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NEW TECHNIQUES IN IRRIGATION
AND MANAGEMENT OF LARGE OIL PALM
NURSERIES

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NEW TECHNIQUES IN IRRIGATION AND MANAGEMENT OF LARGE OIL PALM NURSERIES

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ABSTRACT

A new method for irrigation as applied to a 25 hectares oil palm nursery is described and the method of installation and layout discussed. Capital costings are given and it is shown that these can be significantly lower than those for conventional overhead sprinkler systems. The methods described are those found most satisfactory after considerable trial and error. Manpower requirements for operation are discussed and compared with conventional overhead sprinkler systems.

Associated nursery techniques and adaptations to these whilst utilising this irrigation system are described.

Production costs of the 9 month old seedling from receipt as germinated seed until ready for the field under this two-stage nursery system are tabulated.

Advantages, of the system, other than financial are discussed, as are any possible disadvantages. Nursery fertilisers, treatment of doubletons, use of solar powered electric fencing and transporting of palms to the field are also discussed.

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1. INTRODUCTION

Kerdau Estate in Pahang is being developed from 4,856 hectares of jungle. Felling of the development areas commenced in March 1986 and the area is planned to be fully planted by March 1988, a period of two years. Nursery site clearance commenced in August 1985 and first deliveries of seed were received in October 1985.

With the scheduled programme, it was apparent that the nursery would have to be large and capable of holding up to 500,000 polybag seedlings at any one time. The brief life span of the nursery (under 3 years) also made it desirable to minimise the capital expenditure on irrigation and other nursery equipment in view of the short period available for write-off. Therefore a cheaper alternative to the conventional systems of overhead-sprinkler nursery irrigation was sought.

Labour shortage and lack of accommodation on site made it essential that any system used should require the minimum of labour and this factor indicated that a permanent, as opposed to moveable, irrigation system be used.

The major part of this paper describes the utilisation, in an oil palm pre-nursery and main nursery, of Sumisansui MK II black polythene layflat tube of 50 mm width obtainable in 100 m rolls (Fig. 1). The upper surface of this tube has two rows of holes, punctured by laser, 15 cm apart. The tube is designed to withstand a water pressure of 0.8 kg/cm^2 .

Each 100 m roll is 25 cm in diameter and weighs 2.5 kg and is thus very light and easy to transport. A five tonne lorry can carry 2,000 rolls, adequate for 54 hectares of nursery.

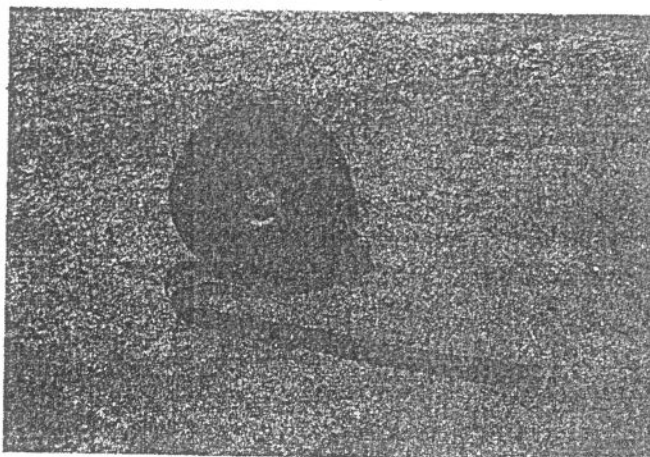


Fig. 1 A 100 m roll of the layflat perforated tube.

The tube was designed originally for operations in Japan on horticultural small-holdings with relatively low water-pressures provided by small pump units. It was first seen by the senior author in use in a small cocoa nursery in Pahang and a length was then purchased for trial within his garden.

Its application as described in this paper for a 25 hectare oil-palm nursery is believed to be the largest unit utilising this irrigation method to-date.

The advantages of the system recommend it for wider usage. In isolated areas with poor communications (e.g. certain areas of Sarawak and Sabah) where transport of heavy or bulky materials can add so much to initial equipment costs, even greater cost advantages could be forthcoming.

As well as irrigation aspects at Kerbau, several other points on techniques that differ from earlier standard practice are also described, where thought to have advantages for general application.

Note:

Whilst it is appreciated that for technical papers it is now the norm to use only metric designations, it is a fact that in Malaysia many items e.g. piping, sawn timber etc., are still marketed in standard sizes utilising Imperial measure units. Where this is applicable and unavoidable in this paper the Imperial unit is so quoted and we apologise to those readers who may be unfamiliar with this.

For general conversion usage 1 inch (also expressed as 1") converts to 2.54 cm.

Pipe lengths in Malaysia come in standard 20 foot lengths equivalent to 6.096 m.

2. PRE-NURSERY LAYOUT

In the pre-nursery at Kerdau, germination beds measuring 1.22 m wide and 45.73 m long are constructed from cheap 1 cm thick x 15 cm wide planking. This type of pre-nursery bed has long been used in Malaysia (Duckett 1964).

The width of the bed allows for 13 filled small perforated polybags (15 cm x 23 cm layflat) to be placed across the bed, and this number allows workers easy access, from both sides, to all bags for future operations.

The bags are filled with good quality and preferably free draining soil and within these the germinated Oil Palm seeds are planted at receipt.

