MINISTRY OF FORESTRY
FOREST DEPARTMENT

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

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

Proceeding of the Seminar on Teak Seed Production Area Management and Tree Improvement

Forest Research Institute, Yezin

20 February 2008

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Seminar on Teak SPA Management & Tree Improvement

20 February 2008

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

Seminar on Teak Seed Production Area (SPA) Management & Tree Improvement

Opening Ceremony

20 - February, 2008. Nay Pyi Taw

Report of the Seminar

A. Introduction

1. The project entitled "*Ex-situ* and *In-situ* Conservation of Teak (*Tectona grandis* Linn. F) to Support Sustainable Forest Management" PD 270/04 Rev.2 (F) is being implemented by the Forest Department, Ministry of Forestry with financial assistance from International Tropical Timber Organization (ITTO) since April 2006. In accordance with the project activities of the yearly plan of operation for the period April 2007 to March 2008, seminar on Teak SPA Management and Tree Improvement was held at the Forest Research Institute, Yezin, Nay Pyi Taw, Myanmar on 20 February 2008.

2. The objectives of holding the seminar are: (1) to present papers and technical guidelines on SPA establishment and tree improvement of teak together with a set of relevant activities of the project; (2) to discuss and find the ways and means for the conservation of genetic resources of teak in Myanmar; (3) to discuss on the development of teak improvement program.

3. The expected outputs from the seminar are (1) technical and management issues on the supply and demand of teak seeds for the plantation establishment will be discussed and resolved; (2) project activities regarding genetic conservation of teak and tree improvement will be successfully implemented with findings and recommendations made by the seminar and active participation and cooperation of the Forest Department and relevant stakeholders.

B. Opening of the Seminar

4. The seminar was attended by the Minister, Ministry of Forestry, Representative of Forest Tree Breeding Centre Japan, the forestry-related NGOs, private Teak growers, participants from Ministry of Forestry and observers from Forest Research Institute and University of Forestry, Yezin.

5. The seminar was opened by the Minister, Ministry of Forestry, H.E. Brig. General Thein Aung. In his keynote address delivered at the opening session, the minister extended a warm welcome to all the participants, resource persons, and representative from the various organizations including NGOs and expressed his appreciation for their cooperation and presence at this auspicious occasion. The full text of the Minister's speech is as given below:

Minister of Forestry, H.E. Brig. General Thein Aung delivering the opening speech

Inaugural Address by H.E. Brig General Thein Aung, Minister, Ministry of Forestry, at the opening Ceremony of the "Seminar on Seed Production Area Management & Tree Improvement" at Forest Research Institute, Yezin. (20 February, 2008)

Distinguished Guests,

Representative of Forest Tree Breeding Centre Japan,

Resource persons, Participants, Ladies and Gentleman

It is a great pleasure for me to have the privilege to inaugurate the "Seminar on Seed Production Area Management and Tree Improvement" which is jointly organized by Forest Department, Ministry of Forestry and International Tropical Timber Organization (ITTO). I am also very much delighted to have the opportunity to welcome the distinguished speaker Dr. Susumu Kurinobu, International Consultant and representative of Forest Tree Breeding Centre of Japan. I would also like to express my appreciation to all the distinguished guests and representative from the various organizations including NGOs, for their cooperation and presence at this auspicious occasion.

Ladies and Gentleman,

As you are all aware, about half of the land area of Myanmar is still covered with forests, of which 39% is composed of teak bearing mixed deciduous types. The forestry sector has contributed significantly to the country's economy and timber, particularly teak wood, has been a major source of export earnings for many years. After more than a century and a half of scientific management the natural forests of Myanmar are still in comparatively good extent and condition. However, due to demographic pressure and various kinds and extent of human intervention, forest degradation is being encountered. Much effort is focused on the management of natural forests to provide timber, especially premier teak wood, and strengthen their protective functions to ensure environmental stability and ecosystem integrity with supportive services for agriculture, community livelihood, recreation and ecotourism. Due to the greater demand in timber,plantations will have to gradually bear a greater share of the economic burdens in forestry. With the application of proven techniques and the involvement of private enterprises, large scale teak plantations, therefore, are now being established to complement the primary effort in natural forest management.

Apart from quantitative production, a long standing concern about plantation teak is quality. The need for improved planting materials of superior genetic quality has been a strong driving force behind the existence of the ITTO Project "*Ex-situ* and *In-situ* Conservation of Teak (*Tectona grandis* Linn. F) to support Sustainable Forest Management", through which this seminar is being organized. The development objective of the project is to promote the production of high quality teak through its genetic improvement in order to support sustainable forest management in Myanmar. In order to initiate an efficient tree improvement scheme, project activities started with the first, simple and very important step which is the establishment of SPAs. This is followed by the selection of plus trees and clone collection, establishment of Clonal Seed Orchards and Hedge Gardens, Provenance Trails, macro and micro vegetative propagation including tissue culture and strengthening of the supportive infrastructure. Apart from the technological advancement, opportunities for cooperation between the public and private sectors have been initiated by the project with the involvement of NGOs through sub-contracts and the participation of local communities in project activities.

Ladies and Gentlemen,

We are most fortunate to have with us today the distinguished speaker Dr. Susumu Kurinobu, the National Consultant and staff of the project and resource persons from NGOs, who will share their experience with us on the topics related to the aforementioned project activities, and set the stage for the deliberations. There are altogether 8 papers dealing with technology toward tree improvement, some with the involvement of the private sector and participation of the local communities.

I would sincerely and strongly encourage all the participants to take every opportunity of this seminar and try to gain as much as possible from the papers and the deliberations. I also hope that the participants will respond very favorably with follow-up actions in the application of the newly gained technologies to promote our tree improvement activities through the sustainable use of our teak genetic resources.

Distinguished guest, Participants, Ladies and Gentlemen

In Conclusion, I would like to bring my statement to a close by thanking all of you for your cooperation, and wishing you success in your deliberations.

Thank you.

C. Presentation of Papers

6. Following the opening ceremony, the seminar elected U San Lwin, Director General, Planning and Statistics Department, U Khin Maung Zaw, Rector, University of Forestry and U Kyaw Htun, Deputy Director General, Planning and Statistics Department as the Chairmen for the three sessions of the seminar.

U San Lwin ,
Director General
Planning and Statistics Dept.

U Khin Maung Zaw,
Rector
University of Forestry

U Kyaw Htun,
Dy. Director General
Planning and Statistics Dept.

7. Papers were presented by the resource persons from the ITTO (Teak) Project, PD 270/04 Rev.2 (F), international and national consultants, and sub-contractors (FREDA and ECODEV) of the project. The papers covered a wide range of topics relating to Teak seed production area management and tree improvement. Altogether 8 papers were presented at the Seminar. The floor was opened for discussion at the end of each session. Abstracts of papers presented at the Seminar are given below.

Time for Conserving Myanmar Teak

1. U Mehm Ko Ko Gyi, National Consultant
SPA Management and Silviculture
2. U Zaw Win Myint, Technical Staff
SPA Management Section
ITTO (TEAK) Project PD 270/04 Rev.2 (F)

U Zaw Win Myint, presenting paper on Time for Conservation Myanmar Teak

1. Introduction

Approximately, 53% of Myanmar's total area is covered with forests containing about 2,000 tree and small tree species. 39% of these forests are Mixed Deciduous Forests containing the most reputable teak of Myanmar.

2. Why Myanmar teak

Teak is durable, stable, has anti-termitic chemical and beautiful grain and colour. Myanmar has golden teak, brownish coloured teak, black strip teak, etc., indicating that there is variation in the species.

Moreover, its natural forests produce seasoned and large size teak which adds to the good reputation of teak from this country. Teak from Myanmar has held this good reputation for over one century and can therefore be considered to be well proven.

3. Teak plantation

The increase in population, illegal cutting and the need of the country, lead to the heavy exploitation of teak and other forest resources. In order to supplement the production of the natural forests, teak plantations are being established all over the country. The first teak plantation with taungya system was established in 1856 at Thonze forests, Thayawady District. There was also a report on teak plantation established in 1856 at Thingannyinaung, Thaninthayi District. Plantation establishment was systematically organized by the Forest Department starting from1896. The establishment of plantations from 1896 to 2007 of some important species is given in table 1.

Table 1. Plantations established by species (1896 – 2007)

Sr. No.	Species	Area Established (acres)	Area (%)
1.	Teak	948,784	42.2
2.	Pyinkado	152,150	6.8
3.	Padauk	43,042	1.9
4.	Pine	53,562	2.4
5.	Others	1,040,799	46.5
	Total	**2,238,337**	**100.0**

It can be seen that teak form 42.4% of the total planting. The emphasis on planting of teak in this country is undisputable.

