The Organisation and Control of Field Practice for Large-Scale Oil Palm Plantings in Malaysia

by

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To

Taib

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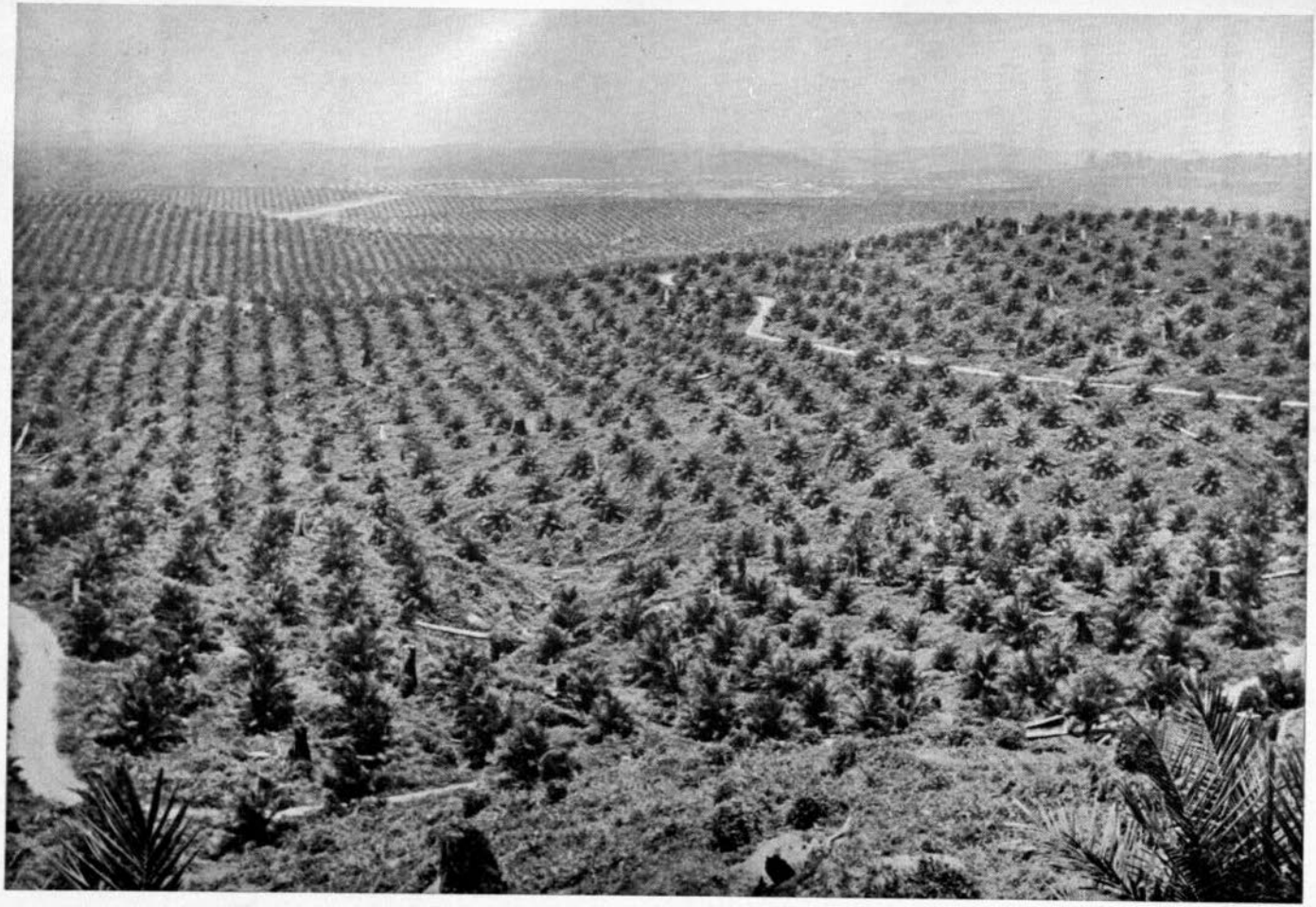

(F.L.D.A.)

Frontispiece—An FLDA Oil Palm Scheme of 22,000 Acres at Kulai.
An example of large scale oil palm planting in Malaysia.

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INTRODUCTION

In recent years the oil palm has become increasingly important in the agricultural development programme of Malaysia. The primary objective of this book is to develop a rationalised approach to the organisation and control of field operations in relation to large-scale oil palm plantings.

In view of the large capital investment that has to be committed over a long period, the increased emphasis being given to quality standards by the end-users and the recent substantial decline in the prices of palm products, there is an urgent need for reducing development and operating costs to a minimum so as to ensure maximum returns to investment. To achieve these ends, a systematic approach to all aspects of establishment and operation is obviously essential.

The current trend in development, particularly in the public sector, is towards the establishment of 5000-acre, single-stage plantings. Because of the complexity and interdependence of the operations relating to both the establishment and production phases, correct timing and the achievement of efficient work standards are essential for the attainment of development programme targets.

In the following chapters it has been assumed that the pre-investment feasibility studies pertaining to the physical and economic environment have been carried out and the Master Plans of the development programme prepared. The emphasis in this book is centred upon the implementation of the field operations involved in executing the Master Plan programme.

The basic objective throughout has been to examine the critical factors associated with the main field operations, both during the establishment and production phases. When implementing a development programme, the first stage involves the drawing up of work schedules outlining the phasing of the main operations and subsequently, within each operation, determining the timing, job specification and the method and control systems to be used in their execution. Although the main emphasis relates to the development and operation of 5000-acre units, the approach used is equally applicable to the smaller-scale operations generally prevailing in the private sector.

Labour is the major input factor involved in current oil palm planting practice and, for this reason, it is essential to ensure that effective use is made of the labour force, both in terms of its organisation and operating technique. The assumptions made with respect to the labour requirements for the various operations described in the following chapters aim at providing benchmarks for general guidance with respect to the size of the labour force and its distribution at different stages of development and production.

There is little published information relating to the systematic organisation and management of field practices in oil palm planting. It is hoped that this book will provide a basis for formulating work study programmes aimed at increasing the efficiency of field practice.

This book deals essentially with the organisation and control of field operations. It does not deal with the agronomic techniques of planting and hence should be read in conjunction with its forerunner, *Planting Techniques for Oil Palms in Malaysia*, by Bevan, Fleming and Gray (1966).

The Nursery

CHAPTER 1

PLANNING CONSIDERATIONS FOR DIFFERENT NURSERY SYSTEMS

1.1 DECISION ON NURSERY POLICY

A major factor in planning and establishing a nursery which is to be used for a given field planting, is whether the area to be developed is near to existing cleared areas or is isolated. If cleared areas are available, *e.g.* in the current or previous year's field plantings, the nursery should be sited within these areas so as to avoid the problems associated with site selection and development in uncleared areas. The main advantages of using existing cleared areas can be listed as follows:

(a) Site selection is easier as rentices do not have to be cut into the area and through potential sites within the area.

(b) Access roads will be available, as agricultural roads would have been established by the time the pre-nursery is prepared.

(c) The access road made when establishing a nursery in uncleared jungle may not be suitable for integration into the ultimate (agricultural) road system for the planting. The cost, therefore, would have to be debitted solely against the nursery. Conversely, in the case of nurseries in cleared areas, there would be no cost of access road to debit against the nursery.

(d) There would be no need to leave fire-belts, which are potential sources of pests.

A possible disadvantage in using existing cleared areas, could be that the cost of transporting seedlings from the nursery to the field may be greater than if the nursery were located centrally within the area being developed. If, however, the existing cleared areas are close to the boundaries of the new area being developed, the differential between these transport costs could well be negligible.

1.1.1 *Cost comparisons for a permanent central nursery and separate nurseries*

When considering a policy for nursery establishment in relation to a continuous programme of new development or replanting, the advantages and disadvantages of establishing a permanent central nursery, as opposed to a number of separate nurseries used on one occasion, must be examined thoroughly. The

advantages of a permanent central nursery are associated with savings in establishment costs and increased yields resulting from improved nursery growth, obtained through a higher level of efficiency in nursery management. The disadvantage of a permanent central nursery is in the distance which seedlings have to be transported to the areas being planted. The question therefore, is one of comparing the gains attributable to savings in nursery establishment, operating costs and increased yields, with additional seedling transport costs involved when using a central nursery.

In the following analysis certain basic assumptions have been made with respect to:

(i) cost items that vary when using permanent, as opposed to separate, nursery sites;

(ii) increased earnings resulting from higher yields in the first year of harvesting; and

(iii) additional transport cost per seedling when using a permanent central nursery.

It has also been assumed that costs for labour, materials and equipment for nursery operations such as planting, bag-filling, manuring, weeding, watering, pest and disease control, *etc.*, are the same for both systems.

Variable cost items

The variable cost items can be listed as follows:

Renticing for site selection.

Access roads to nurseries.

Clean-clearing the nursery sites.

Installing the irrigation systems.

Depreciation on irrigation equipment.

The nursery store.

Depreciation on field staff quarters.

Field staff remuneration.

The following assumptions relate to the establishment of nursery sites of approx. 80 acres (400000 germinated seeds) for field plantings of 5000 acres. Allowing 20% for culls and losses, the number of seedlings transplantable, *i.e.* for field planting at 12–14 months from the main nursery, is 320000. This is the number required for a planting density of sixty palms per acre where 5% of the total seed order is reserved for later supplying.

Renticing for site selection. The cost of renticing for the inspection of three potential nursery sites for each 80-acre nursery established (400000 seedlings) has been estimated at $140 per site.

Nursery access roads. It has been assumed that, for any given selected site, approx. ½ mile of access road will have to be constructed at a cost of $20 per chain. It has also been assumed that these access roads would not be integrated into the final agricultural road system of the plantings. Some 60 chains of internal nursery roads are also required, at an estimated cost of $10 per chain.

Clean-clearing. In preparing the nursery site, it has been assumed that mechanical clean-clearing (to ground level) would cost approx. $230 per acre. Assuming that manual felling and burning for field planting would cost $150 per acre, the cost differential attributable to the nursery would be $80 per acre.

Installing irrigation systems. Each 80-acre nursery site would require three separate irrigation systems and it has been estimated that the costs involved in installing the systems would be $60 per system. (See Section ~~4.11~~ 3.)

Depreciation on irrigation equipment. It has been assumed that a 75-acre main nursery requires three irrigation systems, each costing approx. $18000, *i.e.* a total outlay of $54000, inclusive of pump houses, per nursery. For a permanent nursery where irrigation equipment is being operated continuously, the systems are written off over a period of 4 yr.

On this basis, a permanent central nursery operating over a period of 6 yr would require a capital expenditure of $108000 (two 75-acre systems) the residual value of this equipment at the end of the 6-yr period being $27000. The total depreciation element for the permanent central nursery would be estimated at $81000.

For separate nurseries, the overlap in the timing of nursery establishment would necessitate a 75-acre irrigation system in each of Nurseries 1 and 2. The usage intensity of these systems would be 14 months in every 24 months. Despite this relatively low usage rate, the systems are depreciated over 5 yr as a result of the frequency of dismantling and re-assembly over a 6-yr period. Therefore, purchase of three 75-acre systems would be necessary, the residual value of the systems purchased in year 6 being $43200. On this basis, the total depreciation element for six separate nurseries has been estimated to be $118800.

From the figures given in Table 1, it can be seen that the savings in establishment and supervision when using a permanent nursery (A) as compared with separate nurseries (B) would amount to $102950 for a programme of planting

TABLE 1

Estimated cost differential (in $) of establishing and supervising a central permanent nursery for 6 yr (A) or six separate nurseries (B) for 30000 acres developed over 6 yr (all sites are 80 acres)

Variable cost items	System	Years 1	2	3	4	5	6	Residual value	Total expenditure	Remarks
Renticing for site selection	A	780	—	—	—	—	—	—	780	Renticing @ $140 per potential site: $420
	B	780	780	780	780	780	780	—	4680	Slope measurement @ $120 per site: $360
Access internal roads to nursery	A	1400	—	—	—	—	—	—	1400	40 chains of access road (temporary) @ $20 per chain: $800
	B	1400	1400	1400	1400	1400	1400	—	8400	60 chains of internal nursery roads @ $10 per chain: $600
Additional cost for clean-clearing (mechanical) nursery site	A	6400	—	—	—	—	—	—	6400	Assumed that the additional cost when clearing site for nursery establishment as compared with manual clearing for field planting amounts to $80 per acre (whether done mechanically or manual + destumping)
	B	6400	6400	6400	6400	6400	6400	—	38400	
Installation of irrigation system	A	180	—	—	—	—	—	—	180	Estimated that a 25–30 acre irrigation system would cost $60 to install
	B	180	180	180	180	180	180	—	1080	
Expenditure on irrigation equipment	A	54000	—	—	—	54000	—	27000	81000	System A—equipment written off over 4-yr period
	B	54000	54000	—	—	—	54000	43200	118800	System B—equipment written off over 5-yr period
Stores	A	1000	—	—	—	—	—	—	1000	
	B	1000	1000	—	—	1000	1000	1000	3000	
Expenditure on staff quarters	A	3000	—	—	—	—	—	1500	1500	Settler-type houses used @ $1500 per quarter.
	B	3000	3000	400	400	400	400	3250	4350	Depreciated @ $125 per annum.
Staff renumeration	A	6600	6600	6600	6600	6600	6600	—	39600	
	B	6600	9900	9900	9900	9900	9900	—	56100	
Savings when using system A		—	+70060	+12460	+12460	−40540	+67460*	—	+102950	Saving=5.36 ¢ per seedling.
(Compound Interest Factor)		—	+(0.262)	+(0.191)	+(0.124)	(0.06)	—	—		
Interest on savings @ 6%		—	+18355	+ 2379	+ 1545	− 2432	—	—	+ 19847	Earnings on savings=1.03 ¢ per seedling.
							Total saving	=	*+122797*	*Total savings=6.39 ¢ per seedling.*

* No interest charge made on differential between systems A and B in year 6.

30000 acres spread evenly over a 6-yr period. In terms of transplantable seedlings, these savings would amount to 5.36¢ per seedling.

Stores. It has been assumed that, for an 80-acre nursery site, a store would cost $1000 to erect. For separate nurseries, it has been assumed that stores could be used on two occasions. No residual value has been allowed for a store that has been used twice and this compensates for no charge being made against erection.

Depreciation on field staff quarters. For a single nursery, two Field Assistants would be stationed on the site and housed in temporary quarters; each of these quarters has been assumed to cost $1500 to build. Where separate nurseries are to be established in consecutive years, overlap in establishment timing would require two Field Assistants in each of the nurseries, and therefore four staff quarters would be needed. In the example outlined below, which deals with the establishment of nurseries catering for a 6-yr period, it has been estimated that the quarters from Nursery 1 could subsequently be moved to Nurseries 3 and 5, at a cost of $200 per quarter for each move. Similarly, quarters from Nursery 2 could be moved to Nurseries 4 and 6. The depreciation over 6 yr would be $1500 for the two quarters in Nursery 1 and, over 5 yr, $1250 for the two quarters in Nursery 2.

For the permanent central nursery, it has been assumed that two quarters would be required for two Field Assistants in the first year. No additional staff would be required over the 6-yr period, and the depreciation on staff quarters over 6 yr would amount to a total of $1500.

Field staff remuneration. Two Field Assistants would be sufficient staff to supervise the day-to-day operations of a permanent central nursery over a period of 6 yr. It should be noted in years 2–6 that, as new seedlings are brought into the main nursery from the pre-nursery, seedlings are being transferred from the previous year's main nursery to the field at a similar rate (see Fig. 1). Where separate nurseries are to be established, two Field Assistants would be needed for periods of 18 months for each nursery. Taking the overlap in timing into account, this amounts to the equivalent of three field staff per year in salary outlay. The assumed salary rate is $3300 per year for one Field Assistant.

Increased earnings from higher early yields

It has been assumed that a permanent nursery system leads to greater efficiency in nursery management and hence to improved seedling growth. This increased development would result in more rapid maturation and, therefore, a higher yield in the first year of production, and probably also in the second and third years. Experimental evidence is available which shows that there is

a high correlation between leaf area in immaturity and yield in the early years of production. Assuming therefore, a conservative growth increment of 2%, which amounts to approx. 1–1½% weeks advancement in growth, the yield increment that could be expected in the first full year of production could well be in the order of 2%.

Assuming an average yield of 4 tons of fresh fruit bunches (f.f.b.) per acre in the first full year of harvesting, a yield improvement of 2% over 5000 acres would be equivalent to 400 tons f.f.b. At an extraction rate of 18%, this amounts to 72 tons of palm oil.

For this increment in yield, the *additional* production costs involved would be those relating to harvesting, direct manufacture and distribution. Assuming harvesting costs to be $12 per ton of f.f.b. for bunches of this size, and manufacture and distribution costs at $16 per ton of f.f.b., the additional production cost can be estimated at $28 per ton of f.f.b. The total additional cost resulting from an increased yield of 400 tons f.f.b. (72 tons of oil) would, therefore, be $11200. If the 72 tons of oil are valued at $370 per ton f.o.b., the additional earnings resulting from the growth increment in the permanent nursery could be estimated at $15440. Over 320000 transplantable seedlings, this would amount to 4.8¢ per seedling.

Interest on savings in capital expenditure

The earnings from interest on savings in expenditure should be taken into account when comparing the two nursery systems. In Table 1 it has been assumed that a 6% yield can be obtained from savings and that, for the 6-yr planting programme, the earnings per transplantable seedling amount to 1.03¢ in favour of the permanent central nursery.

Additional transport costs with a permanent nursery

The basic assumption made in this comparison is, that the additional transport costs from a permanent central nursery to the field planting areas are only those of getting seedlings to the boundary of any given planting. Within any planting, transport costs to the planting points are assumed to be equal for the permanent and separate nursery systems. Table 2 gives a comparison of the additional costs involved in transporting seedlings varying distances from a permanent central nursery, applying a range of transport costs per mile. It has been assumed that a 5-ton lorry with a long platform can carry 200 seedlings per trip, the total weight of seedlings per load being approx. 3½ tons.

Summary of cost comparisons for the permanent and separate nursery systems

Table 3 summarises the net savings and additional costs of a permanent nursery, compared with separate nurseries for field plantings of 5000 acres per

TABLE 2

*Additional transport costs when using a permanent central nursery (¢ per transplantable seedling)**

Mileage rates for lorry transport (¢)	*Distance from permanent central nursery to plantings (miles)*					
	6	*8*	*10*	*12*	*15*	*20*
40	2.4	3.2	4.0	4.8	6.0	8.0
50	3.0	4.0	5.0	6.0	7.5	10.0
60	3.6	4.8	6.0	7.2	9.0	12.0

* Based on a return trip

year over a period of 6 yr. Similar cost comparisons relating to 5000 acre planting programmes over periods of 2, 3, 4 and 5 yr are given in Appendix I. From the above analysis, there appears to be a strong case for establishing permanent nurseries, as opposed to separate nurseries, where the distances for seedling transportation at the mileage rates given are less than 20 miles, *i.e.* a 40-mile return trip. If growth increments due to improved nursery efficiency are greater than those assumed in this analysis, the distances for transportation could be considerably increased. For example, a 3-week advancement in growth at the time of transplanting could result in a yield increment in the order of 4%.

Having determined the nursery policy (permanent or single planting nurseries) for any given planting programme, the calendar of operations for the establishment of the nursery should be as described below.

1.2 WORK ITEMS IN NURSERY ESTABLISHMENT AND MAINTENANCE

The methods of nursery organisation described in this section have been confined to the two-stage nursery system as, at the time of writing, there is insufficient experience of the organisational problems relating to large-scale, single-stage nurseries.

The work items involved in establishing and maintaining nurseries for large-scale plantings can be listed as follows:

Site selection and clearing

Planning the timing of site selection in relation to field planting.

Preliminary assessment of potential sites.

Inspection of potential sites and the final selection of a site.

TABLE 3

Summary of net savings and additional costs using a permanent nursery for 30000 acres planted over 6 yr

Distance from permanent nursery to plantings (miles)	*Mileage rates for lorry transport (¢)*	*Savings on establishment and supervision per seedling (¢)*	*Interest earnings from savings per seedling (¢)*	*Returns from increased yields per seedling (¢)*	*Additional transport cost per seedling (¢)**	*Net returns per seedling (¢)*
6	40	5.36	1.03	4.80	2.40	+ 8.79
	50	"	"	"	3.00	+ 8.19
	60	"	"	"	3.60	+ 7.59
8	40	"	"	"	3.20	+ 7.99
	50	"	"	"	4.00	+ 7.19
	60	"	"	"	4.80	+ 6.39
10	40	"	"	"	4.00	+ 7.19
	50	"	"	"	5.00	+ 6.19
	60	"	"	"	6.00	+ 5.19
12	40	"	"	"	4.80	+ 6.39
	50	"	"	"	6.00	+ 5.19
	60	"	"	"	7.20	+ 3.99
15	40	"	"	"	6.00	+ 5.19
	50	"	"	"	7.50	+ 3.69
	60	"	"	"	9.00	+ 2.19
20	40	"	"	"	8.00	+ 3.19
	50	"	"	"	10.00	+ 1.19
	60	"	"	"	12.00	− 0.81

* Based on a return trip cost

Preparation of a detailed nursery programme (including an irrigation system).

Alignment and construction of access roads.

Clearing the pre-nursery site, using mechanical methods.

Clearing the main nursery site, using mechanical methods.

Ordering materials and equipment.

Preparation of the pre-nursery

Construction of seedling beds and shade supports.

Building a store.

Polybag filling and placing.

Installing the watering system.

Delivery and planting the germinated seed.

Maintenance in the pre-nursery

Watering.

Weeding.

Fertiliser application.

Consolidating unstable seedlings.

Pest and disease control.

Thinning out.

Preparing and planting the main nursery

Building the main store.

Installing the irrigation system.

Aligning and constructing nursery roads.

Lining, soil preparation and bag-filling on site.

Transplanting the pre-nursery seedlings.

Maintenance of the main nursery

Consolidation and topping-up soil in bags.

Watering.

Weeding.

Surface forking.

Fertiliser application.

Pest and disease control.

Thinning out.

1.3 SITE SELECTION AND CLEARING

Given that palms are to be field-planted at 12–14 months from the germinated seed stage, the pre-nursery and main nursery site clearing must commence some 15 months before the date of field planting. Since demarcation of nursery boundaries, alignment of access roads, drawing up specifications, calling for tenders and awarding contracts can be expected to take 2–3 months, selection of nursery sites must be made approx. 18–19 months prior to the date of field planting. Assuming that the main planting season lies between October and February and that felling of the main clearing commences in November, Fig. 1 illustrates the phasing of pre-nursery and main nursery clearing and establishment in relation to the main felling and burning and subsequent field planting operations. Detailed schedules of nursery operations are given in Section ~~2.2~~ 1.4

1.3.1 *Preliminary assessment of potential sites*

This consists of examining the 1: 25000 topographical map and also the soil survey map to locate the most likely sites with respect to soil, water supplies, topography and central position in relation to subsequent field planting.

1.3.2 *Inspection of potential sites and final selection*

A ground survey of these sites should be carried out using existing timber tracks as a means of access wherever possible. The main rentice from the access track should run approximately through the centre of the potential site. If, from initial inspection along the main rentice, the site appears to be unsatisfactory from the standpoint of topography, the site should be discarded. On the other hand, if the terrain appears suitable, lateral rentices should be cut to the site boundaries at intervals of 7½ chains along the main rentice, so that detailed ground inspections can be made of soil, water supplies and terrain.

This work should be carried out at the same time as the main planting boundary and clearing blocks are demarcated. This facilitates using the same survey gangs and, where possible, the same rentices. A rentice gang comprises a chain and compass team (one *mandore* and one labourer) and a *parang* gang of four labourers.

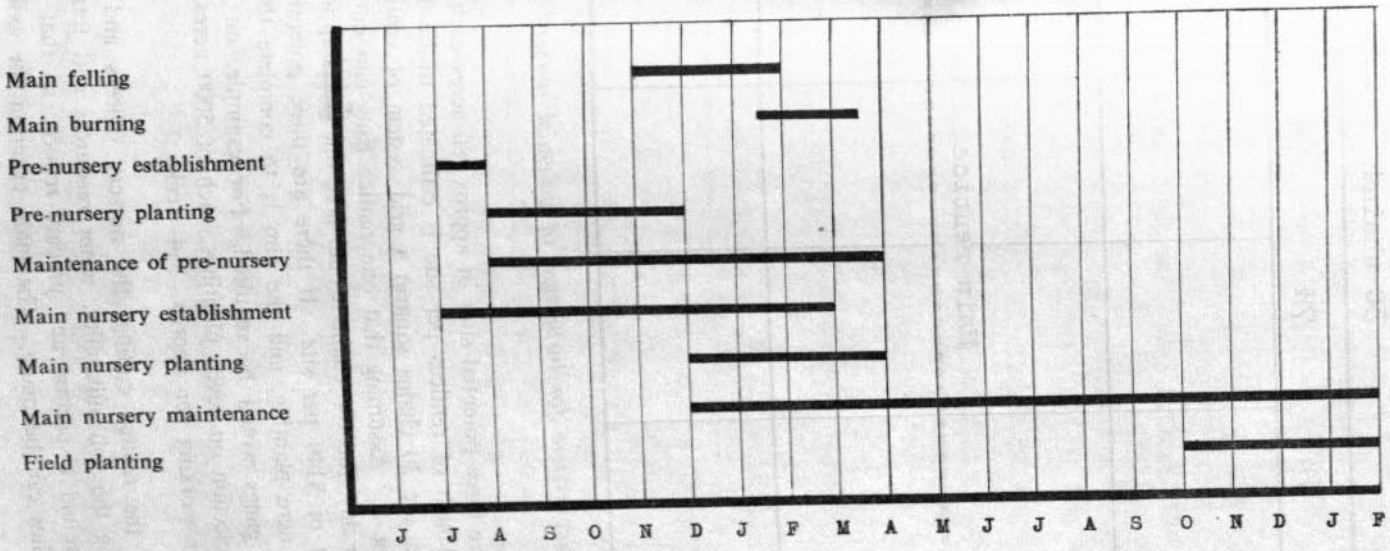


Fig. 1. Diagram of phasing of pre-nursery, main nursery establishment and planting in relation to main clearing and field planting

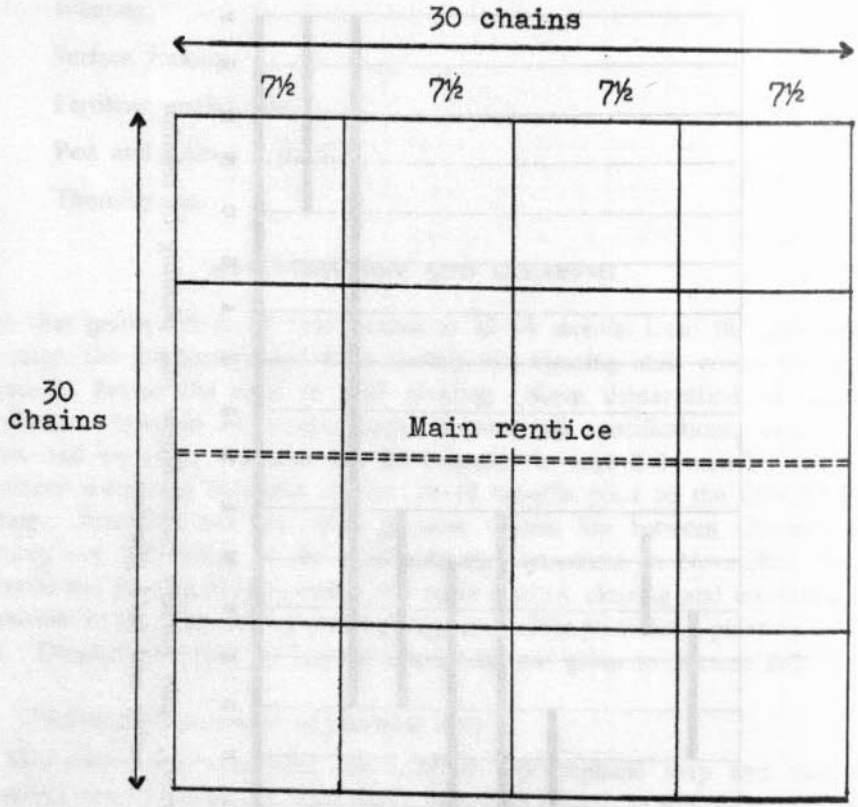


Fig. 2. A rentice system for inspection of potential nursery sites

For example, where three potential sites of approx. 80 acres each have been chosen and the total length of rentices per site is estimated to be 180 chains, (assuming that the sites are 30 chains square) a grid system of rentices should be cut as shown in Fig. 2. Assuming that one rentice gang can cut 35 chains per 6-h day @ $28 per day, the 180 chains would take one gang approx. 5 days to complete, at a cost of $140 per site. If there are three potential sites to inspect for each 5000 acre planting, and the aim is to complete the work in 8–9 days, two rentice gangs would be required. For example, on this basis, the renticing for site selection on seven plantings, each of 5000 acres, could be completed by six gangs working for approx. 3–4 weeks.

Having completed the rentice cutting, the nursery officers and engineers responsible for assessing the soil suitability, water resources and terrain, must carry out a detailed ground inspection and prepare reports, so that systematic comparisons between sites can be made. The main criterion for assessing soil

suitability is texture and this should be determined by taking borings to a depth of 1 ft at intervals of 10 chains along each lateral rentice. The texture at each boring should be recorded according to an agreed system of classification, *e.g.* sandy loam, loam, clay loam, *etc.*

A 25-acre irrigation system with ninety-six sprinklers discharging at 3.6 gal per min per sprinkler, would require (96 x 3.6) + 5% = 360 gal per min. For a water requirement of this magnitude, assuming that spraylines are moved seven times at 1½-h intervals, the total water application time would be 10½ h. At 360 gal per min the rate of water application is 226800 gal over 10½ h. This is equivalent to 36000 cu ft of water, and the rate of flow to supply this volume over 10½ h would be $\frac{36000}{37800}$ = 1 cu ft per sec (approx.) The formula for determination of rate of flow required in cu ft per sec is as follows:

$$\text{Rate of flow} = \frac{X}{6.3 \times 60} \text{ cu ft per sec}$$

Where X = the total number of sprinklers x rate of discharge per sprinkler in gal per min + 5%.

The first step in estimating the water supplies in a potential site is to locate the main natural water courses and to determine the rate of water discharge. A fairly accurate rate of water discharge can be determined by measuring the cross-sectional area of the stream and the rate of flow. To determine the cross-sectional area of the stream, the mean width is multiplied by the mean depth. A number of equidistant depth readings should be taken across the stream (Fig. 3). The speed of water flow can be assessed by measuring the time required for a light float to travel over a fixed distance. It should be ensured that the width of the stream is uniform along this section.

Formula:

$$\text{Mean width (w)} = \frac{a + b}{2}$$

$$\text{Mean depth (d)} = \frac{c + d + e + f}{4}$$

$\therefore$ Area of cross section = (w x d)

$$\text{Speed of flow (s)} = \frac{\text{Time (sec) to travel y ft}}{y}$$

$$= \text{s ft per sec}$$

Where y is any convenient length along the river

Rate of discharge (r) = (w x d) x s cu ft per sec

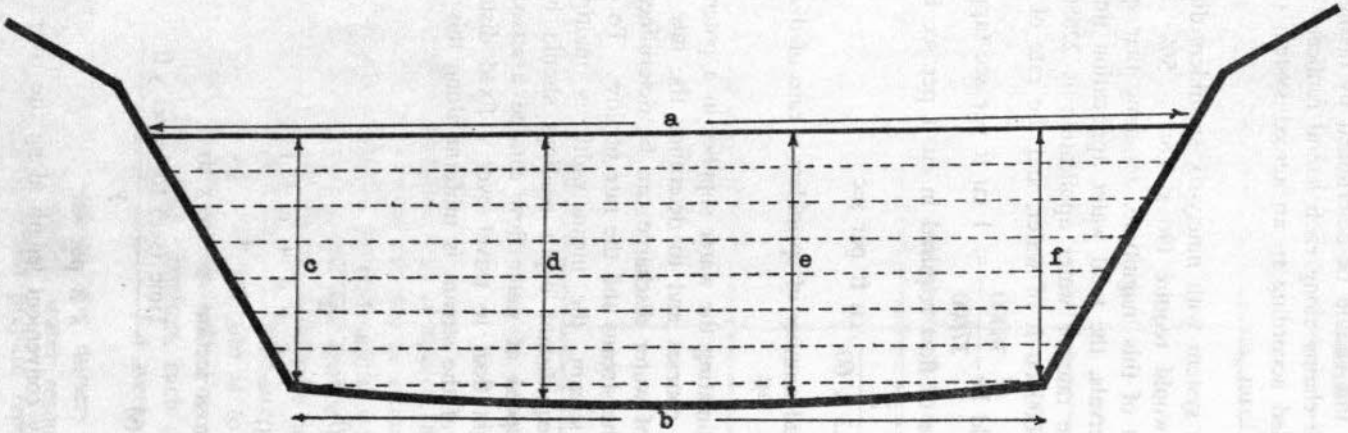


Fig. 3. Cross section of a stream and the data collection points for measuring output

For any given size of nursery, the water requirements of the irrigation system will be known and hence the adequacy of the water resources at the site can be assessed. It is advisable to assess water resources during the drier periods of the year and therefore nursery site selection should, where feasible, be timed accordingly. It is also necessary to analyse water samples to ensure that there are no toxic impurities present.

Having measured the rate of discharge of any main water course, its location should be marked on the map, using the rentice grid layout. If possible, the water course should run along the longer side of the nursery site to facilitate the layout and operation of the irrigation system.

The slope of the terrain should be determined by a survey gang using dumpy level equipment along the rentice grids. Assuming that a survey gang consists of a technician and three labourers, the gang costing $40 per day and measuring 70–80 chains per day, the total cost of slope measurement could be estimated at $120 per site ($360 per planting). On this basis, the slope measurement for seven plantings, each of 5000 acres, could be handled by three gangs working for a period of 3–4 weeks. When assessing site suitability with respect to slope, the criterion is that the height differential between the water pumping station and the highest point of the site should not exceed 50 ft.

1.4 PREPARATION OF A DETAILED NURSERY PROGRAMME

The preparation of a detailed nursery programme falls into three main sections:

(i) Preparing detailed schedules of operation and layout plans for clearing the site.

(ii) Preparing detailed schedules of establishment operations and layout plans for the pre-nursery.

(iii) Preparing detailed schedules of establishment operations and layout plans for the main nursery.