No shade is utilised at any stage and, whilst this has been recommended previously (Ng 1972), we find it unnecessary if adequate watering is ensured and believe that it can lead to undesirable etiolation, particularly if removal is delayed for any reason.

A path 0.61 m wide is maintained between each bed, a distance found to be adequate to allow workers to carry out their various duties in the pre-nursery.

The Sumisansui Mark II tubing is laid in the middle of alternate paths between the beds and, each tube is controlled by a separate 3/4" gate valve leading from a 1" PVC feeder. This permits selective watering of any or all of the beds as required and allows work to continue in sections of the pre-nursery whilst watering is in progress elsewhere. It also permits the heavy application of 0.2 - 0.3 litre per seedling per day determined by Bevan et al (1966) as desirable for pre-nurseries.

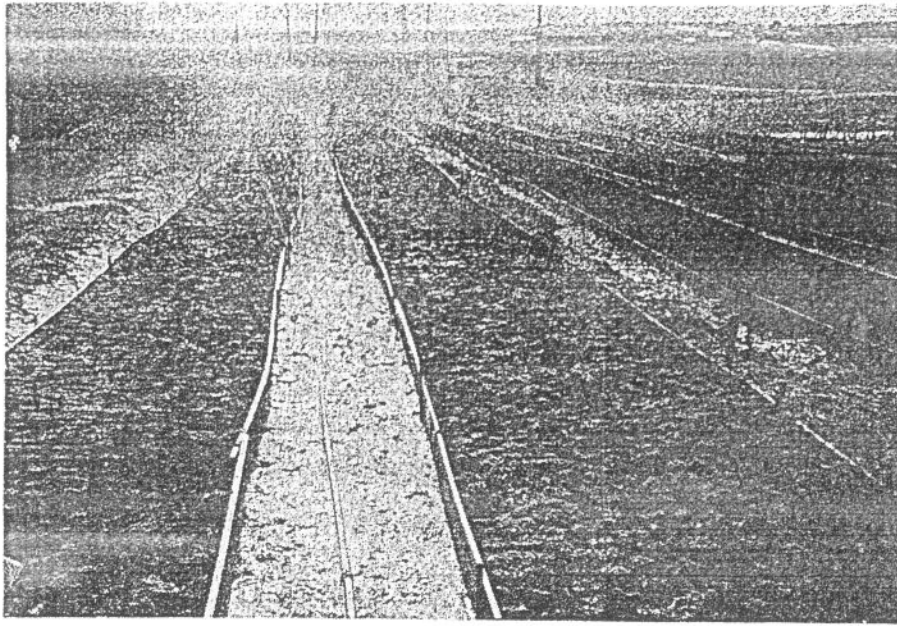


Fig. 2 The perforated tube in use in the pre-nursery

The pre-nursery irrigation system operates from a small separate dam and is powered by a Lister 6hp air cooled diesel engine and 2½" intake/2" outlet pump (China made). This in turn is stepped down to 1½" then 1" PVC piping to ensure adequate pressure. Pressure is regulated for each Sumisansui tube by the adjustment of the gate valve.

Normally watering for half an hour early in the morning and a further half an hour in the evening proved fully adequate with this system. Thorough wetting is fully achieved in around 20 minutes.

Kerdau pre-nursery consists of 44 beds, capable of holding 264,000 seedlings in small polybags.

One full time worker is all that is required to take charge fully of watering, manuring and pest and disease work for the whole pre-nursery.

3. MAIN NURSERY LAY-OUT

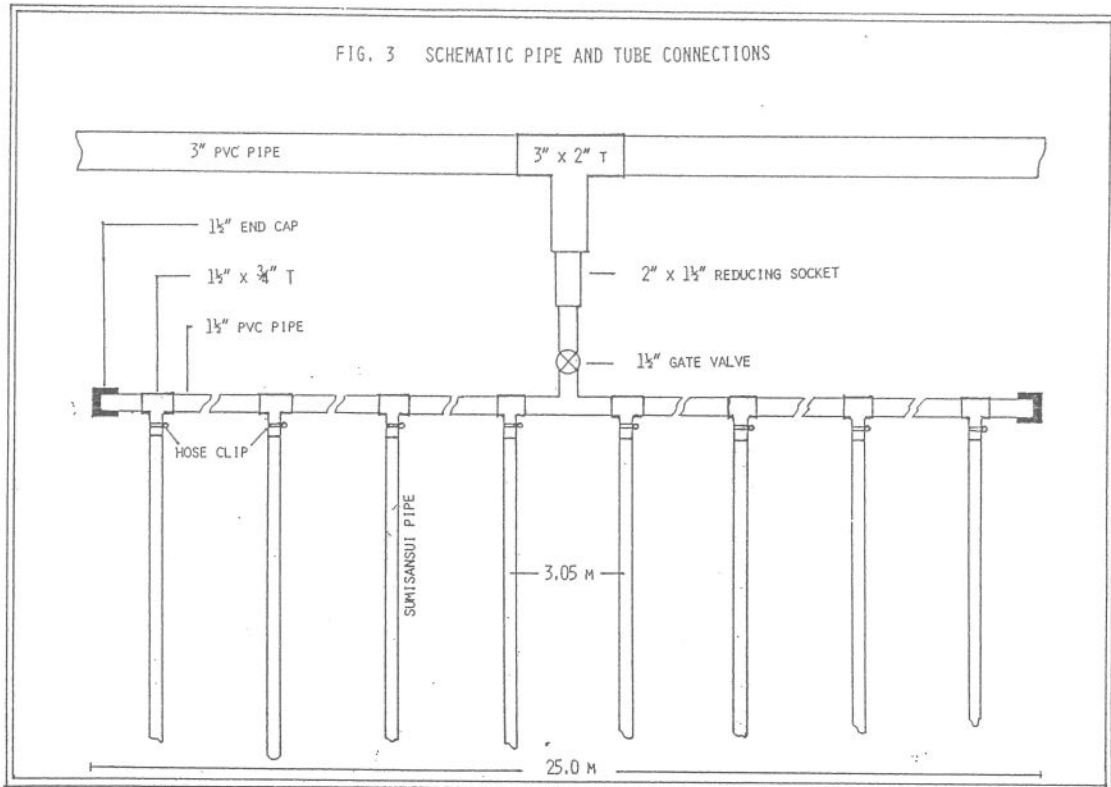
The layout of the irrigation system has been arrived at after much trial and error. Various trials indicated that one line of Sumisansui tube could satisfactorily irrigate 5 rows of bags when these were placed at 0.76 m. triangular spacing. Thus distance between two lines of tube is 3.05 m. This spacing allows for 19,900 polybags per hectare.

