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To promote the advancement and facilitate the acquisition of that knowledge which constitutes the professional qualification of planter.

To watch over, promote and protect the mutual and individual interests of its members in respect of matters pertaining to or arising from their employment in the planting profession.

To promote and maintain good feeling, co-operation and understanding between members and their employers.

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The Planter

MAGAZINE OF THE INCORPORATED SOCIETY OF PLANTERS

(1) *The Planter* is published monthly from the Society's Office at No. 29, 31 & 33, Jalan Taman U Thant, Kuala Lumpur, Malaysia.

(2) It features original technical articles in tropical agriculture, for the benefit of the planter (in active service or practice), papers relating to the Society's Technical Education Scheme, and other contributions of more general interest.

(3) The magazine's current print order is 2 500 copies and this is steadily rising.

(4) *The Planter* is read in some 50 countries*.

(5) Copies are exchanged with a wide range of agriculturally based institutions.

(6) Subscription copies go to 32 countries.

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Editorial:

The coconut - urgent need for attention

The coconut appears to have been side-tracked in economic importance in Malaysia in recent times by the oil palm. This is particularly so in the estate sector where acreage under coconut has been replanted with oil palm. However, in the smallholder sector, there appears to be a steady increase in planted acreage, despite its relative low yield as compared with either rubber or oil palm. This is largely due to the encouragement of the government through the Coconut Smallholders' Development Scheme and RISDA.

Coconut, traditionally a smallholder crop, is reported to be cultivated by about 80 000 households, about two-thirds of them are dependent on the crop as their main source of income. Therefore, unless positive steps are taken to replant and rehabilitate existing smallholdings, smallholders would face a bleak future.

Main reasons for the comparatively poor return from coconut holdings are: low yield from land with poor drainage, poor cultivation practices, lack of fertilizer usage and limited research for the best high-yielding hybrid of coconuts.

Corrective measures have in fact been undertaken by the Drainage and Irrigation Department, complemented by the farmers' own efforts with internal drains. But there are still large areas that lack full drainage systems. This calls for greater effort on the part of the Government.

The efforts by MARDI and private research stations are appreciated. What is basically lacking though is the provision of advisory services on the RISDA pattern for rubber smallholders. In addition to research and advisory services it must be remembered that smallholders lack the capital to implement projects. It is here that the Replanting and Rehabilitation Subsidy Scheme has a major role to play. The present grant of $500 for replanting per acre and $300 per acre for rehabilitation, introduced in 1963, is far from adequate today and ought to be increased to something more meaningful.

Then the question of smallholders' copra. The traditional method of disposing products leaves them at the mercy of the middlemen. It is here that authorities like FAMA could be of assistance.

Inspite of the shortcomings that have been referred to it must be noted that RISDA has, successfully organised the replanting of 40 355 acres of old rubber with coconuts. The forecast is, there will be further increases in smallholdings with the rising popularity of intercropping coconuts with cocoa.

About a million Malaysians depend on the coconut for their livelihood. They need help – urgently. Any stepping up of movement in this direction would be in line with the Government's policy of diversification in agriculture.

Selamat Hari Raya
Aidil Fitri

from

The Chairman and Executive Council

of

The Incorporated Society of Planters

Planter, Kuala Lumpur **54** : 310–328 (1978)

Some aspects of natural pollination in oil palm (Elaeis guineensis)

P.D. TURNER

Harrisons Fleming Advisory Services, London, England

This paper is intended to place in perspective problems encountered in obtaining commercially adequate fruit set by comparing conditions outside West Africa with those in the oil palm natural environment and natural pollination requirement for continuation of the species. A much-overlooked facet of pollination is that adequate pollination for the palm is totally different from that of commercial requirements. Research requirements have been indicated. A brief description of inflorescences has been given to provide the necessary background information on floral biology.

Pollination by insects (entomophily) is summarized. In most instances, it is concluded that some chance pollination occurs but that this is not consistently adequate for commercial purposes. Studies in areas where a high level of entomophily is indicated is considered worthwhile since it might be possible to introduce pollinators to problem areas. Most natural pollination seems to be by airborne pollen (anemophily) and levels seem to be adequate in older palms where atomospheric conditions are suitable. The depressing effect of rain on the density of airborne pollen is very marked, irrespective of the number of male inflorescences present. Comparative rainfall data are given, with problems being greatest where rainfall is most frequent. Canopy density is a further contributing factor to poor pollination in some instances. Young palms of Malaysian origin comprise a special case because of high sex ratio, with inadequate pollen availability irrespective of climate.

For some time, the accent on oil palm pollination studies has been that of increasing fruit set above levels obtained by natural pollination agencies, with the result that, in many areas, assisted pollination has become an integral and essential part of routine estate practice. Assisted pollination has not been proved necessary in other areas where selection for early high sex ratio has not been carried out and where conditions are such that natural pollination normally provides adequate fruit set. Problems have arisen in obtaining commercially adequate fruit set in certain areas in the far east and especially in Sabah and the New Britain region of Papua New Guinea, the nature of which have still to be resolved. In the Labuk Valley of Sabah, for example, natural pollination has been described as practically nil (Speldewinde & Pereira, 1974). The theoretically possible explanations for these problems are very numerous, requiring extensive research, but the lines of initial investigation needed to provide immediate solution to the commercial problem can be defined by consideration of various aspects of natural pollination. It is the intention here to consider pollination not so much from the approach of the commercial practice of assisted pollination but from the aspect of the oil palm in its natural environment. From this can be derived possible problems which might have arisen through the great expansion of planting in different environments throughout the tropics, through breeding and selection practices, and through attempting by various means to achieve maximum yields.

THE INFLORESCENCES

A brief description of the inflorescences is required to comprehend fully the problems which have arisen; more detailed descriptions have been given elsewhere (Alibert, 1945; Beirnaert, 1935, 1935a; Heusser, 1922; Uhl & Moore, 1973). Both male and female inflorescences are borne on the same palm, *i.e.*, the palm is monoecious, but it is very unusual to find viable male and female inflorescences simultaneously on the same palm. Some anomolies occur, such as occasional palms producing only male inflorescences, or hermaphrodite inflorescences (especially in young palms) bearing both male and female flowers. In addition, the female flower has a rudimentary male flower on each side, these rarely reaching a stage of pollen production. For all practical purposes however, separate male and female inflorescences comprise the vast majority of those occurring and the abnormal conditions, which would be of interest in evolutionary studies, are not considered further.

The female inflorescence is a spadix, 24–45 cm long, which contains thousands of flowers borne on thorny spikelets arranged spirally on a central axis. Spikelet and flower numbers vary considerably with age and location. Spikelet number ranges have been given as 100–283, 85–285 (most 125–165) and 100–200, the first two for Congo palms and the last for Deli (Hartley, 1977). In Malaysia, counts of female inflorescences gave about 3 500 individual flowers for an inflorescence from a 5-year-old palm, increasing to about 5 000 individuals in a 10-year-old palm (Gray & Bevan, 1966), with 6 000 individuals estimated for a large female inflorescence in Sumatra (Heusser, 1922). Just prior to anthesis, there is a considerable temperature rise within the flower cluster and there is quite an intense aniseed aroma. Usually, about one-sixth of the flowers of an inflorescence open on the first day, two-thirds on the next, and the remaining one-sixth on the third day (Heusser, 1922). Whilst the flowers are receptive they are white to pale yellow in colour. A red stripe develops along the three lobes of the stigma and the flowers change to a reddish and finally purplish colour as they pass beyond the receptive stage. Because of the interval over which flowers are produced, the inflorescence has usually been assumed to contain a proportion of receptive flowers over a period of 3-5 days. The stigma exudes a liquid during the receptive period (Hartley, 1977). The stalk of the female inflorescence is so short that part of the inflorescence remains covered by a fibrous sheath, especially in very young palms, and this tends to prevent complete pollination.

The male inflorescence comprises a similar number of spikelets to that of the female, each about 12–20 cm long, arising from a central stalk. The pale yellow flowers are very small and mature from the base of the spikelet upwards. Each spikelet bears between 600 and 1 200 flowers. One Sumatran study showed that a medium-sized male inflorescence bore about 750 flowers per spikelet, so that a mature inflorescence with 200 spikelets bore 150 000 male flowers, such an inflorescence producing about 40 ml of

pollen, which equals about 900 million pollen grains (Heusser, 1922). Depending on age, the amount of pollen produced by a single inflorescence is in the range of 25–50g, and this is liberated over a period of 2–3 days, after which anthesis is complete and fungal invasion occurs. Later-produced pollen may have a lower viability than that first formed. Pollen has a very strong smell of aniseed which is much more intense than that of the female flower.

INSECT POLLINATION

There are a number of oil palm characteristics which have led to suggestions from time to time that insects play a significant part in pollination. These have mainly been based on observations that numerous insects can be found on both types of inflorescence, together with an assumption that the strong aniseed odour has some attractive function. Whilst there are inherent dangers in comparing one plant species with another, it is worthwhile here mentioning the various characteristics which point to insect pollination, or entomophily.

Floral features indicating entomophily

The most obvious feature is the odour of aniseed produced particularly by the pollen and, to a lesser degree, by the female inflorescence. Whilst odour is not necessarily a feature recognised as important by all authorities on pollen ecology, there can be little doubt that the strong aniseed smell attracts certain insects to pollen-bearing palm flowers. The most obvious example is the pollen harvesting by bees. The pollen is not used as food by the imago but is collected and tranported for larval development. It is extremely likely that pollen grains adhere to the bees and would thus effect pollination should they visit a female flower, but there is no record of this occurring. Such visits may well occur occasionally for the purpose of energy replenishment from stigmatic fluid, but are very unlikely to contribute significantly towards pollination generally.

Temperature and odour are features of the female inflorescence which indicate a strong link with insect pollination. The situation finds a close parallel in a few other plants, especially species of the sapromyophilous Arum. In this instance, there is a marked temperature rise at the time of first flower opening, which is also that of female receptivity, with temperature increase inducing volatilization of substances to produce a strong smell, attracting small beetles which might previously have come into contact with pollen from another Arum plant (Meeuse, 1977). A temperature rise to 5–10°C above ambient, with accompanying strong aniseed odour, was recorded for oil palm in Sumatra (Henry, 1947; Heusser, 1922), and there is a quite rapid falling off of odour strength with time. It seems quite possible that insects attracted to the strong odour of male inflorescences could also

be attracted to females, especially during the initial period of receptivity. Any deposition of pollen grains on flowers not quite receptive would not necessarily be disadvantageous since it has been shown that such pollen, under dry conditions, can still bring about pollination (Hardon & Turner, 1967). Similar temperature rise has been recorded for other palm genera, and has also been noted in male inflorescences at anthesis (Henry, 1947; Rodrigues, 1903).

Change in floral colour once the period of receptivity has passed is associated with entomophily in other plants. The horse chestnut flower, for example, develops a red mark when it is no longer receptive and such flowers are no longer visited by potential pollinators. The inflorescence does not wither, as do single flowers of other plants after pollination, but remain attractive since there are other flowers on the inflorescence which are still receptive. Again, there is a strong similarity with the situation found in oil palm.

