
FOREST DEPARTMENT
AND
INTERNATIONAL TROPICAL TIMBER ORGANIZATION
(ITTO)

"Ex-situ and *In-situ* Conservation of Teak (*Tectona grandis* LinnF.)
to Support Sustainable Forest Management"

ITTO Project PD 270/04 Rev.2 (F)

The second technical report of international consultation on Teak tree improvement for ITTO project in Myanmar

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Executive Summary

The result of the second consultation on teak tree improvement in Myanmar was reported. The duty trip was carried out from 10th February till 23rd February in 2008 with project members, starting from Yangon to Pyay then move to Sagain division to visit SPAs currently established by ITTO project. Comments and advises for the two SPAs as well as the newly established provenance tests and clonal orchard at Moeswe near Yezin were reported. A skeleton of teak tree improvement in Myanmar was presented at the seminar held by the project at Yezin. This topic was composed of the current status of Teak tree improvement in ASEAN countries and the proposed program for Myanmar which includes choice of breeding procedure, breeding zone, time schedule and form of implementation. The contents of the proposed Teak tree improvement was almost the same as in the first report: recurrent selection with CSO seemed as an appropriate choice for teak tree improvement program and the orchards might be better to establish under drier climate to solve for the low productivity of seed. Current forestry division might be used as breeding zone for smooth implementation, while an investigation to optimize breeding zone need to be continued by analyzing the results of provenance trials as well as the plantation management strategy in Myanmar. Expected time schedule for tree improvement was presented together with optional activities. A form of implementation of tree improvement work was proposed briefly by emphasizing the importance of full involvement of Forestry Department.

Contents of the report

Objective

The missions assigned to an international consultant on tree improvement are as follows.

1. to prepare a skeleton of teak improvement programme together with a set of relevant research plans and to assist initial process for developing such a programme to be lead by the Forest Department
2. to prepare and to submit training materials on tree improvement and to conduct training to the Forest Department staff
3. to advise NPM on the present project activities
4. to submit technical report

These issues are regarded as essential to implement Teak tree improvement in Myanmar by utilizing resources and technologies that have been developed in the present ITTO project: Ex-situ and In-situ conservation of Teak to support sustainable forest management.

To attain the missions listed in the above paper presentation on the skeleton of Teak tree improvement was scheduled at the seminar. Field visit was also arranged to give advice for the on-going project activities.

The technical report presented here is composed of the above two issues together with a brief introduction of Teak tree improvement programs in Southeast Asia that will be of help in formulating the improvement program in Myanmar.

I. Schedule of the second visit for consultation in Myanmar

The second duty trip in Myanmar was summarized as in Table 1. SPA at Nattarin was visited after the first day's discussion with project staff on the schedule and objectives of this consultation. Then the field trip to visit SPA and plus trees at Kanbaru was made by way of Mandalay. After returning to FRI in Yezin, newly established provenance test and CSO at Moeswe were visited. The paper presentation on Teak tree improvement in Myanmar was made at the seminar held by ITTO project. The final discussion of the trip was arranged at ITTO project office one day before leaving from Yangon to share the findings and expected recommendation of this consultancy work.

Table 1. Duty trip conducted by International Consultant (Tree Improvement)

Date	Particulars	Night Halt
10-02-2008 (Sun)	Arrive at Yangon	Yangon
11-02-2008 (Mon)	Discussion with project staff, preparation for field trip	"
12-02-2008 (Tue)	Yangon to Nattalin by car, night stop at FGH, Pyay	Pyay
13-02-2008 (Wed)	Pyay to Yangon	Yangon
14-02-2008 (Thu)	Yangon to Mandalay by flight	Mandalay
15-02-2008 (Fri)	Mandalay to Kanbalu by car, night stop in Kanbalu	Kanbalu
16-02-2008 (Sat)	Kanbalu ↔ Chatthin, visit Teak SPA and select Plus Tree	"
17-02-2008 (Sun)	Kanbalu to Mandalay, night stop at Nadi Myanmar Hotel, Mandalay	Mandalay
18-02-2008 (Mon)	Mandalay to Yezin, night stop at FRI Guest House	Yezin
19-02-2008 (Tue)	Visit Experimental CSO and Teak Provenance Trial at Moe-swe	"
20-02-2008 (Wed)	Paper presentation at Seminar on SPA Management and Tree Improvement organzied by ITTO Teak project	"
21-02-2008 (Thu)	Yezin to Yangon.	Yangon
22-02-2008 (Fri)	Review and discuss on project activities and the field trip with project staff and National Consultants	"
23-02-2008 (Sat)	Leave Yangon	

The field trip arranged to inspect 2 seed production areas (SPA) was done successfully owing to the good weather during the trip. The visit of new provenance trial and CSO was also successful and it suggests the activities of the project have been conducted as scheduled. The seminar at FRI in Yezin on 20th February was held successfully with more than 50 attendance including minister of Forestry and other high-class officials.

