

The CEYLON FORESTER

Vol. VI, Nos. 1 & 2 (New Series)

January—December, 1963



Published by the Forest Department, Ceylon

PRINTED AT THE GOVERNMENT PRESS, ON PAPER MANUFACTURED AT THE EASTERN
PAPER MILLS CORPORATION, VALAICHCHENAI, CEYLON

Price: Rs. 3.00

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THE CEYLON FORESTER

The Ceylon Forester is published biannually by the Forest Department, Ceylon.

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Contributors will be supplied with 12 extra copies of their contributions together with illustrations free of charge if 2 pages or more in length.

Subscriptions—

			Rs. c.
Annual	..	..	5 00
Single copies	..	..	3 00

(Special concession rates applicable to Ceylon Forest Department staff will be notified through D. F. OO.).

CONTENTS

	PAGE
EDITORIAL NOTES	1
PRE-SOWING TREATMENT TRIALS ON TEAK	4
	<i>L. C. A. Wijesinghe</i>
POTENTIALITIES OF BEEDI LEAF PRODUCTION IN CEYLON	12
	<i>W. G. Weeraratne</i>
THE CONTRIBUTION OF IMPROVED FOREST UTILISATION TO PRODUCTIVITY IN DEVELOPING COUNTRIES	18
	<i>A. E. K. Tisseverasinghe</i>
AN INVESTIGATION OF THE RELATION BETWEEN THE QUANTITY OF SEED SOWN AND THE OUT-TURN OF STUMPS IN TEAK NURSERY WORK	31
	<i>L. C. A. Wijesinghe</i>
REPORT ON THE REGIONAL TRAINING COURSE IN FORESTRY TECHNIQUES, JANUARY-FEBRUARY, 1962	37
(By A. D. R. Ratnarajah, L. Abeynaike, S. B. Herat, and C. Wijeratnam)	

(Edited by L. C. A. Wijesinghe)

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The Ceylon Forester

Jan. - Dec., 1963

Hony. Editor .. A. E. K. TISSEVERASINGHE

Editorial Office .. FOREST DEPARTMENT

Vol. VI, Nos. 1 & 2 (New Series)

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COLOMBO 2

"The forest is a peculiar organism of unlimited kindness and benevolence that makes no demands for its sustenance and extends generously the products of its life activity ; it affords protection to all beings, offering shade even to the axeman who destroys it."—Gautama Buddha.

EDITORIAL NOTES

Teak Nursery Technique

THE two articles in this issue of the "Ceylon Forester" by Mr. L. C. A. Wijesinghe will help to focus the attention of all foresters in Ceylon on the need for continuous research in fields in which most of us imagine there are no unsolved problems. Teak is an exotic species which has been grown in Ceylon for a very long time. Introduced into Ceylon in 1680 by Van Rhede, it has, since then, been sporadically planted until the latter part of the nineteenth century when planting on an organised scale began. A great deal of experience has been acquired on the propagation of Teak. We also had access to the vast body of Indian Forestry literature in the propagation of Teak. Foresters in this country tended to be complacent about our knowledge of the technique of raising Teak and were generally content to carry on with the same technique which had been "proved by experience" in India and Ceylon.

The two articles by Mr. Wijesinghe teach two very important lessons. Firstly it shows how little is known about the germination of Teak—the reasons for the dormancy of the seed whether physical or physiological, or a combination of both, whether the age of the seed has any relation to dormancy, what the exact process is of breaking dormancy and so on. The second is that experience is no substitute for continuous experiment. The former can be acquired by anybody and an intelligent person can learn by it ; but the latter can only be carried out by a scientist using the tools of research. This is a particularly pertinent lesson for foresters, because here more than in any other field of study, the view is propagated by some that experience is as good as or even better than disciplined study.

In this period when, in accordance with a plan for economic development, this country has embarked on an ambitious planting programme—far in excess of anything which had been contemplated earlier, it is more than ever necessary to question our current techniques. We cannot afford failure and any mistakes made—perhaps in our planting or thinning techniques—will affect very large areas. The Departmental Research organisation will have to be strengthened to cope with the demands which will be made on it in the future when the large areas of new plantations go through their growing phase.

Minor Forest Produce

ANOTHER important aspect which will make demands on the Research Organisation in the future is investigation into the field of Minor Forest Produce. An editorial in a previous issue of this journal (Vol. II, No. 3) called attention to the need for exploitation of this valuable resource. What was then a more or less academic argument has now become an urgent practical problem. This country imports, for instance, a large volume of medicinal herbs which are available in the forests. With the stringent control which has now been imposed on the drain of foreign exchange, it has become necessary to exploit our own resources of these herbs and stop imports. In fact, there have been export inquiries as well and it may even be possible to find export markets for our surpluses if we can ensure systematic management of this industry on a sustained yield basis.

The Beedi Leaf (*Diospyros melanoxylon*) industry is a good example of how much can be achieved with little effort. All the Island's requirements of this leaf used to be imported—the availability of this leaf in our forests was never explored. Now it is anticipated that the country can become self-sufficient in this commodity, thus saving the large sums of money which were sent out annually for its import.

Transmission Poles

THE writer had the opportunity to visit the U.S.S.R. in August and September last year to participate in a Study Tour on Aerial Forest Inventory. One feature which struck him very forcibly was the great extent to which timber was being used for telegraph and power transmission poles. We are using some wooden poles in this country for power transmission, but the extent to which this can be increased is limited by the very strict specifications which are laid down by the Electrical Department. The Electrical Department is of course, quite right in insisting on quality, since one cannot take risks with high tension current, but this problem is got over in the U.S.S.R. by coupling poles together and even making timber trestles for use as pylons. The coupling is done very simply, usually two poles being tied together with wire. Sometimes a wooden pole is tied on to a concrete pole which forms a short base. If an advanced country like the U. S. S. R. can use poles of this type there is no reason why this country which at present produces no iron or steel should not attempt something on the same lines. Long straight poles with little taper are difficult to obtain in our forests. If short length poles could be coupled together most of the supply difficulties will be solved.

Welcome

IT is a pleasure to welcome to our midst Mr. H. F. Rafter, F.A.O. Expert, who has been sent to advise the Forest Department on large scale saw milling. It is vitally necessary at this juncture to make the optimum use of valuable capital equipment and we have no doubt that Mr. Rafter, who has just completed a seven year spell in Cambodia, will be of the greatest assistance to this Department.

Congratulations

WE take this opportunity to congratulate Mr. M. Namasivayam on his appointment as Acting Conservator of Forests. After a lapse of nearly six years the Forest Department has again got a technical head.

PRE-SOWING TREATMENT TRIALS ON TEAK

L. C. A. Wijesinghe

INTRODUCTION

THE teak nursery techniques adopted in Ceylon are based on practices prevailing in India. In India itself, there is no standard method in regard to any particular aspect of nursery work; there being variations in the method of pre-sowing treatment, the quantity of seed* sown per bed, the extent to which watering is carried out, and other such nursery operations. This lack of uniformity is due chiefly to two factors, (1) the existence of inherent differences in the germinative capacity and degree of dormancy of the seed collected from different localities, and (2) the climatic variations in the different parts of India. Thus for instance, teak seed from the moister parts of India is found to germinate more readily and therefore requires less intense pre-sowing treatment than seed from drier regions (Griffith, 1942). Because of this diversity of technique it is not easy to decide on suitable standards for Ceylon based on Indian practices unless these methods are subjected to some experimental treatment here, and, as this has not yet been done, the methods now practised here cannot be regarded as being the most suitable.

The need for perfecting our nursery techniques is most urgently felt at the present time as the teak reforestation programme has been stepped up considerably in recent years. In 1954 a total of 310 acres was planted, while in the financial year 1961-62 the figure was 3,720 acres (Administration Reports of the Conservator of Forests, for 1954 and 1961-62). The annual collection of teak seed in the island is about 60,000 lbs., and it costs the Forest Department as much as 90 cents a pound for collection, storage and distribution. This expenditure, together with the cost of maintaining central teak nurseries in different parts of the island accounts for a large portion of the funds voted for reforestation. The need for improving our nursery techniques and thereby economising on nursery costs cannot, therefore, be over emphasised. With this end in view the writer carried out two sets of pre-sowing treatment trials, and these are described in this paper.

Pre-sowing treatment is generally required with teak as the presence of a hard pericarp prevents the ready entry of water into the fruit. The treatment is intended to weather or soften the pericarp before sowing so that there will be no undue delay in germination. Various types of pre-sowing treatment are adopted in India, such as, stacking layers of seed and straw alternately in a pit and watering the stack daily for a week, and alternately soaking and drying the seed for varying periods. The method adopted in Ceylon is the latter of the two mentioned above, the treatment being carried out for two weeks. The seed is put into gunny bags and immersed in water in the night. In the morning the sacks are emptied and the seed spread out under shelter to dry. This is carried on for two weeks after which the seed is sown.

* What is commonly referred to as the teak seed is really an indehiscent fruit, which may contain anything up to four fertile seeds. The term 'seed' is often applied in forestry to the material used for sowing, which, in the case of teak, is the fruit. In this paper the writer will not deviate from this practice, and when he refers to the 'seed', what is meant, unless the context otherwise requires, is the seed together with the enveloping pericarp, i.e., the fruit in the strict botanical sense.

This method of pre-sowing treatment is very tedious especially when several thousand pounds of seed have to be treated as at the central teak nurseries. Besides being tedious and costly (the latter because of the labour involved), this method is also unsatisfactory in that the germination obtained is poor. 15 lb. are sown per bed of 40 ft. by 4 ft., and, as a pound contains about 800 fruits and each fruit about 2 fertile seeds (on an average), each bed receives about 24,000 seeds. Despite this, observations made by the writer at the teak nursery at Monkey Bridge show that there are rarely over 2,000 seedlings per bed. Of course, the number of stumps eventually obtained is much less than this figure as a large number of seedlings get suppressed and do not attain a size suitable for stumping. A more effective method of pre-sowing treatment should improve the germination, and this in turn will result in a larger out-turn of stumps per unit weight of seed.

The object of these trials is to find a simpler and also, if possible, a more effective method of pre-sowing treatment than the one presently employed.

EXPERIMENTS AND RESULTS

Experiment I

METHODS

Four types of treatment were tested, namely—

- (1) Soaking in water for 72 hours,
- (2) Soaking in water for 36 hours,
- (3) Alternate soaking and drying for 7 days,
- (4) Alternate soaking and drying for 14 days (control).

Treatment 1

The seed was placed in a gunny bag, and the bag was put into a trough (4 ft. $\times$ 2 ft. $\times$ 1 ft.) of water. The water was *unchanged* throughout the period of treatment. The seed was sown after 72 hours.

Treatment 2

This was identical with treatment 1, except that the period of treatment was halved.

Treatment 3

The gunny bag containing the seed was placed in a trough of water in the evening. In the morning it was emptied and the seed spread on a cement floor under shelter. This treatment was carried out for a week, the water being changed daily.

Treatment 4 (control)

The method was the same as in treatment 3, but its duration was increased to 2 weeks.

The object of treatments 1 and 2 was to find out how the simple method of soaking in water (for two different periods) compares with the method now employed at the nurseries (treatment 4). The object of treatment 3 was to find whether simplifying the standard 14-day treatment by reducing the period by half would appreciably reduce the effectiveness of the method.

Teak seed collected in 1962 in the Eastern Division was used in the trials.

Nursery beds of the standard size (40 ft. by 4 ft.) were prepared in a section of the central teak nursery at Monkey Bridge. Because of the undulating nature of the land it was not possible to select an absolutely uniform site, and minor variations in the site factors could not therefore be avoided. The beds were dug to a depth of 1 foot, and the stones picked out. The beds were then raised to a height of 6 inches from the general ground level and their sides supported by off-cuts secured to the ground by wooden pegs.

The beds were laid out according to a completely randomized design, with 4 replications of the treatments.

The quantity of seed sown was on the basis of 15 lbs. of the dry seed per bed. Therefore, for each treatment, 60 lbs. of seed was taken, and after treatment, the seed was re-weighed and divided into 4 equal lots, and the 4 beds sown. The commencement of the pre-sowing treatment was arranged in such a way as to make it possible for all the beds to be sown on the same day. Sowing was done on April 1, 1963.

The seed was sown broadcast, gently pressed down, and covered with a layer of soil $\frac{1}{2}$ inch thick. One nursery labourer sowed all 16 beds, and another applied the soil cover. During the first two months the beds were watered twice daily—approximately 20 gallons per bed at a time—except when heavy rains made watering unnecessary. From the commencement of the third month watering was done only once a day. The beds were weeded periodically.

The effectiveness of the method of pre-sowing treatment was judged by making germination counts and comparing the figures from the different beds.

RESULTS

Germination commenced in all the beds about a week after sowing. A germination count was made on April 24, 1963; the results of this are given in Table 1:—

Table 1.—Germination count 23 days after sowing

Treatment	1	2	3	4
Total No. of seedlings	.. 4,275 ..	2,417 ..	1,423 ..	2,948
Mean per bed ..	.. 1,069 ..	604 ..	356 ..	737

The writer was not present when this count was made, and, inadvertently, no record was kept of the counts from the individual beds. It is therefore not possible to make a statistical analysis of these results. However, it is noteworthy that set 1 (72 hours soaking) has the highest average number of seedlings per bed.

A second count was made on May 16, 1963. The result are given in Table 2 :—

Table 2.—Germination count 45 days after sowing

Treatment	1	2	3	4
No. of seedlings	.. 2,165 ..	1,754 ..	229 ..	1,255 ..
	.. 2,228 ..	1,887 ..	660 ..	1,283 ..
	.. 2,273 ..	2,008 ..	320 ..	1,736 ..
	.. 2,497 ..	1,565 ..	781 ..	1,843 ..
Total ..	.. 9,163 ..	7,214 ..	2,190 ..	6,117 ..
Mean per bed	.. 2,291 ..	1,804 ..	548 ..	1,529 ..

A statistical analysis of these results shows that there is a highly significant difference (i.e., at the 1 per cent level) between the following treatments: 1 and 3, 1 and 4, 3 and 4, and 2 and 3; and a significant difference (i.e., at the 5 per cent level) between 1 and 2.

Treatment 1 (soaking in water for 72 hours) is therefore the best of the four treatments tried.

There was no significant difference between treatments 2 and 4. However, it was observed that the seedlings in the beds of treatment 2 were noticeably smaller than those in the control beds, indicating delayed germination in the former set as compared with the latter. In sets 1, 3 and 4 the average size of the seedlings was about the same.

Treatment 3, which was introduced to find out whether simplifying the standard 14-day treatment by halving its duration would cause an appreciable reduction in germination, is in fact found to be very much inferior to the control set; the germination drops to about one-third as a result of halving the period of treatment. This observation indicates that the poor germination obtained in some nurseries might be due to the pre-sowing treatment not being carried out for the full prescribed period.

It was considered most unlikely that further germination counts would give any useful information about the relative merits of the different methods of pre-sowing treatment, since, after a certain period, the weathering action of water and the sun's heat on the seed would be a more potent factor in inducing germination than the pre-sowing treatment carried out some weeks previously. This was confirmed by counts made during the period June to September. The results of a count made on September 7, 1963, are given in Table 3 :—

Table 3.—Germination count 5 months and 7 days after sowing

Treatment	1	2	3	4
No. of seedling	.. 1,808 ..	1,666 ..	820 ..	1,202 ..
	.. 1,868 ..	1,676 ..	944 ..	1,212 ..
	.. 1,876 ..	1,843 ..	887 ..	1,385 ..
	.. 1,880 ..	1,563 ..	993 ..	1,421 ..
Total ..	.. 7,432 ..	6,748 ..	3,644 ..	5,220 ..
Mean for bed	.. 1,858 ..	1,687 ..	911 ..	1,305 ..

Surprisingly, this count indicates a decrease in the number of seedlings in all the beds except those of treatment 3. This is probably the result of die back of some seedlings due to the combined effects of drought and suppression. It should be noted that after the second month watering was done

only once a day, and that during the months June to August the rainfall is very low. As is to be expected, the drop in the number of seedlings is sharpest in the most crowded beds, namely, those of treatment 1.

There was an appreciable increase in the number of seedlings in the beds of treatment 3. This is understandable as these beds were understocked and there was ample room for more seedlings, and furthermore, these beds would have had a larger number of ungerminated seeds than the others.

Even at this stage the number of seedlings in the beds of treatment 1 was higher than in the other sets. However, no importance is attached to this count as far as this experiment is concerned as it appears that after the second count the beneficial effects of the pre-sowing treatment are to some extent vitiated by die back, and the beds where the pre-sowing treatment was most effective have suffered most in this respect. This observation indicates that with good pre-sowing treatment the number of plants produced per unit weight of seed could be increased by reducing the quantity of seed sown per bed to something less than 15 lb.

The most important conclusion from this experiment, then, is that pre-sowing treatment by soaking in water for a continuous period of 3 full days (the water being unchanged throughout this period) is superior to the currently practised method of alternate soaking and drying for 2 weeks; not only is it simpler and more economical to carry out but it also gives significantly better germination.

However, although this experiment shows that soaking in water for 72 hours is the best of the four treatments tried, it does not indicate what the optimum period of soaking is, i.e., it is possible, for example, that soaking for 2 days, 4 days or 5 days might give better results than the 3-day treatment.

Experiment II

METHODS

After the second count in Experiment I was made and the results analysed it was decided to lay out a fresh set of trials with the following four treatments:—

- (1) 120 hours soaking in water;
- (2) 96 hours soaking in water;
- (3) 72 hours soaking in water;
- (4) 48 hours soaking in water.

In order to reduce the work involved, particularly in regard to watering, it was decided to use smaller beds 1/4 the size of those used in Experiment 1. The quantity of seed taken was proportionately reduced. 15 lbs. of seed was taken for each treatment, and, after the appropriate period of soaking, it was divided into four equal lots and the four beds sown. There were four replications of the treatments, but unlike in Experiment I where a completely randomized design was used, in this experiment a randomized block design was employed.

There was no difference from Experiment I in the preparation of beds, sowing, watering and weeding, except that the watering was reduced in proportion to the size of the bed. Sowing was done on July 20, 1963.

RESULTS

A germination count was made on August 8, 1963, the results of which are given in Table 4:—

Table 4.—Germination count 19 days after sowing

	<i>Treatment 1</i>	<i>Treatment 2</i>	<i>Treatment 3</i>	<i>Treatment 4</i>
Block I	93	122	117	151
Block II	123	98	90	122
Block III	65	86	84	104
Block IV	59	62	107	116
Total	340	368	398	493
Mean per bed	85	92	100	123

On application of the variance ratio test it was found that there was no significant difference between the treatments evident at this stage.

A second count was made on September 2, 1963, the results of which are given in Table 5:—

Table 5.—Germination count 44 days after sowing

	<i>Treatment 1</i>	<i>Treatment 2</i>	<i>Treatment 3</i>	<i>Treatment 4</i>
Block I	367	439	317	452
Block II	350	343	300	379
Block III	222	300	306	377
Block IV	237	251	314	351
Total	1,176	1,333	1,237	1,559
Mean per bed	294	333	309	390

A statistical analysis of these results indicates that there is a highly significant difference between treatments 4 and 1, and a significant difference between treatments 4 and 3. Out of the three treatments 1, 3 and 4, the last is the best. Between treatments 4 and 2 there is no significant difference. This is anomalous when we consider the fact that the difference between treatments 4 and 3 is significant. This could only be explained as being due to the presence of variable factors, other than the actual pre-sowing treatment, the effects of which statistical randomization minimises but does not eliminate. One shortcoming in this experiment compared to the first is that smaller beds were used. Any variability due to site differences would therefore be more evident in this experiment than in the first.

