SOME OBSERVATIONS OF NATURAL REGENERATION OF TEAK (*Tectona grandis* Linn f.) IN TEAK-BEARING FORESTS OF BURMA

U Tun HLA*

Summary

Teak naturally occurs in Burma between latitude 23°-30′ North and 10° latitude North. It is predominant in the Pegu Yoma Range in the mixed deciduous forest and also occurs scattered over other areas with varying climatic conditions and geological formations. Its best growth however occurs on the deep, moist, fertile and well drained sandy loam soils of the Pegu Yomas and Chindwin drainage area.

Germination per cent of teak seeds from lower Burma was found to be better than that of seeds from upper Burma, based on experimental results. It is a fire hardy species and in areas located near human settlements which are not deep in the jungle, teak natural regeneration is found to be profuse.

In bamboo flowering areas, gap areas, and in areas in which seedling coppices are already available in great numbers, natural regeneration is proposed.

Under the existing conditions, Burma Teak Selection System with Improvement Fellings is found to be the most satisfactory and suitable method for the present.

Introduction

Burma is situated roughly between latitudes 10° and 28° north and longitudes 93° and 103° east. It extends over about 2,092 km from north to south and is 805 km wide from east to west. It has an area of 676,577 square kilometers of which 387,278 square kilometers or 57% is covered by forests.

Elevation varies from sea level along the coastal regions to 6,096 meters or thereabouts on the mountains bordering China. The rivers and the main ranges run generally from north to south. The Arakan Yoma Range (3,048 m) which divides the Irrawaddy basin from the sea, the Pegu Yoma Range between the Irrawaddy and the Sittang Valleys, contain some of the most extensive and finest teak forests. Teak bearing forests do not occur in areas above 914 meters in height.

Temperature and rainfall

The rainfall of Burma varies from as low as 635 mm to well over 5,080 mm along the coastal lines. There is an area roughly about 130 square kilometers between the Sittang and the Yunzalin, where the rainfall ranges from 2,540 mm to 5,080 mm within this comparatively small area.

The 1,016 mm rainfall area extends from Thayetmyo in the south to about 113 kilometers north of Mandalay; and from about 32 kilometers east of Mt. Victoria in the west to a little beyond longitude 90° east in the east. This region is known as the dry zone of central Burma. Away from this drier region rainfall again increases, and temperatures change as one proceeds north, east, south or west.

The temperature ranges from a minimum of −1°C (Maymyo) to a maximum of 39°C (Mandalay). The central dry zone has a range of temperatures from about 10°C to 41°C.

The cold season lasts from mid-November to February; the hot months are March through May; the rains start from about mid-May or early June and continue till about the middle of October.

* Deputy Director, Forest Department, Rangoon, Burma.

Occurrence of teak

The northern boundary limit of teak is about 25°—30'N latitude. This boundary extends up to the Kachin State and is some distance outside the northern tropic. Its southern boundary is about 10° to 16°N latitude in the Amherst District. In the east it appears through the Shan State and extends beyond the frontier into Thailand where its northern limit is set at about 20°N latitude. In the northwest it does not extend beyond the western watershed of the Irrawaddy and Chindwin rivers. In the south-west it occurs on the west bank of the Irrawaddy extending into the foot hills of the Arakan Yoma in decreasing abundance up to about 18° to 19°N latitude. There is no teak in the drier parts of the dry zone in central Burma, the tidal and swamp regions of the delta and high elevation evergreen hill forests as well as in the low-lying tropical evergreen forests.

Teak-bearing forest types

Teak is found in a number of different types of forest. It occurs scattered throughout these forests in mixture with a large number of other species. It generally accounts for 10 to 12% of the entire forest composition.

Teak occurs normally in the Mixed Deciduous type of forests and occasionally it is found thriving around the fringes of semi-evergreen forests along the bank of streams, adjoining to either Moist Upper Mixed Deciduous forests or Lower Moist Deciduous forests. Whereas in the Semi-deciduous Dipterocarp or Semi-indaing forests where the soil is sandy, gravelly and lateritic, teak is often abundant and it can exist as an understorey suppressed tree, much branched and twisted.

In the Semi-evergreen type teak occurs usually as scattered individual trees or in small groups. Generally trees are large and often fluted and there is little or no natural regeneration present.