II. Comments and advises for the current ITTO project activities

There were opportunities to observe the on-going activities in the ITTO project during this visit. They were the two SPAs: Nattalin and Kanbalu, one CSO and one provenance trial at Moeswe. Therefore the comments on the results of those activities are given briefly.

1. Establishment of seed production area (SPA)

SPA at Nattalin

This SPA was established in the youngest plantation, 16 years old, among the 6 SPAs to be established at this project. The growth is well with this age class, while the flowering and fruiting seemed still limited to a few individuals. Although the thinning to covert to SPA has been done, there remained a few inferior trees. Therefore additional thinning might be necessary when the trees are grown up to certain size.

SPA at Kanbalu

This SPA was probably the best one among the six in terms of its growth and tree form. Thinning has not yet been finished, but it will be done in few more months. Considering from the frequency of flowering trees in the plantation as well as the previous history of seed collection, good amount of seed production can be expected after the thinning.

It is recommended to record annual seed production in the six SPAs so that the data could be utilized to predict seed production using climatic information at the flowering and fruiting time.

2. Establishment of clonal seed orchard

An experimental clonal seed orchard was established at Moeswe and at Pyay. They were planted at an appropriate time, July in 2007, showing 87% survival and the layout of clone was well documented. Since the annual precipitation is around 800mm at this site, early flowering might be expected with this CSO.

Since the CSO area was crossed by a small stream, the shape was not a square or rectangular. If the site survey were done prior to out planting, more complete clone allocation would be made by PC. Therefore the procedure to establish CSO was attached as an annex with this report.

3. Establishment of provenance trial

The provenance trial established in Moeswe seemed to start growing well with the initial survival of 100%. It was established in July 2007 and the plot layout was well documented. The border of every plot was surrounded with different species of Ipil-Ipil to facilitate later measurement. Therefore it would provide valuable information on provenance variation.

Although the trial was established in a compact shape by carefully choosing site: 8 provenances by 5 replications, the blocking might be re-examined by analyzing with the data of later measurement. This is because the shape of block seemed stretching too long in the direction from east to west, hence it could not satisfy the homogeneity of site fertility within the block on which the later statistical analysis relied upon.

III. Review of Teak tree improvement program in Southeast Asia

Current trend and experiences for Teak tree improvement in the ASEAN countries would be a good help to prepare the successful tree improvement in Myanmar.

1. Tree improvement in Thailand

Tree improvement was initiated in 1965 with the aid by DANIDA and leading Teak tree improvement in the Region. Teak tree improvement Center is conduction the program and it preserved 450 clones of Teak plus trees at the clone bank. Trial plantation with tissue cultured Teak the oldest one planted in 1992 showing good growth and form at age 15 years old (Photo 1).

Photo.1 The oldest plantation of tissue cultured Teak

Photo.2 Practical acclimation procedure for tissue cultured Teak

Clonal seed orchards were established in the late 1960' with bud-grafting, however, the seed supply from 2,000 ha of CSO at 7 locations could not meet the operational demand, hence it prompted to start tissue culture research. Current seed production in CSO is 20Kg/ha with 30% germination.

Tissue cultured Teak has become popular in Thailand (Photo 2), however, FIO, state cooperation that has established 50% of Teak plantation recently, is hesitated to use the tissue cultured teak for their plantation establishment because of its high price. Therefore the tissue cultured Teak currently supplied by several facilities is used by the farmers for their

plantation activities.

2. Tree improvement in Indonesia

Teak tree improvement started in the early 1980 with plus tree selection. 4,000ha of SPA and 1,300ha of CSO have been established. 2 tons of seed out of 4 tons of annual demand is supplied by CSO and remaining was by SPA.