The main conclusion from this experiment is that 48 hours soaking in water is a better treatment than 72 hours soaking. In fact one can tentatively take 48 hours to be the optimum period for this method of treatment, subject to confirmation by further work.

It must be noted that no direct comparison between the germination counts of the two experiments could be made as the climatic conditions (e.g., rainfall) during the two periods when the experiments were carried out would have been different.

Discussion

TWO experiments on pre-sowing treatment of teak seed were carried out. The first experiment showed that pre-sowing treatment by soaking in water for a continuous period of 72 hours gives better germination than the currently practised method of soaking for 12 hours followed by drying for

12 hours and carrying this on for a fortnight. The second experiment showed that soaking the seed for 48 hours gives even better results than the same treatment for 72 hours, and that 48 hours appears to be the optimum period for this type of treatment.

The result of Experiment I is surprising in view of the fact that soaking in water as a method of pre-soaking treatment is now rarely if ever practised in India. However, one cannot take this to mean that the method has been experimentally compared with others and found unsatisfactory, as no work appears to have been done to assess the relative merits of the different methods. In India, the actual technique adopted at any centre is based on the experience of forest officers and is not backed by experimental observations.

The commonest method of pre-sowing treatment in India is that of alternate soaking and drying. The main effect of such a treatment would be a weathering of the pericarp, while, the predominant effect of soaking would be softening. Experiment I has shown that, with the seed used, softening is more effective than weathering in breaking dormancy.

While accepting the fact that the teak seed used in Experiment I responded better to soaking than to alternate soaking and drying, the question may be asked as to whether this method could now be applied to the treatment of teak seed at the central nurseries.

In these experiments the procedure adopted in all the nursery operations except for the actual method of pre-sowing treatment, was in accordance with the standard practices in Ceylon. Even in respect of the treatment, the bag of the seed to be treated was placed in a trough of water instead of in the large treatment tank at the nursery in order that the ratio, volume of water/quantity of seed, would be about the same as when several bags are placed in the treatment tank prior to sowing in the nurseries. In these experiments, where the seed was treated by continuous soaking, the water was unchanged. This was done in order to simplify the operation.

The seed used in the experiments was collected in the Eastern Division from where 90 per cent of the teak seed supplies come. There was no information as to the plantation from which the seed was obtained. However, there is no reason to believe that seed from different plantations or localities would react differently to these methods of pre-sowing treatment.

Every effort was made to reduce the effects of variable factors other than the pre-sowing treatment. The sowing and covering of the seed was done by two experienced nursery labourers, each operation being done by one of them. Watering was carefully regulated. However, difficulty was experienced in selecting a suitable site. Because of the undulating nature of the land a perfectly uniform site could not be found, and slight variations in the site factors (such as drainage) could not be avoided. However, this would not have affected the results to any great extent, since the conclusions are based on germination counts taken within $1\frac{1}{2}$ months of sowing. Furthermore, the randomization of beds would have minimised the effects of these variable factors.

Therefore, it is considered that there is sufficient justification for switching over to this method of pre-sowing treatment, at least on a limited scale, for a trial period. Apart from the fact that it is found to give more satisfactory results than the method now practised, its simplicity and cheapness makes it preferable to the present one. The teak seed to be

treated is allowed to soak in water in the treatment tank for 48 hours, after which it is sown. It is hoped that further observations will be made on the results obtained by applying this technique at the nurseries.

It is also suggested that an alternative method of placing the bags of seed in a stream be tried out at some of the smaller nurseries where there are no special treatment tanks. Under such conditions the seed will be less liable to rot than when placed in still water, and it is therefore recommended that the period of treatment be lengthened to say 72 hours.

ACKNOWLEDGMENTS

The writer wishes to thank the instructors and trainees of the Ceylon Forest College for their assistance in carrying out the experiments, and the Statistical Officer of the Forest Department for carrying out the statistical analyses.

SUMMARY

At present the pre-sowing treatment carried out in Ceylon for teak seed is soaking in water for 12 hours followed by drying for an equal period and repeating this process for a fortnight. This method, which is based on Indian technique, is tedious when large quantities of teak seed are treated as at the central teak nurseries, and, besides, the germination obtained is poor.

An experiment was laid out to study the effectiveness of three other methods of treatment as compared with the current method. The methods tried out were (1) soaking in water for 72 hours, (2) soaking for 36 hours, and (3) alternate soaking (12 hours) and drying (12 hours) for a week. A fourth treatment (which consisted of the current method) was added to serve as the control. The first method gave better germination than any of the other three, including the control. This method is more attractive than the current practice also because of its simplicity.

A second experiment was carried out to determine the period of soaking which would give the best germination, and 48 hours was found to be the optimum. It is recommended that this treatment (48 hours soaking in water) be applied, at least on a limited scale for a start, at the teak nurseries.

REFERENCES

- GRIFFITH, A. L. (1942)— *Indian Forest Records Vol. 5, No. 2, Teak Plantation Technique*. Government of India Press, New Delhi.
 Administration Report of the Conservator of Forests for 1954. (1955). Ceylon Government Press, Colombo.
 Administration Report of the Conservator of Forests for 1961/1962 (1963). Ceylon Government Press, Colombo.

POTENTIALITIES OF BEEDI LEAF PRODUCTION IN CEYLON

W. G. Weeraratne

GENERAL

BEEDI is of Indian origin. It is the cheapest form of smoke and is most popular among the poorest class of people. It should, however, not be taken that beedi is preferred only for its cheapness. In India, many persons who can afford to purchase cigarettes smoke beedi because of its peculiar flavour and strength which suit their taste.

A beedi consists of two parts—the beedi tobacco which is the filler and the wrapper which is produced from a jungle leaf. Beedi making is a simple process. It is made by wrapping tobacco (flakes) in a specially prepared leaf and then tying with a common thread.

Up to now, almost all the beedi tobacco and all the wrapper leaves have been imported from India. This is because of the Indo-Ceylon Agreement on Tobacco, whereby manufactured beedies came to Ceylon at a concessional rate of duty. This gave little encouragement for the production of beedi tobacco and wrapper leaf locally in Ceylon. The concessions in this agreement apart from the damage to the Island's Tobacco Industry resulted in a very unfavourable balance of trade, for instance, during 1956, in return for India's acceptance of a quantity of Malayalam chewing tobacco valued at less than 2 million rupees, Ceylon permitted the import of manufactured and unmanufactured beedi tobacco to the value of nearly 12 million rupees.

On 31st August, 1961, this pact was abrogated and it became desirable to produce beedi tobacco and wrapper leaf locally.

In 1962, the Government appointed a Committee "to organise the collection and marketing of locally grown beedi wrapper leaf with a view to self sufficiency."

Domestic consumption of beedi

The domestic consumption of manufactured beedies for the past five years is given below :—

<i>Year</i>		<i>Quantity in lbs.</i>
1958	..	3,383,395
1959	..	4,650,792
1960	..	3,819,501
1961	..	4,800,000
1962	..	4,600,000

In recent years, the demand for beedies has increased considerably due to heavy excise duty imposed on cigarettes. This demand is likely to continue. There is, however, bound to be a shift in smoking preferences and taste on account of higher standard of living, finish and mildness of cigarettes and their availability at competitive rates, depending on the excise policy of the country and industrial advance.

Taking these factors and population increase into consideration, it is estimated that in three years, the local consumption of beedies would be about 4.8 million pounds.

Requirement of beedi leaf

For the production of 4.8 million pounds of beedies, 2.4 million pounds of processed beedi tobacco will be required. On the basis that three pounds of beedi leaf would be required for every pound of beedi tobacco used in the manufacture of beedi, the annual requirement of beedi leaf (at the end of three years) would be over 7 million lbs. It is considered reasonable to estimate the Island's annual requirements of beedi leaf in the next few years at 8 million pounds.

BEEDI LEAF

The beedi plant

A number of indigenous plants are used for beedi leaf production in India. The best and the most suitable type of leaf is, however, obtained from the botanical variety *Diospyros melanoxylon* Roxb. (Ebenaceae—Sinhala—*Kadumberiya*, Tamil—*Karumthumbai*, Indian Languages—*Kendu*, *Tendu*).

The leaf of this plant is generally preferred as beedi wrapper everywhere due to its peculiar flavour, flexible and leathery texture, suitable workability when dried, and resistance to early decay as compared with the leaves of other species such as *Bauhinia racemosa*, *Butea frondosa*, *Castanopsis indica*, *Shorea robusta*, *Careya arborea*, *Cordia myxa*, etc., which have also been used for beedi wrapping on a small extent.

Distribution

In Ceylon the plant *Diospyros melanoxylon* (*Kadumberiya*) is found growing in the Savannah forests of the Uva and the Eastern Provinces. It is found best at Ekriyankumbura and near Buttala. The natural associates of this species are *Aralu*, *Bulu*, *Nelli*, *Gammalu* and *Dawu*. These forests (as in India) are characterised by annual fires due to the heavy infestation of grass. Fires occur in the months of July-August. The above-named species being fire-hardy have survived to maintain their place in these forests.

The forest area carrying the beedi wrapper leaf plant naturally in Ceylon is not as extensive as in India, though the density of these plants in the Ceylon Forests compares favourably with some of the Indian forests which the writer visited. At present local forests carry almost 200 to 300 plants per acre in patches. The density could be increased by clearing round the existing stumps, promoting root suckering and planting out where necessary.

Intensive fire protection in these forests is not advisable since this would bring about a change in the vegetation to a more mesophytic type adversely affecting the regeneration and propagation of *Kadumberiya* and its associates. Though firing of forests is an offence under the Forest Ordinance in India, it is a common sight to see the whole forest area carrying these plants on fire during the season (March/April.) Casual fires are also common in our forests containing this species.

Morphology

Diospyros melanoxylon is a small tree, at times growing into a large straight tree. Trees up to about 40' in height and 3 feet in girth have been located in Ceylon. The leaves are opposite, sub-opposite or alternate, elliptic, coriaceous and varying much in size and form. The upper surface is shining green but tomentose to glabrescent beneath. The fruit is fleshy sweet, edible, 1-1½ ins., globes with 4-6-ovate; triangular acute segments.

A characteristic feature of the tree is the extensive production of root suckers and their hardness and immunity to damage by grazing and fires. Thus, on cleared forest land, sucker growth persists for many years after other species have disappeared, and in areas of abandoned cultivation sucker growth springs up readily and if left alone may result in pure crops.

Propagation

Around large trees regeneration occurs by seed fall, the seeds being fairly heavy. Regeneration also occurs by root suckers.

Artificial regeneration by seed has been experimented with. Observations on artificial reproduction show that transplanting of seedlings raised in nurseries is not always satisfactory owing to the large size of the tap root. It is best to raise seedlings in long narrow baskets and to plant the seedlings along with the basket. Direct sowing in lines has been found to be preferable to transplanting, and lines should be weeded during the first 2 or 3 years.

Experiments are being carried out to ascertain the suitability of growing this species in sites other than those where it occurs naturally. Nursery techniques are also being investigated. Two experimental plots are being maintained at Buttala and Ekriyankumbura.

Indian experiments indicate that this species is a strong light demander and is not frost hardy. It is not suited to arid tracks and cannot stand water-logging. In the Indian Peninsula, it appears to attain its best development on metamorphic rocks.

Pests and Diseases

In India, boring insects *Plocaederus ferrugineus* LINN, *Stromatium barbatum* F, *Xyleborus noxius* Samps., etc., and defoliators *Hypocala rostrata* F, *Lamida carbonifera* Meyr., etc., are found on this species. The leaves of young plants are frequently damaged by the scale insect—*Psylla obsoleta* Buckton.

In Ceylon, a leaf-eating Caterpillar and a Gall forming insect (identified tentatively as *Psylla obsoleta*) have been recorded.

Biological as well as chemical methods of control could be tried out to reduce the infestations.

No BEEDI LEAF MANUFACTURE-

Since the leaf should have an optimum texture the green leaf has to be plucked at a particular time. The leaf should not be too tender nor too mature. Good quality leaf should not have an excess of pubescence on the lower surface. The best quality leaves are those which have turned from crimson to green. The leaves from large trees are unsuitable as they are stiff and brittle. The best leaf is obtained from young coppice shoots and root suckers.

In the trade, there are several qualities of cured beedi leaf designated Nos. 1, 2 and 3. Quality is assessed on the following characteristics :—

- (a) Texture and venation
- (b) Colour and brightness
- (c) Smoothness and pubescence
- (d) Smell and odour
- (e) Size—leaves larger than 9" are not preferred.

Method of Collection

The entire collection of leaves in India is from natural forests and no plantations of the species have ever been raised.

According to Indian practice, trees over nine inches girth are left out as mother trees for seed regeneration.

Small trees of *Diospyros melanoxylon* over six inches girth are cut at heights ranging from two to three feet from ground level in order to obtain a good branch of tender shoots. It has been found that *pollarding* produces better quality and large-sized leaves. Diseased and very young trees are not pollarded. Pollarding should be clean and smooth cut without injuring the main stem.

Plants up to about six inches girth are cut near the ground in order to promote coppice shoots. Coppice shoots produce the best leaves and further it is easier to collect leaves from them. Coppicing enables the plant to take advantage of natural fires. The leaves on the middle part of the coppice shoots are preferred because top leaves are too immature and bottom ones stiff.

From the time of cutting back or coppicing, coppice shoots produce suitable leaves within a period of 35 to 60 days depending on the season. If the coppicing is done earlier in the year, the time taken will be more, if done later, the time will be less. Coppicing is generally done in the months of February and March. About three plucks at equal intervals are carried out in these coppice shoots. A healthy coppice shoot produces about 10 leaves per pluck.

Leaves are also collected from *root suckers* which are about 2' to 3' in height. Cutting back of these suckers is essential in order to produce soft and pliable leaves. The leaves from root suckers are considered to be as good as those from coppice shoots.

Time of Collection

The limiting factor to leaf collection is the monsoonal rains. In India, leaf collection is done between mid-April to mid-June, till the monsoonal rains arrive. Since the collected leaves have to be dried cured in the sun, no collection and curing is possible during the rain.

Since the north-east monsoon rain commences in about September and continues up to about February to March in Ceylon, the optimum time for collection would be after mid-April to early September. However, inter-monsoonal rain should be expected even during this period.

Unexpected rain can cause serious dislocation to drying and curing of these leaves. This happens in India too and causes considerable loss to the industry. On an average 30 to 40 per cent. loss is recognised.

Technique of Curing

The right type of leaves, neither very old nor very young, are collected. In India, the collection of these leaves is done by women and children in the locality as they work better and at cheaper rates. Little instruction is given regarding the type of leaves to be collected except that a nominal control over the quality of leaves is kept by rejecting or marking at lower rates individual collection of leaves.

Before delivery to the collecting centre, the leaves are tied into small bundles, varying from 25 to 200 leaves per bundle. In Hyderabad where the temperatures are higher than in Orissa, a large number of leaves are put in each bundle for drying. The bundles are tied with jungle fibres.

The leaves are not dried singly because they get blown off and also the leaves develop a red tinge which is not desirable. In Ceylon, due to the high atmospheric humidity during curing time, it would be desirable to see that the moisture is dried off the leaf before bundling. This could be achieved by exposing the leaves singly for a short while before bundling.

Drying is carried out in the open. Dry and sunny weather for about a week during the drying period is essential. The bundles are turned over several times during drying. Rainy or dull weather during drying will cause deterioration of the quality of leaves. Proper drying is very important as the quality of the leaf is reduced due to defective drying.

Trial curings carried out have produced satisfactory grades of cured beedi leaf which have been commented on favourably by the local trade. Sample of cured beedi leaf submitted by the local Beedi Manufacturers to the Indian beedi leaf merchants have also been commended on very favourably.

Storage and Packing

The bundles of leaves are stored in go-downs. These are generally cheap wattle and daub structures, and some precautions are taken to guard against rain and termites. The bundles of cured leaves are packed in gunny bags and may be stored for 2 years if in good condition when collected and kept under good storage condition. However, they are said to lose about 50 per cent. of the sale value after one year.

DISCUSSION

Because of the limited area, beedi leaf production in this country will have to be on a semi-intensive scale so as to keep to minimum requirements of forest area and to aim at maximum leaf production. Forest areas should be demarcated and reserved for the exploitation of this product, as well

for the other forest products mentioned which grow in these forests in close association. There is a good case for the "Zoning" out of these forests because of the peculiar ecological characters. Any other agricultural undertaking within a forest Zone such as alienation of land for highland cropping of subsidiary crops should be geared to the scheme of beedi leaf production.

The major zone will be contained in Bibile-Moneragala-Gal Oya catchment—Mannampitiya forest areas. With the opening of the Aluthnuwara-Padiyatalawa super-highway the potential of this area for agricultural development is likely to increase considerably. It will, in fact, become necessary to attract more people into these areas by such deliberate schemes to supply man-power for beedi leaf production. This man power will obtain additional income by employment in beedi leaf production, during the months of April to September which period generally is the off season for highland crops, and when labour is generally idle.

On an estimated annual requirement of 8 million pounds wrapper leaf and on the calculation that an acre of forest will be developed on a semi-intensive scale, to carry 2,000 plants, with an average yield of about 100 pounds per acre, it is estimated that 80,000-acre forest area (i.e. 125 sq. miles) will be required to produce the Island's requirement of wrapper leaf. If the forests could be developed more intensively the acreage required would, of course, be less.

Therefore,

(i) It is necessary to make a "Stock survey" of the forest carrying *Kadumberiya*. A nett area of approximately 125 sq. miles (80,000 acres) of Savannah Forests where *Kadumberiya* occurs, naturally should, thereafter, be reserved for beedi leaf collection and should not be given for any other form of land use.

(ii) In view of the limited extent of forests where *Kadumberiya* occurs naturally, it would be imperative to promote intensive cultivation and to extend existing areas by artificial propagation. The possibility of extending *Kadumberiya* in chenas and under the Co-operative Re-forestation system should be explored.

The Forest Department and the Department of Agriculture could manage a few experimental plots of 10 acres each in different centres of the Island to work out the economics of beedi leaf production on an intensive scale. When this information is available (say in 3 years) the whole beedi leaf production scheme could be reviewed and re-organised, if necessary.

(iii) Since the cultural operations carried out to promote leaf production and curing of leaves are technical, collection should be allowed only to authorised bodies who are capable of carrying out this work.

(iv) Since the areas are Crown Forests under the management of the Forest Department, the Forest Ordinance will apply. As the forests have to be developed, the tenure of the lease could be on a medium term basis. It will be necessary to clear up large non-economic trees to provide a more open canopy for the better development of the *Kadumberiya*.

Along with the harvesting of the beedi leaf, *Aralu*, *Bulu*, *Nelli*, *Gammalu*, etc., which are found in association with this species could also be intensively harvested.