Insect associations with inflorescences

Many insects have been recorded as visiting oil palm inflorescences, particularly male flowers. Predominant amongst these have been bees collecting pollen, an activity frequently seen in Malaysia and Sumatra, but also occurring in other countries where the crop is grown. Records of insects in various countries have restricted significance since it would be expected that the fauna would vary between countries. In one study in Malaysia (Gater, 1925), systematic collection from both inflorescence types gave a total of 1 426 insects, of which only 4.5% were caught on female inflorescences and 88% were the bees *Apis florea, A. indica, A. dorsata* (*Megapis*), and *Trigona* (*Melipona*) *laeviceps* (Gater, 1925; Hartley, 1977). Of the bees, only 5.4% were collected from female inflorescences. Whilst this may be a small percentage, it would be expected that one bee might visit numerous flowers in a single inflorescence. It was stated that 'the fact that only a few were found visiting the female flowers seems rather curious in view of the smell of anise which emanates from flowers of both sexes, and which would presumably be attractive to certain insects.' A possible explanation here is that whilst the odour might be attractive, the concentration of the sugar in the stigmatic fluid available for energy could be inadequate to attract bees. It has been shown in other plants that sugar concentration in the nectar considerably influences the type of pollinator visiting the flower, with bees preferring a high concentration (Corbet, 1977). Populations of *Apis dorsata* can be so high in Malaysia as to bring about localized pollen shortages (Gray & Turner, 1966). The Malaysian study also showed male inflorescences to be visited by various species of Demaptera (earwigs, mostly *Chelisoches moris*), Coleoptera (beetles), Diptera (true flies) and other Hymenoptera (ants, wasps, bees). In another Malaysian study (Jagoe, 1934), it was suggested that nocturnal insects might be involved, including *Pyroderces centrophanes.* Conclusions reached for Malaysia have been that

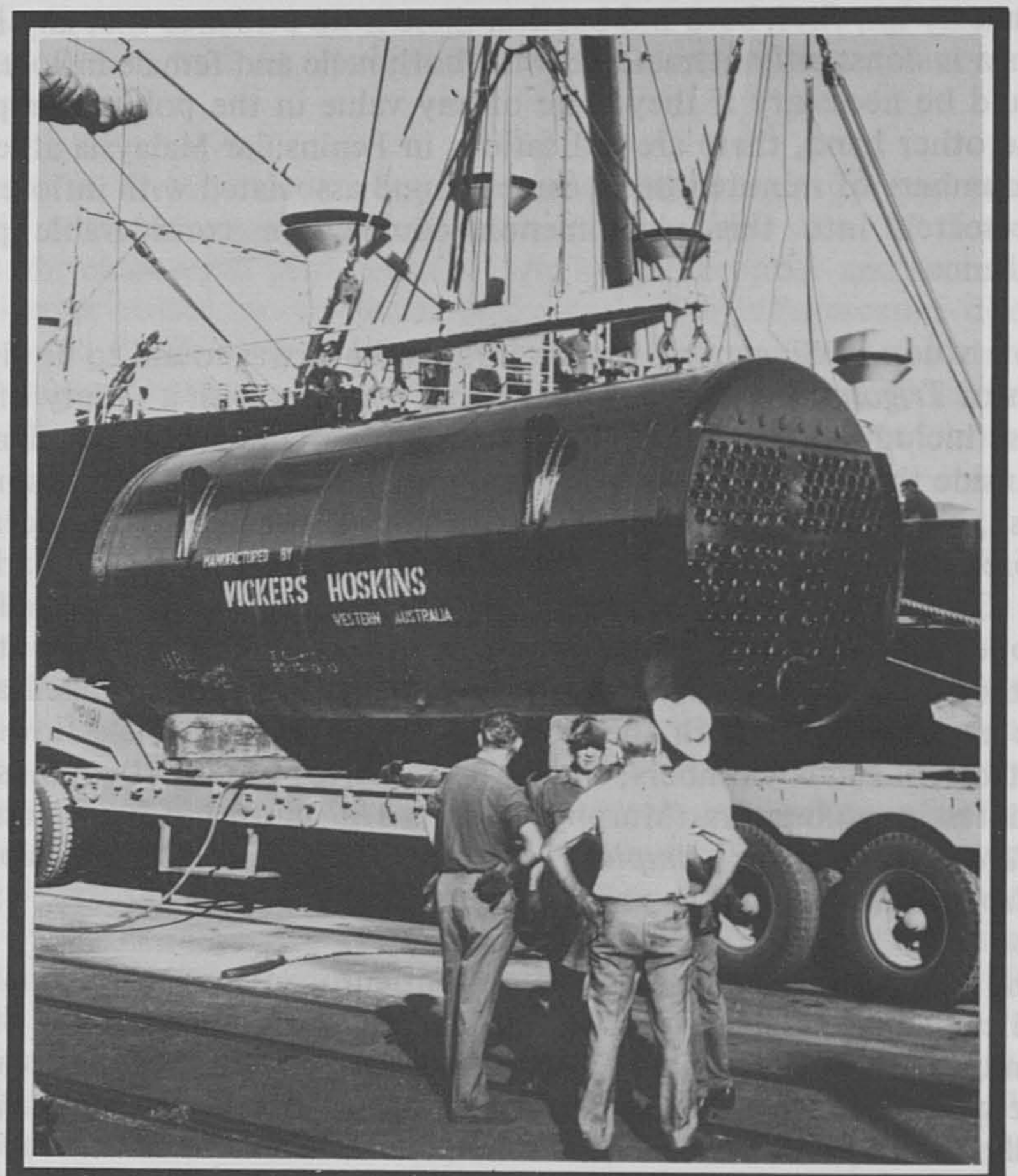
insects do not play a significant part in pollination (Jagoe, 1934; Turner & Gillbanks, 1974; Wood, 1968). Thus, for Malaysia at least, the situation has been summarized by Wood (1968) as 'although there is undoubtedly a certain amount of casual transfer of pollen from male to female flowers by various earwigs, flies, bees and beetles, there is no evidence that any insect in Malaysia is constantly attracted to visit both male and female inflorescences, as would be necessary if they were of any value in the pollination process.' On the other hand, there are indications in Peninsular Malaysia at least that large numbers of minute insects can be found associated with inflorescences, and research into this phenomenon could have considerable practical significance.

In a study in Singapore, a male inflorescence was found to be visited by species of *Trigona* and *Apis* during the day, together with a variety of smaller insects, including a Drosopholid fly, which was present in small numbers deep inside the inflorescence. The activity of this fly increased conspicuously at dusk, and during the night it was active all over the inflorescence and was present in large numbers. Also during the early hours of darkness, a small Gelechioid moth occurred abundantly. When an aniseed odour developed from a female inflorescence, no diurnal pollinators were attracted, even though a *Trigona* nest was close by. When the odour peaked abruptly in the early evening, both the flies and moths seen on male flowers were attracted in small numbers; these seemed to be the two most likely candidates as pollinators (Murphy, 1975). The moth has been classified as *Pyroderces,* possibly *P. simplex,* and the Drosophilid fly provisionally as *Baeodrosophila,* possibly *B. pallens* (Simmonds, 1976).

The conclusion that insects play an insignificant part in pollination has periodically been reached for countries in Africa (Alibert, 1945; Bucher & Fickendey, 1919; Hartley, 1977), but not always so. Oviposition is a feature of one group of pollinators and a weevil, *Derelomus* sp., was long ago stated to pollinate oil palm in Africa (Chevalier, 1910). This weevil is found in both male and female inflorescences, where it lays its eggs, but the grubs subsequently destroy the buds. In New Britain, a few small moths and a variable number of earwigs have been seen in male inflorescences (Prior, 1976; *pers. comm.*).

In Cameroun, it has been observed that good fruit set occurs even at times when frequent rainfall would be expected to preclude wind pollination, indicating a high level of entomophily. A strong case has been made for both entomophily and anemophily in West Africa, based on trials with bagged inflorescences (Henry, 1948). It was found that 14.2% of the insect fauna of a male inflorescence could exist on female inflorescences, and 16.3% vice versa. On both inflorescence types insect numbers ran into thousands, although they were less on female inflorescences (Le Stanc, 1947). The smallest weevil found on oil palm flowers, *Prosoestus subvittatus,* constituted about 4–7% of the fauna on female inflorescences and, on removal from the female flowers, pollen grains were observed on the rostrum

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abdomen and legs. Whilst it was concluded that the relative significance of wind and insect pollination requires evaluation, and that this was likely to vary, the fact that insects did play a part in pollination was undisputed (Henry, 1948). More recent studies in the Republic of Cameroun revealed fourteen species of flying insects which occurred regularly on both male and female inflorescences, with eleven of these carrying pollen grains adhering to their bodies. Most moved during the day and their movement was restricted by wet weather. By comparison, very little insect activity occurred in Sabah, and there was also considerable differences in the composition of insect populations between the two countries (Thorniley, 1977). There are indications that entomophily may occur in South America, both of the oil palm and *Elaeis oleifera,* with beetles and possibly wasps being implicated (Hardon, 1968).

Conclusions on possible entomophily

There is quite strong evidence that the oil palm has, at some stage of its evolution, been strongly entomophilous, as indicated by the floral characteristics listed above. Other palms have remained entomophilous, but for the most part it seems that anemophily has become of increasing significance in oil palm. The occurrence of odour in pollen is considered to be a primitive characteristic, as are floral homogeneity and the yellowish colour of flowers (Henry, 1947; Vogel, 1977). A reversion from entomophily to anemophily as one end point of an evolutionary sequence is a quite frequent occurrence, with such plants tending to occur in forest environments and in groups (Proctor, 1977).

The part played by insects today is far from clear. Insect visits to anemophilous plants have often been recorded, including palms, and these have often been assumed to act as pollinators. However, such assumption is fallaceous unless an association with pollination can be shown to occur consistently beyond reasonable doubt and that they are not just pollen consumers or collectors (Faegri, 1977; Meeuse, A, 1977; Stelleman, 1977; Van Der Goot & Grabandt, 1970). In oil palm, the possibility of chance insect pollination would seem even more slight unless definite pollination activities are involved since at any one time male and female inflorescences occur on different palms. Of the references which exist on possible entomophily, the likelihood seems greatest in West Africa. This in itself could be significant. Hartley (1977) has reviewed the origin of *E. guineensis,* and there is strong evidence that oil palm has been in existence in West Africa from very early geological times (Miocene) (Zeven, 1964). If entomophily were both to exist and persist, then it could reasonably be expected to occur in areas where palms have ancient origins, with the possibility of coevolution between palms and pollinators. On the other hand, the areas where the possibility of entomophily is greatest are also those where the chances of a high degree of pollination success through air-borne pollen is also greatest over a greater proportion of the year than

elsewhere. The extensive dry period of 3–5 months in many parts of West Africa allows free daytime pollen movement, whilst distribution of rainfall in all other months except the wettest only slightly restricts anemophily. The influence of moisture stress on floral sexuality also ensures that high numbers of male inflorescences are produced. Against this must be weighted the apparently good pollination recorded during wetter periods.

Movement of palms to other areas could pose problems if insect pollination were required for continuation of the species. Transfer to countries relatively close geographically would be unlikely to incur such difficulties because of overlap in the range of pollinator species, but severe problems could occur following introduction to more distant places where established pollinators were absent. There are, however, examples of introduced plants being accepted by existing pollinators of other plant species (Valentine, 1977). It could be argued that oil palm offers considerable potential for insect pollination, with pollinators specializing on this host, since one requirement of specialization is that density and quality of one or a few resource plants should be high and the resources offered to be predictable (Levin, 1977). Both male and female inflorescences are present in plantation throughout the year, although in variable amounts.

Whilst insects occur on inflorescences in their thousands, and some almost certainly effect pollination, their comparative importance to anemophily is unknown. There can be no doubt that a high percentage is attracted to inflorescences, especially male, for feeding purposes, either for direct pollen ingestion or collection for larvae. Foremost here are the bees, whose visits to female inflorescences could be related to nectar as an energy source (Faegri, 1977). Flower size may well be of importance. Smallness of oil palm female flowers may favour small pollinators, and investigations could well show that one or more of the small beetles, weevils, flies or mosquitoes have a more significant influence on pollination than bees or wasps (Faegri & Van Der Pijl, 1971; Stanley & Linskens, 1974). Only research can define the possibilities.