A 3" main supply pipe line of Class 'B' PVC is utilised and this is placed so as to bisect the nursery as far as is possible. If necessary the nursery can be divided into several sections, each centrally served by a 3" pipe which in turn can be served by a larger bore PVC Class 'D' 4" pipe direct from the pump to achieve the same objective.

From the 3" PVC pipe, outlets are stepped down to 2" and then 1½" and a 1½" gate valve is fitted to control the main flow.

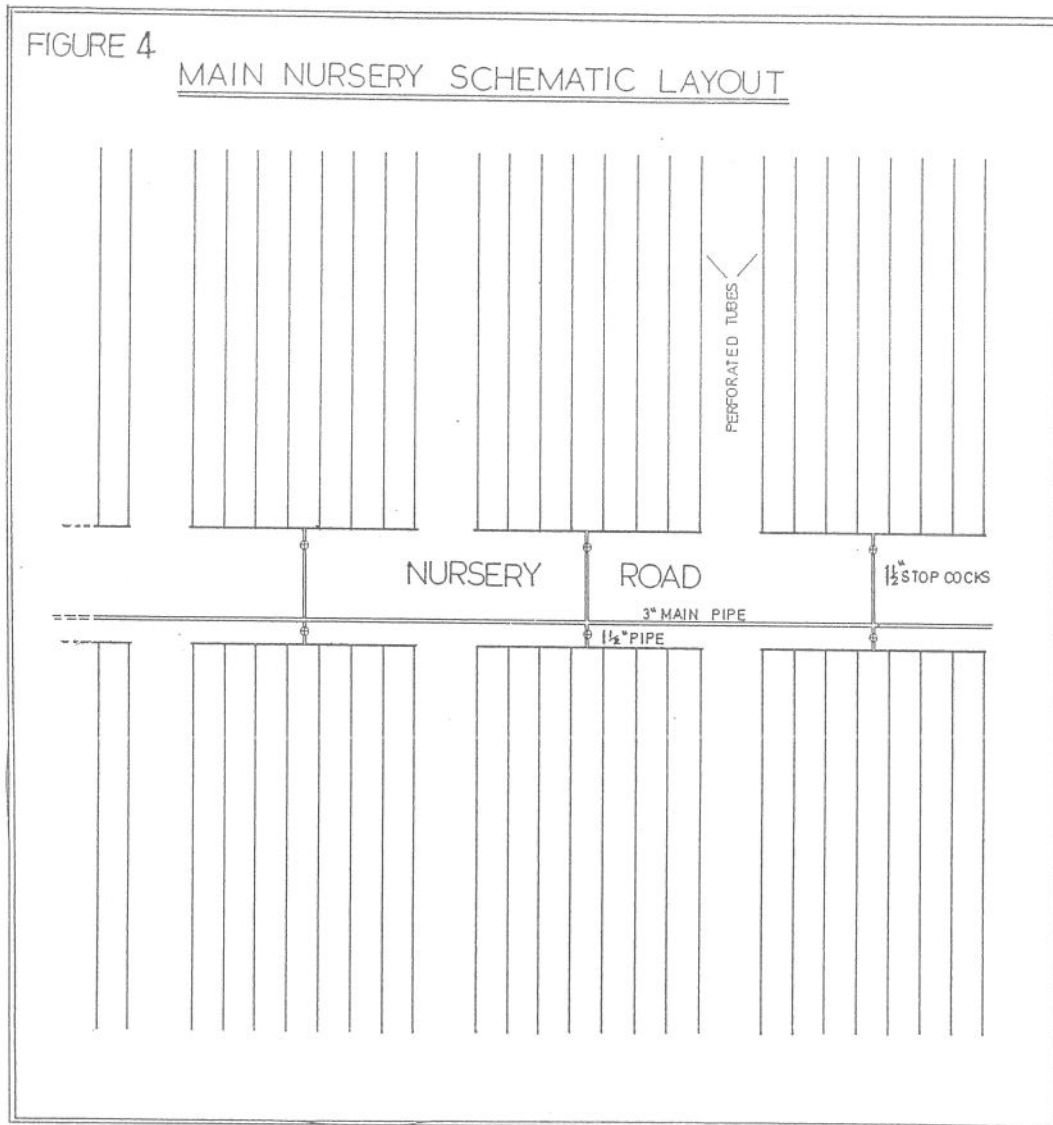
From this gate valve the flow is transferred to a 1½" Class 'B' PVC pipe to which are connected 8 lengths of Sumisansui perforated tube via 1½" x ¾" PVC T-joints. (Fig. 3).