THE CONTRIBUTION OF IMPROVED FOREST UTILISATION TO PRODUCTIVITY IN DEVELOPING COUNTRIES

A. E. K. Tisseverasinghe

INTRODUCTION

ANYONE who has even a nodding acquaintance with tropical forests—particularly the Tropical Wet Evergreen Forest, often referred to as the Tropical Rain Forest, never fails to be struck by the lushness and density of the vegetation in general and the size and height of the trees comprising the forest. Such a situation seems, at first sight, to be ideal from a forestry point of view, but closer knowledge of this Forest type reveals that the lush vegetation is mostly economically valueless, composed as it is of a few valuable species in a matrix of inutilisable trees, shrubs, climbers, etc. The management of this embarrassment of riches is beset with many problems and no universally acceptable solution has yet been devised. Historically, the problem has been simplified into an attempt to find ways and means of increasing the proportion of valuable species by appropriate silvicultural techniques. On the face of it this seems a perfectly sensible procedure, but it is only one way, and not necessarily the best way, of approaching the problem. As Oliphant (1937) has pointed out, this is an illogical approach, because use should come before replacement, but nevertheless, the direction taken by most tropical foresters has been towards devising new methods of regeneration with a view, not so much to increase *total* productivity, as to get a higher stocking of so-called valuable species. A host of new problems have arisen in the wake of these new systems; some ecological, such as the difficulty of raising, or even maintaining, the proportion of valuable species in a forest which is essentially of a seral type, and some economic, such as the difficulties encountered in applying complicated and expensive techniques such as the Tropical Shelterwood system in countries where utilisation is at a low level of efficiency.

These problems however, instead of making silviculturists question the direction in which they were going, only served as fresh challenges to their ingenuity and new methods of increasing the proportion of valuable species are continually being devised. When these methods fail (as they often do unless all the conditions are conducive to success), foresters tend, in despair, to fall back on replacing the perverse natural forest with plantations of exotics.

Many of these difficulties would not have arisen if more attention had been paid to the utilisation of the various species which comprise these forests. If a reasonable proportion of the skill, time and money which have been lavished on silvicultural techniques had been spent instead on testing, treating (where necessary), processing and marketing the so-called valueless species, not only would production from these forests have been enormously increased, but the problems of regeneration would have become correspondingly simpler. The level of production that can be achieved by improved utilisation is more certain and often higher than that which would result from regeneration techniques to favour valuable species.

(1954) has pointed out that in Budongo (in Uganda), sustained yield can be increased by 400 per cent. if only four additional species, viz., *Celtis*, *Chrysophyllum*, *Alstonia* and *Cynometra* were saleable. Other instances of potential increases in productivity will be mentioned later.

Increased productivity from forest areas in the tropics is much more vital than it is in countries where land use and bases of development have been more or less fixed. Most of the tropical forest areas of the world are situated in countries which are commonly referred to as "underdeveloped" or "developing". Nearly all these countries have plans for economic development and if forestry is not able to demonstrate its value by an immediate increase in revenue and thus contribute to National Development, the chances are that other uses will be found for the land. This is being realised by foresters the world over, but trends in forestry are slow to adjust themselves. Dawkins (1954) has given a picture of the shape of things to come: "As the population develops the green blocks on the map are likely to be scrutinised with envious and critical eyes. If they are not earning their keep by supplying the whole internal demand and possibly export as well, their productivity will be compared unfavourably with that of agricultural land and they will inevitably, and perhaps rightly, be whittled away by dereservation 'in the public interest'. The hydrological and climatic arguments for retaining forest will be better understood in the future, but so will other forms of land management, and no potentially arable land can escape an obligation to be productive as well as protective."

As will be shown below, the productivity of tropical forest areas is, in general, pitifully low, and to expect Governments which are usually short of capital and skills, to sink further capital into increasing forest resources in the expectation of a return in the distant future, is unrealistic. This paper is concerned with treating forest productivity from a National point of view. The economic background to the problem will be dealt with and then the contribution which better utilisation can make to increased productivity. Methods of improving utilisation in tropical countries will be discussed and finally, reasons why investment in utilisation should be given priority in a programme of forest development.

The Political Economy of Forestry in Tropical Countries

In many tropical countries the proportion of forests to total land area is high. This does not however mean that all tropical countries are favoured with even the minimum generally considered necessary. For example, in Kenya forest comprises only 3.4 per cent. of the total land area and in Pakistan 3 per cent. (F. A. O. World Forest Inventory—1958). Further, it is also necessary to point out that in many tropical countries where the forest area may be considered high, populations may also be high. An instance is Ceylon, in which although forest area is between 40 and 50 per cent of the total land area, the forest area *per caput* is only one-fourth of the world average of 1.6 hectares *per caput*. Still others may have a very unevenly distributed forest area—the populated parts of the

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country having little or no forest while the forest area is concentrated in the inaccessible and unpopulated hinterland. In Indonesia, Java which has 23 per cent. of its land area as forest contains 72 per cent. of the population, while the outer islands with 70 per cent. of the land area as forest, contains 28 per cent. of the population (von Monroy and Maronne—1954.) It is also necessary to dissipate the commonly held belief (not, of course, among foresters), that most of Asia and Africa is covered with dense forest. The picture is in fact, quite different. Asia comprises one-third of the land area of the world and contains 53 per cent. of the population, but the forest area is only 13 per cent. of the world forest area and in terms of population, Asia has the lowest *per caput* forest area in the world. (Thirawat—1956.) Again, Africa comprises 22 per cent. of the world area but contains only 17 per cent. of the forest area, 25 per cent. of the land area of Africa is covered with forest as compared with 33 per cent. for the world. (F. A. O. World Forest Inventory—1958.)

In countries where the percentage of forest is high, forestry might be expected to make a substantial contribution to National Income. The facts are quite different. In most of these countries the production is depressingly low and the income from forests hardly makes an impact on National Income. For example, according to Thirawat (1956), Indonesia which has 61 per cent. of its land area as forest produces a mere 0.02 cubic metres per hectare per year (0.29 cubic feet/acre/year) of timber as compared with 1.1 (15.7) for the U. S. A., 1.7 (24.3) for Sweden, 1.9 (27.1) for Finland, 2.2 (31.4) for France, 2.7 (38.6) for Japan and 3.6 (51.4) for Germany. This extremely low figure for the production from the forests of Indonesia is all the more inexplicable when it is considered that one of the highest increment rates per acre for any kind of forest has been reached in Indonesia. According to von Monroy and Maronne (1954), *Agathis loranthifolia* plantations in Indonesia produce an annual increment of 15 to 20 cubic metres per hectare (214 to 286 cubic ft. acre)! Even in India where the forests compared to other tropical forests are well managed, and where minor forest produce is intensively exploited, the picture is bleak. The 40 per cent. of the land that is developed to Agriculture produces 50 per cent. of the National Income, while Forestry which covers 22 per cent. of the area, contributes only 0.6 per cent. to the National Income. The net revenue from forests is Rs. 2.50 per acre as compared with Rs. 65 per acre per year in Switzerland, although timber prices are 50 to 100 per cent. higher in India than in Switzerland (von Monroy—1960). In Nigeria, a country which exports substantial quantities of timber, the value of total timber production (excluding firewood) was less than 1 per cent. of the Gross Domestic Product. (Prest and Stewart—1953, quoted by MacGregor—1959).

The position in other tropical countries is, if anything, worse. Table I below gives figures for production per acre per year for a few selected countries. The table has been constructed from figures for total production and forest area obtained from Administration Reports of the countries concerned. Variations are possible since the figures relate only to the relevant year. They are not average figures.

Table I—Production in cubic feet per acre per year

<i>Country</i>	<i>Production</i>	
British Honduras	.. 0.9	(State Forest only) ¹
British Guiana less than	0.2	(All State Forest) ²
French Cameroons less than	0.4	(All high forest) ³
“ “	.. 2.5	(Economically exploitable high forest)
Ceylon	.. 1.3	(Reserves and Proposed Reserves) ⁴
Ghana	.. 1.5	(All forest)
Ghana	.. 7.5	(Closed forest only) ⁵
India—		
Andhra State	.. 0.6 ⁶	
Madras State	.. 0.2 ⁷	
Orissa State	.. 2.0 ⁸	
Malaya	.. 2.5 ⁹	
North Borneo	.. 3.0	(All forest)
“ “	.. 7.5	(Lowland Dipterocarp forest only) ¹⁰

¹ Administration Report of the Forest Department for 1959. (Administration Reports and Annual Reports will be referred to in future by the initials “A.R.”)

² A.R. (1959)

³ Morellet (1954)

⁴ A.R. (1960)

⁵ A.R. (1957)

⁶ A.R. (1960/61)

⁷ A.R. (1958/59)

⁸ A.R. (1956/57)

⁹ A.R. (1959)

¹⁰ A.R. (1959)

The figures for production were obtained from the above by dividing the total production by the area of forest as stated.

The above figures from a cross section of Asian, African and American tropical forests give a fair picture of the deplorably low production from the tropical forest areas. The higher than average figures have been obtained only in countries where Dipterocarps predominate in the Wet Evergreen Forest type, e.g., Malaya and North Borneo. The low average production is *not* the result of low average increments, but is generally the result of incomplete utilisation. There are very few reliable figures for the increment rates of tropical forests. Wadsworth (1954) has stated that in Puerto Rico the net increment was 24.3 to 50 cubic feet per acre per year. In Ceylon, a country in which three-fifths of the forest consists of

low yield dry evergreen forest, a conservative figure for net increment is about 10 cubic feet per acre per year. (Andrews—1961). The actual production in 1960 was, however, between 0.5 and 1.0 cubic feet per acre. (A. R. 1960 for figures of production; total forest area taken into consideration.)

In the absence of reliable statistics it may seem unwise to draw any general conclusions, but it is possible to say that the range of increment of tropical forest which is under management is from about 5-50 cubic ft./acre/year. This is true of Ceylon (except for very extreme forest types). This figure for increment when compared with figures for actual production reveal that the annual production in most tropical countries varies from about a twentieth to about a tenth of the annual increment. The reasons for this state of affairs will be discussed in subsequent sections, but the figures do indicate the enormous scope for improvement in the exploitation of *natural forest*. With better methods of natural regeneration or with the establishment of plantations, the increments will be of a much higher order. In no other form of land use is there such a wide gap between possible and actual production. It should not surprise foresters therefore, when economists give such a low priority to forestry when different uses of land are under consideration. The only factor which saves these countries from even more drastic deforestation is the almost mystical conception of forests as guardians of soil and climate which exists in the lay mind. No other permanent form of land use can afford to be as prodigal of resources as forestry is in most tropical countries.

If it is accepted that the potential increment of most tropical forests is between 5 and 50 cubic feet per acre per year, what is the reason for the extremely low production from these forests? What prevents potential from becoming actual? Many workers have considered this question and have supplied various answers. A common feature of these answers is usually the fact of incomplete and inadequate utilisation. In Assam, Burns (1957) gave as his reason for the low productivity of the forests the following reason: "A few species are in constant demand and thus find a ready market There are however, dozens of other timbers occurring in abundance for which markets should be developed. Very often there are species which are not being used, either because they have first to be properly seasoned or because they require preservative treatment. In the absence of facilities for these operations and a market for treated timber, they have remained unused." MacGregor (1959) summarising the views of the Forest Department of Western Nigeria states: "At present our forests yield an average of less than 300 cubic feet per acre out of possibly 5,000 cubic feet of timber of various species actually standing on each acre of forest land Until such time as the present regeneration operations undertaken by the Forestry Division of this Ministry gave rise to a richer, second crop on the areas which have been exploited, the only permissible means of expanding production from the annual area allocated for exploitation is by greater utilisation of the existing crop, not by an increase of the area annually cut, which would only mean ruin both to the forests of the region and to the industry which shortsightedly demands it." In most tropical forest areas incomplete utilisation appears to be rapidly becoming the limiting factor to better management.

In Ceylon, the utilisation pattern has changed considerably in the last few years, but there is still plenty of scope for improvement. Enumerations based on aerial survey carried out in 1960 have shown that one of

the most frequently occurring trees in the Wet Evergreen Forest is Kataboda (*Cullenia ceylanica* (Gardn.) K. Schum. and *C. rosayroana* Kosterm). These two very similar species constitute 4.5 per cent. of the total growing stock of the Wet Evergreen Forest but are not presently utilised. Tests carried out by the writer indicate that in strength and working properties Kataboda is in no way inferior to the commonly used, general purpose softwoods (Tisseverasinghe—1963). It is also relatively permeable to wood preservatives. There is therefore no apparent reason why this species should not be commonly used. Another very frequent species is Katukenda (*Scolopia acuminata* Clos.) which again is not used. To what an extent productivity can be increased by using these frequently occurring species can be imagined. Similar problems exist in all other tropical countries. In Bolivia according to Berthon (1954), Mara (*Swietenia* spp.) is the most important species and only five others are used in limited quantities. In British Guiana, two-thirds of the total production was contributed by Greenheart (*Ocotea rodiaei*) and nearly one-fourth by five other species. (A. R. 1959). In Uganda, according to Swabey (1954), of 200 species growing to timber size, 92 per cent. of the production from Reserved Forests came from 20 species and 70 per cent. from five species only. In British Honduras, four species constituted 90 per cent. of the total production.

Oliphant was one of the earliest foresters to stress the importance of increasing production by utilisation of secondary species and to suggest practical means of achieving this object. Malaya's good record in the field of timber utilisation as compared with other tropical countries, is perhaps a result of this early influence. "The technique of use, or utilisation, is of more immediate importance in such regions (tropical forest areas) and logically precedes the technique of replacement or silviculture; though there is a tendency to consider these two main aspects of forestry in the reverse order." (Oliphant—1937).

In the same paper, Oliphant also focussed attention on the application of basic economic laws to the problem of forest utilisation, e.g., "Inadequacy of marketing facilities, often cited as an important contributory cause, is generally a very secondary one: the tendency to stress marketing and neglect production is based on a process of inverted reasoning similar to that which puts silviculture before utilisation." And again: "The only line of attack that can be expected to yield rapid results is the development of better utilisation methods in application of the familiar principle that lowered prices of produce mean increased consumption." This is indeed a familiar principle and is adopted to some extent when fixing royalties for forest produce, but what Oliphant called "the process of inverted reasoning" is actually the result of neglecting a not so familiar principle which is, that supply creates demand. Most people are familiar with the principle that if there is a demand for a particular class of material, it would begin to be produced. What is often forgotten is the reverse operation of the law. This cyclic nature of supply and demand is of great importance and in fact, the reverse operation of the law is a commonplace occurrence. For example, the demand for soapless

detergents arose after they began to be produced in quantity and the position in respect of Polythene is similar. Foresters and timber merchants who complain of lack of demand for secondary species will often find that it is impossible for a consumer who wishes to buy sawn timber of secondary species, to obtain it in the timber market.

Experience in marketing timber in Ceylon, where production and marketing are handled by the Forest Department, has shown that almost any reasonably durable species can be sold provided firstly, that adequate quantities of sawn timber of these species are made available, and secondly that unlimited quantities of the preferred species do not flood the market. Non-durable timber treated with preservatives can also be sold if the price differential is attractive enough. (The prices of timber in Ceylon are fixed with a view to encouraging the use of the lesser known species. This policy, together with the publication of information on the characteristics and uses of these timbers has contributed to improved utilisation.)

It must be pointed out here that it is idle for the Forest Departments of the different countries to persuade consumers to use lesser-known timbers, unless other Government Departments are prepared to set an example. No consumer is likely to be converted by a Forest Department campaign while at the same time Public Works Departments, Railways, Port Authorities, Postal Departments and so on, insist on using only preferred species. The campaign of persuasion should start with the latter class of consumer. In Ceylon, in 1960, twenty new species were accepted as suitable for the manufacture of furniture for Government Departments. In the past, only four species were regarded as acceptable. Similarly the Ceylon Government Railway extended its list of species for use as sleepers from seven to sixteen. (A. R. 1960).

Increasing Productivity by Better Utilisation

The need to utilise new species should not blind foresters to the possibility of increasing productivity by making better use of the trees which are presently being felled. The first step in improving utilisation is the elimination of waste which occurs in felling, logging, extraction, conversion, storage and sale of timber. The extent of waste in the different countries would probably vary widely, but there is hardly a single tropical country which can claim to have brought down waste to the economically irreducible minimum. Aguilov and Suarez (1950) say of the Phillipines that only one-third of the volume of a tree which is felled forms usable timber. 23 per cent. is left in the forest and 43 per cent. is lost in conversion. Burns (1957) showed that in Assam 30 per cent. of the volume is left behind in the forest in the form of high stumps, tops and branches, and that the saw-milling industry operates at only 50 per cent. efficiency. The records of other tropical countries are likely to be no better.

Waste starts in the act of felling trees. In many tropical countries, felling is still carried out by axe alone. This results in the wastage of a proportion of the volume of the tree. A portion of timber, approximately equal in

volume to the volume of a cylinder (of height equal to the distance between the top and bottom of the felling notch), less the volume of a neiloid contained within it, is lost in the process of felling. The actual volume of timber lost depends on the diameter of the tree being felled and the angle of the felling notch. Assuming a constant angle of 45 degrees (the angle may increase with increasing diameter of the tree to be felled), the amount of timber lost in felling is shown below :

Diameter of tree : 1' 1' 6" 2' 2' 6" 3'

Water in cubic feet : 0.26 0.88 2.09 4.09 7.07.

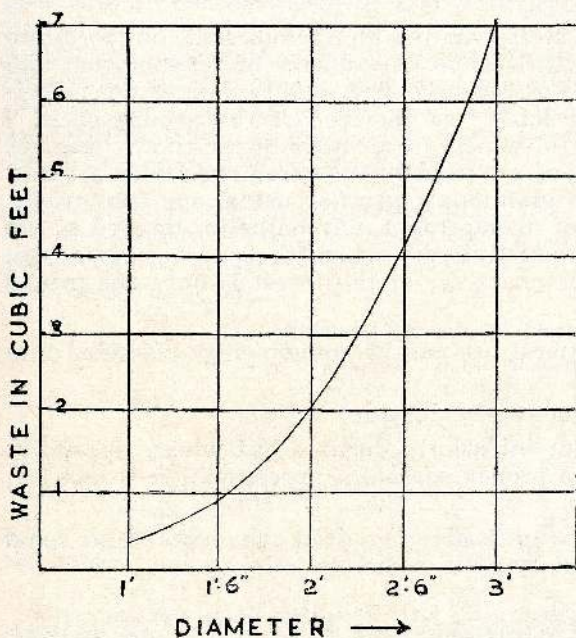


FIGURE 1

The graph in Figure 1 indicates how steeply the amount of waste increases with increasing size of tree. When it is realised that high stumps are also likely to be left when felling large trees by axe alone, the false economy of using unskilled fellers or inadequate equipment becomes apparent.

The use of axe plus saw in felling reduces the waste to negligible proportions; the stump need not be high and buttressed trees can be much more easily dealt with. The use of saws also enables the direction of fall of the tree to be more closely controlled and will thus reduce damage to the standing crop—a consideration which is most important in forests which are being worked on the Selection System.

Waste during logging occurs from two sources. Firstly the waste involved in leaving behind the small diameter logs in the forest and secondly the waste involved in cross-cutting by axe instead of by saw. Serevo (1938) and Tryon and Smiley (1945) showed that the percentage loss increased with size when cross-cutting by axe. Using a saw has the further advantage of providing flat surfaces which can be easily coated with water proofing compounds to prevent splitting and consequent degrade.