Research requirements on insect pollination

In considering requirements for research on the actual and potential importance of insect pollination in oil palm, it is realized at the outset that any programme would need to be duplicated in a number of countries due to the vast differences which would exist in possible pollinator fauna. However, such duplication would be well worthwhile for two main reasons. Firstly, and of immediate importance, negative results could have significant practical implications, pointing particularly to necessity for improving pollination in other ways in the so-called problem areas. Secondly, and perhaps of long-term significance, discovery of a high level of entomophily in, for example, Cameroun, could well warrant an assessment of such a finding in possible practical application elsewhere. It might prove possible to transfer known

pollinators to countries where they do not occur, although this should only take place after exhaustive examination to ensure that such introductions would not become pests.

Major aspects of required pollinator research would be as follows, the overall aim being to demonstrate that identified members of the inflorescence fauna play a significant part in pollination and to allow consideration of their possible use on an estate scale in problematical areas.

1. *Inflorescence fauna*

- Collection and identification of fauna by hand sampling and trapping. Netting with adhesive material placed over inflorescences, rather than conventional insect traps, this defining those clearly visiting inflorescences as distinct from casual passers by. Special attention to smaller visitors, especially beetles, weevils, small Hymenoptera and mosquitoes.

- Diural population studies. There is a strong likelihood of marked variations during the day and night.

- Variation in inflorescence fauna (quantity and quality) throughout the year to assess seasonal effects, especially the effect of climatic variations on inflorescence fauna.

- Differences in visiting populations at different stages of anthesis, *e.g.*, does the initial temperature rise and accompanying odour attract a different or more numerous population?

- This study to be continued for at least a year. Some plants are visited only intermittently as alternative choices when more attractive flowers are absent. As soon as the latter re-appear, the alternatives are neglected (Faegri, 1977).

- Does the ground/interrow flora have any significance?

- Has pest spraying any importance in reducing the population of potential pollinators?

2. *Function of visiting fauna*

- Examination of gut contents to determine if they are pollen feeders.

- Examination of fauna from female flowers for the presence of pollen grains adhering to their bodies in significant numbers. Use of the SEM method would be useful.

3. *Floral function in pollination*

- The importance of temperature increase at anthesis; origin of heat source and odour and associated physiological changes.
- The significance of the aniseed odour, using absorbent strips and a very rapidly-dispersing solvent which would not deter insects. Heptane is likely to prove most suitable, disappearing in about a minute.
- Length of flower receptivity time, which could well vary between different periods of the year in relation to climatic conditions.
- The relative importance in overall fruit production of flowers formed during different stages of anthesis.
- Sugar concentration in stigmatic fluid in protected and unprotected inflorescences and its relation to attraction of potential pollinator species; daily variations in fluid characteristics.
- Pollen germination and stigmatic fluid. In one investigation, oil palm pollen grains did not germinate in stigmatic extract medium (Rao & Khoo, 1974).
- Significance of flower/stigma colour during the receptive and post-receptive phases.

4. *Pollen transfer*

- Proof of pollination. Methods include: dusting fluorescent powder onto the male inflorescence and examining fauna on females in the vicinity, using a portable UV light (Woodell, 1977); staining pollen (*e.g.*, by spraying with aqueous methylene blue and neutral red) on the donor palm and recording any transfer in an upwind direction, with air sampling for inbetween control (Stelleman, 1977); labelled possible pollinators; inspection for pollen on fauna from female inflorescences; dusting insects with coloured powder, *e.g.*, soot (Meeuse, A., 1977).

POLLINATION BY AIRBORNE POLLEN

The following observations primarily concern palms over 7 years old in the field. Younger palms constitute a special case in some instances and will be considered separately.

Climate and pollen transfer

Most authorities regard pollination in oil palm as occurring predominantly through the agency of air currents transporting pollen grains (Hardon & Turner, 1967; Hartley, 1977; Jagoe, 1934, 1934a; Turner & Gillbanks, 1974). Most investigations have been carried out in Peninsular Malaysia, with the conclusion todate that natural pollination is almost entirely anemophilous, with insects playing an incidental and largely unimportant part. Studies showed that most pollen is produced by male inflorescences 2–3 days after anthesis, and this pollen is the most viable. When artificially protected, pollen viability on female inflorescences is good up to 6 days from the time of deposition, after which it declines. In practice, this period is likely to be very much shorter. The majority of the pollen remains below the canopy, especially at bunch level. Results of quantitative evaluation of pollination dispersal showed that atmospheric pollen density is very variable and governed by numerous factors. There is a marked diurnal variation, with airborne pollen density rising during the morning to a peak in the afternoon, with negligible amounts during night and early morning.

Correlation of the depressing effect of rain on pollen density was clearly demonstrated, even when rainfall was very slight, with pollen densities being influenced more by the number of days on which rain fell than by total rainfall. Such a relationship would also be expected to occur if very small insects function as pollinators since they also tend to disappear during wet weather. A relationship exists between pollen density, rainfall and the number of male inflorescences in the vicinity, but the effects of relative humidity, sunshine and wind are obscure. Whilst pollen density drops rapidly within a short distance from the inflorescence, there is quite significant dispersal over greater distances. Most pollen falls within 20m of the male inflorescence (Hardon & Turner 1967; Jagoe, 1934), which is in keeping with anemophilous trees generally. The rate of pollen deposition on test slides has been considered sufficient for optimum pollination in Peninsular Malaysia when atmospheric conditions are suitable and adequate numbers of male inflorescences are present (Jagoe, 1934). Tests in the Republic of Cameroun on palms 4–5m high showed that anemophily could occur provided the female inflorescence was down-wind from the pollen source and was on the side of the palm facing the source (Thorniley, 1977).

In addition to wind currents, pollen is also transported in thermal currents. These occur in 'bubbles' of warm air and are generally short-lived, but radar studies have shown that coalescence of such bubbles can occur to give warm air pockets of up to 1 sq km (Hardy & Ottersten, 1968). These last until sunset, when they abruptly disappear. Such an occurrence was recorded in a temperate climate and it is not known whether a similar phenomenon can be found in the tropics.

It is possible that some incidental fertilization could occur through pollen which has previously been deposited on the foliage reaching the

female flowers in water droplets during rain, although some could well be non-viable. The major practical effect of rainfall is the immediate depressing effect on the density of airborne pollen, with the amount of anemophilous pollination taking place during rainy weather being extremely small. A wet inflorescence does not disperse pollen. Therefore, whilst the total rainfall and its distribution in an area are important in achieving potential yield, of far greater significance in pollination is the number of days during which rain is recorded. Some data from various estates, shown in the following section, indicate the variation which occurs.

Male inflorescence number and pollination

In general, anemophily appears adequate for commercial purposes when palms reach 7 – 8 years old, by which time the sex ratio has tended to become more balanced, although this is less likely to be an influential factor in West Africa than, for example, in Peninsular Malaysia. Since male inflorescence number increases with age, attempts have been made to correlate male inflorescence production within an area with commercial pollination adequacy. Trials have indicated that production in the range 24–32 per acre was adequate in Peninsular Malaysia for 7–9 year-old palms (Gray, 1969).

However, use of male inflorescence counts is of very limited value in assessing likely pollination levels. Whilst a very high number might ensure adequate natural pollination, the lower number limit is unknown. In addition, use of male inflorescence counts means that future action is based on events which have already passed and where the situation may have changed considerably. Experience has been that numbers of inflorescences produced one month bear little relation to those developing in successive months, as might be expected from the influence of environmental and agronomic factors on sex differentiation.

Estate	*Country*	*Av. days rain*	*No. years records*
Okitipupa	Nigeria	91	5
Rambung Sialang	Sumatra	111	28
Dolok	Sumatra	129	38
Dunkwa	Ghana	133	41
East Estate	Pen. Malaysia	136	5
Gunung Malayu	Sumatra	153	36
Klanang Bahru	Pen. Malaysia	154	23
Ulu Tiram	Pen. Malaysia	179	6
Giram	Sabah	182	9
Mostyn	Sabah	190	15
Mosa	New Britain	206	12

Anemophily and climate

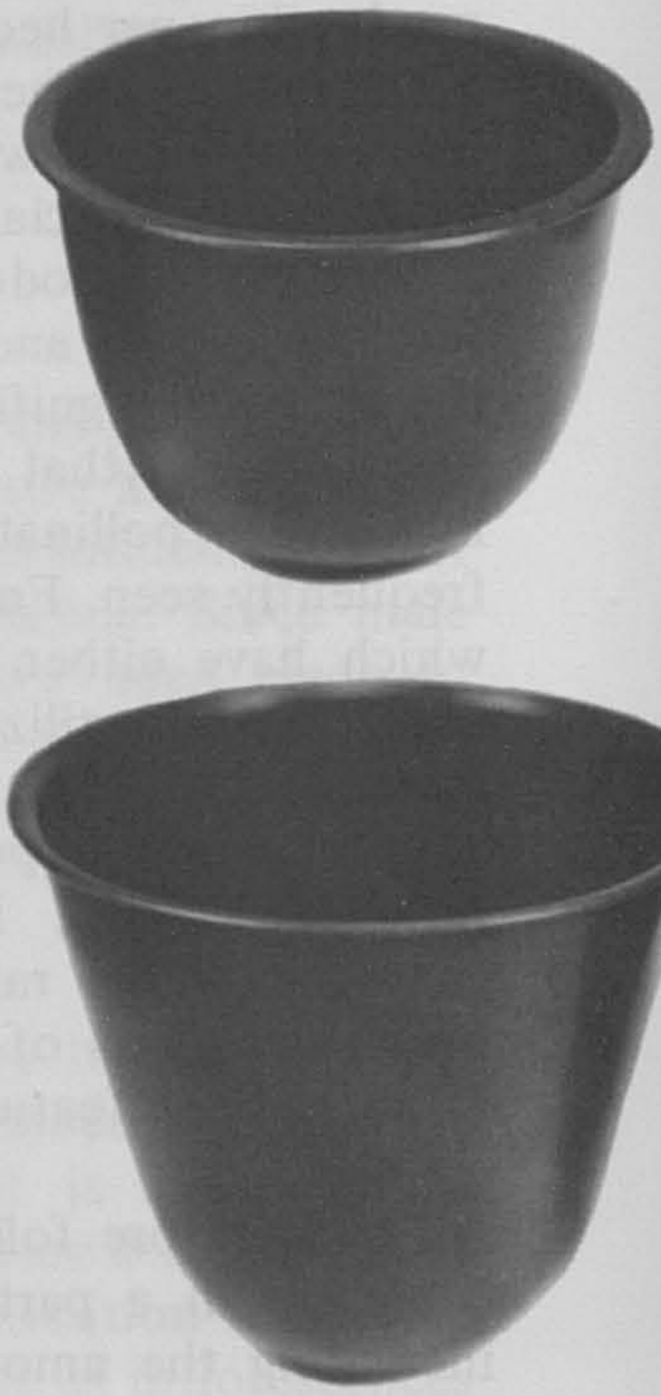
From the practical viewpoint, rainfall during a period of normally high atmospheric pollen density negates the fertilization potential of that pollen almost immediately and totally. Natural pollination can thus be at an inadequate commercial level even when there is an abundance of male inflorescences in the area. In New Britain, for example, male inflorescence production per hectare over successive months was recorded as 90, 84 and 98, which elsewhere might be expected to result in adequate pollination levels but which were shown by the New Britain control plots to be well below commercial requirements. During the period of high male inflorescence production, days on which rain was recorded per month totalled 24, 23 and 17 respectively. The rainfall factor thus greatly affects the practical significance of male inflorescence production records. It also seems likely that most oil palm areas will show signs of commercially inadequate pollination in varying degrees at some time of the year, as is frequently seen. For example, in Malaysia and North Sumatra, fruit bunches which have either aborted through inadequate pollination, or containing numbers of fertilized fruits well below the norm, are often seen about 6 months after the period of heaviest rains. In Sumatra, profitability of seasonal assisted pollination for this reason has been suggested (Tailliez, Lubis & Pamin, 1975). This situation would be most pronounced in countries where rainfall rates are very high and spread over much of the year (*e.g.*, parts of Sabah and New Britain), and especially where rain is a frequent daily feature during the late morning and early afternoon.