Thus each 1½" gate valve controls a 25 m length of 1½" PVC pipe to which are connected at 3.05 m intervals 8 x 100 m lengths of Sumisansui tube i.e. each gate valve controls the irrigation of 2,440 sq. m.



We do not recommend using less than eight Sumisansui tubes served from one 1½" gate valve as the increased pressure with all valves fully opened can lead to pipe-joint and tube bursts.

Step downs from the 3" main pipe are continued along each side of the main pipe with each serving an 8 tube unit (Fig. 4).



As shown in Fig. 4 the main 3" pipeline runs along the side of a nursery road and the lead-off pipes crossing the road are buried beneath the road surface.

Thus in summary the arrangement, and practical application of these at Kerbau, are as follows -

A second hand Isuzu 120 hp diesel engine with an 8" intake/6" outlet mining pump, provides the water source. The 6" outlet is stepped down to a relatively short length of 4" Class 'D' PVC pipe which is in turn stepped down to the centrally positioned 3" Class 'B' PVC main lines. With this arrangement, we have found that with 20 of the 1½" gate valves fully opened (i.e. using 160 x 100 m lengths of Sumisansui covering approximately 5 hectares) we obtain optimum pressure over the optimum area to be watered at any one time. Thus to cover the whole nursery of 25 hectares, we have to carry out watering over five separate irrigation sections.

Under normal circumstances an irrigation period of 30 to 45 minutes, as a single application each day, is fully adequate. However during prolonged dry periods this is extended to one hour per day.

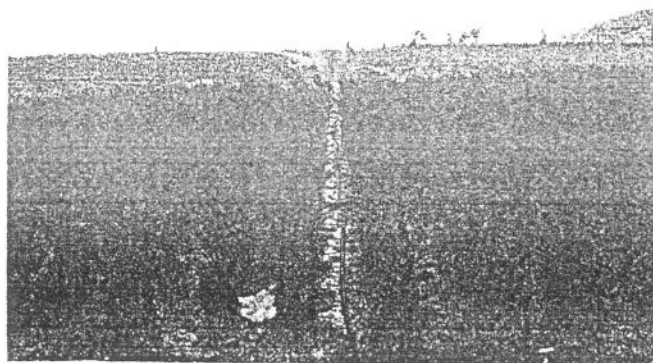


Fig. 5 Placement of the perforated hose between every fifth row of palms.

4. WATERING EFFICIENCY IN THE MAIN NURSERY

Bevan and Gray (1969) indicate that for optimum growth in nurseries, there should be 8 mm water per day applied.

We wished to confirm that our applications, which were obviously fully adequate, were within the indicated range and measurements were taken on windless days. We had anticipated that the centre section of each bed (i.e. that area within range of the two perforated tubes to both left and right) would record higher levels. The actual readings obtained were as follows -

	<u>Precipitation in 30 minutes</u>	<u>Precipitation in 45 minutes</u>
Side of bed	3.81 mm	5.59 mm
Centre of bed	21.08 mm	28.96 mm

From the above, it is apparent that precipitation from the perforated hose is very variable when recorded at different distances from the hose. As all palms showed comparative and excellent growth regardless of distance placed from a hose, it would be easy to say that the 3.81 mm received per day as recorded above is adequate. However, the above readings were taken upon completely still days where there was no air movement. Such days are comparatively rare and when there is any air movement whatsoever, it is very obvious that there is sympathetic movement of the very fine mist droplets produced and that these are continually swirling back and forth and thus on non-still days the variation in precipitation at various locations in the beds is greatly reduced. In view of this we have concluded that the variation in precipitation at varying distances from the hose has very little practical significance and we most definitely have observed no difference in palm growth at the different locations.

At half an hour per day irrigation we would appear to be applying on average around 10 - 12 mm of water, which is above the minimum 8 mm previously considered necessary.

We do believe however, from experience elsewhere that most conventional nurseries in Malaysia do utilise far heavier rates than the recommended 8 mm per day to achieve thorough wetting of bag soil. Our experience leads us to suggest that 15 mm to 20 mm is about the norm and in view of this we feel that the perforated tube is more effective, possibly due to the very fine mist droplet produced.

We have noted that with the perforated tube, there is no 'hard cap' formed on the bag soil as occurs from the pounding of the soil surface by heavy droplets that we have observed in the sprinkler system. We have also observed that fertiliser placed on the soil surface of the bag is not disturbed or splashed out of the bag as occurs with conventional, large droplet, sprinkler systems.