4. Seed supply for teak plantation

The question now is that are we getting sufficient good seeds for the establishment of our teak plantation. In order to maintain the reputation of Myanmar teak, it is vital that seeds used for planting should come from good mother tree and of good genetic quality. The use of improved seed is most essential in the improvement of growth, stem quality and other characters of the plantation.

5. Efforts to get good quality seeds

The idea of planting with good quality seeds was conceived in the mind of foresters in Myanmar since the beginning of scientific forestry. The need for proper tree improvement program was greatly debated at the initiation of the East Pegu Yoma (EPP) Project in 1980's. Two clonal seed orchards and some seed production areas (SPA) were established at that time, but the tempo slows down with the completion of the EPP. In 1996, the Director of the Training and Research Development Division issued a detailed instruction on the establishment of SPA to the States and Divisions. Quotas for establishment of SPA were also allotted in the Annual Plan of Operation. However, proper conversion of plantations into SPAs is still needed.

Table 2. SPA established up till 2006

Species	Area of SPA established (acres)	(%)
Teak	7,922.77	77.41
Pyinkado	1,874.71	18.05
Pine	269.15	2.63
Mangrove spp.	120.00	1.17
Yamane	50.00	0.49
Padauk	25.00	0.25
Total	**10,234.63**	**100**

SPA establishment should be initiated as it is a quick and most inexpensive way of getting quality seed. CSO can follow as it requires expertise, time and money.

6. Conservation of good genetic materials

Selection of plus trees should be quickly and intensively carried out throughout the country as the chain saw is moving very fast. It is desirable to have at least 100 plus trees selected all over the country. The scions/explants from these plus trees should be planted in a well designed and properly recorded hedge gardens or gene banks. These scions/explants from the hedge garden can be used in the establishment of CSO or tissue culture. Township Forest Officer should be involved in these activities.

7. ITTO Teak Project

The "*Ex-situ* and *In-situ* Conservation of Teak (*Tectona grandis* Linn. F) to Support Sustainable Forest Management" project was formulated with the object of initiating a tree improvement program effectively in Myanmar. The project is focused on the simple establishment of SPAs with community development of those areas together with preparatory work for more sophisticated tree improvement program such as establishment of hedge gardens and strengthening of tissue culture laboratory.

So far, the project has established 3 SPAs with Users' Groups formed at Paukkaung, Nattalin and Pyinmana Townships. Three more SPAs with Users' Groups are being formed at Myan-aung, Kanbalu and Saw Townships.

Seed Production Area at Paukkaung

The tissue culture laboratory at the Central Forestry Development Training Centre is also being strengthened. Forty nine plus trees were identified and clones have been collected and used in the establishment of 2 experimental CSOs at Tone Ye reserve, Pyay Township and Ngalaik reserve, Pyinmana Township and a Hedge Garden at Yezin. Twenty two plus trees were recently selected thus, making a total of 71. At the same time, provenance trials were also established at Ngalaik reserve, Pyinmana Township and Yenwe reserve, Kyauktaga Township.

8. Seed Production Area establishment

8.1 Purpose – SPA is established primarily to increase quality seed production and facilitate seed collection. It is very important to identify a good plantation with a minimum number of deformed trees, i.e. forked, crooked, twisted, fluted, etc. trees for conversion to SPA.

Forked Tree *Twisted Tree* *Tree with Big Branch* *Crooked Tree*

Genetic improvement is attempted through selection of only phenotypically superior stands and heavy selective thinning. Trial plantings in Thailand showed a superiority in growth of 5% – 12% compared to teak in natural teak forests and at the same time, trees maintained a high level of quality.

8.2 Selection of stands – In the establishment of SPA, the following points should be considered:

8.2.1 Region – The SPA should be selected as close as possible to regions designated for future large scale plantation establishment.

8.2.2 Site quality – Generally, only stands on sites that are above average (i.e. SQ III and above) are desirable.

8.2.3 Quality of stand – Usually, selected stands must be of superior phenotype. The number of deformed trees should be at a minimum. Excessive number of deformed/inferior trees in a stand may require very heavy thinning, thus, causing the stand to be too open. It is more preferable if the stand has been thinned regularly. However, stands demonstrating specific qualities may be included even though it may not be phenotypically superior.

8.2.4 Age of stand – Selected stands should be approximately 15 – 35 years old. If the stands are younger than 15 years of age, it may be difficult to make a reliable assessment of their long term growth potential and timber quality and not all trees may have produced seed yet. Stands older than 35 years of age may not react adequately to the prescribed heavy thinning.

8.2.5 Area – The minimum area of SPA is approximately 12 acres. There is no upper limit to the size of seed stands.

8.2.6 Accessability – Easy, all weather accessability to the selected stand is preferable but, not vital.

8.2.7 Treatment of selected stand – The selected stand will normally be treated uniformly throughout the area, and division into plots is unnecessary. Only if upper height differs more than about 16 ft. should division into plots be considered.

8.2.7.1 Maps – A position map should be prepared at a scale of 1:50,000 or 1:250,000. A detailed map of a convenient scale should likewise be prepared, showing natural and artificial boundaries of the selected stand.

8.2.7.2 Clearing – In order to facilitate seed collection, undergrowth should be cut and burnt and the ground must be bare during the dry season. However, in order to prevent erosion, undergrowth should be encouraged to grow during the raining season. Bare soil can cause heavy sheet and rail erosion.

8.2.7.3 Low thinning – Thinning for conversion of plantation to SPA is very intensive compared to normal thinning. Steps involved are:

(1) remove all dead and moribund trees,

(2) remove inferior and suppressed trees,

(3) mark the phenotypical inferior trees such as forked trees, crooked trees, twisted trees, fluted trees, buttressed trees, trees with big branch diameter, etc. for felling,

(4) Comparatively late flowering type of trees should be retained.

8.2.7.4 Elite thinning – In this method, elite trees are first selected for retention. The steps involved are:

(1) remove all dead and moribund trees,

(2) remove inferior and suppressed trees,

(3) mark the phenotypically best trees at desired spacing,

(4) Favour the development of these trees by opening up the canopy around them,

(5) favour the late flowering type of trees for retention.

8.2.8 Demarcation – The seed stand should be demarcated with strong posts. Distance between the posts may be 90 ft. Border trees should be painted with yellow band at breast height.

8.2.9 Registration and recording – The standard SPA sheet should be completed.

8.2.10 Maintenance – The stand should be kept constantly short-weeded during the dry season. However, undergrowth should be encouraged during the raining season. Thinning should be repeated whenever necessary.

8.2.11 Fertilization – Since teak prefers friable soil, it is preferable to fertilize it with bio-fertilizer especially where the soil is stiff or poor. It will be beneficial by plowing in between the lines before fertilizer is applied.

9. Conclusion

(i) In order to maintain the reputation of Myanmar teak, it is important that the quality of timber produced is also maintained.

(ii) Forest Department has been raising extensive areas of teak plantation, it must be assured that the quality of timber produced from the plantations be as good as those produced from the natural forests.

(iii) Factors affecting the growth and quality of plantations are site quality, seed and silvicultural management. It is therefore important to select a suitable site before proceeding with the establishment activities.

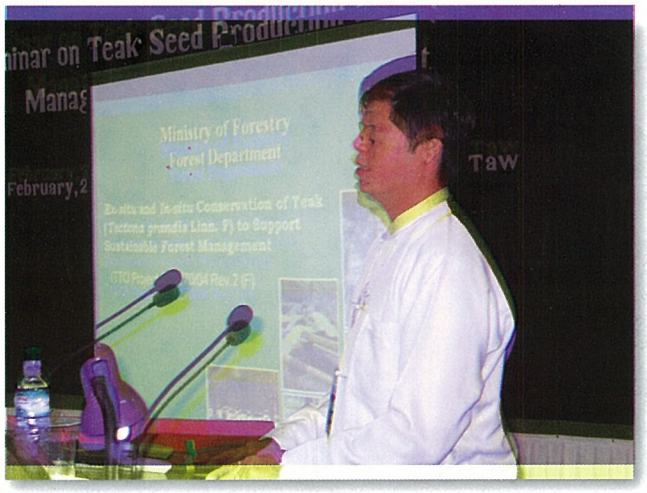
(iv) As the growth and quality of timber is strongly controlled by the genetic make-up of the tree, plus trees should be intensively selected, scions collected, conserved and utilized in the establishment of plantations before it is too late.

(v) In the mean time, sufficient areas of SPAs should be established so that quality seeds could be used in the establishment of teak plantations.

(vi) In order to support the selection of good site quality and the use of quality seed, it is also important to apply timely and appropriate silvicultural treatment.