1.4.1 *Site clearing*

The pre-nursery site should be clean-cleared, leaving a 2-chain fire belt of cleared land on all sides. A 5000-acre planting would require a pre-nursery site of approx. 2 acres; therefore, allowing a 2-chain fire belt on all sides, a total area of 7 acres should be clean-cleared, using mechanical equipment, with all debris and timber being pushed into the adjacent main nursery area, which should be cleared simultaneously. The main nursery site should be felled mechanically, leaving a 2-chain fire belt of cleared land around the whole perimeter of the site. With mechanical felling, the nursery area would be de-stumped,

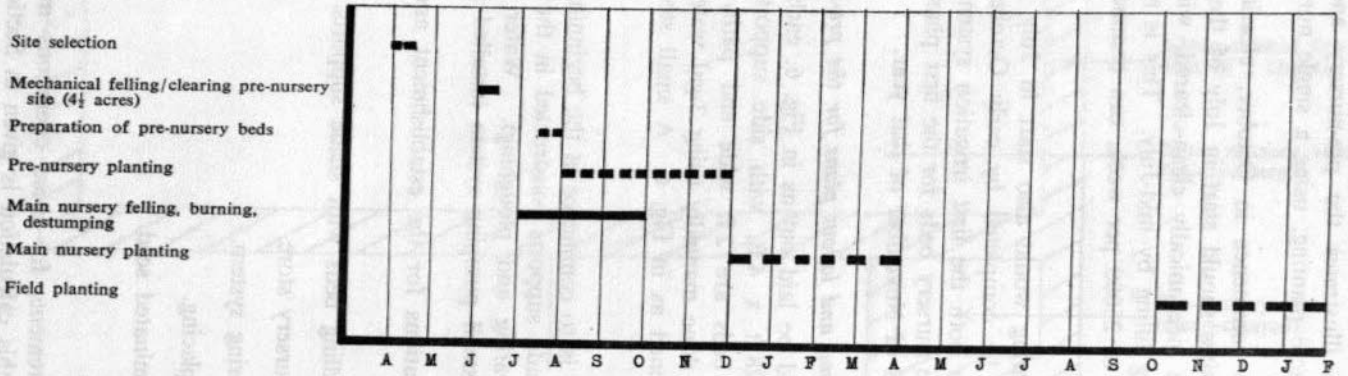


Fig. 5. Phasing of pre-nursery/main nursery clearing operations

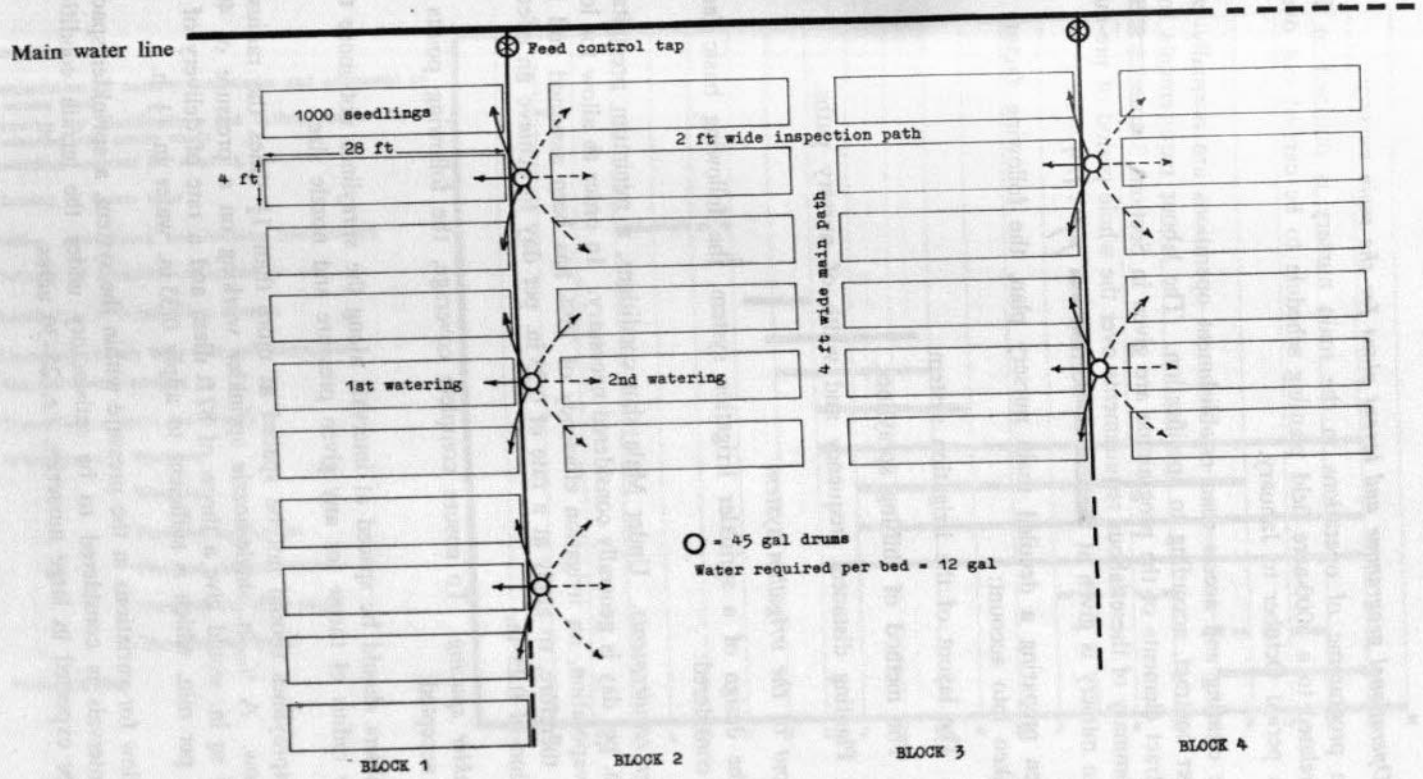


Fig. 6. Layout of a pre-nursery

1.4.3 *Operational programme and layout plans for the main nursery*

The programme of operations in the main nursery is outlined in Fig. 7 and is related to a 5000-acre field planting schedule to be carried out over the 4-month period October to January.

The clearing and access road establishment operations are normally carried out under contract, according to specification. The labour requirements for the non-contract elements of the programme are given in Sections 3.4 and 3.5 below, and a summary of these labour requirements over the whole period of pre-nursery and main nursery is given at the end of Section 3.5. pp. 119–121.

When preparing a detailed main nursery plan, the following factors have to be taken into account:

(i) The layout of the irrigation system.

(ii) The method of shifting spraylines.

(iii) Planting distance; frequency and width of nursery paths.

Layout of the irrigation system

In the design of a sprinkler irrigation system, the following basic factors must be considered:

Water requirements. Under Malaysian conditions, a minimum precipitation of 0.25 in. per day is generally considered necessary. In order to allow for losses due to evaporation, an irrigation efficiency of 75% has been assumed and it is necessary therefore, to apply at a rate of 0.33 in. per day to achieve an effective precipitation of 0.25 in.

Sprinkler spacing. To ensure complete coverage, the following points are generally accepted:

Sprinklers should be spaced at intervals along the spraylines not more than the radius of throw for any given pressure and nozzle size.

The spraylines should not be spaced at more than $1\frac{1}{2}$ times the radius of throw. A $^{5}/_{32}$ in. single-nozzle sprinkler working on a pressure of 40 lb per sq in. would give a throw of 87 ft diam and a rate of delivery of 3.6 gal per min, which is sufficient to apply 0.33 in. water in $1\frac{1}{2}$ h.

To allow for variations in the pressure within the system, a sprinkler spacing at 30-ft intervals is considered to be satisfactory under the terrain conditions that can be expected in large nurseries, *i.e.* 25–30 acres.

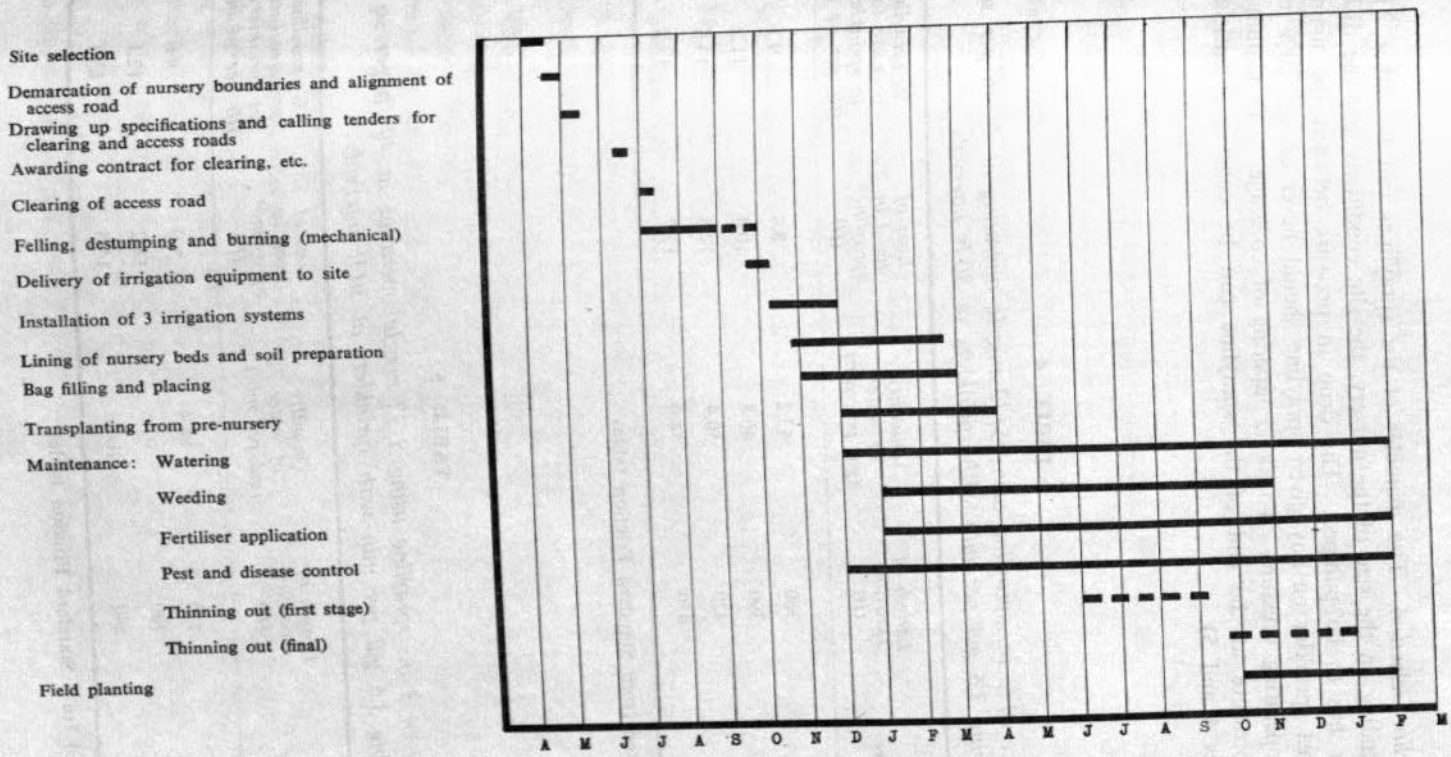


Fig. 7. Programme of operations in the main nursery for a 5000-acre planting

Sprayline selection. The diameter of the spraylines can be either 2 in. or 3 in., depending on the size of the nursery, the site conditions and the distances that water has to be pumped. The drop in pressure between the main line and the last sprinkler on any given sprayline should never exceed 20% of the sprinkler operating pressure. To avoid tapering of coverage, a maximum 15% drop in pressure at the end of the sprayline can be considered satisfactory (see Tables 4 and 5).

TABLE 4

Performance of 2 in. sprayline using 5/32 nozzle operating at 40 lb per sq in. and delivering 3.6 gal per min with sprinklers at 30 ft intervals

No of sprinklers	*Length of sprayline (ft)*	*Quantity of water (gal per min)*	*Loss of head in sprayline* (ft)*	*% sprayline pressure loss in sprinklers (lb per sq in.)*
12	360	43.2	8.4	9.1
13	390	46.8	10.4	11.2
14	420	50.4	12.6	13.6
15	450	54.0	17.7	17.2

* calculated from Standard Friction tables

TABLE 5

Performance of 3 in. sprayline using 5/32 nozzle operating at 40 lb per sq in. and delivering 3.6 gal per min with sprinklers at 30 ft intervals

No of sprinklers	*Length of sprayline (ft)*	*Quantity of water (gal per min)*	*Loss of head in sprayline* (ft)*	*% sprayline pressure loss in sprinklers (lb per sq in.)*
24	720	86.4	8.9	9.6
26	780	93.6	11.2	12.1
28	840	100.8	14.8	15.7

* calculated from Standard Friction tables

Main line selection. The diameter of the main line will depend largely on the size of the nursery and hence the volume of water required over any given time period. For nurseries of 25–30 acres, 6-in. asbestos cement pipes or a combination of 6-in. and 4-in. pipes will normally be required.

Pumping units. When selecting the pumping unit for any irrigation system, the total head of water required should be calculated by taking the following factors into account:

Suction lift, which is the vertical height from the lowest water level to the pump.

Suction friction. Friction loss in the suction line is normally calculated for twice the length of the suction line to allow for losses in foot-valves, bends, *etc.* However, in the case of very long suction lines, friction losses in fittings should also be taken into account.

Static discharge. This comprises the static head, *i.e.* vertical height from the pump to the highest point on the ground, and height of the sprinkler standpipes.

Mainline friction.

Sprayline friction.

Sprinkler head—pressure required to operate sprinklers.

A further 5% should be added to allow for losses in fittings, such as bends, hydrants, valves, *etc.*

The design and layout of any large irrigation system is quite a complex engineering problem and therefore should be the responsibility of specialist engineers. However, close co-operation between engineers and agriculturalists is essential to ensure that water is applied at the required rate and frequency. An example of an irrigation layout for a 25-acre nursery is given in Fig. 8.

Method of shifting spraylines

Between two spraylines, the length of the beds is determined by the frequency that paths are required to facilitate the shifting of the spraylines. During the first 5–6 months in the main nursery, where the palm spacing is 3 ft x 3 ft triangular, labourers should be able to move freely across the beds when shifting sprayline sections. In the last 4–5 months however, palm leaves tend to interlock and so sprayline sections need to be carried along the cross-paths between the beds. If cross-paths are made at intervals of 125 ft, (allowing 5 ft width for the path) the maximum carry when shifting sprayline sections would be approx.

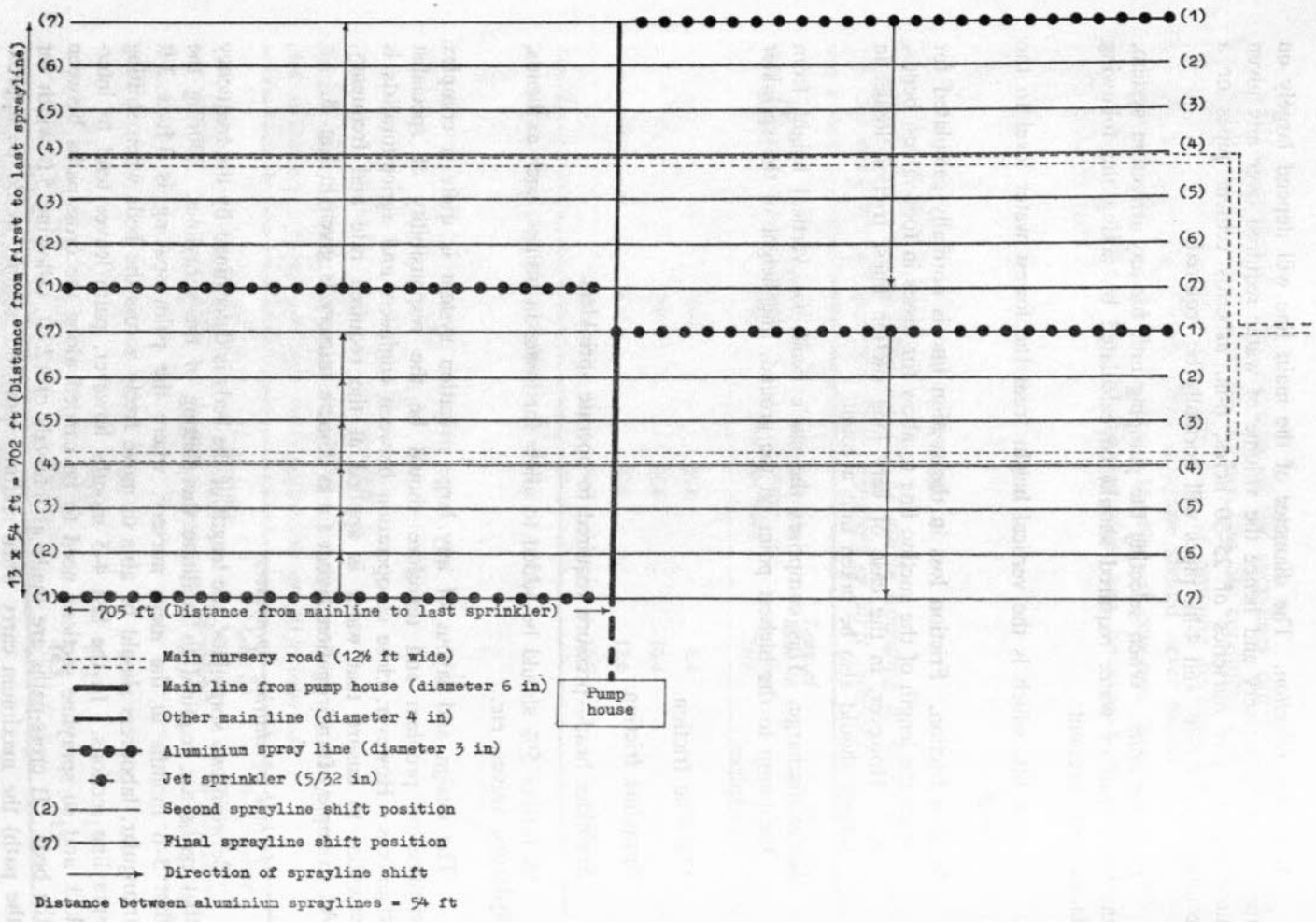


Fig. 8. Diagrammatic layout of irrigation system and main roads for 25 acres

60 yd. A sprayline 705 ft long would be composed of twenty-four sections (twenty-three of 30 ft and one of 15 ft). The length of spraylines will depend on the general shape of the nursery. Ideally, a nursery should be rectangular, with the length of main line (width of nursery) approximately one-half of the total length of lateral sprayline (length of nursery). It must be emphasised that the main nursery store should be sited outside the irrigation area.

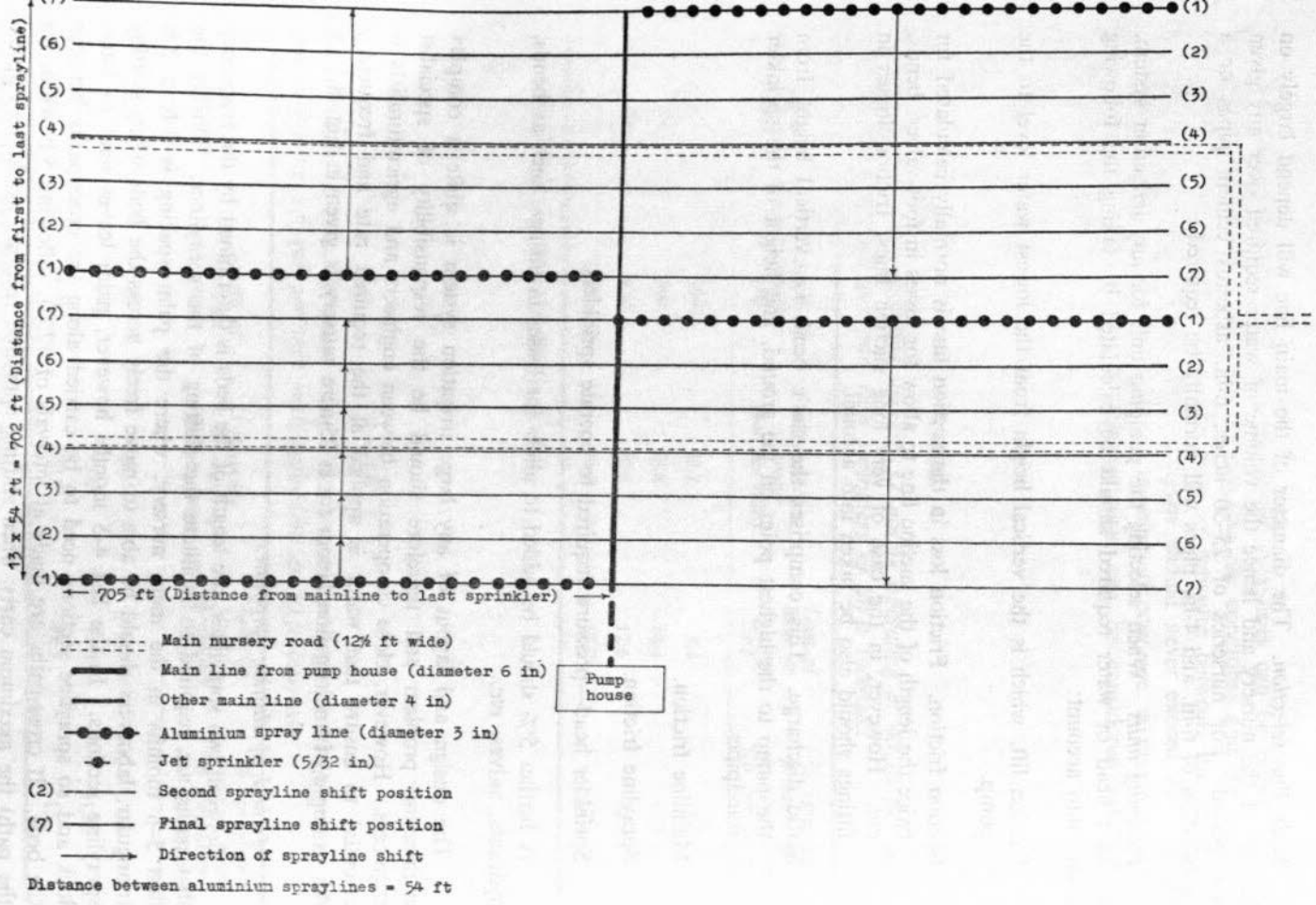
Planting distance

To avoid etiolation, weakening at the collar, and to ensure good growth in the nursery and hence in the field, seedlings which are to be in the nursery until 12–14 months old should be spaced at 3 ft x 3 ft triangular. At this spacing, the distance between rows would be 2.6 ft and with twenty rows in a bed 49.4 ft wide (ten long rows and ten short rows due to the triangular spacing), the width of the sprayline paths would, therefore, be $54.0 - 49.4 = 4.6$ ft.

If the length of the beds is 120 ft, (excluding the 5 ft cross-path between beds) the long rows will contain forty-one seedlings and the short rows forty. The total number of seedlings per bed would be $(10 \times 41) + (10 \times 40) = 810$ seedlings.

The total area per bed $= 125 \times 54.0 = 6750$ sq ft, the area per seedling being $\frac{6750}{810} = 8.33$ sq ft. A main nursery catering for 380000 seedlings would, therefore, require 380000 x 8.33 sq ft = approx. 73 acres. If nursery roads and store are assumed to require 2 acres of surface area, and allowing a total cleared area of 7 acres for the pre-nursery, the total area involved in a nursery for a 5000 acre planting would be just over 80 acres.

A layout of the type described above involves approx. 15% of the surface area being occupied by sprayline and cross paths. It must be borne in mind that this area would ultimately need to be cleared for planting in any case and, assuming that the differential between the cost of mechanical clean clearing for a nursery and manual felling for a field planting is approx. $80 per acre, the additional cost attributable to these paths would therefore be of the order of 12 acres x $80 = $960. It should be emphasised that spraylines have to be moved daily over the whole life of the nursery and a path network allowing easy movement is essential. Given the small establishment cost involved, reduction in paths below the levels outlined above cannot be considered sound practice. Fig. 9 shows the number of seedlings per bed and the detailed layout of beds in relation to spraylines, roads and paths.



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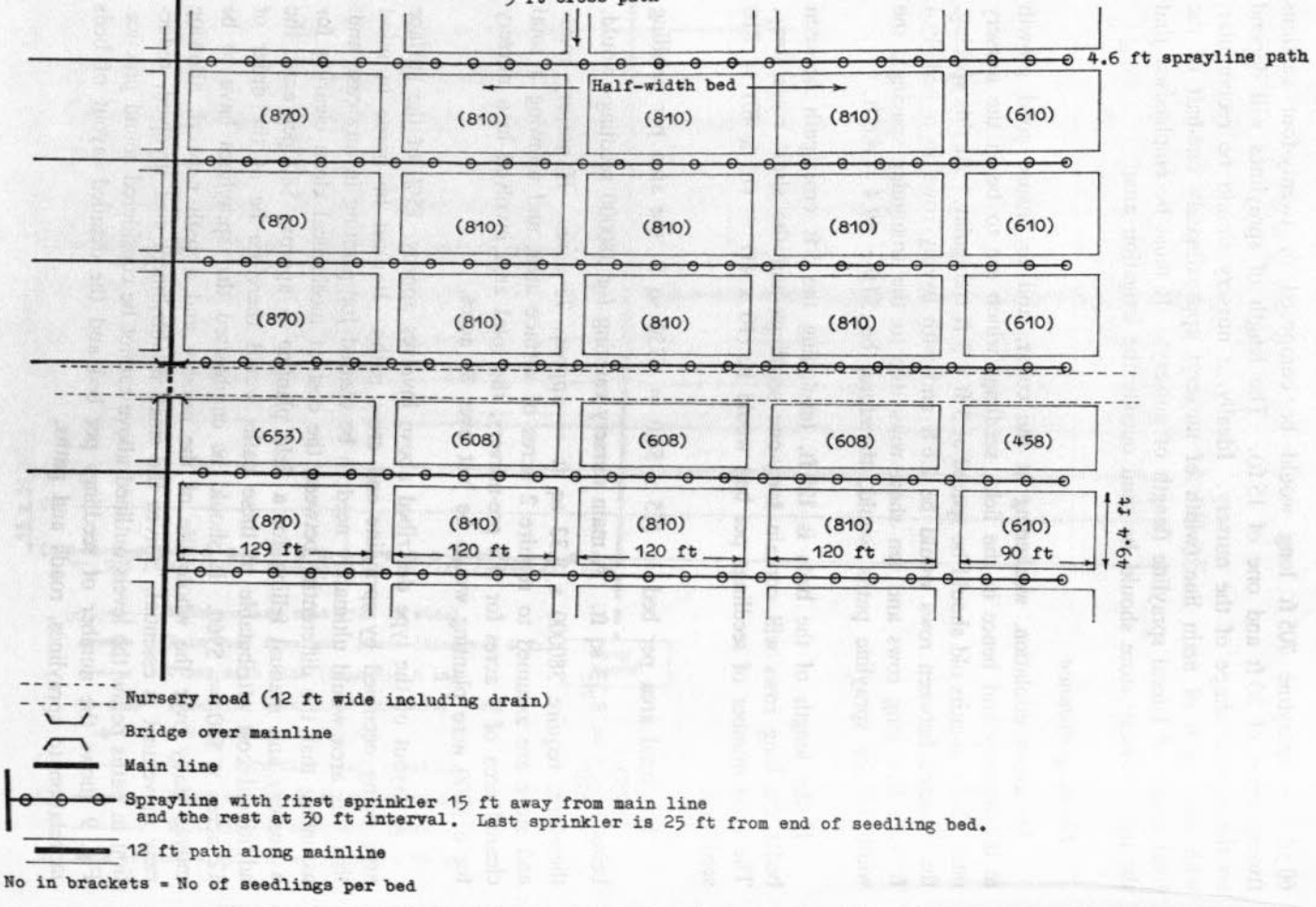


Fig. 9. Layout of nursery beds, paths and roads

A method of calculating the number of seedlings in a main nursery bed for a given irrigation layout and seedling spacing.

The basic information required is:

(a) The distance between spraylines (s).

(b) Distance between seedling rows (x_1) and the distance between seedlings within the rows (x_2).

(c) Width of paths along the spraylines (w_1), which should not be less than 4.5 ft.

(d) Length of a bed. This must be a whole number multiple of x_2.

If the distance between spraylines is 54 ft, and the planting distance is 3 ft x 3 ft triangular, the following procedure can be used for calculating the number of seedlings per bed:

(*i*) The distance between spraylines is 54 ft.

(*ii*) The minimum width of sprayline path is 4.5 ft.

(*iii*) Therefore, the maximum width available for a bed is $54 - 4.5 = 49.5$ ft.

(*iv*) The distance between rows (x_1) is 2.6 ft (for 3 ft x 3 ft triangular).

(*v*) Therefore, $\frac{s-w_1}{x_1}$ = the number of intervals between rows, *i.e.* $\frac{54.0-4.5}{2.6} = 19.04$ intervals. As it is not possible to have part of an interval, and as it is advisable to have a minimum sprayline path width of 4.5 ft, the maximum number of row intervals will be 19. However, 19 intervals x 2.6 ft = 49.4 ft. Therefore, the width of sprayline path in this case would be $54 - 49.4 = 4.6$ ft.

(*vi*) The total number of rows would, therefore, be the number of row intervals + 1, in this example the total number of rows being 20.

Formula: Number of rows (r) $= \frac{s-w_1}{x_1} + 1$

Number of seedlings per row. The length of a bed (L) should be a whole multiple of the distance between seedlings along the rows (x_2); in this case the distance between seedlings would be 3 ft. A convenient length for moving sprayline sections is considered to be 120 ft, *i.e.* 40 x 3 ft.

With triangular planting, there will be long rows and short rows, and out of a total of twenty rows, there would be ten long and ten short.

The number of intervals in the long rows is $\frac{120}{3} = 40$ and hence the number of seedlings would be forty-one.

Formula: No of seedlings in long rows $(p_1) = \frac{L}{x_2} + 1$

No of seedlings in short rows $(p_2) = \frac{L}{x_2}$

Total number of seedlings per bed. In this example, therefore, the total number of seedlings is:

No of long rows x no of seedlings per long row, *i.e.* 10 x 41 = 410

No of short rows x no of seedlings per short row, *i.e.* 10 x 40 = 400

Total number of seedlings per bed = 810

Ordering materials and equipment for the nursery. Estimates of materials and equipment required for both pre-nursery and main nursery should be prepared well in advance and orders placed (or tenders called for) so as to allow sufficient time for delivery to the site by the time the equipment and materials are needed.

CHAPTER 2

THE PRE-NURSERY

2.1 ALIGNMENT AND CONSTRUCTION OF THE ACCESS ROAD AND CLEARING THE PRE-NURSERY AND MAIN NURSERY SITES

Having selected the nursery site, the access road to the site should be aligned and tender specifications for its construction prepared, together with those for clearing pre-nursery and main nursery sites.

Before tenders can be called, the following have to be assessed:

(a) The extent to which any existing timber tracks can be utilised to provide access to the nursery site.

(b) What improvements in terms of alignment, gradients, surfacing and bridges, *etc.*, have to be made to existing tracks.

(c) Additional length of new road required, together with specifications for this road.

Having assessed the work involved in establishing the access road, and knowing the area of the pre-nursery and main nursery, tender specifications should be prepared for the completion of access road works, together with the felling and clearing of both pre-nursery and main nursery sites by mechanical means. Tender specifications should therefore be drawn up and tenders called, leaving sufficient time (2–3 weeks) for contracts to be awarded *at least 2 weeks* prior to the date on which work is due to commence. The areas of responsibility for supervision should be as follows:

(a) Day-to-day supervision of work in progress should be carried out by the Field Assistant, who would report progress to the Nursery Officer.

(b) As work reaches agreed stages of completion, *i.e.* access road completed, or road plus pre-nursery clearing completed, the Nursery Officer would:

(i) inspect the work to check that it complies with the specifications;

(ii) take measurements of works completed; and

(iii) inform his Manager/Visiting Manager that works have been completed and are ready for his inspection and approval for payment.

2.2 PREPARATION OF THE PRE-NURSERY

2.2.1 *Constructing seedling beds and shade supports*

When the pre-nursery site has been mechanically felled and de-stumped, the area should be cultivated by two ploughings to loosen the top 9 in. of soil and to level out any major depressions. After cultivation, sufficient soil for bag filling should be pushed to the sides of the pre-nursery site, using a bulldozer blade. It is very important that only the top 6–9 in. of soil be used for bag filling. After pushing this soil to the sides, the pre-nursery site should be harrowed for final levelling purposes.

The layout of the seedling beds should be as shown in Fig. 6 before bag filling commences. If shade supports (1–1½ in. diam) are to be constructed with uprights at 7-ft intervals along each bed, assuming each upright to be 7 ft in height (1 ft in the ground), the timber requirements per seedling bed would be:

10 x 7 ft of uprights,

5 x 4½ ft of cross-struts,

8 x 8 ft of side-struts, and

9 x 8 ft of side supports for bags.

When planning the establishment of pre-nursery beds, allowance should be made for finding and cutting sufficient timber for the whole pre-nursery. As shade is required for 1 month, shade supports can be used twice and the total length of timber required for a 400-bed nursery would be approx. 50000 ft. This timber would normally be cut from the surrounding jungle areas, and three men working for 10 days should be able to meet these requirements. Assuming a team of two men can construct ten beds in a day, including shade supports, 400 beds could be constructed by a labour force of two men working for 40 days. The first twenty-five beds should be constructed sufficiently early to allow bag filling and placing for these beds to take place 1 week before the first consignment of germinated seeds is scheduled to be planted. The construction of the remaining 375 beds to complete the pre-nursery should be geared to the seed delivery schedule. A store for seed reception and other materials should also be constructed at this stage.

2.2.2 *Installing a watering system*

When the layout of the beds has been completed, the watering system should be installed as illustrated in Fig. 6. A small pumping unit linked to the main water supply would be adequate for filling the 44-gal drums. The watering system must be installed at this stage as water is required during the bag filling operation (see below).

2.2.3 *Filling and placing the bags*

After the soil for bag filling has been heaped at the sides of the pre-nursery, bag filling should commence. The 6 in. x 9 in. polybags normally contain about 3½ lb of soil and should be filled using a trowel. After filling, the bags should be placed upright in compact rows in the pre-nursery beds.

For a 5000-acre planting, involving a pre-nursery containing 400000 seedlings, assuming that bag filling and placing is spread over a 4-month period, the daily requirement would amount to 4000 bags (25 days per month and 7 h per day). Assuming that one man can fill and place 1000 bags in 7 h, a team of four men would be sufficient to complete this task. The rate at which bags have to be filled depends on the rate of delivery of germinated seed. In the example above, it has been assumed that seed is delivered over a 4-month period.

To avoid drying and hardening of the soil in the bags, but, at the same time, to allow the soil to settle, bags should be filled approx. 1 week before planting germinated seed. The bags should be watered 1–2 days after initial filling to encourage the soil to settle. After a further 1–2 days, these bags should be topped up with soil to within ½ in. of the top of the bag. The labour requirement for top-filling can be estimated on the basis of 8000 bags per man-day and, therefore, during the 4 months of bag filling, an allowance of approx. 50 man-days should be made for topping-up in a 400000 seedling nursery.

If seed is delivered in consignments of 50000 at two-weekly intervals over the 4-month period, bag filling should commence 2 weeks before the first delivery date and should continue at the rate outlined above.

2.2.4 *Planting germinated seed*

The watering system should be finally checked and tested prior to the delivery date of the first batch of germinated seed. It is important that the officer responsible for the nursery has a schedule of dates and quantities of seed to be delivered. He should also be given advance notice of any changes in this schedule. This could be effectively achieved by the seed supplier notifying the head office, with a copy direct to the officer concerned.

On reception, seed should be planted out with the minimum of delay, preferably within 4 days. Assuming that one man can plant 1500–1600 seeds in a 7-h day, a team of eight men could handle a consignment of 50000 seeds in 4 days. As the beds are planted up, the same men place the shade fronds on the supports provided. On this basis, the same team would be required for seed planting on a total of 32 days over the 4-month period. So as to retain these trained seed planters, they can be employed on other nursery work in the periods between the arrival of seed consignments.

2.3 MAINTENANCE IN THE PRE-NURSERY

2.3.1 *Watering*

Daily watering is necessary; this is normally done manually and the labour requirements can be estimated at 1 man-day per 40000 seedlings. A pre-nursery which is square in shape would contain approx. twenty-two blocks, with eighteen beds in each block. If the water supply drums are filled by the end of the previous afternoon, there would be sufficient water available at the commencement of any day to complete the watering of one-half of the pre-nursery. The watering gang would start the day by completing the beds in block 1 (see Fig. 6). They should then move to blocks 3, 5, 7, 9, *etc.*, until all the odd-numbered blocks have been completed. By this time, the supply drums for blocks 2, 4, 6, 8, *etc.*, would have been refilled and the watering gang can then return to these blocks and proceed with watering.

2.3.2 *Weeding*

Monthly rounds of weeding should give adequate control and assuming that a labourer can weed 600 polybag seedlings in 1 h, given 7 working hours per day, each labourer should weed approx. 4000 seedlings per day. At 25 working days per month, this means that one labourer could be responsible for the weeding of 100000 seedlings. Given a planting programme spread over a 4-month period at 100000 seedlings per month, the number of seedlings requiring weeding at any one time should not exceed 300000. During this period, a maximum of three labourers should be sufficient to complete the weeding programme.

2.3.3 *Fertiliser application*

A compound fertiliser is applied in solution at weekly intervals, commencing 1 month after planting, the rates of application being as follows:

1–3 leaf stage: $\frac{1}{4}$ oz in 1 gal water per 100 seedlings (for a period of 1 month)

3–5 leaf stage: $\frac{1}{2}$ oz in 1 gal water per 100 seedlings (for a period of 2 months)

At $\frac{1}{4}$ oz of compound per 100 seedlings, the total requirement for 2000 seedlings (two beds) would be 5 oz per application, and at $\frac{1}{2}$ oz the quantity would be doubled. The total fertiliser requirement for a pre-nursery of 400000 seedlings would be approx. 11 cwt and this should be delivered as soon as the store has been constructed.