150 plus tree clones were tested at 4 sites since 1998, then 12 best clones were selected to establish hedged orchards based on their performance as well as rooting ability. Best clone can grow 5 cm DBH at 2 years old (Photo 3). In clonal test planted in 1998, best clones reached 20 cm DBH at 8 years old (Photo 4).

Photo.3 The best Teak clone at 2 years old.

Photo.4 The best Teak clone shows continues growth until 8 years old with 1 inch per year.

Hedged orchards are established as facility of nursery (Photo 5). Stocks are planted with 1 m spacing to produce 120 scions annually. 0.5 million rooted cuttings were produced in 2006, one million in 2007 and 50 million in 2008 are expected to supply for reforestation. 80 ~ 95% of scions are rooted within a month and it takes 3 to 4 months for out planting (Photo 6). Clonal plantation of teak, domestic as well as those from Thailand, has become popular in Indonesia, thus the image of Indonesian Teak, growth is well but low quality, may be changed within a few decades.

Photo.5 The hedged orchards with best Teak clones are established near nursery.

Photo.6 Teak clones will root within a month and grow plantable size within 4 months.

3. Teak plantation management

Teak plantation had been managed with a long rotation, while it gets shorter recently due to the fast growing teak clone as well as diversification in wood processing technology.

Country	Initial density trees/ha	Planting system	Thinning	Rotation
Thailand	625	Taungya	3	30years
Myanmar	1,371	Taungya	4~5	40years
Indonesia	1,000	Tunpangsari	4~5	60years (30years)

State cooperation Peruhutani runs Teak wood factory where door, window frame, furniture of finger-jointed woods are produced. This enables the utilization of smaller diameter logs, hence it contributes shorter rotation management.

4. Tentative summary

Thailand has conducted tree improvement for Teak over 40 years by Teak tree improvement center.

- SPA and CSO could not meet the seed demand.
- Tissue cultured plants were developed, while the cost is still a major obstacle for a wide use of improved trees.

Indonesia started tree improvement of Teak around 25 years ago by Perhutani cooperated with Gadjah Mada university.

- Seed supply from SPA and CSO almost meet the demand.
- Best Teak clones were selected by clonal tests and they are getting ready for operational use.

There is a world-wide trend of shorter rotation for Teak plantation.

- Advanced technology for processing Teak wood enables smaller size logs for industrial use.

• Fast growing Teak clone may reduce rotation for Teak plantation.

IV. A main frame of Teak tree improvement program in Myanmar

Expected activities after the establishment of SPA are plus tree selection, establishment of clone bank (hedged garden) and clonal seed orchards. These activities should be done by each region as a unit, because the Teak plantation area in Myanmar seems variable in climate as well as in product value in timber market.

1. Choice of breeding procedure

The recurrent selection with clonal seed orchard would be the most realistic option for Teak tree improvement (see Fig. 1), although the current clonal seed orchards of Teak are suffered form the poor seed productivities and low germination rates (Apichart 1999).

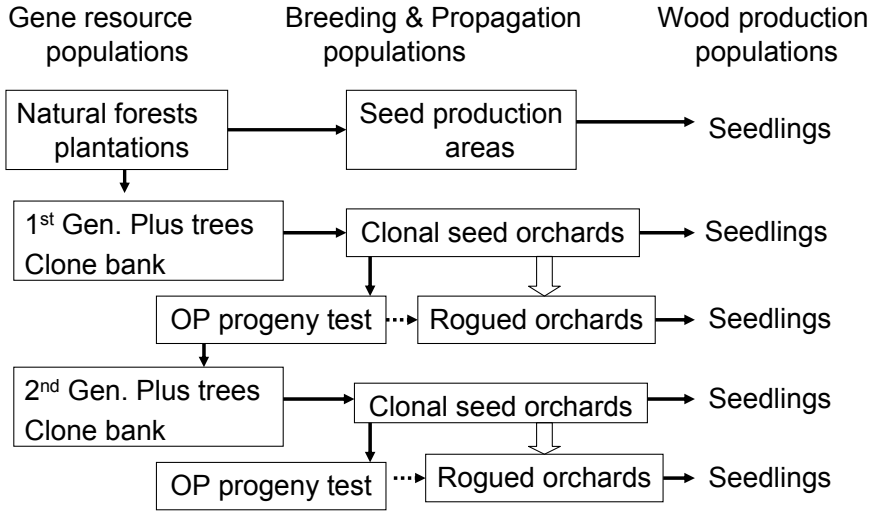


Fig. 1 Flow of operation for a recurrent selection with clonal seed orchard

1.1 Proposed procedure

A flow of the proposed procedure, recurrent selection with clonal seed orchard, was summarized in Fig. 1. In the case of Myanmar, this procedure will be applied to each breeding zone with different set of plus trees. Therefore the teak improvement program may be called as multiple breeding populations.