Plus Tree Selection for Tree Improvement of Teak

Dr. Nyi Nyi Kyaw
National Project Manager
ITTO (TEAK) Project PD 270/04 Rev.2 (F)



Dr. Nyi Nyi Kyaw presenting paper on Plus Tree Selection for Tree Improvement of Teak

1. Introduction

Teak, because of its high wood quality and its great adaptability to wide range of climatic and edaphic conditions is a major plantation species in Myanmar. Thus, sufficient quality seed is needed to fulfill the requirement of the plantation program of the country. Tree improvement program was initiated during early 1980s when the East Bago Yoma plantation project was implemented. Seed Orchard and Seed Production Areas were also established in the Bago Yoma region in Myanmar at that time. To improve the productivity of teak plantation, large quantities of improved quality seed of well adapted provenances are required in executing the plantation program. Better growth quality and adaptability can be achieved through careful selection of the best seed sources and trees when raising seedlings for planting. Genetically broad populations should therefore be maintained as a basis for present and future domestication.

Tree improvement involves three phases, i.e. conservation, selection & breeding and propagation. As one moves from one phase to another, decreasing amount of variations are being managed. Selection and breeding are the central activities of a tree improvement program.

The main objective of tree improvement program is to obtain a significant amount of genetic gain at a reasonable cost while maintaining sufficient genetic variability in the breeding population to ensure future gain. It can be broadly divided into short- and long-term objectives.

Short-term objectives include increased volume production per unit area of plantation through the improvement of growth rate. Improved stem quality of trees, improved wood qualities and production of genetically improved seed.

Long-term objectives include establishment of long-term breeding populations for greater cumulative genetic gains of improved characters, manipulation and maintenance of genetic variabilities of the breeding populations through as many generations as possible, securing the supply of improved seed and/or planting materials of greater cumulative gain for planting programs.

2. Why genetic resource of teak has to be conserved

The key elements of a tree improvement program are gene resource population, breeding population, propagation population and wood production population. Under the gene resource population, a natural population is the most diverse gene resource which must be kept and their genetic diversity maintained as long as possible. The natural populations throughout the teak bearing region are in the endangered stage. The population size is decreasing due to several reasons.

The selection system that is practiced favored a single species, (i.e. teak) in multi-species complex ecosystem. A cutting system that removes all teak trees above the prescribed girth limit may result in genetic erosion. To secure valuable genetic diversity and functions, in-situ gene conservation is urgently needed.

Selected Plus Tree

3. Plus trees selection

Plus tree selection is a basic tool used in tree improvement program. It is the selection of phenotypically superior trees that would give better quality of regeneration and materials for breeding. Plus tree is an outstanding individual, appeared distinctly superior to the average which occurs in natural or in evenaged stands, combining as many desirable traits as possible. Once a right base population has been identified, then the plus tree selection begins. It has to be a continuous process.

4. Phenotypieal assessment of teak trees

Phenotypie is defined as the appearance of an individual for one or more traits, which is the product of the interaction of individual's genes and its environment. Genotype is characterized by a certain genetic constituent.

Phynotype = Genotype x Environment

Choice of traits – Choice of traits is primarily based on the interest of a utilization point of view. The characters observed and evaluated from individual selected trees are – diameter at breast height, total height, bole height, crown diameter, bark thickness, crown position and form, stem form, axis persistence, branch size, mode of branching, butteressing, epicormics, protuberant buds. The method involves scoring a candidate tree and 4 or 5 surrounding trees nearest to the selected one. It is accepted as plus tree if its scores are **"not minus more than one characteristic"**

1. **Diameter at breast height (dbh)** - Diameter at breast height is measured at 1.3 m above ground by diameter tape.
2. **Total height** - Total height of trees is measured with Suunto dendro-clinnometer.
3. **Bole height** - It is measured from the base of the tree to the lowest whorl of living branches.
4. **Crown diameter** - The area of a crown can be estimated to be equivalent to the area of a circle defined by an average crown diameter which is commonly used in tree mensuration. The crown diameter is calculated by the average of the maximum and minimum diameter of the crown.
5. **Bark thickness** - The bark thickness is measured at breast height of the tree by bark meter.
6. **Crown position and form** - Crown position and crown form are used to predict the diameter increment of individual tree growth in moist tropical forest. Crown position and crown form classification are as given below in figure 1.

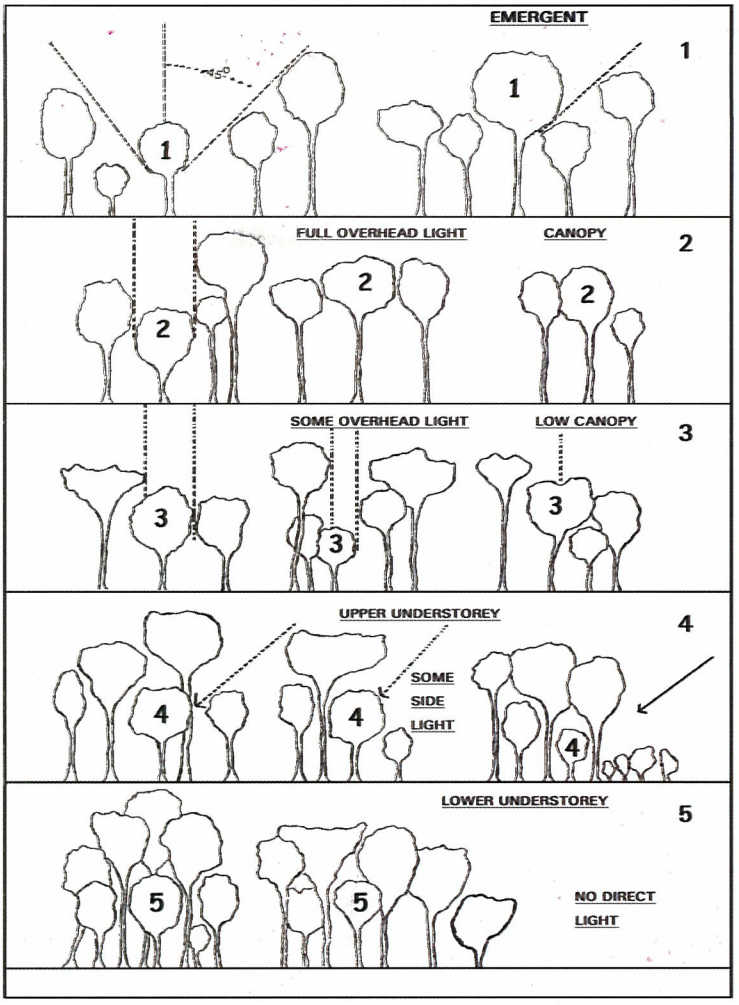


Fig.1 Crown position and crown form classification and scoring system.

7. **Stem form** - For the judgment of stem form or stem straightness, the severity of bends is evaluated. A bend is defined as the distance between two tops of the curve of a stem as indicated in figure 2a. It is considered serious if the side of the stem curves outside a straight line drawn through the length of a bend.

Class	Stem form (straightness)
1.	Straight tree
2.	Slightly wavering, few small bends
3.	Wavering tree, many small bends
4.	Crooked tree with 1-2 severe bends
5.	Crooked tree with 3 or more severe bends

8. **Axis persistence** - A branch is considered a stem or axis if it exceeded the others a quarter in thickness. The 9 classes of axis persistence are illustrated in figure 2b.

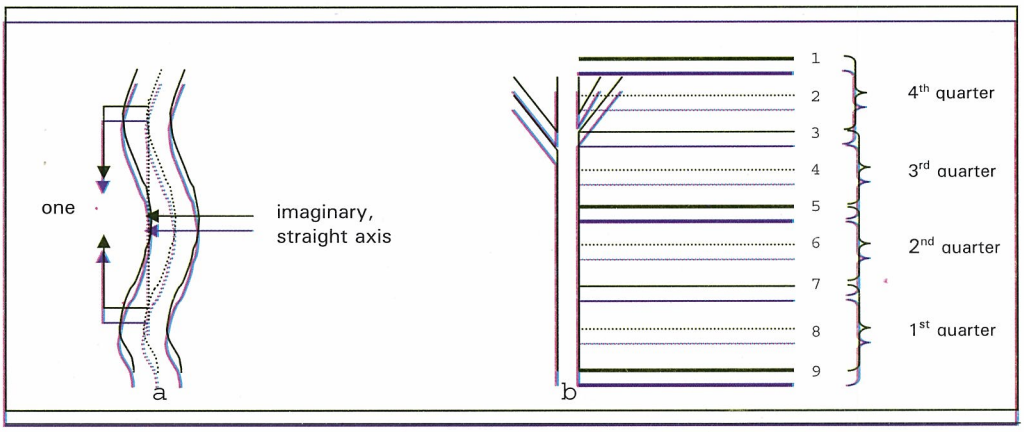


Fig. 2: a: Illustration of a bend, b: Classes for assessment of axis persistence

Class	Axis persistence
1.	Complete persistence
2.	Axis branch out in middle of 4th quarter
3.	Axis branch out between 3rd and 4th quarter
4.	Axis branch out in middle 3rd quarter
5.	Axis branch out between 2nd and 3rd quarter
6.	Axis branch out in middle of 2nd quarter
7.	Axis branch out between 1st and 2nd quarter
8.	Axis branch out in middle of 1st quarter
9.	Double or multiple stems from ground level

9. **Branch size** - It is a relative measure of branch diameter in proportion to stem diameter at the foot of the branch. The branch size of teak trees is classified into 5 classes as follows:

Class	Branch size	(in stem diameter)
1.	Very light	less than ¼ of stem diameter
2.	Light	around ¼ of stem diameter
3.	Medium	between ½ and ¼ of stem diameter
4.	Heavy	around ½ of stem diameter
5.	Very heavy	from ½ to ¾ of stem diameter

10. **Mode of branching** - The mode of branching are recorded and scored in 5 classes. They are illustrated in figure 3.