Fertiliser application should be the responsibility of trained labour, and the labour requirements for this operation can be estimated on the basis that the solution can be applied at the rate of 1 man-day per 40000 seedlings. For any

particular rate of application, a concentrated solution of the compound should be prepared at the start of the day. The following is a suitable mixture of water and compound for preparing a concentrate solution:

Rate of application	*Mixture for 2000 seedlings*
$\frac{1}{4}$ oz per 100 seedlings	5 oz compound in $\frac{1}{3}$ pint water
$\frac{1}{2}$ oz per 100 seedlings	10 oz compound in $\frac{2}{3}$ pint water

Therefore, for fertilising fifty beds at $\frac{1}{4}$ oz compound per 100 seedlings, the concentrate should be prepared by mixing 125 oz compound with $8\frac{1}{3}$ pints water.

2.3.4 *Consolidation of loose seedlings*

Regular weekly rounds of inspection should be made to ensure that seedling root systems which have become exposed as a result of water wash are re-covered with soil. It is important that, when topping-up with soil, the labourers should also make firm the shoot in an upright position.

This work is most important in the early stages of seedling growth (up to the two-leaf stage). Hence, with regular phasing of seed planting (50000 every 2 weeks) the number of seedlings requiring inspection for topping-up with soil should not exceed 50000. Assuming that, in any given batch of 50000 seeds, a maximum of 20% of the seedlings would require topping-up and consolidating, the labour requirements to cover this operation would be in the order of 2 man-days per round (*i.e.* 5000 seedlings per man-day).

2.3.5 *Pest and disease control*

As regular prophylactic spraying against insect pests or fungi is not recommended in oil palm nurseries, it is not feasible to make firm estimates of labour requirements for pest and disease control in the nursery. However, where required, a round of spraying of 400000 seedlings in the pre-nursery would involve spraying just over 1 acre of seedling beds. Using a knapsack sprayer, this would require approx. 1 man-day per round.

The responsibility for pest and disease inspection, and subsequent action where necessary, rests with the officer in immediate charge of the nursery. In cases of doubt, the advice of a specialist should be requested at an early stage.

2.3.6 *Thinning out*

In the pre-nursery, approx. 5–7% of seedlings may be lost, sometimes through pests and diseases, *etc.*, but mainly through being thinned out as runts. When laying out the seedling beds, an additional area equivalent to approx. 5% of

the area of each bed should be left vacant, so that runts can be moved into this section for subsequent inspection prior to final discarding by the Nursery Officer. One round of thinning out just prior to transplanting into the main nursery is normally adequate. Assuming, (a) a seed planting schedule that was phased on a basis of 50000 seedlings every 2 weeks, and (b) that transplanting to the main nursery is similarly phased, then at any given time the number of seedlings requiring thinning would be approx. 50000 (fifty beds of 1000). At 5% runts per bed, the total number requiring transfer to the vacant sections at the end of each bed would amount to approx. 2500 seedlings. This work should be the responsibility of the *mandore* in charge of the nursery labour force and it should not take more than 2 days to cull runts from 50000 seedlings.

(M.E.R. Vickers)

Plate 1. A large FLDA pre-nursery with seedlings at various stages of growth.

involved in setting up an irrigation system can be listed as follows:

(i) Building the pump house.

(ii) Digging the main line trench.

(iii) Coupling-up main line sections.

(iv) Coupling-up sprinklers, standpipes and laying sprayline sections.

(v) Testing the system.

Building the pump house

The pump house should be built to the required specifications, which would include foundations of reinforced concrete for the pump and engine. At current prices, the cost would be .approx. $500 for a pump house for a 36 h.p pumping unit.

Digging the main line trench

Pipes for the main line are made of asbestos cement and should be buried in a trench 1 ft wide x 2 ft deep. The total chainage of trench for a rectangular-shaped 25-acre nursery would be in the region of 12 chains. Assuming that one man can dig 1 chain of trench in 1 day, at $3 per man-day, the total cost can be estimated at about $40.

Coupling-up main line sections

The main line sections are coupled up by a team of two labourers, one levering in the new section, while the other holds rigid the section already laid. A team of two men can fit four lengths in 1 h, *i.e.* in a 7-h day, two men would fit twenty-eight lengths of piping. Therefore, sixty lengths should be fitted by two men in 2 days. At an average cost of $3 per man-day, the total cost for laying main line pipes and for fitting hydrants and T-junction pieces would be $12.

Coupling-up sprinklers, standpipes and laying sprayline sections

This work is also carried out by teams of two labourers, and one team should be able to assemble and lay the complete sprayline system for a 25-acre nursery (approx. 2800 ft) in 1 day. At $3 per man-day, the total cost of assembling and laying the spraylines for a 25-acre nursery can be estimated at $6.

The total cost of assembling and laying such an irrigation system, but excluding pump house cost, could therefore be estimated at approx. $60.

After establishment, the system should be tested by the suppliers of the equipment in the presence of the Engineer and the Nursery Officer or Manager.

3.1.4 *Lining and soil preparation*

Having laid out the first phase of the irrigation system, the nursery bed layout should be demarcated and lining for triangular planting within the beds commenced.

The labour requirement for nursery lining is estimated at 1½ man-h per bed. On completion of lining and pegging in a bed, a trench 6–9 in. deep should be dug between the rows (along the contour where applicable) so as to provide loose soil for bag filling *in situ*. The labour requirements for trenching can be estimated at 3 man-h per bed. Therefore, the total labour requirements for completing lining and soil preparation in a main nursery of 380000 seedlings can be estimated at 300 man-days, spread over 4 months.

3.1.5 *Bag filling and placing*

Bag filling should commence as soon as lining and trenching are completed. Where bags are being filled *in situ*, the empty polybags should be distributed alongside each peg and the bag filling gang would fill from soil in the trench immediately in front of the row being filled; this avoids 'treading in' the loose soil. The bags should be filled to the top and during the course of filling should be bounced two or three times to consolidate the soil in the bag. When the bag has been filled, the ground immediately surrounding the peg should be levelled, the peg removed and the bag placed in its final position. The labour requirement for bag filling and placing using the above method is estimated at 150 bags per man per day.

Bag filling and placing should be phased so as to ensure that the soil in the bags has had at least 1–2 weeks to settle before transplanting takes place. If the scheduled rate of transplanting from the pre-nursery is 25000 seedlings per 6-day week, the daily rate of bag filling must be at least equivalent to 4000 bags per day. As bag filling may be interrupted by wet weather, it is advisable to have sufficient filled and settled polybags in reserve to allow for 2 weeks planting, *i.e.* 50000 bags. Under these conditions, it is necessary to commence bag filling, at a rate of 4000 per day, approx. 3–4 weeks before the first transplanting takes place. To achieve this, lining and trenching should commence 4–5 weeks prior to transplanting.

3.1.6 *Transplanting from the pre-nursery*

Transplanting should commence approx. 4 months after planting the germinated seed. Given that there is regular delivery of germinated seed at a rate of 50000 every 2 weeks, transplanting a 400000 seedling nursery should be completed over a period of 4–5 months.

Assuming that the rate of transplanting is approx. 4000 seedlings per day, the labour requirements for this operation can be derived by considering the following work items:

(i) Transporting seedlings from the pre-nursery to the main nursery blocks.

(ii) Transporting seedlings from the unloading point to the large polybag planting site.

(iii) Planting seedlings in large polybags.

Seedling transport from the pre-nursery to the main nursery blocks

The main inputs in this work item are loading from pre-nursery beds, unloading at the main nursery block site and transport.

Loading. Assuming that one man stacks the seedlings on the tractor-trailer platform and that two men remove seedlings (two at a time) from the beds to the trailer, the time required to load a 12 ft x 6 ft trailer with approx. 650 seedlings can be estimated at $\frac{1}{2}$ h. Where pre-nursery beds are of a temporary nature, the side supports can be dismantled after each bed is emptied, so that the tractor-trailer can be drawn up alongside the beds during loading.

Unloading. Assuming that the same labourers are used to unload and stack seedlings at the main nursery site, the time required to unload should be approximately the same as for loading, *i.e.* $\frac{1}{2}$ h.

Transport. For a 75-acre main nursery, the average travelling distance would be approx. $\frac{1}{2}$ mile per return trip and, at an average speed of 4–5 m.p.h., each trip should involve a maximum of 10 min. Therefore, at six trips per day, the total travelling time can be estimated at 1 h.

Summary of labour and tractor-trailer requirements per 4000 seedlings

	Labour	*Tractor-trailer*	*Time (h)*
Loading	3	1	3
Unloading	3	1	3
Travel	3	1	1

Therefore, the total labour requirement is 3 man-days per 4000 seedlings. The total tractor-trailer requirement, including one driver, is 1 day.

Seedling transport from the unloading point to the large polybag planting site

It has been assumed that seedlings are transported from the unloading point to the planting site by wheelbarrow. The main inputs involved in this item of work are:

(a) loading seedlings into the wheelbarrow;

(b) transporting seedlings to the planting site; and

(c) unloading and placing each seedling at its planting point.

Assuming that one man can stack forty seedlings in a wheelbarrow in 2½ min and wheel and carry them to their planting point in 10 min, an allowance of 15 min should be adequate for the return trip. At this rate, one man should distribute between 1100–1200 seedlings per day. At a planting rate of 4000 per day, three or four labourers would be required for this operation.

Planting seedlings in large polybags

Labour is the main input involved in this item of work. The method of planting is basically as follows:

(i) Scooping soil out of the large polybag so as to leave a planting hole of a depth equal to that of a small polybag, *i.e.* approx. 9 in. This planting hole will be conical in shape, the width at the bottom being at least 4 in., which is the width of the polybag ball of earth.

(ii) Removing the polythene around the base of the small polybag, placing the seedling in the planting hole in the large polybag, slitting the side of the small polybag and removing the polythene cover.

(iii) Packing earth into the planting hole and consolidating the seedling in an upright and firm position, ensuring that the collar of the seedling is at the correct depth, *i.e.* ½ in. below the rim of the large polybag.

Assuming that one man can carry out the above operations at the rate of one seedling planted in 1½ min, the output per man-day should be of the order of 250 seedlings. Therefore, for 4000 seedlings, the daily labour force required for this work item can be estimated at sixteen men.

3.2 MAINTENANCE OF THE MAIN NURSERY

3.2.1 *Watering*

On the day before planting, the large polybags should be watered to facilitate soil handling at transplanting. After watering, the laterals and sprinklers of the irrigation system should be moved to allow access by wheelbarrows along the paths. As soon as a nursery block is planted, the lateral irrigation pipes and sprinklers in that section of the nursery should be re-coupled, so that watering may commence on the following day.

Pre-starting procedure. At the start of each day, the hydrants for the spraylines attached to the mainline should be opened and a check made to see

that *all other* main line hydrants are closed. Before starting the pump, the attendant should check the oil level and see that adequate fuel is available. A check should be made to ensure that there is enough water surrounding the foot-valve and to see that it is well protected from floating debris.

When setting up the spraylines on the previous afternoon, the joints should be inspected to ensure that they are properly connected. Sprinkler standpipes must be vertical and properly supported to ensure even distribution of water.

Operating procedure. When the sprinklers are in operation, the following checks should be made:

(i) The engine should be running at the correct speed and pump pressure, so as to give optimum working pressure at the sprinklers. This can be measured by fixing a pressure gauge on each sprayline, preferably towards the end of the line. When all spraylines are in operation, the pump should be running at full throttle.

(ii) There should be no excessive leaks at the couplings and the stop ends. To repair a leak, the hydrant for that sprayline must be shut off and the fault corrected.

(iii) Sprinklers must not be sticking; when working properly, they should be rotating slowly at a regular speed.

(iv) The throw of the sprinklers should be a minimum of 41 ft so as to provide an overlap covering 50% of the distance between spraylines.

(v) The amount of precipitation should be measured over the whole nursery. This can be done easily by placing empty tins of similar size at selected points along the spraylines. (It is between sprinklers, along the sprayline that the lowest amount of precipitation takes place for the irrigation system being used in this example). An adequate estimate of precipitation can be obtained by placing tins permanently, on level sites, at points one-quarter and three-quarters along every alternate sprayline.

Recording the depth of water in the tins should be made after spraylines have been moved. These records should be maintained by the officer in charge of the nursery. Where precipitation is inadequate, it will be necessary to determine whether it is due to any one or more of the following faults:

(a) Inadequate uptake at the suction pump.

(b) Low pumping pressure due to either pump or engine, or both.

(c) Leaks at hydrants and/or T-junctions.

(d) Leaks along spraylines at couplings and stop ends.

(e) Sticking sprinklers.

Procedure for sprayline shifting. The first step is to close the main line hydrant and then to uncouple the 30 ft sections, starting at the main line end. The uncoupled sections are carried to the next sprayline position and recoupled, again starting from the main line end. When all sections have been recoupled and standpipes set in a vertical position, the main line hydrant for the sprayline should be opened.

Rotation of sprayline shifting. In a 25-acre nursery of rectangular shape, (see Fig. 8) there would be four spraylines operating simultaneously. Each individual sprayline would be operated in seven positions during a $12\frac{3}{4}$-h day ($1\frac{1}{2}$ h per position allowing 15 min for each change of position). In days 1, 3, 5, 7, *etc.*, the spraylines would be moved from positions 1 to 7 in sequence. On days 2, 4, 6, 8, *etc.*, they would be moved from position 7 to 1, again in sequence. To give $1\frac{1}{2}$ h watering in each position and to allow time for shifting, in the schedule outlined in Table 6 the first sprayline is opened up at 06.00 h, the second at 06.15 h, the third at 06.30 h and the fourth at 06.45 h. The pump pressure, and hence engine revolutions, should be adjusted according to the number of spraylines in operation. This system has the advantage that the first shift is always in Block 1 followed by Blocks 2, 3 and 4 respectively.

Labour requirements and shift organisation. Spraylines are uncoupled in 30 ft sections, and the maximum walking distance involved in shifting sections from one sprayline position to the next, is approx. 60 yd. The average walking distance would, therefore be 30 yd and at a walking pace of 2 m.p.h. along the paths, the time involved per return trip can be estimated at 1 min.

Two men working as a team could uncouple and recouple two sections in 20 sec. If there are twenty-four sections in one sprayline of 705 ft, this work could be done in 5 min. Assuming that two men carry two sections at a time to the next positions, the shifting of a sprayline should take two men approx. 20 min. A team of four men per irrigation system should, therefore, be able to complete this operation in 10 min. The time schedule given above allows 15 min for this operation, which includes walking from one sprayline block to the next.

The advantage of having a team of four men, instead of two, is that:

(a) The time lag between moving successive lines is reduced by about one-half.

(b) It provides a pool of experienced labour of sufficient size to cater for absenteeism, illness, *etc.* This is important, as the time-table must be followed strictly to ensure adequate and even distribution of water.

The pump attendant should be responsible for opening the hydrants on the first sprayline of each block, following the rotation in Table 6. One of the four nursery *mandores* should also be present at the start of daily operations, when the three irrigation systems in a 75-acre main nursery would be opened up. As the

TABLE 6

Schedule of sprayline shifts and watering periods for alternate days (A) and (B) for a four-line system

Block	Day A Line	Day B Line	Spraying time	Shift	Maintenance or rest period
1	1	7	06.00 — 07.30		
	2	6	07.45 — 09.15	1	—
	3	5	09.30 — 11.00	5	—
	4	4	11.15 — 12.45	9	—
	5	3	13.00 — 14.30	13	—
	6	2	14.45 — 16.15	17	—
	7	1	16.30 — 18.00	21	—
2	1	7	06.15 — 07.45		
	2	6	08.00 — 09.30	2	—
	3	5	09.45 — 11.15	6	—
	4	4	11.30 — 13.00	10	—
	5	3	13.15 — 14.45	14	—
	6	2	15.00 — 16.30	18	—
	7	1	16.45 — 18.15	22	—
3	1	7	06.30 — 08.00		
	2	6	08.15 — 09.45	3	—
	3	5	10.00 — 11.30	7	—
	4	4	11.45 — 13.15	11	—
	5	3	13.30 — 15.00	15	—
	6	2	15.15 — 16.45	19	—
	7	1	17.00 — 18.30	23	—
4	1	7	06.45 — 08.15		
	2	6	08.30 — 10.00	4	08.30 — 09.15
	3	5	10.15 — 11.45	8	10.15 — 11.00
	4	4	12.00 — 13.30	12	12.00 — 12.45
	5	3	13.45 — 15.15	16	13.45 — 14.30
	6	2	15.30 — 17.00	20	15.30 — 16.15
	7	1	17.15 — 18.45	24	—

total watering time covers a period of 12¾ h, the sprayline shifting gangs should be organised in two shifts. The first shift would start work at 06.30 h (together with other nursery labour) and finish sprayline work at 12.45 h, when they would be engaged on other nursery work until 14.30 h. The second shift would report for work in the nursery at 10.45 h, spending the first 2 h on general nursery maintenance and starting sprayline shifting at 12.45 h. The early and late shifts could be rotated on a weekly basis.

3.2.2 *Weeding*

Regular monthly weeding should commence 1 month after transplanting and continue until seedlings are approx. 11 months old, when weeds should be completely suppressed by shade. In effect, this means that each batch of seedlings would be weeded six times. The area of nursery and the number of bags requiring weeding will progressively decrease as seedlings reach the 11-month stage. Weeding operations consist of:

(i) weeding the polybags, and

(ii) weeding between the bags.

One labourer should be able to weed 2500 bags per day, and at this rate one man could adequately cover the bag-weeding of 62500 seedlings per month of 25 working days. Assuming that one labourer can weed in between approx. 800 bags in 1 day, then in 1 month he should cover around 18000 bags.

3.2.3 *Fertiliser application*

The organisation of fertiliser application can be divided into the following main aspects:

(a) Timing and quantity.

(b) Method of application.

(c) Labour requirements.

Timing and quantity of fertiliser. Fertilisers are applied at monthly intervals immediately after weeding and the initial application ($\frac{1}{4}$ oz per seedling) should be given 3–4 weeks after planting in the large polybags. This means that seedlings would receive nine applications during their period in the main nursery. Since rates of fertiliser application vary according to the period of time in the nursery, it is essential to draw up a schedule of fertiliser application which is geared to the planting schedule, so as to ensure that plants of different ages receive the correct quantity.

Assuming that planting in the nursery has been phased at a rate of 50000 every 2 weeks, Table 7 shows the quantity of fertiliser required for this number of plants at the various fertiliser rates recommended.

Method of fertiliser application. The basic steps are as follows:

(i) The nursery *mandore* should confirm the appropriate rate of application for each block to be fertilised on any given day. This involves checking the date of planting in the main nursery and the date of the last application.

TABLE 7

Fertiliser requirements in the main nursery

Application rate (oz)	*Quantity for 50000 seedlings*	
	lb	*cwt*
$\frac{1}{4}$	782	7
$\frac{1}{2}$	1562	14
$\frac{3}{4}$	2344	21
1	3126	28
$1\frac{1}{2}$	4688	42

(ii) Labourers should be instructed in the method of application involving:

(a) Light scratching of the surface soil in the polybag.

(b) Application of a level spoon or scoop in a broad band, taking care to avoid the collar region and the leaves.

(c) Labourers should be taught to see that all seedlings are upright in their bags and, wherever necessary, bags should be refilled to the correct level.

(iii) Labourers should be supplied with a spoon or scoop which is of a size appropriate to the application rate, *e.g.* $\frac{1}{4}$ oz, $\frac{1}{2}$ oz, $\frac{3}{4}$ oz.

(iv) Labour should be allocated to specific nursery blocks with instructions relating to the appropriate rate of application for these blocks.

(v) Fertilisers should be issued from the store according to the work programme for the day and deposited at central supply points. They should also be protected from rain.

Labour requirements for fertiliser application. Assuming that one labourer can apply fertiliser to approx. 1700 seedlings in a day, the labour requirement per application for 50000 seedlings can be estimated to be 30 man-days. For each batch of 50000 seedlings to be fertilised over a period of 1 week, (6 days) the daily labour requirement would be equivalent to five men.

3.2.4 *Pest and disease control*

As regular prophylactic spraying against insect pests and disease is not normally practised in oil palm nurseries, it is important that both supervisory staff and labourers be familiar with the recognition of the major nursery pests and diseases. These are as follows:

Pests

Apogonia (night flying beetle)
Proedenia
Crickets
Valanga (grasshopper)
Red spider mite
Sugar ants
Snails
Rats

Diseases and disorders

Pathogenic

Curvularia Seedling Blight
Anthracnose
Blast
Corticium Leaf Rot

Physiological

Nitrogen deficiency
Potassium deficiency
Magnesium deficiency

At all times, the nursery *mandore* should look for symptoms of pests and diseases, and at the end of each day record whether pests and diseases were present in the blocks in which he worked during that day. As a routine procedure, the *mandore* should record (a) the areas of the nursery visited that day, (b) the presence or absence of pests and diseases, and (c) where the latter are present, inform the Nursery Officer immediately. Given that the nursery *mandore* covers the entire nursery in 1 week, then the maximum time for pests and diseases to build up would be less than 1 week.

A basic stock of equipment and materials for treatment of major pests and diseases should be available in the nursery store. As soon as the Nursery Officer observes or is notified of an outbreak, the procedure should be to diagnose, prescribe and supervise treatment. In cases of doubt, the advice of a specialist should be requested at an early stage.

The following is a list of materials that should be kept available for a nursery of 400000 seedlings:

Fungicides

Thiram—effective against *Curvularia* at 0.2% conc.

Thibenzole—effective against all other nursery diseases of importance at 0.12% conc.

Insecticides

Dipterex—effective against *Apogonia* at 1 lb in 25 gal water.

Lead arsenate—effective against *Apogonia* and *Valanga* at 1 lb in 25 gal water.

Rogor—effective against red spider mite at 1 oz in 6 gal water.

Dieldrex—effective against crickets at 1 fl oz in 2 gal water (Dieldrex 15).

Spreading/sticking agent

Citowett—1 cc in 1 gal

Rat bait. The following mixture is sufficient for 120 baits of 4 oz each.

15	lb maize
7½	lb paraffin wax
1½	lb fish heads
4½	lb palm oil
1½	lb warfarin
30	lb

The quantities of fungicides and insecticides required to spray a nursery. The assumptions made for knapsack spraying have been:

(a) Seedlings at the 4–5 leaf stage require 5 gal soln per 1000 seedlings.

(b) Seedlings at the 10–12 leaf stage require 5 gal soln per 200 seedlings.

(c) The nursery contains 400000 seedlings.

(d) The disease attacks can be expected to affect up to 25% of the population.

(e) That insect attacks may affect up to 50% of the population.

(f) Treatment is by means of three rounds of spraying at 10-day intervals.

(g) Materials sufficient to cater for three rounds of spraying should be kept in store.

A summary of the requirements at two different stages of seedling growth for three rounds of control is shown in Table 8. Trained labour should be used for control of pest and disease outbreaks and should be drawn from the permanent nursery labour force. Where, for example, labourers are taken off weeding, they can be replaced by temporary labourers, so that the weeding operations are not interrupted. The labourers engaged in control of pests and diseases should be trained in both recognition and the methods of treatment so that even when not working on pest and disease control they can report outbreaks to the nursery *mandore.*

The assessment of labour requirements for spraying operations in the nursery is a function of the output of the spray jet, the operating pressure, the rate of application and the stage of seedling growth. If the following assumptions are made:

(i) a 2½-gal knapsack sprayer operating at 40 lb per sq in. with a fan jet, size 000, is sufficient to spray 500 seedlings at the 4–5 leaf stage and 100 seedlings at the 10–12 leaf stage, and

TABLE 8

*Quantities of materials required in storage (in lb) for pest and disease control at two stages of nursery development**

Material	*Conc.*	*4–5 leaf stage*		*10–12 leaf stage*	
		per 100000	*per 200000*	*per 100000*	*per 200000*
Fungicides	0.2%	30	—	150	—
Insecticides	1 oz per 2 gal	—	94.5	—	472.5
	1 oz per 6 gal	—	31.5	—	157.5
	16 oz per 25 gal	—	120.0	—	600.0
Rat bait:					
Warfarin		10	—	—	—
Paraffin wax		40	—	—	—

* Assuming 25% incidence of disease and 50% incidence of pest attack

(ii) a labourer can discharge and refill a knapsack sprayer in 40 min, including walking time. Therefore, the approximate number of seedlings that one man can spray in a 7-h day can be estimated as follows:

$$\text{4–5 leaf stage:} \quad 500 \times \frac{7}{0.66} = 5000$$

$$\text{7–9 leaf stage:} \quad 300 \times \frac{7}{0.66} = 3000$$

$$\text{10–12 leaf stage:} \quad 100 \times \frac{7}{0.66} = 1000$$

the labour requirements for any given round of spraying can thus be determined by applying these conversion factors to the incidence of infestation or infection occurring at various stages of growth.

3.2.5 *Thinning out*

Thinning out is done in two stages, at 9–10 months and at time of removal from the main nursery to the field.

First stage thinning. Assuming that *mandores* are employed at a rate of one per 100000 seedlings, a 380000 seedling nursery would have four *mandores* and a Nursery Officer available to carry out the first stage of thinning. At a nursery planting rate of 50000 seedlings every 2 weeks, the number ready for thinning out at any given time can be estimated at around 100000 seedlings.

These seedlings would occupy approx. 120 nursery blocks, and each *mandore* would therefore be responsible for thinning out in thirty blocks. If a *mandore* and labourer take ½ h to inspect a block and, using aerosol silver spray, mark palms for thinning after a final check by the Nursery Officer, each *mandore* should cover fourteen to fifteen blocks per day. On this basis, 100000 seedlings could be marked for thinning by four *mandores* and four labourers in 2 days. When marking potential culls, the *mandore* should record the number marked in each nursery block. After final checking by the Nursery Officer, the numbers to be destroyed in each block should be recorded.

Assuming 5% thinning in the first stage, approx. forty seedlings would have to be cut out in each nursery block. If a labourer can complete the cutting out operation for a block in 12–15 min, four labourers should complete the thinning out of 100000 seedlings in 1 day. The labourers involved in marking potential culls are clearly the most suitable for the cutting out operation.

Final stage thinning. This should be carried out at the time of transfer from the nursery to the field. As palms are brought out from the blocks for loading onto the field transport, the *mandore* in charge should put aside all potential culls for final checking by the Nursery Officer. Again, up to 5% can be expected.

The Field

(F.L.D.A.)

Plate 2. An FLDA Scheme showing a Jungle Clearing after completion of pruning, stacking and re-burning.

CHAPTER 4

JUNGLE CLEARING

4.1 TIMING OF CLEARING AND ESTABLISHMENT OPERATIONS

The essential items of work that have to carried out in clearing and initial establishment operations can be listed as follows:

(a) Demarcation of the perimeter boundary.

(b) Nursery site selection and establishment (where a central nursery has not already been established).

(c) Calling tenders for the main clearing and major establishment works.

(d) Awarding contracts for main clearing and major establishment works.

(e) Demarcation of blocks within the clearing (done by the contractor).

(f) Underbrushing and felling.

(g) Main burning.

(h) Pruning, stacking and re-burning.

(i) Main road alignment (and later secondary roads and drains).

(j) Lining.

(k) Establishment of harvesters' paths and clearing planting points.

(l) Sowing covers.

(m) Maintenance of covers.

(n) Field planting.

The phasing of these operations in relation to the timing of field planting is shown in Figs. 10 and 11. This phasing relates to a planting programme commencing some 19 months after demarcating the perimeter boundary. Where a central nursery has already been established, the time span between perimeter demarcation and field planting could be reduced to some 16 months.

In Malaysia, jungle clearing for large-scale planting is still carried out using manual techniques (chain saw and axe), although preliminary trials on mechanical clean clearing, using bulldozers, are currently being undertaken. In view of the lack of experience in large-scale mechanical clearing, the sections following are confined to the organisation of jungle clearing by manual methods.

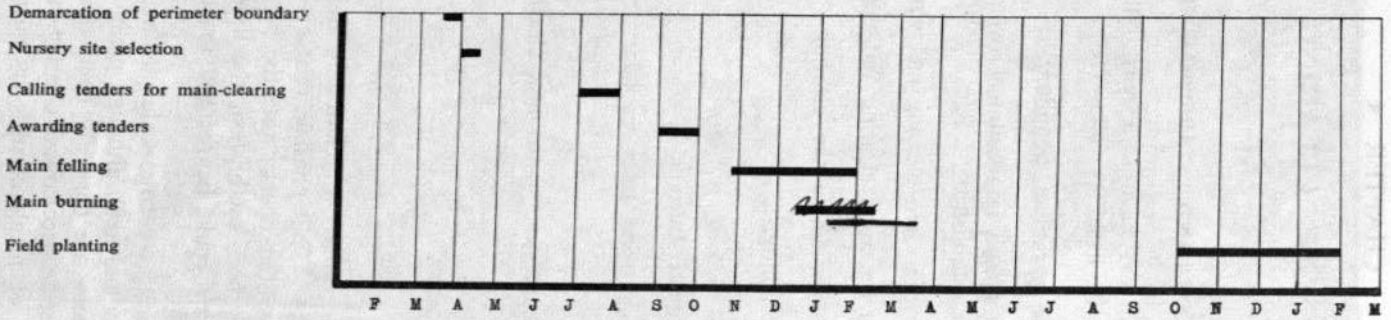


Fig. 10. Phasing of clearing operations in relation to a field planting of ~~8000~~ 5,000 acres

Prior to calling tenders for clearing, the perimeter of the area scheduled for development has to be demarcated by means of cutting rentices. The renticing would be done by a team, consisting of a *mandore* and one labourer, using a chain and compass and a *parang* gang of four labourers slashing the undergrowth. Such a team should be able to cut 35 chains of rentice in 6 h (this allows 2 h for getting in and out of the area). Therefore, to rentice the perimeter of a square area of 5000 acres, involving approx. 900 chains, would take three teams 9 days to complete. For any shape of clearing, the chainage involved can be traced from the area map and the requisite number of teams to complete the work in a given period of time can be estimated.

Having renticed the perimeter, tenders can be called for the major works involved in clearing and initial establishment according to specification. Details of tender specifications, currently used by the Federal Land Development Authority in Malaysia, relating to the following major works are given in Appendix II, and include:

(i) Felling, burning, pruning, stacking and re-burning.

(ii) Construction of jeep tracks.

(iii) Renovation of existing timber tracks.

(iv) Lining.

(v) Establishing leguminous covers.

(vi) Maintenance of leguminous covers.

(vii) Holing and field planting.

(viii) Establishment of harvesters' paths and clearing planting points.

4.2 ORGANISATION OF JUNGLE CLEARING

Having been awarded a contract for jungle clearing, the first operation which the contractor would undertake is to divide the area by renticing into blocks of 100–200 acres for control of subsequent underbrushing and felling operations. The main contractor usually sub-contracts the actual work of underbrushing and felling and utilises these blocks for progress assessment and control of payments. It is essential that the main contractor or sub-contractors engage sufficient labour to ensure that the underbrushing and felling operations are completed according to the time schedule specified within the contract. It is the responsibility of the Manager/Officer in charge to check continually that the work is progressing according to both specification and timing, because a significant delay in any one of the major work items may throw the planting programme seriously out of phase. The adverse effects of such delays on future production cannot be over-emphasised.

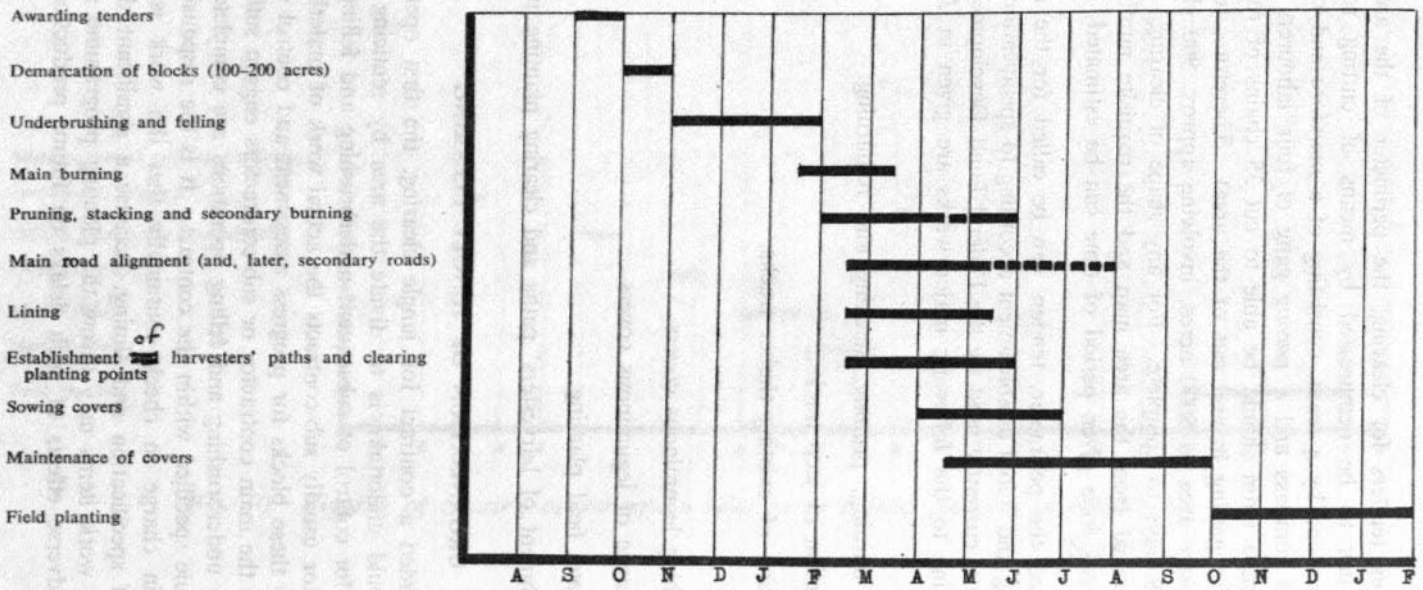
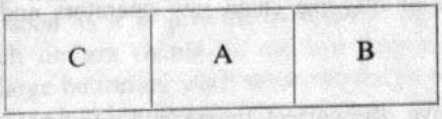


Fig. 11. Phasing of clearing and field establishment operations for 5000 acres

4.2.1 *Underbrushing and felling*

With manual clearing, a good burn is essential because the presence of large quantities of partly-burned timbers has a very considerable effect on the cost of subsequent field operations. When drawing up a programme for clearing jungle, the main factor in determining the timing of operations is the season during which a successful main burn can be anticipated. In Fig. 11 it has been assumed that the earliest date on which burning can take place is towards the end of January and that the season extends to mid-March. Under West Malaysian conditions, it is advisable to allow a period of 8 weeks on average for drying-out after felling. The drying-out period should not be extended much beyond 12–14 weeks because extensive regeneration of vegetative growth will result in an inferior burn. Under these circumstances, when clearing large areas (5000 acres or so), felling should commence in early November and proceed at a rate that enables about one-third of the area to have been felled by early December and ready for burning at the end of January. The remaining two-thirds should be felled by the end of January, leaving sufficient time for drying-out prior to the second main burn in early March.

If the main burning is to be done on two occasions over the period late January to mid-March, the organisation of the felling programme would involve dividing the total area into three main sections of equal size, as shown below.



By starting felling operations in Section A in November (burning late January) and commencing felling in Section B and C on the sides furthest from A, fire-breaks between the three sections would not be required. With this schedule of operations, the labour force requirements could be geared to a felling programme of 1700 acres per month. Should it be considered necessary to step up the rate of felling during December and January, so as to bring the second burn forward, appropriate increases in the labour force would have to be made. When opening up large areas in comparatively remote regions, the availability of labour is often a major problem. The rate of the clearing schedule given above is the minimum if a satisfactory drying out period is to be achieved.

Underbrushing is done just prior to felling and consists of slashing undergrowth, creepers and small saplings (up to 3 in. diam) as close to the ground as possible. A high standard of underbrushing is necessary to (1) reduce the quantity of green vegetation present at the time of the main burn, (2) provide tinder for the burn, and (3) allow easy access for the felling gangs following behind. Underbrushing is done by general labourers and not by the felling gangs, who are specialists in felling large jungle timbers.