Teak is sometimes found in gregarious patches in Lower Moist Deciduous forests, in low-lying areas. Its maximum height growth is 46 meters and it attains large girths but is often considerably fluted at the base. The percentage composition of teak in this type is higher than in any other types. There is also a thick undergrowth.

In Moist Upper mixed deciduous forests, the percentage composition is somewhat lower than in the Lower Moist type, but teak usually produces cleaner and straighter boles. Elsewhere its density is usually low. Dry Upper Mixed deciduous forest is a forest of poorer quality than the former types and the maximum height can be around 24 to 30 meters.

Some of the more common forest trees which are found in association with teak in Mixed Deciduous forests are: *Xylia dolabriformis, Pterocarpus macrocarpus, Terminalia* spp., *Homalium tomentosum, Lannea grandis, Gmelina arborea, Salmalia malabarica, Shorea oblongifolia, Pentacme siamensis* and *Dillenia* and *Sterculia* spp.

The undergrowth in teak forests is of varied and characteristic composition depending upon the type of forests. It is composed chiefly of bamboos and of many kinds of shrubs. Common bamboos found in teak forests are *Bambusa polymorpha* and *Dendrocalamus strictus* in the south, *Dendrocalamus hamiltonii* and *Thyrsostachys oliveri* in the north. *Cephalostachyum pergracile* is also commonly found with teak.

Climatic requirements of teak

Growth and development of teak are greatly determined by the amount and distribution of rainfall and the altitude above sea level. Teak grows well in warm, moist, tropical regions with an annual rainfall ranging between 1,270 mm to 3,810 mm. But it does occur in areas with rainfall as low as 762 mm or as high as 5,080 mm. In these extreme limits the growth is generally not satisfactory. The optimum development is within a rainfall range between 1,270 mm to 2,032 mm. The seasonal distribution of rainfall also determines its distribution and performance. A definite dry season of at least three to four months is essential for satisfactory growth of teak.

No detailed studies have been made on temperature requirement of teak. Available records show that teak grows best between 12.5°C and 40°C. It was reported that it can survive extreme

temperatures as low as 2°C and as high as 46°C. The optimum temperature for teak is reported to be between 22°C and 27°C with extremes of 15°C and 30°C.

Geology, soil and topography

Teak occurs on various geological formations, and the quality of its growth depends more on physical characters such as depth, drainage, moisture regime of the soil than on chemical constituents. Such favourable edaphic conditions are generally found in the Moist Deciduous forests. Its best growth however occurs on the deep, moist, fertile and well drained sandy loam soils of the Pegu Yomas and in the Chindwin drainage area.

Teak occurs at various altitudes from flat and undulating grounds to about 1,000 m. On steep hill slopes which are often stony and precipitous, and where the overlying soil is shallow and poor, the stocking may be low and the trees do not attain large dimensions. In the lower slopes with improved soil depth and good drainage, teak becomes comparatively more abundant and is of better quality. Waterlogged depressions, soggy and stiff clayey soils are not favourable areas for teak regeneration. In such situations hygrophylous species take over the place of teak whose absence is particularly conspicuous.

Exposure also has significant effects on the composition and the regeneration of teak forests. Its influence is also related with the amount of rainfall and the altitude. In dry localities teak grows better on cooler northern and eastern aspects than on the hotter southern and western ones. On the contrary, teak is said to prefer the hotter southern and western aspects in areas where the rainfall is heavy. Cooler areas are being occupied by evergreen species.

Flowering and fruiting

Teak is monoecius and flowers freely nearly every year. Large terminal panicles of small white flowers appear during the rainy season, generally from June to August or September according to season and locality. In abnormally wet season they may begin to appear as early as April. Generally inflorescences in a single teak tree may contain 5,000—8,000 buds though not all of these will develop into viable seed producing flowers.

The fruit ripens from November to February and falls gradually towards the end of the hot season in April. Seed production is relatively poor in spite of its profuse flowering. There are some 40—60 fruits per inflorescence head. In some forests parrots destroy a great deal of it and the ground is littered with the remains of the cracked nuts. It is likely that the noticeable lack of regeneration in certain forests may be due to the almost total destruction of the seed drop in particular years. Seeds that fall early are not fully developed and viable. They contribute little towards the natural regeneration.