It therefore follows that if airborne pollination is consistently affected adversely in a particular area, then this problem cannot be overcome by increasing the amount of airborne pollen by planting material producing higher numbers of male inflorescences, or by cultural practices inducing male inflorescence production. It has been suggested, for example, that selection be made of an extended male phase palm, small numbers of which could be interplanted with existing high-yielding material, possibly as a supplement to the introduction of pollinator insects (Simmonds, 1976). It also follows that assisted pollination is likely to be required for a very extended period, even throughout the life of the palm, in areas where environmental factors largely prevent natural pollination at commercially required levels.

Comparison of anemophily in different environments

There are a number of conditions in their natural environment which are very suitable for anemophily in oil palms. In West Africa, the comparatively low number of days on which rainfall occurs – one day in three – means that at most times of the year there are sufficient interludes for pollen distribution and fertilization to occur, and it is likely that the period of female flower receptivity covers the full 3 days usually assumed as the norm. Periods of decreased efficiency in airborne pollination are therefore generally

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likely to be few. The annual periods of drought, during which little or no rain falls for a period of 3–6 months, assists anemophily considerably. Such periods have another influence in that they induce the production of large numbers of male inflorescences through effects on sex differentiation and such numbers, in association with conditions suitable for anemophily, would be expected to result in efficient natural pollination by airborne pollen dispersal alone. Rainfall conditions would also have little influence on movement of possible insect pollinators over much of the year; for oil palm, these are likely to be small and might thus be affected adversely by frequent rainfall. Another factor favouring anemophily in West Africa is that pollen landing on a flower before it is receptive is more likely to retain its viability, and thus effect fertilization later, in the drier climate.

Outside the palm's natural environment, pollination problems may well arise, especially where climate differs significantly from that of the original area. In environments with a higher and more evenly distributed rainfall, general development of the palm is favoured but conditions for anemophily become less satisfactory. Yields are also potentially higher, but the numbers of male inflorescences smaller. Examples have been given above of plantings in 'newer' oil palm countries where, although natural pollination would be adequate for continuation of the species, reduced pollen availability, either through lower overall production or transfer difficulties, results in levels of pollination which are commercially unacceptable. To this it might be possible to add a shorter period of female flower receptivity.

A further contributory factor is canopy density. Even in young palms, canopies in West Africa tend to be less tightly interwoven than in countries where vegetative growth is stronger, with this difference being largely maintained throughout the life of the palm. Canopy effects reach their extreme in areas where an inter-palm competition problem exists. In this context it is immaterial whether the observed poor pollination is a partial cause or effect of the density problems, but in such areas there can be little doubt that significant numbers of aborted bunches, or bunches with a high proportion of parthenocarpic fruit, are associated with impeded pollen access and lower male inflorescence production. There is an interaction between planting density and palm age. At high density, there is a tendency towards etiolation, with fronds tending to be more erect, causing the inflorescences to be partially occluded, especially at the base. Pollination difficulties are accentuated by female inflorescences under such conditions being abnormally small, but they are still receptive.

Anemophily in young palms

Various cultural practices affect male inflorescence production in young palms in addition to the more importance influences of climate in relation to moisture stress. Most significant amongst these is ablation, which has numerous agronomic and managerial advantages. One result of ablation is

that fields newly brought into bearing contain much lower numbers of male inflorescences than where no ablation was practised. Natural shortage of pollen thus becomes acute, necessitating the introduction of measures for artificially assisting pollination. It seems likely that anemophily is commercially inadequate even in parts of Africa during the first year or two following ablation, and there is a tendency there for fields to receive assisted pollination during this period. The requirement is more pronounced elsewhere, especially in parts of south-east Asia and the South Pacific, where a combination of ablation and planting material necessitate assisted pollination.

As a result of breeding and selection practices for high early yields in Malaysia, the number of female inflorescences produced by young palms has been increased at the expense of the male. The point has been reached where the sex ratio is so high that there is a widespread shortage of pollen in many plantings, this being very evident from direct observations of poor fruit set in areas where male inflorescences are scarce. After some years, the sex ratio becomes more balanced, but before this time the problem of inadequate pollination is frequently one of considerable economic importance if reliance is solely on natural agencies. In the same country, anemophily has been considered commercially adequate in the absence of assisted pollination but where other material has been planted, largely because such material has a higher rate of male inflorescence production. However, higher yields from the newer material make the cost of assisted pollination to supplement anemophily economically worthwhile.

Research requirements for oil palm anemophily

There is considerable value to be gained through comparing results of studies on oil palm pollen ecology carried out, using similar techniques, in countries where problems in obtaining pollination to the required commercial standard are likely to be related to environmental climatic factors. Where problems are encountered, an essential basic requirement is to discover if and where impedence of pollen transfer or normal fertilization occur. Investigations should be concentrated in the first instance in those areas where serious pollination problems are known to occur, so as to provide information which might immediately reduce the economic importance of the problems. The data obtained can be compared with the few already available, and comparison with similar investigations in a country as Nigeria could provide both interesting and economically valuable results.

Examination is required of all the mechanisms of pollen transfer in air currents. Basically, this could follow the general investigation carried out in Peninsular Malaysia (Hardon & Turner, 1967) but with closer examination of certain features. Major aspects for study could be grouped as follows. Such a study would require at least one year to complete if the effects of climate and inflorescence production variations are to be confidently assessed.

1. *Pollen release*

- Pollen dehiscence and release in relation to climate.
- Effect of surface wetness on pollen release, including effects on pollen clumping which might reduce distance of dispersal.
- Pollen quantities and viability at stages of anthesis, and the effect of fungal invasion in the later stages.

2. *Pollen transfer*

- Climatic effects on pollen concentrations in the atmosphere, using mainly continuous sampling apparatus.
- Distance of pollen transfer, using marked pollen.
- Interrelationships between pollen density, male inflorescence production and climate.
- Loss of viability under natural conditions.
- Effects of radiation. Radiation can exert a negative effect on pollen development. Exposure to UV light, such as occurs when pollen is shed in sunlight, decreases the viability of some pollen by as much as 80%, while only slightly affecting others. Wind dispersed pollen tends to be more resistant to the effects of sunlight or shade (Werfft, 1951).

3. *Pollen arrival*

- Stigmatic features affecting pollen acceptance and retention.
- The fate of pollen on floral structures other than the stigma. For example, is there a chemotropic reaction of pollen tubes along the style, as has been widely described for other plants? (Johri & Vasil, 1961).
- Pollen transfer from foliage.
- Dynamics of pollen deposition.
- Receptivity of female inflorescences, including when wet. A point here is that high temperature, especially during dry seasons, may cause stigmatic surfaces to dry out, thus shortening the receptive period. Pollen germination depends, amongst other

things, on the rate at which water is released from the germination medium and taken up by the pollen (Visser, 1955).

DISCUSSION

It is frequently pointed out that fruit set in oil palm in numerous countries is inadequate in the absence of assisted pollination, this resulting from a shortage of pollen and/or pollinators. Two important points arise here. Firstly, it must be remembered that oil palm outside West Africa is not in its natural habitat and suitable pollinators may be absent. Also, in the early years especially with some material, male inflorescence production is so low as to reduce pollen availability severely, even if pollinators were present. Secondly, adequate pollination for the palm is totally different from that of commercial requirements, and it is believed that this is a grossly overlooked factor in considering pollination problems. Pollination is needed for the continuation of the species but this does not necessitate the extensive fruit set sought commercially. It requires only a very small number of pollinated flowers to develop on a spikelet to prevent its abortion (Williams & Rajaratnam, 1971), this also being adequate for continuation of the species. All measures which increase the level of fruit set above the natural average, inducing unavailability in any way, or growing the species outside its normal environment can all lead to problems. Such problems can be seen in perspective when considering each situation in relation to the palm in its natural habitat at the end of a long period of evolution.

The survey of oil palm as an entomophilous plant indicates that the part played by insects or other fauna in pollination is likely to vary considerably between various parts of the world and at different times of the year or seasons. In most areas there seems to be little doubt that entomophily leads to levels of pollination which are totally inadequate for commercial purposes. Investigations are likely to show that there is no sharp delineation between entomophily and anemophily, and apportionment of relative importance is likely to prove difficult in the few areas where entomophily may seem to be significant.

Anemophily and its commercial adequacy is more easily demonstrated, although there are numerous points which require further elucidation. Comparisons of anemophily in countries where climate favours pollen distribution in air currents with areas where high rainfall frequency restricts this would be well worthwhile. From the evidence available, it would be remarkable if the pollination problems in Sabah and New Britain and the higher rainfall frequencies there proved to be only coincidental occurrences, although this may not be the only influential factor.

Consideration of oil palm pollination and the factors which affect it can be useful in future developments. A consideration of the environment is normally made in preparing feasibility studies in connection with other

aspects of oil palm cultivation; the present situation now indicates that assessment of possible future pollination problems should be included in any study.

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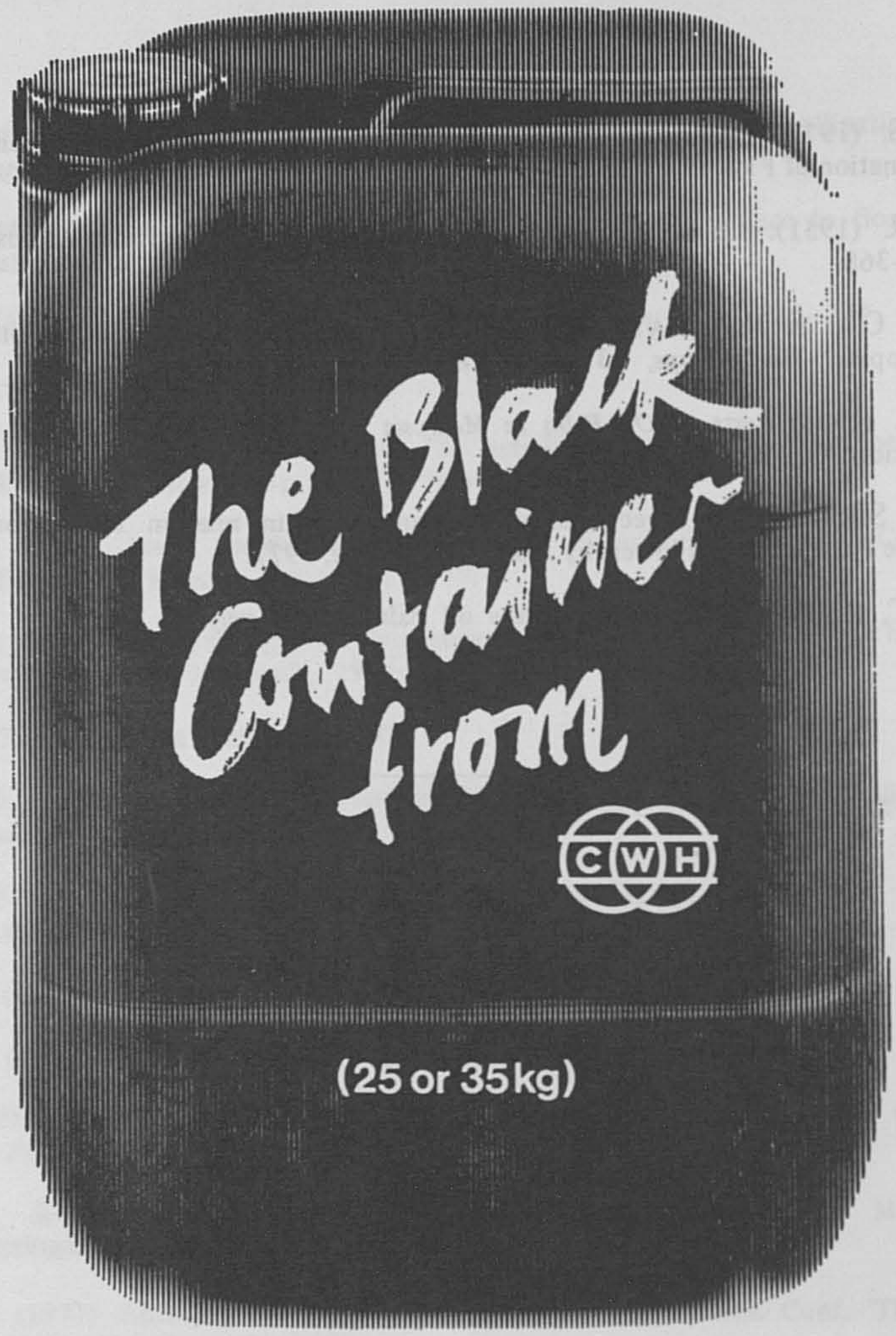
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Intercropping of coconuts with cocoa in Malaysia*

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There is a large acreage of land on the west coast of Peninsular Malaysia where the coconut is grown as a monocrop on fertile alluvial clays. A considerable proportion of this area can be underplanted with cocoa. Small-scale trials in the fifties were highly encouraging; by 1965, large-scale commercial cocoa plantings under coconuts had become a reality.