Under Pahang jungle conditions, the labour requirements for underbrushing appear to be approx. 2½ man-days per acre. Therefore, to complete a programme of 1700 acres in one month (20 working days, allowing for heavy rains), a minimum labour force of 210 would be required.

The heights at which trees can be felled are 6 in. from ground level for small trees up to 3 in. diam, ranging to 5 ft from ground level for trees between 30–60 in. diam. All trees over 60 in. diam should be felled at the point where the buttress roots meet the main trunk. Details of felling specifications are contained in Appendix II. Where a tree in falling strikes another and breaks it at a height in excess of the specification, that tree should be cut down to the required height. All trees must be cut so as to fall clear of the stump and not left suspended. Trees should be felled inwards from the perimeter rentice, and all roads and jeep tracks which are to be used for access during inspection must be kept clear of fallen timber. All natural drains and waterways must also be kept clear of timbers.

Felling is done by gangs using chain saws and axes in the approximate ratio of 1:3. Under Pahang conditions, the labour requirements for felling large timbers by chain saw can be estimated at around 0.65 man-day per acre. The axemen working alongside the chain saws can be expected to work at the rate of 2 man-days per acre. To complete 1700 acres in 20 working days would require a labour force of fifty-five chain saw operators and 170 axemen.

4.2.2 *Burning*

As mentioned above, the correct timing and organisation of the main burn are important if maximum clearance of timber is to be achieved. Useful indicators of adequate drying-out are signs of bark cracking on the large trees, with the foliage both dry and beginning to fall.

On the basis of the experience of the Federal Land Development Authority in large-scale clearing, no single burn should exceed 2000 acres. The actual date of burning must be kept flexible, as it is important that a period of at least 5 days dry weather immediately precedes firing. Prior to the expected commencement of burning, one week's notification should be given to the District Officer, the District Fire Officer, Game Department, Police and any neighbouring estates or smallholdings. Warning notices must be placed near public footpaths and roads; control points and fire escape routes for labourers must be established. During the burn, guards must be stationed at entrances to tracks used by the public. Labourers should be made completely familiar with the location of all escape routes and control points. Wherever sites being burned adjoin planted areas, a fire belt of about 2 chains in width should be left standing. After the main burn these fire belts can be felled and piled well clear of the boundary before burning.

A common practice in Malaysia is to use the open fire method, in which the firing labourers are spaced out in a line at 1-chain intervals on the downwind side of the clearing. The labour force employed must be experienced and agile. Each member of the firing gang should have a fire brand and a small bottle of kerosene. At a signal from the control point, the firers should advance in a line into the prevailing wind, setting alight the tinder (applying kerosene where necessary) at intervals of approx. 1 chain. The supervisors must make certain that they can keep all firers continually in view and a roll call should be held on reaching the windward end of the clearing.

The labour requirements for burning are normally estimated on the basis of one firer for every 10 acres, the supervision requirements being one *mandore* per 15 labourers. Given that timbers are suitably dry, the success of a burn is basically dependent on establishing a high intensity of firing points at even intervals over a wide belt. In view of the importance of a good burn in relation to subsequent field costs, it is essential that an adequate labour force is engaged for this critical operation. To burn 1700 acres in 1 day would require a minimum of 170 labourers and eleven *mandores*, which is a very small outlay to ensure a satisfactory burn.

4.2.3 *Pruning, stacking and re-burning*

Pruning, stacking and re-burning of timbers that are 6 in. diam or less should commence as soon as it is possible to re-enter the area (7–10 days after the main burn). Such timbers should be cut into lengths suitable for carrying and stacking around large buttresses; each stack should be fired and kept burning. Pruning, stacking and re-burning should be completed block by block, so that lining and sowing the cover crop are not delayed until the whole area has been cleared. Dead trees, which have been left standing during felling and have not fallen during the burn, should be dealt with at this stage by stacking and burning around their base. If this is not effective, such trees should be felled and pruned. Lining and, where necessary, terracing, platforming and silt pitting, should commence when clearing has been completed and any weed regeneration eradicated by spraying and manual removal prior to sowing the cover crop.

Immediately following lining, work on the establishment of harvesters' paths and clearing planting points should commence. At this stage of the establishment works, four types of operation would be proceeding simultaneously—pruning, stacking and reburning; main road alignment; lining; and establishment of harvesters' paths and clearing planting points.

When developing an area for oil palms, irrespective of whether the terrain is flat, undulating or hilly, a detailed plan of the agricultural road and drainage systems should be drawn up. Where terrain is undulating or hilly, this plan must be based on a 10 ft contour map. In the stage of pruning, stacking and

re-burning immediately after the first main burn, only the 25 ft contour map would be available and the main road alignment, which is necessary to provide access for field operations, has to be based on this map. The main agricultural roads should be established simultaneously with pruning, stacking and re-burning, and would essentially consist of alignment of the roads and clearing stumps and timbers on a 22 ft width basis (12 ft pavement and 5 ft shoulders). This work would normally be done on a supplementary contract basis, using bulldozers and permitting a maximum gradient of 1 in 10. Where filling or cutting is in excess of 6 ft, it is normal practice to make allowance for additional payments to be made.

A 10 ft contour map can be produced by aerial photography combined with ground control. If this work cannot be done until the major burn has been completed and the smoke has cleared, it is recommended that the fly-over and ground control surveys be done as soon as possible after the final main burn. To ensure that the atmosphere is clear for satisfactory aerial photography, re-burning operations in the first main burn area should be suspended for a short period. The officer in charge should instruct the contractor to stop re-burning operations as soon as the final main burn has been completed. However, pruning and stacking operations can continue. Clearly, the arrangements for the fly-over should have been made well in advance to ensure that resumption of re-burning is not delayed. As soon as the 10 ft contour map has been prepared, which should preferably be within 6 weeks of the final main burn, a detailed plan of the entire agricultural road and drainage systems can be drawn up. The establishment of these systems should then proceed in phase with the pruning, stacking and re-burning operations.

Should techniques be developed which enable ground control work to be organised during the pre-felling stage, and the aerial photography carried out immediately after felling has been completed (before the main burn), the production of the 10 ft contour map would be considerably speeded up. Clearly, this would be advantageous from the standpoint of preparing the plans of the road and drainage systems. It would also avoid delaying re-burning during the pruning, stacking and re-burning operation.

The detailed layout of agricultural road systems will vary according to terrain and the shape of the area being developed. However, a general principle that must be followed is to construct roads at intervals of 20 chains or less, depending on topography, so as to facilitate a maximum carry of 10 chains or less. On flat land, $\frac{3}{4}$ chain of agricultural roads per acre would normally be sufficient and of this, $\frac{1}{4}$ chain would be main and $\frac{1}{2}$ chain subsidiary road. On undulating and hilly land, an exact ratio cannot be given, as the chainage required would be dependent on the nature of the terrain. However, an average of 1.2–1.5 chains per acre should be adequate.

Lining should commence as soon as pruning, stacking and re-burning have been completed in any given area and should continue in phase with these operations, the spacing used being dependent on the planting density. As the time lag between lining and field planting may be between 7–8 months, lining pegs (usually bamboo) should be dipped in creosote to a depth of 1 ft as a precaution against white ants and rotting.

The establishment of harvesters' paths and clearing timbers from planting points follows the lining operations, utilising part of the skilled labour force (chain saw operators) engaged on pruning, stacking and re-burning. Harvesters' paths are established by cutting 10–12 chains per acre of 5 ft widths along every alternate avenue and removing cut timber to either side of the path, so that it does not roll back onto the paths and obstruct access. Removing timbers from planting points consists of clearing all timber and logs lying on or across the planting points and all stumps not exceeding 18 in. diam within a radius of 8 ft from the lining peg. Timbers should be cut with chain saws and standing stumps cut as close as possible to ground level. All cut timber must be removed into the avenues and stacked well clear of harvesters' paths.

The advantages of including these works within the main contract for felling, pruning, *etc.*, can be summarised as follows:

(i) A skilled pruning labour force is already on site.

(ii) There would be no increase in maintenance costs during the first 2 yr because the whole area needs selective weeding, irrespective of the establishment of harvesters' paths. The contractor would, therefore, not be expected to keep the paths free from cover crops should they encroach. When these paths are required for harvesting purposes, the covers can be sprayed out. However, during the early establishment years, these paths would provide easy access for weeders, manuring gangs and inspection by staff.

(iii) Removal of timbers at this stage is very much easier than when they are overgrown by covers.

(iv) By establishing harvesters' paths in every alternate avenue, placing palms at planting points during field planting is made easier and the risk of damage to palms through bad handling by labourers is reduced. This could well reduce the amount of supplying required at a later stage.

The main advantages of clearing timbers from the planting points prior to planting the palms are, firstly, that the actual planting operation should be both speeded up and more effectively carried out and, secondly, subsequent weeding operations are facilitated.

Pruning, stacking and re-burning. Labour requirements for this operation can be estimated at 6 man-days per acre, with a ratio of five labourers for axe-work, carrying, stacking and re-burning to one labourer using a chain saw. To complete 5000 acres in 75 days, work should proceed at a rate of 67 acres per day. Allowing 10% loss for bad weather, the programme should be geared to completing 75 acres per day. On the basis of the above labour input figures, the man-power requirements could be estimated at 450 labourers (including seventy-five chain saw operators).

4.2.4 *Lining*

To be in phase, this work (in a 5000-acre area) should be completed at the rate of 75 acres per day. In undulating terrain, the labour requirements for lining can be based on a labour input of 1 man-day per 2½ acres. Therefore, the daily labour requirements for 75 acres would be thirty labourers.

4.2.5 *Establishment of harvesters' paths*

Again, this operation has to be carried out at a rate of approx. 75 acres per day and, at an average of 11 chains per acre, the total chainage would amount to 825 chains. Assuming a labour input factor of 4 chains per man-day, the labour force required would be in the order of 200 men.

4.2.6 *Clearing timber from planting points*

To complete 75 acres per day, assuming that the labour input is approx. 2 man-days per acre, would require a daily labour force of 150 men. In the two latter operations, the ratio of labourers clearing and carrying to chain saw operators could be estimated at 5: 1.

From the above, it can be readily appreciated that, to keep these critical clearing and establishment operations in phase with respect to both timing and sequence, a large labour force must be available, particularly over the 3–4 month period following the first main burn. If these operations fall out of phase, the cover crop establishment programme would be delayed, and if covers are not well established at the onset of the rainy season, selective weeding costs could well be much higher than normal. As weeding covers is a major item of expenditure during immaturity, high priority should be given to ensuring that cover establishment is correctly phased.

CHAPTER 5

ESTABLISHMENT AND MAINTENANCE OF COVER CROPS

5.1 PREPARATION FOR SOWING COVERS

The essential items of work that have to be carried out after completion of pruning, stacking and re-burning, and prior to sowing covers, are:

Lining (see Section 4.2.3 above).

Clean-weeding after pruning, stacking and re-burning.

Ordering and preparing cover crop seed and fertiliser starter mixture.

5.1.1 *Clean-weeding*

During the course of pruning, stacking and re-burning, weed regeneration will take place and these weeds should be eradicated, by spraying or manual means, prior to sowing covers. The extent of regeneration will depend on the distribution of rainfall following the main burn but, in general, a time lag of 4–5 weeks would have elapsed before clean-weeding operations commence. To facilitate control, lining should have been completed before clean-weeding commences. Clean-weeding is normally carried out in two stages, the first consisting of a round of spraying, and the second of a final clearing up of small timbers and manual removal of any remaining woody growths. This final stage of clean-weeding should be undertaken 1–2 weeks after spraying to allow time for the sprayed vegetation to die back. This means that 5–7 weeks after the main burn is the earliest that covers can be sown. As clean-weeding in any given area should not be carried out until pruning, stacking and re-burning have been completed, the rate of progress in these latter operations determines the speed at which cover crop establishment can proceed.

The labour requirements for clean-weeding will depend on the degree of regeneration that has taken place and the composition of the weed flora, *i.e.* the proportion susceptible to spraying and those requiring manual removal. Given these circumstances, the labour requirements for different areas may vary quite considerably. However, for clean-weeding by spraying and manual removal, the main elements involved in organising and carrying out a round of weeding are as follows:

(a) Estimating and ordering materials and equipment.

(b) Demarcation of the area to be covered in any time period.

(c) Organisation of spraying and manual weeding.

(d) An estimate of labour requirements for the different operations involved.

5.1.2 *Estimating and ordering materials and equipment*

The quantity of materials and equipment required should be assessed well in advance, so that orders can be placed and deliveries made before spraying operations are scheduled to commence.

Materials. The quantity of materials required will depend on the techniques being used and the dosage rate per unit of area to be sprayed. When calculating the quantity required, the dosage rate per acre x the total acreage = the quantity required per round of spraying. For example, if blanket-spraying with a 2½% soln of sodium arsenite in 70 gal water per acre, the quantity of sodium arsenite required per acre would be 17½ lb. Therefore, for 5000 acres the quantity required per round of spraying would be 17.5 x 5000 = 87500 lb.

Equipment. The quantity of spraying equipment required will depend on:

(i) the acreage involved,

(ii) the total time available to complete the work, and

(iii) the output per spraying unit.

For example, if 5000 acres have to be blanket-sprayed over a period of 75 working days and the output per knapsack sprayer is 1 acre per day, the minimum number of sprayers required would be sixty-seven. It is advisable, however, to allow a 10% contingency factor for days when spraying cannot take place (rainy days, *etc.*).

The formula for calculating the number of sprayers required is:

$$\frac{\text{Total acreage}}{\text{No of days available}} \times \frac{1}{\text{Acreage per sprayer per day}}$$

5.1.3 *Demarcation of the area to be covered*

To facilitate control, wherever possible spraying operations should be carried out over a square or rectangular area. The schedule of work for clean-weeding should aim at keeping pace with the rate of progress being achieved in the pruning, stacking and re-burning, allowing a time lag of 4–5 weeks for weed regeneration. To complete 5000 acres in 75 working days, the area pruned, stacked and re-burned per day should be 67 acres. However, making an allowance of 10% for rainy days, an area of 75 acres would need to be covered in each effective working day. This is the area that has to be clean-weeded each working day to keep the programme of operations in phase.

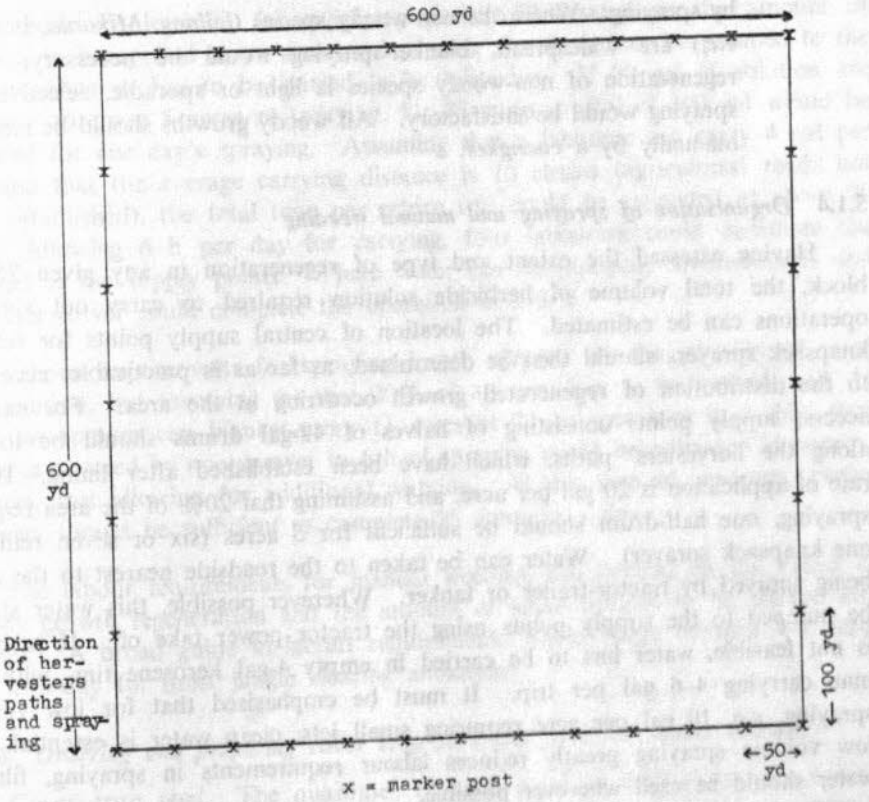


Fig. 12. Demarcation of an area of 75 acres for spraying

Some 2–3 days before an area is due for clean-weeding, its boundaries should be clearly demarcated from surrounding weeded or unweeded areas. To assist in control and delineation, marker posts should be placed in the boundary harvesters' paths at intervals of 100 yd, as shown in Fig. 12. The boundaries running at right angles to the harvesters' paths are more difficult to control and should be marked off at 50-yd intervals (every third harvesting path).

Having finished demarcation, the amount of weed regeneration in the area should be assessed by walking down every third or fourth harvesters' path. The assessment would consist of marking on a plan of the area:

(i) The extent of regeneration—heavy, light or sporadic.

(ii) The type of vegetation involved, *i.e.* woody or non-woody. Woody species will generally be removed manually and the non-woody treated

by spraying. Where the non-woody species (*lallang*, *Mikania*, bracken, *etc.*) are widespread, blanket-spraying would be necessary; where regeneration of non-woody species is light or sporadic, selective spot spraying would be satisfactory. All woody growths should be removed manually by a *changkol*.

5.1.4 *Organisation of spraying and manual weeding*

Having assessed the extent and type of regeneration in any given 75-acre block, the total volume of herbicide solution required to carry out spraying operations can be estimated. The location of central supply points for refilling knapsack sprayers should then be determined, as far as is practicable, according to the distribution of regenerated growth occurring in the area. For ease of access, supply points consisting of halves of 44-gal drums should be located along the harvesters' paths, which have been established after lining. If the rate of application is 20 gal per acre, and assuming that 20% of the area requires spraying, one half-drum should be sufficient for 5 acres (six or seven refills of one knapsack sprayer). Water can be taken to the roadside nearest to the areas being sprayed by tractor-trailer or tanker. Wherever possible, this water should be pumped to the supply points using the tractor power take off. If pumping is not feasible, water has to be carried in empty 4-gal kerosene tins, with one man carrying 4–6 gal per trip. It must be emphasised that for low volume spraying, *e.g.* 10 gal per acre requiring small jets, clean water is essential. As low volume spraying greatly reduces labour requirements in spraying, filtered water should be used wherever possible.

The herbicide concentrate should be carried to the supply points in amounts related to the area being sprayed. To facilitate control, spraying gangs should work along the avenues demarcated by the lining pegs.

The manual weeding operation will again be geared to the initial assessment of woody growth regeneration and the labour force should work along the avenues, clearing up and burning any remaining small timbers and removing the woody growths with a *changkol*.

5.1.5 *Estimation of labour requirements*

Labour requirements for clean-weeding operations can be functionally classified into the following categories:

Supplying the spray solution.

Spraying.

Manual weeding of spray-resistant weeds.

Labour requirements for supplying water will depend on the amount of solution to be applied in an area, and whether the water can be pumped to the supply points or has to be carried in by labourers. If 20 gal of solution are sufficient to cover 5 acres of spraying, for 75 acres a total of 300 gal would be required for one day's spraying. Assuming that a labourer can carry 4 gal per trip and that the average carrying distance is 10 chains (agricultural roads not fully established), the total time per return trip could be estimated at about 20 min. Allowing 6 h per day for carrying, four labourers could distribute the 300 gal to the supply points. Where water can be pumped, two labourers and a tractor driver could complete the operation in 2–3 h.

Labour requirements for spraying largely depend on the intensity of weed regeneration, but assuming (a) that 20% of an area has to be treated, and (b) that one sprayer can blanket-spray 1½ acres at 20 gal per acre in 1 day, then the area covered by one sprayer in 6 h of spraying could be estimated at approx. 6 acres, this allowing for additional walking. At this rate of coverage, twelve sprayers should be sufficient to complete 75 acres in a day.

The labour requirements for manual weeding will depend on the extent of woody growth regeneration and the amount of small timbers to be cleared and burned. A broad guide to labour requirements would range between 1–3 acres per man-day for most jungle clearing situations.

5.1.6 *Ordering and preparing cover crop seed and fertiliser starter mixture*

Cover crop seed. The quantities of seed required depend on the sowing rates. Having calculated the total quantity of seed required, orders (to include an equal weight of Christmas Island rock phosphate) should be placed well in advance, so as to ensure delivery before sowing is due. If cover crop sowing is to be completed within 3 months, a single seed delivery would be acceptable, provided that seed can be stored, at room temperature, in containers that are moisture proof and are protected against pest damage.

As cover seed must be mixed with *Rhizobium* culture immediately prior to sowing, adequate supplies of this material must be available and should be ordered from the Rubber Research Institute of Malaya at the rate of 1 x 10 g packet per 20 lb of seed. As *Rhizobium* only remains viable for 1–2 weeks, regular deliveries must be arranged to coincide with the cover crop planting programme.

Fertiliser starter mixture. To calculate the quantity of starter mixture required, the following formula should be used to assess the footage of drills per acre:

$$f = d \times s \times n$$

where f = length of drills in ft
d = planting density of the palms
s = distance between palms

At an application rate of 1 oz per 18 ft of single drill, the quantity of starter mixture required would be $\frac{f}{18} \times \frac{1}{16}$ lb per acre. For example, the footage of drills per acre, with palms at a density of sixty per acre, planted 29 ft triangular and with five drills of cover per avenue, is $60 \times 29 \times 5 = 8700$ ft. Therefore, the quantity of starter mixture required would be $\frac{8700}{18} \times \frac{1}{16} = 30$ lb per acre.

5.2 SOWING COVERS

Treated seed can be sown after clean-weeding operations have been completed. Seeds are sown in five shallow drills, 4 ft apart, the two outer drills being 4½ ft in from the planting line (Fig. 13).

A satisfactory arrangement for sowing cover seed after jungle clearing is for one team of labourers to prepare the shallow drills and another team to sow the seed. The labour requirements for drilling and sowing can be estimated at 0.7 man-day per acre (2900 yd of drill) where covers are sown at 5 lb per acre, with five drills in each avenue. It should be noted that a quantity of C.I.R.P. equal to the weight of seed should be mixed with the seed before sowing. A suitable method for lining the drills is to place marker pegs, some 5–6 ft high, for the outer drills at the end of an avenue and to place another two marker pegs on the outer drills at intervals of 50 yd up the avenue. These pegs are used as an approximate guide for lining. When the five drills have been completed, the cover seed should be sown and the same procedure is repeated in the next 50 yd of avenue, giving a total of 250 yd of drill. By sowing short distances each time, the need for elaborate lining is avoided and the correct direction of the lines can be easily maintained despite the presence of fallen timber.

On steep land which has been terraced, with timbers from the terraces pushed into the avenues, drills would be impractical and seeds should be sown in pockets at a rate 5 lb per acre of avenue.

5.2.1 *Fertiliser application*

In the example given in Section 5.1.6, the quantity of starter mixture required per acre was 30 lb per application for five drills of cover, with palms planted at a density of sixty per acre.

Starter mixture should be applied in two doses, when the foliage is dry, at approx. 1 week and 3 weeks after emergence of the cover. The mixture should be sprinkled on top of the foliage and, assuming that this can be done at an average pace of 1–1½ m.p.h., one man should complete at least 4 acres per day, or 11600 yd of drill.

5.2.2 *Inspection of the success of cover establishment*

One month after sowing, the cover crop should be inspected to determine the degree of success in establishment. In large-scale development operations, it is normal practice to carry out the inspection in blocks of 250 acres. Wherever vacancies in a drill occur, supplying should be immediately carried out. At the same time, a check should be made to assess the extent to which the area has been kept clear of weeds.

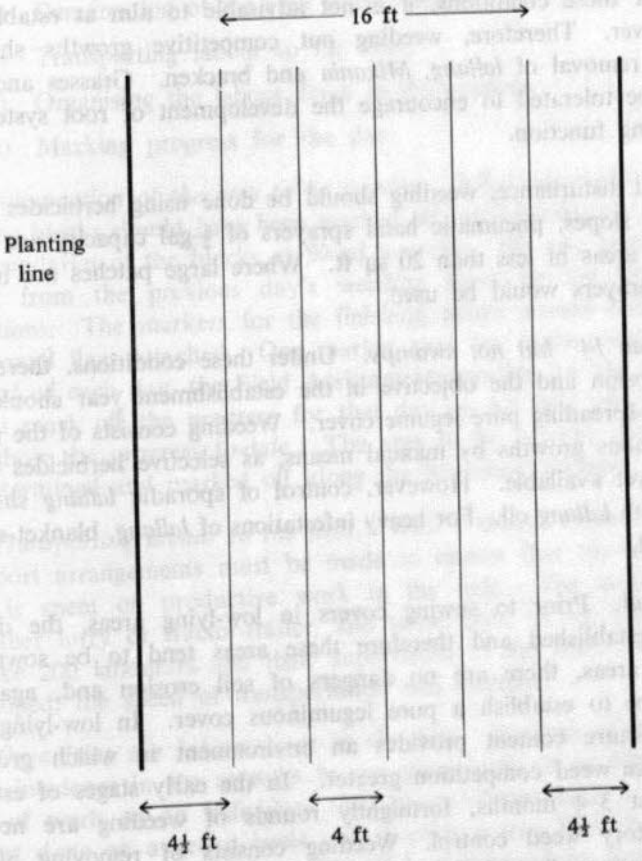


Fig. 13. Placement of drills for sowing cover crop

5.3 MAINTENANCE OF COVERS AND CIRCLE WEEDING

5.3.1 *Weeding*

The type of weeding needed to maintain leguminous covers varies according to the topography of the area. The types of terrain encountered can be broadly classified as:

(a) Steep land where the slope is greater than 14°.

(b) Land of less than 14° slope but not swampy.

(c) Low-lying land.

Steep land. Under these conditions, soil is very liable to erode and it is important that the soil surface becomes covered with protective vegetation as early as possible. Given that legumes take approx. 5 months to form a complete cover under these conditions, it is not advisable to aim at establishing a pure legume cover. Therefore, weeding out competitive growths should be restricted to the removal of *lallang, Mikania* and bracken. Grasses and woody growths should be tolerated to encourage the development of root systems that have a soil-binding function.

To avoid soil disturbance, weeding should be done using herbicides. When working on steep slopes, pneumatic hand sprayers of $\frac{1}{2}$-gal capacity are suitable for spot-spraying areas of less than 20 sq ft. Where large patches are involved, light knapsack sprayers would be used.

Slope less than 14° but not swampy. Under these conditions, there is less danger of soil erosion and the objective in the establishment year should be to produce a rapidly-spreading pure legume cover. Weeding consists of the removal of all non-leguminous growths by manual means, as selective herbicides for this purpose are not yet available. However, control of sporadic *lallang* should be done by wiping with *lallang* oil. For heavy infestations of *lallang*, blanket-spraying would be required.

Low-lying land. Prior to sowing covers in low-lying areas, the drainage system must be established and therefore these areas tend to be sown later. Clearly, in these areas, there are no dangers of soil erosion and, again, the objective should be to establish a pure leguminous cover. In low-lying areas, the high soil moisture content provides an environment in which growth is vigorous, and hence weed competition greater. In the early stages of establishment, *i.e.* the first 3–4 months, fortnightly rounds of weeding are necessary to ensure satisfactory weed control. Weeding consists of removing all non-leguminous growth manually. *Lallang* control would again be by herbicides.

5.3.2 *Organisation of weeding rounds*

Weeding rounds should commence 2–3 weeks after sowing covers and, apart from low-lying areas, monthly rounds should give satisfactory control.

When 5000 acres of covers have been established, assuming 25 working days per month, the area to be weeded in any given day would be 200 acres. Avenue weeding is comparatively light work, and women and youths are generally employed on this operation. One labourer should be able to weed 1 acre per day and pull back the legume covers from the planting pegs. Therefore, a total labour force of 200, supervised by six *mandores*, would be required to maintain the weeding programme. Additional labour requirements will be necessary in swampy areas and each situation should be assessed separately.

The organisation of avenue weeding involves the following basic steps:

(a) Demarcation of the area to be weeded in any given day.

(b) Transporting labour to the field.

(c) Organising the labour force in the avenues.

(d) Marking progress for the day.

Demarcation of the area to be weeded. After completion of lining, 200-acre weeding blocks should have been marked off, with permanent marker posts, along the boundaries of the blocks at 50-yd intervals. On any given day, the finishing points from the previous day's weeding serve as the baseline for weeding operations. The markers for the finishing points should consist of 6–8 ft poles with small flags attached. One marker post for each avenue is adequate. At the end of each day, the Field Assistant responsible for the weeding programme should mark off the progress for that day on his field plan. This plan would also show the progress to-date. The area to be covered the next day can then be determined and marked off along the boundary avenues.

Transporting labour to the field. With a labour force of this size, adequate transport arrangements must be made to ensure that the maximum amount of time is spent on productive work in the field. The mode of transport will be either lorry or tractor-trailer, and some eight to ten trips will be necessary to take 200 labourers and their supervisors to the field. As road systems are developed, the speed of transportation will increase.

Organising the labour force in the field. Because of the wide variation in weed incidence in the avenues in any given area, it is difficult to allocate this type of work on an individual task basis. Given such a situation, this work is best done on a group basis and in such a way that the *mandore* can keep close control of the labourers. This is best achieved by concentrating the labour force so that four labourers are working along each avenue, keeping in line

abreast as far as possible. Each *mandore* will have a gang of thirty to thirty-five labourers and, therefore, at any given time he will be supervising around eight groups each of four labourers, working along eight avenues. If the baseline from which weeding operations take place is wide enough, the six *mandores* and their gangs would be working along thirty-two avenues simultaneously. To make even progress through the area, the aim should be to keep the labourers in line abreast, both within gangs and between gangs.

5.3.3 *Inspection path maintenance*

If inspection paths are established in every sixth row, the length of path per acre would amount to 4.39 chains. This is derived as follows:

$$\text{Total length of avenue in 1 acre at 29 ft triangular planting} = \frac{\text{Area in sq yd}}{\text{Width of avenue in yd}}$$

$$= \frac{4840}{8.36}$$

$$\text{Length of inspection path per acre at one path in every sixth row} = \frac{4840}{8.36 \times 6}$$

$$= 96.58 \text{ yd}$$

$$= 4.39 \text{ chains}$$

Inspection paths 2 ft wide are manually weeded during normal weeding rounds. The paths should be kept clean of vegetation and, provided this work is commenced when covers first start encroaching over the path, the work involved in keeping these paths clear should not be heavy.

The area of path per acre is approx. 64 sq yd. Assuming that the cost of clean-weeding paths is at a similar rate to circle weeding, *i.e.* 4–5¢ per circle of 8 ft diam and approx. 6 sq yd, the estimated cost of clean-weeding the inspection paths could be about $\frac{64}{6} \times 4 = 43¢$ per acre per round. The annual cost at twelve rounds would be in the order of $5 per acre.

The total area of inspection paths to be weeded in 200 acres would be 200 x 64 = 12800 sq yd. This could be done by thirty-six labourers, each labourer weeding approx. 360 sq yd, which is equivalent to sixty circles of 8 ft diam.

5.3.4 *Fertiliser application*

In the establishment year, 160 lb (two bags) per acre of rock phosphate should be applied, in a single application, approx. 3 months after sowing. The

phosphate should be broadcast by hand, and one labourer should be able to cover 3 acres in 1 day. If the schedule of cover crop establishment has been at a rate of 75 acres per effective working day, the programme of manuring would be at the same rate, but with a time lag of 3 months. On this basis, a labour gang of twenty-four would complete the programme in 3 months (allowing a 10% margin for adverse weather conditions).

Where the agricultural road system has not yet been fully established, and distances between existing roads range up to approx. $\frac{2}{3}$ mile, the approach to organising fertiliser application outlined below is aimed at minimising the time spent by labourers in refilling their buckets. For example, the factors affecting the procedure in applying rock phosphate to a square area of 75 acres, *i.e.* approx. 600 yd x 600 yd, are as follows:

Rate of fertiliser application. If 160 lb of rock phosphate has to be applied per acre, and the width of avenues is 25.1 ft, the rate of application per 50 yd of avenue would be approx. 13 lb.

Number of labourers. Assuming that one labourer can broadcast fertiliser over 3 acres in 1 day, a total labour force of twenty-four would be required to complete the application. To minimise refilling time, supply points along inspection paths should be established at 100-yd intervals. At an average walking speed of 2 m.p.h., the total time involved in establishing these supply points can be estimated to be approx. 26 man-h. Assuming a 7-h working day, five labourers should be able to complete the task, including loading 150 bags from the store and unloading the requisite number of bags at the end of the thirteen inspection paths (see Fig. 14). For this situation, a total labour force of twenty-nine is required. The application gang would be supervised by one *mandore.*

Method of applying fertiliser. If two labourers working simultaneously along an avenue can each cover a swathe of one-half avenue width, two buckets containing 13 lb of rock phosphate each would be sufficient to fertilise a distance of 100 yd along the avenue, this being the basis on which the supply point distribution is determined. At the end of each 100 yd of avenue covered, the twenty-four labourers would refill their buckets, which are marked at the 13 lb level, from four bags. This means that in a single bucket-filling operation, the bags involved are completely emptied and this should reduce the chances of error in the rate of fertiliser being applied. Using this system, twenty-four labourers, working along twelve avenues, *i.e.* between three inspection paths, would cover approx. 2 acres in every 100 yd. By concentrating the labour force into such an area, one *mandore* is sufficient to provide adequate supervision. In six passes covering a distance of approx. 600 yd each, the group of labourers would cover 72 acres. The remaining 3 acres, to achieve the day's task of 75 acres, would be completed by the whole group working in the remaining three avenues (see Fig. 14).

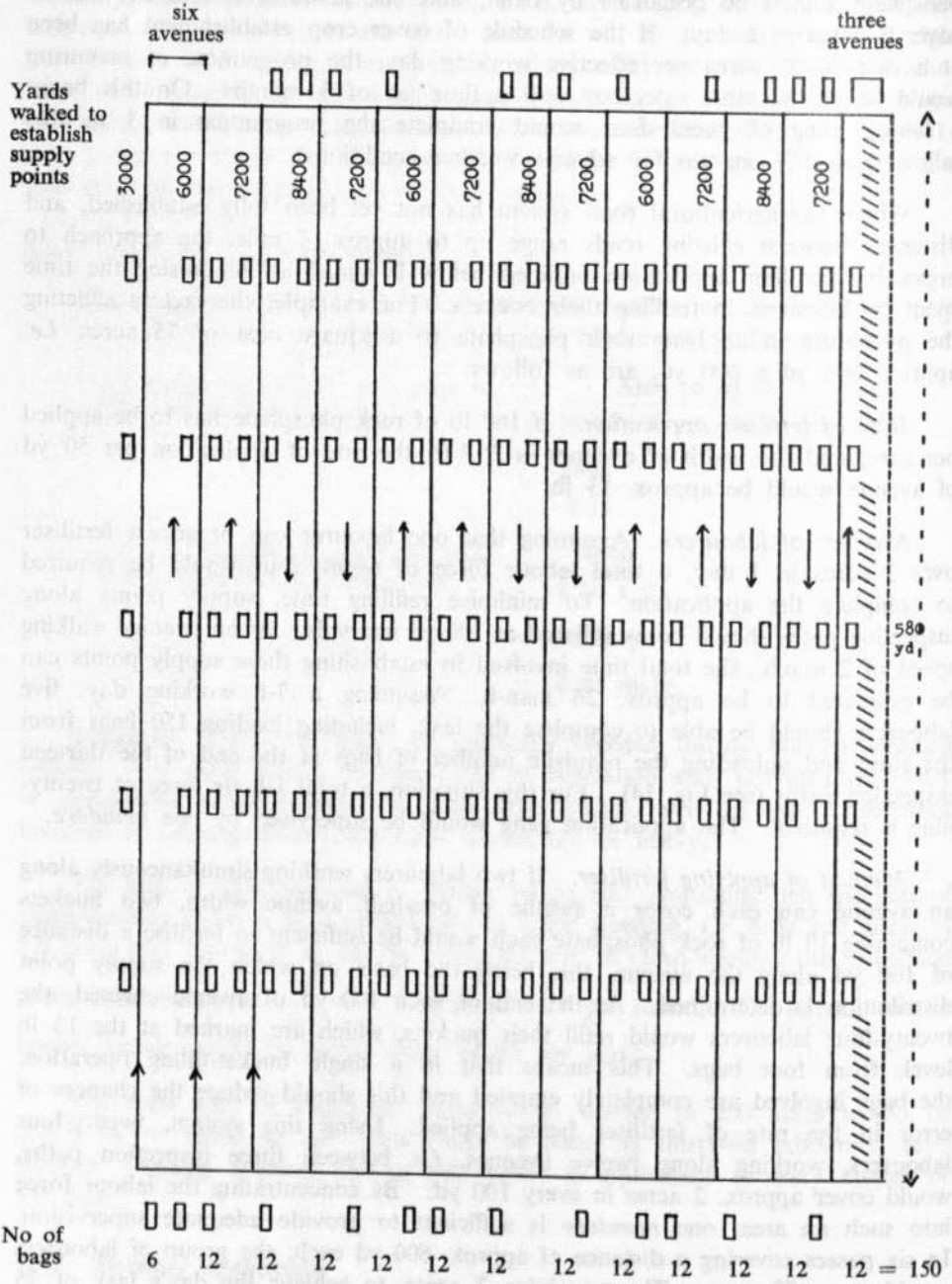


Fig. 14. Bag distribution for manuring seventy-five avenues (580 yd long)

Where agricultural roads have been established at a distance of 20 chains apart, giving a maximum carry of 10 chains, the time spent in establishing supply points in any given area would be substantially reduced when compared with the example illustrated above. However, the location of supply points, the method of fertiliser application and the labour force required for application would be the same.