This procedure does not separate breeding population from the propagation population in order to simplify the tree breeding operation. Thus the clonal seed orchard will supply seed for operational use as well as provide seed for progeny test. The progeny tests will provide data to evaluate genetic quality of each plus tree and the results will be utilized for roguing the clonal seed orchard to up grade the genetic quality of seed orchard seed. These tests will be utilized also as a base population for selecting 2nd generation plus trees.

1.2 Comparative investigation on CSO vs. SSO

Another potential option for tree breeding procedure might be the use of seedling seed orchard. The merits and demerits between the clonal seed orchard and seedling seed orchard are summarized as in Table 2.

Table 2. Merits and demerits between clonal seed orchard and seedling seed orchard.

Type	Genetic gain	Inbreeding	Seed production	Technical difficulty	Implementation
SSO	Comparatively smaller	Slower increase but hard to control	Slower but species dependent	No need grafting	Easy and consistent but site dependent
CSO	Greater	Rapid increase but control	Earlier	Cloning is essential [grafting]	Repeatable across sites

In the case of Teak, an option with clonal seed orchard (CSO) is regard suitable because of the following reasons,

(1) The vegetative propagation for Teak is well established in Myanmar with budding grafting method. According to the results in ITTO project, more than 50% of grafts were successfully obtained, therefore CSOs could be established without serious loss of plus tree clones.

(2) Teak generally flowers and fruits at the top of their crown and this tend to be the cause forking of heavy flowering trees. This negative relationship between stem form and flowering makes the selection work in SSO difficult, because testing and seed production is sequentially conducted in SSO.

(3) Clonal seed orchard can be established under the favorable environment for flowering and fruiting separate from the progeny test, while seedling seed orchard generally requires the site to satisfy the dual purposes: testing and seed production (Fig. 2).

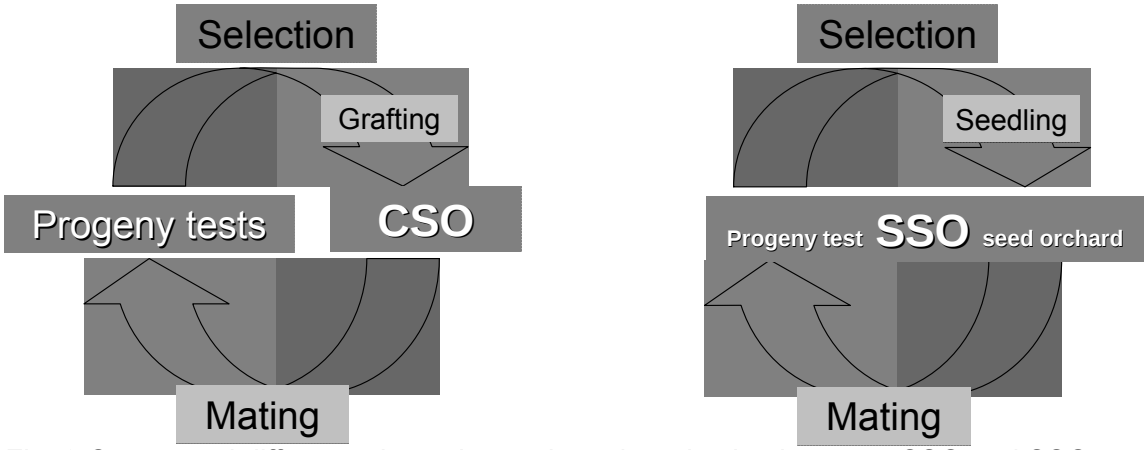


Fig. 2 Conceptual difference in testing and seed production between CSO and SSO

1.3 Deployment of CSO to enhance seed production potential

There is a good possibility for the clonal seed orchard of Teak to increase its seed production capacity by establishing at drier area, such as Magway Division where the seed production would be generally better because of the climate. This assumption will be examined with establishing the experimental CSOs by the current ITTO project.