The question of the type of saw to be used in converting the logs is complex and many factors have to be taken into account before a decision is made. In many tropical countries handsawing is carried out, and in certain circumstances, this may be preferable to the use of circular saws which are commonly used in the tropics. The writer showed earlier (Tisseverasinghe—1959), that the saving in the loss in conversion compensated for the increased cost of handsawing if the timber itself were valuable. It is necessary to dispel the illusion that handsawing is primitive and therefore inefficient. It is inefficient only in respect of time and if wages are low, it may turn out to be the most efficient method. It is

usually forgotten that in countries with a shortage of resources, output per unit of resource takes precedence over output per man. In the course of development the latter will become important, but a technology which takes cognizance of both needs is preferable in the fairly thickly populated underdeveloped countries.

The above points have been considered at some length because so much can be done to increase *net* productivity from the trees already being felled without the expenditure of large sums of money.

From the utilisation point of view, any further increase in productivity can only be achieved by making use of species not so far used.

It may seem unnecessary to stress what is an obvious fact, but foresters tend to become preoccupied with technical problems of regeneration and thus confuse ends and means. For example, Pitt (1961) defines the principal object of management as being "to replace a forest composed of a large number of species, many of which are of little or no known use and in which the more useful species are usually the rarer ones with a forest composed of a large number of individuals of a few useful and very useful species." The principal object of management may be better defined as the achievement of the highest productivity of which the site is capable, on a sustained basis. Changing the character of the forest is only one means of achieving this.

Species which are not in general use can be conveniently classified into three groups :

- (a) Timbers which are inherently durable.
- (b) Timbers which are not inherently durable but whose durability can be improved by proper seasoning, preservative treatment, etc.
- (c) Timbers which can be utilised only after conversion into some other form—plywood, particle board or pulp.

Almost every tree species of reasonable form will fall into one of these classes—only a negligible proportion of the growing stock need be treated as completely useless.

In the case of species which are inherently durable but which are not used, a campaign of education, persuasion and *example* would normally achieve the result of increased utilisation. The importance of this cannot be over emphasized. Most tropical forest departments have little direct contact with the consumer since retail selling is not part of their business. The timber merchants who do the retailing are naturally interested mostly in their profit margin—if they can make profits by selling, say, European conifers, they will deal in that commodity rather than spend their energies on popularising the indigenous secondary woods. It is the Forest Department therefore which must consider the needs of the country and take the initiative in this campaign. Prices could also be reduced at the early stages of introduction of the species into the market until the timber establishes a reputation for itself. The number of such species would not normally be very large ; durable timbers often remain unused because of factors such as difficulty of sawing or floting which can be taken care of by improved methods of extraction and conversion. A much larger proportion of species remains unused because they are not durable *under certain conditions*. This qualification is most important because durability is such a relative term ; quite often a species of timber which is commonly

regarded as non-durable will be suitable for indoor use or under other conditions where it is not likely to be exposed to weathering and agencies of decay. It is also usually possible to use non-durable timber for purposes where durability is not absolutely necessary, e.g., for concrete shuttering.

If durability is a necessary quality, there is no alternative but to treat the timber. For this purpose, brush coating, spraying or even soaking in preservatives is not usually sufficient. The timber will have to be subjected to hot and cold treatment or to pressure treatment. Although the former method is cheaper (in capital cost), the output cannot be very high because the process is so lengthy and the method itself cumbersome. Pressure treatment remains therefore as the most feasible means of increasing production. The factor which prevents more general use of pressure impregnation is the high capital cost of the plant. However it is not generally realised that in plants of this kind, the output per unit of capital is very high and such investments are very desirable in developing countries, which are usually short of capital.

In Ceylon a large impregnation plant has been operated for some years and the figures below give an indication of the high level of production which can be achieved. The initial cost of the plant was approximately Rs. 600,000.

Output of Impregnation Plant in Ceylon

Year	Sleepers* (Nos.)	Sawn Timber (cu. ft.)	Transmission Poles (Nos.)
1956	.. 52,384 ..	?	?
1957	.. 51,395 ..	17,631	231
1958	.. 51,191 ..	11,717	613
1959	.. 67,403 ..	20,000 (Approx)	?
1960	.. 44,707 ..	?	?

*Mostly Broad Gauge sleepers of approximately 3.1 cubic feet each. (Figures from A.R.R. 1957—1960).

The species used hitherto for impregnated sleepers has been Hora (*Dipterocarpus zeylanicus* Thw.) This species is not durable in the open without treatment. Taking only the output of impregnated sleepers into account and assuming that an average of 60,000 sleepers can be treated annually, the value of the output at selling price is Rs. 1,320,000 (at Rs. 22 per sleeper). Assuming that the value of an untreated sleeper is Rs. 15 the value added as a result of impregnation is Rs. 7 per sleeper or Rs. 420,000 annually. This gives a capital/output ratio of 1.43! In developed countries this ratio on average, is in the region of 4. i.e., in order to get an increased output of Rs. 420,000 capital amounting to nearly Rs. 1,800,000 will have to be invested. Investments such as this, which produce a high output per unit of capital can make a very real and immediate contribution to economic development in underdeveloped countries.

Whether similar conditions exist in other countries it is not possible to say, but it is certainly worth investigation. It will be noted that in the calculation above, the actual cost of the treatment has not been taken into account. This will, of course, have to be done before deciding on the economics of operating a plant. It might also be argued that chemicals used as preservatives have usually to be imported and that thus, the increase in value obtained after treatment is not a net increase. In Ceylon, the position is that until 1956, sleepers were imported into the country. In fact, for the period 1948 to 1956 a total of nearly Rs. 28,000,000 of foreign

exchange was spent on the import of sleepers. In 1957, as a result of producing the full sleeper requirements of the country locally, the saving of foreign exchange amounted to approximately Rs. 3,000,000 (A.R. 1957). The import cost of creosote is a negligible amount compared to this. In countries which export timber, the use of treated timber locally will release that such more preferred timber for export and there will thus be a net gain. These matters however, will have to be considered in detail for each country; the capital/output ratio calculation was made only to show that the high capital cost of an impregnation plant need not be an insuperable obstacle to its more general use.

There will always be a residue of species which cannot be used even after treatment, perhaps due to inherent lack of strength or other causes. Such species will have to be converted into other products such as plywood, particle board, fibre board or pulp if full utilisation is to be achieved. Many tropical countries such as India, Ceylon and Nigeria manufacture plywood and there do not seem to be any technological arguments against expansion of this industry. Not only would this help to make use of inferior species, but the better quality logs of superior species which are at present sent abroad for peeling and slicing can be more advantageously used to make face veneer within the country.

The question of particle board and fibre board is more complicated. It is generally argued that the manufacture of these require a high level of technology and also that capital costs are very high since only high-output mills are economic. These matters require a great deal of detailed study—always keeping in mind the crucial differences between developed and under-developed countries. The former countries tend to adopt capital-intensive methods of production and such methods are difficult to adopt in tropical countries. Whether it is possible to make these processes more labour-intensive and thus perhaps more economic for under-developed countries, has to be investigated. However some tropical countries have already established particle board plants—e.g. Indonesia and British Guiana. New methods of manufacture which can reduce costs can only be developed when tropical countries which have different problems, begin manufacture themselves. South African experiments in particle board manufacture are an example of this. Resin is the more expensive component of particle board, and in fact, the cost of Phenol-formaldehyde resin (which has to be used if the board is likely to be exposed to damp conditions), is high, and this cost may make all the difference between the manufacture being economic or not. Parrish (1958) reported that it was possible to make a Phenol-formaldehyde resin suitable for bonding particle board from wattle bark extract, which contains Phenol. In fact this resin, if made directly from wattle bark, was cheaper than imported resin.

In the case of paper pulp, it had hitherto been thought that only restricted categories of wood were suitable for conversion into pulp. also that only large-scale plants were economic. Modern processes are however, now available to make use of almost any timber tree of reasonably good form. So far in the tropics, hardly any pulp from wood has been manufactured. In this field, unless some technological breakthrough makes it possible to reduce the size of mill which is considered the economic minimum, the prospects for pulp manufacture are not good, except in countries which are exceptionally well favoured from the point of view of cheap timber and markets for pulp. In the tropics the availability of abundant supplies of water and means of disposal of effluents are major problems.

Increasing Productivity by Establishing Plantations

It is generally accepted that clear felling and planting will provide the maximum productivity in tropical forests. There are however, several economic reasons why this cannot be adopted on a large scale in under-developed countries. Firstly, the capital cost of reforestation is very high and secondly, the time taken for the investment to mature is very long. This second consideration is most important. Classical Forest Economics tends to stress percentage net yield, because for an individual owner this is the most decisive consideration. If the percentage net yield is higher than the rate at which money can be borrowed, then the investment is worthwhile. It is a mistake to extend this proposition to National Policy merely because it is true for an individual owner—an instance of the fallacy of composition in logic. A producer of timber from a single forest operates under conditions approaching perfect competition while Forest Departments generally operate under monopoly conditions. Further, Forest Policy must take cognizance of National Development Plans. In a highly developed country like Britain, with a large population and a relatively small forest area, accelerated planting programmes are necessary, but in a country like say, British Honduras, with a population of less than 100,000 and with 80 per cent. of the land under forest, it is not sound economics to embark on an ambitious planting programme. The pointed criticisms made by Jack Downie, of the Forest Department's planting's programme, quoted in A. R. 1959, show that although the estimated return was 8 per cent. and the interest rate 6 per cent yet an economist would not approve of such a programme. The soundest policy for an under-developed country is to try to achieve an immediate increase of productivity by better utilisation and to plough back part of this increase into raising plantations.

SUMMARY

This paper discusses the extent and productivity of forests in under-developed tropical countries and points out that the levels of productivity in these forests are very low. It is suggested that an immediate increase in productivity can be achieved by improved utilisation, and methods of achieving this object are discussed. It is further suggested that capital investment in improving techniques of utilisation is more desirable in an under-developed country than expenditure on reforestation.

REFERENCES

- AGUILAR AND SUAREZ (1950)—Nature and extent of logging and saw milling wastes and how to minimise them. Proc. 1950 Foresters Conference. Reported in Philippine J. Forestry Vol. 7-8 1950/51. 138-139.
- ANDREWS (1961)—A forest inventory of Ceylon. A Canada-Ceylon Colombo Plan project. Government Press, Ceylon. 1961.
- BERTHON (1959)—Informe al Gobierno de Bolivia sobre la creacion de nuevas industrias y la modernizacion de los aserraderos. FAO/ETAP Report No. 962. pp ii & 127.
- BURNS (1957)—Report to the Government of India on the development of forest industries in the State of Assam. FAO/ETAP Report No. 630 pp. 83.
- DAWKINS (1954)—The productivity of Uganda high forest. Uganda For. Dep. Tech. Note 3/1954 pp. 3.

- MACGREGOR (1959)—Some economic problems of forestry in Western Nigeria. A report to the Government of Western Nigeria. (Unpublished) pp. ii & 184.
- MORELLET (1954)—Rapport General du Cameroun Francais. Proc. IV World Forestry Congress. Vol. III. Dehra Dun 1954. pp. 12-21.
- OLIPHANT (1937)—The development of more intensive use of mixed tropical forest. Emp. For. J. Vol. XVI No. 1 pp. 28-39.
- PATERSON (1956)—The forest area of the world and its potential productivity. Goteberg pp. 216.
- PITT (1961)—Possible methods of regenerating and improving some of the Amazon forests. Caribbean For. Vol. 22 Nos. 1/2. pp. 26-32.
- SEREVO (1938)—Losses increased in bucking by axe. Phillipine J. For. Vol. 1. pp. 127-149.
- SWABEY (1954)—Forest productivity in Uganda. For. Dep. Uganda Tech. Note No. 9/54. pp. 9.
- THIRAWAT (1956)—The value of Eucalypts in Asia. Indian For. Vol. 82. pp. 66-667.
- TISSEVERASINGHE (1959)—The economics of sawing. Ceylon For. Vol. 4.
- TISSEVERASINGHE (1963)—The utilisation of Kataboda (*Cullenia ceylanica*). (Gardn.) K. Schum. Comm. For. Rev. Vol. 42 (2) No. 112.
- TRYON AND SMILEY (1945)—Chips or sawdust? J. For. Vol. 43.
- VON MONROY (1952)—Report to the Government of Burma on integration of forests and industries. F.A.O./ETAP Report No. 16. pp. 205.
- VON MONROY (1960)—Report to the Government of India on integration of forests and forest industries. F.A.O./ETAP Report No. 1298. pp. 157.
- VON MONROY AND MARONNE (1954)—Report to the Government of Indonesia on a preliminary pulp and paper survey. FAO/ETAP Report No. 294. pp. 51.
- WADSWORTH (1954)—Tropical Rain Forest. Proc. IV World Forestry Congress Vol. III. Dehra Dun. 1954. pp. 119-129.

AN INVESTIGATION OF THE RELATION BETWEEN THE QUANTITY OF SEED* SOWN AND THE OUT-TURN OF STUMPS IN TEAK NURSERY WORK

L. C. A. Wijesinghe

INTRODUCTION

AT present it is the practice in the teak nurseries of Ceylon to sow 15 lb. of seed per bed of 40 ft. by 4 ft. The average out-turn of stumps is about 700 per bed in a well managed nursery. On this basis, the out-turn per pound of seed is 46.7. This appears unsatisfactory as a pound contains about 1,600 seeds (i.e., about 800 fruits with an average of 2 seeds per fruit). The germination percentage is much better than the production of stumps indicates, and, when the nursery stock is removed from the beds for stumping, it is found that there are large members of undersized plants which are discarded.

With about $1\frac{1}{2}$ million teak stumps being produced annually at great expense at the Forest Department nurseries, it is necessary to examine critically the nursery techniques and practices now adopted and to devise ways of increasing the output of stumps in relation to the money spent. The figures quoted above suggest that one of the ways in which this could be done is by increasing the out-turn of stumps per pound of seed sown. The present investigation is an attempt to find the effect of reducing the quantity of seed sown on the out-turn of stumps, and from the data obtained to find out the optimum quantity of seed to be sown per nursery bed.

Methods

The experiment was carried out at the central teak nursery at Monkey Bridge. Though it was desirable to select a uniform site for laying out the experiment, the terrain was such that it was not possible to avoid making the beds on slightly undulating ground.

16 nursery beds of the standard size (40 ft. $\times$ 4 ft.) were made. 4 seed quantities with 4 replications of each were used, and the experiment was laid out on a completely randomized design. The 4 seed quantities were :

6 lb. per bed	..	.. (A)
9 lb. per bed	..	.. (B)
12 lb. per bed	..	.. (C)
15 lb. per bed	..	.. (Control, D)

Seed collected in the Eastern Division in 1962 was used. It was weighed dry and then given the standard pre-sowing treatment of alternate soaking (12 hours) and drying (12 hours) for 2 weeks. The results of the experiments on pre-sowing treatment carried out by the writer and

*See footnote on page 4. The same applies to this paper too.

reported elsewhere in this volume were not known at the time of commencement of this experiment and hence the standard pre-sowing treatment was given.

Sowing was done on April 1, 1963. The seed was sown broadcast, gently pressed down with a board and covered with about $\frac{1}{2}$ inch of earth. The two operations, sowing and covering with earth, were done by two experienced nursery labourers, each labourer doing one operation. During the first two months the beds were watered twice daily (each bed receiving 20 gallons at a time), except during rainy weather when no watering was done. From the third month onwards the beds were watered once a day. Weeding was done periodically when necessary.

The plants were uprooted on October 8, 1963. They were graded according to the diameter at the base of the stem and counted. The counts from the 16 beds were recorded separately.

Results

The plants were divided into two lots, namely—

- (a) plants with a diameter of over $\frac{1}{3}$ inch, and
- (b) plants with a diameter of under $\frac{1}{3}$ inch.

The counts are given in Table 1:—

Table 1.—Number of Plants per bed after grading into (a) over $\frac{1}{3}$ in. and (b) under $\frac{1}{3}$ in. in diameter

	A (6 lb. per bed)		B (9 lb. per bed)		C (12 lb. per bed)		D (15 lb. per bed)	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
	449 ..	506 ..	472 ..	720 ..	443 ..	915 ..	635 ..	1,176
	397 ..	457 ..	447 ..	782 ..	521 ..	892 ..	524 ..	1,600
	410 ..	440 ..	491 ..	663 ..	551 ..	954 ..	562 ..	1,162
	345 ..	381 ..	441 ..	492 ..	513 ..	1,060 ..	456 ..	1,023
Total ..	1,601	1,784	1,851	2,657	2,028	3,821	2,177	4,961
Mean ..	400.3	446.0	462.8	664.3	507.0	955.3	544.3	1,240.3

There were very few plants with a diameter of over 1 inch, and even these were not too large for stumping.

Stumps with a diameter of less than $\frac{1}{3}$ inch are generally regarded in India as being unsuitable for planting (Griffith, 1942), hence the grading in this experiment into plants above and below $\frac{1}{3}$ inch in diameter. However, as the grading was in progress it was found that a fair proportion of plants falling into the smaller diameter class had well developed tap roots and would make quite good stumps. Such plants had a diameter of only slightly less than $\frac{1}{3}$ inch, and they would not have been discarded in normal planting work. It was therefore decided to divide lot (b) into utilizable plants and rejects. This was done as follows: The plants were divided into two groups, (i) plants with a diameter of over $\frac{1}{3}$ inch at the widest point of the root and (ii) those with a diameter of less than $\frac{1}{3}$ inch. All the plants of lot (ii) were found to be undersized and were therefore treated as rejects. Now, 1,000 plants of lot (i) were taken and sorted into usable plants and rejects by eye assessment by an officer with wide experience in teak planting work. It was found that 28 per cent. of these plants were suitable for stumping. In order to test this method of

assessment, it was repeated with a fresh lot of plants and it was found that the percentage obtained was not much different. Therefore, 28 per cent. of the plants with a diameter of less than $\frac{1}{3}$ inch at the base of the stem and over $\frac{1}{3}$ inch at the widest point of the root were taken as being suitable for stumping and a fresh computation made of the utilizable plants and rejects in each bed. The figures are given in Table 2. This table is considered to give a more accurate estimate of the out-turn of plants suitable for stumping than Table 1:—

Table 2.—Estimated out-turn of (a) plants suitable for stumping (= stumps) and (b) undersized plants

	A		B		C		D	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
	522..	433..	570..	622..	567..	791..	786..	1,025
	496..	385..	573..	656..	650..	763..	742..	1,382
	467..	383..	584..	570..	684..	821..	701..	1,023
	386..	340..	485..	448..	674..	899..	583..	896
Total ..	1,844	1,541	2,212	2,296	2,575	3,274	2,812	4,325
Mean ..	461.0	385.3	553.0	574.0	643.8	818.5	703.0	1,081.5

The figures in Table 1 indicating the number of plants with a diameter of over $\frac{1}{3}$ inch and in table 2 giving the number of plants suitable for stumping were statistically analysed. The results of the analysis are as follows:

Table 1.—There is a significant difference at the 1 per cent. level between A and D, and a significant difference at the 5 per cent. level between A and C, and B and D.

Table 2.—There is a significant different at the 1 per cent. level between A and C, A and D, and B and D.