A Field Assistant would be in overall charge of fertiliser application and on the day prior to application he should ensure that:

(a) The boundaries of the area involved have been clearly demarcated.

(b) The roadside off-loading points at the ends of inspection paths are marked, indicating the number of bags to be off-loaded.

(c) The supply points along each inspection path have been marked off at 100-yd intervals. For practical purposes, every tenth planting point would be sufficient.

CHAPTER 6

FIELD PLANTING

6.1 TIMING OF FIELD PLANTING

Decisions on the timing and rate of planting determine the phasing of the field programme. With the polybag nursery system, palms can be successfully planted over a wide range of soil moisture and hence rainfall conditions. In most areas of Malaysia, polybag nursery palms can be successfully planted during 9 months of the year. In any given situation, the programme should be capable of adjustment to avoid having to plant palms during periods when conditions of severe drought or waterlogging are being experienced. However, for a 5000-acre programme, the objective should be to field-plant 300000 seedlings, which have been 12–14 months in the nursery, over a 4-month period, which has been selected for climatic suitability, at a rate of 75000 per month. Assuming 21 planting days per month, the daily rate of planting would be 3600 seedlings, or 60 acres.

6.2 ORGANISATION OF FIELD PLANTING

The organisation of field planting can be divided into six main categories of work:

(i) Census of the number of planting points along the rows in the area that has been demarcated for planting on the following day.

(ii) Preparing rock phosphate packets for each planting point.

(iii) Transporting seedlings from the nursery to the field, including painting leaf bases with zinc phosphide paste.

(iv) Unloading in the field.

(v) Transporting seedlings to planting points.

(vi) Holing, planting and consolidating seedlings.

6.2.1 *Census of planting points*

The area to be planted should be demarcated, using marker posts at each end of the last row to be planted in any given day. The agricultural roads at 20-chain intervals will normally form two boundaries, with the last row scheduled to be planted on the day of the census forming the fourth boundary. In a rectangular area of 60 acres, 30 chain x 20 chain, marker posts should be placed

at the 10-chain point, or half-way between the two roads, and this marks the maximum distance that seedlings have to be carried along any row.

A count should be taken of the planting points in every half-row (a half-row is the distance from an agricultural road to the half-way point between two roads), so that the number of palms to be off-loaded at the end of each harvesters' path can be determined. Such a system reduces to a minimum the walking distance involved when carrying seedlings from the roadside to their planting points.

The count can be taken by a responsible labourer using a hand counter, proceeding from the roadside along a harvesters' path to the half-way point, counting the number of planting points in the rows on either side of the path. At the half-way point, this number should be noted on a row plan of the block to be planted. The labourer should cross into the next harvesters' path and return to the roadside, again recording the number of planting points along the rows. On reaching the roadside, the labourer should write the number of planting points for each of the harvesters' paths recorded so far on a card, which is attached to a marker peg placed at the end of the respective harvesters' paths. This procedure should continue until the whole block has been completed (see Fig. 15). These block plans could subsequently form the basis of a point-to-point plan for the whole planting.

6.2.2 *Preparation of rock phosphate packets*

To avoid carrying C.I.R.P. to the individual planting points in a separate operation, this fertiliser can be packed into ½-lb packets wrapped in paper in the nursery store. Two labourers should be able to make up 3600 packets in 1 day. These packets would subsequently be tied to each seedling, after off-loading at the end of each harvesters' path (see 6.2.3 below). This system also ensures that fertiliser is applied to each planting hole.

6.2.3 *Seedling transport from the nursery to the field*

As a control measure against rat and porcupine attack, the leaf bases of seedlings should be painted with recommended concentrations of zinc phosphide paste prior to their removal from the nursery. Three women should be able to complete this work on 3600 seedlings in 1 day.

So that labour can be utilised and supervised efficiently, it is recommended that separate teams or gangs are used for the following operations:

(a) Loading seedlings onto transport vehicles in the nursery.

(b) Off-loading seedlings at the end of each harvesters' path.

(c) Carrying seedlings to planting points.

(d) Holing, fertiliser application and planting.

Assuming that 3600 seedlings are to be planted per day (500 per h), to ensure that sufficient seedlings are available to keep the planting teams fully supplied, approx. 2-h planting supply should be carried into the planting points on the preceding afternoon and distributed over fifty rows. As the rate of carrying seedlings to planting points is about 500 per h, this system enables the carrying gangs to be 2 h ahead of the planting teams, and it also facilitates the organisation of planting (see Section 6.2.5). The rate of delivery from the nursery would be 3600 per day.

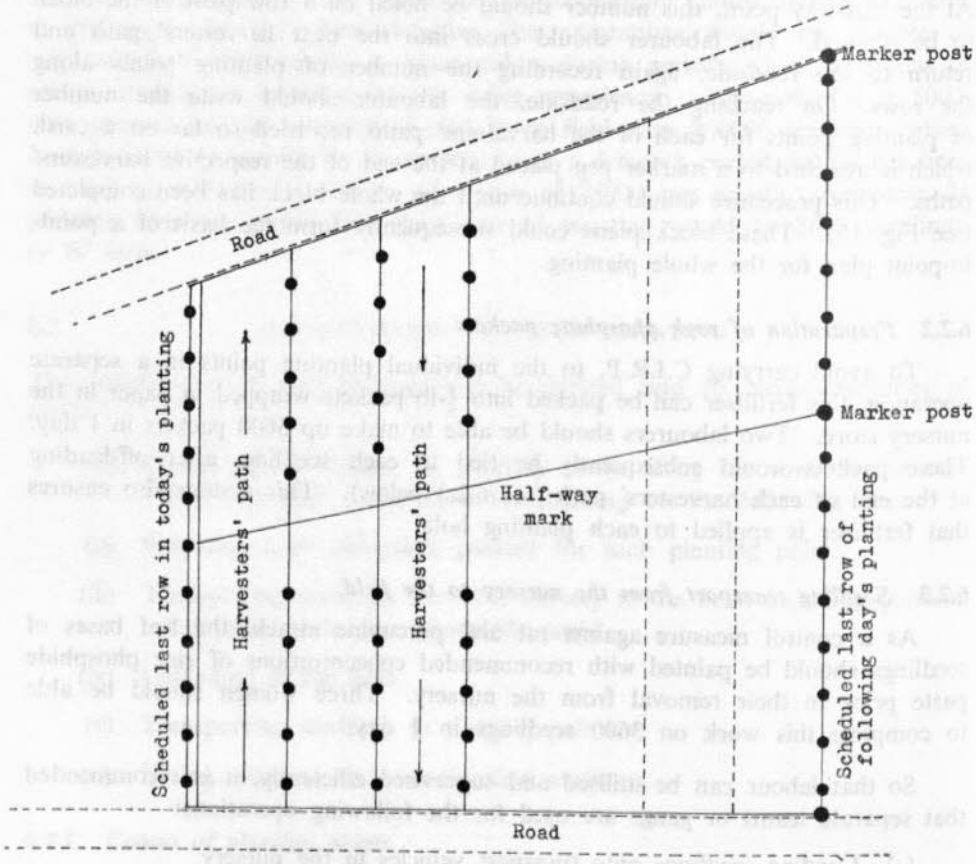


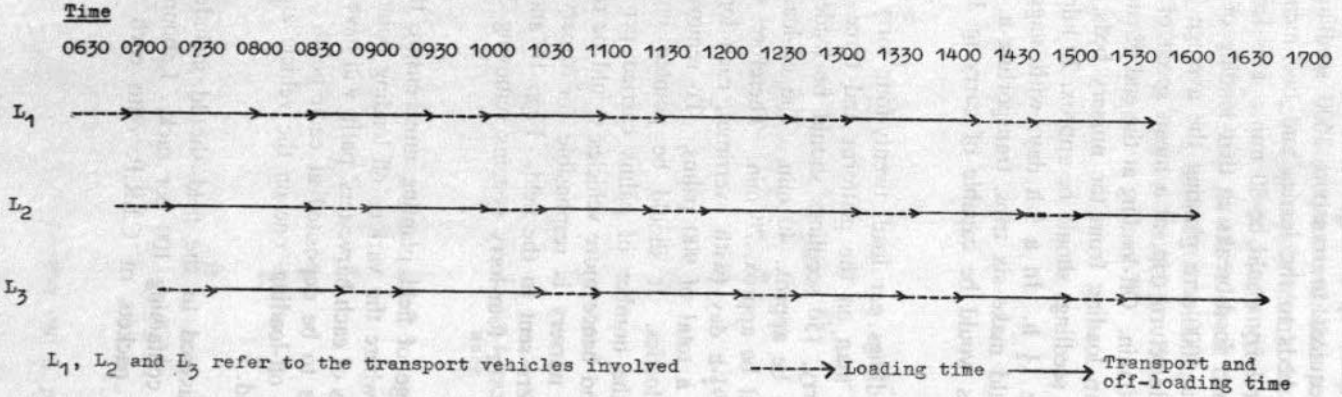
Fig. 15. Method of carrying out a planting point census

Using long-platform lorries with drop sides, carrying 200 seedlings per load, eighteen lorry loads would be required to transport 3600 seedlings in a day. With six men carrying from the beds to the lorries and two men stacking on the platform, the loading time per lorry would be 30 min. This leaves sufficient time for labourers to take staggered food-breaks so that loading of all lorries is continuous. Assuming that, on a 5000-acre planting the average journey from the nursery to the field is a 5-mile return trip, at a mean speed of 8 m.p.h. the travelling time would be approx. 40 min. Off-loading at the end of each harvesters' path would tend to be faster than loading from the nursery beds, and the off-loading time for each load of 200 seedlings should be approx. 20 min. Therefore, the total time per trip would be 1½ h. In a 9-h day, with staggered starting times for drivers, each lorry would make six trips, transporting a total of 1200 seedlings, and hence three lorries would be capable of carrying 3600 seedlings to the field.

If lorries can carry 150 seedlings per load, twenty-four lorry loads would be required per day. With one man on the platform and three men carrying from the nursery beds to the lorry, 150 seedlings should be loaded in 30 min. Again, the travelling time would be approx. 40 min. The off-loading time for each load of 150 seedlings should be approx. 20 min. Therefore, the total time per trip would be 1½ h. In a 9½-h day (with overtime), each lorry should be able to make six trips, carrying a total of 900 palms. To remove 3600 palms would, therefore, require four lorries. It should be pointed out that where tractor-trailers are being used, the number of palms carried per trip and the rate of delivery would be less, and hence more vehicles would be required. The *mandore* in charge of he main nursery is responsible for supervising seedling loading and recording the numbers sent to the field. Figs. 16 and 17 illustrate suitable time schedules for three- or four-lorry systems removing 3600 seedlings per day.

The Field Assistant in charge of field planting must ensure that drivers of transport vehicles know exactly where the various off-loading points are located. The off-loading points, at the ends of each harvesters' path, will have been marked, showing the number of seedlings to be deposited at each point. Two or three labourers would be required for off-loading, one on the vehicle and one or two stacking seedlings on the ground.

Each load of seedlings delivered to the field should include 200 packets of C.I.R.P., in two sacks each containing 100 per sack. Labourers should be responsible for tying the ½ lb packets of C.I.R.P. onto each seedling after off-loading.

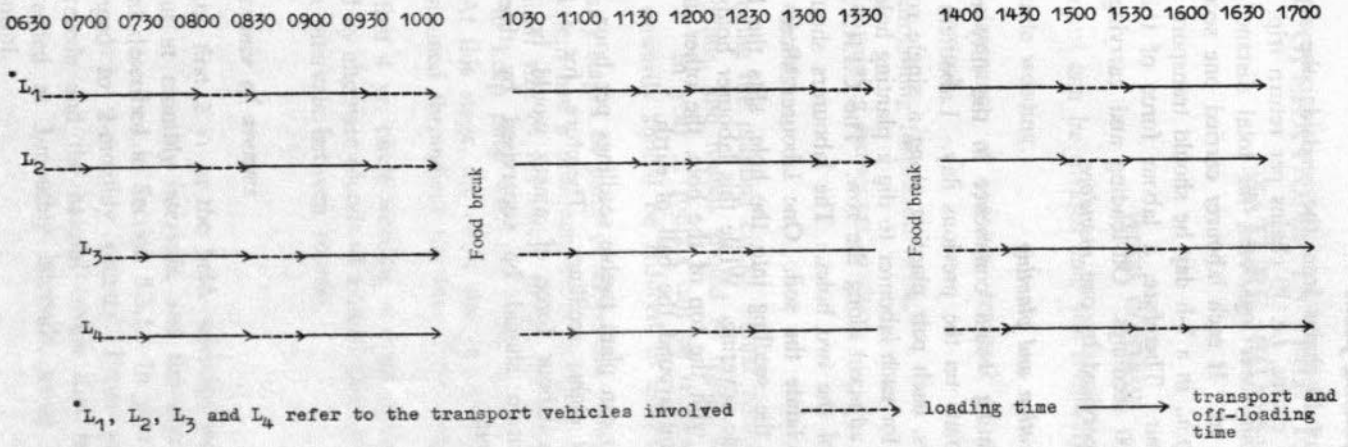


Notes:—Loading team: This would consist of eight labourers—six labourers carrying from nursery bed to the vehicle and two labourers arranging seedlings on the platform

Seedlings per trip: 200

Time per round trip (including loading and off-loading): 1½ h

Fig. 16. Time schedule for transport loading and despatch from the main nursery using three vehicles



Notes:—Loading teams: There would be two teams each consisting of three labourers carrying from nursery bed to the vehicle and one labourer arranging seedlings on the platform (total eight labourers)

Seedlings per trip: 150

Time per round trip (including loading and off-loading): 1½ h

Fig. 17. Time schedule for transport loading and despatch from the main nursery using four vehicles

6.2.4 *Carrying seedlings to planting points*

With a maximum carry of 10 chains from the roadside, the average distance of seedling carry would be 5 chains, *i.e.* 10 chains per return trip. Allowing an additional 10–15% for climbing over logs, *etc.*, the total distance per trip can be estimated at approx. 250 yd. If each labourer carried one seedling per trip at an average speed of 2 m.p.h., in a 7-h day he should transport 100 seedlings, or fourteen seedlings per hour. Therefore, a labour force of thirty-six would be required to transport 3600 seedlings. Off-loading and carrying seedlings to planting points should be supervised by one *mandore*.

6.2.5 *Holing, fertiliser application and planting*

On any given day, planting would commence in the fifty rows supplied with seedlings at planting points on the previous day. Labourers employed in planting should work in pairs, each pair planting along a single row at a time. The first operation would be for each labourer to dig a planting hole, 18 in. x 18 in. x 15 in., the holes being adjacent along the row. The C.I.R.P. should then be spread over the bottom of the two holes. The labourers should then team up to plant, refill and consolidate the soil. One labourer slices and removes the bottom of the bag, lifts the seedling into the hole, slits the bag vertically and throws away the polythene covering. While this labourer holds the seedling upright, with the collar level with the top of the hole, the other labourer refills the hole, consolidating the soil around the ball of earth.

Assuming that each team can plant twelve seedlings per hour, in a 7-h day they should be able to plant eighty seedlings. Therefore, for a planting programme of 3600 per day, a labour force of ninety would be required, *i.e.* forty-five teams. This operation should be supervised by three *mandores*, responsible to a Field Assistant.

CHAPTER 7

FIELD OPERATIONS IN THE IMMATURE AND MATURE PHASES

7.1 WEED CONTROL

Weed control can be divided into the following work categories:

(a) Circle weeding.

(b) Maintenance of avenues, removal of noxious growths and *lallang* control.

(c) Maintaining inspection paths.

(d) Maintaining harvesters' paths.

7.1.1 *Circle weeding*

Clean-weeding the planting circles should commence about one month after planting the palms, and rounds should be repeated at monthly intervals during years 1 and 2. In year 3, rounds can be reduced to alternate monthly, and from year 4 onwards should be reduced to quarterly intervals.

In the early stages of palm development, it is important to ensure that the young root system has a minimum of competition from the surrounding vegetation. The initial size of the circle should be 6–8 ft diam. and the size should be increased to keep pace with the frond spread, until the commencement of harvesting. At this stage, the circle size should be 10–12 ft diam. and this size must be maintained throughout the life of the palm.

For the first 4 yr, circle weeding is done manually. Thereafter, circles can be maintained by alternate rounds of manual clean-weeding and herbicide spraying, with 3-month intervals between rounds.

7.1.2 *Maintenance of avenues*

During the first 2 yr in the field, selective weeding of the avenues should be carried out at monthly intervals, and the organisation of this operation is similar to that described in Section 5.3.1. In year 3, the frequency of weeding can be changed to 2-monthly rounds. From year 4 onwards, the legume covers will recede and the natural covers that become established should be selectively weeded at 3-monthly intervals, using manual and, where feasible, herbicidal control.

7.1.3 *Maintaining inspection and harvesters' paths*

Inspection path maintenance will be carried out by avenue weeders during the first 3 yr after planting and can be organised as described under Section 5.3.1. Just prior to commencement of assisted pollination ($2\frac{1}{2}$–3 yr from planting, depending on growth and soil type), harvesters' paths should be opened up by manual clean-weeding. These paths should be weeded at 2-monthly intervals for the first 6 months and subsequently maintained at 2-monthly intervals during the normal avenue weeding rounds in year 3. After 4 yr from planting, when fronds are well clear of the ground, paths can be maintained at 3-monthly intervals using alternate rounds of manual slashing and herbicides.

7.1.4 *Organisation and labour requirements for weeding*

The demarcated weeding blocks (200 acres) referred to in Section ~~5.3.1~~ 5.3.2. will continue to be the basis for planning weeding operations. On a 5000-acre planting, where weeding rounds are carried out at monthly intervals, the acreage to be completed per working day would be 200 acres. If weeding rounds are on an alternate-monthly basis, the acreage to be covered per day would drop to 100 acres. At quarterly intervals, the daily area completed is reduced to 67 acres. All these acreages assume 25 effective working days per month.

In Tables 9, 10, 11 and 12 examples are given of the frequency of weeding operations and man-day requirements at different ages.

7.1.5 *Organising the labour force in the field*

After planting, the weeding operations become more specific than in the pre-planting period, and tasks can be allocated in relation to the four main categories of work. In the interests of specialisation, it is desirable that workers be engaged on the same operation throughout the day. Providing this can be achieved without any significant increase in walking time, the aim should be to divide the labour force into specific work categories. If a labourer was engaged on circle weeding only, the walking distance between circles, when weeding sixty palms along a row, could be estimated at approx. 59 x (29–8) = 1239 ft, or just over 400 yd. At an average walking speed of 2 m.p.h., this represents about 7 min walking between circles over the whole day. Such a time factor is of no significance and cannot therefore be used as an argument to justify combination of circle and avenue weeding into a single labourer's task.

It would appear, therefore, to be advantageous to have a division of function relating to the weeding operations. This means that the weeding labour force would be divided into:

(a) Circle weeders: clean-weeding around palms.

(b) Avenue weeders: selective weeding in avenues.

(c) Inspection and harvesters' path weeders: clean-weeding and spraying along paths.

As the two major operations are circle and avenue weeding, at any given age of planting, the distribution of tasks between these operations should be geared to their man-day requirements. For example, in year 1 the bulk of the labour force should be distributed evenly between circle and avenue weeding, whereas in year 3 the ratio of circle to avenue weeders would be 13: 10 (see Table 12).

TABLE 9

Frequency of weeding operations at different ages

Type of operation	*Yr*				
	1	*2*	*3*	*4*	*5+*
Circle	monthly	monthly	2-monthly	3-monthly	3-monthly
Avenue	monthly	monthly	2-monthly	3-monthly	3-monthly
Inspection path	monthly	monthly	2-monthly	—	—
Harvesters' path					
(a) opening	—	—	1 round	—	—
(b) maintenance	—	—	2-monthly	3-monthly	3-monthly

Notes on Tables 9–12

(1) *Circle weeding*

(a) It is assumed that in year 2, although circles are increasing in size, the increasing shade compensates with respect to the amount of weed growth and hence the labour input per acre per round is unchanged.

(b) In year 3, the effect of increased shading reduces weed growth and the intervals between weeding rounds can therefore be increased. However, because of the increase in frond length and circle size, access for clean weeding becomes more difficult. It is reasonable therefore to assume that the net effect is an increase in labour input *per round.*

(c) From year 4 onwards, access becomes easier as a result of a combination of pruning the lower fronds and the increasing height of the palm.

(d) In year 5, weeding rounds are carried out alternately by manual and herbicidal means. In the herbicide treatment, it is assumed that the labour required is one man per 6–7 acres.

(2) *Avenue weeding*

(a) It is assumed that in year 2, as covers become fully established, the labour requirement for selective weeding will be less than in year 1.

(b) In year 3, the increasing effect of shade will reduce the amount of weed growth and hence the frequency of rounds. However, the labour input per round has to be increased, but not in direct proportion to the reduction in frequency.

(c) From year 4 onwards, legumes are receding and it is no longer necessary to weed out grasses. For these reasons, it is feasible to increase the interval between rounds and at the same time the area covered by one labourer can be increased.

TABLE 10

Labour inputs for weeding at different ages in man-days per acre per round of weeding†

Type of operation	*Yr* 1 Manual	2 Manual	3 Manual	4 Manual	5+ Manual	5+ Herbicide
Circle	1.0	1.0	1.3	1.0	1.0	0.15
Avenue*	1.0	0.8	1.0	0.8	0.8	—
Inspection path	0.17	0.17	0.17	—	—	—
Harvesters' path						
(a) opening	—	—	1.0‡	—	—	—
(b) maintenance	—	—	0.7	0.7	0.6	0.1

* includes *lallang* wiping

‡ over 2 months just prior to commencement of assisted pollination

† See also footnotes—Table 9

TABLE 11

Man-day requirements per acre per annum for weeding†

Type of operation	*Yr* 1 Manual	2 Manual	3 Manual	4 Manual	5+ Manual	5+ Herbicide
Circle	12.0	12.0	7.8	4.0	2.0	0.3
Avenue*	12.0	9.6	6.0	3.2	3.2	—
Inspection path	2.0	2.0	1.0	—	—	—
Harvesters' path						
(a) opening	—	—	1.0	—	—	—
(b) maintenance	—	—	2.1‡	2.8	1.2	0.2
Total	*26.0*	*23.6*	*17.9*	*10.0*	*6.4*	*0.5*

* includes *lallang* wiping

‡ three rounds at intervals of 2 months

† See also footnotes—Table 9

Labourers should be given tasks, *e.g.* in year 1 circle weeders would cover sixty palms per day, but they would work in teams of two, at 120 palms per team. Similarly, the avenue weeders would work in teams of two and be responsible for 2 acres per team at this stage of planting.

By concentrating the labour force in this way, with each row and avenue involving four labourers, supervision should be more effective. With one *mandore* supervising about thirty labourers, his weeding gang, at any given time, would be spread over seven avenues, or about 175 ft. By gearing the distribution of the labour force to the rate at which the two main weeding operations proceed, the work should progress along the avenues at a fairly uniform rate, this again facilitating control. At the end of each day, the Field Assistant responsible for the weeding programme should mark off the progress for that day on his field plan, as described in Section ~~3.3.1~~ 5.3.2.

To summarise, for any given situation the main factors to be assessed when formulating the weeding programme for an area would be as follows:

(a) The frequency of rounds at different stages of growth (Table 9).

(b) The productivity per unit of labour at different stages of growth (Table 10).

(c) The total annual labour input per acre (Table 11).

(d) The daily labour force required to complete weeding operations (Table 12).

In a planting where palms of different ages occur, the determination of weeding programmes, and hence labour requirements, has to be made separately for each age of planting. These separate programmes can then be combined to formulate the overall weeding programme.

TABLE 12

Daily labour requirements for a 5000-acre planting†

Type of operation	*Yr* 1 *Manual*	2 *Manual*	3 *Manual*	4 *Manual*	5+ *Manual*	*Herbicide*
Circle	200	200	130	67	67	10
Avenue*	200	160	100	54	54	—
Inspection path	34	34	17	—	—	—
Harvesters' path						
(a) opening	—	—	100*	—	—	—
(b) maintenance	—	—	70‡	47	40	7
Total	*434*	*394*	*247*	*168*	*161*	*17*

* 100 labourers over 2 months, just prior to commencement of assisted pollination

‡ seventy labourers for three rounds of maintenance in the second half of the year

† See also footnotes—Table 9

In year 1, a single application of rock phosphate should be applied to the covers at rates of 240 lb (three bags) per acre. As the covers were established over a 3-month period, the application of fertiliser should also be made over a similar period, but avoiding the season of heavy rains.

The daily area to be covered would be 75 acres (see Section 5.3.4) and the labour requirements will vary with the quantity of fertiliser being applied and the density of the cover to be walked through. The basic approach to organising the operation is as described in Section 5.3.4, with adjustments made to allow for varying rates of application and the condition of the covers.

In year 1, each labourer should be able to broadcast fertiliser over 2 acres of covers in 1 day, and the total labour requirement for this operation would be thirty-six men working simultaneously along eighteen avenues. The distribution of supply points would be as in Fig. 14, but with a 50% increase in the number of bags at each point. The labour requirements for loading, unloading and carrying in to supply points can be estimated at six men per day.

In year 2, the rate of rock phosphate application is reduced to 80 lb (1 bag) per acre, and at this stage of growth the rate at which labourers can broadcast fertiliser would not be significantly less than year 1. However, the distance between supply points could be doubled to 200 yd and the total number of bags reduced by 50%. The labour requirement for establishing supply points would also be reduced in direct proportion to the quantities being applied.

Table 13 contains a summary of the labour and supervision requirements for completing the cover fertiliser programmes for 5000 acres during the first 3 yr.

TABLE 13

*Daily labour requirement for manuring covers**

	Yr		
	Establishment	*1*	*2*
Rate per acre (lb)	160	240	80
Establishing supply points	5	6	2
Application	24	36	36
Total	*29*	*42*	*38*
Supervision (*mandores*)	1	2	1

* completed over a 3-month period at 75 acres per day

7.3.1 *Method of application*

Placement of fertiliser varies according to the age of the palms. With palms that are less than $2\frac{1}{2}$ yr in the field, the fertiliser should be spread thinly, to avoid root scorching, over the whole of the weeded circle, but avoiding the portion that is within a few inches of the palm collar. Fertiliser should be applied to young palms immediately after a weeding round. With older palms, where roots have spread beyond the weeded circles, fertiliser should be applied in the zone between the edge of the weeded circle and the extremities of the fronds. In Malaysia, the general practice followed is two applications per year in the first 2 yr and annual rounds thereafter.

7.3.2 *Timing of application*

In the first year after planting, fertilisers should be applied at approx. 3 months and again at 6 months after field planting. To complete each application over a period of 3 months (75 working days) the acreage to be covered per day would be equivalent to $\frac{\text{total acreage.}}{75}$ For example, for a 5000-acre planting, the acreage completed per day for a single application would be 67 acres.

In the second and subsequent years, the timing of fertiliser application should be related to the time of sampling for leaf analysis. It is assumed that:

(i) The time required to complete sampling, analysis, ordering and delivery of fertiliser is 3 months.

(ii) It is desirable to have a 6-month interval between completion of fertiliser application and the next leaf analysis.

(iii) Fertilisers are not applied during the heaviest rainfall months (this is usually a period of 2 consecutive months).

Leaf sampling should not be carried out during the period commencing 6 months prior to the onset of the wet season and ending 3 months before the wet season finishes. It is considered desirable, for comparative purposes, to complete the leaf sampling for any given planting within as short a period as possible, and preferably at the same time each year.

In Fig. 18, it has been assumed that the heaviest rainfall months are November and December and hence leaf sampling would not be carried out during the period May-September inclusive.

Given the situation outlined above, in order to leave 6 clear months between the completion of fertiliser application and the next leaf sampling, fertiliser application must be completed within a 3-month period. A schedule giving the

timing of fertiliser application in relation to different months of leaf sampling is shown in Table 14.

For any planting, if the fertiliser application programme has to be completed in 75 working days (3 months) the minimum acreage covered per day will depend upon the number of separate applications being made. For example, on a 5000-acre planting, if fertiliser is being applied in a single dose, then the minimum acreage to be covered per day would be $\frac{5000}{75} = 67$ acres. Allowing 10% for bad weather conditions, the acreage covered per day should be 75. On the other hand, if two separate applications are required, the minimum acreage covered per day, to complete the programme within 3 months, would be 150 acres.

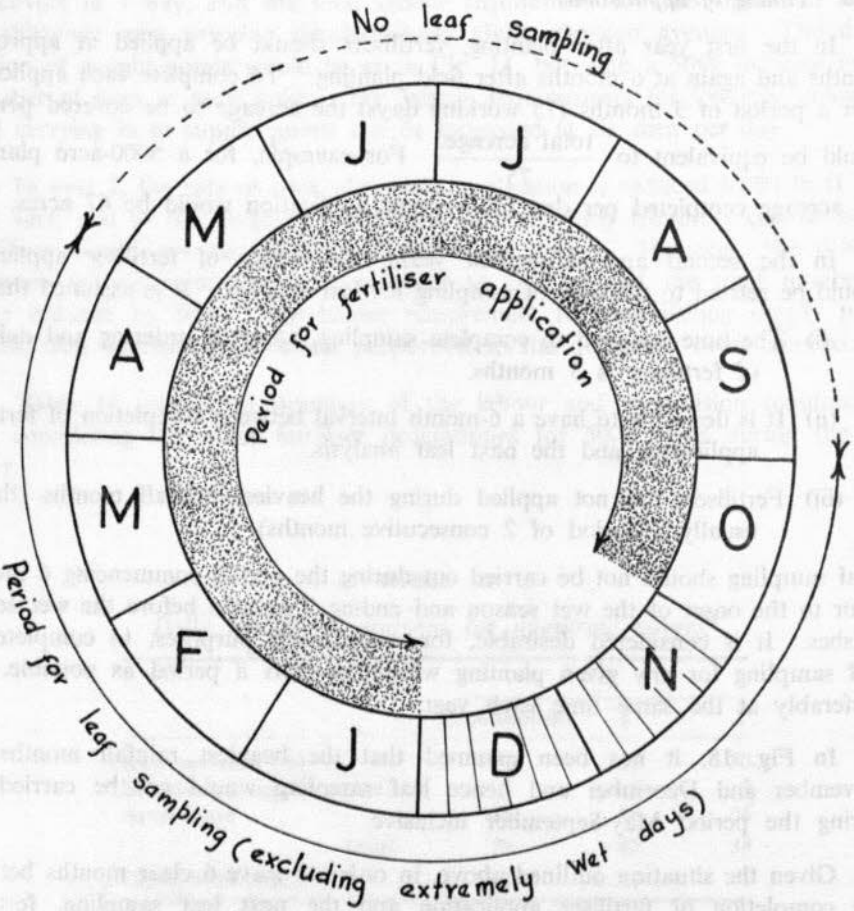


Fig. 18. Timing of leaf sampling and fertiliser application

TABLE 14

Schedule of leaf sampling/fertiliser application

Month of sampling	*Commencement of fertiliser application*	*Completion of fertiliser application*
October	January — February	March — April
November	February — March	April — May
December	March — April	May — June
January	April — May	June — July
February	May — June	July — August
March	June — July	August — September
April	July — August	September — October

The formula for calculating the number of acres to be completed per day is as follows:

$$\frac{\text{Total acreage x no of separate applications}}{\text{No of working days in 3 months}} = \text{Acreage completed per day}$$

Table 15 shows the acreage to be completed per working day for different-sized plantings receiving up to four separate applications.

TABLE 15

*Acreage of fertiliser application to be completed per working day**

no of applications	*Total acreage to be fertilised*		
	5000	*3000*	*1000*
1	75	45	15
2	150	90	30
3	225	135	45
4	300	180	60

* Allowing 75 working days in the 3-month period and adding 10% for adverse weather conditions.

7.3.3 *Organisation and labour requirements*

The main work items to be considered when organising fertiliser application are:

(i) Loading, transport to the field, unloading and carrying to the supply points. These supply points should be established ahead of the arrival of the spreading gang.

(ii) Spreading fertiliser. The distance between supply points will depend upon the rate of application per palm. Table 16 shows the theoretical distance between supply points along alternate harvesters' paths (each supply point catering for four rows).

Because it is difficult to measure fractional distances, the figures shown in Table 16 can only be taken as guides to the distribution of supply points, when operating over four rows from each supply point. It should be pointed out that minor shortages and/or surpluses may occur and the necessary adjustments must be made by the Field Assistant or *mandore* in charge. As the rates of application reach the level of 8–9 lb per palm, supply points should be located along every harvesters' path at the appropriate distances.

For a fertiliser programme covering 75 acres at an application rate of 3 lb per palm, five labourers working for 7 h should be able to complete the loading, unloading and carrying in to supply points. When estimating the labour requirements for other rates of application, it is reasonable to assume that labour requirements would tend to increase or decrease in proportion.

When spreading fertilisers, it is important to ensure that the correct quantities are applied to each palm. This can be facilitated by having graduated buckets as fertiliser containers and by using 1 lb scoops for spreading. Labourers should

TABLE 16

Theoretical distance between supply points

Rate of application (lb per palm)	*No of palms per bag (112 lb)*	*Distance between supply points**
1	112.0	28.0
2	56.0	14.0
3	37.3	9.3
4	28.0	7.0
6	18.7	4.7
7	16.0	4.0
8	14.0	3.5 (7.0)**
9	12.4	3.1 (6.2)
10	11.2	2.8 (5.6)
11	10.0	2.5 (5.0)
12	9.3	2.3 (4.6)
14	8.0	2.0 (4.0)
16	7.0	1.75 (3.5)

* Distance measured in number of palms along the supply avenue when catering for four rows.

** Distance between supply points when located along every harvesters' path when catering for two rows.

be instructed to distribute the fertiliser equally over the four quadrants of the palm circle, applying the appropriate number of scoops per palm. For example, if the rate of application is 4 lb per palm, one scoop should be applied over each quadrant and in the appropriate zone. Table 17 gives some basic guides to the labour required for spreading fertilisers at different rates under varying operating conditions.

TABLE 17

Estimated daily labour requirements for spreading fertiliser at different rates

Rate per application (lb per palm)	*Palms per man-day**	*Acreage per man-day*	*Total labour for 75 acres*
2	210 — 270	3½— 4½	17 — 22
4	180 — 240	3 — 4	19 — 25
6	180 — 240	3 — 4	19 — 25
8	210 — 270	3½— 4½	17 — 22
10	210 — 270	3½— 4½	17 — 22
14	180 — 240	3 — 4	19 — 25
16	180 — 240	3 — 4	19 — 25

* Makes allowance for the stage of growth and hence for ease of application. It is assumed that the higher rates (above 6 lb) are applied to mature palms when access has become easier.