Germination

Germination is one factor that is directly related to the natural regeneration. Very little is known of the germination of seeds under the natural conditions. But it is known from experiments carried out that germination of seeds from central and lower Burma under ordinary nursery conditions is much better than that of the seeds from northern Burma. The seeds from the former regions gave 36—59% germination while those from northern Burma gave only 7—20%, in a series of experiments carried out under the same conditions.

It was noted that a considerable portion of fresh seeds sown in nursery beds remain dormant till the following or subsequent years. Seeds from dry areas have been found to have a longer persistent period of dormancy. The germinative capacity of teak seeds determined under the nursery conditions is not a good index to use under natural forest conditions. Troup noted instances of teak seeds remaining dormant, under natural forest conditions, for periods varying from 4 to 5 years or even more. It should also be noted that conditions in the natural forest vary considerably depending upon the closeness of the canopy, the density of trees, the condition of the forest floor as the germinating medium and so on. In one experiment it was observed that under the canopy of teak-

bearing mixed deciduous natural forest the germination was practically nil. On another site with sandy soil in semi-evergreen forests, germination percentage was as high as 15%. On the third site under the canopy of Indaing forest, germination percentage was found to be as high as or slightly higher than that obtained in open nurseries.

Natural regeneration within the forest

Practically all or almost all of the teak-bearing forests of Burma have been in one way or the other affected by man. Some accessible areas have been heavily exploited for teak and other valuable species including bamboos. On the other hand some of the less accessible forests have remained almost untouched except for the girdling and extraction of teak alone.

In most of the teak forests in the proximity of human habitation and villages, annual fires occur every year which are mainly due to human intervention. These repeated annual fires, which may occur more than once in a year, may kill some of the fire-tender seedlings and saplings. Teak, being fire-hardy, can withstand the onslaught of these annual fires and survive. In addition, it has been found that annual fires have the added effect of enhancing teak regeneration and increase the density of teak at the expense of less fire-hardy tree species. However in the dry forests fire is inimical to the regeneration of teak. Furthermore, it was found that teak has a remarkable vitality in resisting the effect of mechanical injury. It coppices vigorously and sometimes retain this power of coppicing up to a considerable size. It was observed that there is nearly always a thin scattering of teak regeneration in deciduous forests where fires occur annually.

On more or less level topography, the fallen seeds remain under and around the trees until germination takes place. On hill sides with insufficient soil-covering of grass or other material to hold them up, the seeds are washed down the slopes early in the rainy season. Most of the seeds that are transported with flood waters are normally deposited on alluvial flats. This resulted in the development of teak stands in such areas.

One experiment indicates that in a good teak forest with an understorey of bamboo, only a minute fraction of the seeds dropped each year germinates. These seedlings remain in a suppressed stage for many years without being able to establish themselves while other seedlings such as *Xylia* spp. and *Pentacme siamensis* may exist for only two or three years after which they disappear. The fact is that teak seedlings can survive in a state of suppression for many years. In spite of some casualties, these suppressed teak seedlings increase year after year.

In poor forests such as Dry Teak or even Semi-indaing forests where teak was found established outside its natural habitat, the amount of regeneration is much more possible due to the forest being more open and the occurrence of frequent annual fires.

However, in a good type of teak-bearing forests, when the canopy is closed, there is reduced or no regeneration at all. If the canopy is opened up regeneration will come in including other non-valuable species and weeds. Thus to establish teak regeneration, at least 2 or 3 years of weeding has to be done.

In Bamboo flowered areas, the appearance of abundant natural regeneration of teak was also noticed. Since the life cycles of individual bamboos differ it is not known how much bamboo flowering helps in the regeneration of teak forests.

It is not unreasonable to expect that in a forest in which heavy exploitation has taken place, more regeneration should come in and more seedlings should survive to become suppressed advanced growth. Most of the seedlings will remain in a suppressed state under the bamboo undergrowth and weeds; with the exception of a few which fall on favourable ground and unless something is done to open up, it is uncertain what their fate will be. Also in some patches where fierce fires occurred, they would have a better chance of survival and establishment on account of the opening of the canopy.

It seems possible from the above data that in teak forests, young stages of regeneration are present on the ground. The amount, no doubt, varies from one type of forest to another depending on factors such as soil conditions, density of shade, amount of disturbances in the canopy, forest

types etc. Extraction operations may help to increase the regeneration in some parts of the area while some other areas remain unaffected.