The production of stumps per pound of seed was calculated for each of the 4 sets. The results are given in Table 3:—

Table 3.—Production of stumps per pound of seed

A		B		C		D	
..	76.8	..	61.4	..	53.7	..	46.9

Finally, the number of pounds of seed required to produce 1,000 stumps was calculated for each of the 4 seed quantities. The figures are given in Table 4:—

Table 4.—Number of pounds of seed required for producing 1,000 stumps

A		B		C		D	
13.0	..	16.3	..	18.6	..	21.3	

DISCUSSION

The mean out-turn per bed of plants suitable for stumping is 703.0 for beds sown with 15 lbs. of seed (Table 2). This represents the normal out-turn obtained from other teak nurseries as the various operations and their timing in this experiment were the same as in those teak nurseries

A striking feature of the plant counts is the large number of undersized plants, particularly in those beds sown with 15 lb. of seed, where the mean per bed is 1,081.5. It should be noted that all the plants, irrespective of their size, were uprooted and a large proportion of those rejected consisted of weak, etiolated and suppressed plants. Their numbers dropped sharply with decrease in the quantity of seed sown per bed, the mean number of rejected plants in the 6 lb. beds being 385.3.

The statistical analysis which was carried out indicates that the out-turn of stumps from the 15 lb. beds is significantly higher than that from the 9 and 6 lb. beds, but not significantly different to that of the 12 lb. beds. Although the difference in the production of stumps between the 15 lb. and 12 lb. beds was not found to be statistically significant it is doubtful whether one could assume that there is no difference between these two for the same applies to all the adjacent sets (6 lb.; and 9 lb.; and 12 lb.; and 12 lb. and 15 lb.). It is very probable that the differences between the adjacent sets are too small to prove significant unless more replications are used. It may be noted that though the 15 lb. sowing is superior to the 9 lb. (D and B), the 12 lb. and 9 lb. are not significantly different. This indicates that the out-turn of stumps from the 15 lb. beds is superior to that from the 12 lb. beds.

Taking the means of the out-turn of stumps from the 4 sets (Table 2), it is observed that there is a drop in the production of stumps with decrease in the quantity of seed down per bed; but what is important is that the decrease in production bears no proportion to the reduction in the quantity of seed sown. This is clearly indicated in Table 3 which gives the out-turn of stumps per pound of seed. The out-turn is highest (76.8) with 6 lb. per bed, and it drops to 46.9 with 15 lb. per bed. This same general trend can be seen in the figures for the out-turn of stumps in different parts of India, (Griffith, 1942). The data for Madras, Coorg and Orissa given in the table below are from figures published by Griffith, while the figures for Ceylon are from this experiment.

		<i>Lb. per sq. yd. sown</i>		<i>Stumps per lb. of seed</i>	
Madras	..	..	1 to 2	..	60
Orissa	..	..	.05	..	140
Coorg	..	..	3.0	..	12
Ceylon	..	..	.34 (A)	..	76.8
			.51 (B)	..	61.4
			.68 (C)	..	53.7
			.84 (D)	..	46.9

If economy in the use of seed was the main consideration in teak nursery work then 6 lb. per bed would be the best of the 4 quantities tried, since it gives the highest return per pound of seed. Thus, 1,000 stumps would be produced by 13 lb. of seed with 6 lb. per bed as against 21.3 lb. required to produce the same number of stumps with 15 lb. per bed; the saving

is 8.3 lb. of seed for every 1,000 stumps produced. However, with less seed sown per bed, the production of stumps per bed falls, and to produce a particular number of stumps an increased amount of bed space will be required. Thus, if the quantity sown is reduced from 15 lb. to 6 lb. the number of beds will have to be increased by about half and the cost of nursery maintenance will rise in approximately the same proportion. In order to compare the relative merits of using the 4 seed quantities the comparative costs of producing 1,000 stumps were calculated (see appendix). The costs are as follows:—

				<i>Rs. c.</i>
6 lb. per bed	..	..	..	50 76
9 lb. per bed	..	..	..	47 25
12 lb. per bed	..	..	..	44 64
15 lb. per bed	..	..	..	44 73

From these figures it is seen that there is a slight financial gain in using 12 lb. per bed instead of 15 lb., and that 12 lb. appears to be the optimum of the 4 quantities. The calculations were based on the assumption that watering is done manually; but as the central nurseries are now being equipped with mechanical watering devices, the cost of maintenance should decrease and the saving in sowing 12 lb. per bed instead of 15 lb. should be greater than indicated above.

Another distinct advantage is using less seed per bed is that, with the resulting increase in the production of stumps in relation to the seed weight, a greater production of stumps could be obtained from the available stocks of seed.

ACKNOWLEDGMENTS

The writer thanks the Instructors and the trainees of the Ceylon Forest College and Mr. S. Kathiresu, Range Forest Officer, for their help in carrying out this experiment, and Mr. D. F. S. Fernando, Statistical Officer, Forest Department, for carrying out the statistical analyses.

SUMMARY

With a decrease in the quantity of seed sown per bed there is a drop in the out-turn of stumps per bed but an increase in the out-turn per pound of seed. The first effect is disadvantageous as more bed space will be required to raise a given number of stumps, while the second effect is advantageous as the seed will be used more economically. Considering the financial aspects of both effects, the best of the 4 seed quantities tested (6 lb., 9 lb., 12 lb., and 15 lb.) was 12 lb. per bed.

REFERENCE

GRIFFITH, A. L. (1942)—*Indian Forest Records*, Vol. 5, No. 2: *Teak Plantation Technique*. Government of India Press, New Delhi.

APPENDIX

Calculation of the comparative costs of producing 1,000 stumps using 4 different quantities of seed per bed (6 lb., 9 lb., 12 lb., and 15 lb.).

(a) Cost of maintenance (per bed).

	<i>Rs.</i>	<i>c.</i>
(i) Cost of formation	4	0
(ii) Cost of manuring (annual expenditure) ..	1	0
(iii) Cost of labour for April and May (proportion per bed) ..	6	0
(iv) Cost of labour for the period, June to 10, October ..	6	50
(v) Cost of equipment (watering cans, etc., proportionate expenditure per bed)	50	
Total ..	18	0

The above estimate is based on observations made by the writer at the Monkey Bridge teak nursery. It is estimated that for the first 2 months one labourer could attend to the work (sowing, watering and weeding) on 25 beds. From then on until 10th October 1 labourer could cope with 50 beds as the work will be much lighter than at first. The wage rate taken for the computation is that of a casual labourer (Rs. 2.46 per day). There are a few permanent labourers attached to most nurseries, but when the main nursery operations start casual labourers are recruited to supplement the permanent labour force. If the quantity of seed sown per bed is reduced the number of beds will have to be increased and extra casual labour will have to be employed to attend to the extra beds. Hence the estimate is based on wages of casual labour.

The cost of equipment is the proportionate amount which will be spent on a bed per year. The figure is based on the actual requirements and current costs of watering cans, &c.

The estimate does not include the cost of carrying out the pre-sowing treatment (i.e., the cost of labour for this work). This will be negligible if the seed is treated by soaking in water. In any case the costs will increase with an increase in the quantity of seed sown per bed as in this case more seed will have to be treated.

(b) Comparative cost of producing 1,000 stumps, using the 4 different quantities of seed per bed.

The stages in the calculation and the results are given in the table below which is self explanatory.

<i>Quantity of seed</i>	<i>No. of stumps per bed</i>	<i>No. of beds necessary to produce 1,000 Stumps</i>	<i>Cost of main- taining these beds @ Rs. 18 per bed</i>	<i>Wt. of seed required (from table 4)</i>	<i>Cost of seed @ -/90 cts. a lb.</i>	<i>Total</i>
			<i>Rs. c.</i>		<i>Rs. c.</i>	<i>Rs. c.</i>
6 lb. per bed ..	481.0 ..	2.17 ..	39 06 ..	13.0 ..	11 70 ..	50 76
9 lb. per bed ..	553.0 ..	1.81 ..	32 58 ..	16.3 ..	14 67 ..	47 25
12 lb. per bed ..	643.8 ..	1.55 ..	27 90 ..	18.6 ..	16 74 ..	44 64
15 lb. per bed ..	703.0 ..	1.42 ..	25 56 ..	21.3 ..	19 17 ..	44 73

A pound of seed has been estimated to cost 90 cts. for collection, storage and distribution.

It must be noted that the above figures do not give the actual cost of producing 1,000 stumps since these items of expenditure which will not alter as a result of reducing the quantity of seed sown per bed have not been included, e.g., cost of stumping, salaries of supervisory staff, &c.

REPORT ON THE REGIONAL TRAINING COURSE IN FORESTRY TECHNIQUES— JANUARY—FEBRUARY, 1962*

L. C. A. Wijesinghe

INTRODUCTION

ON the invitation of the government of Burma, a regional training course in forestry techniques, organised under the joint auspices of the Food and Agricultural Organization of the United Nations and the International Labour Organization, was held in Burma from 15.1.62 to 28.2.62. There were 30 participants in all—14 from Burma, 3 from India, 1 from Malaya and 4 each from Pakistan, Thailand and Ceylon.

The training course covered the following fields:—

1. Forest road construction.
2. Maintenance of hand tools and sharpening of saws.
3. Field maintenance of mechanical equipment used in forest work.
4. Use of mechanical equipment for timber extraction with special reference to—
 - (a) crawler tractors with logging arches, and
 - (b) use of one-man and two-man chain saws for felling.
5. Timber extraction by elephants.

The party was divided into 4 groups to facilitate field work, and each group worked approximately 9 days in each specialized field. Emphasis was placed on field work which was carried out in one of the logging sites in Hopa, north of Mandalay. Thirty-two working days (including Sundays) were devoted to field work.

This training course was held under the direction of U. Tin Htut, Chairman of the State Timber Board, Rangoon. He was assisted by the following:—

Co-Director of the Course:—U. Maung Maung Kyi, Director of Extraction, State Timber Board, Rangoon.

Asst. Organiser of the Course:—F. Zurbugg (Switzerland), (Timber extraction expert) (F.A.O.).

Road construction expert:—R. Wettstein (Switzerland), (I.L.O.).

Equipment maintenance expert:—F. Gilling (S. Rhodesia), (I.L.O.).

Saws and hand tools maintenance expert:—J. L. Briggs (Australia), (F.A.O.).

The course opened at Rangoon on 15.1.62, and after introductory talks by officials of the Burma Forest Service, including the Chief Conservator designate, the participants departed for Hopa.

This report is in two parts. Part I gives an account of forestry in Burma. This has been included in the report as it would be of general interest to readers. Part II deals with the training course.

* By A. D. R. Ratnarajah, L. Abeynaike, S. B. Herat and C. Wijeratnam.

PART I—FORESTRY IN BURMA

The total area of Burma is 261,000 square miles, supporting a population of about 20 million; of this area approximately 34,700 square miles are reserved forests and 110,700 square miles unclassified forests. The total area under reserved and unclassified forests thus covers more than 50 per cent. of the area of Burma.

Teak which is indigenous to Burma, is generally found in the dry deciduous and moist deciduous forests, up to an elevation of 3,000 feet. The other Hardwood species of economic importance are Pyinkado (*Xylia dolabriformis*), Padauk (*Pterocarpus macrocarpus*), *Chukrassia tabularis*, *Terminalia tomentosa*, *Adina cordifolia* and *Acacia catechu*. *Salmalia malabaricum* and *S. insignis* are the chief matchwood species. *Pinus khasya* is the main species of the coniferous forests of Burma. The coniferous forests are restricted to the northern and eastern borders of Burma and are not under regular management due to their inaccessibility.

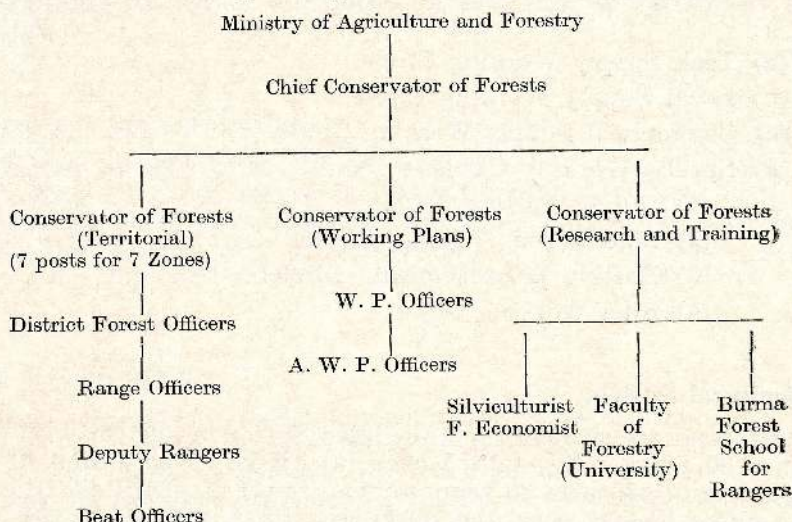
Teak is by statute a reserved tree. According to the Burma Forest Act all standing teak trees, wherever situated, unless expressly alienated by grant or lease, are state property and constitute reserved trees. Teak has, in fact, been a "royal" tree since the days of the Burmese kings, and the disposal of a teak tree was the prerogative of the king. The growth of teak in the natural forests is slow and the stocking is as low as one mature tree (about 150 years old and 28 inches in diameter at the base) per acre. The timber obtained floats when dry, a property not possessed by other hardwood species of first class commercial value. It is thus possible to extract teak from remote areas by floating.

Under the British regime, three-fourths of the teak bearing areas in Burma was leased out to 5 European firms by the Forest Department on long-term leases for timber extraction. These firms supplied roughly 70 per cent. of the annual production of round logs, while the government supplied only 10 per cent. The balance 20 per cent. was supplied by local long-term lessees (10 per cent.), and petty local traders (10 per cent.). After the country's independence in 1948, all the long-term leases were nationalised and the *State Timber Board* was formed. All the personnel of these big firms were absorbed into the State Timber Board, so that from its very inception this organization was a full blown and smooth running commercial unit.

The *Forest Department* of Burma is a sister department to the State Timber Board. The two departments function separately. The Forest Department is engaged on conservation work and forest management on strict scientific lines. The State Timber Board is concerned with extraction, conversion and marketing of teak. The exploitation of other hardwood is carried out by private timber traders.

FOREST DEPARTMENT OF BURMA

The administrative set up of the Forest Department of the Government of the Union of Burma may be represented thus :—



Forest Policy

All the forests are state owned and are called Public Forests. Within the Public Forests, Reserves are constituted. The forests of Burma, being a valuable national asset, are thus safeguarded for all time by state ownership and management. The sole object of the policy is that the forests shall be administered for the direct and indirect benefits of the public. Consideration of revenue is of secondary importance except in those forests which are managed for commercial purposes only. In accordance with this forest policy, the chief aims of the forest department are as follows :—

- (a) To meet the timber and fuel requirements of the public. The working plan includes a Local Supply Working Circle to produce hardwoods from reserves for the use of the villagers. The villagers are allowed to obtain their requirements from their section of the forest, the only restrictions being that reserved trees should not be felled and public forests beyond a 20 miles radius of the village should not be tapped. Shifting cultivation is allowed anywhere in public forests except in Reserves.
- (b) To increase the area under permanent forest cover (Reserves) from 13 per cent. of the land area to 25 per cent.
- (c) To ensure proper protection and management of Protection Reserves.
- (d) To develop the forest estate with a view to securing a sustained yield.

Management

The need for intensive management of forests has not been felt because of the vastness of the forest area and the presence of adequate natural regeneration of teak. In 1920, a complete enumeration of teak and other

hardwood species of enonomic importance was undertaken and the data obtained formed the basis for the preparation of working plans. These figures are corrected every thirty years, when girdling enumerations are made available. The working plans are for ten-year periods and consist of :—

- (a) Teak Supply Working Circle.
- (b) Local Supply Working Circle.
- (c) Commercial Supply Working Circle.
- (d) Special Working Circles—
 - (1) Cutch Working Circle.
 - (2) Matchwood Working Circle.
 - (3) Rafting poles Working Circle.
 - (4) Fuel Working Circle.

Silvicultural System

The forests are worked on a modified Selection system with a felling cycle of 30 years. This felling cycle was fixed as according to Brandis' computation, teak takes 30 years to pass from 6 ft. girth to 7 ft. girth. In areas where teak is poor, the selection girth is 6 ft. and over, while in areas where teak growth is good the extraction limit is 7 ft. 6 inches and over.

In the moist deciduous forests there is a tendency for succession towards the wet ever green type with the elimination of teak. This succession is retarded by gaps opened during improvement fellings and main fellings. There are two improvement fellings within a felling cycle—the first one is at the time of girdling and the second 15 years after the main fellings.

The Teak Supply Working Circle and Commercial Supply Working Circle overlap, and in such areas preference is given to teak so that, in time, there will be a preponderance of teak. In fact there are certain areas of pure teak at the moment and for such areas the Selection system is not suitable as teak is a strong light demander. The intention is to introduce the Uniform system in such areas.

Release of Areas for Extraction of Teak

The extraction of teak is the prerogative of the State Timber Board. In accordance with the working plan prescriptions, the areas due for extraction under the Teak supply working circle are released by the Forest Department to the State Timber Board for the extraction of teak. 22,750 square miles of forests are under the Teak Supply Working Circle. This forms about 65 per cent of the reserve forests. Before releasing the forests, the Forest Department carries out a complete enumeration of all teak trees above 4 ft. girth, and exploitable teak trees of selection girth are ring girdled. The girdling ring is 2 inches wide and as close to the ground as possible. A thin continuous ring of heart wood is exposed. At the time of girdling, the girdled trees are numbered in serial order and the year of girdling is also marked. Girdled trees are felled only after a period of 3 years so as to allow the trees to dry. Hence the actual felling operation by the State Timber Board commences three years after girdling. On

completion of teak extraction, the State Timber Board submits a completion report to the Forest Department and the area is taken back by the Department. The Forest Department then auctions the area among local contractors to extract the rejects of teak left behind by the State Timber Board.

Extraction of other Hard Woods

This is done by the Forest Department with the aid of the local contractors. As pointed out earlier the Teak Supply W. C. over laps other working circles, and approximately twenty percent of the area falling within the Teak Supply W. C. is exploitable for other hard woods as well. Such areas are exploited only after teak exploitation is completed.

Artificial Regeneration

In natural teak forests, teak takes about 150 years to attain a girth of 6 ft. while in plantations it takes only 80 years. However the quality of teak in natural forests is found to be better in that the timber is better grained and the trees are not markedly fluted. Adequate natural regeneration of teak can be obtained, and it is estimated that the present rate of natural regeneration will suffice to ensure sustained yield production for the next 80 years. Because of the high cost of raising artificial plantations the annual extent taken up for planting is restricted to 1000 acres. Artificial regeneration is done on the *Taungya* system. Only those areas where teak is poor due to suppression by bamboo are planted under the *Taungya* system. Each family is given 1 to 1½ acres, and they are allowed to inter cultivate paddy and other crops leaving a radius of 3 ft. round the teak plants. Whenever *Xylia dolabriformis* is grown in mixture with teak, eleven lines of teak alternate with eleven lines of *Xylia dolabriformis* which is a shade bearer. The programme of work under the *Taungya* system is as follows :—

- (1) Clear felling operation is done during December.
- (2) First burn of felled material is done in April and the second burn in May.
- (3) The area is aligned and staked at 6 ft. by 6 ft. in late May.
- (4) Planting is done with the first rains in June. Teak seeds are either sown direct at 3 seeds per stake, or stumps are planted. Best results are obtained with stump planting. If seeds are sown direct the germination percentage of the untreated seed is said to be 30 per cent.
- (5) Weeding round teak plants, once in the first year, once in the second year and twice in the third year.
- (6) First mechanical thinning in the fourth year.