7.3.4 *Leaf sampling for nutrient analysis*

This operation should be carried out by special gangs and details of the procedures currently used in Malaysia, together with labour and staff requirements are dealt with in pp. 72–76 of 'Planting Techniques for Oil Palms in Malaysia'.

7.4 CASTRATION

7.4.1 *Timing and method*

Castration comprises the removal of young male and female inflorescences and bunches; this is normally carried out by monthly rounds, commencing about 14 months after field planting, and continuing until about the 26th month. Harvesting would, therefore, begin at just over 2½ yr from field planting.

In the first 3–4 months, there are comparatively few inflorescences and at this stage they can be readily removed by hand (gloved). In the later stages, both the numbers and size of inflorescences increase and removal by cutting with

a narrow chisel is necessary. Care should be taken not to damage fronds, and all inflorescences and bunches should be carried in light baskets or sacks to clearly-marked disposal points for subsequent spraying as a precaution against *Tirathaba* breeding.

Castration does not involve heavy manual labour and can easily be done by youths or the female labour force.

7.4.2 *Organisation and labour requirements*

In order to concentrate the labour force and facilitate supervision, it is advisable to allocate a row per labourer. Having demarcated the area to be covered in any given day, the end point for any row will be known. Inflorescence disposal points should be either at the roadside or at the mid-point of the avenues, and the Field Assistant in charge should ensure that the mid-points have been marked prior to commencing castration.

The labour force required to complete the rounds will vary with the stage of growth and the acreage to be covered. In the early months of castration (first 3–4 months) a labourer should be able to cover 5 acres in a day. Five months after castration has commenced, the rate of coverage declines, reaching 3 acres per day at the 26th-month stage. The spraying of disposal points would require an additional one or two labourers, depending on the size of the area being covered. Table 18 gives the estimated labour requirements for different acreages at varying stages of growth.

TABLE 18

*Daily labour requirements for castration by monthly rounds**

Months from field planting	*Acreage to be covered per month*					
	5000 acres		*3000 acres*		*1000 acres*	
	Acreage per day	*Labourers per day*	*Acreage per day*	*Labourers per day*	*Acreage per day*	*Labourers per day*
14 — 18	200	40	120	24	40	8
19 — 22	200	50	120	30	40	10
23 — 26	200	67	120	40	40	14

* Excluding labour for spraying disposal points.

(Yong Photo Studio)

Plate 3 A. An immature palm one month after the previous castration round.

(Yong Photo Studio)

Plate 3 B. The same palm after castration. Note the narrow chisel used to avoid frond damage.

7.5.1 *Method of assisted pollination*

Assisted pollination is normally carried out from the age of 2½–3 yr until 7–8 yr after planting. During this period, regular pollen applications are made at 3–4 day intervals.

Collection of pollen. On an established planting, pollen should be collected from those areas that have an abundant supply of male inflorescences. The ripe male inflorescences are wrapped in a paper cover, cut and shaken to release the pollen, which is subsequently sieved and dried in a drying box at 100°F for 24 h.

The cost of pollen collection is largely composed of the labour involved in finding and cutting male inflorescences. In the early years, the production of male inflorescences tends to be low and, therefore, more time has to be spent in locating ripe male inflorescences. Table 19 provides a general guide to the labour required for collecting pollen from plantings of different ages.

In order to determine the number of labourers required for pollen collection, with pollen stocks to be maintained at adequate levels, the daily pollen requirements for any given acreage being artificially pollinated have to be assessed. The rate at which pollen is applied per acre does not vary for palms between 2½ and 8 yr of age; however, the labour required for collecting a given quantity of pollen does vary according to the age of the palms supplying the pollen (see Table 19). Table 20 indicates the labour force needed for pollen collection at different stages of growth and for varying daily pollen requirements.

In order to build up adequate pollen stocks, collection should commence at least 2 weeks ahead of the date when assisted pollination is due to start. In

TABLE 19

Quantity of pollen collected per man-day at different palm ages

	Palm age (yr)		
	2½–3	4–5	6+
Number of male inflorescences collected per man-day	20	25	30
Acreage covered per man-day	20	20	15
Quantity of dry pollen per inflorescence (g)	6.0	9.0	24.0
Quantity of dry pollen per man-day (g)	120.0	225.0	720.0
(oz)	4.2	8.0	25.0

TABLE 20

Labour requirements for pollen collection

		Daily acreage pollinated		
		1700	*1000*	*500*
Quantity of dry pollen required at 2 g per acre. (g)		3400	2000	1000
(oz)		121	72	36
Labour requirements for pollen collection at different palm ages	*Yr*			
	2½–3	29	17	9
	4 –5	15	9	5
	6+	5	3	2

areas that are subject to heavy monsoon rains, a reserve sufficient for 2 months pollination must be built up prior to the onset of the rains, since there may be no collection during the monsoon. This will clearly involve additional labour being temporarily engaged on pollen collection.

When drawing up a programme for the rotation of male inflorescence collection within the mature areas of a planting, the following conversion factors can be used as a guide:

(i) In 2½–3 yr palms, a labourer would have to cover approx. 20 acres to collect twenty ripe inflorescences.

(ii) In 4–5 yr palms, a labourer would cover approx. 20 acres in collecting twenty-five inflorescences.

(iii) At the 6-yr stage and over, thirty inflorescences could be collected from 15 acres.

Drying pollen. In 24 h, 6 lb of pollen can be suitably dried for storing in drying boxes of 25 cu ft dimension. These boxes cost approx. $250 each. For a 5000-acre planting in which 1700 acres are being pollinated each day, the daily pollen requirement would be approx. 8 lb, and therefore two drying boxes would be required to keep pace with this rate of consumption. As pointed out above, for heavy monsoon areas, 2-months pollen stocks should be in reserve and it would be advisable to have an additional drying box (total of three boxes) for a 5000-acre planting.

Application of pollen. When organising a round of assisted pollination, the basic steps involved can be outlined as follows:

(i) Calculation of pollen and talc requirements for the acreage to be covered that day. At 2 g pollen per acre and a dilution ratio of 1 part pollen: 5 parts talc, when covering 1700 acres per day, the quantities requiring mixing would be:

Pollen = 121 oz (8 lb approx.)
Talc = 605 oz (40 lb approx.)

(ii) Mixing in eight batches consisting of 1 lb pollen to 5 lb talc, so as to ensure thorough dispersion of pollen.

(iii) Determining the quantity of mixture to be issued to each labourer, according to the acreage that each labourer is expected to cover that day. This will vary according to the age of the palms (see Table 21).

(iv) Weigh out the correct quantity for each plastic bottle and issue to the labour force. As the quantity applied does not vary with the age of the palms, the quantities issued to each labourer will vary directly according to the daily acreage being covered by each labourer. The acreage covered per labourer varies with the age of the palms and the equipment being used.

At the 2½–3 yr stage, labourers are expected to cover 12 acres per day when removing sheaths from the female inflorescences and using the hand puffer. The quantity of pollen mixture per labourer would therefore be 12 x 12 g = 144 g (24 g pollen + 120 g talc) = 5 oz mixture.

At the 4–5 yr stage, there is no need to remove the sheath, but pollen is still applied by the hand puffer. Each labourer should cover 18 acres per day (see Table 21 below) and would therefore require 216 g mixture (8 oz approx.).

During the 6–8 yr stage, pollen is applied using the long lance puffer and each labourer can be expected to cover about 25 acres per day. The quantity of mixture required for a day's work is therefore 300 g (11 oz approx.).

(v) Pollinators usually operate in groups of fifteen under the supervision of one *mandore:* each labourer should follow one row of palms at a time. All receptive inflorescences should be pollinated and the *mandore* must make continual checks that this is being done.

The labour requirements for pollen application vary considerably at different stages of palm growth and estimates of labour requirements are given in Table 21 for different-sized plantings.

TABLE 21

Estimated daily labour requirements for pollen application at a rate of 8–9 rounds per month

Age of palms (yr)	Acreage being pollinated								
	5000			3000			1500		
	Acres per day	Acres per labourer	Labourers per day	Acres per day	Acres per labourer	Labourers per day	Acres per day	Acres per labourer	Labourers per day
2½ – 3	1700	12	142	1000	12	84	500	12	42
4 – 5	1700	18	95	1000	18	55	500	18	28
6 – 8	1700	25	68	1000	25	40	500	25	20

It should be pointed out that, where a round of assisted pollination is missed as a result of rain, the scope for making up the programme is limited in that female inflorescences are only receptive for 3 days. This means that the labour force required for this operation remains comparatively stable during the year. In the long term, however, the labour force required for this operation will decline until assisted pollination ceases altogether.

7.6 PRUNING PALMS

7.6.1 *Timing and method*

It is desirable to retain as many active fronds on the palm as possible; however, to provide access for fruit cutting and collection, it eventually becomes necessary to carry out frond pruning. Frond pruning is carried out in two basic situations:

(a) *Initial pruning of young palms.* To avoid retarding the development of the young palm, it is advisable not to carry out any major frond pruning until the lowest ripe bunch is situated approx. 2 ft above ground level. The first systematic round of frond pruning, using a long-handled chisel, should be done at this stage, taking care that the two whorls of fronds immediately below the lowest ripe bunch are not pruned.

(b) *Annual pruning of mature palms.* After 4 yr, some pruning occurs during normal harvesting rounds where it is necessary to facilitate access to and cutting of the fruit bunches; wherever possible, however, two whorls of fronds should be left beneath the lowest ripe bunch. An annual pruning round should be carried out to remove excess fronds which may have accumulated during male phases and/or resting periods. As pruning is done by harvesters, the most appropriate time for this operation is during the low cropping periods.

The pruning operation, whether initial or annual, consists essentially of the following:

(i) Selection of those palms that have *excess* fronds below the lowest ripe bunch.

(ii) Cutting and removal of such fronds.

(iii) Stacking the fronds neatly in the interrow in such a way as to leave free access along the harvesters' paths.

(iv) Removal of debris from the frond bases and the palm circle.

Up to the time when fruit bunches are being produced at a height of 9–10 ft above ground level, pruning is carried out using a long-handled chisel. After

TABLE 22

*Estimated labour requirements for pruning**

Stage of growth (yr)	*Palms per man-day*	*Total acreage to be pruned*								
		5000			*3000*			*1500*		
		Acres per day	*Palms per day*	*Total Labourers*	*Acres per day*	*Palms per day*	*Total Labourers*	*Acres per day*	*Palms per day*	*Total Labourers*
3–4 (Initial pruning)	30–35	50	3000	86–100	30	1800	52–60	15	900	26–30
5–8	35–40	50	3000	75–86	30	1800	45–52	15	900	23–26
9–16	25–30	50	3000	100–120	30	1800	60–72	15	900	30–36
17 onwards	20–25	50	3000	120–150	30	1800	72–90	15	900	36–45

* To be completed over a 4-month period (100 working days) and at a planting density of sixty palms per acre.

(Yong Photo Studio)

Plate 4. A palm after pruning, leaving two fronds below the lowest ripe bunch.

CHAPTER 8

HARVESTING

8.1 OBJECTIVES OF HARVESTING

The objective of any harvesting system should be the attainment of the maximum quantity of high-quality palm oil through the most efficient utilisation of labour and equipment.

As fruits attain full ripeness, the oil content of the mesocarp increases rapidly as a result of the conversion of carbohydrates into fats. When the oil content in a fruit has reached maximum, the fruit becomes loose in the bunch and some of these loose fruits fall to the ground. As the fruit ripens, its colour changes from deep purple to reddish-orange.

As palm age increases, the number of bunches produced over any given period declines but the size of the bunches increases. The proportion of fertile fruit to bunch weight, before sterilisation at the factory, is approx. 60%. However, where pollination has been inadequate, the proportion of fruit to total bunch weight may be considerably lower and this will obviously affect the output per harvester.

To be readily acceptable on world markets, palm oil must have a very low content of impurities, moisture and free fatty acid (f.f.a.). The current international market standard stipulates that the f.f.a. content should not be higher than 5% at point of delivery to the manufacturer. For each 0.1% that the f.f.a. is below 5%, buyers usually offer a premium amounting to 0.1% of the purchase price prevailing for the 5% level. Bleachability is becoming an increasingly important quality factor and this will very probably be a factor for inclusion in grade determination in the future. Low contents of impurities and moisture depend upon efficient collection and subsequent processing in the factory. Bleachability is influenced by both good harvesting and processing standards. The f.f.a. content is largely determined by the efficiency with which operations are carried out from the bunch cutting stage through to bulk storage and subsequent shipment. Correct selection of ripe bunches, careful handling and speedy transportation to the factory, rapid processing under clean factory conditions and storage in clean bulking tanks are essential for the production of high-quality oil.

As already pointed out, the oil content of fruit is a function of its degree of ripeness. However, the fruits on any given bunch do not ripen simultaneously

and the time lag between the ripening (loosening) of the first fruit on a bunch and the last fruit may be as long as 16–20 days. When fruit loosens and falls to the ground, the f.f.a. content of the mesocarp oil begins to rise rapidly. As it is necessary to keep the f.f.a. content low, and since the process of fruit ripening on any given bunch is relatively slow, when harvesting a bunch a compromise has to be reached between maximum oil content and f.f.a. To achieve this, any bunch at harvesting will consist of a mixture of over-ripe, ripe and under-ripe fruits. Similarly, there will be a variation in the degree of ripeness between bunches harvested at any one time.

There is little experimental evidence on which to base an exact criterion of ripeness, but the indications are that a bunch is at its optimum stage of ripeness when there is one loose fruit on the ground per pound of bunch weight, *e.g.* for a 40-lb bunch, there should be forty loose fruits on the ground. If it was feasible to harvest the whole plantation in 1 day, cutting only those bunches which had reached the optimum stage of ripeness, then a maximum crop of oil with very low f.f.a. would be obtained. Such a practice cannot be justified, and harvesting has to be organised on the basis of a compromise between suitable ripeness of the fruit and economy in the use of labour and transport. Current plantation practice for palms that are over 4 yr in the field is to harvest at intervals of 7–10 days. Given a harvesting interval of 7–10 days, a *minimum* ripeness standard of one loose fruit per pound of bunch weight would tend to result in a considerable proportion of the bunches harvested being over-ripe. To take the example of a 40-lb bunch, the minimum loose fruits on the ground would be forty and any bunch with less would not be cut. Therefore, a bunch with, *e.g.* thirty-five loose fruits, would not be harvested, and by the time the next harvesting round took place this bunch would be in a very advanced stage of ripeness. For this reason, current plantation practice is to set a minimum ripeness standard of ten to twelve loose fruits on the ground: furthermore, this is a number which can easily be assessed by the harvester.

Although rapid processing of fruit is necessary to obtain a low f.f.a. content, again a compromise must be reached, this time between the increase in f.f.a. content and the capacity of the factory. Bunch cutting and fruit collection is only feasible in daylight hours, whereas a costly factory must be kept running for two or three shifts per 24 h. The attainment of such a compromise involves commencing the processing of any given day's crop around mid-morning and completion of processing that crop within 24 h. If harvested fruit is stored unsterilised in the factory for longer than this, the f.f.a. content is liable to rise to excessively high levels. During peak crop production periods, if the amount of ripe fruit available exceeds the capacity of the factory, it is advisable to leave it on the palms for a day or two. A delay in harvesting for 1 or 2 days will result in a slower build-up of f.f.a. than would occur in fruit stored at the factory in an unsterilised form for a similar period of time.

8.2 HARVESTING METHODS AND STANDARDS REQUIRED

The basic procedures in cutting and collecting ripe fruit bunches can be listed as follows:

(a) Identification of ripe fruit bunches, using the criteria of loose fruits on the ground (10–12) and fruit colour (reddish-orange).

(b) Removal of any frond or fronds which obstruct access for cutting and removing the bunch or bunches. No other fronds should be removed during harvesting, and excess fronds are cut during the annual pruning round. A clean cut should be made and the frond base severed close to the trunk, so that loose fruits are not held in the frond butt.

It should be noted that, when chisel-harvesting bunches at around waist level or below, it is unnecessary to remove fronds at bunch cutting.

(c) Cutting the bunch stalk when access has been obtained. When bunches are held tightly in the palm crown with palms that are too high for chisel-harvesting, it may be necessary to ease the bunch forward by pulling with the knife to expose the bunch stalk, which is then cut.

(d) Trimming the bunch stalk as short as possible to facilitate better loading in the lorries and steriliser cages, and to reduce loss of oil through absorption into stalk tissue during sterilisation and threshing.

(e) Stacking cut fronds neatly in the inter-row and well clear of paths, circles and drains. The cutter would then proceed along the row to the next palm bearing a ripe bunch.

(f) Collection of bunches and all loose fruits and placing these in the carrying baskets. In young palms where fronds obstruct the circle, the baskets would be placed in the harvesters' path, which at this stage will be at the extremity of the fronds. In older palms, when the circles are clear of fronds, the baskets would be placed in the clean-weeded circle and filled. Having filled from one palm circle, the collector moves on to the next circle containing a cut bunch and continues this procedure until the basket is filled to the individual carrier's capacity.

(g) Carrying bunches and loose fruits to collection points, which may consist of harvesters' road-side platforms, road-side containers, or collection points within the avenue where mechanised collection along the row is being practised. Bunches and loose fruits should be systematically laid out on the harvesters' platforms or avenue collection points.

(Yong Photo Studio)

Plate 5. A harvesting platform with bunches and loose fruits arranged separately.

(h) Return to the harvesting area with carrying baskets and proceed with collection as in (f) above.

(i) Transport of crop to the factory. The transport of crop from the field to the factory will vary depending on the type of transport being used, the distance between field and factory, and where manual carrying ends and mechanised transport begins. The basic principle to follow is to keep the amount of fruit handling to a minimum, so as to reduce bruising and hence f.f.a. increase.

Harvesting in Malaysia is normally carried out by gangs of labourers working in pairs, one cutting and one carrying. Where the pairs of labourers are working in several non-adjacent areas during the day, on the completion of cutting in any given area or row, the cutter would assist the collector/carrier in finishing the work in that particular area before proceeding into the next harvesting area. Provided the majority of the teams are working at a similar rate, this approach facilitates concentration of supervision and hence control of standards.

8.2.1 *Standards required for efficient harvesting*

In view of the vital importance of efficient harvesting to the profitability of a planting particular attention should be given to the attainment of the following standards:

(a) No unripe bunches cut.

(b) No ripe bunches missed.

(c) All loose fruit collected.

(d) Avoiding excessive handling and bruising.

(e) Rapid transport to the factory.

(f) No contamination of fruit with soil and debris.

(g) Shaking out good fruits from badly pollinated bunches and discarding the empty bunches.

(h) Trimming long bunch stalks.

(i) No excessive pruning.

(j) Stacking fronds well clear of paths, circles and drains.

It should be emphasised that the main function of the supervisory staff is to ensure that (a) the harvesting labour force is fully aware of these critical standards, and (b) that where they are not being attained, appropriate penalties are enforced. It must be constantly borne in mind that palm oil has to be sold in extremely competitive world markets where quality standards are becoming

increasingly critical. The ready availability of substitutes within the end-use fields in which this product is used, creates a situation where low quality produce will become increasingly difficult to sell at a profit.

8.3 FIELD COLLECTION AND TRANSPORT OF CROP TO THE FACTORY

The most widely-practised method for collection and subsequent delivery of fruit to the factory is manual collection and carrying to the roadside harvesters' platform, followed by transport to the factory by lorry or tractor-trailer.

An alternative to harvesters' platforms as road-side storage is the use of containers. Containers of dimensions 3 ft 9 in. deep and 3 ft 3 in. square at the top with a slight taper, giving a total capacity of approx. 32 cu ft, have been found to be suitable for carrying ½-ton loads. With fairly careful handling, low-cost plywood containers can be expected to last for approx. 2 yr of regular use. A capacity of ½-ton appears to have the following advantages:

(i) It is suitable for harvesting tasks in that two or three containers are sufficient for 1 ton of fruit.

(ii) Equipment to handle these loads is comparatively cheap and not bulky.

The number of containers required would clearly depend on a combination of the following:

(a) The daily acreage being harvested.

(b) The yield of the area.

(c) The distance the fruit has to be transported to the factory or central collection point and the turn-round time involved.

The container system, although in the early stages of development in Malaysia, appears to have a number of advantages:

(i) As containers are loaded directly by the collection gang, the fruit is less likely to be contaminated with soil and stone particles, which are harmful to factory machinery and affect oil quality. Furthermore, the reduction in handling leads to less bruising and, presumably, a slower f.f.a. increase.

(ii) There is a lower labour requirement for fruit handling, since the loaded container is lifted onto the lorry/trailer in a single operation, as opposed to the lifting of individual bunches.

(iii) Crop weights for individual harvesting teams can be readily recorded separately. Containers are weighed as they are loaded onto the lorry/trailer.

(iv) Crop records for individual production areas can be easily obtained.

(v) This system provides an effective cross check between the weights leaving the field and those arriving at the factory weighbridge. There is thus no need for weighbridges on the individual plantations which feed a central factory.

In order to reduce labour costs and also the amount of fruit handling, various systems of mechanised carry from the palm circles or avenue collection points have been introduced, where terrain and soil conditions permit. Mechanised carrying systems can be divided into two main categories:

(i) Fruit is loaded in the field into tractor-trailers or containers and transported directly to the factory.

(ii) Fruit is loaded in the field into tractor-trailers or dump trunks for transport to central collection points, where it is transferred into vehicles for delivery to the factory.

Under large-scale production conditions, fruit collected in the field may have to be transferred into large road vehicles (6 tons) for delivery to a central factory, which may be 20–30 miles distant. In these circumstances, the aim should be to achieve efficient utilisation of both the field collection and factory delivery vehicles. Under most operating conditions, it would be extremely difficult to synchronise the arrival of the field collection vehicles and that of the factory vehicles. Given such a situation, delays to either vehicle systems can, to a large extent, be avoided by the establishment of storage facilities at central collection points. These storage facilities may take the form of ramps or large containers. By providing such facilities, the turn-round time of the vehicles of both systems can be speeded up, thus enabling more effective utilisation of all vehicles in terms of running hours.

When determining the central storage capacity required to cater for the fruit collection from a given production area, the following factors should be taken into account:

(i) *The timing and rate of fruit collection from the field.* This provides a quantitative assessment of the weight of crop available for delivery to the factory over a given period of time, using the minimum number of field collection vehicles. For example, if the period of time available for fruit collection was 8 h and the crop to be handled in any given area was estimated at 48 tons per day, the average rate of delivery to the central collection point would be 6 tons per hour. With a vehicle capacity of 3 tons and an average round trip time of 1 h, two vehicles would be required to handle the field collection of fruit.

(ii) *The timing and rate of fruit delivery from the central fruit storage (collection) point to the factory.* If the factory road delivery system is operating over a period of 12 h and the lorry capacity is 6 tons, with an average round trip time of 2 h, one vehicle could handle 3 tons per hour. In 12 h, one vehicle could deliver 36 tons to the factory and, therefore, to clear the fruit from the central collection point, an additional vehicle (of similar capacity) would be required for a period of 4 h, the average rate of delivery to the factory being 4 tons per hour. The storage capacity required (ramp or large containers) to meet this situation can be determined by taking into account the differential between:

(a) the total field delivery hours x tonnage per hour, *i.e.* in the example given, 8 x 6 = 48 tons, and

(b) the factory delivery rate over the same 8-h period, *i.e.* in the example given, 8 x 4 = 32 tons. Under these circumstances, storage capacity of 16 tons would be adequate to handle the situation. To allow for unforeseeable breakdowns in the factory delivery system, a surplus storage capacity of about 8 tons would be sufficient to cover a 2-h breakdown period.

8.4 THE ORGANISATION OF HARVESTING

8.4.1 *Effects of variation in crop production on harvesting organisation*

Although oil palms produce fruit throughout the year, there is considerable seasonal variation in the rate of production. However, current practice in the determination of factory capacity is to plan on the basis that $12\frac{1}{2}\%$ of the total annual crop will be harvested in the peak crop month (the mean monthly production rate of $8\frac{1}{3}\%$ being about two-thirds of this peak month's crop). Within the peak and trough production months, there will be short periods of a few days when even greater variations in production occur. To cope with these wide fluctuations, the organisation for harvesting, transporting and processing must be kept flexible. Prolonged periods of very dry or dull weather tend to delay fruit ripening while, on the other hand, alternating periods of rain and sunshine speed up ripening.

Given such a production pattern, it is not possible to lay down a rigid harvesting interval and the number of days between harvesting rounds should be adjusted, so that fruit is delivered to the factory in a suitable stage of ripeness. Adjustments in the harvesting interval will necessitate flexibility with respect to:

(a) the number of labourers engaged in harvesting cutting and collection),

(b) the acreage covered per day by a single cutting and collecting labour unit, and

(c) the number of factory running hours.

When fruit is ripening rapidly, it is normal practice to increase the frequency of harvesting rounds (decrease of harvesting interval), to increase the number of harvesting labourers and the number of factory running hours. Obviously, the extent to which harvesting intensity can be increased will depend upon factory capacity. Depending on the extent of the increase in the quantity of crop from the harvested area, it may also be necessary to reduce the acreage covered by a single cutting and collecting unit. On the other hand, if fruit is ripening slowly, the reverse procedure will apply. There may be occasions when, because of the low rate of cropping, it becomes necessary, from the standpoint of factory efficiency, to suspend harvesting and processing for a few days, rather than to continue operations at low throughput rates. During such short close-downs, the factory personnel can be employed on maintenance and repair work, while the harvesters can be given tasks, such as pruning.

Under average growing conditions, it would appear that a 10-day harvesting interval is suitable for Malaysia, but this interval will require shortening or lengthening according to the rate of ripening. Unless there is evidence of a significant increase in the rate of ripening, harvesting intervals should not be decreased below 10 days because, with shorter intervals, harvesters may have to walk greater distances looking for ripe fruit; there is also the chance that they will harvest unripe bunches.

Normal harvesting routines may be interrupted by rainy days and by factory closure. Wet weather rarely disrupts harvesting to an extent that puts harvesting programmes seriously out of gear. The flexibility inherent in the normal programme should accommodate most interruptions due to rain. On the other hand, factory close-downs can be more serious. However, if the closure can be foreseen, a period of a week or so may well be dealt with by shortening the harvesting interval, increasing factory shift intensity before the close-down and resuming harvesting and processing at maximum capacity immediately afterwards. If at all possible, factory maintenance should be planned to coincide with low cropping periods. For long close-downs, arrangements should be made for crop to be sent to another factory.

8.4.2 *Demarcation of harvesting blocks*

The organisation of harvesting operations should be based on the fields and blocks into which the planting has been divided. It is important that the depth of a block, as measured from the road, should not exceed the distance of the maximum harvesters' carry. For example, if the maximum carry is 10

chains, the depth of the block should not exceed this distance. Inspection paths can be used to mark the limits of the block boundaries.

8.4.3 *Development of a daily working programme*

The factors to be determined when drawing up a daily harvesting programme are the following:

(i) *The area to be harvested.* This will be a function of the frequency of harvesting rounds in operation at the time. The frequency of harvesting will vary according to the rate at which bunches are ripening at any given time. Under average conditions, after 4 yr of age, harvesting intervals of 10 days are usually satisfactory. In younger palms, the normal frequency of rounds should range between 10–14 days. However, during the heavy cropping season, the harvesting interval will generally have to be reduced to 7 days to avoid a large proportion of the bunches becoming over-ripe. In low cropping periods, or where bunches are ripening slowly, the frequency of rounds may be decreased to 10–14 day intervals.

(ii) *The labour requirements.* These will depend on both the area to be covered and the age of the palms in the area, in that the area covered per man-day varies with the age of the palms and hence accessibility.

The essential factors affecting the output of labour in cutting and collecting fruit bunches can be summarised as follows:

(a) Accessibility to the bunches. During the early years, access could be difficult due to fronds impeding movement in the circle. In later years, the ease of cutting is affected by the height of the palm.

(b) The number of bunches per acre per harvesting round.

(c) Bunch weight.

(d) The distance a bunch has to be carried to the collection point.

(e) Bunch ripeness. This affects the number of loose fruits which have to be picked up.

(f) Field conditions in relation to terrain, soil conditions, undergrowths, *etc.* These affect ease of access to the palms and harvesters' path.

The output of a cutter is mainly affected by the number of bunches per acre, the height of the palms and access and general field conditions. The output of a carrier is affected by the weight of the bunches, the number of bunches per acre, the number of loose fruits,

the distance of carry to collection points and field conditions, particularly terrain and cleanliness of circles.

Payment may be based on the weight or number of bunches, and cutters or collectors may be paid separately or jointly. However, this does not alter the fact that the amount of work involved in harvesting or collecting fruit is governed by the various conditions affecting the separate work elements.

In Malaysia, harvesting teams usually consist of one male cutter and a female or youth collecting and carrying the loose fruits and bunches. The cutter would also do some of the carrying and the distribution of payment is in the order of two-thirds to the cutter and one-third to the collector/carrier.

The acreage covered by a harvesting team will vary according to (a) the crop density, which in turn varies with age and season, and (b) the height of palms and ease of access to the bunches. Clearly, the labour force needed for harvesting will fluctuate, both between and within years, but the conversion factors given in Table 23 serve as a broad guide for the determination of daily labour requirements.

(iii) *The transport requirements for collection and delivery to the factory.* This is a direct function of the quantity of crop, the distance to the factory, and the number of hours over which fruit has to be delivered to the factory.

(iv) *The capacity of the factory.* This only becomes a limiting factor during periods of very heavy cropping, as already discussed above.

TABLE 23

Estimated mean acreage covered per harvesting team per day*

Age of palms (yr)	*Acreage per team*
3 — 4	12
5 — 8	10 — 12
9 — 16	9 — 10
17 — 25	8 — 9

* One team consists of one male cutter and one collector/carrier.

Table 24 shows the minimum area to be harvested daily for different frequencies of harvesting for a range of mature acreages.

In Table 25 the daily labour requirements (in terms of harvesting teams) to harvest different acreages at various stages of growth have been estimated on the basis of current plantation experience.

TABLE 24

Minimum area to be harvested daily in relation to frequency of rounds

Frequency of rounds (intervals in days)	*Max. no of working days**	*No of effective working days**	*Total acreage in harvesting*		
			5000	*3000*	*1500*
14	12.0	10.8	470	280	140
12	10.3	9.3	540	320	160
10	8.6	7.7	650	390	200
7	6.0	5.4	930	560	280

* Assuming that 1 day in 7 is a day of rest and that 10% of the remaining days is lost through adverse weather conditions.

TABLE 25

Daily labour requirements in teams for harvesting a range of acreages at different stages of growth*

Daily acreage to be harvested	*Age of palms (years from planting)*			
	3–4	*5–8*	*9–16*	*17–25*
140	12	12–14	14–16	16–18
160	14	14–16	16–18	18–20
200	17	17–20	20–23	23–25
280	24	24–28	28–32	32–35
320	27	27–32	32–36	36–40
390	33	33–39	39–44	44–49
470	40	40–47	47–53	53–59
540	45	45–54	54–60	60–68
560	47	47–56	56–63	63–70
650	55	55–65	65–73	73–82
930	78	78–93	93–104	104–117

* One team consists of a male cutter and a collector/carrier.

8.4.4 *Organisation of labour*

Harvesting should commence as soon as light intensity is adequate to enable the cutter to identify suitably ripe bunches.

To maintain the flexibility essential to oil palm harvesting, it is generally undesirable to allocate specific areas to individual harvesters as their permanent harvesting tasks. A harvesting gang of about sixteen teams and a *mandore* is considered to be a unit which can be effectively controlled. On arrival in the harvesting area, the *mandore* should allocate a number of adjacent rows to each harvester. The number of rows per harvester in any given block will vary according to the amount of ripe fruit available. It should, however, be adjusted so as to provide approx. 3 h work in cutting and carrying to the roadside collection point. As each harvester completes his allotted number of rows, he moves on to a second and later, possibly, a third task. This system makes it simpler for the *mandore* to supervise and to ensure that only ripe bunches are being harvested. It also allows earlier delivery of fruit to the factory (desirable for reduction of f.f.a. build-up) in that collection of fruit for transportation to the factory can commence as soon as the harvesters have completed their first tasks. If a large number of rows is initially allocated to each harvester, and fruit is to be delivered to the factory in a fresh condition, it will be necessary for transport to make several journeys during the day to any given area. Hence, the former system of task allocation provides a more efficient utilisation of transport, whether by road or by rail. If a railway system is in operation, a system is desirable whereby trucks are kept coupled together and not allocated to individual harvesters. This reduces to a minimum the time lag between harvesting and the delivery of fruit to the factory. If individual harvesters are given separate trucks, they must also be given initial tasks that are large enough to keep them fully occupied throughout the day. With such a system, there may be an undesirable delay in the delivery of fresh fruit to the factory. When using a coupled rail truck or road transport system, special loading gangs accompanying the train or the lorries are advantageous in speeding up fruit delivery.

If transport is based on allocation of separate rail trucks to individual harvesters, the recording of each harvester's crop is usually done at the factory weighbridge. In all other cases, each harvester's daily crop is based on the number and average weight of the bunches harvested. The average bunch weight from any given field is derived by weighing the total crop from that field at the factory weighbridge and dividing this figure by the total number of bunches harvested from that area. For identification purposes, each harvester should be given a code number that is marked on the stumps of the fruit bunches when they are placed at the roadside collection point. Prior to loading, a receiving clerk can then record the number of bunches brought in by each harvester and their origin. These records can then be used for determining harvester's production (plus bonuses) and also for yield recording purposes.

Whilst the *mandores* of the harvesting gangs are responsible for ensuring that suitably ripe fruit is harvested, cross checks of ripeness should also be regularly made by the field supervisory staff, the receiving clerk at the factory weighbridge and the factory staff. Under-ripe bunches tend to be the main source of crop loss, but over-ripeness must also be checked as this leads to a high f.f.a. content and, as more loose fruits have to be collected from these over-ripe bunches, costs tend to be increased.

8.4.5 *Implements and equipment*

The implements normally used for harvesting are 4-in. chisels and knives fixed to bamboo poles. The choice of implement depends on the accessibility of bunches, which is again related to the height of the palm. Generally, chisels are used until ripe bunches are produced at approx. 9–10 ft above ground level. From this stage onwards, cutting is done using knives on bamboo poles. The poles must be of a type of bamboo that is both strong and light, the knives are curved and are lashed to the pole using twine that is periodically soaked in order to prevent slipping. Knives have to be kept sharp, using honing stones, and the twine should be rewound at frequent intervals.

Light cane baskets of suitable strength and stability are used for carrying both bunches and loose fruit from the palm circles to the roadside/avenue collection points. Where one labourer carries two baskets, these are suspended from a *kanda*, or shoulder stick.

8.4.6 *Reception at the factory*

For efficient reception at the factory, the critical factors that need to be considered are: a rapid road vehicle unloading system, together with minimum fruit handling; a simple and efficient steriliser cage charging system; a fruit reserve to ensure continuous factory operation during delivery hours; and sufficient reserve to provide for the differential between factory and fruit delivery vehicle operational hours.

When siting a factory, undulating land can be used to advantage in locating and constructing the fruit reception ramp: however, the cost of establishing a level site for the main factory buildings must be given primary consideration. Where a relatively level site leads into elevated ground, full advantage should be taken of this situation when locating the site for fruit reception. Alternatively, an artificial elevation can be constructed from site levelling material.

Having selected the factory site and the position of the fruit reception area in relation to the factory building, the following factors should be taken into account when designing the layout for fruit reception:

(i) The weighbridge at the factory reception point should be as near as possible to the fruit reception area, but its positioning must also facilitate a quick turn-round of vehicles entering and leaving the site.

(ii) If steriliser cages are to be filled by gravity feed, the ramp construction should provide sufficient clearance for filled steriliser cages to pass just under the hoppers.

(iii) The distance from the ramp to the steriliser section should be sufficient to allow a suitably curved rail system into and out of the building. On a light rail track a minimum rail curvature of 40 ft is normally considered necessary.

(iv) If end-tipping road vehicles are to be used, with a view to reducing the ramp length required for a given number of discharging vehicles, adequate space for manoeuvre must be allowed at the top of the ramp.

(v) The ramp site should be planned so as to meet requirements when the factory is functioning at full capacity.