The favourable prices for cocoa beans in recent years, coupled with low and unstable economic returns from coconut monoculture and the provision of a ready-made shade system, have given a boost to this cropping system, so that it accounts for a major part of the rapid expansion of the cocoa industry in the country.

The present situation with respect to planting materials, cultural practices, fertiliser inputs, pests and diseases, harvesting and processing, as well as yields and profitability is considered and the main areas of research are discussed.

The establishment of new coconut plantings derived from high-yielding hybrid materials could significantly enhance the potential of this cropping system.

The coconut is a long-established, traditional crop in Malaysia, having been cultivated since ancient times. The manifold uses for its many products have always made it an important socio-economic component in the life of the people. The demand for vegetable oils in the world market led to the establishment of large coconut plantations in the early part of this century. By 1924 (see *Table 1*), there were nearly 200 000 ha. of coconuts in Peninsular Malaysia mainly on the west coast, on fertile alluvial clays, and on poor sandy soils, on the east coast. Low returns due to poor copra prices led to a number of the plantations switching over to more profitable crops like rubber and oil palm in the fifties. This trend was arrested in the sixties by the introduction of cocoa as an intercrop. During and since this period, coconut acreage in Peninsular Malaysia has remained static – losses in plantation acreage being more or less made up by smallholder plantings. There are further coconut areas in East Malaysia – about 55 000 ha. in Sabah and 17 000 ha. in Sarawak (Ramanathan & Kah, 1971; Child, 1974).

*Presented at the International Symposium on Coconut Research and Development, Kasaragod, India, 1976.

The introduction of improved coconut planting materials, of hybrid origin, with potential for very high yields, offers interesting possibilities for a new era of expansion for the coconut industry (Arasu, 1971; Fremond & de Nuce de Lamothe, 1971; Vanialingam, Khoo & Chow, 1975; Arasu; Vanialingam & Chan, 1976).

TABLE 1. AREA UNDER COCONUTS IN PENINSULAR MALAYSIA

Year	*Area under Smallholdings ('000 ha)*	*Area under Estates ('000 ha)*	*Total Area ('000 ha)*
1924*	n.a.	n.a.	199.36
1958†	173.33	35.90	209.23
1967≠	178.55	24.36	202.91
1975§	188.55	22.44	210.99

*Child (1974)
†Dickinson (1958)
≠Commonwealth Economic Committee's Review of Vegetable Oils and Oilseeds, 1970.
§Ministry of Agriculture, Malaysia.
n.a. not available.

The large number of coconut smallholders in the country have also had to face the economic pressures referred to earlier. These farmers now constitute a large poverty group in the Malaysian economy. The Malaysian government has now embarked on a coconut replanting and rehabilitation scheme aimed at improving the livelihood of small coconut farmers (Othman, 1972).

Broadly, there are perhaps three approaches to increasing the economic returns of coconut farmers:

1) replacing the coconut with a more profitable crop,

2) replanting with new high-yielding coconut material,

3) increasing the returns from existing land by suitable measures, including intercropping.

The first approach has been adopted by some plantations. However, it does not offer any advantage on a national scale, especially in the socio-economic context. The replacement crops, rubber and oil palm, already cover extensive acreages in the country and coconut oil continues to be a preferred vegetable oil for local consumption.

The second approach has obvious attractions, especially in the light of the highly productive hybrid material. On the other hand, the systematic replanting of some 300 000 ha. of existing coconut land is a considerable task and can only be undertaken in slow stages. Further replanting entails a period of zero return for a considerable period of time and will therefore be only reluctantly undertaken by farmers.

The third approach, therefore, offers the best prospect for the most rapid improvement in the productivity of existing coconut holdings. Much of the existing coconut land is poorly drained, poorly-maintained and rarely fertilised. While correcting these inadequacies will increase coconut yields, it is not estimated that increased yield will justify the expense involved. On the other hand, if this form of rehabilitation is coupled with a suitable intercrop, then returns from the intercrop will be more than adequate to cover the expenses involved and the improved coconut production will be an added bonus. For this reason intercropping is an integral part of the coconut replanting and rehabilitation programme. While bananas, coffee and pineapples have been recommended in the early days of the replanting and rehabilitation programme, cocoa has increasingly come into the picture and has become the principal intercrop recommended today.

There has been considerable interest in planting cocoa in Malaysia. Earlier efforts to establish cocoa plantations as a monoculture met with only a limited success and suffered a serious setback from cocoa dieback (Arasu & Phang, 1971; Chan & Lee, 1973). Although Cheesman (1948) considered the interplanting of cocoa under coconuts on coastal clay as unorthodox, test plantings showed that cocoa performed far better under these conditions than it did either under rubber or oil palm (Allen, 1953). Encouraged by these findings, large coconut plantations took to interplanting their coconut areas with cocoa in the sixties (Leach, Shepherd & Turner, 1971). Interplanting coconuts with cocoa spread rapidly and about 32 000 ha. are now cropped in this manner. Most of the coconut estates are now extensively intercropped with cocoa but a further 100 000 ha. of coconut smallholdings are considered suitable for intercropping with cocoa (Wong, 1971).

CURRENT COCOA PLANTING PRACTICE

Planting materials

When cocoa research began in earnest after the Second World War, Trinitario material from various sources as well as Amelonado material introduced from West Africa were tested. The latter was found to be superior and more uniform and therefore recommended for commercial planting (Rosenquist & Sockalingam, 1953). Unfortunately both Amelonado and Trinitario material proved highly susceptible to cocoa dieback (Haddon, 1961). A limited range of Upper Amason material was introduced. These material as well as some Upper Amason x Amelonado and Upper Amazon x

Trinitario hybrid progenies proved more vigorous and somewhat tolerant to dieback. For this reason, selected progenies, one or both parents of which are Upper Amazon lines, have become preferred material although they exhibit considerable variability. Current breeding programmes are aimed at identifying suitable parental combinations which perform well in terms of growth and yield, tolerance to dieback and bean quality (Chee, 1971; Edwards, 1971; Arasu & Phang, 1971). As most of the parental lines are self-incompatible, seeds of the chosen parental combinations are produced in seed gardens of suitable designs (Edwards, 1969).

Nursery practice

Teoh & Shepherd (1971) have confirmed the unreliability of planting seeds-at-stake as a cultural practice; also they have demonstrated that there is little or no benefit likely to be derived from retaining seedlings for more than four months in the nursery. However, seedlings will have to be retained longer in the nursery depending on when seeds become available and when it is practicable to plant in the field. Seeds are usually sown in soil mixtures in polybags, 30 x 20 cm – larger polybags are recommended if seedlings are to be kept longer in the nursery. Small amounts of fertilisers (either nitrogen alone or complete mixtures) are applied but fertilisers become more important when seedlings are retained longer in the nursery. A cocoa nursery (*Figure 1*) requires shade, water and protection from wind. Palm fronds, on a simple framework of posts and cross-pieces, are normally used to provide shade and lateral protection; this shade is easily adjustable and is advantageous in that it lets in more light as the fronds decay. Initial shade is about 20 per cent of full sunlight; when the seedlings are ready for transplanting, the shade should be of the same degree as the shade in the field (approximately 30–40%). The plants are kept close together up to six weeks and then spaced out 30 cm apart. A certain amount of culling is practised, discarding poorly-girthed and undersized seedlings.

Field planting

Tall coconuts are normally planted at 9 m on the triangle or square while dwarf coconuts are planted at 6 m. Cocoa is planted out as two rows, 3 m apart under talls (*Figure 2*) or a single row under dwarfs in the avenues between the palm rows. Spacing within the cocoa rows varies from 1.8 m to 2.4 m.

In many areas, the coastal alluvial soil is poorly drained and drains are constructed in every or alternate avenue.

The normal shade regime under coconuts appears to be satisfactory for cocoa growth. Where vacant points exist, these are filled with a shade plant *e.g., Glyricidia maculata.*

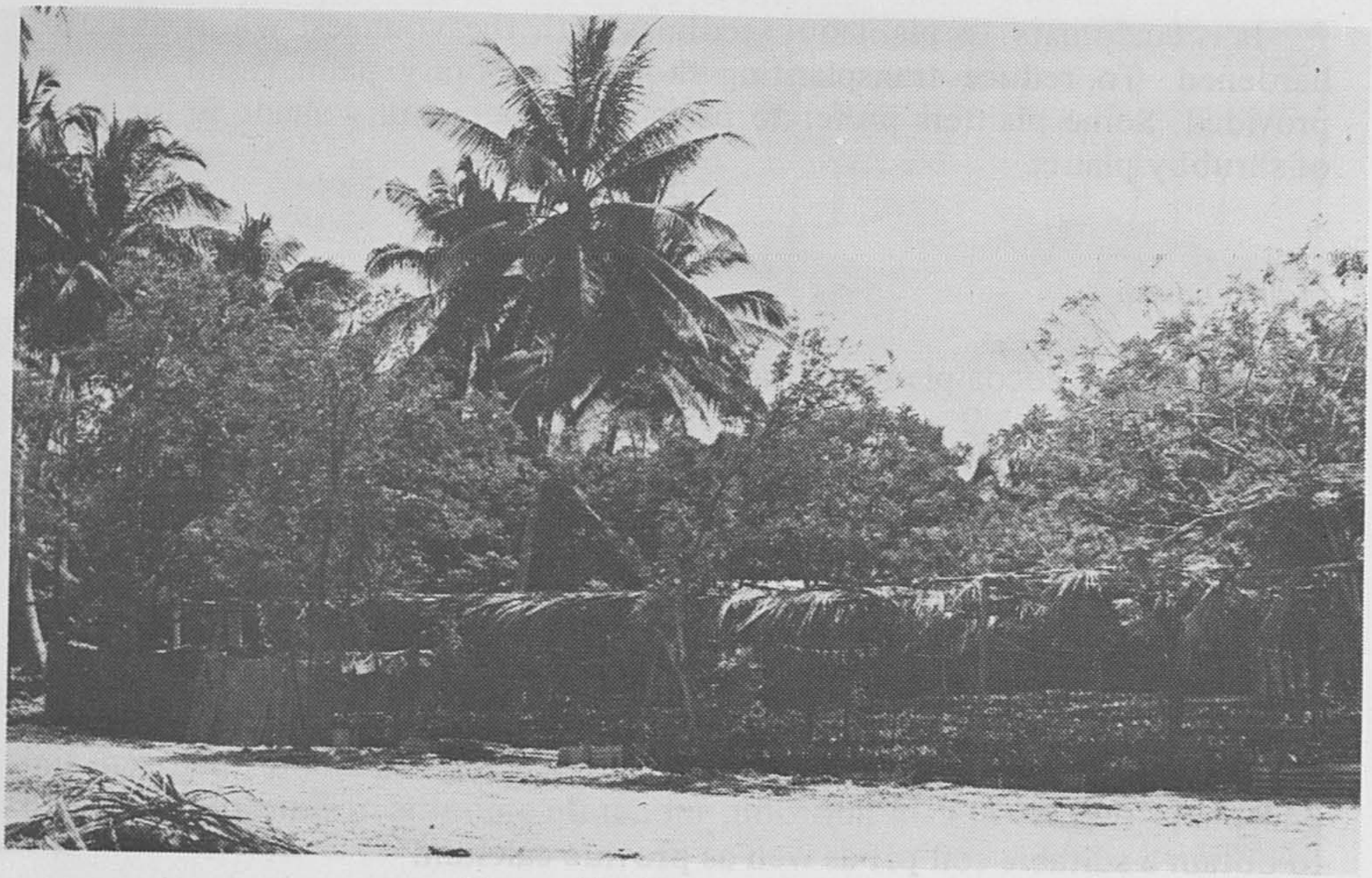


Figure 1. Cocoa nursery



Figure 2. Mature cocoa under tall coconuts

It is customary to plant out seedlings with the youngest whorl of leaves hardened. To reduce transplanting shock, temporary palm frond shade is provided. Some planters prefer to provide supplementary shade in the form of shrubby plants.