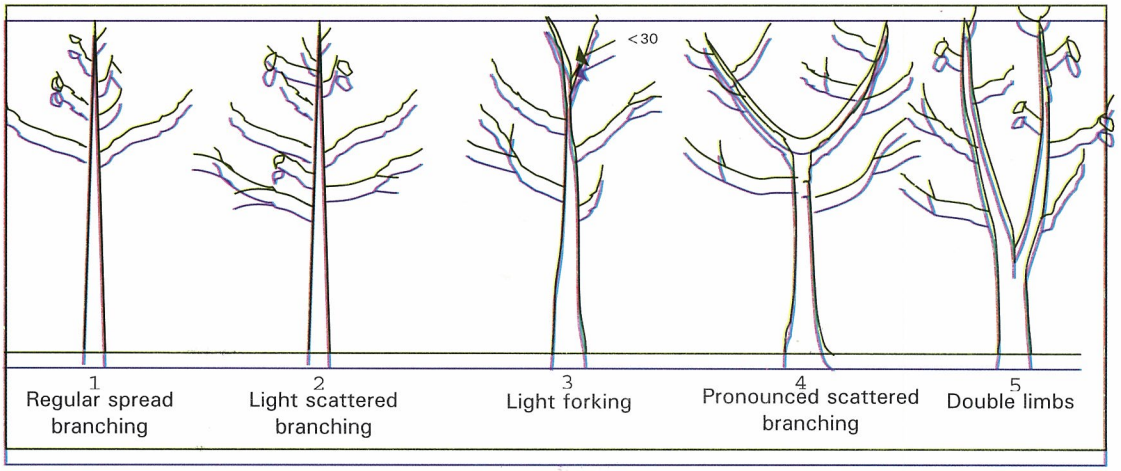


Fig. 3: Scoring of mode of branching

11. **Buttressing** - It is a feature of non circular cross-section of the stem that typically develops by large planklike upgrowth of the upper side of the roots, providing support for the tree. The severity of buttressing is evaluated at 1 meter height of the tree. Scoring of buttressing is illustrated in figure 4.

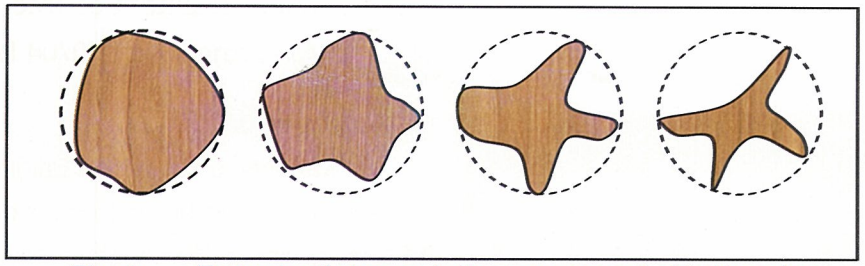


Fig. 4: Example of classes in the assessment of buttressing

Class	Severity of buttressing (stem cross sectional area)
1.	near 100% of area of ideal stem
2.	about ¾ of area of ideal stem
3.	about ½ of area of ideal stem
4.	about 1/3 of area of ideal stem

12. **Epicormics** - Epicormics are shoots arising spontaneously from dormant buds on the stem. It is a common feature in teak and is a reaction of the tree to environmental stress or to sudden change in conditions as a result of exposure to light.

Class	Presence of epicormics
1.	Stem free of epicormics
2.	Around 25% of stem with epicormics
3.	Around 50% of stem with epicormics
4.	Around 75% of stem with epicormics

13. **Protuberant buds** - It is described as bulging scars after natural pruning of branches or epicormics.

Class	Presence of protuberant buds
1.	Stem free of protuberant buds
2.	Around 25% of stem with protuberant buds
3.	Around 50% of stem with protuberant buds
4.	Around 75% of stem with protuberant buds

5. Selected plus trees for *ex-situ* and *in-situ* conservation

At present, there are 71 tress selected in different localities of planted and natural stands and which qualified as plus trees. They are included in the breeding population and conserved in hedge gardens and clonal seed orchards. Explants collected from plus trees are also used in micro propagation. Since the plus trees have been selected based on their phenotype, it is essential that progeny test should be carried out for the plus trees so as to know their breeding value and to identify good genotypes.

6. Conclusion remarks

This paper is focused only on the phenotypical assessment of teak trees applied for selection of teak plus trees. It can be stated that the rating and evaluation system of phenotypical assessment in plus tree selection for teak is much simpler although it may not be applied to other tree species. The system adopted does not depend on points scored by individual selected tree but is determined by the competitive performance of the tree. As a rule of thumb, a tree can be taken or selected as a plus tree as long as it looks much better than the five nearest surrounding trees for comparison.

Teak Tree Improvement in Southeast Asia

Dr. Susumu Kurinobu
International Consultant of Tree Improvement
ITTO (TEAK) Project PD 270/04 Rev.2 (F)

Dr. Susumu Kurinobu presenting paper on Teak Tree Improvement in Southeast Asia

1. Introduction

Majority of teak plantations are growing in Tropical Asia. India has more than one million hectare, Indonesia: one million hectare, Myanmar: 0.4 million hectare and Thailand: 0.2 million hectares.

2. Tree improvement in Thailand

Tree improvement was initiated in 1965 with the aid from DANIDA. 450 clones were preserved in clone banks. Clonal seed orchards were established with bud-grafting in the late 1960's. However, seed supply from 2,000 ha of CSO at 7 locations could not meet the operational demand. This prompted them to start tissue culture research. However, FIO is hesitant to use the tissue cultured teak for their plantation establishment due to its high price.

3. Tree improvement in Indonesia

Teak tree improvement started in the early 1980 with plus tree selection. Four thousand ha of SPA and 1,300 ha of CSO were established. Two tons of seed out of 4 tons of annual demand is supplied by CSO and the remaining by SPA. One hundred and fifty plus tree clones were tested at 4 sites since 1998. Twelve best clones were selected to establish hedge orchards based on their performance as well as rooting ability. Hedge orchards were established as facility of the nursery. Stocks are planted at 1 m spacing to produce 120 scions annually. Half a million rooted cuttings were produced in 2006, one million in 2007. Fifty million are expected to supply for reforestation in 2008. Clonal plantation of teak has become popular in Indonesia and it can be expected that they may be producing quality teak within a few decades to come.

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

Skelton of Teak tree improvement in Myanmar by ITTO project

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Dr. Susumu Kurinobu presenting paper on Skelton of teak tree improvement in Myanmar by ITTO project

1. Introduction

Myanmar teak is known as the best in quality in the world. Teak wood production can be further increased by tree improvement program.

Therefore appropriate tree improvement strategy should be determined, i.e. to adopt either clonal seed orchard or seedling seed orchard. The difference between the two methods is as shown in the table below;

Type	Plus tree	Testing	Selection	Mating	Seed Production
SSO	Collect seed	SSO	SSO	SSO	SSO
CSO	Collect scion	CSO ↑ Grafting	Rogued CSO ↑ Progeny Test	CSO Control pollination	CSO

The merits and demerits between SSO and CSO is further illustrated in the table below;

Type	Genetic gain	Inbreeding	Seed production	Technical difficulty	Implementation
SSO	Comparatively Smaller	Slower Increase but hard to control	Slower but Species Dependent	Grafting not needed	Easy and Consistent but site dependent
CSO	Greater	Rapid increase but can control	Earlier	Cloning is essential (grafting)	Repeatable across sites

The recurrent selection with clonal seed orchard would be the most realistic option for teak tree improvement as reliable grafting technique is already available in Myanmar. The major drawback of teak clonal seed orchard is the poor seed productivity and low germination rates. However, this problem might be solved by identifying optimum zones for seed production. CSO can be established under favorable environment for flowering and fruiting which can be far away from planting areas or plus trees. Possible candidate areas might be Magway and neighboring dry areas where seed production would be generally better because of the dry weather.

2. Breeding Zone

Breeding zone is an area where a single breeding population is developed by selection and mating. Since teak plantation areas in Myanmar are variable in climate as well as in product value at the market, appropriate division of breeding zone should be examined based on the differences in climate, product type and plantation management strategy.