It is therefore possible that both penetration of water and uptake of fertiliser are more efficient with the perforated tube system and that both leaching and loss of fertiliser are minimised. These points would go a long way to explain the good growth rates as evidenced by the following measurements.

Using one of the parameters given by Tan & Mohan (1981) we give measurements as follows -

Length of Youngest Opened Leaf (in cm)	
At 4 months	32.3 cm
At 7 months	44.3 cm
At 9 months (i.e. at field planting)	78.3 cm
At 12 months (i.e. 3 months after field planting.)	93.9 cm

Further data obtained at Kerdau as regard percentage of seedlings with pinnate leaves are as follows -

At 7 months	91%
At 8 months	100%
At 9 months	100%

5. SOME GENERAL POINTS NOTED IN THE USE OF THE SUMLSANSUI MARK II IRRIGATION TUBES AT KERDAU ESTATE

- i) The ground upon which the tube lies should be free of grass or weeds as this can block holes or divert the direction of the spray.
- ii) The ground should be free of hard or sharp articles that could lead to puncturing of the tubes if any weight is placed on them.
- iii) The very effective spread of spray is achieved by the elliptical shape that the tube assumes once water pressure is built up. This ensures that the two lines of laser perforated holes are pointed one to the left and one to the right of the tube and this is most important for correct spread of the mist. It is therefore essential that the tube is laid on a level base along its length or an uneven spread of mist will result (Fig. 6).

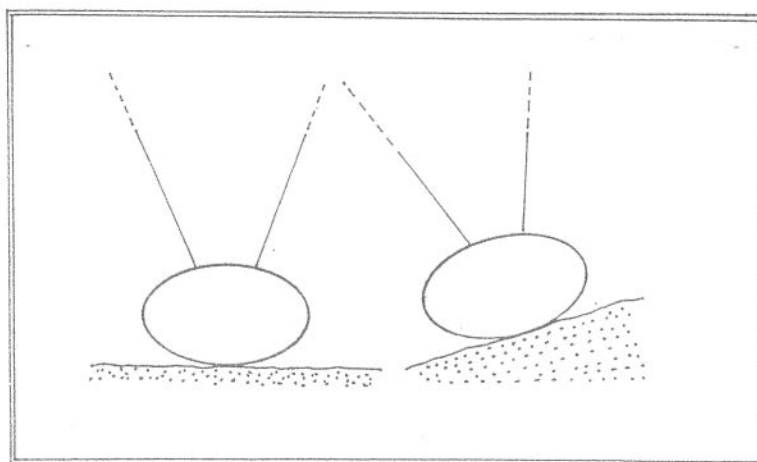


Fig. 6. Indicates how mist spray distribution can be affected if ground on which tube lies is not level.

- iv) Whilst a completely flat site is of course ideal, this in practice is not always attainable and in fact Kerdau pre-nursery is located on a slope. The germination beds are set up on small terraces that are cut into the slope and this arrangement has caused no problems whatsoever.
- v) Both in the pre-nursery and the main-nursery heavy wind can misplace the pipe when it is unweighted by water and to prevent this, we in all locations use 18 gauge GI wire "staples" made from 15 - 20 cm lengths of wire by nursery workers which are pegged over the Sumisansui tube at every 6 m or so (Fig. 7).

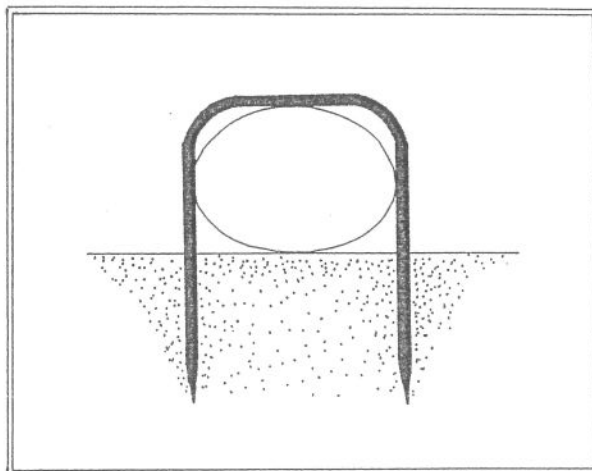


Fig. 7 The wire 'staple' used to ensure that wind does not blow the empty tube out of place.

- vi) Blockages due to sediment in tubes can happen. The best answer is a water filter at the suction valve of the nursery pump. However if such blockages do occur, open the stop end of the pipes once a fortnight with the water running - this soon flushes through any debris or sediment that is trapped in the tube.

- vii) In determining whether the pressure in the tubes is correct, the ideal would be to incorporate a meter for check read-offs. However we have not done so and as a very useful rule of thumb, we have noted that if water pressure is such that the height of spray does not exceed 2.13 m, there is no undue pressure on the tube that will result in bursts.
- viii) Whilst in the paper we refer to the tube ends being closed by 3/4" stop-caps, which was the method used initially, we find that in practice it is perfectly satisfactory to close the tubes by simply knotting the end.
- ix) Where, as is normal, soil for bag-filling is dug on site it is a relatively easy procedure to roll up the perforated tubes so that preparation by ploughing and rotovation can be carried out over large sections of the nursery at one time.
- x) In Japan life of the perforated tube has been proven to be at least five years, admittedly under temperate conditions. We have, at time of presenting this paper, had the tubing in use for two years and as yet there is no indication of deterioration or wear that would suggest that it is approaching the end of its useful life. We have little doubt that it will complete the requirement at Kerdau and that most, if not all of it, will be able to be transferred for use elsewhere.
- xi) We have found from experience that it is desirable that all PVC pipes should, wherever possible, be covered by several inches of soil to avoid solar heating to a degree whereby seedlings could be scorched. If this is done the lines of the pipes should be clearly and permanently marked to avoid vehicle damage.

