REPORT ON THE POSSIBILITIES OF MECHANIZING TEA CULTIVATION IN CEYLON

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This report is the outcome of an invitation, under the Colombo Plan, to pay a short visit to Ceylon to examine the possibility of mechanizing tea cultivation, with particular reference to replanting. I arrived in the Island on February 10th and proceeded almost immediately to the Tea Research Institute at Talawakelle. From there I paid visits of varying duration to fourteen estates on both sides of the island; while at the Tea Research Institute Conference at Nuwara Eliya on March 6th and 7th, and on other occasions, I had opportunities of meeting, and talking with, a much greater number of planters. I am most grateful, to the Director and Staff of the Tea Research Institute; to the Superintendents of the estates that were visited; and to many others in the tea industry, for the help and encouragement they so readily gave. From the outset it was clear that this enquiry could only be a preliminary one; that specific recommendations could hardly be made on the basis of only a few weeks' experience. The purpose was rather to consider whether the potentialities of mechanization were promising enough to warrant further enquiry and experiment; and to indicate some lines that further enquiry might follow.

General Observations on Mechanization

Ceylon tea uses more labour than any other large-scale crop in the world. The number of workers on a tea estate is at least 20 times as great as on a U.K. farm of the same size growing crops with a high labour requirement, like sugar beet or potatoes, yet the value of production per acre is not much greater. But the lower labour requirement of Western farming is not so much the result of mechanization in its modern sense of tractors and combine-harvesters, as of much earlier developments like that of the reaping machine in the early 19th century. In most Western farming it is more than 100 years since primary crops like grain or hay were harvested, and far longer since any general cultivation was done by hand. By contrast everything in a field of tea is still done either literally by hand, or with hand-wielded tools.

It is also worth noting that most early developments in mechanization were brought to practical fruition as the result of acute labour shortage; as, for example, when the prairies had to be opened up by the unaided efforts of the first pioneers and their families. But in Ceylon tea there is no general shortage of labour; while if during peak work periods there are occasions of temporary shortage, these only accentuate the fact that at other seasons surplus labour may have to be employed unremuneratively. Here, the reasons for considering mechanization are economic ones in the purely financial sense. On the one hand, the general urge towards higher wages and better living conditions on the part of a very large labour population has brought about a sharp, and still continuing, rise in the cost of producing tea. On the other hand, in the main consuming countries—where the same rising curve of wage rates and purchasing power is almost certainly nearer its peak—the price of tea is rising to the point at which what has hitherto been every man's beverage may become a luxury. If mechanization is to be worth while, it must aim at making it possible for tea to be produced with a substantially lower labour requirement all round.

In the writer's view this means that attention should mainly be concentrated in one or both of two directions—on the jobs with a high labour requirement which go on all the year round, on the peak labour seasons which, if they exist, will determine the size of the labour register. With this in mind, an analysis of present labour use on some typical estates is given later in this report. But, even without such analysis, it seems obvious that mechanization will not be fully effective unless it can be extended actually into the tea field itself.

Difficulties of Mechanizing Field Operations

One obvious difficulty in the way of mechanizing field operations is the nature of the terrain; the steep and rocky slopes that are so regular a feature of tea estates. But a still more general one lies in the present arrangement of the tea bushes themselves, and the virtual impossibility of manoeuvring any mechanically propelled appliance between and around them. Because of this, even where there are no steep slopes or rocks, immediate field mechanization is likely to be practicable only at the level of the appliance which is carried, together with the engine that drives it, on the labourer's back. Appliances of this kind are already being used experimentally for both mechanical plucking and spraying; but what they can accomplish in labour saving is limited, while it is doubtful whether the principle can be applied as effectively to other essential work.

More effective field mechanization will almost certainly depend on getting some kind of mechanically-propelled power unit into the tea field. This may be some kind of tractor pulling or carrying its own implements, or it may be no more than a means of providing a larger and more robust source of power than the labourer can carry on his back. But the use of any such appliance will of necessity be bound up with the introduction of a more appropriate bush pattern—*i.e.* one which gives room for a small tractor or something of the kind to manoeuvre—as and when tea is replanted, or new areas are opened.

Replanting with high yielding clones is already being seriously considered as a means of higher production, and on several estates newly planted areas are to be seen at all stages up to bushes just in production. But in every case the replanting has been done in a manner which is likely—because the rows are too close together with no provision for turning at the ends—to prohibit mechanization for another 50 years. If, therefore, the wider possibilities of mechanization are to be seriously considered—and it may be said immediately that, in the light of subsequent discussions, there is a case for doing so to be made out—then the institution of experimental work to determine the most suitable replanting pattern is a matter of urgency.