In conclusion, it must again be emphasised that crop should be processed as soon as possible after cutting. The factory should start operating as soon as an adequate and continuous flow of crop is available and the rate of fruit delivery must be sufficient to keep the factory operating at full capacity. In periods of low or average cropping, the usual pattern will be one of operating from mid-morning to night, so that all the crop is processed in a maximum of two factory shifts. In peak crop periods, the pattern will change to the factory starting up earlier in the day, processing crop harvested and delivered the previous afternoon and then carrying on to process the current day's crop on a three-shift system.

8.5 TRAINING HARVESTERS

In view of the importance of a high level of harvesting efficiency (as emphasised in Section 8.2), labourers to be engaged in harvesting operations must be systematically trained in the methods to be used and the standards required. These methods and standards have already been discussed under Section 8.2. However, for instructional purposes, the following approach is recommended.

A group of sixteen labourers should be trained under the supervision of one Field Assistant (part-time) and one experienced instructor *mandore*. The training would be given over a period of 6 weeks, the basic procedure used being one of field demonstration followed by individual field practice under supervision.

The work elements which are critical, and therefore need emphasis, during training are:

(i) Identification of ripe, unripe and over-ripe fruit.

(ii) Frond removal, bunch cutting and trimming bunch stalks.

(iii) Stacking cut fronds.

(iv) Collection of bunches and loose fruit.

(v) Care and maintenance of tools and equipment.

As frond cutting and bunch removal techniques vary according to the stage of palm growth, demonstrations and field practice should be carried out in the three main growth stages where the different cutting techniques are used. These can be classified as:

(a) Ripe bunches occurring at waist level and below, with chisels being used for cutting.

(b) Ripe bunches found between waist level and 9–10 ft and cutting done by chisel.

(c) Ripe bunches produced above 9–10 ft when the knife and bamboo pole are used for cutting.

Having selected these areas, the procedure used in field demonstration would be as follows:

Identification of ripe bunches. Trainee labourers should be shown bunches which are ripe, unripe and over-ripe and the colour differentials emphasised. The criteria for selecting ripe bunches is a minimum of 10–12 loose fruits in the circle and this again must be stressed. Labourers should be given an explanation of the effects of over-ripeness and under-ripeness with respect to quality (high f.f.a.) and loss of crop respectively.

Removing fronds obstructing access to the bunch. In areas where bunches occur below waist level, labourers should be instructed to cut bunch stalks without removing any fronds. Where bunches are produced above waist level, the trainees should be taught to confine frond removal to cutting only those fronds that obstruct access to bunch cutting and removal.

In all cases of frond removal, the instructor should demonstrate how to make a clean cut fairly close to the trunk, so that loose fruits are not held in the frond butts. At the same time, he should show how the tool should be held and used most effectively.

Cutting bunches and trimming bunch stalks. Instructors should demonstrate the efficient action for bunch stalk cutting using chisel or knife, whichever is appropriate. After the bunches have fallen, the stalks should be trimmed and an explanation given that short stalks are required for ease of loading in lorries

and steriliser cages. It should also be pointed out that long stalks can result in a loss of oil due to absorption by the stalk tissue during sterilisation and threshing.

Stacking cut fronds. Trainees should be shown both where and how to stack fronds, emphasising the need for neat stacking clear of paths, circles and drains.

Collection of bunches and loose fruit. In young palms where fronds obstruct the circle, the trainees should be instructed to leave the carrying baskets in the harvesters' paths and proceed to collect all bunches and loose fruit within the circle. In older palms, baskets would be placed in the clean-weeded circle.

Care and maintenance of tools and equipment. Throughout demonstrations, the instructors should emphasise the advantages of keeping cutting edges sharp and knife twine binding tight by regular soaking. The need for keeping baskets free of dirt and debris should also be stressed.

8.5.1 *Schedule for training*

A suitable schedule for a 6-week training programme would be as follows:

Week 1. Training in areas where bunches occur at waist level and below and bunch cutting is by chisel.

Day 1. (a) Demonstration of tools, equipment and their maintenance.

(b) How to recognise the various stages of ripeness.

(c) Bunch cutting, stalk trimming.

(d) Collection and carrying of fruit to harvesters' platforms or collection points.

The instructors (Field Assistant and *mandore*) should demonstrate on three or four palms and then split the sixteen trainees into two groups of eight. The Field Assistant and *mandore* would take a group each and allocate the eight trainees to four rows, where they work independently. The trainees should each select and cut bunches from three or four palms, collect the bunches and loose fruit, and leave them in the baskets on the harvesters' paths. When this has been completed, the instructor should inspect each of the palms selected and cut by the trainees, pointing out any errors that have been made and making quite sure that the trainees understand their mistakes. The trainees should then carry the bunches to the harvesters' platforms, where bunches and loose fruit should be laid out separately for inspection and recording. The trainees should return to the harvesting area and continue selecting, cutting and carrying bunches, under supervision, for the remainder of the day.

Day 2. The instructor should briefly repeat the previous day's demonstration, stressing any mistakes that were made during the day. As on the previous day, the trainees should continue to practise harvesting in two groups under supervision.

Days 3–6. Each trainee would be detailed to work alongside an experienced harvester, who is compensated for time spent helping the trainees by receiving the crop harvested by the trainees. During this time, the trainees are paid a fixed wage.

Week 2. Training in areas where bunches are found between waist level and 9–10 ft and cutting is done by chisel.

Days 1–2. The training procedure is similar to that outlined in Week 1, Days 1–2, except that fronds which impede bunch removal are cut prior to bunch cutting and these fronds must be neatly stacked in the inter-row.

Days 3–6. The routine is as described for Week 1, Days 3–6.

Week 3. Training in areas where bunches occur above the 9–10 ft level and cutting is done by knife and bamboo pole.

Days 1–6. The training routine is as described under Week 2.

Weeks 4–6. The trainees, still on probation, operate as a single harvesting gang under the instructor *mandore.* They should work in areas that are at the three different growth stages. Throughout this period of training, the trainees would be subject to the normal harvesting quality standards and a final grading of trainees made at the end.

8.5.2 *Harvesting quality standards*

The quality of a trainee's work should be based on a daily assessment of the critical aspects of harvesting. These can be listed as:

(i) Missed ripe bunches—assessed in the field.

(ii) Loose fruits uncollected—assessed in the field.

(iii) Excessive frond pruning—assessed in the field.

(iv) Unripe bunches—assessed at the harvesters' platform.

(v) Untrimmed bunch stalks—assessed at the platform.

The *mandore's* assessment of missed ripe bunches and excessive frond pruning should be made in a sample of six rows (two rows for each of the three sections in which the harvester works during the day), involving approx. 130 palms. At

the same time, the *mandore* should record the number of loose fruit uncollected in a total of ten palm circles. All unripe bunches and bunches with untrimmed stalks should be counted at the platform.

Grading of the trainee should be based on the following points system, which would be recorded daily:

Missed ripe bunches

No of missed bunches	0	1	2	3 or more
Points awarded	10	7	4	0

Loose fruits uncollected

No of loose fruits found	0	1	2	3	4	5	6	7	8	9	10 or more
Points awarded	10	9	8	7	6	5	4	3	2	1	0

Excessive frond pruning

No of palms with excessive frond pruning	0	1	2	3 or more
Points awarded	10	7	4	0

Unripe bunches

No of unripe bunches	0	1	2	3 or more
Points awarded	10	7	4	0

Untrimmed bunch stalks

No of untrimmed bunches	0	1	2	3 or more
Points awarded	10	7	4	0

At the end of the 3 weeks probationary harvesting, the grading achieved by each trainee should be calculated on a percentage basis. Those trainees with 70% or over would be considered suitable as harvesters. Trainees with less than 50% would be rejected. Those with grading between 50% and 70% should be considered as redeemable failures and given a further 2 weeks training, followed by 2 weeks probationary harvesting and another grade assessment. Those not attaining 70% after extra training would be rejected as harvesters.

CHAPTER 9

SUMMARY OF THE TIMING AND LABOUR REQUIREMENTS FOR MAIN WORK ITEMS

In the tables below, the main work items in the establishment, immature and mature stages are summarised in relation to timing and manpower requirements. When computing the labour requirements, allowance has been made for direct field supervision by *mandores*. No differentiation has been made between male and female labour and, when costing, appropriate adjustments should be made.

Estimates have not been made of the labour requirements for such work items as pest and disease control, road and drainage system maintenance, terracing, transport and processing. The labour inputs pertaining to the majority of these operations will vary considerably between one planting and another and within any given planting from time-to-time. For these reasons, it was considered inappropriate to attempt to generalise with respect to the labour requirements for such operations.

The objective of the summary given in the following tables is to provide a basic guide to the annual distribution of labour requirements during the development and production stages in a 5000-acre planting established from jungle.

Summary of labour requirements for main work items in Establishment Year — 1*

Work item	Timing and length of operation	Man-day requirements	Percentage of annual total	Remarks
1. Demarcation of perimeter boundary	mid-March—end March	162	0.74	
2. Nursery site selection	end March—mid-April	121	0.55	
3. Nursery access road alignment and construction	mid-April—early July	Mechanical		
4. Clearing pre-nursery and main nursery	July—end September	Mechanical		
5. Preparation and planting of pre-nursery	mid-July—end December	916	4.19	*Including one mandore for 100 days*
6. Maintenance of pre-nursery	August—December			
Watering		750	3.43	
Weeding		250	1.14	
Fertiliser application		68	0.31	
Consolidation of unstable seedlings		16	0.07	
Thinning out		4	0.02	
7. Preparation and planting of main nursery	end September—end December			
Installation of irrigation system	end September—end November	54	0.25	
Lining of beds and soil preparation	end October—end December	150	0.69	
Bag filling and placing	November—end December	1266	5.79	
Transplanting from the pre-nursery	December	595	2.72	*Including one mandore for 25 days*
8. Maintenance of main nursery				
Watering	December	320	1.46	*One system operating for 1 month. Two mandores per day*
9. Main felling	November—December			
Underbrushing		8344	38.19	
Felling		8834	40.43	
	Total	*21850*		

* The Establishment Year is the year in which field planting commences.

Summary of labour requirements for main work items — Establishment Year*

Work item	Timing and length of operation	Man-day requirements	Percentage of annual total	Remarks
1. Maintenance of pre-nursery	January—end March			
Watering		450	0.30	
Weeding		150	0.10	
Fertiliser application		52	0.03	
Thinning out		12	0.01	
2. Preparation and planting of main nursery	January—end February			
Lining of beds and soil preparation	January—late February	150	0.10	
Bag filling and placing	January—end February	1266	0.85	
Transplanting from the pre-nursery	January—end March	1785	1.19	*Including one mandore for 75 days*
3. Maintenance of main nursery	January—end December			
Watering	January—end December	10560	7.06	*Watering—3 months with two systems (Jan, Nov, Dec)* *Watering—9 months with three systems (Feb–Oct)* *Watering—includes two mandores per day*
Weeding	January—end November	3762	2.52	
Fertiliser application	January—end December	1956	1.31	
Thinning out	June—end December	82	0.05	*Weeding—six rounds per batch*
Supervision (other than watering)	January—December	600	0.40	*Supervision—two mandores at 25 days per month*
4. Main felling				
Underbrushing	January	4156	2.78	
Felling	January	4416	2.95	
5. Burning	mid-January—mid-March	530	0.35	
6. Pruning, stacking and re-burning	February—end April	30000	20.06	
7. Main road alignment (and later secondary roads)	mid-February—end July	Mechanical		
8. Lining	mid-February—mid-May	2000	1.34	
9. Establishment of harvesters' paths and Clearing timber from planting points	mid-February—end May	23750	15.88	
10. Sowing covers	April—end June			
Clean-weeding prior to sowing		3668	2.45	*Includes one mandore*
Sowing		3618	2.42	*Includes two mandores*
Starter fertiliser application		2634	1.76	*Includes two mandores*
11. Maintenance of covers and palms	mid-April—December			*1700 acres at eight rounds (including mandores). 1700 acres at seven rounds (including mandores). 1600 acres at six rounds (including mandores)*
Weeding covers and palms	mid-April—December	42532	28.43	
Inspection path maintenance	mid-April—December			
Fertiliser application to covers	July—September	2000	1.34	*Includes one mandore*
12. Field planting	October—December			
Census		63	0.04	
Painting zinc phosphide paste		189	0.13	
Transporting seedlings and planting		9198	6.15	*Includes four mandores*
	Total	*149579*		

* The Establishment Year is the year in which field planting commences.

Summary of labour requirements for main work items — Year 1*

Work item	Timing and length of operation	Man-day requirements	Percentage of annual total	Remarks
1. Maintenance of main nursery	January			
Watering		320	0.22	*One system operating for 1 month*
Fertiliser application		56	0.04	*Fertiliser to 95000 seedlings (one round)*
2. Field planting	January			
Census		21	0.01	
Painting zinc phosphide paste		63	0.04	
Transporting seedlings and planting		3066	2.13	*Includes four mandores*
3. Maintenance of covers and palms	January—December			
Weeding of covers and palms	January—December	134400	93.23	*Includes fourteen mandores*
Inspection path maintenance	January—December			
Fertiliser application to covers	July—September	2948	2.04	*Includes two mandores*
Fertiliser application to palms	January—October	3283	2.28	*Applied in two applications of 2 lb each*
				Includes one mandore
	Total	*144157*		

* Year 1 is the year following the Establishment Year.

Summary of labour requirements for main work items — Year 2*

Work item	Timing and length of operation	Man-day requirements	Percentage of annual total	Remarks
1. Maintenance of covers and palms				
Weeding of covers and palms	January—December	122200	84.69	*Includes fourteen mandores*
Inspection path maintenance	January—December			
Fertiliser application to covers	July—September	2613	1.81	*Includes one mandore*
Fertiliser application to palms	January—October	3283	2.28	*Applied in two applications of 2 lb each. Includes one mandore*
2. Castration	January—December	16200	11.23	*A small proportion of this labour may be used in the early months of Year 3 for the later plantings. Includes two mandores*
	Total	*144296*		

* Year 2 is the year following ~~the Establishment~~ Year.

Summary of labour requirements for main work items — Year 3

Work item	*Timing and length of operation*	*Man-day requirements*	*Percentage of annual total*	*Remarks*
1. Maintenance of covers and palms	January—December			
Weeding of covers and palms	January—December	92300	70.66	*Weeding—includes eight mandores 300 days. Harvesters' path opening — includes two mandores for 50 days. Harvesters path maintenance—includes two mandores for 150 days.*
Inspection path maintenance	January—December			
Opening and maintenance of harvesters' paths				
Fertiliser application to palms	January—October	3618	2.77	*A total of 6 lb is applied in two applications over a period of 6 months. Includes two mandores*
2. Assisted pollination	end June—December			
Pollen collection		4176	3.20	*Collection—pollen collected in 2½–3 yr old areas at eight rounds per month. No supervision. Application — pollen applied at eight rounds per month. Includes ten mandores per day*
Pollen application		21888	16.76	
3. Harvesting (12-day interval)	July—December	8649	6.62	*Commencing in July, approx. 6–8 months after end of castration. Assuming a mean harvesting period of 4 months for 5000 acres. Includes three mandores supervising forty-five teams*
	Total	*130631*		

Summary of labour requirements for main work items — Year 4

Work item	Timing and length of operation	Man-day requirements	Percentage of annual total	Remarks
1. Maintenance of avenues, palms and harvesters' paths				
Weeding avenues and palms	January—December	51500	36.86	*Includes five mandores*
Fertiliser application to palms	January—October	3953	2.83	*A total of 8 lb is applied in two applications over a 3-month period. Includes one mandore*
2. Assisted pollination	January—December			
Pollen collection		6327	4.53	*Pollen collected in areas 3–4 yr old*
Pollen application		36288	25.97	*Pollen applied at eight rounds per month. Includes eight mandores per day*
3. Pruning (initial)	January—December	9600	6.87	*Carried out when lowest ripe bunch is approx. 2 ft above ground*
4. Harvesting	January—December	32034	22.93	*Mean harvesting interval of 10 days. Includes four mandores supervising fifty-five teams*
	Total	*139702*		

Summary of labour requirements for main work items — Year 5

Work item	*Timing and length of operation*	*Man-day requirements*	*Percentage of annual total*	*Remarks*
1. Maintenance of avenues, palms and harvesters' paths				
Weeding avenues and palms	January—December	36000	30.83	*Includes five mandores*
Fertiliser application to palms	January—October	4221	3.61	*A total of 10 lb is applied in two applications over a 3-month period. Includes one mandore*
2. Assisted pollination	January—December			
Pollen collection		4320	3.70	*Pollen collected in areas 4–5 yr old. Pollen applied at eight rounds per month. Includes six mandores per day*
Pollen application		29088	24.91	
3. Pruning	January—December	8300	7.10	*During low crop period. Includes three mandores per day*
4. Harvesting	January—December	34844	29.84	*Mean harvesting interval of 10 days. Includes four mandores supervising sixty teams*
	Total	*116773*		

Summary of labour requirements for main work items — Years 6, 7 and 8

Work item	*Timing and length of operation*	*Man-day requirements*	*Percentage of annual total*	*Remarks*
1. Maintenance of avenues, palms and harvesters' paths				
Weeding avenues and palms	January—December	36000	33.59	*Includes five mandores*
Fertiliser application to palms	January—October	4422	4.13	*A total of 12 lb is applied in two applications over a 3-month period. Includes one mandore*
2. Assisted pollination	January—December			
Pollen collection		2880	2.69	*Pollen collected in areas 6–8 yr old. Pollen applied at eight rounds per month. Includes four mandores per day*
Pollen application		20736	19.35	
3. Pruning	January—December	8300	7.74	*During low crop period. Includes three mandores*
4. Harvesting	January—December	34844	32.51	*Mean harvesting interval of 10 days. Includes four mandores supervising sixty teams*
	Total	*107182*		

Summary of labour requirements for main work items — Years 9–16

Work item	*Timing and length of operation*	*Man-day requirements*	*Percentage of annual total*	*Remarks*
1. Maintenance of avenues, palms and harvesters' paths	January—December	36000	39.25	*Includes five mandores*
Weeding avenues and palms	January—October	4422	4.82	*A total of 12 lb is applied in two applications over a 3-month period. Includes one mandore*
Fertiliser application to palms	January—December	11400	12.43	*During low crop period. Includes four mandores*
2. Pruning	January—December	39902	43.50	*Mean harvesting interval of 10 days. Includes four mandores supervising sixty-nine teams*
3. Harvesting	*Total*	*91724*		

Summary of labour requirements for main work items — Years 17–25

Work item	*Timing and length of operation*	*Man-day requirements*	*Percentage of annual total*	*Remarks*
1. Maintenance of avenues, palms and harvesters' paths				
Weeding avenues and palms	January—December	36000	36.12	*Includes five mandores*
Fertiliser application to palms	January—October	4422	4.44	*A total of 12 lb is applied in two applications over a 3-month period. Includes one mandore*
2. Pruning	January—December	14000	14.05	*During low crop period. Includes five mandores*
3. Harvesting	January—December	45241	45.39	*Mean harvesting interval of 10 days. Includes five mandores supervising seventy-eight teams*
	Total	*99663*		

CHAPTER 10

THE CONTROL AND INSPECTION OF FIELD OPERATIONS

The previous sections of this book have dealt with the organisation of the main operations involved in the development and production phases. The objective in this section is to outline an approach to the control of field operations, so as to ensure that work proceeds according to schedule and agreed standards. It has been assumed that the overall policy formulation with respect to administration, finance and agricultural techniques will be under the ultimate control of a central authority, which is responsible for the planning and phasing of plantation development. If these plans are to be successfully implemented, a high standard of efficiency must be attained at field operational level. To achieve a high standard of efficiency, field management must be fully supported by specialists in the spheres of administration, agriculture and factory processing.

The planting Manager is the vital link with the central authority. He is responsible for seeing that programmes for development and/or production are put into operation at the correct time and that the desired standards of work are attained.

10.1 SUPERVISORY STRUCTURE FOR THE CONTROL OF FIELD OPERATIONS

The basic functions of the supervisory staff on a planting are:

(a) Development of annual estimates on which monthly and daily work programmes are based.

(b) Implementation of these work programmes.

(c) Inspecting field operations and recording progress and work standards.

The execution of these broad functions involves a wide range of skills including administration, agricultural technique, accounting and man management. In large-scale plantings, the size and complexity of the field operations necessitates an effective chain of command being established between the Manager and his subordinate staff. To achieve this, it is vital that the spheres of responsibility of all staff are clearly defined and appropriately delegated.

The intensity of staff required to supervise the running of a planting will vary depending on the stage of development that has been attained and the

operating conditions, particularly with respect to terrain and communications. It is difficult to make precise estimates of staff requirements at all stages of development and production: however, the requirements for field supervision will tend to be at a maximum during the development and early production phases. It should be noted that during the jungle clearing and early field establishment stages, contractors are largely responsible for the day-to-day supervision of field operations; however, these operations become increasingly the responsibility of the plantation staff. In the first 4–5 yr after field planting, staff requirements for the direct supervision of field work are at a peak due to the wide range of operations and hence heavy demands resulting from intensive cover crop maintenance, castration, assisted pollination, initial pruning and early harvesting. This is particularly applicable in the case of large single-stage plantings in the order of 3000–5000 acres. During this critical period therefore, it may well be necessary to have a somewhat higher field staff establishment than that required in the main production phase. For the above reasons, when estimating the permanent staff required to run a planting, it would appear more appropriate to assess these requirements at the fully-mature stage. The estimates given below in Table 26 are based on experience in large-scale plantings in West Malaysia; it shows the various categories of staff, the acreages which they would supervise together with their basic spheres of responsibility, shown in the list below.

TABLE 26

Managerial and field staff requirements for a 5000-acre planting at the mature stage

Staff category and no	*Area supervised (acres)*	*Spheres of responsibility**
Manager (1)	5000	1—15
Assistant Manager (2)	2500	1 (draft)
		2—9
		12—15
Senior Supervisor (4)	1250	4—9
		12
		15
Field Assistant (8—10)	500—625	4—5
		7—9
		15

* See text

The main spheres of responsibility that are involved in the running of a planting are:

1. Preparation of annual estimates (draft and final).
2. Preparing calendars of operation and monthly work programmes (based on annual estimates).
3. Ordering materials and equipment in relation to calendars of operation.
4. Preparation of daily work programmes.
5. Drawing materials and equipment from store.
6. Organisation of transport.
7. Supervision of field work.
8. Inspection and reporting on work standards.
9. Preparation of daily records and reports (labour, crop, progress of field work).
10. Integration of field and factory operations, including despatch of products.
11. Overall general administration, including progress payments, inventory preparation and stock-taking.
12. Divisional administration.
13. Preparing monthly progress reports.
14. Preparation of monthly accounts.
15. Labour relations.
16. The provision of advisory, training and central inspection services.

10.1.1 *Qualifications and experience required for the various staff categories*

Manager :

Qualifications. Managerial staff should preferably have a formal agricultural education up to Degree or Diploma standard. Staff without formal qualifications should still be able to be appointed as Managers, provided that during the course of their service they have successfully completed systematic inservice course work and training in both technical and administrative subjects.

Experience. Managerial staff must have acquired experience over a wide range of technical and administrative skills and should have demonstrated their ability to organise field operations and maintain good staff and labour relations. With a formal agricultural training, a suitable candidate should be able to

acquire sufficient experience (at Assistant Manager level) to become a Manager after 7–10 yr. Candidates without formal qualifications should be able to reach management status after 12–15 yr.

Assistant Manager:

Qualifications. These are the same as for Managers.

Experience. A candidate with formal agricultural training would serve a probationary period of 1–2 yr as a Cadet Assistant and, after a further period of 5–8 yr as an Assistant Manager, could be considered for promotion to Manager. The level of Assistant Manager should also be attainable by keen staff who commenced their careers at the Field Assistant level and have been promoted through the Senior Supervisor stage to Assistant Manager, after a total period of 6–7 yr. Following a further period of 6–8 yr, such staff could well achieve Manager status. Assuming that Field Assistants are recruited at the age of 18–20 yr, there should be the opportunity for them to reach Manager level in their early thirties.

Senior Supervisor:

Qualifications. School Certificate and inservice course work.

Experience: Senior Supervisors should be promoted from the Field Assistant level, where they should have spent a minimum of 2–3 yr after 1 yr initial training. Senior Supervisors could be considered for promotion to Assistant Manager after a minimum of 2–3 yr, during which they would acquire experience in preparation of daily work programmes, field supervision over a wide range of operations, inspection and assessment of work standards, record keeping, divisional administration and labour management.

Field Assistant:

Qualifications and experience. School Certificate and initial training (1 yr), including course work. During the period that a man works as a Field Assistant, he should gain experience of the preparation and organisation of daily work programmes, field supervision, inspection and assessment of work standards, record keeping and labour management.

To keep staff familiar with the latest technical and organisational developments and to facilitate promotion of the more progressive members, it is essential to offer inservice training at regular intervals throughout their careers.

As pointed out at the beginning of Section 10.1, the main functions of the field staff relate to the development of annual estimates and work programmes, together with their implementation in the field to agreed standards. Examples of annual estimates, monthly progress reports and accounts, together with a

short discourse on plantation administration, are included in 'Planting Techniques for Oil Palms in Malaysia', to which reference should be made. The organisation and implementation of work programmes has been described in earlier chapters, and the remaining sections of this book are concerned with methods of inspection and assessment of standards achieved in the main field operations.

10.2 INSPECTION FOR ASSESSMENT OF WORK STANDARDS

The annual estimates should include a detailed annual work sheet, from which a monthly work programme can be drawn up in chart form for each block and for each main operation. This involves drawing up detailed calendars of operation, showing the phasing and timing of the major work items throughout the year. The daily work schedules should be planned to cover the month's commitments in 25 working days, adjustments being made where necessary in relation to progress to-date and weather conditions. Direct supervision of field works is normally the responsibility of Senior Supervisors, Field Assistants and/or *mandores*. When a new or particularly complicated operation is being started, the Assistant Manager responsible for the division should be present in the early stages. In connection with each operation, field staff should make a daily record of the following essential details:

(a) Location and type of operation, *e.g.* Field 15, castration.

(b) Acreage completed.

(c) Where applicable, number of palms completed, *e.g.* field planting.

(d) Chainage completed: roads, drains, terraces.

(e) Labour used: number of males, females, youths employed.

(f) Materials used.

(g) Equipment used: numbers and type.

(h) In the case of harvesting, crop per unit area and per harvesting team.

(i) Brief comments relating to operating conditions.

(j) Presence of pests and diseases.

These details should be recorded in the office daily diary for cost analysis and progress reporting, together with inspection by senior managerial staff. As a result of examination of these daily work reports, together with field inspection, the Management should be in a position to make any amendments or alterations necessary in relation to the overall work programme.

Inspection and assessment of work standards should be done at two distinct levels; (a) by the field staff directly supervising the field work while it is in progress, and (b) by the Management and Senior Supervisors working on a sample basis. The aim should be to make assessments of work standards on a quantitative basis so that objective judgements can be made.

In theory, it would be desirable for Management to carry out inspection when all the various operations are in progress, so that any corrective action can be implemented immediately. However, in practice, it is clearly not feasible for the Managerial Staff to be on the spot while all operations are in progress. For this reason, it is necessary to rationalise the approach to inspection. This can be done by dividing the timing of inspection into four main groups and classifying the various field operations according to these groups. These four main groups can be listed as follows:

(a) Inspection prior to carrying out the field operation.

(b) Inspection of materials and equipment prior to their use.

(c) Inspection while field work is in progress.

(d) Inspection just after the completion of work.

Inspection that falls into groups (a) and (b) could largely be made in the afternoon prior to the actual field work in question being done. Where necessary, inspection in group (d) could be carried out in the afternoon immediately following the completion of the field operation.

The field operations that can be classified within these four main inspection groups are summarised below. It should be noted that several of these operations fall into more than one inspection category.

10.2.1 *Inspection prior to carrying out the field operation*

Cover crop sowing: check that lining is completed and that the area has been clean-weeded.

Fertiliser application: check that weeding rounds have been completed in the covers and palm circles.

Castration: check that before the first round some 25% or more of the palms bear inflorescences.

Harvesting: immediately prior to initial harvesting, the presence of sufficient ripe bunches should be assessed.

Pests and diseases: on receiving reports of new outbreaks, the Management should carry out an inspection to diagnose the type of pest or disease damage and prescribe treatment.

Maintenance of drain outlets, tide-gates and culverts: check for obstructions to flow, breakages and operating efficiency at regular intervals.

10.2.2 *Inspection of materials and equipment prior to their use*

Cover crop sowing: check that the correct species and quantities of scarified seed, treated with *Rhizobium*, are issued and that C.I.R.P. has been added.

Fertiliser application: ascertain that the correct quantities and types of fertiliser are available for the manuring programme involved, cover crop and/or palms.

Herbicide application: note that correct spray nozzles, equipment and quantities of the selected herbicides are issued and that the stipulated concentration of solution is made up.

Assisted pollination: check that the correct quantities of viable pollen and talc are issued for the day's operations. Also ensure that the pollinators are using the appropriate equipment.

Pests and diseases: ensure that the correct spray nozzles and equipment are used and that the appropriate concentrations of the recommended fungicides or insecticides are prepared.

10.2.3 *Inspection while field work is in progress*

Cover crop sowing: ensure that drills are made at the correct depth and spacing, that seed is sown at the appropriate rate and that drills are covered over after sowing.

Weeding: check that circles are clean and that all noxious growths have been removed in the avenues. Inspection and harvesters' paths should also have been clean-weeded or sprayed to the appropriate width.

Planting of palms: check seedling age and method of loading, transporting and planting.

Castration: check that all inflorescences and bunches are removed and taken to disposal points.

Fertiliser application: ensure that fertiliser is applied in the correct place and at the recommended rates.

Assisted pollination: check that pollinators are working in the appropriate area and that they are applying pollen to all receptive female inflorescences in the area.

Pruning: with initial pruning, the supervisors must ensure that the lowest ripe bunches are 2 ft above ground level and that the two fronds immediately below the lowest ripe bunch are not pruned. During annual pruning also, two fronds should be left below the lowest ripe bunch.

Harvesting: the main checks involved relate to missed ripe bunches, unripe bunches, uncollected loose fruits, excessive frond pruning and untrimmed bunch stalks.

Pests and diseases: ensure that the correct method of application is being used in the appropriate area.

10.2.4 ***Inspection just after completion of the work***

Jungle clearing: check that the standards achieved for felling, pruning, stacking and re-burning are according to specification and that, where progress payments are being made, the acreage is correct.

Lining: check that the lining is according to the spacing specified for both flat and contour planting.

Clearing timbers from planting points and harvesters' paths: ensure the work is done according to specification and that the chainage is correct.

Planting of palms: check that palms are firmly planted at the correct depth and that polybags have been removed.

Weeding: check that circles are clean and that all noxious growths have been removed from the avenues. Inspection or harvesters' paths should also have been clean-weeded to the appropriate width.

Castration: check that all inflorescences and bunches have been removed and sprayed at the disposal points.

Harvesting: the main checks involved relate to missed ripe bunches, unripe bunches, uncollected loose fruits, excessive frond pruning and untrimmed bunch stalks.

Pests and diseases: check that treatments have been applied in the appropriate areas. Observations of response to treatment should be made; this involves regular inspection to assess increase or decrease of infestation and, in the case of insects, to find evidence of the extent of kill achieved.

Maintenance of roads, drains, culverts, terraces: wherever maintenance work is being done, checks should be made that the appropriate corrective action has been taken.

10.3 CRITICAL FACTORS IN THE SUPERVISION OF FIELD OPERATIONS

This section outlines the critical factors involved in the attainment of satisfactory work standards during the execution of the main field operations. Staff responsible for direct supervision of field work should draw up check lists (as reminders for field use) of the critical factors pertaining to the various operations and ensure that work is carried out accordingly. These check lists should continually be revised in accordance with advances in field techniques. This approach is essential for the attainment of satisfactory work standards and should be used by (a) Field Assistants/Senior Supervisors responsible for direct supervision while work is in progress, and (b) managerial staff concerned with inspection. Clearly, it is important for all staff to have uniform check lists of the critical factors.

The following check lists of critical factors for the main field operations are recommended in the light of current technical knowledge.

10.3.1 *Nursery operations*

(a) *Pre-nursery*

(i) Reception of germinated seed:
Number.
Age.
Incidence of disease and/or malformations.

(ii) Planting of seed:
Plant within 4 days at $\frac{1}{2}$ in. depth.

(iii) Watering:
Daily, 12 gal per 1000 seedlings.

(iv) Weeding:
Monthly, clean weeding.

(v) Fertiliser, weekly intervals:
1–3 leaf stage—$\frac{1}{4}$ oz in 1 gal water per 100 seedlings.
3–5 leaf stage—$\frac{1}{2}$ oz in 1 gal water per 100 seedlings.

(vi) Consolidation of loose seedlings:
Weekly rounds of firming and top filling.

(vii) Pest and disease control:
Continuous observations and action where necessary.

(viii) Thinning out:
Prior to transplanting.
Transfer runts to vacant sections.

(b) *Main nursery*

(i) Irrigation system:

Pump house built to specifications.

Depth of main line trench and effective pipe coupling.

Correct spacing of sprayline sections.

Effective coupling of sprayline sections, standpipes and sprinklers.

(ii) Lining:

Correct spacing and size of beds.

(iii) Bag filling:

Consolidation and correct depth of soil.

(iv) Transplanting:

Collar $\frac{1}{2}$ in. below rim of polybag.

Seedling firmed.

Small polybag removed.

Correct spacing.

(v) Watering:

Start on time.

Correct timing of sprayline changes.

Correct rate of precipitation.

Sticking sprinklers.

Leaks at couplings and sprayline stop ends.

(vi) Weeding:

Monthly.

After watering.

Clean within bags and between rows.

No damage to seedlings or bags.

(vii) Fertiliser:

Monthly.

After weeding.

At correct dosage for age.

Placement in broad band, avoiding collar.

(viii) Pest and disease control:

Continuous observation and action where necessary.

(ix) Thinning out:

At 9–10 months and at transplanting to the field.

Culls put to one side for final checking.

10.3.2 *Jungle clearing*

(i) Under-brushing:

According to specifications, time schedule and within perimeter boundaries only.

(ii) Felling:

According to specifications and time schedule.

Adequate labour force.

Within perimeter boundaries only.

Correct acreage for progress payment.

Patrolled during drying out period.

(iii) Burning:

Correct area for burning.

Suitable condition for burning.

Correct materials and equipment.

Adequate labour force (one firer per 10 acres).

Notification to local authorities and neighbouring estates.

Escape routes clearly marked.

Access road entrances manned.

Fire-belts established where necessary.

(iv) Pruning, stacking and re-burning:

According to specifications and time schedule.

Adequate labour force.

Correct acreage for progress payment.

(v) Lining:

Immediately after pruning, stacking and re-burning.

Correct spacing between and within rows.

Correct alignment in relation to contours and agricultural road system.

Pegs treated with preservative and firmly placed.

(vi) Clearing timbers along harvesters' paths and from planting points:

According to specifications and time schedule.

Correct chainage and planting points for progress payment.

10.3.3 ***Establishment of covers***

(i) Clean weeding prior to sowing:

Check lining completed.
Spray regenerated growth 4–5 weeks after main burn.
Manual removal of woody species 1–2 weeks later.
Time schedule.
Demarcation of block.
Adequate labour force and spraying equipment.

(ii) Sowing of covers:

Check clean-weeding completed.
Rhizobium culture and C.I.R.P. added in correct proportions.
Drills made to correct depth and spacing.
Correct rate of sowing of scarified seed of selected species per yard of drill.
Time schedule.
Adequate labour force.

(iii) Application of starter mixture:

First application of 30 lb per acre at 1 week and second of 30 lb per acre at 3 weeks after sowing.
Apply on top of foliage when dry.

(iv) Application of C.I.R.P.:

Demarcation of area.
Apply 160 lb per acre C.I.R.P. 3 months after sowing covers.
Distribution of supply points.
Correct organisation of broadcasting labour force.
Adequate labour and transport.

10.3.4 ***Field planting***

(a) *Preparation*

Census of planting points.
Correct age of seedlings from nursery (12–14 months).
Painting with zinc phosphide.
Loading.
Distribution at roadside.
C.I.R.P. packets attached.
Carrying in to planting points.