6. USE OF DOUBLE STAGE NURSERY

Whilst there are differences of opinion as to whether a single-stage or a double-stage nursery produces the best results (cf. Hertslet & Duckett 1983 and Tan & Mohan 1981) the decision to utilise the double-stage nursery was to provide a degree of insurance for the very large planting area involved. If field preparation had at any time fallen behind schedule and the plants for one phase had been unable to be cleared from the nursery at the programmed date, there would be less pressure for space in the main nursery. Seeds planted for the subsequent phase could be held in the pre-nursery for up to four months or more in the worst possible situation, before requiring transfer to large polybags.

Under normal circumstances we programme to have seedlings in the pre-nursery for a maximum of only 3 months, and agree fully with Tan & Mohan that transplanting at four months is definitely too late and that in such circumstances etiolation and reduced leaf production can occur.

We believe that if seedlings are held no longer than 3 months in the pre-nursery, there is no restriction on growth although we admit that no comparative trial has been carried out at Kerdau.

Certainly measurements recorded at Kerdau appear to compare with the results noted by Tan & Mohan (1981) for the single-stage nursery but this is not truly conclusive as the use of different planting material could give rise to genetic differences which could make the comparison non-valid.

Whilst, on first reaction the nine month old palm transplanted to the field at Kerdau may appear too young when reviewed against some literature (Khoo & Choo 1977), we are firmly convinced that size, not age, should be the criteria for planting out and in this respect the irrigation and management systems used have had advantageous rather than deliterious effects.

Shortening of the nursery period by 25%, brings considerable cost reduction.

7. PRE-NURSERY & MAIN NURSERY FERTILISER REGIMES

Pre-nursery fertiliser

- In bag soil at filling - 10 gm Rock Phosphate
- 4th week from planting to 7th week - Weekly drench of a complete soluble fertiliser (21:21:21) at 15 gm in 5 litres distributed over 100 seedlings.
- 8th - 12th week - Weekly drench of complete soluble fertiliser (21:21:21) at 15 gm in 5 litres of water distributed over 25 seedlings. This rate is continued if seedlings for any reason have to be retained in the pre-nursery above the optimum 3 months.

Main Nursery Fertiliser

- In bag soil at filling - 100 gm rock Phosphate
- 1st - 3rd Week after transplanting - Weekly drench of a complete soluble fertiliser (21:21:21) at 15 gm in 5 litres of water distributed over 25 seedlings.
- 4th week after transplanting - 10 gm Mix 15:15:6:4 per seedling

8th week after transplanting	-	10 gm Mix 12:6:22:2 plus)	per
		10 gm Kieserite) seedling.
12th " " "	-	15 gm Mix 12:6:22:2	per seedling.
16th " " "	-	20 gm Mix 12:6:22:2	" "
20th " " "	-	25 gm Mix 12:6:22:2	" "
24th " " "	-	30 gm Mix 12:6:22:2 plus)	per
		15 gm Kieserite) seedling.

At planting out 1 kilo of Rock Phosphate is incorporated in the planting hole.

Unlike most nurseries we have, from the 4th week after transplanting into the main nursery, discontinued the use of Compound Fertilisers and use solely Urea based mixtures. This has meant very considerable savings in costs, and with the mist-spray irrigation we have found the above programme to be fully satisfactory.

The only disadvantage noted with the above is the lack of trace elements which are often included with compounds. The most common deficiency symptom appearing (and in fact the only one at Kerdu) is boron and after experience with the 1st Phase nursery, we now apply a High Grade Fertiliser Borax foliar spray (0.25% Borax in solution) at the 8th week as a standard practice. If initial symptoms persist, further applications are given as required.

After transfer to the large polybag further foliar applications of Borax are given if at any time there is incidence of the pendulous fibre as illustrated by Turner and Gillbanks on p. 93 of their "Oil Palm Cultivation and Management" (1974).

8. COST COMPARISONS FOR MAIN NURSERY IRRIGATION SYSTEMS

Tables 1, 2 and 3 give actual costings per hectare for piping and sprinklers utilised for each hectare of main nursery for 3 different permanent nursery irrigation systems.

From these tables it can be seen that comparative costs are as follows for a permanent irrigation system -

- a) Full galvanised iron piping
with overhead sprinkler units M\$18,661:40 per hectare.
- b) Full PVC piping with overhead
sprinkler units M\$11,292:70 " "
- c) Sumisansui Mark II perforated
tube with PVC ancillary piping
and fittings. M\$ 3,178:45 " "

Whilst one would not expect a fully GI piping system to be installed now, there is still the occasional user and the costing is given to show the very significant savings that arose with the introduction of the PVC pipe some years ago.

A further system utilising moveable aluminium sprinkler lines has had considerable popularity in Malaysia (Turner & Gillbanks 1974) and has been used by both authors in the past. Unfortunately we do not have detailed costs for the moveable sprinkler line system available to include in these comparisons.