Silvicultural treatment

Teak can be treated under:-

1. Seedling coppice method.
2. Burma selection system with improvement fellings.

1 Seedling coppice method :-

This method aids the natural regeneration on the ground to become established. It depends on the natural advanced growth being there. It has been demonstrated that there is usually a surprisingly large amount of advanced growth already available.

When gregarious flowering of any bamboo species takes place, the low overhead cover disappears over many square miles, and counting of teak advanced growth on the ground done in various forests leads to the expectation that, after a gregarious flowering, a lot of scattered teak saplings will make their appearance and in some places it was found that the density of regeneration in these areas approached to that of the plantation. Operations are carried out to help this young growth. At first only one operation is carried out. It includes the cutting of the remaining bamboos and worthless species interfering with teak, climber cutting and coppicing of malformed teak. This single operation was found to be insufficient and later further fellings were done in about 8 or 10 years.

After carrying out these operations in some of the large gregariously flowered areas, it was found that teak had established itself and needed no further treatment other than cultural works. These cases were seen in Pyinmana, North Toungoo and Mongmit forest divisions.

This method involved much labour and cost. If sufficient funds are available the method can be used in bamboo flowered areas, large gaps caused by wind storms and severe fires and in other exploited areas.

2 Burma selection system with improvement felling:-

The reserve forests of Burma are divided into the following working circles for the purpose of management.

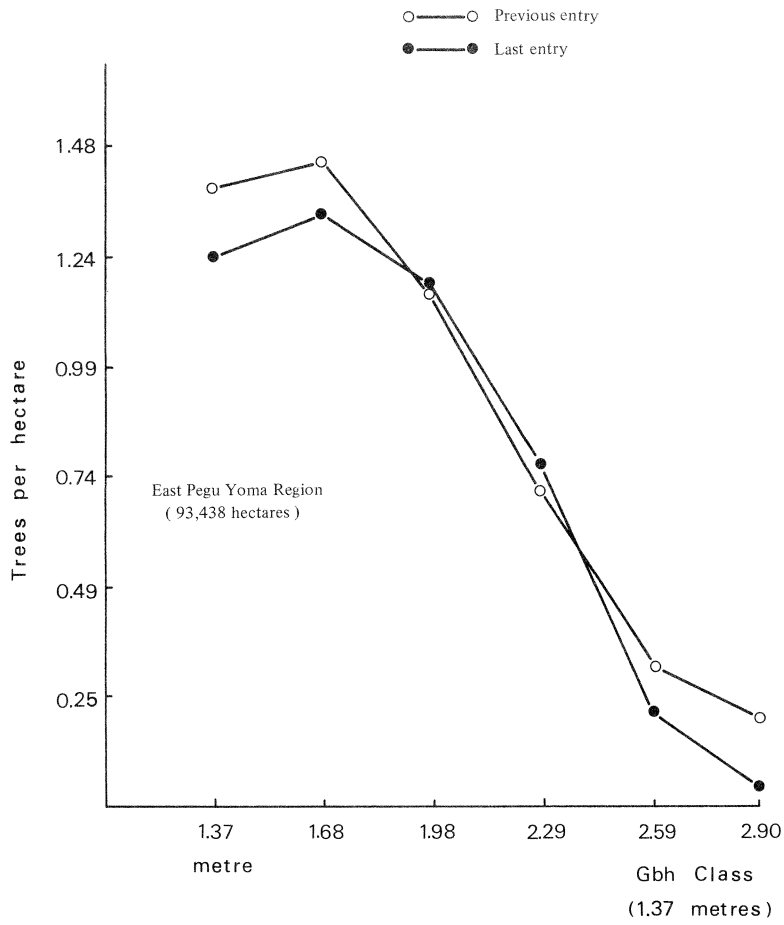
(1) Teak Selection Working Circle;
(2) Commercial Supply Working Circle; and
(3) Local Supply Working Circle.

They are formed, based mainly on accessibility. The Local Supply Working Circle consists of the most accessible areas which are designed for the supply of the needs of the local people and silvicultural system adopted is Coppice with Standards or Clear Felling. Selection System is adopted in the former two working circles where teak and other valuable hardwoods are exploited selectively.

After the forests had been heavily exploited in Moulmein during 1827 to 1854, Dr. later, Sir. Dietrich Brandis had enforced this system in the year 1856 to prevent over-exploitation of teak and to ensure an adequate regeneration of teak for future stock. He fixed minimum cutting size-class for teak as 7′-6″ (2.29 meters) in good teak forest and 6′-6″ (1.98 meters) in poor teak forest and adopted a cutting cycle of 30 years.