Maintenance

The young cocoa plants are normally pruned to only one jorquette, after a height of about 1.2 m has been achieved, in order to prevent keeling over. Volunteer chupon shoots which arise on the stem or trunk are periodically removed.

Accurate information on fertiliser requirements is lacking and considerable variation exists with respect to the type and amount of fertiliser applied. The principal nutrients that need to be added for immature cocoa is nitrogen and phosphate; when the cocoa comes into bearing, potassium becomes the most important nutrient and must be balanced by adequate nitrogen and phosphate (Ng, 1971). In addition, moderate amounts of limestone are used to obtain a suitable soil pH as well as provide calcium.

Leaf-eating insects constitute a serious danger to the cocoa crop. An integrated programme of control is practised using natural predators to the extent possible and supplementing this with a programme of insecticide sprays. The incidence of diseases .*eg.*, die-back etc., is countered by pruning and removing the diseased tissues. Prior to planting the cocoa, the fields are sprayed to eradicate the weeds and supplementary control in the form of manual ring-weeding or strip-spraying is practised up to two years. Once the cocoa is well-established, the shade provided by the combination of cocoa and coconuts should be adequate to suppress most weeds; only occasional spot-spraying is necessary in order to maintain a satisfactory ground condition.

Harvesting and Processing

The cocoa comes into bearing in the second year after planting. The pods are harvested, split in the field, and the wet beans transported to the central processing factory. Processing of the beans involves fermentation for a week followed by drying. Drying used to be exclusively by sun in the early days. More recently, artificial drying using oil-fired heaters has come into use (*Figure 3*).

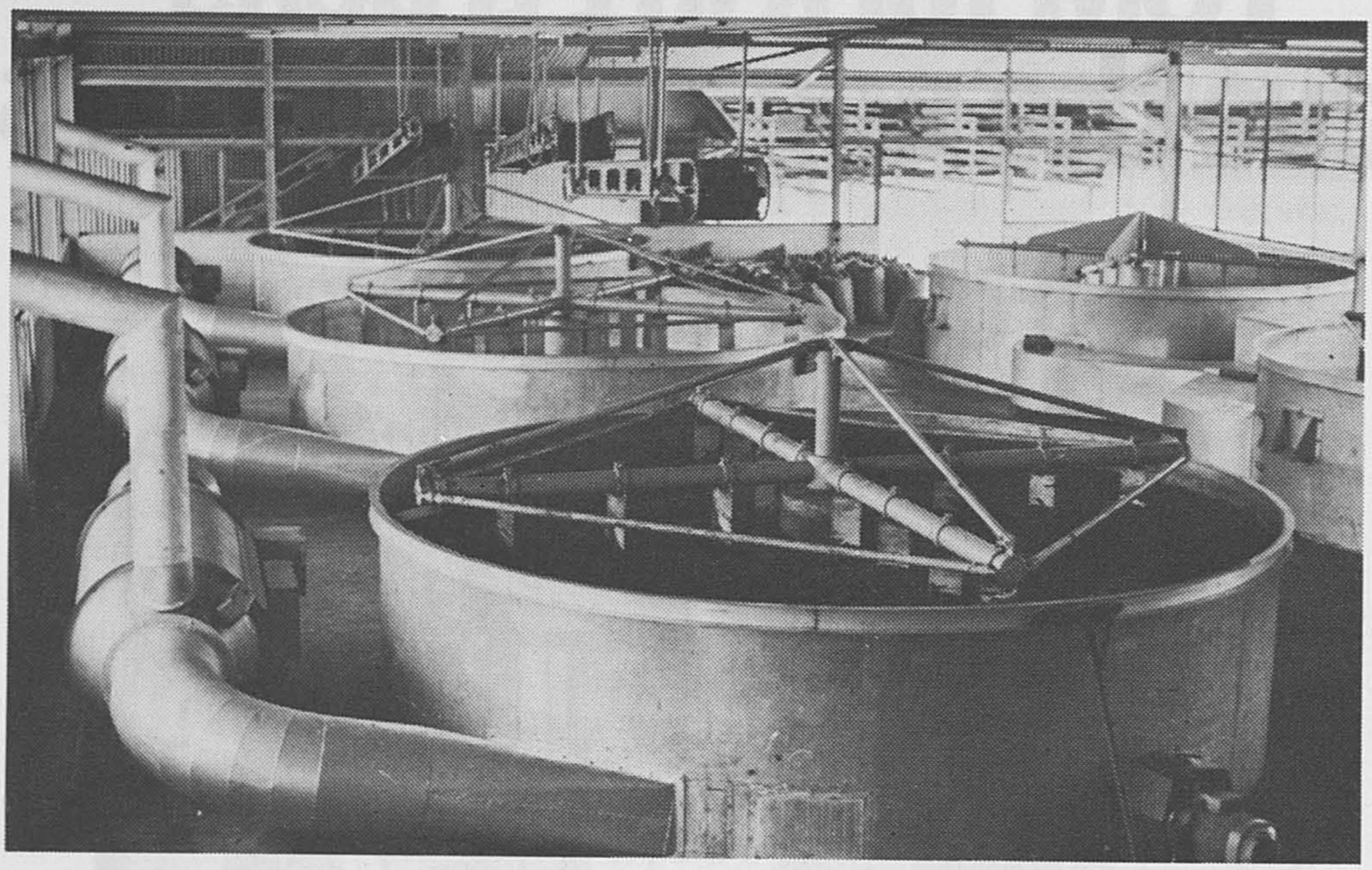


Figure 3. Cocoa processing factory with oil-fired rotary dryers.

EFFECT OF CULTIVATION OF COCOA ON COCONUT GROWTH AND PRODUCTIVITY

In intercropping, two main factors are of concern:

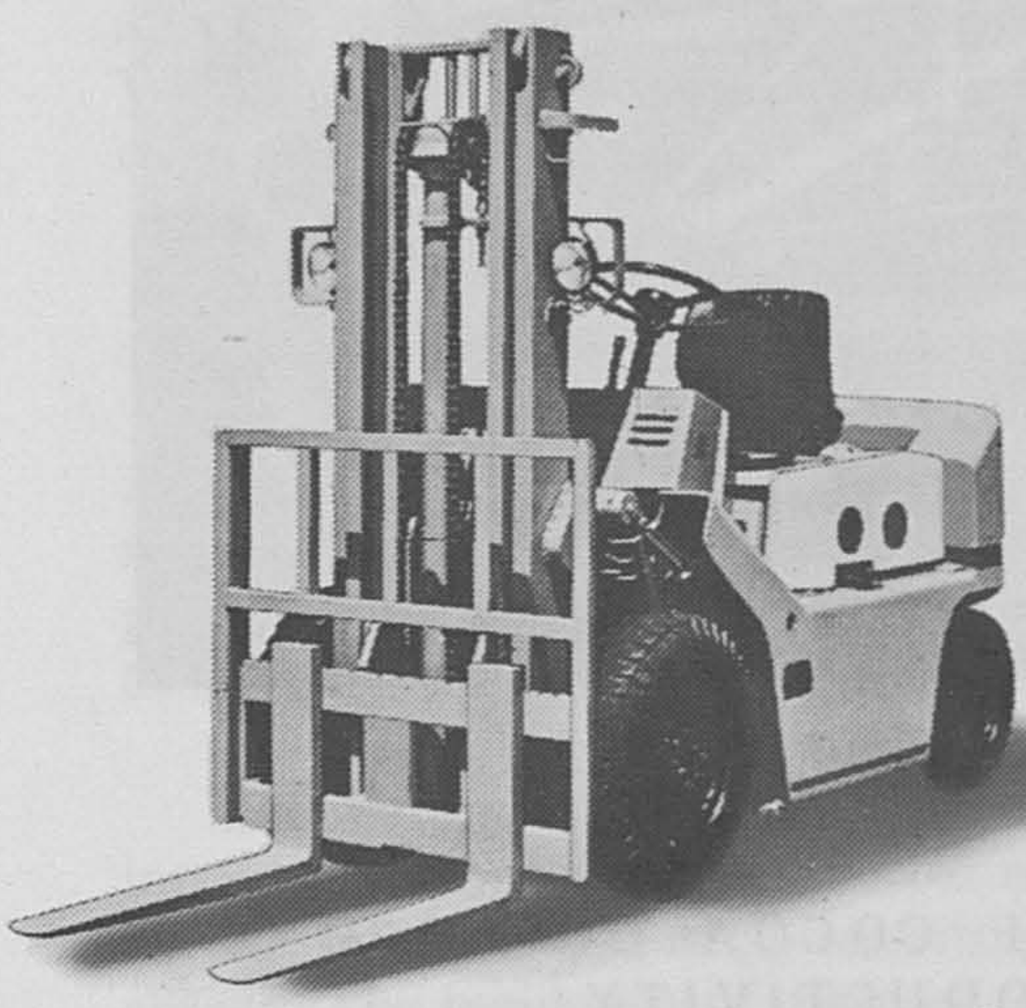
1) the extent to which the two crops are compatible *i.e.*, whether the intercrop will depress the yield of the primary crop, and

2) the type of yields that can be obtained from the intercrop.