The disadvantage of the moveable aluminium sprinkler system is that it has a heavy labour requirement for regular movement of sprinkler lines. Hertslet & Duckett 1983 record that for a 20,000 plant nursery three persons are required each day to move sprinklers but that these persons also do polybag weeding and other minor works in the interim.

From experience, we know that approximately one third of their time is taken up in moving irrigation sprinkler lines. Thus for a nursery of the size of Kerbau, it would be reasonable to expect to employ at least 16 persons full time if the moveable sprinkler line were to be utilised.

With the Sumisansui perforated pipe only 4 persons are required and their functions are:-

- a) To operate pump unit,
- b) To open and close gate valves,
- c) To check on the GI wire staples and ensure piping is secure,
- d) To carry out any running repairs required,
- e) To assist with other nursery works when not actually employed on watering duties.

Thus the labour saving, based on Sumisansui permanent system is 12 persons per day which, assuming a rate of M\$10 per day on 240 days per year (this excludes rainy days, holidays etc.), gives a total monetary saving of \$28,800 per annum. This would approximate to 10¢ per seedling with the Kerdau nursery.

A major advantage of the system described is that it is so very simple to install and does not require skilled fitters or plumbers. The whole of Kerdau irrigation system was set up by general workers under supervision of Estate staff. Similarly maintenance work is equally simple and no special workers are required.

Establishment Cost of a GI Pipe
Permanent Irrigation System Using Overhead Sprinklers

<u>Equipment Required</u> <u>Per Hectare of Nursery</u>	<u>Cost Per</u> <u>Hectare</u>
a) 62 pcs. double action sprinklers @ \$17.50	\$1,085.00
b) 62 pcs. GI 3/4" x 7' sprinkler stand @ \$6.00	372.00
c) 62 pcs. GI 3" x 3/4" T @ \$17.00	1,054.00
d) 25 pcs. GI Class 'B' 6" pipes @ \$180.00	4,500.00
e) 116 pcs. GI Class 'B' 3" pipes @ \$81.50	9,454.00
f) 12 pcs. GI 6" x 3" T @ \$100.00	1,200.00
g) 12 pcs. GI 3" plugs @ \$5.00	60.00
h) 12 pcs. GI 3" gate valves @ \$39.00	468.00
i) 25 pcs. GI 3" nipples @ \$7.00	175.00
j) 62 pcs. GI 3/4" nipples @ \$0.79	43.40
k) Miscellaneous items	250.00

Total cost per hectare = M\$18,661.40

TABLE 2

Establishment Cost of a PVC Pipe
Permanent Irrigation System Using Overhead Sprinklers

<u>Equipment Required</u> <u>Per Hectare of Nursery</u>	<u>Cost Per</u> <u>Hectare</u>
a) 62 pcs. double action sprinklers @ \$17.00	\$1,054.00
b) 62 pcs. PVC 3/4" x 7' sprinkler stand @ \$1.25	77.50
c) 62 pcs. PVC 3" x 3/4" T @ \$15.30	948.60
d) 25 pcs. Class 'D' PVC 6" pipes @ \$122.00	3,050.00
e) 116 pcs. Class 'D' PVC 3" pipes @ \$35.50	4,118.00
f) 12 pcs. PVC 6" x 3" T @ \$99.00	1,188.00
g) 12 pcs. PVC 3" end plugs @ \$6.30	75.00
h) 12 pcs. 3" gate valves @ \$36.50	438.00
i) 25 pcs. PVC valve sockets @ \$3.00	75.00
j) 62 pcs. PVC 3/4" valve sockets @ \$0.30	18.60
k) Miscellaneous	250.00

Total Cost per hectare = M\$11,292.70

TABLE 3

Establishment Cost of a PVC Pipe and Sumisansui MK II
Perforated Tube Permanent Irrigation System

Equipment Required Per Hectare
of Nursery

<u>Tube Irrigation System - Design A (5 Rows Polybags Per line)</u>	<u>Cost Per Hectare</u>
a) 1 pc. PVC 4" pipe Class 'D' @ \$33.10	\$ 33.10
b) 1 pc. 4" gate valve @ \$56.00	56.00
c) 2 pcs. PVC 4" valve socket Class 'D' @ \$12.50	25.00
d) 16 pcs. PVC 3" pipes Class 'B' @ \$22.30	356.80
e) 16 pcs. PVC 1½" pipes Class 'B' @ \$7.60	121.60
f) 10 pcs. PVC 1½" PVC end caps @ \$0.75	7.50
g) 37 pcs. PVC 1½" x ¾" T @ \$3.30	122.10
h) 74 pcs. 35 mm hose clips @ \$0.40	29.60
i) 37 pcs. PVC ¾" stop caps @ \$0.25	9.25
j) 1 pc. PVC 4" x 3" T Class 'B' @ \$10.00	10.00
k) 5 pcs. PVC 3" x 2" T Class 'O' @ \$2.80	14.00
l) 5 pcs. PVC 1½" bush Class 'O' @ \$0.30	1.50
m) 5 pcs. 1½" gate valves @ \$10.50	52.50
n) 10 pcs. PVC 1½" valve sockets @ \$0.95	9.50
o) 5 pcs. PVC 1½" T Class 'O' @ \$2.00	10.00
p) 37 rolls 100 m irrigation tubes @ \$60.00	2,220.00
q) Miscellaneous items	100.00

Total Cost per hectare = \$3,178.45

9. COST PER PALM UP TO DATE OF PLANTING

The breakdown of the various component costs are given in Table 4 and it will be seen that total costs (including depreciation) amount to \$1.65 per palm.