It is empirically known that high-quality teak are supplied from the drier area in Myanmar and the quality gradually decreases in more humid area in spite of its good growth. A possible plantation management strategy may be to plant in the drier area where teak of good form and high density for traditional use is required and to plant in more humid area where the productivity of teak is to meet the demand for industrial use. The target for tree improvement will be determined by the production purpose of teak plantation management.

Areas of SPA and CSO to meet the estimated seed demand for plantation establishment are as estimated in the table below;

Division	Plantation (ha)	Thai standard		Myanmar's case	
		SPA (ha)	CSO (ha)	SPA (ha)	CSO (ha)
Sagaing	28,851	1,466	170	122	13
Bago	120,731	6,134	710	511	55
Magway	41,522	2,110	244	176	19
Mandalay	45,127	2,239	265	191	21
Total	**236,230**	**12,002**	**1,389**	**1,000**	**108**

3. Number of plus tree per breeding zone

Around 60 plus trees per zone will be selected as base breeding population in each forestry division. This is because 50 is the minimum population size to ensure continuous gain. More than 50 plus tree clones will be conserved in hedge garden. CSO will be established with 50 clones. Progeny test will be carried out with more than 40 families (clones). CSO will be improved to retain 25 clones that are confirmed as superior in progeny test.

In order to conduct an operational tree improvement program, more positive involvement of the Forest Department is essential together with the research group at FRI. Forest Department should organize a unit at the department of forestry to coordinate tree improvement activities. Staff at regional level should be assigned to support plus tree selection, trial and orchard establishment, management and measurement. FRI on the other hand should have research division specifically to conduct research on tree improvement. University of Forestry can join in by establishing laboratory to conduct advanced research on tree breeding and private sector can also support this activity by forming tree improvement association.

Community Participation In Management of Teak Seed Production Area

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Environmentally Sustainable Economic Development (ECODEV)

U Win Myo Thu presenting paper on Community Participation In Management of Teak SPA

1. Introduction

"*Ex-situ* and *In-situ* Conservation of Teak to Support Sustainable Forest Management" is one of the projects that the Forest Department collaborates with the International Tropical Timber Organization. The main idea of the project is to build the capacity of the community on sustainable management of teak plantation where plantations converted to Seed Production Areas (SPA) are transferred to the community as SPA development program.

The project has two portions namely, social mobilization program and enhancing technical and management skills in the establishment of SPA. Environmentally Sustainable Economic Development (EcoDev) group is sub-contracted for sensitization of the community, base line survey & PRA, formation of Self Help Group, mobilization of micro-saving, potential IG products development, selecting and providing training for micro enterprise development, delivery of seed fund to the community, monitoring of monthly meeting and financial management.

2. Project sites

Three project sites were selected for implementation of the project. They are:

(1) Se Oo village in Pyinmana Township,
(2) Nyaung Wun village in Paukkaung Township, and
(3) San Gyi village in Nattalin Township.

3. Sensitization

In order to enhance the understanding of the community on the project, advocacy meetings were conducted in each project village. The background of the project, short term and long term objectives of the project, activities to be implemented, expected outputs and outcomes, the role of the community and the Forest Department were advocated to the community.

Table 1. Advocacy meeting held in project sites

Sr. No.	Village	Date of Meeting	Venue	Attendants
1.	Se Oo	5th January 07	Video Parlor Se Oo village	56 people
2.	Nyaung Wun	13th January 07	Primary School Gon Min Gon village	147 people
3.	San Gyi	12th January 07	Primary School San Gyi village	54 people

Project Orientation meeting

4. Baseline data collection

At the beginning of the project, social mobilization team of EcoDev started building trust with the community by explaining the project activities to key informants. PRA tools and household survey were employed for collecting socio-economic, demographic and related livelihood activities. Social Ranking of each household was assessed through food security condition, forest dependency status and participation level of households at their social activities. Existing village administrative and social organization was explored by using Venn diagram for understanding coordination and networking among groups.

5. Formation of self help group

During the advocacy meetings, group formation for SPA development was introduced, membership criteria were discussed and members' obligation, roles and responsibilities were clarified. Membership application forms were distributed at the end of the advocacy meeting.

Table 2. Membership applied and screened

Sr. No.	Village	Membership Applied	Approved
1	Se Oo	19	18
2	Nyaung Wun	20	20
3	San Gyi	18	15

Applicants were asked to attend the first member meeting where draft group norms, objectives, necessary ground rules, regulation and roles were facilitated, discussed and decided among the attendants. Among the applicants, 1 out of 19 in Se Oo and 3 out of 18 in San Gyi villages withdrew their application due to unaffordable condition regarding regular saving, labor contribution to SPA development, rules and regulations, fine and punishment for default, that was decided at the meeting.

6. Mobilization of saving

Before the saving mobilization, villagers were fully aware on why they should save. It is not just in monetary value but, is building capacity of members' habitual practices on time keeping, doing specific work constantly, alarm members' to reduce expenses, recognize the need to earn more so as to uplift the living standard of their family. At the first meeting, they decided to contribute Ks. 200 as membership fee and save Ks. 500 per member per week.

Data for 11th, 15th and 25th March 07 for San Gyi, Nyaung Wun and Se Oo respectively are as given in the table below:

Table 3. Saving status

(Kyats)

Month	Se Oo	San Gyi	Nyaung Wun
January 07	36,000	22,500	30,000
February 07	36,000	30,000	40,000
March 07	36,000	15,000	20,000

Seed fund handover ceremony at Nyaung Wun Village

After completion of the 9th regular weekly saving, EcoDev provided seed fund equivalent to 1000 FEC (1,260,000 Kyats) per village to all the three villages. The provided seed fund were kept at Myanmar Economic bank by opening a joint saving account with the name of the local Township Forest Officer and two committee members.

7. Screening of potential income generating activities (IGA)

Potential IG activities assessment has been carried out during January and February 2007 in all three project villages. In that assessment, open discussion employed to identify potential products based on group member's opinion and views were ranked based on 20 indicators. The selected products were analyzed by cash flow analysis.

Table 6. Screened IG activities by site

Village	Screened products	Return on investment	Remark
Se Oo	Bamboo furniture	21.7%	(24.1.07)
Se Oo	Fruit preservation	N.A	(23.1.07)
Se Oo	Plum seedling distribution	16.8%	(22.1.07)
San Gyi	Rice trading	N.A	(3.2.07)
San Gyi	Bamboo roofing sheet	20%	(3.2.07)
Nyaung Wun	Bamboo roofing sheet	20%	(7.2.07)
Nyaung Wun	Sesame trading	9.1%	(7.2.07)
Nyaung Wun	Cotton trading	3.2%	(7.2.07)

Survey & Assessment conducted for Potential Income Activities

8. Monitoring of saving and financial management

Regular meetings were held on monthly basis so as to smooth the transaction of information flows among group members and build transparency and accountability for all financial transaction. In the earlier meetings, members discussed mainly on identification of loan amount, loan requisition system, repayment period, interest rate and prioritization of purposes of loan taken. The meeting agenda was emphasized more on SPA development issues when the SPAs were started.

Members who wanted to take loan can propose a loan, mentioning the amount, purpose, repayment plan with 5% monthly interest rate and mentioning at a meeting. The loan repayment period set by members during mobilization period is one month in all three villages.

Basic book keeping and simplified accounting system was installed in all three groups. Individual saving book was provided to individual group members in order to check their weekly savings and transactions. Cash book, loan record book and meeting minutes were kept at committee level. Table 7 shows the financial status of San Gyi, Nyaung Wun and Se Oo on 11th, 15th and 25th March 2007 respectively.

Table 7. Financial status of three project villages **(Kyats)**

Village	Member fees	Total saving	Other earning	Gross dis-bursed loan	Gross repay-ment received	Cash in hand	Group money	Seed money	Total fund
San Gyi	-	67,500	500	84,000	88,200	6,960	79,160	1260,000	1,339,160
Nyaung Wun	4,000	94,000	-	130,000	136,500	2,000	106,500	1260,000	1,366,500
Se Oo	3,600	111,600	2,300	170,000	178,500	N.A	126,000	1260,000	1,386,000

9. Loan proposal planning and priotization

Feasible income generation products were identified after the survey and assessment made for IG activities during the last and first week of January and February 2007. Enterprise development training was conducted in order to ensure effective use of seed fund for member's income generating activities. During the training, each member livelihood activities were carefully analyzed and they were asked to provide loan proposal plan when the seed fund was secured. Main income generating activities proposed were inputs requested for agriculture activities, expansion of livestock, additional investment request for small trade and commodities purchase for shop.