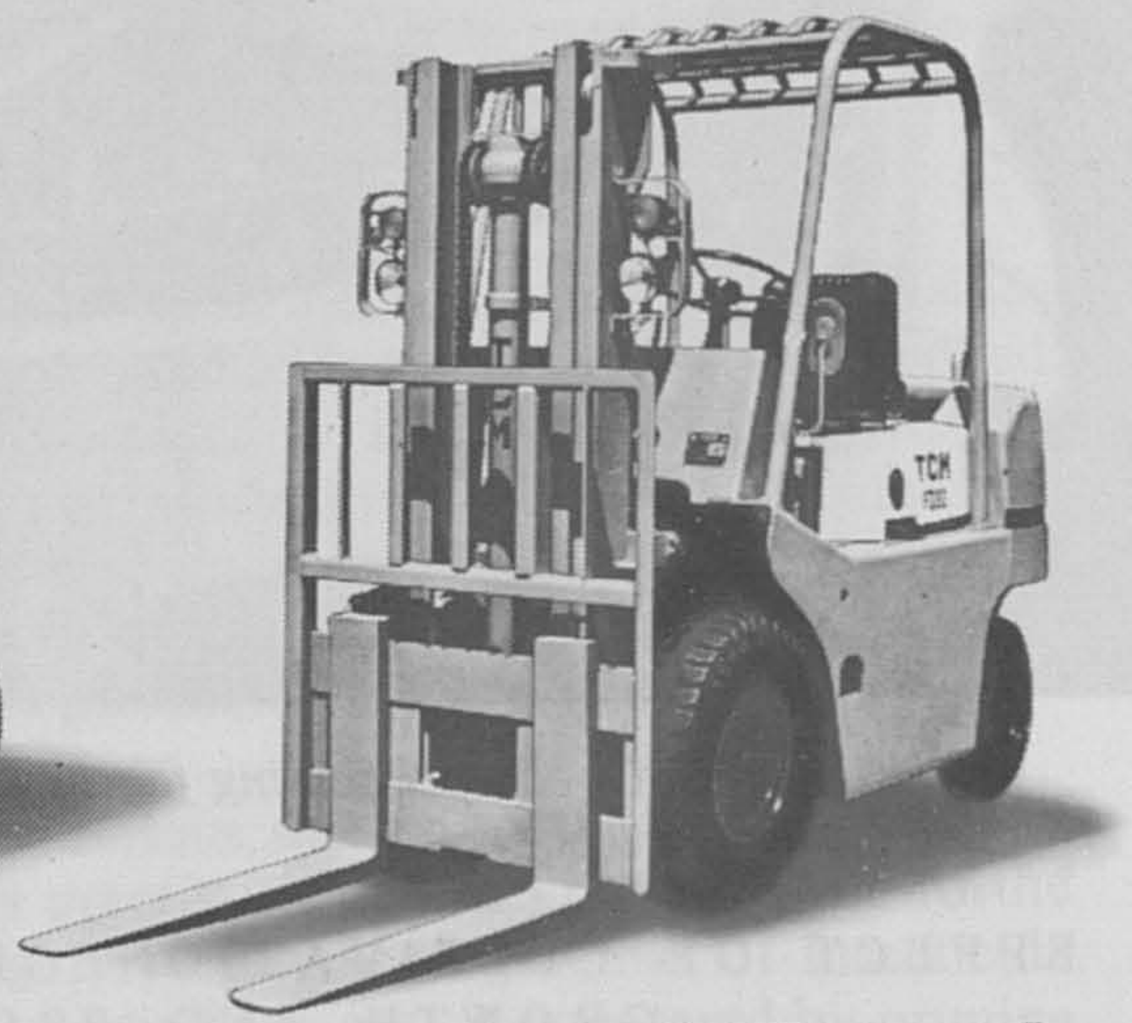
Experience so far in Malaysia has indicated that there is no adverse effect on the growth and yield of the coconuts. The initial cultivation and suppression of weeds during the establishment of cocoa would have a beneficial effect on the coconuts. When the cocoa comes into production, it can be expected that competition between the two crops will begin to set in; in normal practice, this is minimised by adequate application of fertiliser to the cocoa. There is evidence which indicates that the improved management levels, better drainage and fertiliser inputs associated with cocoa as an intercrop could benefit coconut yields (*Table 2 & 3*); on the other hand, absence of manuring depresses coconut yields (Tam, 1968). It may be argued that productivity of coconuts could be increased by simply providing these inputs, particularly fertiliser, without any intercrop at all; this is not an economic proposition given the low and unstable copra prices. In fact, due to negative responses to fertiliser in earlier experimentation (Belgrave & Lambourne, 1933; Wilshaw, 1941) as a result of poor drainage (Kanapathy,

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1971; Chew & Lee, 1971), it has been the general practice in this country to grow coconuts with minimum maintenance and fertiliser. Even if given the best coconut planting materials, optimum management levels and suitable agricultural inputs, it is highly unlikely that the economic returns of coconut monocropping would be as rewarding as a cocoa-coconut dual culture. Losses in coconut productivity, if any, would be far outweighed by high returns for cocoa beans. Estimates of profitability are given in *Table 5.*

Insofar as cocoa is concerned, it requires and grows well under the shade provided by the coconuts. Yield data from some commercial estates are given in *Table 4.* With improved planting materials and better cultural practices, significant increases in yield can be envisaged. While the primary objective is to increase the productivity of coconut lands, it is also true that it is so much cheaper and more rapid to establish cocoa under the ready-made shade system available under coconuts than as a monoculture so that the cocoa-coconut cropping system currently accounts for the major part of the expansion of the cocoa industry in Malaysia.

AREAS OF RESEARCH

The earlier breeding efforts in Malaysia have been carried out with the objective of developing improved materials suitable for cocoa monoculture on inland soils (Arasu & Phang, 1971). These are now being interplanted with coconuts. It is obvious that breeding objectives should be reorientated towards production of superior genetic materials whose performance is optimal under coconuts. Yields could be increased considerably, if clonal plantings were resorted to. With this in view, implementation of an integrated programme of research on vegetative propagation and related problems merits top priority (Ramadasan & Arasu, 1976).

There exist strong possibilities for raising the potential of mixed cocoa-coconut plantings with high-yielding coconut materials. In terms of accelerated coconut improvement, the development of intervarietal hybrids offers the brightest prospect (Arasu *et al.,* 1976).

More information on the physiological characteristics of young cocoa seedlings is obviously necessary for development of optimum nursery techniques. If it were possible to relate early juvenile characteristics to final growth and yield patterns, the advantage to breeding and selection in a perennial crop is only too obvious.

There is a need for more studies to determine the optimum cocoa density and planting pattern such that there is maximum efficiency in utilisation of the light and land available, with minimum interspecific and intraspecific competition for water and nutrients. Deep-planting techniques may enable different soil zones to be tapped by the two species. In this context, studies on root distribution and physiological activity assume

TABLE 2. COPRA YIELDS (KG/HA.) OF MALAYAN TALLS* ON NEIGHBOURING PLOTS WITH AND WITHOUT INTERPLANTED COCOA

Year	*Cocoa planted in 1967*		*Neighbouring plot without cocoa*	
1960	1 164.8		1 448.5	
1961	1 523.2		1 299.2	
1962	1 657.6		1 045.3	
1963	1 717.3	$\bar{x}$ = 1 627.7	1 314.1	$\bar{x}$ = 1 209.6
1964	1 687.4		1 090.1	
1965	1 597.8		1 224.5	
1966	2 075.7		1 075.2	
1967	1 612.8		1 344.0	
1968	2 404.2		836.3	
1969	1 687.4	$\bar{x}$ = 2 210.1	925.85	$\bar{x}$ = 881.1
1970	2 538.6		895.98	

(Extracted from an IRHO technical report to Messrs Barlow Boustead)

*Approx. 40 yr old when interplanted with cocoa.

TABLE 3. COPRA YIELDS (KG/HA.) FROM VARIOUS ESTATE FIELDS BEFORE AND AFTER INTERPLANTING WITH COCOA*

Coconut variety	*Year of planting*	*Year interplanted with cocoa*	*Mean copra yields for 5 years before interplanting*	*Mean copra yields after interplanting, 1971-75*
Malayan Talls	1926	1971	1 508.2	2 120.5
	1926	1971	1 717.3	1 926.4
	1927	1967	1 971.2	2 075.7
	1927	1968	1 911.4	2 016.0
	1927	1968	2 030.9	2 254.9
	1927	1968	2 045.8	2 105.6
	1928	1971	1 806.9	1 926.4
	1930	1968	1 941.3	2 120.5
	1930	1968	2 135.4	2 180.2
Dwarfs	1931	1964	2 165.3	2 254.9
	1936/37	1964	2 045.8	2 075.7
	1940/41	1964	1 881.6	2 001.0
	1940/41	1966	2 075.7	2 256.4

*Data from Messrs. United Plantations

TABLE 4. SOME YIELD DATA FOR COCOA INTERPLANTED WITH COCONUT UNDER ESTATE CONDITIONS*

Year planted	*Stand/ hectare*	*Coconut variety*	*Yield per hectare (kg of dry beans)*					
			1970	*1971*	*1972*	*1973*	*1974*	*1975*
1966	951	Malayan Talls	770.6	744.8	340.5	780.6	1 301.4	1 190.6
1969	1 010		282.2	627.2	608.2	730.2	1 070.7	1 085.3
1969/70	886		–	13.4	159.0	430.1	922.9	968.8
1969/70	886		–	13.4	159.0	430.1	905.0	916.2
1970	973		–	–	21.3	392.0	842.2	813.1
1971	867		–	–	–	–	236.3	747.0
1972	689		–	–	–	–	231.8	542.1
1972/73	756		–	–	–	–	–	156.8
1973	803		–	–	–	–	–	169.1
1973	847							
1968	864	Dwarfs	–	–	785.1	903.8	1 080.8	759.4
1968/69	642		19.0	443.5	678.7	641.8	703.4	600.3
1969/70	736		–	13.4	159.0	565.6	777.3	619.4
1971	886		–	–	–	114.2	430.1	412.2

* Data from Messrs. Barlow Boustead

TABLE 5. ESTIMATED PROFITABILITY* FROM COCOA-COCONUT INTERPLANTINGS AT DIFFERENT COPRA & COCOA YIELDS

Coconuts		*Combined net profits ($)†*		
		Cocoa yields (kg/ha. dry beans)		
Yield (kg/ha.)	*Net profit/ hectare ($)†*	*500*	*800*	*1 100*
700	119.00	889.00	1 351.00	1 813.00
1 000	170.00	940.00	1 402.00	1 704.00
1 300	221.00	991.00	1 433.00	1 915.00
1 600	272.00	1 042.00	1 504.00	1 966.00
1 900	323.00	1 093.00	1 555.00	2 017.00
2 200	374.00	1 144.00	1 606.00	2 068.00
2 500	425.00	1 195.00	1 657.00	2 119.00

* Expected average profit margins:
for cocoa = $1.54/kg.
for coconut= $0.17/kg.

† in Malaysian Currency

importance; this, of course, has its relevance to fertiliser inputs. Pruning practice should be studied in relation to obtaining a photosynthetically-efficient canopy, permitting maximum light penetration. In the case of new coconut plantings, it is necessary to obtain the ideal combination of cocoa and coconut densities, from the point of view of shade requirements for cocoa, competition and economic considerations.

Studies of nutrient uptake data suggest a potassium requirement mainly for coconuts and calcium for cocoa (Ng, 1968). The mutually antagonistic relationship between calcium and potassium could result in nutrient imbalance; also the type of nitrogenous fertiliser may affect absorption of these cations. Fertiliser placement may offer an effective solution and therefore merits urgent attention; a knowledge of root systems of both crops is therefore important. For timing fertiliser applications, an understanding of the growth and yielding patterns of cocoa is clearly desirable. Foliar analysis as a diagnostic tool, which has yet to be worked out satisfactorily for cocoa, would result in more efficient evaluation of nutrient status and, if necessary, appropriate remedial fertiliser recommendations.

With regard to diseases, there is a need for more information on their etiology and factors influencing their occurence, distribution and build-up. A deeper understanding of ecological relationships and natural enemies is essential in formulating more effective integrated pest control programmes.

High bean acidity, which at present poses a serious problem, is attributable to faulty fermentation and drying (Shepherd, 1976). Microbial and biochemical aspects also merit study in order to find a solution.

DISCUSSION

Intercropping of coconuts with cocoa has only recently been introduced as a solution to the problem of low productivity of coconut lands. The vacant land in between coconut rows, hitherto uncultivated, is now utilised to produce another valuable crop. The success achieved, as demonstrated by the phenomenal growth in acreage and production, is a clear indication that this cropping system is here to stay as an integral component of the agricultural scene in Malaysia.

The use of high-yielding coconut hybrid material in replanting exercises could significantly enhance the potential of this cropping system. In the long term, the replanting of oil stands which are past their economic life appears to be inevitable.

There is considerable interest, particularly in the plantation sector for expanding cocoa cultivation in inland areas in the light of the success achieved by a large undertaking. However, this entails the use of shade species such as *Albizzia chinensis* and *Parkia speciosa* (Mainstone, 1971) which do not yield products of great economic value, to provide permanent top shade. There is a strong possibility that this type of shade could be provided by high-yielding coconut hybrid material – provided they receive adequate maintenance.