It is understood that by Government Ordinance all replanting will be done on the contour. This will tend to reduce the difficulties arising from steep slopes, as well as from open field drains, although, here again, experimental work on arrangement will need to be done.

Present Labour Utilization

The following analysis is based on detailed information from five estates, only three of which were actually visited. The sample is obviously not large enough to be conclusive and if the subject of mechanization is to be given more detailed consideration in the future, a corresponding analysis for a much greater number of estates ought to be undertaken. At the same time, the figures relating to these five estates—which varied quite widely in area and situation—were so remarkably consistent, at least as regards main items, that they provide a satisfactory enough basis for present discussion.

The analysis includes all labour other than supervisory and office staff. Of the individual items listed; "Maintenance" includes all work on roads, paths, drains, terracing, ravines and boundaries; "Bush Sanitation" includes all the work of mossing, ferning and root growths incidental to pruning; "Factory" includes red leaf picking, which may amount to as much as half the total factory labour employed; "Services" includes all the labour concerned in scavenging, general health and welfare services, etc. The final column—labour cost in cents per pound of tea—has been calculated by assuming an average daily wage of 2.05 rupees, with an average yield of 800 pounds per acre, and is included only to enable comparison to be made with estimates from other estates.

Analysis of labour use on five estates

	Labour days as % of total	Labour days per acre	Labour Costs Cents/lb.
Plucking	44.4	127.6	32.8
Weeding	18.7	53.7	13.7
Forking & Manuring	4.3	12.3	3.2
Dusting & Spraying	3.6	10.3	2.6
Bush Sanitation	3.1	8.9	2.3
Green Manure	2.4	6.9	1.8
Pruning	1.9	5.5	1.4
Maintenance	6.4	18.3	4.7
(Total for field work)	(84.8)	(243.3)	(62.5)
Factory	8.5	24.4	6.3
Services	6.7	19.3	5.0
GRAND TOTAL	100.0	287.0	73.8

The analysis makes it clear that at least from the standpoint of effecting an overall reduction in labour, plucking and weeding are the two operations most worthy of study. Together they account for nearly three-quarters of the whole labour expenditure on field works; while both go on almost continuously throughout the year. In theory, therefore, any labour that can be saved in either plucking or weeding represents labour that can be dispensed with entirely. Mechanical plucking—which involves questions concerning bush management and quality to which there are no definite answers at present—is discussed in some detail later in this report. In the meantime mechanical weeding provides an immediate illustration of what fairly straight-forward mechanization might accomplish.

Mechanical Weeding

A convenient outfit to consider for purposes of illustration is one of the small tracklaying tractors with an engine of 6 to 7 h.p. that are quite commonly used by large-scale market gardeners in the U.K. There are, of course, other possibilities, e.g. the small 4-wheeled drive tractors that are used in some continental vineyards, or even the two-wheeled "walking" tractors that are used in smaller-scale market gardening. But, on the whole, a small tracklayer seems to offer the best combination of small overall dimensions and manoeuvrability with an adequate output of power. A tractor of this kind would have an overall width of not more than about 3 ft. and could operate without difficulty in 7 ft. tea rows. With appropriate shielding to push longer branches aside it might even operate in 6 ft. rows, but this would be a matter for experiment in the field. The tractor could carry weeding equipment arranged so as to work right up to the boles of the bushes on either side.

The exact nature of the weeding equipment would, again, be a matter for experiment. It might, for example, be an arrangement of shallow working hoes similar to those used in sugar beet and other root crops; or one of the so-called finger

or rod weeders; or even some form of rotary cultivator. It is, however, quite certain that out of the very wide range of light cultivating equipment now available suitable tools for weeding tea rows could be found.

Working in 7 ft. rows at an average of 1½ m.p.h. a tractor mounted outfit of this kind would cover about 10 acres in a day; and, working 25 days per month, would be capable of handling the weeding of 250 acres of tea. If all weeding were done with tractors in this fashion, at the rate of one to every 250 acres, the whole labour force of the estate could be reduced by over 20 per cent.