Loan amount requested by each member was screened based on their existing socio-economic status and current experiences in income generating activities. Proposed repayment period was set based

on the purpose of nature of the loan. Group income generating activities were also identified and screened based on suitability of local condition, profitability, access to market and technical feasibility. San Gyi group proposed rice trading so that villagers will get access to food with reasonable price during the raining season. Nyaung Wun group proposed long staple cotton trading as it is the most profitable, while Se Oo group proposed pig raising and fattening as they have abundant feeding materials such as algae and snails which can be collected in the dam free of charge.

10. Issue regarding social mobilization

Some group members are temporarily employed in forest operations and could not participate fully in monthly meeting, regular saving and contribution to seed production area development program. Although the group would like to encourage them to abide by the group's rules and regulation, they have difficulties as the absentees also have close relationship with the Forest Department.

Group members are reluctant to contribute their time and energy for the seed production area development program unless necessary field operations with work plan, budgeting details and close technical supervision are enhanced in advance before the field work started.

Members of the groups are worried whether the local Forest Department would be able to give the time needed for checking their loan proposal, giving approval and disbursement process as, the Forest Department staffs are always busy with their assigned duty and responsibility.

Group members noticed and appreciate the habitual practice change by saving activities and also observed some improvement in capacity on communication and presentation skills. However, they still need to learn and build capacity on enterprises development concept, risks assessment and marketing of local products that are assisting in promotion of their livelihoods in sustainable ways.

11. Lesson learnt

Group members should be from the same village otherwise, regular savings, meeting, participation in seed production area development will be difficult to coordinate among the members.

Members who are elite and affiliated to Local Forest Department staff should not be included in the group for better social cohesion and contribution.

Local Forest Department staffs still have limited motivation, interest and gaps on participatory forest management practices.

Social mobilization and field level operations for seed production area should be facilitated and initiated by the same person in order to achieve better planning, coordination and smooth implementation for the whole process and activities.

Repayment period should not be set on monthly basis for agriculture and livestock loan unless the member's livelihood depends on regular earning activities such as vendor and shop keeper.

12. Recommendations

1. Sensitization and consensus building among stakeholders is very much crucial in order to achieve project goals. Community and local Forest Department staffs play vital role. Their understanding on the project is a key for success of the project goals and objectives.

2. Due to the very short project period, monitoring and facilitation should be regularly provided by local staffs to the project villages especially at their early age with limited experience.

3. The more the dependent on the forest, the more likely to have better participation and interest on the project than lesser dependent one in either at household or village level.

Seed Production Area (SPA) Establishment in Myanmar

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U Soe Myint presenting paper on Seed Production Area Establishment in Myanmar

1. Introduction

Myanmar's forestry practice had been and has been teak oriented forest management and the world's teak market also is dominated by Myanmar's teak. In girdling operation, girdling officer has the right to leave good seed bearers in area where natural regeneration of teak is inadequate or absent irrespectively of whether the tree is of exploitable size or not. In the later years, this practice was no longer applied and seeds were collected haphazardly. Thus, the reputation of the future Myanmar teak is questionable.

2. Rationale of the project

In this "*Ex-situ* and *In-Situ* Conservation of Teak (*Tectona grandis* Linn. F) to Support Sustainable Forest Management" project, seed stands will produce seeds of improved quality by removing inferior ones in the stand. Removal of such inferior trees will produce viable good quality seeds to serve economic purposes in forest plantation programs for quality timber.

Creation of such concentrated seed production areas will make it convenient for seed harvesting, processing and storage. Moreover, it would ensure stable seed supply with a clearly identifiable seed lots and prevent uncontrolled seed collection and trading.

3. Objectives, Responsibilities and Expected Outputs

FREDA had a contract with the project to establish model seed production areas (SPA) and provide assistance for the sustainable management of established SPAs and to strengthen the capacity of the local forestry staff and the local community groups in the maintenance of SPAs and the production of quality seeds.

Thus, FREDA is responsible in the selection of good trees for retention and thinning out of inferior deformed and forked trees from the selected plantations that are to be converted into SPAs. The felled trees and the debris have to be removed and the forest floor clear weeded. Moreover, FREDA is also responsible for fencing the SPAs, construction of briefing halls & guard posts, erection of boundary pillars & signboards and regular reporting.

FREDA was contracted to implement these activities in 3 project sites. The following table shows the areas where the activities were implemented:

No.	Location	Year establi-shed	Area selected	No. of trees/ha	Average Dominant height(m)	Average Diameter (cm)	Av. Basal Area/ha (m^2/ha)	Site Index	Location
1	Pyinmana Tsp. C 59, Taung Nyo RF.	1966 (40 years)	10.17 ha (25 ac)	183	22.9	29.5	7.54	35	N19051.9' E95057.3'
2	Paukkaung Tsp. C. 49, S. Nawin RF.	1973 (33 years)	10.17 ha (25 ac)	143	24.22	33.7	12.76	35	N18054.77' E95044.61'
3	Nattalin Tsp. C.99, Bawbin RF.	1990 (16 years)	10.12 ha (25 ac)	311	12.9	13.98	5.36	40	N18030.1' E95044.6'

Thinning – Thinning or conversion of selected plantations into SPA was carried out in the above 3 locations. E-grade thinning was applied at the plantations at Taungnyo RF and Paukkaung RF as they both can be considered as old plantations. D-grade was applied to the plantation at Bawbin RF as it is only 16 years old and is quite young to carry out E-grade thinning. If necessary, E-grade thinning can be applied to this plantation after 3 or 5 years. After thinning was conducted, the status of the stands was as given in the table below:

Sr. No.	Name of Reserve	Compt. No.	Area in acres	Trees left	Trees felled	Total
1	Taungnyo	59	25	613	361	974
2	South Nawin	49	25	658	344	1,002
3	Bawbin	99	25	1,740	1,986	3,726

Logging – Logging was done by the rangers of the respective township. Butt ends, branches and debris were carried out by the users' group and paid by FREDA.

Climber cutting and clearing – It is the policy of the project that all field activities should be carried out by the users' group so as to generate income for them. Thus, climber cutting and clearing were all done by the users' group of the SPA in April before thinning. Fencing, erection of boundary pillars & sign board was done only after the logs were removed.

Construction of briefing halls – Briefing halls were constructed by the Forest Rangers of the respective townships and closely supervised by the Township Forest Officers. Labourers used were the users' group.

4. Recommendations

(1) The project should be extended for at least 5 years with adequate funding and staffing.

(2) SPA areas should be 2500 acres or more and natural teak stand with adequate stocking should also be included.

(3) Forest Department should have a seed testing team or committee for grading of teak seed and keeping up the quality of seed. The committee should also issue seed certificate.

(4) Export of teak seed should be strictly controlled.

Shoot Cutting Techniques for *Ex-situ* Conservation of Teak

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Daw Thwe Thwe Win presenting paper on Shoot Cutting Techniques for Ex-situ Conservation of Teak

1. Introduction

Teak, because of its unique wood properties is widely planted in its natural range in Southeast Asia as well as in outside its natural range. Therefore it has become necessary to develop quick and economical methods for producing quality planting material. Establishment of teak Clonal Seed Orchard (CSO) will take at least 10 years for it to produce seed. An alternative is to use vegetative mass propagation method by means of shoot cutting. Vegetative propagation method not only enables replication of the genotype but also ensures early seeding. The collected branches from plus trees, through grafting or branch cutting are made to produce epicormic shoots for juvenile shoot cutting. Seedlings of plus trees are used to produce genetically qualified plants through juvenile shoot cutting.

2. Objective

To conserve the genetically superior teak by means of *ex-situ* conservation and to overcome the insufficiency of sound seeds for the establishment of commercial teak plantation through shoot cutting.

3. Teak plantation

Teak has been used for decades for planting either as indigenous or exotic species. The cost of improving teak however, is high due to poor fruit set capacity and low seed quality. It was estimated that at least 1 ha. of CSO is required for the establishment of 16 ha. teak plantation. Forest managers are therefore forced to acquire planting materials from whatever source that is available.Traditionally, the rotation age for teak is high, i.e. 60 – 100 years. By using improved seeds, it is expected that the rotation could be reduce to 40-50 years.

4. Vegetative propagation

Many tree species can be propagated from vegetative shoots thus, reproducing their exact genotype. Vegetative propagation not only enables the replication of genotypes, but also ensures early seeding. Rooting of cutting method however, should be tried extensively for propagation of tree species in order to overcome potential graft-incompatibility in the ramets.

5. Gains from selecting phenotypically superior plus trees

In selecting plus trees, mature trees will normally be selected as, they are close to rotation age

and exhibit the desired mature trait. The selection is based on the visual performance of the trees which is the product of the reaction between the environment and their genetic make up. Generally, gains achieved from such selection are only a few percentage points in the increased growth rate but, the gain in stem form may be substantially higher. Sometimes higher values can be achieved when considering the important stem form.