This original system of harvest cutting was later modified and incorporated with the improvement fellings to help increase the dwindling stock of teak. These improvement fellings consist of thinnings in immature teak, removal of a certain proportion of silviculturally undesirable mature trees, opening up of patches of established advance growth, climber cuttings, removal of inferior growth suppressing the teak and its valuable associates, and cutting of dead and moribund trees. These fellings are extremely beneficial to the forests. The selection of teak of exploitable sizes

coupled with "Improvement Felling" operations eventually came to be known as the Burma Selection System. This system has been adopted in the country continuously over a hundred years up till now, with varying degree of success.



Teak stand curves

(Girdling enumeration data–trees girdled + trees left)

East Pegu Yoma Region–

1. Yamethin
2. Pyinmana
3. North Toungoo
4. South Toungoo
5. North Pegu
6. South Pegu

} Forest Divisions

Discussion and conclusion

From the above, one can conclude that, regeneration in teak-bearing areas of mixed deciduous forests may be sufficient in boosting up the younger age classes for future recruitment into larger girth classes if intensive tending operations are carried out. Although much has been mentioned earlier in the paper on the conditions to get the germination of teak seeds and to get the regeneration of the teak forests as a whole, it is surprising to note that there is a dearth of natural regeneration in the better quality teak forests. This is supported from the results of the forest inventories carried out since 1965 for some 11 years. It is also evident from the stand curves of the six main teak-bearing forests of the Pegu Yomas. The curves are constructed from the enumeration data for two felling cycles. Though the stand curves are somewhat balanced, the general tendency is the fall in tree number in the lower girth classes contrary to what should have been the case. This state of affairs had been noted as early as in 1934 by Mr. A. R. Villar, Conservator of Forests Burma. To quote him verbatim he mentioned that "Natural regeneration of teak is conspicuous by its absence in the selection forests especially in the better areas".

At this stage it behoves the Department to critically examine whether the Selection System as practised today to work the teak forests, together with the improvement fellings to get the natural regeneration of teak is good enough for our teak forests. There are two-edged answers to this query. Improvement fellings do assist regeneration as well as bring it up to maturity and establishment, but it is uncertain to what extent this can happen.

As teak constitutes only 10% of the total growing stock, it is still uncertain up to what degree of intensity the improvement felling should be done to get the required regeneration and at the same time maintain the growing stock for sustained production. It is unquestionable that the greater the intensity of improvement fellings that can be put through, the greater would the teak benefit from it.

There are two main stumbling blocks in tropical forestry. One is the desirability and the other is the practicability within manageable limits. It is most difficult to strike a happy medium between the two.

Professor Kermode presented a paper on the natural regeneration of teak at the sixth silvicultural conference held at Dehra Dun in 1945. He doubted that the opening up of the tree canopy and the removal of most of the low cover (bamboo) would immediately result in marked increase of the young teak stock. He contended that under tropical conditions the most likely was the invasion of a dense weed growth. Teak requires opening to such an extent that it almost approximates to a clear felling in a small area.

Another pertinent question Kermode raised was that, as set out before, improvement fellings do help regeneration, but the regeneration was already there in the form of suppressed seedling crops, suppressed so much that they will go on in that condition until some sort of a sweeping ground fire, or heavy disturbances in the canopy allow more light to come in and help them up to maturity and establishment. What the regeneration operations did was not so much as to induce regeneration and get a new seedling crop. He was also careful enough not to condemn the regeneration operations, as a whole as failing to get a new seedling crop; but he was more than convinced that these operations do more help to get the suppressed growth already there.

Burma provides 75% of world's teak worked under Teak Selection Working Circle in which Burma selection system with improvement fellings has been adopted for the benefit of teak and other valuable species. Regeneration of teak is by natural means.

In inaccessible teak areas experience has now shown that to counterbalance the constant drain on the single marketable species (teak), removal of other hardwood species whether done at a loss as improvement fellings is an essential supplement to the selection working of one species. Such unremunerative fellings are expensive, and inadequate provision of funds will only lead to progressive reduction in the relative teak stock. Where possible it is best to fell trees in the improvement felling operation but they may also be killed by poison as an alternative. The discovery of a cheap, quick and efficient means of killing trees, whether by poison or otherwise, would solve

one of our pressing silvicultural problems. The second remedy lies in the development of markets for other hardwoods and the adequate construction of roads to make extraction of such hardwoods economically worthwhile.