Dry Zone Afforestation

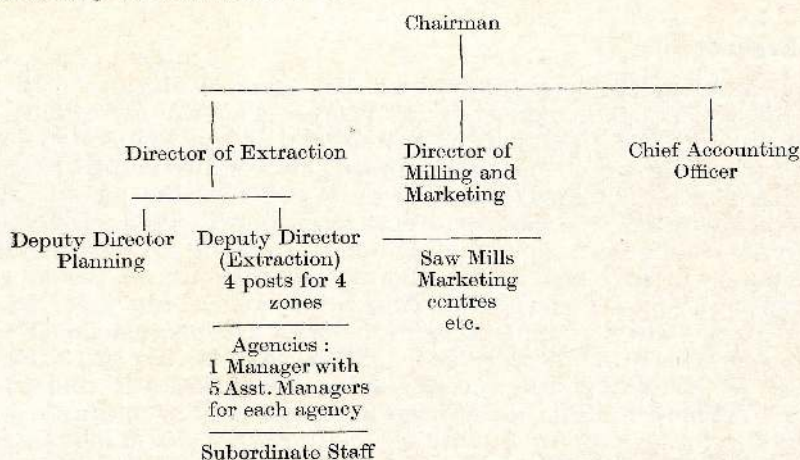
The annual rainfall of this Zone is between 20 and 30 inches. Annually 2,000 acres are planted with *Prosopis*, *Dalbergia sisso* and *Acacia catechu* with a view to improving the dry zone forests. The planting in this zone is carried out by the Agricultural and Rural Development Corporation.

Research

In view of the adequate natural regeneration of teak and the absence of any major problems in the extensive management of forests, the activities of the Forest Department Silvicultural Research section have been confined to the collection of old records, reconstruction of old sample plots damaged during the war and collection of herbarium specimens.

THE STATE TIMBER BOARD

The State Timber Board is run by a ten member board headed by a Chairman who also acts as chief executive of the organization. The main departments within the State Timber Board are Extraction, Milling, Marketing and Accounts. The administrative set up of the State Timber Board may be indicated thus :—



The extraction department of the State Timber Board, as the name implies, carries out the extraction of teak timber from the forests and transports it to the saw mills where the Milling Department takes over, followed finally by the Marketing Department.

The Extraction Department plans the operations according to their working year which begins on the 1st June and ends on the 31st May of the following year. It is roughly split into two periods—rainy season from June to October and dry season from November to May of the following year. Preliminary operations such as stream clearing, blasting, opening of extraction routes, construction of buildings etc. are carried out during the year preceding the year of extraction. Felling operations are carried out during the rainy season usually commencing about the end of May or early June when the ground is soft and hence less damage is caused to the falling tree. The haulage of logs from stumps to the stream is done by buffaloes, elephants or tractors. Elephants work from about the middle of June till the end of February of the following year with a break of a few days in October.

Elephants, in addition to being employed for the extraction from stump site to the stream, are also used in the streams for breaking up log jams and helping in diverting the logs out of the main river depots. Elephants used for this branch of work are good swimmers and

they are trained in the job of breaking up log jams. With very little assistance from their mahouts, they locate the key logs causing the jams and they dislodge them expertly. After the rainy season such elephants are moved into suitable working areas for continued employment throughout the year.

Logs are floated down in jungle streams into the main river (Irrawaddy and Salween) from where they are salvaged and collected at the river timber depots. They are then marked for royalty payment and moved down to Rangoon or Moulmein in rafts. Royalty rates of teak differ from zone to zone depending on the quality of the timber and distance of the forest from Rangoon.

There is an interval of about six years from the time of girdling up to the time the timber reaches the saw mills at Rangoon or Moulmein. The first three years are inevitable as the tree has to be left standing for this period for preliminary seasoning after girdling. It then takes a further 3 years for the timber to be extracted and floated down to Rangoon or Moulmein (the rafting distance from Myitkyina to Rangoon along the Irrawaddy is 600 miles). There is no necessity to expedite the despatch of logs as there is sufficient stock of timber in the depots at Rangoon and Moulmein. Because of this long period between felling and utilization, the operation requires large capital resources. This was one of the main reasons why the teak trade was not given over to private local traders who cannot afford such heavy and long term investments.

Milling

The State Timber Board saw mills are located at Rangoon and Moulmein. The No. 4 saw mill at Rangoon is the largest mill in the country. With only two break down bandsaws, the daily outturn in this mill is 45 tons of sawn timber, i.e., 90 tons or 4,500 cu. ft. of log. Time and labour saving devices such as the hydraulically operated log turner for turning the logs on the bandsaw carriage have contributed towards the high production rate.

The present annual outturn of sawn timber is about 300,000 tons but even this is insufficient to meet world demands.

Marketing

Most of the timber is converted into sawn timber before sale. A small percentage is sold as logs for veneer slicing in Europe. As veneer logs have to be fresh, they are extracted from easily accessible areas near rail heads and transported by rail direct to Rangoon. The veneer logs are classified as either plain, figured or striped.

The non-exportable poor quality logs are auctioned from time to time (two to three auctions per month) among local traders at Rangoon. The exportable logs are graded and supplied on orders to foreign governments or firms.

Roof shingles are mainly exported to Mauritius. Good quality furniture timber is exported to Denmark and the poor quality to India and Ceylon. Japan is now purchasing the trim ends of logs for their handicraft industry at 25 dollars per ton.

The export price of teak varies from £200 to £300 per ton depending on the quality. The revenue earned from the export of teak is only second to that of rice and hence the importance of the teak export trade in the economy of Burma. It is for this reason that the local consumption is restricted to only the poor quality teak. The export of teak is not the monopoly of the State Timber Board as certain firms have leases of forests and teak from such areas could be exported by the firms. The State Timber Board however controls such export, the control being over quality and price in order to ensure that the teak market is not lost.

Production

The annual teak production in Burma from 1934 to 1939 averaged 436,598 tons of which 383,012 tons were produced by the lessees and 53,586 tons by the local licensees. This annual average production was about the maximum tonnage possible under sustained yield operations. Production dropped after the last war, and at present it is about 300,000 tons per annum. The State Timber Board has drawn up plans to increase the production to 500,000 tons per annum.

PART II—THE TRAINING COURSE

Forest Road Construction

The course on forest road construction covered both the theoretical and practical aspects of road construction. The need for planning was stressed as the first requirement in any road construction programme. Planning is in two phases, namely, net work planning and detailed project planning.

Net Work Planning

It is absolutely essential to open a net work of roads within coherent forest areas to extract timber in the most economical manner. In net work planning a rough idea of the net work of road traces determined by gradient and direction on the contour map is obtained. This is followed by detailed project planning which is done in the field to determine the financial implications of the work. Estimates for curves, cuts, fills and culverts are included in this plan. On the basis of this detailed project, period plans are prepared indicating the number of miles to be built per year and the period required to complete the work. This period plan with costs and priority lists of roads is prepared in conjunction with the extraction programme and includes a precise estimate of funds required for each year's work.

In net work planning the basic requirements are :—

- (a) A contour map of the area. This is necessary to locate valleys, ridges and rivers and to determine contour intervals.
- (b) An altimeter to measure the height to which the road should be traced and to check heights as given in the map.
- (c) Aerial photographs of the area. This will provide information relating to the standing crop, like high and low production areas, blanks etc.

The following points should be noted in studying the maps for planning out a net work of roads :—

- (1) The area to be opened up should in the first instance be divided into coherent areas, e.g. catchments.
- (2) The transport limits should then be determined. They are ridges, rivers etc.
- (3) The important points through which the road should pass are then marked on the map e.g. villages, depots, saw mills, sites for hair pin bends, good sites for bridges, high production areas etc. These are the obligatory or positive points.
- (4) The negative points should also be marked on the map e.g. bad bridge sites, swamps, blanks, rocky areas, etc. The positive and negative points will include the skeleton of the trace.

After a study of maps as indicated above, the zero trace line (net work plan) should be plotted with due consideration of the following points :—

- (1) The direction of the road should be first ascertained—towards a saw mill or a landing depot.
- (2) Choose the gradient according to the class of road. The classification of the road will depend on the purpose for which it will be used.

The ruling maximum gradients for different types of roads are :—

- (a) Inspection paths (3 ft. wide)—1 in 6.
- (b) Elephant drag paths (12 ft. wide)—1 in 10.
- (c) Vehicular traffic (trucks)—7 to 8 per cent if traffic is in both directions. However, 10 to 12 per cent may be permitted for short distances (say up to 50 yds.) If the traffic is only in one direction, the maximum gradient is 10 to 12 per cent or even up to 15 per cent for short distances (up to 50 yds.)
- (d) Car traffic—1 in 20.

All roads must have minimum gradient of 2 to 3 per cent which is required to drain water from the road surface.

- (3) The gradient chosen should not be changed unless for a good reason. If obligatory points are not touched by the trace plotted at the chosen gradient then the gradient may be changed and the trace re-plotted.
- (4) When trees to be exploited are few and far between it is best to avoid building roads on the slopes of hills ; instead the roads may be opened in the valleys and, as far as possible, follow the rivers. When the valley is swampy and the slopes rocky, the roads have necessarily to be opened along ridges.
- (5) Roads should not end in blind alleys. All roads should be joined and the net work should cover the entire area.
- (6) As far as possible, any turn in the road trace should be on a plateau. Crossing of rivers should be at pre-determined suitable points.

For plotting the road trace, it is essential first to calculate the horizontal distance within the contour interval that would give the desired gradient. If the contour interval is ten yards and the chosen gradient is 8 per cent,

$$\frac{100 \times 10}{8}$$

then the horizontal distance = ————— = 125 yds. Now, this distance of 125 yds. is set off to scale and plotted within the contour interval.

The plotted trace is the *zero line* or *gradient line* of the net work plan.

Detailed Project Planning of Forest Roads

Detailed project planning is done in the field. This operation may be classified under the following heads :—

- (1) Determination of road axis.
 - (a) Finding the zero line
 - (b) Straightening the zero line
 - (c) Determination of curve elements
 - (d) Laying out of hair-pin curves
- (2) Measurement of cross sections.
- (3) Measurement of lengths.
- (4) Calculation of material to be moved.
- (5) Distribution of moved material.
- (6) Breast and retaining walls.

(1) Determination of road axis—

The first step in detailed project planning is to determine the road axis. This is done by finding the zero line on the ground, straightening same and then laying out the curves.

- (a) *Finding the zero line*—The zero line as shown in the net work plan is laid on the ground. Due to certain plotting errors or inaccuracies of heights as given in the map, the zero line when laid on the ground may not reach the destination point as shown in the net work plan. In such cases, the zero line is relaid so that the error is distributed over the entire length of the zero line.
- (b) *Straightening of the zero line*—The zero line will have to be straightened as much as possible with a minimum of earth movement. Deep cuts and high 'fills' are generally avoided in forest roads, as these would hamper the haulage of logs on to the road. Standing on points on the zero line one could decide how best to minimize the bends on the line while avoiding much earth movement.
- (c) *Laying out of curves*—Having traced the zero line on the ground and straightened it, it is necessary to lay out smooth curves in order to determine the road axis. The laying out of curves may be done in the following three ways depending on the means available—
 - (a) With prismatic compass and Tables.
 - (b) With the use of Aretin's Tables.
 - (c) By approximative methods.
- (d) *Laying out of hair pin curves*—Hair pin curves are associated with roadways on steep hills. The gradient has to be reduced at the approach to a hair pin curve. The radius of the hair pin curve is then decided on, taking into account the terrain, length of logs to be transported etc. The radius should generally be limited to 12 to 15 yards, as larger curves involve much earth cutting. The semi-circular curve is then marked out on the ground.

(2) Measurements of cross sections—

After laying out the road axis, it is necessary to measure the cross sections at suitable points on the road axis to determine the volume of cut or fill at each point. As a general rule, cross sections should be taken at every 30 yds. (for roads constructed with manual labour) and at every point where the terrain changes. Cross sections should be taken at right angles to the axis points, and the horizontal distance to be measured on either side of the axis point will depend on the slope and width of the road. For slopes over 30° the cross section should be equal to the width of the road.

(3) Measurements of length—

This is done with measuring tapes.

(4) Calculation of material to be moved—

The next step in the detailed project planning of roads is to calculate the volume of earth to be cut or filled, i.e., the volume to be moved. The cuts and fills have to be calculated separately in order to find the total volume

of earth to be cut and volume to be filled. This is calculated with the aid of the cross sections already measured. The principle of this calculation is that the average of the surface area of adjacent cross sections, is multiplied by the distance between the two cross sections to give the average volume of earth to be moved between the two points.

(5) Distribution of Moved Material—

After the calculation of the volume of cuts and fills over the entire length of the road, it is necessary to consider the distribution of surplus earth in an economical manner to areas requiring it. For this purpose a table has to be prepared indicating the volume of earth in surplus or the shortfall at different points on the road. The cross-section measurements are used in preparing this table. The table should be completed in respect of the full road length, and on the basis of the table, it could be decided how best earth could be moved from sections where cutting is done to parts where filling is necessary.

(6) Breast and retaining walls—

These are necessary where the angle of repose of slopes is in the region of $1:1\frac{1}{3}$ and $1:1\frac{1}{2}$.

Once the net work plan and detailed project plan have been prepared as above, it will be possible to work out costs of operations and prepare the period plans.

The use of machinery in Forest Road Construction—

Initially only dredgers were used in road construction for selective excavation. At present the most important machines in road construction are the dozer for cutting of the road trace and the tyre-wheeled motor grader for grading the road surface. Angle dozers are preferred to Bull-dozers as the blade on the former could be moved to slanting positions on either side to cut drains etc. For flat areas, angle dozers of the class of D6 Caterpillars are ideal while for hilly areas the D7 class is required.

Cutting of road trace with machines—

There are two methods of tracing the road, and the choice of the method will depend on the type of machinery available.

The first method is adopted when only an angle dozer is available. The procedure is as follows :—

Pegs should be fixed on the uphill and downhill sides of the gradient line to indicate the following :—

- (a) The uphill peg indicates the edge of the road on the uphill side.
- (b) The downhill peg indicates the depth to which earth should be cut.

Once the pegs have been fixed over the entire road length, the site is ready for the angle dozer to start operations. It is always best for the machine to work downhill for maximum efficiency i.e. to start at the top and come down. It is, however, not always possible for the machine to go up the trace to commence work. Hence, the angle dozer should make a rough trace as it goes up. This rough trace consists of cutting just the amount of earth necessary for the machine to go up.

After the rough trace is cut the dozer can work downhill. This second phase of work will be confined to the making of the angle of repose on the rough trace cut. This is done by raising the blade and cutting at an angle.

The third phase of work consists of cutting the balance of the road trace working from the top downwards.

After cutting the trace, the curves and levels should be checked. The angle dozer is then put on the final phase of work which is the grading of the road. While grading the road, any errors on levels or curves are corrected.

The second method of cutting the road trace is adopted when an angle dozer and a motor grader are available. (One motor grader is sufficient for about 6 to 8 angle dozers to form a unit).

The procedure for cutting the road trace is as follows :—

The first phase of work is the same as in the first method i.e. cutting of the rough trace by the angle dozer. Secondly the angle dozer cuts the entire trace commencing from the top of the hill. Thirdly the curves and levels are checked and corrected. The next job is the cutting of the angle of repose of the slope with the motor grader. The final phase of work consists of grading of the road surface by the motor grader. While grading, levels are finally corrected.

Organization of Work Site for Road Construction with Machines

It is imperative that machines brought to the work site should not be allowed to idle. Hence the site should be prepared well in advance, and the following are some of the items of work to be done before the machines are brought to the site :—

1. Laying out the road trace.
2. Fixing in the field the route to be taken by the dozer to reach the site.
3. Fixing the point at which the machine should start working.
4. Cutting of all vegetation on the trace.
5. Blasting all rocks on the trace. A compressor should be at the site for drilling of rock if encountered while cutting into the hill.
6. Blasting of all large stumps. For every 10 c.m. of stump diameter, 100 grammes of dynamite is used for blasting (458 grams. = 1 lb.).
7. Draining of all wet areas.
8. Construction of bridge foundations or even complete bridges if possible before the machines are brought to the site.

MAINTENANCE OF HAND TOOLS USED IN TIMBER EXTRACTION

Saws

The blades of all saws are thicker at the top than at the bottom, the taper being 0.004" per linear inch. The quality of any saw depends on :

- (a) Quality of steel used.
- (b) Presence of a curve on the taper. Such saws can cut without any setting.

Cross-cut saws—There are different types of Cross-cut saws.

(a) *Peg tooth*—The teeth are set alternately ; the disadvantage is that the saw dust is not thrown out.

(b) *M-tooth*—This type is also with an alternate set but there is an improvement on the first type. Here one tooth of each M cuts the timber while the other tooth removes the saw dust out of the cutting surface.

(c) *W-tooth*—Here two teeth of each W are sharpened on one side and the third tooth (middle one) is sharpened on the opposite side.

(d) *Peg-tooth and Raker*—The raker takes out the saw dust. A raker alternates with a pair of teeth. This type was invented in the 18th century but to-date no improvement has been effected. Introduction of 4 teeth to one raker was also tried but it had only one advantage in that the wear on the teeth is less as 4 teeth perform the work of 2. This advantage is set off by the fact that more time is spent on sharpening the teeth because of the increased number. For a raker to work efficiently the teeth of the raker should be wide apart. The top of the raker should be lower than the top of the peg.

When timber is sawn with a peg-tooth and raker saw, the wood waste is in the form of chips and shavings. The depth of gullet in this saw should be maintained. If the depth decreases, there will be more friction, resulting in a decrease in efficiency and ultimate jamming of the saw in the wood. The cut of the Peg-tooth saw is wider than the cut of the peg-tooth and raker saw.

(e) *Bow-saws*—This is also a type of cross-cut saw used for pruning or cutting poles. The bow-saw may be a peg-tooth type or a peg-tooth and raker type. The teeth of bow-saws are made of very hard metal and it is not necessary to sharpen or set them. Bow-saws are cheap and hence it is better to condemn them after the teeth wear away.

Storage of Saws

The saws are best stored after applying a coat of crude vaseline.

Sharpening of Saws

The procedure to be adopted in sharpening saws is as follows :—

- (1) *Hammer setting* : This is not always necessary. It is required to be done only in the case of badly worn out saws. For this operation a hammer set angle and a setting hammer are required. The hammer set angle is a metal block with the top portion set at the angle at which the teeth should be bent. The teeth are placed on the hammer set angle and hit with the setting hammer and this gives the required bend to the teeth.
- (2) *Stripping the saw* : This is the second phase in the sharpening of saws. This is essentially an operation to ensure that all teeth are on the same level so that all work together with less wear. The stripper which consists of a wooden block into which a triangular file is fixed is used to level all the teeth. The stripper should be held straight over the teeth and moved slowly and gently.