The second selection cycle based on progeny involves selection of the best proportion of the phenotypic plus trees and using them for mass propagation. This is based on the average performance of offspring from plus trees. The plus trees will be pollinated by other trees in the stand thus, half the genes in the seed will be of average value. The gain from CSO will be double that of the seedling seed orchard, because here all the genes involved will be from selected trees. However, the gain from CSO will be moderate without genetic thinning.

6. Productivity of Seed Orchard

It was estimated that one ha of CSO is required for planting 16 ha of teak plantation. In other word, it is assumed that one ha of seed orchard produces 180 kg of seeds from the age of 10 years to 30 years. An alternative to CSO is the vegetative propagation of genetically superior teak by means of shoot cuttings. The genetic superiority of this improved material will depend on the efficiency of the plus tree selection.

7. Factors influencing rooting

Rooting of cuttings could be affected by many factors such as plant species, age of plant materials, stock plant management and rooting medium. Moreover, environmental and physical factors such as temperature, relative humidity, light, seasonal changes, hormonal treatment, presence of leaves, source of cutting materials and time of shoot collection were also some of the factors in determining the rooting performance.

Materials and methods – Shoots with 2 or 3 pairs of leaves and height of 8-10 cm were collected from hedge garden from 8:00 am to 11:30 am in the morning; 13:00 pm to 15:00 pm in the afternoon and after 16:00 pm in the evening and leaves were removed to reduce transpiration. Juvenile shoots from one year old seedlings are also collected. Immediately after collection, they were treated with rooting hormone solution for 20 minutes and 10 minutes. The rooting hormone is composed of 5 ml of Thiamine Hydrochloride at a concentration of 0.10% with 1500 ml of water. 0.3 % 4 Indole 3 butyric acid powder is also used for hormonal treatment. The treated cuttings were inserted into a rooting medium consisting of 3 inches of pure sand or soil or mixture of soil and sand at a ratio of 3:1. The temperature was controlled at 30 + 20°C and the relative humidity of 85-100 percent in a glass house.

Figure 1. Glass House

Figure 2. Shoot Cutting in Glass House

8. Results and discussion

The juvenile shoot cuttings started to develop roots within 15-20 days. The sprouting and rooting were completed between 30-45 days and were transferred to plastic bags containing a mixture of sand, soil and cow dung at 2:3:1. The mean percentage of rooting varied from 20-100% depending upon various factors. Juvenile shoot cuttings have a higher rooting ability than old shoot cuttings. A maximum of 100 % rooting was obtained from 2 years old seedlings. Thiamine Hydrochloride with a concentration of 0.10% and a 20 minutes treatment gives the best results. Shoot collected from 8:00 am – 11:30 am gave the maximum rooting followed by collection in the evening after 16:00 pm with a minimum percentage obtained from collection in the afternoon. Rooting percentage of shoot in different media is as given in the table below.

Sr.	Type of medium	Rooting %
1	Sand	94
2	Soil	47
3	Mixture of sand and soil	77

9. Conclusion

Shoot cutting method is an effective method and should be applied for mass production in an operational plantation establishment. It could be an alternative option for seedling production to supply genetically improved planting stock.

Investigation on *In vitro* and *Ex vitro* Root Formation of Micropropagated Shoot of Teak

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Daw Kyu Kyu Thin presenting paper on Investigation on In-vitro and Ex-vitro Root Formation of Micropropagated Shoot of Teak

1. Introduction

Tissue culture is referred to as micropropagation because the size of propagule in tissue culture is so minute. Since this is a technique where small part of a plant (explants) is cultured in the glassware under the artificial condition, it is known as *in- vitro* culture. The antonym of *in-vitro* is *ex-vitro* or *in-vitro*. To obtain plant genetically identical to its mother plant, asexual propagation method is applied. Among the asexual method of propagation, tissue culture method is more preferred to the conventional asexual propagation methods.

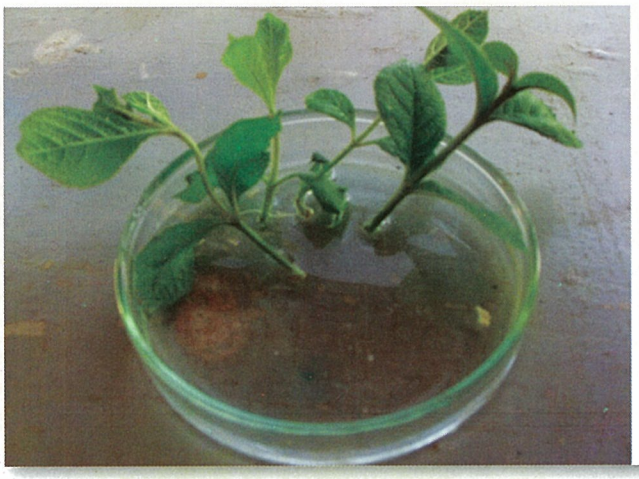
In the tissue culture method, the process from the explants stage to the final stage of transplanting a mature plantlet to the field involves four basic stages. (i) explants establishment or inoculation stage, (ii) multiplication stage, (iii) rooting stage and (iv) hardening or acclimatization stage.

The tissue culture on teak was initiated in Myanmar since 1983 and stage (iii) was not successful up to 2000. It was successfully accomplished only in 2001. Root formation was induced on traditionally micropropagated shoots in in vitro condition.

2. Material and method

Murashige and Skoog, 1979 (MS) medium supplemented with 0.5 mg/L Kinetin and 1 mg/L BAP (6-benzylamino purine) was used for establishment and multiplication of shoot. The shoot obtained from the 5th subculture was used for rooting experiments. The shoot longer than 30 mm including 2 to 3 leaf pairs were harvested for rooting. They were rooted in 2 different media and condition.

For *in-vitro* rooting, the shoots were rooted on Woody Plant Media, 1981 (WPM) medium supplemented with 0.5 mg/L Kinetin and 1 mg/L 3-indole-acetic acid (IAA) under aseptic condition. For *ex-vitro* rooting, the base of the shoots was dipped in 100 ppm Indole-3-butyric acid (IBA) for 3 minutes. The shoots dipped 4 – 6 mm from the base were directly planted in plastic box containing pure sand. This plastic box was placed in a plastic bag where high humidity condition is created inside. The plastic bag was placed under natural condition with 30% shade. Each experiment consists of 15 shoots raised from tissue culture and replicated 3 times.



Shoot dipped in IBA solution

Shoots treated in high humidity condition

For *in-vitro* rooting, the leaves and callus from the base of shoot obtained from the multiplication stage was removed and the shoot including 2 – 3 pairs of leaf was placed on the rooting media under aseptic condition.

For *ex-vitro* rooting method, the leaves and the callus from the base of the shoot were removed and the base of the shoot, including 2 – 3 pairs of leaves were dipped in 100 ppm IBA solution for 3 minutes and transplanted into pure sand box.

3. Results and discussion

For *in-vitro* rooting method, the shoot produced a callus at the base within one week. Root formation began at the base of the callus after 15 days of planting. The plantlet reached the size for transplanting into hardening stage after 3 weeks of root formation. The plantlets could be transplanted into plastic bags with soil mixture after 3 – 4 weeks of hardening. After about 3 months in the nursery, the plantlets that have good performance can be planted out in the field. Rooting percentage is very low in *in-vitro*. Contamination is one of the factors that reduce the survival rate.

In the *in-vitro* method, the callus at the base of the plantlet must be removed so as to transplant to hardening stage. If the root system is attached only to the callus, it is detached from the stem together with the callus. Even if it is attached to the stem through the callus, the root system is often nonfunctional.

Root attached to callus

Callus with Root detached from stem

The leaves of the *ex-vitro* rooting shoots turned into darker colour after 2 days of planting. Emergence of leaves can be seen after 10 days of planting and the plants became more vigorous. The plantlets were ready to be transplanted to polythene bags with soil mixture after 25 days of planting. After 3 months of planting, plantlets that have good performance were planted out in the field.

In the *ex-vitro* rooting method, adventitious roots emerge directly from the base of the stem without callus formation. Root hairs are also vigorous with normal root development. In this method, the rooting and hardening stages can take place simultaneously. Therefore, the culture steps can be reduced. Moreover, the plantlets are more vigorous than that produced by *in-vitro* method. In this study, the rooting percentage of *ex-vitro* is 90%.

Performance of stem and root in ex vitro rooting

4. Conclusion

Generally, micropropagation of teak requires four steps in *in-vitro* rooting method. *Ex-vitro* rooting method can reduce the duration and the culture steps because rooting and hardening can be carried out simultaneously. Moreover, *ex-vitro* rooted plants also show higher percentage of field survival. Therefore, *ex-vitro* rooting method can be considered to the most efficient rooting method for teak micropropagation so far.