Some indication of the comparative costs of the two methods may also be of interest. At 53.5 man days per acre the present annual cost of weeding 250 acres of land would be about 27,000 rupees. The capital cost of the tractor outfit would be about 5,000 rupees; and if this were entirely written off in four years, depreciation charges would be about 5 rupees per day. From experience already gained with the tractors now being used for haulage on tea estates the daily running cost, including the driver's wage, would be not more than 20 rupees a day. At the all-in total of 25 rupees a day, the annual cost of weeding 250 acres by tractor would be only about, 6,250 rupees—a saving of over 20,000 rupees, or five times the first cost of the equipment, annually.

Use of Equipment in Other Operations

Deep forking could probably not be done mechanically except at the risk of excessive root disturbance; but the lighter forking that accompanies fertiliser application, and the actual application of fertiliser, could certainly be done in much the same way, and at much the same saving of labour and cost. Indeed, in the long run, the separate items of manure application might disappear from estate estimates altogether. Two out of the twelve annual weedings would be done with a rather deeper-working tractor attachment—with something on the lines of a harrow instead of a hoe—the fertiliser being applied mechanically and more accurately, at the same time.

As a further example of how mechanization may change existing practices: it would almost certainly be desirable to plant the uncovered space between rows (*i.e.* the strip about 3′ wide on which the tractor runs) with some low-growing green crop. It would then be quite practicable to arrange for the tractor to mow this strip, and to windrow the material on to the weeded area under the tea bushes on either side. Moreover, the cutting and windrowing could be done simultaneously with weeding so as to avoid a separate operation.

Finally, there would be no great difficulty in developing a powerdriven sprayer or duster, which could be mounted on the same type of tractor, and which by covering 10 or more rows at a time, would greatly reduce the labour requirement of spraying in just the same way. It is not in any way fanciful to suppose that with equipment of the kind outlined, developed and proven by practical experiment at the Tea Research Institute or elsewhere, labour on field work could be reduced by something like 65 labourers per acre; and the total labour requirement of the estate by something like 25 per cent. This estimate, moreover, is based only on what might be done in weeding, manuring and spraying. The only essential requirements are a contoured bush layout that gives room for the tractor, and reasonable freedom from obstruction and rocks.

Mechanization of Estate Maintenance Services

Now that ordinary tractors are coming into use on many estates for the haulage of leaf and general supplies, it is natural to consider extending their use to road making, timber handling, sawing and so on.

To give only one example, the length of holes for blasting that a mason now accomplishes in a week with a hammer and jumper, could be done with a pneumatic drill operated by a tractor mounted air-compressor in only an hour or two. And on practically every estate visited there were similar jobs to be seen in which some readily available, but not necessarily inexpensive, appliance could be used to enable, say, four workmen to do as much work as now requires ten. But the other six workmen could not be dispensed with entirely; nor was it at all certain that, at that particular moment, they could be profitably employed elsewhere. The real economy of mechanization in such instances was, therefore, open to some doubt. In any case, if the labour analysis given earlier is any guide, the total labour requirement of estate maintenance is so relatively small, and the mechanizable part of it so much smaller, that mechanization in these directions is hardly likely to reduce overall production cost at all significantly.

There are, of course, exceptions; and where an extensive road-making or building programme means bringing in still more labour from outside, or diverting men from other essential work, the case for mechanization will be very much stronger. But in the light of the broader purpose of this survey it was not thought worth while to devote much attention to problems of this kind.

Mechanical Plucking

In a commercial experiment which has been in progress on the Dickwella Estate for rather more than a year, complete records of 32 consecutive rounds of mechanical plucking have been kept. Whatever these and future records may prove in regard to labour and costs, it is clear that mechanical plucking will stand or fall in the long run on its performance in regard to bush management (*i.e.* maintenance of yield) and the manufacturing qualities of the leaf. Nor can conclusive evidence on these points be expected until the experiment has run for at least one complete pruning cycle. In the meantime, only 18 months after pruning, and at least to the inexperienced eye of the writer, the mechanically plucked field appears to have developed a quite outstanding bush cover. The writer would also venture the opinion that if mechanical plucking proves satisfactory from the standpoint of bush management, any short-comings on the manufacturing side will not be difficult to rectify.

Over the 32 plucking rounds so far recorded, mechanical plucking has given an average daily outturn of 56 pounds of leaf per labourer and 112 pounds per machine. This is rather more than double the daily average of 25 pounds per plucker which seems to be commonly accepted as a general standard for hand work. On the face of it, therefore, mechanical plucking offers, as it stands, the possibility of reducing plucking labour by something like 50 per cent, and overall estate labour by a further 20 per cent over and above the saving envisaged in the discussion of weeding, etc.