- (3) *Adjustment of Raker height* : The height of the Raker should be less than that of the peg and the difference in level is about $1/20$ of an inch. A raker gauge is used for filing down the rakers so that they are below the level of the pegs.
- (4) *Sharpening of Raker* : The saw-blade should be kept vertical and as low as possible on the clamp and the rakers sharpened by filing.
- (5) *Sharpening of pegs* : All pegs must be filed at the same angle keeping the file straight. The pegs should not be filed below the level of the rakers. However, if this happens, the raker should be checked and filed down as in (4) above.
- (6) *Setting* : After filing the rakers and pegs, the teeth are set with a set lever and meter—the latter indicating the set. A steel plate may be used as the setting instrument. There is no fixed amount of set as it varies with the type of timber on which the saw would be used.

FILES. The proper file to use in filing any saw is the 9" mill saw bastard file. Handsaws are filed with triangular files so that two teeth are sharpened at a time. Files should be cleaned often with a file brush. Brushing should be done in the direction of the grain of the file.

Axes

THINNING AXES. These are not meant for felling big trees. In these axes, the handle does not go through the eye of the axe.

STANDARD FELLING AXE. The centre of the axe eye is narrower than the ends of the eye. The blade is broad and has a round surface and is made of hard steel.

SHARPENING OF AXES. This consists of three operations, namely grinding, filing and oiling.

GRINDING. This can be done with an electrically operated emery wheel. It has, however, been found that grinding on sandstone is even better. It is important to avoid heating of the axe while grinding as heat will tend to destroy the temper, hence it is necessary to wet the sandstone often. The cutting surface should not be ground either too thick or too thin. Grinding should be done along the curve of the axe from the base to the tip.

FILING. After grinding the axe, all uneven surfaces should be filed to make the surface smooth.

OILING. Once filing is completed, oil should be applied with an oil stone in a circular fashion to sharpen the cutting edge. Oil stone is made of sand, glass etc. and it has a rough and a smooth surface. Oiling should first be done with the rough surface and then with the smooth surface.

NOTE. Felling axes should be oiled with the oil stone after felling each tree and they must be ground on the sand stone daily. This will ensure longer life and maximum efficiency.

Chain Saws

The first chain that was brought out in the chain saw industry is the chisel chain. Here the sprocket goes in between the link and grips the teeth. The guide bar of the chisel chain saw is of an inferior type and it cannot be tapped back if the metal expands. The bar is very wide to take in the links. As the bar is thick, only half the amount of set required is given to the teeth of the chisel chain.

The improvements on the chisel type are :—

- (a) Use of two sets of cutters for every raker as the bar is wide.
- (b) Use of chipper saw blade with the chisel chain.

The chisel chain is generally made of a harder metal and hence the wear is less than on the chipper chain.

Types of Uneven Wear on Bar

- (a) If the chain is too tight, there will be excess wear of the front portion of the bar, and if the chain is loose, the excess wear will be at the bottom of the bar.
- (b) If the chain is filed unevenly, then the chain will run unevenly on the bar resulting in uneven wear of the bar.
- (c) If the File-N-Joint is not set on the centre of the bar before filing, the teeth on one side will be longer. Hence while the saw works, there will be a greater pull to one side resulting in an uneven wear of the bar.
- (d) Uneven filing will result in the bending of the bar. The bar can be tapped back to the original shape (Chipper chain saw). If a hammer is used to tap, the metal may expand resulting in the bar twisting. Hence a wooden or plastic mallet should be used.

Tension on a Chain

Generally the manufacturers prescribed the correct tension of the chain on the bar. However, a general guiding rule is that for every foot of length of bar, the chain should have a play of $1/8$ inch i.e. the chain should stretch to $1/8$ inch over the bar. Hence if the bar is 2 ft. the play is $1/4$ inch.

Care of the Chain

The following are points to be noted in the care of chains :—

- (1) 3 chains for each saw should always be sent to the field—one for the morning, one for the afternoon and one to spare. This will ensure equal wear on all 3 chains.
- (2) A new chain should not be used with an old sprocket and vice versa.
- (3) Pitch of chain and pitch of sprocket should be the same.
- (4) Teeth should be of equal angle, equal length and equal height.

- (5) The depth guide on a chipper chain should be of uniform level. If not the machine will tremble. If every second depth guide is lower than the normal level, then the cut will curve down. The depth guide regulates the depth of cut and prevents deep cutting.
- (6) If the depth guide is too low, then the cut is too deep and the tips of the teeth will be chipped off. Hence absolute uniformity of the angles of teeth and levels of depth guides is essential for a straight and easy cut without damage to the chain.

Sharpening of Chain Saws

HANDFILING OF SAW IN THE FOREST. The chain should be washed in petrol or diesolene. The master link of the chain should be located and the nut on the master-link should be loosened. Then the chain is fitted on to the hand-filing clamp on top of a stump or log and filing of the teeth is done.

The diameter of file to be used in machine filing is usually given by the manufacturer. For handfiling, it is safe to use the file which is a fraction smaller than the one prescribed for machine filing. While filing, the angle of teeth should not be changed. After filing the teeth, the depth gauge is placed on top of the depth guides and the depth guides are filed.

Machine Filing with the File-N-Joint Machine

For chipper chain filing, this file-N-Joint machine is very essential for accurate work. This machine has an automatic device for ensuring—

- (a) uniform length of teeth
- (b) uniform angle of teeth
- (c) uniform height at which the cutting edges of the teeth are sharpened.

The File-N-Joint is a very handy instrument and it could be taken to the field for filing in the forest.

FIELD MAINTENANCE OF MECHANICAL EQUIPMENT

The first requirement for field maintenance is a field workshop. A field workshop as opposed to a base workshop is a temporary structure which may be shifted every 3 to 4 years.

Field Workshop

SITING. It should be sited in the centre of the area of operations and should be on a well-drained site with a large area of cleared ground around it. The building itself should be so positioned as to allow the maximum amount of natural light to fall on the work benches.

BUILDING. The workshop itself should be a metal pre-fabricated structure enclosed at least on three sides and preferably on the fourth as well, in which case, large lockable doors should be provided. The walls

should contain the maximum amount of window space, particularly near the work benches. The floor should be of thick concrete, say six inches, over a good rock foundation. This is necessary to withstand the weight of heavy machinery. A building of 50' by 30' is generally suitable.

FITTINGS. A strong bench, running the whole length of one of the long walls and bolted to the wall, is very desirable. The bench should be provided with drawers and cupboards, preferably lockable. The bench should be covered with a thin sheet metal (galvanised iron is ideal).

PITS. Adjacent to the workshop and provided with a roof only, a pit of the size 3 ft. wide, 12 ft. long and 5 ft. deep may be dug for purposes of servicing and inspection of machinery. Repairs should not be carried out when the vehicle is over the pit.

STAFF. The number required will obviously depend on the amount of equipment in use and the distance of the field workshop from the main workshop. It is, however, better to over-staff than to under-staff and have equipment idle. The following categories of staff are required for a workshop :—

Workshop Foreman

Storekeeper/Workshop Clerk

Mechanics

Service/Lubrication man

General Assistant—for sweeping, cleaning machines, etc.

The possibility of making bonus payments to workshop staff and operators based on the number of hours the repaired machine runs should be considered as it would be an incentive for maximum efficiency.

STORES. In a workshop there are 3 classes of stores, namely :—

(a) Tool store

(b) Spare parts store

(c) Petrol, oil and lubricant store.

A complete kit of tools which are considered basic should be supplied to each mechanic.

EQUIPMENT. Jacks, Pulley blocks and Stands are the basic equipment for a workshop. Others considered essential are oxy-acetylene welding equipment, a small compressor, a battery charging set, a plug cleaning machine, towing chains, lead lamps, fire extinguishers, etc.

Types of Engines

Engines may be divided into two classes—internal combustion and external combustion. In an internal combustion engine, the fuel is burnt inside the working cylinder. In an external combustion engine the fuel is burnt outside the working cylinder, and is used to produce steam which is then piped into the working cylinder or turbine.

Of the two types, the internal combustion type is used for earth moving and transport.

Internal combustion engines may be divided for our purpose into two types :—

- (a) Compression ignition, i.e., Diesel engines
- (b) Spark ignition, i.e., Petrol engines.

Heavy equipment is usually powered by diesel engines as they are more suitable in many respects than petrol engines.

Both diesel and petrol engines come in a wide variety of designs such as 4 stroke, 2 stroke, supercharge, turbo-charged, side-valve, overhead valve, single and twin overhead canshafts, overhead inlet, side exhaust, inline, V formation, horizontally opposed, air-cooled and water-cooled. Each type has points for and against it and it must be considered from the point of view of the job it is expected to do.

Four-stroke Engine

All engines have cylinders and in the simplest form there is one cylinder. Engines may, however, have combinations of two, four, eight or even twelve cylinders but the functions of the various parts of the mechanism remain the same.

In a single cylinder four-stroke engine two revolutions of the engine crankshaft are required to produce one firing stroke. Hence in a four cylinder four-stroke engine, two firing strokes are produced at every revolution of the engine crankshaft.

Compression Ratio

The compression ratio is the ratio of cylinder volume to the clearance volume. A ratio of 6 : 1 means that the volume of the mixture is reduced to one-sixth by compression. Most petrol engines nowadays have a compression ratio ranging from 6 : 1 to 9 : 1. The higher the compression ratio, the better the petrol should be (i.e., higher octane value). The compression ratio of diesel engines varies from 16 : 1 to 19 : 1. The usual ratio is 16 : 1.

The necessity for a high compression ratio in diesel engines is to raise the temperature of air in the cylinder to about 1000°F in order to ignite the diesel injected into the cylinder. All parts of the diesel engine are heavy and strong to withstand the high compression ratio. With a side-valve engine, it is difficult to obtain a high compression ratio. For this reason no diesel engine has side valves. The valves of the diesel engine should be well maintained. If not it will be difficult to start the engine when it is cold as much heat is required.

Just prior to explosion, the compression pressure in a petrol engine is only 80 to 125 lbs. per square inch while in a diesel engine it varies from 500 to 600 lbs. per square inch.

ADVANCE IGNITION. This phenomenon occurs when the mixture sparks before the piston reaches what is called the top dead centre of the cylinder in its compression stroke. Hence the piston is pushed down in the power stroke before it reaches the normal position.

PINKING. This occurs when the explosion of the mixture takes place before it should.

VALVE CLEARANCE. This is the clearance between the tappet and the bottom of the valve. The inlet valve has a smaller clearance than the exhaust valve. The valve clearance can be varied by adjusting the tappets. Clearance is necessary for valves to close air-tight. Inlet valves are cooled by the cool air and the water circulating round the valve seats. The exhaust valves, however, get heated by the hot gases despite the water circulating round their seats. For this reason, a larger clearance is given for exhaust valves.

Two-stroke Engine

In a two-stroke engine, one power stroke is produced at every revolution of the crankshaft. It has one advantage over a four-stroke engine in that it has no valves. While the burnt gases are pushed out through an exhaust port, the piston sucks in fresh mixture through an inlet port via the crankcase.

In a two-stroke engine, oil is mixed with petrol because there is no oil in the crankcase. This petrol-oil mixture is the only source of lubrication for the two-stroke petrol engine.

For efficient performance of a two-stroke engine, the exhaust gases should be removed fast. In practice, the removal is incomplete and hence the combustion is not very satisfactory. To remedy this a super charger for blowing air is incorporated into a two-stroke diesel engine.

Maintenance of spark plugs : This consists of—

- (a) cleaning,
- (b) adjusting the gap,
- (c) testing.

Plugs should be replaced every 10,000 miles or even earlier if the electrodes are worn out.

Maintenance of Diesel Fuel Systems

TANKS. Securing straps or bolts should be kept tight. Small leaks at taps or plugs should be rectified. Caps should fit well to keep water and dirt out and to prevent fuel from spilling out. Ideally tanks should be filled after work each day. This will prevent the condensation of water on the inside surface of the tank and the contamination of the fuel. Any strainers or filters fitted in the inlet to the tank should be cleaned when necessary and should fit well.

TRANSFER PUMPS. As the name suggests these pumps transfer the fuel from the tank to the multiple unit injector pump or combined injector pump and valve units. The points to check for efficient pump operation are tightness of bolts securing the pump, tightness of unions and fittings, condition and cleanliness of relief valve, valve seats and springs and condition of diaphragm and socket.

FUEL FILTERS. Fuel filters may be fitted between transfer pump and injection pump. A filter fitted between the tank and transfer pump protects the whole fuel system, but suffers from a major disadvantage in that the fuel is only forced through the filter by atmospheric pressure and the filters may need frequent replacement. Filters fitted between the transfer pump and injector pump are subjected to transfer pump pressure and this is dependent on the setting of the relief valve. This enables the manufacturer

to select the best pressure for efficient fuel filtration and is the method used in most fuel systems today. The points to check for efficient filter operation are tightness of unions and covers and condition of external and internal seals and gaskets. Both primary and main filters should be drained weekly.

FUEL INJECTION PUMP. Fuel injection pumps should be kept clean and leaks rectified as they develop. They should be dismantled and serviced only by competent mechanics in accordance with the instructions contained in the manufacturer's service manual.

INJECTORS. Injectors ensure the delivery of fuel as a fine spray into the combustion chamber. This spray effect is needed for even and efficient burning of the fuel. Injectors are precision assemblies and hence special care must be exercised in dismantling and adjusting them. Most types of injectors can be tested in the field as the service test equipment is relatively simple. Caterpillar injectors cannot be repaired and hence must be replaced. It is necessary for a very high pressure to be generated in the fuel injection pump because the fuel is sprayed from the injector into the cylinder against a pressure in the cylinder of some 500 to 600 lbs. per square inch.

Maintenance of Petrol Systems

TANKS. The same as for diesel tanks. Small petrol leaks from tanks may be temporarily stopped with soap.

PETROL PUMPS. These are always diaphragm type pumps worked electrically or mechanically. Maintenance consists of keeping all unions and screws tight and cleaning the jar or chamber on the suction side of the pump. When new diaphragms are fitted they must be genuine manufacturer's replacement parts. The rubber type of sealing ring for the jar or chamber is very good and should be used in place of the more usual cork type whenever possible.

CARBURETTOR. These range from very simple to comparatively complicated units. Maintenance includes external and internal cleaning and checking of all nuts and screws. The jets and passage ways in the carburettor should be cleaned with compressed air. The most common cause of trouble in carburettors is the presence of dirt in the needle and seat assembly. This causes "flooding". A sticking needle can often be freed by giving the adjacent area of the piping a tap with a piece of wood. When a heavy air cleaner is fitted directly on to the carburettor it is most essential that the air cleaner be properly secured and it should be braced with an additional support to a convenient bolt on the engine. Carburettor tops are liable to be worn through by loose air filters.

PETROL FILTERS. Fitting of a suitable filter between the petrol pump and carburettor is recommended. These come in various types and are often sold as kits to fit particular vehicles. Fitting of a wire screen type filter in the inlet to the tank is also recommended.

Maintenance of Electrical Systems

The following are the main points in the maintenance of the basic elements in the electrical system :—

BATTERIES. These expensive items should be treated very carefully, they should be firmly but not tightly mounted. Unfortunately most equipment has little or no springing and batteries often fail due to internal damage

caused by shocks. Batteries should be "topped up" with distilled water when required and the level checked at least weekly. The level of the electrolyte should be just over the top of the plates. The most common causes of "battery troubles" are dirty, corroded and loose battery terminal posts and clamps. The battery terminals should be removed at least once a month, and the terminal posts cleaned, coated with petroleum jelly and replaced. Particular attention should be paid to the clamp bolts. Batteries should be kept clean and dry. When removing the cables from a battery the earthed cable should always be removed first. This will prevent a possible short circuit between spanner and chassis if the live cable is removed first.

WIRES AND CABLES. Modern plastic covered cables can be cleaned with paraffin or petrol. Remove battery earth cable before cleaning any parts of equipment with petrol. Paraffin, diesel or petrol should not be allowed to come in contact with rubber or canvas covered wire. Wires should be protected from sharp edges and any frayed parts should be repaired with insulation tape. If a wire has to be replaced care should be taken in selecting a wire of the correct size. All joints in wires should be soldered. Cored wire solder and not soldering fluid should be used as the latter often corrodes the wire.

GENERATORS. Driving belts or chains for generators should be correctly adjusted. Failure to observe this will result in either belt slip or early bearing failure. Fuel and oil should not be allowed to leak on to generators. If this has happened the generator should be wiped clean at once. Terminals should be fitted tight, brushes checked for wear regularly and the generator lubricated as per maintenance guide.

REGULATORS. These are very finely adjusted instruments and should not be interfered with in any way by unskilled men. Terminals should be kept tight and the instrument clean.

STARTERS. Faults in starters may be electrical or mechanical. The main contacts in the starter or solenoid often give trouble due to burning and pitting. It is often possible to clean these items with a fine file. Brushes should be checked frequently. The chief mechanical fault is grit on the engagement mechanism. This can be cleaned. Ammeters, switches, fuses, horns, gauges and coils should be kept clean and all connections kept tight. It is possible to adjust some types of horns but the stripping and adjustment of any electrical assemblies should not be undertaken by unskilled men.

DISTRIBUTORS. Field mechanics should be thoroughly conversant with the maintenance of distributors. Dirty and badly adjusted contact points and loose condensers are frequent causes of ignition faults. Keep all wires and connections clean and tight.

PETROL PUMPS—(ELECTRICAL). Apart from cleaning the points, the repair of electric petrol pumps should be left to the agents. A pump that stops working when one is on the road can often be "brought back to life" by giving it a gentle thump with the side of one's hand, sometimes switching the ignition switch on and off will also cause a pump to start working again. A pump which gives trouble should be overhauled or replaced at the first opportunity.

AMMETERS. These measure the amount of current flowing into or out of the battery. Ammeters give an indication of the efficiency of the generator and other electrical units. Ammeters do not indicate the amount of electricity stored in the battery.

ELECTRICAL TEST EQUIPMENT. A very useful piece of test equipment in a field workshop consists of a bulb, mounted on a holder and two lengths of wire. This simple piece of equipment can be made in the workshop, and its main use is to test the presence of a current during fault locating work. A cell tester is recommended for testing batteries. These items indicate the voltage of each cell individually.

Engine Cooling Systems

WATER COOLING SYSTEM. The basic components are :—

- Radiator assembly and cap
- Hoses
- Water pump and fan
- Water-manifolds
- Passage ways in cylinder block and head
- Temperature gauge

Water passes from the bottom of the radiator, through the bottom hose into the passage ways in the cylinder block, up through the block into the cylinder head ; from the cylinder head it passes through the water manifold into the water pump ; from there it is pumped through the top hose into the header tank of the radiator and then it passes down through the radiator core into the bottom tank. The circulation is closed. During its passage through the block and cylinder head the water absorbs heat from them and during its passage down through the radiator core the water gives up heat to the core tubes and fins ; this heat is carried away by the air which is being drawn through the spaces between the tubes and fins by the fan.

A thermostat is often fitted between the cylinder head and header tank. The purpose of the thermostat, which may be considered as a temperature control valve, is to promote the rapid warm up of the engine and to maintain the engine heat at the best operating temperature.

Water pumps and fans are often combined into one unit and driven by the fan belt.

Maintenance of Water Cooling Systems

Check water level daily.