Ensuring 2-h planting supply carried in on the previous afternoon.
Adequate labour force.

(b) *Planting palms*

Operate in teams of two labourers.
Planting holes of correct size.
Application of C.I.R.P.
Correct depth of planting.
Removal of polybag.
Consolidation of soil.
Adequate labour force and transport.

(c) *Maintenance of covers and palms*

(i) Circle weeding:

Correct interval between rounds for stage of growth.
Correct circle size for stage of growth.
Circle clean-weeded.
No damage to fronds or roots.
No saucer depressions.
Adequate labour force.
Correct equipment and materials.

(ii) Avenues (including inspection paths in first $2\frac{1}{2}$ yr and harvesters' paths):

Correct interval between rounds for stage of planting.
Removal of all non-legumes during pure legume cover phase.
Removal of all noxious growth in post-pure legume phase.
Correct sequence of manual/herbicidal treatments.
Clean-weeded inspection paths of 2-ft width at six-row intervals.
Adequate labour force.
Correct equipment and materials.

(iii) Fertiliser application to covers:

Demarcation of blocks.
Correct timing for C.I.R.P. applications in years 1 and 2.
Apply 240 lb per acre in year 1 and 80 lb per acre in year 2.
Distribution of supply points.
Correct organisation of broadcasting.
Adequate labour force and transport.

(iv) Fertiliser application to palms:

Correct types and quantities of fertiliser in relation to foliar analysis results.

Correct timing of application.

Circle weeding completed in the area.

Distribution of supply points in demarcated area.

Organisation of labour force for spreading fertiliser.

Correct placement of fertiliser for stage of growth.

Adequate labour force and transport.

(d) *Castration*

(i) Preparation:

25% or more of the palms to bear inflorescences in a minimum of 50 acres in a 5000-acre planting.

(ii) Operation:

Monthly rounds from 14–26 months.

Complete removal of all inflorescences and bunches to disposal points.

Disposal points for spraying.

No damage to fronds.

Adequate labour force.

(e) *Assisted pollination*

(i) Pollen collection:

Collect in area where male inflorescences are abundant.

Determine labour force requirements in relation to age of palms in the supply area and the daily pollen requirements.

Drying of pollen for 24 h at 100°F.

Storage in suitable dry containers (for long periods, deep freeze).

(ii) Pollen application:

Determine daily pollen requirements in relation to area being covered (2 g per acre).

Check pollen viability.

Mix pollen and talc evenly in proportion of 1: 5.

Issue correct quantity of pollen mixture to labour force.

Issue hand puffers or long lances according to age.
Remove female inflorescence sheaths in 2½–3 yr stage.
Apply pollen mixture to receptive female inflorescences.
Adequate labour force.

(f) *Pruning*

(i) Initial:

Pruning confined to palms with lowest ripe bunches 2 ft above ground level.
Two fronds retained below lowest ripe bunch.
Remove debris from circle.
Place pruned fronds in avenue, clear of harvesters' paths.
Adequate labour force.

(ii) Annual:

During low crop period.
Two fronds retained below lowest ripe bunch.
Remove debris from circle.
Place pruned fronds in avenue, clear of harvesters' paths.
Adequate labour force.

(g) *Harvesting*

Determination of harvesting interval in relation to quantity of crop and rate of ripening. (Normal intervals: 2½–3 yr, 10–14 days; 4 yr, 10–12 days; over 5 yr, 7–10 days).
Determination of labour force requirements in relation to area to be harvested and terrain conditions.
Harvesting and collection standards.
Missed ripe bunches.
Unripe bunches.
Uncollected loose fruits.
Excessive frond pruning.
Untrimmed bunch stalks.
Disposal of fronds clear of harvesters' paths.
Fruit collection and delivery in relation to factory working hours.
Adequate transport for delivery of fruit.

(h) *Maintenance of roads, culverts, drains and terraces*

Assessment at regular intervals of maintenance requirements in terms of obstructions to water flow.

Breakages of culverts.
Operating efficiency of tide gates.
Breakdown of terrace lips.
Corrective action taken at an early stage.
Roads maintained by regular rounds of grading.

(i) *Pests and diseases*

(i) Assessment:

Daily reporting of the presence of pests or diseases.
Management/specialist diagnosis and decision regarding treatment.

(ii) Treatment:

Demarcation of area to be treated.
Materials and equipment to be used.
Labour requirements.
Correct method of treatment.
Assessment of response by regular inspection to determine increase or decrease of infestation and, in the case of insects, evidence of kill. This should be recorded until control has been achieved.

10.4 A BASIS FOR INSPECTION AND QUANTITATIVE ASSESSMENT OF WORK STANDARDS

The objective in this section is to develop a basis for inspection and quantitative assessment of work standards in relation to the main field practices that are the direct responsibility of the field management. With regard to operations that are carried out under contract, it is assumed that the specifications stipulated within the contract are rigidly used for quantitative assessment of work standards.

The main work items discussed below are therefore confined to the following routine field operations:

(i) Nursery.
(ii) Field planting.
(iii) Weeding: circle and avenue.
(iv) Fertiliser application.
(v) Castration.
(vi) Assisted pollination.

(vii) Pruning.

(viii) Harvesting.

In all cases where systematic quantitative assessments are being made, it is necessary for the inspection staff (Visiting Agents/Manager, Managers and Assistant Managers) to carry field recording forms so that observations may be enumerated for subsequent analysis.

Nursery

The main work items which require systematic inspection and assessment are:

(a) Planting seed and transplanting seedlings.

(b) Consolidation of loose seedlings.

(c) Watering.

(d) Weeding.

(e) Fertiliser application.

(f) Pest and disease control.

(g) Thinning out.

Work items (a), (c), (e) and (f) can only be effectively inspected at the time the operations are being carried out. In view of this, it is essential to employ a full-time senior staff member for nursery supervision. As it is not possible to compensate for growth retardation resulting from faulty techniques in respect of these work items, any necessary corrective action must be taken immediately. Work items (b), (d) and (g) can be inspected within a few days of completion and where work has not been done to the specified standards, corrective action must be taken without delay.

In order to assess the efficiency levels attained in a nursery, it is necessary to record:

(a) The number of germinated seeds in each consignment that are suitable for planting.

(b) The date of planting in the pre-nursery and main nursery.

(c) The numbers transplanted from pre-nursery to main nursery and from main nursery to field. These figures give percentage success at the different stages.

(d) Precipitation.

(e) Dates, types and quantities of fertiliser application.

(f) Incidence of pests and diseases.

In addition to these records, an assessment of the general state of seedling health and vigour should be made at monthly intervals.

Field planting

Inspection and assessment of work standards should be based on observations relating to the following:

(a) Presence of runts and habit abnormalities.

(b) Depth of planting.

(c) Firmness of planting.

For any of these factors, the numbers not conforming to specified work standards should be recorded and expressed as a percentage (for each factor) of the total number of palms inspected during that visit. Systematic inspections should be carried out progressively over the whole period of field planting, so that any corrective action considered necessary can be implemented with minimum delay.

Weeding

Circle: Inspection and assessment of work standards should be based on field observations of the following:

(a) Size of circles in relation to age.

(b) Cleanliness of circles.

(c) Damage to root systems.

(d) Saucer depressions.

Again, for each of these factors, the number of observations where work items have not been completed to specified standards should be recorded and expressed as a percentage of the total number of circles in the inspection sample. Necessary corrective action must again be taken either to remedy the fault or ensure it is not repeated in subsequent rounds.

Avenues: Quantitative assessment is difficult and, for purposes of checking work standards, subjective judgement of the presence or absence of undesirable species is a practical approach. Except in cases where there is considerable infestation by undesirable species, corrective action would usually be taken at the next round. Nevertheless, the field supervisory staff responsible for the area should be warned and instructed to improve subsequent work to the standard required. At the next round in any unsatisfactory area, a careful check should be made to ensure that remedial action has been taken and that standards have returned to normal.

Fertiliser application

Inspection can only be effectively carried out at the time of application and consists essentially of making the observations listed in the check list above in Section 10.3.4.

Castration

Inspection and assessment of work standards consists of observations relating to:

(a) Presence of unremoved inflorescences or bunches.

(b) Non-removal of debris to disposal points.

(c) Damage to fronds.

The percentage occurrence of these factors should be recorded and immediate corrective action taken with respect to items (a) and (b) within the area being inspected. With regard to item (c), no remedial action is possible, but steps should be taken to avoid recurrence.

Assisted pollination

As correction of faulty techniques in any given area cannot be achieved by subsequent inspection, it is essential that periodic inspection by senior management, as well as direct supervision by Field Supervisors/Assistants, should be carried out at the time that the work is in progress. Assessment of work standards should again be based on the factors listed in the check list given in Section 10.3.4 above.

Pruning

Quantitative assessment of work standards should consist of recording:

(a) Number of palms with less than two fronds below the lowest ripe bunch.

(b) Presence of debris in the circles.

(c) Untidy placement of pruned fronds in avenues.

The percentage occurrence of these factors should be determined and in the cases of (b) and (c) corrective action implemented. With regard to (a), the staff responsible for the area should be notified as to the correct procedure to be applied in subsequent rounds.

Harvesting

Assessment of harvesting standards has been fully described in the section dealing with training of harvesters in Chapter 8. In view of the importance

of this work, regular assessment should be made of work standards achieved by both harvesters and the field supervisory staff responsible.

In all cases, regular and systematic inspection should be done, either during the progress of work or as soon as possible after completion. Recording of field observations for subsequent analysis should be a continuous process at all stages of establishment and production. Staff should always be concerned with finding improved methods for organisation, control and inspection of field operations and, to this end, frequent discussion between senior management and field supervisory staff is most desirable.

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APPENDIX I A (1)

Estimated cost differential (in $) of establishing and supervising a central permanent nursery for 2 yr (A) or two separate nurseries (B) for 10000 acres developed over 2 yr (all sites are 80 acres)

Variable cost items	*System*	*Year* 1	*Year* 2	*Residual value*	*Total expenditure*	*Remarks*
Renticing for site selection	A	780	—	—	780	
	B	780	780	—	1560	
Access internal roads to nursery	A	1400	—	—	1400	
	B	1400	1400	—	2800	
Additional cost for clean-clearing (mechanical) nursery site	A	6400	—	—	6400	
	B	6400	6400	—	12800	
Installation of irrigation system	A	180	—	—	180	
	B	180	180	—	360	*(See Table 1)*
Expenditure on irrigation equipment	A	54000	—	27000	27000	
	B	54000	54000	75600	32400	
Stores	A	1000	—	600	400	
	B	1000	1000	1400	600	
Expenditure on staff quarters	A	3000	—	2500	500	
	B	3000	3000	5250	750	
Staff remuneration	A	6600	6600	—	13200	
	B	6600	9900	—	16500	
Savings when using System A			+70060*	—	+17910	*Saving = 2.80¢ per seedling*
(Compound Interest Factor)			—	—	—	
Interest on savings at 6%			—	—	—	
				Total savings	*+17910*	*Total savings = 2.80¢ per seedling*

* No interest charge made on differential between System A and B in year 2.

APPENDIX I A (2)

Summary of net savings and additional costs using a permanent nursery for 10000 acres planted over 2 yr

Distance from permanent nursery to plantings (miles)	*Mileage rates for lorry transport (¢)*	*Savings on establishment and supervision per seedling (¢)*	*Interest earnings from savings per seedling (¢)*	*Returns from increased yields per seedling (¢)*	*Additional transport cost per seedling (¢)**	*Net returns per seedling (¢)*
6	40	2.80	—	4.80	2.40	+ 5.20
	50	"	—	"	3.00	+ 4.60
	60	"	—	"	3.60	+ 4.00
8	40	"	—	"	3.20	+ 4.40
	50	"	—	"	4.00	+ 3.60
	60	"	—	"	4.80	+ 2.80
10	40	"	—	"	4.00	+ 3.60
	50	"	—	"	5.00	+ 2.60
	60	"	—	"	6.00	+ 1.60
12	40	"	—	"	4.80	+ 2.80
	50	"	—	"	6.00	+ 1.60
	60	"	—	"	7.20	+ 0.40
15	40	"	—	"	6.00	+ 1.60
	50	"	—	"	7.50	+ 0.10
	60	"	—	"	9.00	− 1.40
20	40	"	—	"	8.00	− 0.40
	50	"	—	"	10.00	− 2.40
	60	"	—	"	12.00	− 4.40

* Based on a return trip cost.

APPENDIX I B (1)

Estimated cost differential (in $) of establishing and supervising a central permanent nursery for 3 yr (A) or three separate nurseries (B) for 15000 acres developed over 3 yr (all sites are 80 acres)

Variable cost items	*System*	*Years* 1	2	3	*Residual value*	*Total expenditure*	*Remarks*
Renticing for site selection	A	780	—	—	—	780	
	B	780	780	780	—	2340	
Access internal roads to nursery	A	1400	—	—	—	1400	
	B	1400	1400	1400	—	4200	
Additional cost for clean-clearing (mechanical) nursery site	A	6400	—	—	—	6400	
	B	6400	6400	6400	—	19200	
Installation of irrigation system	A	180	—	—	—	180	
	B	180	180	180	—	540	
Expenditure on irrigation equipment	A	54000	—	—	13500	40500	*(See Table 1)*
	B	54000	54000	—	54000	54000	
Stores	A	1000	—	—	400	600	
	B	1000	1000	—	600	1400	
Expenditure on staff quarters	A	3000	—	—	2250	750	
	B	3000	3000	400	4750	1650	
Staff remuneration	A	6600	6600	6600	—	19800	
	B	6600	9900	9900	—	26400	
Savings when using System A (Compound Interest Factor)		—	+70060 +(0.06)	+12460* —	—	+39320	*Saving = 4.10¢ per seedling*
Interest on savings at 6%		—	+4204	—	—	+ 4204	*Earnings on savings = 0.44¢ per seedling*
				Total savings		*+43524*	*Total savings = 4.54¢ per seedling*

* No interest charge made on differential between Systems A and B in year 3.

APPENDIX I B (2)

Summary of net savings and additional costs using a permanent nursery for 15000 acres planted over 3 yr

Distance from permanent nursery to plantings (miles)	*Mileage rates for lorry transport (¢)*	*Savings on establishment and supervision per seedling (¢)*	*Interest earnings from savings per seedling (¢)*	*Returns from increased yields per seedling (¢)*	*Additional transport cost per seedling (¢)**	*Net returns per seedling (¢)*
6	40	4.10	0.44	4.80	2.40	+ 6.94
	50	"	"	"	3.00	+ 6.34
	60	"	"	"	3.60	+ 5.74
8	40	"	"	"	3.20	+ 6.14
	50	"	"	"	4.00	+ 5.34
	60	"	"	"	4.80	+ 4.54
10	40	"	"	"	4.00	+ 5.34
	50	"	"	"	5.00	+ 4.34
	60	"	"	"	6.00	+ 3.34
12	40	"	"	"	4.80	+ 4.54
	50	"	"	"	6.00	+ 3.34
	60	"	"	"	7.20	+ 2.14
15	40	"	"	"	6.00	+ 3.34
	50	"	"	"	7.50	+ 1.84
	60	"	"	"	9.00	+ 0.34
20	40	"	"	"	8.00	+ 1.34
	50	"	"	"	10.00	− 0.66
	60	"	"	"	12.00	− 2.66

* Based on a return trip cost.

APPENDIX I C(1)

Estimated cost differential (in $) of establishing and supervising a central permanent nursery for 4 yr (A) or four separate nurseries (B) for 20000 acres developed over 4 yr (all sites are 80 acres)

Variable cost items	*System*	*Years* 1	2	3	4	*Residual value*	*Total expenditure*	*Remarks*
Renticing for site selection	A	780	—	—	—	—	780	
	B	780	780	780	780	—	3120	
Access internal roads to nursery	A	1400	—	—	—	—	1400	
	B	1400	1400	1400	1400	—	5600	
Additional cost for clean-clearing (mechanical) nursery site	A	6400	—	—	—	—	6400	
	B	6400	6400	6400	6400	—	25600	
Installation of irrigation system	A	180	—	—	—	—	180	
	B	180	180	180	180	—	720	
Expenditure on irrigation equipment	A	54000	—	—	—	—	54000	
	B	54000	54000	—	—	32400	75600	*(See Table 1)*
Stores	A	1000	—	—	—	200	800	
	B	1000	1000	—	—	—	2000	
Expenditure on staff quarters	A	3000	—	—	—	2000	1000	
	B	3000	3000	400	400	4250	2550	
Staff remuneration	A	6600	6600	6600	6600	—	26400	
	B	6600	9900	9900	9900	—	36300	
Savings when using System A		—	+70060	+12460	+12460*	—	+60530	*Saving = 4.73¢ per seedling*
(Compound Interest Factor)			+(0.124)	+ (0.06)	—	—	—	
Interest on savings at 6%			+ 8687	+ 748			9435	*Earnings on savings = 0.74¢ per seedling*
						Total savings	+69965	*Total savings = 5.47¢ per seedling*

* No interest charge made on differential between Systems A and B in year 4.

APPENDIX I C (2)

Summary of net savings and additional costs using a permanent nursery for 20000 acres planted over 4 yr

Distance from permanent nursery to plantings (miles)	*Mileage rates for lorry transport (¢)*	*Savings on establishment and supervision per seedling (¢)*	*Interest earnings from savings per seedling (¢)*	*Returns from increased yields per seedling (¢)*	*Additional transport cost per seedling (¢)**	*Net returns per seedling (¢)*
6	40	4.73	0.74	4.80	2.40	+ 7.87
	50	"	"	"	3.00	+ 7.27
	60	"	"	"	3.60	+ 6.67
8	40	"	"	"	3.20	+ 7.07
	50	"	"	"	4.00	+ 6.27
	60	"	"	"	4.80	+ 5.47
10	40	"	"	"	4.00	+ 6.27
	50	"	"	"	5.00	+ 5.27
	60	"	"	"	6.00	+ 4.27
12	40	"	"	"	4.80	+ 5.47
	50	"	"	"	6.00	+ 4.27
	60	"	"	"	7.20	+ 3.07
15	40	"	"	"	6.00	+ 4.27
	50	"	"	"	7.50	+ 2.77
	60	"	"	"	9.00	+ 1.27
20	40	"	"	"	8.00	+ 2.27
	50	"	"	"	10.00	+ 0.27
	60	"	"	"	12.00	− 1.73

* Based on a return trip cost.

APPENDIX I D (1)

Estimated cost differential (in $) of establishing and supervising a central permanent nursery for 5 yr (A) or five separate nurseries (B) for 25000 acres developed over 5 yr (all sites are 80 acres)

Variable cost items	*System*	*Years* 1	2	3	4	5	*Residual value*	*Total expenditure*	*Remarks*
Renticing for site selection	A	780	—	—	—	—	—	780	
	B	780	780	780	780	780	—	3900	
Access internal roads to nursery	A	1400	—	—	—	—	—	1400	
	B	1400	1400	1400	1400	1400	—	7000	
Additional cost for clean-clearing (mechanical) nursery site	A	6400	—	—	—	—	—	6400	
	B	6400	6400	6400	6400	6400	—	32000	
Installation of irrigation system	A	180	—	—	—	—	—	180	
	B	180	180	180	180	180	—	900	
Expenditure on irrigation equipment	A	54000	—	—	—	54000	40500	67500	
	B	54000	54000	—	—	—	10800	97200	*(See Table 1)*
Stores	A	1000	—	—	—	—	—	1000	
	B	1000	1000	—	—	1000	800	2200	
Expenditure on staff quarters	A	3000	—	—	—	—	1750	1250	
	B	3000	3000	400	400	400	3750	3450	
Staff remuneration	A	6600	6600	6600	6600	6600	—	33000	
	B	6600	9900	9900	9900	9900	—	46200	
Savings when using System A (Compound Interest Factor)		—	+ 70060	+12460	+12460	−40540*	—	+81340	*Saving = 5.08¢ per seedling*
		—	+(0.191)	+(0.124)	+ (0.06)	—	—	—	
Interest on savings at 6%			+ 13381	+ 1545	+ 748			+15674	*Earnings on savings = 0.98¢ per seedling*
						Total savings		*+97014*	*Total savings = 6.06¢ per seedling*

* No interest charge made on differential between Systems A and B in year 5.

APPENDIX 1 D (2)

Summary of net savings and additional costs using a permanent nursery for 25000 acres planted over 5 yr

Distance from permanent nursery to plantings (miles)	*Mileage rates for lorry transport (¢)*	*Savings on establishment and supervision per seedling (¢)*	*Interest earnings from savings per seedling (¢)*	*Returns from increased yields per seedling (¢)*	*Additional transport cost per seedling (¢)**	*Net returns per seedling (¢)*
6	40	5.08	0.98	4.80	2.40	+ 8.46
	50	"	"	"	3.00	+ 7.86
	60	"	"	"	3.60	+ 7.26
8	40	"	"	"	3.20	+ 7.66
	50	"	"	"	4.00	+ 6.86
	60	"	"	"	4.80	+ 6.06
10	40	"	"	"	4.00	+ 6.86
	50	"	"	"	5.00	+ 5.86
	60	"	"	"	6.00	+ 4.86
12	40	"	"	"	4.80	+ 6.06
	50	"	"	"	6.00	+ 4.86
	60	"	"	"	7.20	+ 3.66
15	40	"	"	"	6.00	+ 4.86
	50	"	"	"	7.50	+ 3.36
	60	"	"	"	9.00	+ 1.86
20	40	"	"	"	8.00	+ 2.86
	50	"	"	"	10.00	+ 0.86
	60	"	"	"	12.00	− 1.14

* Based on a return trip cost.

APPENDIX II

CONTRACT SPECIFICATIONS

The following specifications are those used by the Federal Land Development Authority:

(a) *Specification for felling, burning, pruning, stacking and re-burning*

1. Felling and burning shall be carried out in areas which carry a stand of virgin jungle, excluding swamps, ravines, occupied lands, river reserves, steep land over 12½% slope, vacant and *lallang* areas and any other areas unsuitable for planting of the oil palm within the perimeter of the area shown in the attached plan, the approximate acreage of which is as stated therein. After completion of the major burn, if applicable, the Authority shall demarcate and reserve an area for village site, if any, the approximate acreage of which is stated in the plan attached, and in such area the Contractor shall not be required to prune, stack and re-burn and do any or all other works required under the contract.

2. The area is as shown on the plan attached and the boundaries thereof shall be marked on the ground by stakes. No account shall be taken of any works carried out outside the boundaries so marked.

3. The Contractor shall carry out underbrushing (felling of undergrowths) before the work of felling shall commence.

4. Felling of trees shall be as follows:

Dimension of trees	*Felling shall be done at a height of*
All *belukar* and small trees up to a diameter of 3 in. shall be felled first	6 in. from ground level
All trees between 3–6 in. diam	1 ft from ground level
All trees between 6–12 in. diam	2 ft from ground level
All trees between 12–30 in. diam	3 ft from ground level
All trees between 30–60 in. diam	5 ft from ground level
All trees 60+ in. diam	Shall be felled at the point where the buttress roots meet the main trunk

5. Where a tree is struck by another and thereby breaks at a height in excess of the above-mentioned specification, that tree shall be cut to the required height. All trees shall be cut clear of the stumps and no tree shall be left suspended.

6. All trees shall be felled inwards from the perimeter rentices. Roads and tracks which are indicated by the Superintending Officer within the area shall be left clear for vehicles to pass. If, however, any trees have been felled on or across such roads, tracks and perimeter rentices, the clearance of the roads, tracks and perimeter rentices shall be done by the Contractor at his expense or, if he fails to do so, by the Authority at the expense of the Contractor.

7. Trees shall not be felled into or across any river, stream, swamp or ravine. Any tree or part thereof falling into or across river, stream, swamp or ravine shall be cleared by the Contractor at his own expense or, if he fails to do so, by the Authority at the expense of the Contractor.

8. Trees in swamps, ravines, river reserves, alienated lands, lands illegally occupied, vacant and *lallang* areas, and any areas unsuitable for planting, shall not be felled. Any tree so felled shall be cleared out of the swamps, *etc.*, by the Contractor at his expense or, if he fails to do so, by the Authority at the expense of the Contractor. The Contractor is also liable for damages, if any, for such illegal felling.

9. All timber 6 in. and less in diameter shall be cut, stacked and completely burnt to ashes. Dead trees shall be felled within one month of the first major burn of the entire felled area.

10. After pruning, stacking and re-burning, all growths and regenerations of any kind of vegetation whatsoever, including *lallang*, undesirable grass, weeds, bamboos, bertams, rotan, wild bananas and other noxious growths, shall be completely eradicated and dead by the roots before lining takes place and the area shall so be kept absolutely clean until and up to the time of sowing of the cover crop seeds and the final take over of the covers from the Contractor. The Contractor shall obtain his own poison spraying licence and shall strictly comply with the Poison Ordinance (1949).

11. The Contractor shall be held responsible and shall pay for any damages caused by any means whatsoever to the neighbouring estates or property.

(b) *Specification for construction of jeepable tracks*

1. Jeepable tracks shall be constructed in the area which carried a stand of virgin jungle and ploughed and harrowed area and vacant area covering the whole phase as shown in the Plan. Works shall begin immediately after the first major burn has taken place.

2. The length of the tracks shall be at the rate of about 1.0–1.5 chains per acre of development area.

3. The alignment of the tracks shall follow the contour and shall be pegged by the Contractor in consultation with the Superintending Officer. The top 6 in. of the pegs shall be painted red.

4. The tracks shall be with a minimum pavement width of 12 ft. No side drains are required.

5. The tracks shall have a camber with an average crossfall of 1 in 12.

6. Where there is a dead end the Contractor shall construct a turning place as indicated by the Superintending Officer.

(c) *Specification for repairs and renovation of old timber tracks*

1. Repairs and renovating shall be carried out to old timber tracks as indicated by the Superintending Officer.

2. The tracks shall be graded mechanically and put back to have a camber with an average crossfall of 1 in 12.

3. All pot-holes shall be filled up with laterite or approved granular material and finished to the required camber.

(d) *Specification for lining in oil palm areas*

1. The whole of the plantable oil palm area shall be lined under the direction and supervision of the Superintending Officer.

2. Lining stakes shall be supplied by the Contractor. Stakes shall be 4 ft high and coloured as directed by the Superintending Officer.

3. Planting distance shall be triangular 29 ft x 29 ft giving 60 points to one acre.

4. Issue of certificate. Certificate for payment will only be issued after satisfactory compliance of all works under this specification, provided also the entire area has been kept clean of all growths and regenerations of any kind of vegetation whatsoever as provided

under Item 10 of the Specification for felling, burning, pruning, stacking and re-burning.

(e) *Specification for the establishment of leguminous cover*

1. Prior to sowing, the entire area shall have been clean-weeded of all growths and regenerations of any kind of vegetation whatsoever including *lallang*, undesirable grass, weeds, bamboos, bertams, rotan, wild bananas and all other noxious growths which shall have been completely eradicated and dead by the roots.

2. Sowing of the creeping leguminous cover seeds shall be carried out over the entire plantable area, provided the weather is suitable, and as soon as possible after the work of lining is completed as directed by the Superintending Officer.

3. The species of the cover plants and the rate of application per acre shall be as follows:

Species of cover crops	*Rate of application per acre*
Centrosema pubescens	3 lb
Pueraria javanica	2 lb
Total	5 lb

4. The seed-mixture shall be treated with *Rhizobium* Compost in the proportion as specified by the Rubber Research Institute; and the seed-mixture shall then be mixed with its own weight of rock phosphate before application in the field.

5. Sowing of seed-mixture shall be at five cultivated drills to be spaced at 5-ft intervals or at any distance as indicated by the Superintending Officer.

6. Sowing of the seed-mixture shall be carried out in the following manner:

   (a) The drills shall be made by using a *changkol* or other means to a depth as indicated by the Superintending Officer.

   (b) The seed-mixture shall then be evenly distributed along the drills.

   (c) The drills with the seed-mixture shall then be covered with earth.

(d) The number of labourers required shall be as directed by the Superintending Officer so as to enable the sowing of the cover to be completed within the date of completion.

7. Dusting with rock phosphate or any other fertiliser approved by the Authority shall be carried out as and when directed by the Superintending Officer after sowing of covers at the rate of 2 oz per running yard (approx. 180 lb per acre) in two applications. The interval between the two applications is to be decided by the Superintending Officer.

8. The Contractor shall, at his own expense, purchase and deliver for storage to the Authority's Scheme store, the stipulated quantity of cover crops seeds from a source to be approved by the Authority, *Rhizobium* compost and rock phosphate or any other fertiliser to be approved by the Authority, prior to their application in the field. Safety of storage shall be the responsibility of the Authority.

9. (a) A Certificate for Payment, in respect of any block of not less than 250 acres, may be issued not earlier than one month after the cover crops have been sown thereon in accordance with this Specification for the Establishment of Leguminous Cover Crops, provided that:

(i) the cover crops have germinated in not less than 90% of the said block of 250 acres; and

(ii) the said block of 250 acres has been kept clean and free from all noxious and undesirable growths, as provided under Item 10 of the Specification for felling, burning, pruning, stacking and re-burning.

(b) The take-over acreage for maintenance of the said block of 250 acres or part thereof shall be based on the acreage where the cover crops sown have germinated as provided under Item 9 (a) (i) above and such maintenance acreage shall be the acreage for which a Certificate for Payment shall be issued under Item 9 (a) above.

(c) Where a part or parts within the said block of 250 acres has or have been excluded from a Certificate for Payment by reason of the failure of the cover crops to germinate, then the Contractor shall, in regard to the area in which the cover crops have failed to germinate, at his own cost and expense, re-sow and maintain the cover crops and the area until successfully germinated. A Certificate for Payment for the balance of the block not originally certified shall be issued when the cover crops sown in the balance area has fully germinated.

(f) *Specification for maintenance of oil palm area*

1. Maintenance shall commence from the date on which the Contract for establishing of covers is taken over by the Authority. The work of maintenance shall continue until such time as the Settlers are able to take over the maintenance work or earlier as may be decided by the Authority.

2. The entire area to be maintained shall be free from all noxious growths and regenerations of any kind of vegetation whatsoever including *lallang*, undesirable grass, weeds, bamboos, bertams, rotan, wild bananas and other noxious growths which shall be eradicated and dead by the roots to the entire satisfaction of the Superintending Officer.

3. Circle weeding around the planting point shall be clean-weeded to radius of 4 ft around the planting point or up to the periphery of the lowest fronds when such peripheries have extended beyond the original 4 ft radius and maintained as per (2) above.

4. The Contractor shall have sufficient number of labourers per working day so as to enable the work of maintenance of the entire area to be successfully completed on the basis of every round of not less than 30 days. Every round of work shall not in any event be completed earlier than 30 days but with the consent in writing of the Superintending Officer every round of work may be completed later than 30 days provided the Contractor shall not be entitled to any extra payment for such extended days.

5. The Contractor shall, at his own expense, purchase and deliver to the Authority's Scheme store the necessary chemicals, *etc.*, as directed by the Superintending Officer, for the due performance of the above work. The Contractor shall obtain his own poison spraying licence and shall strictly comply with the Poison Ordinance (1949).

6. Upon completion of every round of maintenance over the entire area to specification and upon the Contractor's compliance with all the terms herein agreed to by the Contractor to the entire satisfaction of the Superintending Officer, the Contractor shall be paid for every such round of 30 days or more 90% of the agreed price for maintenance and the balance 10% shall be retained by the Authority as a Retention Fund which fund shall be additional to the Security Deposit. Provided that when the sums retained as Retention Fund and added to the Security Deposit amount in the aggregate to a

sum equivalent to the Contract Sum of one round then any subsequent certificate issued by the Superintending Officer shall amount to the full value of the work of one round, provided the Superintending Officer is satisfied with the Contractors' work.

7. The aggregate Retention Fund retained for every round of work and the Security Deposit shall be paid to the Contractor within 3 months from the date of completion of the last and final round of work and upon the area worked by the Contractor has a certified surveyed acreage;

or

if the work has been completed by the Contractor but the area does not have a certified surveyed acreage then within 3 months from the date the certified surveyed acreage is known;

and

that in any event the Contractor shall have satisfied the Superintending Officer by a Statutory Declaration made by the Contractor and a certificate signed by or on behalf of the Commissioner for Labour of the nearest Labour Office to the effect that all wages due, Employees Provident Fund contribution, monies due under the Workmen Compensation and all workmen employed have all been paid.

(g) *Specification for holing and field planting of oil palm seedlings from polythene bags*

(i) *At the nursery* (location of nursery to be indicated by the Superintending Officer):

1. The oil palm seedlings in polythene bags (hereinafter called 'the seedlings') shall be thoroughly watered in the manner and time to be indicated by the Superintending Officer before they are lifted for transportation to the field proper for planting.

2. The seedlings shall be lifted carefully from the ground to prevent breakage of the polythene bags and carried to and loaded onto the transport for conveyance to the field proper. Transport shall be provided by the Contractor at his own expense.

3. The seedlings shall be transported to the field area for planting and unloaded at various points therein as indicated by the Superintending Officer.

4. Any seedlings found to be in damaged/torn polythene bags shall be wrapped and tied with a hessian bag to prevent the earth clod from disintegrating.

(ii) *On the field proper:*

1. The Contractor shall at his own expense purchase and deliver for storage at the Authority's Scheme Store the stipulated quantity of rock phosphate or any other fertiliser to be approved by the Authority:

2. Just prior to planting in the field proper, holes shall be dug to a size sufficiently large to accommodate the earth ball of the seedling in the polythene bag. The Contractor shall then apply 8 oz of rock phosphate per hole.

3. The bottom of the polythene bag shall be slit and the bag placed in the hole and then the side of the polythene bag shall be slit and carefully removed upwards, at the same time soil added to the hole, so that the chances of the earth ball breaking is minimised. The top soil shall be placed firmly around the earth ball and rammed firmly until the earth surface is in line with the seedling's collar. The ramming shall be carried out with a heavy wooden rammer to be supplied by the Contractor. The rammer shall be of a size and shape as directed by the Superintending Officer. The empty polythene bag will then be used as a mulch around the collar of the seedling.

4. A minimum of 3000 seedlings per working day shall be transported from the nursery and planted into the field proper or of an increased number as may be directed by the Superintending Officer depending on the acreage and time involved for the work under this Specification.

5. The Contractor shall compensate the Authority at $5 per seedling damaged as a result of Contractor's negligence and or non-compliance with the conditions in this Specification and the Authority shall deduct such compensation from any monies due to the Contractor under this Contract.

6. The Authority reserves the right to stop the Contractor from further works should damages as per clause (ii) (5) above exceed 2% of the total number of seedlings to be planted.

7. The whole planting shall be completed within the period stipulated in the Contract, provided the weather is suitable.

The Superintending Officer reserves the right to stop th planting at any time if in his opinion the weather is n suitable. In such a case extension of date of completio shall be given for the number of days during which th planting work was stopped by the Superintending Officer du to unfavourable weather.

(h) *Specification for the works of cutting and removal of timber on plantin points in oil palm schemes*

1. The Contractor shall cut and remove:

   (i) All timber logs lying on or across the planted points, and

   (ii) all standing stumps not exceeding 18 in. diam within a radiu of 8 ft from the base of the oil palm.

2. The Contractor shall cut such timber by means of chain-saws an standing stumps shall be cut as close as possible to the ground leve

3. The Contractor shall then remove all cut timber into the interrows such cut timber shall not be removed and placed on or across th harvesting paths.

(i) *Specifications for clearing and removal of timber along harvesting paths*

1. The alignment of the harvesting paths (hereinafter called 'the paths' shall be indicated to the Contractor by the Superintending Officer It is estimated that in 1 acre of planted/plantable area there may be 10–12 chains of paths.

2. (i) All fallen timber lying across the paths shall be cut out to a width of not less than 5 ft, *i.e.* the width of the paths.

   (ii) The cut timber shall then be removed to either side of the paths at a distance far enough for it not to roll onto the paths, so as to keep the paths free from all obstacles and to allow unobstructed access at all times.

3. The Contractor shall supply at his own cost and expense the required number of chain-saws, labour and everything else necessary for the due performance of the work under the Specifications. The number of chain-saws, labourers, *etc.*, required for the due performance of the work under these Specifications shall be decided by the Contractor and the Superintending Officer using the period of completion and daily output of work as a basis of reckoning.