In the type of equipment now being used each plucker has a self-contained unit driven by a small high-speed 2-stroke engine carried in suitable harness on his back. There is one box carrier to each plucker and the two men change jobs half way through each day's work. Each unit costs approximately 1,000 rupees, and 13 such units are being used on the 50 acres. This number is known to be excessive, and the actual plucking time during each nominal 10-day plucking round amounts only to 5 or 6 days. On the records to date it is estimated that, working as nearly as possible continuously, one unit could deal with 7 to 8 acres. Plucking costs in 1952 averaged just over 30 cents per pound (22.71 for labour and 7.35 for fuel and oil). If the entire first costs of the equipment were to be written off over 4 years, depreciation would amount to an additional 4 or 5 cents per pound. At the moment, therefore, mechanical plucking is not markedly cheaper than hand plucking.

In earlier experimental work the cutting heads were electrically driven, a group of 6 or 8 units being supplied with power through cables from one centrally-situated generator set. But this generator set could not be manoeuvred into the tea; it could

get no nearer than an adjacent field path, and long cables had to be used to give the pluckers sufficient mobility. It is probable it was the general inconvenience of threading long cables in and around closely planted tea bushes that led to this system being abandoned—in any case, the wear and tear of cables would be likely to be prohibitive.

If, however, in the light of what has been written earlier, it becomes practicable in the future for power to be supplied at comparatively short range from a mechanically-propelled power unit which can manoeuvre actually in the tea rows, the economics of mechanical plucking should be greatly improved; by more systematic working, and by the elimination of most of the box-carrying labour. Indeed the writer would go further and suggest that, if only from an experimental standpoint, the possibility of pruning the bushes mechanically to a plucking surface plane enough to permit of fully-mechanical plucking ought not to be overlooked. In this conception the whole row would be pruned originally, and plucked from then on, by a wide cutter bar attached to, and driven by, the tractor. It would be easily within the compass of such an outfit to prune or pluck over 3,000 bushes an hour, or 7 to 8 acres a day with one man.

If mechanical plucking in its present form proves satisfactory as regards bush management and quality, there is, in the writer's view, nothing fanciful about extending the process still further on these lines. Moreover, the potential savings of labour and cost are great enough to warrant the expenditure of a considerable effort on the necessary experimental work.

Arrangement of Replanting

The following notes are intended as a basis for experiment rather than as a guide to immediate practice. The spacing now commonly adopted in new clearings in which the bushes are 1½ feet apart in contour "hedges", which are themselves 5 feet apart, it too close to be worked by tractor in the manner outlined earlier.

A better arrangement, giving exactly the same overall bush density of 5,808 bushes per acre, would be to space the rows alternately at 3 feet and 7 feet so as to give the effect of double hedges ($3 \times 1\frac{1}{2}$) with 7 foot intervals between. But with this arrangement only the wide rows could be tractor worked; and all weeding, and possibly all fertiliser distribution, between the 3 feet rows would still have to be done by hand. With this in mind, and unless it can be shown by experiment that the extra labour requirement of the double hedge will not be serious, a still better arrangement would be to have single rows 7 feet apart to give an overall bush density of about 4,150 bushes per acre.

In either case, a clear space of about 3 feet would need to be left as turning room for the tractor at both ends of every row; as well as on all sides of any boulders or rocky outcrops that might be included in the area. All shade trees should be painted in the tea rows.

In order to economise both turning space and turning time, the rows should obviously be as long as possible. Indeed, in planting replanting programmes it might be well worth while to consider working in strips instead of in blocks; the strips being as long as such natural obstacles as deep ravines would allow. Working in this way the area of, say, 10 acres selected for clearing in any one year might be a strip up to a mile long and only about 30 yards wide; similar strips being added in subsequent years. This procedure might also simplify the operation of lining out rows and drains, over which, in any case, great care would need to be taken so as to avoid awkward short rows and other hindrances to economical working.

Mechanization of Replanting

Apart from the mechanical pulling out of old bushes, which is a relatively straight-forward matter, it has not been possible in the short time available to reach any very definite conclusions on this subject. So little replanting with vegetatively propagated material has yet been done that there is no settled procedure, nor any definite standard of costs against which to judge the possibility of effecting reductions by mechanization.