Once the optimum seed production area was identified, most of CSOs composed of several sets of plus trees from different breeding zones are established in drier areas, although the testing and selections are conducted by their original breeding zone. This separation of seed production function from the testing and selection function would realize much better seed productivity and it consequently bring about greater gains by teak tree improvement.

2. Breeding zone

Since the Teak forest area in Myanmar is variable in climate as well as in product value at the timber market, appropriate division of breeding zone should be examined based on the differences in climate, product type and provenance. However, for the purpose of smooth implementation, it might be better to start using current forest division as tentative breeding zone.

2.1 Breeding zone based on administrative boundary by forest department

The most practical way of delineating breeding zone might be to follow the currently used administrative boundary by forest department. In the case of teak tree improvement, the five forest division: Sagain, Magway, Mandalay, West Bago and East Bago, the study area of the current ITTO project, may be enough for breeding zone of teak tree improvement, because these are the divisions where most of the teak plantation has been established extensively, almost 80% of the total plantation in Myanmar is shared by these five divisions.

This type of breeding zone is best suited to carry out various collaborative works with forest department due to its conformity of their boundary. Many of the forestry information related to tree improvement, plantation area, seed and seedling demand and supply, seed production area, plus trees, are directly available from divisional forest office. It also facilitates to carry out collaborative work in the field, because management line is basically controlled by the divisional forest office.

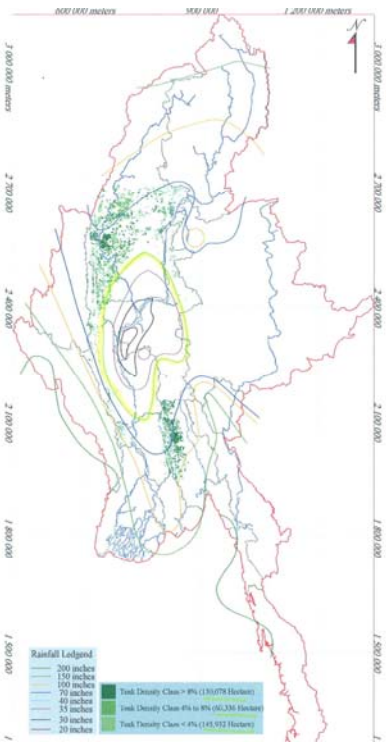
From the aspect of tree breeding, this type of zoning is not the optimum choice, because natural and management environments for teak plantation would be variable even within the forestry division. Therefore it is important to take into account that the current breeding zone is tentatively determined for the purpose of management and it would be subject to change

when necessary information, such as provenance performance, has become available.

2.2 Potential factors for breeding zone in Myanmar

The distribution of teak forest and its market value seemed to have some relationship with the precipitation as shown in Fig 3. The dry zone locates at the central part of Myanmar and the teak forest distributes at the fringe of the dry zone of around 1,000mm up to 2,000mm of precipitation (Fig. 3A). In addition the golden teak zone that has the highest market value is almost overlapped with the central part of the teak forest distribution (Fig. 3B). This indicates that the wood quality of teak is generally better in drier zone and enhanced growth due to abundant precipitation reduces its wood quality. This type of trend is also known in Indonesia where the teak grown in East to Central Java is generally better in wood quality than the fast growing teak in West Java.

A. Mean annual rainfall and Teak forest



B. Distribution of Teak wood quality

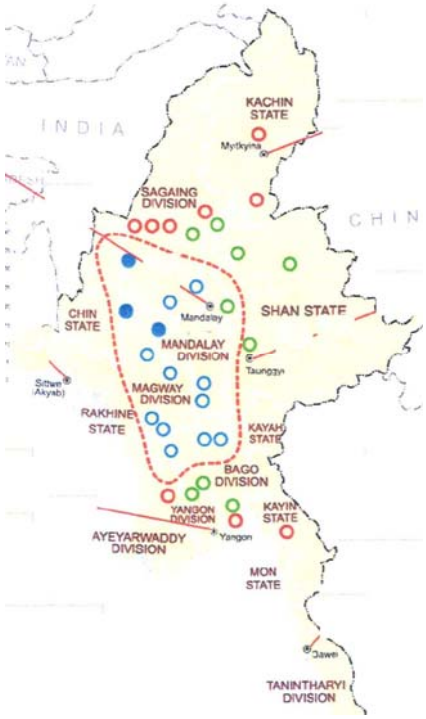


Fig. 3 Geographic distribution on precipitation, teak forest and market value of Teak wood in Myanmar