We are grateful to a fellow planter (Private communication) who has been involved with a moveable sprinkler system in a nursery providing material for planting of 1,010 hectares per annum over the last three years and quotes his production costs for the three phases as M\$2.43, M\$2.06 and M\$2.25 per palm respectively.

These figures would appear to compare with generally quoted costs of between M\$2.00 to \$2.50 within the industry.

The cost savings from the nursery system described here are therefore very significant and could be at least 60 c per palm below the average. This saving on the 660,000 palms required for Kerbau Estate amounts to a total M\$396,000.

TABLE 4

Breakdown of Costs per palm from receipt of
germinated seed until ready for field planting

<u>COSTING/SEEDLING</u>	Actual	See Notes
<u>Details of Work</u>	<u>Costs</u>	<u>Attached</u>
a. Land ploughing & rotovation	0.04	
b. Preparation of germination beds	0.02	
c. Bag filling - 6" x 9"	0.09	(i)*
15" x 18"	0.11	
d. Seed sowing	0.02	
e. Transplanting	0.08	
f. Manuring - Labour	0.03	(ii)
g. Manuring - Material	0.12	(iii)
h. Nursery tools	0.01	
i. Miscellaneous	0.05	
j. Security	0.01	(iv)
k. Cost of polybags	0.10	
l. Watering	0.07	(v)
m. Weeding	0.10	(vi)
n. Cost of seeds	0.60	
o. Pest & diseases	0.02	(vii)
p. Depreciation (on Capital Expenditure)	0.18	(viii)
	\$1.65	
	=====	

NOTES ON COSTINGS IN TABLE 4

- (i) One should normally be able to fill bags from soil on site at 6 cts each and the 3 cts per seedling additional cost here arises from the fact that soil for filling the pre-nursery 15 cm x 23 cm polybags was brought in from an adjacent area as the soil on site was not considered suitable for this stage of the nursery.
- (ii) & (iii) The large saving on both the labour and material cost for fertilisers arises from several factors -
- a) In the pre-nursery only liquid fertiliser is utilised and thus application cost is lower.
 - b) Instead of using compound fertilisers we used Urea based mixtures.
 - c) Under the irrigation system used uptake of fertiliser appeared far better than normal and intervals between applications were extended.
 - d) Rapid growth reduced time in nursery.
- (See notes under 'Nursery Manuring')
- (iv) The electric fence virtually eliminated the need for a pest watchman. The fact that some nursery workers took up temporary residence at the nursery site also reduced the need for security watchman.
- (v) The effectiveness of this perforated tube system required less total amount water to be applied due to the reduced period in the nursery. As discussed elsewhere the labour requirement under this heading is also drastically reduced.

SUMISANSUI

Sumisansui is a totally new irrigation tube developed by **SUMIKA AGROTECH CO., LTD.** The tube is made of LLDP-based highly durable and pressure resistant film. Many micro-holes are perforated through the tube with a laser beam machine and both sides are sealed with a special heat sealer. The irrigation hole pattern is designed by computer. All these features enable Sumisansui to provide a long and wide area with very uniform irrigation.

With the conventional punching or heated needle methods, it was difficult to make the hole diameter smaller than 0.6 mm, resulting in the too much water flow through each hole. It was, therefore, impossible to irrigate the long and wide area uniformly.

SUMIKA AGROTECH has developed the technology of perforating very fine holes (diameter: 0.15 - 0.3 mm) in a high density (4 holes/10 cm) in irrigation hoses with a special laser machine and optical systems developed by the Company. With a computer system calculating the irrigation uniformity of the irrigation tube from the diameter of hoses and holes and the interval of holes, the Company has succeeded in developing the unique irrigation tube, Sumisansui which provides uniform irrigation in the long and wide area.

Both sides of conventional lay flat irrigation tubes easily break by rubbing at the time of installation and storage. This problem has made these conventional tubes unreliable for long-run use. Sumisansui, whose sides are fused by heatsealing, has much improved in the strength of both sides. By the conventional heatsealing technology, it was impossible to process the 200-micron film at a constant high speed with reliable strength. **SUMIKA AGROTECH** has, however, overcome such heatsealing problems with a special machine developed by the Company.

The newly developed irrigation tube, Sumisansui, has the following characteristics:

- 1 Fine rain-like irrigation of Sumisansui is suitable for a wide range of applications such as vegetables, flowers and fruit trees. It is most effective to use Sumisansui at the time of sowing or transplanting.
- 2 Sumisansui is light in weight and a lay flat tube so that the operating is easy. It is easy for farmers to install, store and move the tube by themselves.
- 3 Sumisansui has good durability because it is made of special LLDPE film. It can survive the long-term outdoor exposure.
- 4 Sumisansui is superior to sprinklers in irrigation at a low pressure (0.1 - 1.0 kg/cm²), which leads to a lower operating cost.