Soil Conditions on Teak Seed Production Areas (SPA)

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Daw Tin Tin Ohn presenting paper on Soil Conditions on Teak Seed Production Areas (SPA)

1. Introduction

Teak is indigenous to continental Asian countries and grows naturally over a wide range of climatic and soil conditions. The species grows on well drained alluvial deep soils, derived from lime-stone, schist, genesis and shale. It does not prefer sandy shallow soil with hardpan or lower water table soil and compacted water logged soil. The optimum pH range for growth is between 6.5 to 7.5. It prefers relatively fertile soil with high calcium, phosphorus, potassium, nitrogen and organic matter content. The amount of calcium content in the soil is also used as a criterion for the teak site quality.

2. Study area

According to the project document, a total of 150 acres of Seed Production Areas (SPA) are to be established at Pyinmana, Pyay, Thayawaddy, Shwebo, Gangaw and Hinthada Districts. In this report, studies were carried out at Compartment 59, Taung Nyo RF, Pyinmana Township; Compartment 49, South Nawin RF, Paukkaung Township, Pyay District and Compartment 99, Bawbin RF, Nattalin Township, Thayawaddy District.

3. Methods

Soil samples were collected in 3 layers (0-10 cm, 40-60 cm, 60-80 cm) at the three sites where SPA were to be established. Determination of physical and chemical properties regarding soil colour, organic matter, soil texture, pH, total N%, Available P, extractable K, Ca and Mg were made in soil laboratory, Forest Research Institute, Yezin. Through matching with the analytical data, plant growth in the study areas were checked out in January 2007. Additional soil sample collection and profile studies were carried out during that time.

4. Result and Discussion

The soil properties of the study areas were found to be in favourable condition for teak growth. The organic matter contents are found to be varied and it is mainly attributed to the diverse magnitude of the under-story and wild fire.

Wide range of soil pH in the study areas is noted (5.5 – 8.0). However, most of the soil reactions in the study areas are of acidic condition. Several investigators revealed that the optimum pH range for teak is from 6.5 – 7.5.

Several studies indicated that teak requires relatively large amount of calcium for its growth and development. The calcium content in the study areas are high enough for teak growth except in Compt. 59, Taung Nyo Reserve where soils were derived from sand stone parent material. However, the growth rate of teak trees in this compartment is still acceptable and found to be vigorous. The calcium contents of soils from SPAs in compt. 49, South Nawin Reserve and compt. 99, Bawbin Reserve are found to be higher, i.e. 4-11 and 4-14 me/100 gm respectively. These soils are derived from lime stone parent material and it is desirable for teak.

The soil texture of the study areas are sandy loam to clay loam. Although the clay content at Bawbin Reserve is high, the plant growth was found to be normal because it has moderate organic matter, adequate moisture content and very short dry spell.

The study areas with specific soil properties are justified to be acceptable for wood production. However, it is needed to improve the seed production with the following activities.

(1) Soil working and mulching should be carried out in all the study areas.

(2) Young plantation below the age of 25 years should receive fertilizer in the rainy season at 50gm/plant of NPK (16:16:16) compound fertilizer. Since the plantation at the study areas are above 20 years, 2kg/plant of NPK (16:16:16) compound fertilizer should be applied.

(3) Apart from fertilization, soil working, mulching, and application of enriched compost to the SPA at Bawbin Reserve should be carried out so as to improve the high clay content and early soil dryness.

(4) Because of the low calcium content, calcium enriched compost/manure should be applied.

(5) In Paukkaung, soil working, mulching and adding enriched compost/manure should be encouraged.

(6) In order to reduce abortion of ovaries or get more fertile seed, 2% Boron enriched compound fertilizer should be applied.

(7) Regular evaluation of soil properties to reduce soil deterioration with systematic seed yield recording is adivisable.

5. Suggestion

The following activities should be carried out in Seed Production Areas.

(1) Soil mulching without disturbing the seed collecting area should be practiced.

(2) Soil working or inter-cultivation between the rows should be done especially on heavy high clay content.

(3) Logging residues should be removed immediately after thinning. Removal of weeds and other debris are desirable so as to reduce potential danger from pests and wildfire.

(4) Apply fertilizer to promote growth and flowering. Phosphorus and potassium should be applied as they enhance flower differentiation and increase fruit setting.

(5) Remove weeds around the tree before application of fertilizer and apply fertilizer along the periphery of the tree after proper soil working.

(6) Undertake pruning of all inflorescences regularly after fruits are harvested.

(7) In strongly acidic soil, moderate application of lime (2.5-5.0 kg/plant) at the time of establishment can assist growth in the juvenile stage.

(8) Inoculation with nitrogen-fixing root nodule bacteria (Rhizobium) can provide considerable amount of nitrogen to the soil system. In order to increase growth intercropping with nitrogen fixing field crops in teak plantation should be practiced.

(9) In young plantation, two doses of fertilizer in the month of August and September with 50gm/plant of NPK (15:15:15) compound fertilizer should be provided up to three years.

(10) Combination of Urea 89kg / ha (41Nkg / ha) and Triple Super Phosphate 182 kg / ha ($H_2P_2O_5$ kg / ha) at the rate of 90 g / plant is advisable for young teak plantation.

D. Conclusion and Recommendations

8. The participants participated actively in the discussion session. The need for the tree improvement programme was acknowledged and the following recommendations were reached.

(1) The project is to publish a manual for the establishment of Seed Production Area.

(2) More Seed Production Areas are to be established so as to meet the demand of teak seed requirement for plantation establishment.

(3) Seed Production Area establishment and management are to be carried out according to the instruction issued by the project and approved by the Forest Department.

(4) Tree improvement activities are to be continued even after the project.

(5) In order to continue with the tree improvement programme, the Forest Department should form a tree improvement unit either at the FRI or the Department itself.

(6) Capacity building for members of the tree improvement unit should be carried out whenever opportunity prevails.

(7) In order to conserve the superior genetic resources of the country, plus trees are to be selected all over the country in accordance with the instruction issued by the project and approved by the Forest Department.

(8) Gene banks in the form of hedge gardens should be established.

E. Closing of the Seminar

9. Closing remarks were made by U Khin Maung Zaw, the Rector, University of Forestry, Yezin.

Annex (I)

List of Participants

Sr. No.	Name	Title	Department
1	U Sein Htun Lin	Deputy Director	Planning and Statistics Department
2	U Tint Lwin	Assistant Director	Forest Department
3	Daw Phyu Phy Lwin	Range Officer	Forest Research Institute
4	U Ngwe Thee	Staff Officer	Forest Department
5	U Kyaw Moe Aung	Staff Officer	Forest Department
6	U Than Naing Win	Staff Officer	Forest Department
7	U Saw Win	Assistant Director	Forest Department
8	U Win Aye	Staff Officer	Forest Department
9	U Than Aye	Assistant Director	Forest Department
10	Daw Yee Yee Han	Research Officer	Forest Research Institute
11	U Min Zaw Oo	Staff Officer	Forest Research Institute
12	U Aung Zaw Moe	Research Assistant -2	Forest Research Institute
13	Daw Mu Mu Aung	Research Assistant -2	Forest Research Institute
14	Daw Khin Pa Pa Shwe	Research Assistant -2	Forest Research Institute
15	U Khin Maung Oo	Professor	University of Forestry
16	U Htun Nyo	Professor	University of Forestry
17	Dr. San Thwin	Lecturer	University of Forestry
18	Dr. San Oo	Lecturer	University of Forestry
19	U Tin Moe	Assistant Lecturer	University of Forestry
20	U Win Hlaing	Deputy Principal	Central Forestry Development Training Center
21	U Maung Maung Lay	Staff Officer	Central Forestry Development Training Center
22	U Aung Kyaw Soe	Range Officer	Central Forestry Development Training Center
23	U Win Myint	Staff Officer	Forest Department, Paukkaung Township
24	U Zaw Myo Hlaing	Staff Officer	Forest Department, Nattalin Township
25	U Kyaw Moe Aung	Staff Officer	Forest Department, Pyinmana Township
26	Daw Phyo Ei Hlaing	Range Officer	Forest Department, Kanbalu Township
27	U Tet Toe	Staff Officer	Forest Department, Myanaung Township
28	U Aye Chan Aung	Range Officer	Forest Department, Saw Township
29	U Thein Win	Manager	Myanmar Timber Enterprise
30	U Thein Htun	Manager	Myanmar Timber Enterprise

Annex (II)

List of Observers

Sr. No.	Name	Title	Department
1	Daw Yin Yin Kyi	Deputy Director (Retd.)	Forest Research Institute
2	U Sein Thet	Project Coordinator	NCEA
3	Daw Myint Myint San	Research Assistant -2	Forest Research Institute
4	U Win Myint	Staff Officer	Forest Research Institute
5	Daw Wai Wai Than	Assistant Research Officer	Forest Research Institute
6	U Myint Lwin	Manager	Jade King and Queen Co., Ltd.

Discussions


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Participants

Proceeding of the Seminar on Teak Seed Production Area Management and Tree Improvement

Forest Research Institute, Yezin
20 February 2008