Although the above mentioned relationship between wood quality and climatic difference of the precipitation needs further investigation, it should be taken into consideration when delineating breeding zone for Teak. This is because the teak in Myanmar is known with its high quality and it should be sustained by breeding as well. Therefore one of the possible options might be a stratification of the planting environment into two zones; drier zone for high

quality wood production and the surrounding zone for mass wood production.

This differentiation of wood production purposes in the two zones will affect the breeding objectives. In the drier zone, improvement on form traits and possibly adaptability might be more emphasized rather than the growth for the purpose of high quality wood production. On the other hand, an improvement for growth would be preferred to increase wood productivity in the surrounding area.

2.3 Breeding zone to be developed

At the moment, breeding zone for teak in Myanmar may be a composite of the two different ways of classifications; the one with administrative boundary of forest division and the stratification of area by the product value which seemed more or less affected by precipitation. This suggests that each forestry division should be examined on the possibility of stratification by the trend mentioned in 2.2.

The results of provenance test might be another source of information to examine breeding zone, because the base population in each of the breeding zone is ideally developed with the provenances which proved as superior in the zone. However, the results may be better to reviewed from the aspect of dry to humid climatic condition.

3. Time schedule for teak tree improvement

Expected time schedule for the proposed tree improvement is shown in Fig 4 together with some optional activities. This schedule is prepared with an assumption that department of forestry will organize operational tree improvement center consisting of several tens of staff and allocating supporting sections at each of the divisional forestry office (chapter 4 for details).

Plus tree selections would be finished in the first two years and it is followed by scion collections to establish clone bank. Clonal seed orchard will be established in the second to the fourth year using grafts collected from the clone bank. Seed production assumed to start 10 years after field planting, while it may be possible to start 5 years after planting under favorable environment for flowering and fruiting. Then progeny tests are established using open pollinated seed of most of the plus trees in the orchards.

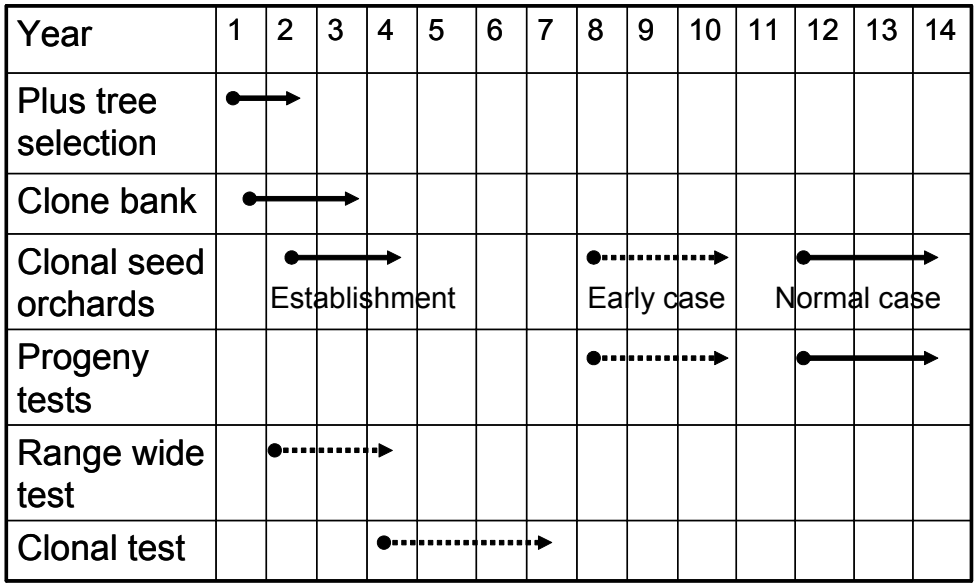


Fig. 4 Expected time schedule for the proposed tree improvement

There are two optional activities in Fig. 4. These activities would be carrying out until the start of seed production in CSOs.