Check external cleanliness of core at least daily, more often during "bush" clearing operations. The best way to clean the outside of the core is to blow the dirt out with compressed air or to use a jet of water. This is best done in the opposite direction to the normal air flow through the radiator ; obviously the engine must be stopped for this operation.

The cap must fit well otherwise it will not retain pressure.

Radiator mountings should be checked regularly particularly rubber or similar flexible mountings.

Water used in radiators should be soft and clean. Never put cold water into a hot engine.

HOSES. Oil, etc., should not be allowed to come into contact with hoses as it damages them rapidly. "Hard" or cracked hoses should be replaced; check hoses and clips once a week. Worm drive hose clips are the best. They can be used many times over whereas other types give trouble with screws and loose "trapped" nuts. On flexibly mounted radiators it is essential that there is some "give" in the hoses; the convolute type is best for this. Many cases of rapid hose failure can be traced to inflexible hoses on flexibly mounted radiators.

WATER PUMP AND FANS. Water pump trouble is usually confined to leaking glands or thrust washers. Glands can be adjusted or repacked but thrust washers usually need replacing. Attention to greasing will safeguard against bearing failure. When overhauling it is best to fit all new internal parts if there is any doubt as to their servicibility. Fans usually give trouble free service; the bolts should be checked at major services and attention to fan belt adjustment will ensure that there is no belt slip. Do not overtighten fan belts. Keep guards in place, both for safety and for efficient cooling. Water manifolds, cylinder heads, and blocks should be cleaned as per maintenance manual. Faulty temperature gauges should be replaced at once.

AIR COOLING SYSTEM. This form of cooling is becoming increasingly popular, even for medium size diesel engines. The basic components are—

- (a) cooling fins on cylinders and heads;
- (b) fan; and
- (c) ducting.

The cooling fins are designed to have a large surface area to enable the heat to be conducted away rapidly; they must be kept clean and dry. Fans may be belt-driven or they may be integrated with the flywheel. These should be kept clean, dry and tight. Ducting is provided to direct the air to the areas where it is most needed; keep this clean and do not run engine with ducting removed.

Maintenance of Lubrication Systems

SUMPS. Sumps often need to be protected from damage from rocks or stumps. On tractors "belly" plates are essential for forestry and road building operations. Vehicle manufacturers also supply sump guards and these should be fitted where necessary. Bolts and screws should be kept tight. Gaskets should be replaced when necessary. It is advisable to carry spare drain plugs and washers. The correct type of spanner should be used on drain plugs. Any build up of mud on sumps must be removed as it will prevent proper oil cooling. Sumps should be drained and filled as per maintenance guide.

RELIEF VALVES. In many cases these are adjustable; study the maintenance guide. However, the need for adjustment is usually very rare. Occasionally trouble is experienced due to dirt on the valve seat. This very rarely cuts out the oil supply completely and often only affects the pressure at low engine speeds. Adjustment of the relief valve may not increase the maximum oil pressure in a badly worn engine.

PIPES. Internal oil pipes very rarely give trouble, external pipes are liable to be damaged accidentally; any such damage should be repaired by brazing or silver soldering. Ordinary solder should not be used. Obviously the pipe must be completely clear inside. Union nuts should

be tightened carefully making sure that the threads are not crossed. In overhead valve engines, the oil supply to the valve rockers sometimes fails. Very often this trouble can be traced to a blocked restrictor. Pressure gauges and warning devices should be maintained in working order.

FILTERS. There are two systems of oil filtering: by-pass and full flow. The full flow type is becoming more common on modern heavy equipment. Filter elements should be replaced at recommended intervals and seals and gaskets should be kept available for use if required.

OIL COOLERS. These are fitted by some manufacturers, usually they only need to be kept clean and secure. They are liable to be damaged accidentally and their repair calls for special equipment and skill.

Gear Box Maintenance

General maintenance consists of keeping all external nuts and covers tight, replacing faulty gaskets, checking, draining and refilling with oil, changing filters and cleaning breathers as per makers' manual.

Gear boxes should not be abused by rough handling of the clutch. Correct clutch adjustment and proper handling will greatly prolong gear box life.

Brakes—Maintenance

The following should be checked:—

- (a) Brake adjustment
- (b) Lining condition and wear
- (c) Handbrake operation and linkage
- (d) Wheel bearings and seals, check before adjusting brakes
- (e) Pipes and flexible hoses
- (f) Pedal mounting and bushes
- (g) Pedal to master cylinder or control valve linkage
- (h) Master cylinder or control valve mounting
- (i) Fluid or air leaks in wheel cylinders
- (j) Brake fluid in master cylinder
- (k) Trailer brake couplings and hose
- (l) Pressure or vacuum tank mountings
- (m) Air gauges and warning devices
- (n) Moisture air systems

Servicing

It is possible only to generalise on this subject as machines differ in their requirements. The manufacturers, their agents or oil companies will supply servicing charts or plans to suit individual machines. In any case it is best to attend to one section of the machine at a time, e.g., engine, tracks, steering, braking system, electrical system, etc. The whole system of efficient servicing hinges on planning and then checking off each item on the plan as it is completed.

Most equipment is serviced on "hours worked" and most vehicles on "mileage covered". Bearing in mind the number of hours or mileage that the respective units are expected to do each day, week or month, one should prepare a *maintenance plan* indicating the intervals between servicing. In this way the staff will know well in advance when the machine will not be available for work and can plan their work accordingly.

Chain Saws—Maintenance

During the course McCulloch chain saws were used. Types 172 and 182 are one-man saws and type 99 is a two-man saw.

The starting procedure will be indicated in the operation manual.

Care while operating:—

1. Do not run engine at full throttle unless the saw is cutting.
2. Pump oil on to chain regularly.
3. Do not let chain dig into ground.
4. If the chain jams in the cut, release throttle at once to prevent centrifugal clutch from overheating and consequent wearing.
5. Change or clean air filter after every 5 working hours or sooner if necessary.
6. Stop engine when carrying saw from place to place.
7. Never operate saw with any parts removed.
8. Keep all fittings tight.
9. To stop switch off ignition. In the type 99 close fuel valve as well.

Maintenance:—

1. Check over daily for broken, loose or worn parts.
2. Study and observe lubrication requirements given in the manual.
3. Keep all parts clean.
4. Handle and store saw with care.
5. Fix time for periodic inspection, e.g. once a week check plug and muffler, etc.
6. Consult manufacturer if in doubt on any point.

MECHANICAL TIMBER EXTRACTION

As an introduction to this subject, it is useful to outline briefly the introduction and progress of mechanical timber extraction in Burma.

Mechanical Extraction in Burma

Mechanization of timber extraction in Burma was introduced to supplement the shortage of elephants. In view of the difficult terrain and the scattered nature of the trees to be felled, tractors will never be able to take over completely the work of elephants, but can only supplement elephant power by doing their share of the work in areas suitable for mechanical extraction.

On the recommendation of an expert in mechanical logging from the F. A. O. the State Timber Board purchased in 1954/'55 its first mechanical unit comprising one D7, two D6 and two D4 caterpillar tractors, two loading winches fitted with caterpillar engines, one "Logger's Dream", five diesel timber trucks and some power chain saws. On the experiment being found successful, the State Timber Board extended the mechanisation of extraction by establishing 3 more units in 1957/'58, 1958/'59 and 1959/'60.

The D4 tractors were found to be lacking in power for the prevailing conditions and hence only D6 and D7 tractors were purchased together with suitable track type logging arches. With each unit, motor graders (Caterpillar No. 112) for road maintenance and mobile workshops were also procured. For log haulage three Walter trucks were bought with each of the second and the fourth units and four Kenworth trucks with the third unit.

It is the intention of the State Timber Board to purchase two more units within the next two years.

Power Chain Saws

GENERAL. One-man chain saws are ideal for felling operations, Two-man chain saws are generally in use in depots for cross-cutting of logs but these too will be replaced by one-man chain saws soon. A one-man chain saw requires one operator and an assistant whereas a two-man chain saw requires two operators and two assistants to carry the saw. Hence the operational cost of 2-man saws is very high.

Choice of Power Saws

There are various makes of power chain saws such as Dolmar, Pioneer, Homelight, McCulloch, etc. Hence, in the choice of power saws, the following points should be considered :—

- (1) A one-man saw is ideal for felling operations. Two-man saws may be used for cross-cutting of logs in the depot.
- (2) A well-known make of saw for which spare parts are readily available should be selected.
- (3) The saw should be light and strong. A one-man saw should be below 25 lb. in weight without the cutter-bar and the chain.
- (4) The saw should be easy to handle and maintain. Maintenance should be simple. For instance the removal of chain, bar, sprocket, filters, plugs, etc., should be simple.
- (5) The saw should have a high cutting speed.
- (6) The Engine should have a high carry through, i.e., it should not stall.

When an order is placed for a saw it is important that tools and spare parts should also be indented for. The basic tools are an oil tin, funnel with filter, tool kit, plug spanner and files for sharpening. The spare parts list should include the chain, sprocket, starting rope, cutter bar and plugs. In addition, a first-aid kit should be made available to each felling team. The frequency of accidents is less with power saws than with ordinary saws. However, power-saw accidents are more serious and hence the necessity for first aid kits.

Training of Operators

To expect good results with power saws the operators should be trained on—

- (a) Handling of saw.
- (b) Maintenance of saw.
- (c) Sharpening of chain.

It has been proved that the failure of power saws is mainly due to incorrect handling or bad maintenance and hence the importance of training the operators. The following are some of the factors which contribute towards the failure of power saws :—

- (a) Use of wrong fuel mixture.
- (b) Insufficient lubrication of chain and transmission while operating the saw.
- (c) Incorrect sharpening of chain.
- (d) Failure to tighten blade or check on chain adjustment prior to commencement of operation.
- (e) Failure to change or clean air filter after every five working hours.

Use of Power Saws

Power saws are used for cross-cutting of logs and for felling trees.

CROSS-CUTTING OF LOGS : Care should be taken when cross-cutting logs in tension, as the saw will jam in the wood unless special precautions are taken. The following techniques should be followed when logs in tension are cross-cut.

The principle is that the side of the log where the saw is likely to jam should be first cut to a depth equivalent to one fourth of the diameter of the log. This is followed by a second cut from the opposite side to completely sever the log

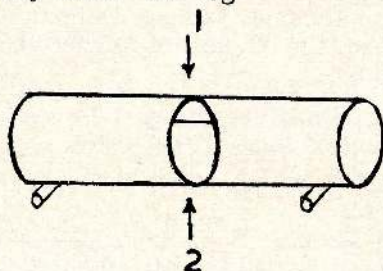


FIG: I

In the illustration in figure I, the saw is likely to jam on the top portion of the log. Hence the first cut should be from top downwards followed by a second cut from bottom upwards to meet the first cut.

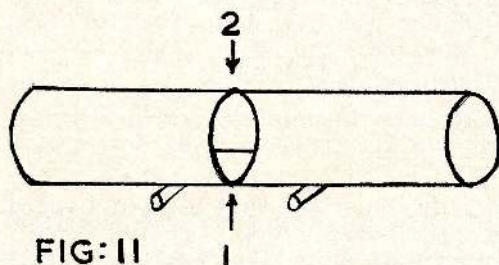


FIG: II

In figure II the first cut should be from the bottom and the second cut from top.

Felling of trees: Before the actual felling operation commences the direction in which the tree should fall should be first determined. The direction of fall will be determined by the following factors.

- (1) The golden rule is to fell trees always uphill as this involves a shorter fall and less damage.

- (2) Lean of the tree. If the lean of the tree is downhill, then the direction of felling will be along the slope.
- (3) While felling the tree uphill, it is essential that the direction of fall be at 45° to the main extraction path (main skid trail) in order to ensure downhill skidding of logs in a straight line on to the main skidding trails.
- (4) The direction of felling should be such that the falling tree does the least possible damage to the standing crop and does not strike rocks or humps on the terrain.

Once the direction of felling has been decided on, the felling operations could commence. Two types of cut are involved in felling a tree—the “under cut” and the “main cut”. The under cut is first made on the same side as the desired direction of fall. This cut determines the direction of fall. It also prevents the splitting of the tree from the stump end while the tree is falling. The under cut consists of two cuts. The first one is a horizontal cut into the tree to about $1/3$ the diameter of the tree. This cut should be as low as possible. The second cut is a slanting cut at 45° to the horizontal cut. The cone of wood thus cut should be removed. The main cut is then made just 2" above the horizontal cut of the under cut. When the cutter bar is longer than the diameter of the tree, it is best to commence the main cut at a point 2" away from one end of the under cut and to cut round the tree. The two inches of solid wood between the under cut and the spike ensures the direction of fall according to the under cut.

Crawler Tractors

There are different makes of crawler tractors e.g., Caterpillars, Euclids, Innco, Allis, Chambers, Huber Waroo, Ferguson, International Harvester, Vickers, etc. Tractors are classified into five types depending on the flywheel horse power and draw horse power. Flywheel horse power is the horse power produced in the engine and the transmitted horse power is the draw horse power. The difference in horse power between the two is due to the loss in transmission.

In the choice of a tractor it is therefore necessary to decide on the class of tractor required i.e., the horse power. This will obviously depend on the type of work to be performed, weight of timber to be skidded at a time etc. Other factors to be considered are :—

- (a) Diesel or petrol engine,
- (b) Number of track and carrier rollers,
- (c) Width of track shoes,
- (d) Number of gears,
- (e) Dry clutch or clutch in oil,
- (f) Standard front idler or oversized front idler,
- (g) Supply of additional equipment such as canopy over drivers seat, winch, bull dozer etc.,
- (h) Fuel and oil consumption,
- (i) Availability of spare parts and their costs,
- (j) Whether the local agent is competent enough to undertake major repairs.

Tractor Attachments used in Logging

WINCH. A tractor should not be used without even a single-drum winch. When the sulki or logging arch is used, a single-drum winch with an automatic brake is very essential. Automatic brakes are necessary to stop logs falling down from the arch. For high lead loading, a double drum or three drum winch is required.

LOGGING ARCH. The logging arch should be well balanced, and manufacturers should quote the type of arch suitable for their tractors.

DOZERS. There are two types—angle dozers and the bull dozers. Dozers are controlled either hydraulically or mechanically by cables. Both types are satisfactory. Dozers are used in pushing logs, road cutting etc.

Tools used in Mechanical Timber Extraction

CABLES. Depending on the machine size, cables ranging from $\frac{1}{2}$ inch diameter to $1\frac{1}{2}$ inch diameter are used. Most of the cables used have a steel core. Occasionally hemp core cables are also used.

CABLE SLINGS. These are used on tractors and are made of wire ropes of the same diameter as the cable used in the winch.

Skidding with Tractor and Logging Arch

It is absolutely essential that skid trails be opened prior to the skidding operation. The skid—trails should be so opened as to form a herring bone pattern with the main skid trail. The skid trails should be at 45° to the main skid trail. Skidding operations should start from the top and work downwards along the skid trails. As the tractor comes down, pre-bunching of the logs can be done to make up a load. In skidding operations, one end of the log is lifted under the arch while the other end drags along the ground. There is a limit to the number of logs that could be accommodated under the arch. Hence for maximum efficiency the logs must be long as there is no limit as to length of log. Logs are normally skidded down to the main skid trail in a straight line. If the tractor cannot reach a stump, the winch is used to haul the log to the arch. The optimum skidding distance for a tractor with a logging arch is about one mile.

It was found during the course that a D7 could haul 800 cu. ft. for a distance of less than one mile.

Logging Equipment other than Tractors

ANIMAL POWER. The animals used in forest work are elephants, buffaloes, horses, oxen, etc., These cannot be replaced completely by machinery for sometime to come.

Winches with 2 or more drums—These are usually mounted on sledges or rubber tyred or track chassis. These are mainly used in high lead operations for lifting logs. Winches are also used for loading logs into trucks.

HIGH LEAD SYSTEM. This is recommended for clear felling operations and not for selective felling. The high lead system may be described briefly thus. The two drum winch or yarder is normally kept near the base of the spar tree. From the yarder, the main line (cable) is taken up to the high

lead block which is a pulley block installed about 125 ft. above ground on a spart tree. From the high lead block, the main line goes into the felling area where the cable is fixed to a stamp and then goes through two haul back pulley blocks to form the haul back line. The main line and haul back line are of different diameters and are therefore under different tensions. Hence either the main or the haulback line may twist. This is prevented by the introduction of a swivel hook. With this system, a strip on either side of the main line is worked, and then the assembly is shifted to the next strip. With modern winches, a 35 ton load can be pulled with a 2 in. diameter main line. Today, the tendency is to avoid using living tree for fixing the pulley block. There are portable high lead towers of about 60-80 ft. in height. The whole unit is mounted on a sledge.

SKYLINES. These are not suitable for tropical forests; skylines can be used over a distance of $1\frac{1}{2}$ miles but the range on either side of the main line is only 100 ft. Here the logs are skidded uphill at 45° to the main line.

Loading of Logs on to Trucks

The introduction of heavy equipment for loading logs on to trucks can only be justified if the daily output is sufficiently high to keep the equipment fully engaged. The following are some of the methods of loading logs—

- (1) The most common form of loading is off loading banks. The logs are stacked on the slope and the end of the slope is in level with the truck platform. The logs are rolled down to the platform of the truck.
- (2) In a flat terrain, the pit method is adopted. This method is unsuitable during the rainy season as the pit is liable to get water logged. The approach roads to the pits should be of a gradual gradient so that the trucks could go in from one side and drive out of the other with the load.
- (3) Cross haul system—In this case the logs are hauled up to the lorry on a skid with a winch. The winch may be on the lorry or it may be on the ground with a set of pullies on the lorry body.

MECHANICAL EQUIPMENT FOR LOADING. Many types of equipment are available for loading. Some are yarding and loading machines while others are exclusively loading machines.

LOGGER'S DREAM. This is a yarding and loading American machine which consists of a truck chassis with engine, boom and multiple drum winch. The advantages of a logger's dream are:—

- (a) High mobility,
- (b) Easy to erect,
- (c) Operation does not require skilled labour.
- (d) Purchase price is reasonable as compared with other loading equipment,
- (e) It can also be used for yarding or skidding.

The disadvantages are:—

- (a) Loading capacity is limited
- (b) Loading takes longer than with more expensive equipment,
- (c) About five or six assistants are required.

FRONT-END LOADER. This is a recent improvement on loading machines. The front end opens hydraulically, takes in the log, lifts it and loads it into trucks. Different types are available with different capacities which range from $3\frac{1}{2}$ tons to 40 tons.

Motor Trucks used in Log Transport

Motor trucks are widely used for medium and long distance transport of logs. 15 miles and over is considered as a medium distance and 100 to 150 miles as long distance. Only after the second world war have motor trucks been widely used in timber transport. Transport by motor trucks is gradually replacing rail transport as road construction is cheaper than before. Motor trucks are commonly use in Ceylon for timber transport hence no more will be said about them.

TIMBER EXTRACTION WITH ELEPHANTS

Even today timber is extracted mainly by elephants. During the pre-war period about 6,000 elephants were employed extensively in timber extraction but today the State Timber Board has only about 900 elephants as against the actual requirement of about 3,000. Hence machinery was introduced to augment the shortage of elephant power caused by the last war followed by internal unrest. In water-shed areas however, no machinery is allowed and extraction is done by elephants alone. This again is a subject on which nothing more need be said here as elephants are extensively used in Ceylon for extraction.

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