In almost all circumstances the pulling of bushes by mechanical winch is likely to be far cheaper than grubbing them out by hand. In one instance, using a tractor-mounted winch—the over-all cost of which, including the driver and four other labourers, should not have exceeded 32 rupees a day—bushes are being pulled at an average rate of about one a minute. Winching has the added advantage that it disrupts the soil as effectively as a separate sub-soiling operation. Mechanical bush-pulling has also been done satisfactorily with portable engine-driven winches; but the over-all rate of work is slower, and the cost higher, than with a tractor. Where it is proposed to fit winch attachments to the tractors already used for haulage, a word of caution may not be out of place. Dynamometer measurements made on two estates showed that the uprooting of quite ordinary-looking bushes may need pulls of over 8,000 pounds. This work is, therefore, rather too heavy for the winches of 5 tons nominal capacity that are commonly fitted to light haulage tractors.

Following the clearing of old bushes from reasonably level land (*e.g.* with slopes not exceeding 1 in 7) almost any kind of tractor could be used economically for preparing the land for replanting. The practice now generally recommended is to "build up" the soil by digging contour trenches along the proposed replanting lines and lopping green manures into them over a period of from 18 months to two years, before finally re-covering with soil. On reasonably level land the trenching, lopping and refilling could all be done with readily available tractor equipment with considerable economy of man power and cost; but it is unlikely that more than about 20 per cent of the whole Ceylon tea area would, in fact, be level enough to be handled in this way. On a much greater proportion of the whole tea area—with slopes ranging from 1 in 7 up to, say, 1 in 3—mechanical preparation for replanting would still be practicable, but only with special equipment still to be designed. The writer has in mind a special tractor, somewhat resembling a motor cycle with side car in general layout, with one drive wheel (or track) one steering wheel and one adjustable stabilizer wheel. This would do relatively light work by direct traction, or heavier work by winching itself along.

Excluding preliminary costs of development, an appliance of this kind should not cost more than an ordinary tractor; and should enable one man to dig contour trenches at 20 to 30 times the rate of ordinary hand work. The potential market for such an appliance would, however, be too small to interest large-scale manufacturers; and equipment of this kind is unlikely to be forthcoming unless development is fostered and financed independently.

One advantage of the trenching procedure just mentioned is that the land seems afterwards to fall naturally and fairly rapidly, into contour terraces, which are subsequently stabilised by the tea rows themselves. To judge from the new clearings at the Tea Research Institute this automatic falling of the land into terraces will generally happen quickly enough for the small tractors that are afterwards to be used for weeding, etc. to be first introduced at the time that the young plants are put out. They could, therefore, be used to cheapen upkeep over the next two or three years, and so still further reduce overall replanting costs as these are reckoned at present. On the whole, however, the figure of 3,500 to 5,000 rupees per acre,

now commonly quoted for replanting, includes so many odd (and probably unmechanizable) items that, without more sear ching enquiry, the writer would doubt whether any kind of mechanization can effect an overall reduction of more than one-third of present costs.

Conclusions

With Ceylon tea as it is planted and organised at present, there is little prospect of lowering production costs by mechanization. But given the more appropriate bush pattern that could be introduced wherever tea is replanted, or new tea opened, there is every prospect that, by fairly straight-forward mechanization, the present labour requirement of tea growing could be reduced by at least 50 per cent.

In the writer's considered view, therefore, there is a very strong case for giving serious attention to mechanization in direct association with replanting, and for instituting the further enquiry and experimentation necessary to bring it to practical fruition.

Broadly speaking, experimental work will be required in three directions. First, although most of the basic equipment mentioned in this report is already commercially available, a great deal of minor development, and adaptation by trial and error in the field, will be required in order to fit in to an entirely new purpose. Secondly, in tea as in every other crop to which it has been applied, mechanization will bring about the changes in method: so much of present tea cultivation practice seems to have evolved from the existence of an over-abundant labour supply, that to re-examine the whole agronomy of the crop in the light of mechanical working, is likely to pay handsomely in the long run. Finally, the whole question of bush pattern and the layout of new clearings clearly needs more careful study on the ground itself than the necessarily hurried survey on which this report is based. Moreover, on this point alone, there is likely to be a demand for advisory assistance that will be quite beyond the present resources of the Tea Research Institute of Ceylon.

Generally the work will demand ample funds; the services of men of first-class ability in agricultural engineering; the co-operation of estates; and a close liaison between the tea industry and machinery manufacture in the United Kingdom and elsewhere.