(1) Range wide test

Range wide test or provenance progeny test might be a realistic option that could be done with less technical difficulty. Open pollinated progenies from plus trees selected in around ten SPAs would be used in this series of tests to identify promising SPAs as well as to establish seed transfer zones in Myanmar.

(2) Clonal test

Establishment of clonal tests might be a potential option, once a reliable vegetative propagation technique is established. This is because this technique would be an alternative option of clonal seed orchard to supply genetically improved planting stock as well as a tool to realize greater gain by tree improvement.

As introduced the case in Indonesia, this option may bring about a tremendous benefit in Teak plantation establishment within relatively a short period of time, say around 10 years, as long as the clonal tests were properly laid out. Therefore it is recommended to develop a reliable procedure of shoot cutting technique to establish clonal test as soon as possible.

V. Recommendation on future tree improvement

When the target of tree improvement is determined to meet the national demand for operational plantation establishment of Teak, large area of CSO and genetic test should be established to cover the most of potential areas for Teak plantations in Myanmar. Therefore a full involvement of forestry department in institution building and network establishment is strongly recommended.

1. Form of the executing organization

In order to conduct an operational tree improvement on a national scale, a permanent organization specializing on tree improvement and a network of relevant institution to support tree improvement need to be established. Followings are the ideas based on the experiences in Japan (Fig. 5).

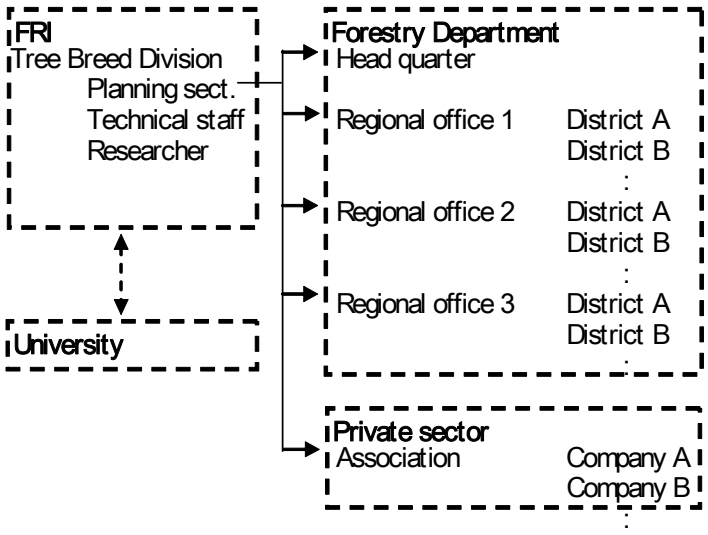


Fig. 5 Expected form of executing organization for tree improvement

- Forest tree breeding center
  This center may be under control of FRI
  * Researcher's group to conduct tree improvement specifically
  * Technical staff to support nursery and field work of tree improvement
  * Administrative staff to support planning, budgeting and documentation
- Department of Forestry
- *Organize unit at department of forestry to coordinate planning and budgeting for tree improvement
  * Assigning staff at divisional forest office to coordinate field activities; plus tree selection, trial and orchard establishment, management and measurement.

* Staff at township forest office will support field activities of tree improvement according to the instructions from the staff of divisional forest office

- University
  Preferable to establish laboratory to conduct advanced research on tree breeding
- Private sectors
  Organize Tree improvement association to support tree improvement

2. Human resource development

Forest tree improvement requires knowledge in various fields of research, such as breeding, silviculture, phenology, physiology, statistics as well as advanced techniques: tissue culture and DNA analysis. Therefore human resource development is essential for a successful implementation of forest tree improvement. It is recommended to let the young staff to get as many opportunities as possible to learn the knowledge in the abovementioned fields in abroad where the tree improvement is actively conducted. One of the most common approaches would be to apply scholarship for studying at universities, while the collaborative study with a well known institution might be another option to get such advanced knowledge and techniques.

Beside the academic knowledge mentioned in the above, domestic training to the staff who are involved in the field work of tree improvement would be necessary (Fig. 5). This is because many field operations, plus tree selection, establishment of CSO or trials and their later maintenance will be carried out in cooperation with the foresters working at township forest offices. This type of training might be conducted occasionally in a form of on the job training or regular course to be held annually.

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