To increase the proportion of teak in mixed deciduous teak-bearing forests, advantage must also be taken of the phenomenon of gregarious flowering of bamboos which is invariably followed by the appearance of abundant natural regeneration of teak. Where regeneration is scarce, it is supplemented by planting of teak stumps and sowing, and subsequently tended by way of weeding, cleaning, fire protection and thinning. But past experience points out that it is useless to broadcast teak seeds in the forest as a measure to induce regeneration; teak stumps can be successfully planted just before the bamboo seed falls but it is useless to plant stumps under bamboo a year or two before or after gregarious flowering, as the stumps either die off on account of the heavy shade or are swamped by bamboo seedlings. These operations should be confined only to those areas in which *Bambusa polymorpha* is predominant. Where it is in heavy admixture with other bamboos, no planting operation will succeed.

In tending operations in regeneration areas both artificial and natural, weedings are too much of a problem. Weeds such as bamboo seedlings, exotic species of *Eupatorium odoratum* and *Imperata cylindrica* are seemingly unsurmountable problems. Now weedings are carried out only by manual means. Where possible it is best to use mechanical as well as chemical means. In West Africa and Indonesia it is learnt that introduction of *Leucaena glauca* is the only species which keeps down the above mentioned weeds and it does not damage teak and even exerts a good influence so as to bring N_2 into the soil. The Forest Department of Burma has just started to experiment with a species belonging to this legume family and known widely as *Leucaena latisiligua* or commonly known as Ipil-Ipil.

In some forest divisions of Lower Burma heavy mechanized extraction of timber is taking place in Hardwoods selection working circle and wide gaps are formed in the forest. When the canopy is opened up and fire protection in some types of forests is carried out properly, teak regeneration is profusely coming up. In such areas it is suitable for planting up teak to let taungya cutters do their work to form miniature plantations in places where the soil is adequate.

Finally it will be realized that Selection System with improvement fellings is still the most common and extensively employed system in Burma. Experience so far has conclusively proved that in the prevailing circumstances of extreme inaccessibility, undeveloped markets for hardwoods other than teak and the readiness with which weeds invade and take possession of any big gap created in the forest cover, this system is regarded as the cheapest and most satisfactory and suitable for the present.

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Discussion

Willan, R. L. (FAO): I would like to know how successful the use of leucaena as a nurse or understorey for teak has been in Burma and Indonesia. In some areas, I believe, leucaena may become an aggressive weed and I would like to know how it is managed as understorey species so that it does not compete with teak.

Answer: Leucaena enables to enrich the teak stock. Also owing to insect outbreaks damaging teak, we would like to establish mixed plantations.

Willan, R. L. (FAO): May I ask the same question to the Indonesian delegates?

Yunus K. (Indonesia): Leucaena is beneficial to teak growth as it can control weed growth. It is deep-rooted and brings nutrients to the surface of the soil, in particular it supplies nitrogen for the plant. Leucaena grows well with teak provided that regular pruning (4 times in 2 years) is carried out so as not to overgrow teak. As fertilizers are applied for the cultivation of food crops, teak growth is very rapid and trees may become susceptible to wind damage. To avoid this, leucaena is kept high.

Tun Hla (Burma) Comment: We plant leucaena to prevent soil erosion and to provide nitrogen. Also, leucaena seeds are used as feed for livestock.

Glori, A. (The Philippines) Comment: Further studies should be carried out before promoting the interplanting of leucaena in teak plantations as it has been demonstrated that the soil surface under Leucaena shows erosion owing to the elimination of the grasses underneath.

Sambas W. (Indonesia): Do you have any experience in teak coppice system? In the case of *Albizzia falcata* the planting of coppices leads to rapid growth. However, after the third generation, (24 years) the coppicing power decreases.

Answer: In Burma only seedling coppices are being used giving rise to rapid growth. Light thinnings are performed at short intervals up to 25 years. Afterwards heavy thinnings are carried out up to the age of 45 years at 10-year intervals. Seedling coppices are treated as natural forests after 40 years. The wood under the form of poles and posts is adequate for local supply.