It must be emphasised that for the full potential of the mixed cocoa-coconut cropping system to be realised, there is a need for adequate research and developmental efforts. There is definitely a requirement for a similar emphasis on coconut research as for cocoa. The research programmes for the two crops must necessarily be integrated in order to take into account the requirements of the cropping system as a whole.

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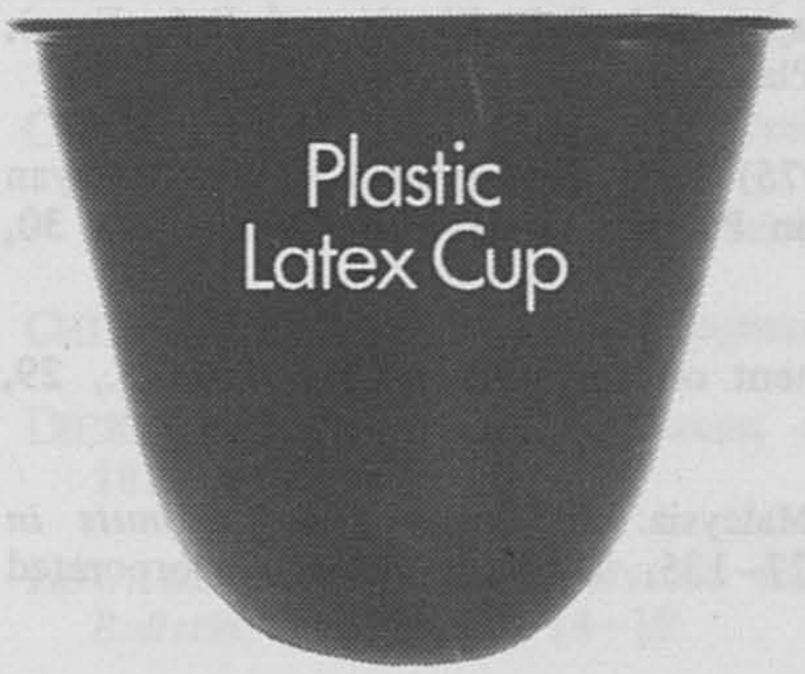
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Coconut hybridization by the Policaps and Mascopol systems

H. C. HARRIES

Coconut Industry Board, Kingston, Jamaica

The POLICAPS system for coconut hybridization uses individual Polyurethane Isolation CAPS to protect each female flower from unwanted pollen. Policaps have advantages over the large bags of plastic, terylene, or heavy canvas that have previously been used to isolate the inflorescence. Using this new system the time for pollination can be judged from ground level without the need to climb the palm or disturb the isolated flowers. The method of pollination positively ensures that pollen is applied to the stigmas and identifies which female flowers have been pollinated and which have not. With the policaps system the female flowers are not exposed to the high temperature and humidity that can occur in isolation bags, and indeed the policaps insulate the female flowers from extreme conditions. All these advantages should lead to improved fruit set from controlled pollinations.

The MASCOPOL system, or MASs controlled pollination, does away with the need to isolate individual flowers or inflorescences by establishing the whole seed garden in an isolated area or by surrounding it with a screen of foliage. The application of large amounts of pollen to large numbers of emasculated palms produces hybrid seed in commercial quantities. The mascopol system allows a new hybrid to be produced simply by bringing a different pollen to the seed garden.

The policaps and mascopol systems complement one another. Policaps will be used on selected, individual palms from desirable, cross-pollinated cultivars to produce improved progenies; these will in turn provide pollen for mascopol hybrid production. It is intended that sufficient information be available here to encourage others to take a practical interest in coconut breeding.

THE COCONUT PALM

Unlike the oil palm, the date palm, or many other crops, the coconut palm produces very few seeds on one inflorescence. However, new inflorescences open at approximately monthly intervals throughout the year and a continuous pollination program can be maintained.

Each inflorescence bears both male and female flowers (*Figure 1*). For hybridization the male flowers must be removed (emasculation) and the female flowers must be kept free from contaminating pollen (isolation) until the correct pollen for the particular cross is supplied (pollination). These

three operations, emasculation, isolation, and pollination, which are the elements of controlled hybridization, have been understood and practiced by coconut breeders for many years. Recent innovations in pollen collection, storage, and application have now liberated the coconut breeder from the limitations of low seed set by allowing him to increase the number of palms which are pollinated. The commercial production of many different F_1 hybrids is a major factor in modern agricultural development schemes in countries where coconuts are grown.



Figure 1. A coconut inflorescence.

The quality of the F_1 hybrid is determined by the two parents. Improvement within a parent type and eventually, perhaps, the development of a true-breeding cultivar as good as the F_1 hybrid, calls for controlled hand-pollination of selected individuals. Here the availability of large quantities of pollen is not essential. What is needed is the ability to set an optimum number of seeds on any one pollinated inflorescence. While investigating the factors that control the number of nuts carried on any one bunch, an improved pollination technique was developed.

THE POLICAPS SYSTEM

Emasculation

Unless the male flowers are needed for pollen collection (*see* below), the best time for emasculation is the day before the inflorescence would normally emerge from its spathe. This can be judged, with experience, from signs such as the bulges at the bottom of the spathe (caused by the developing female flowers), the widening of the longitudinal groove (which is the point of weakness along which the spathe naturally splits), and the loss of the fresh color from the tip of the spathe.

At this stage the tip of the spathe is cut off with secateurs and the point of the blade is used to split the spathe vertically into two or three strips. These are cut off as low as possible. If emasculation is done a week later, when the male flowers are sufficiently developed for pollen collection, the spathe will have dried considerably and is then more difficult to remove. The inflorescence that is exposed by early emasculation is tender and must be handled carefully. The female flowers may not develop if they are damaged and the junction of the branchlets with the main inflorescence stalk is likely to tear.

Sometimes a few male flowers near the tip of the inflorescence may have opened within the spathe before it is split. The risk of pollen contamination from these is slight since the female flowers are not yet receptive. All male flowers are removed by cutting each branchlet 2–3 cm. above the female flowers. Male flowers also occur at the base of female flowers and it is essential to pick these off by hand. Branches without female flowers are completely removed. Other branches may have one, a pair, or more female flowers. Since policaps are intended to cover single flowers, any twin flowers are removed (although it would be possible to make suitable twin policaps). Damaged, insect-infested, or deformed female flowers are removed. If a very high number of female flowers are present, they can be reduced in number since pollinating all of them might require more than two or three visits. If 30 or more nuts are set, these become so heavy that they can pull the bunch out of the leaf axil before it is mature.

Isolation

All but one of the remaining female flowers are covered with policaps, which should fit in place when slightly stretched (*Figure 2*). Since different cultivars and different growing conditions affect the size of the female flower, no exact measurement will be given here; policaps of different sizes are easily made (*see* below). As the female flowers develop, their increase in size ensures that the policaps fit even more securely. The female flower which is not covered should be one that can readily be seen from ground level. When the policaps have been fitted, the date is marked on the petiole subtending the inflorescence and all of the male flower stalks are collected and disposed of (*see* below). None must be left in the leaf axils.

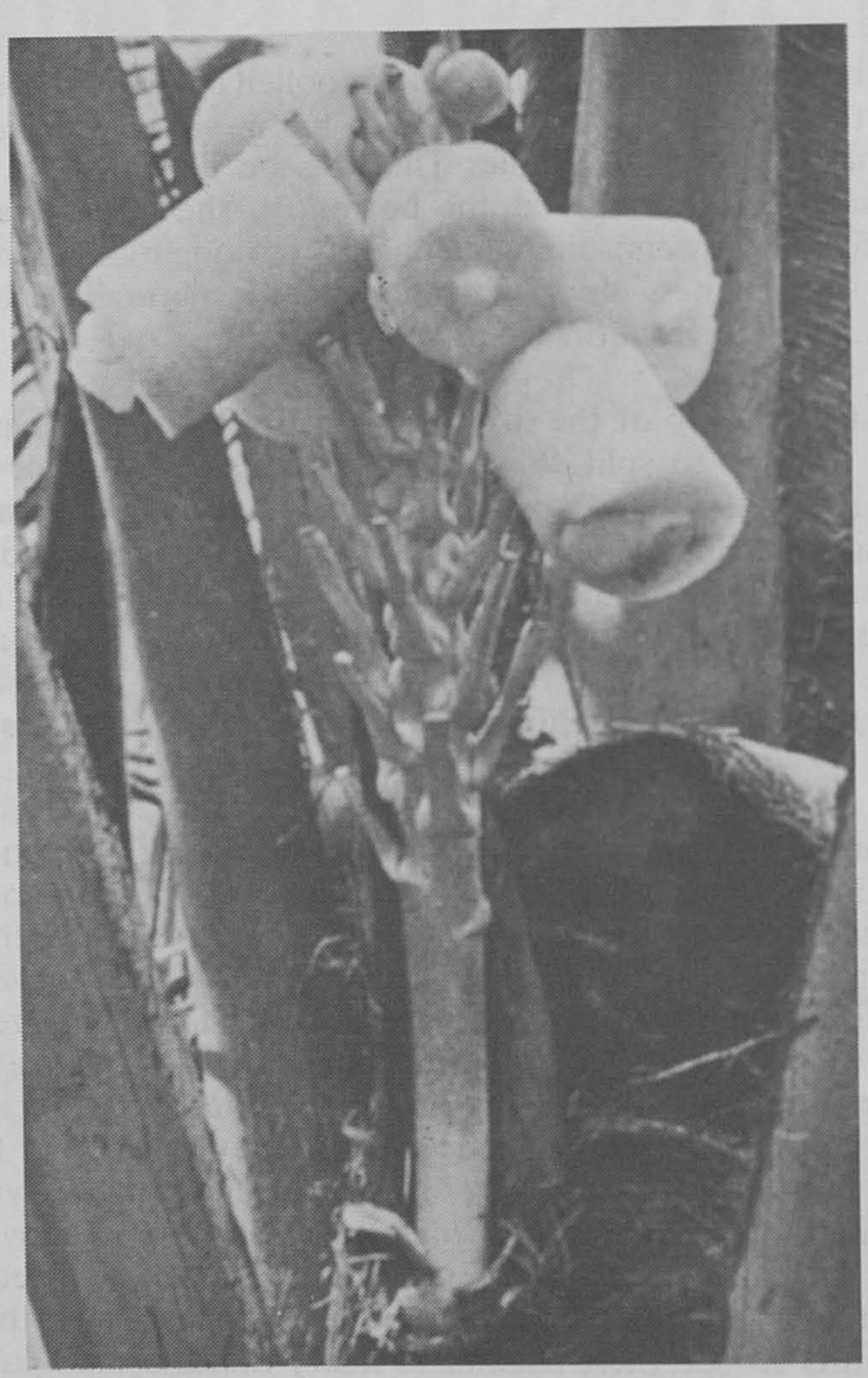


Figure 2. Policaps in place on all female flowers but one of an emasculated coconut inflorescence.

Pollination

When the inflorescence opens, each female flower continues to develop and after about two weeks the ovary begins to emerge between the close-pressed perianth lobes. The exact time for pollination receptivity depends on the cultivar and the growing conditions and occurs when the three-pointed stigma is reflexed, moist, and white. Nectar is produced at this time. If isolation bags are used, receptivity cannot be observed and has to be guessed at, the palm climbed, and the bag opened. With policaps the stage of receptivity of the female flowers can be seen from the one which was not covered (*Figure 3*). Only when it is becoming receptive, need the palm be climbed. The other flowers are then inspected by removing and replacing one plug at a time. Each receptive flower is pollinated. The bunch is labelled, on the occasion of the first visit, with a tag identifying the pollen parent *and the exposed flower is cut off.*

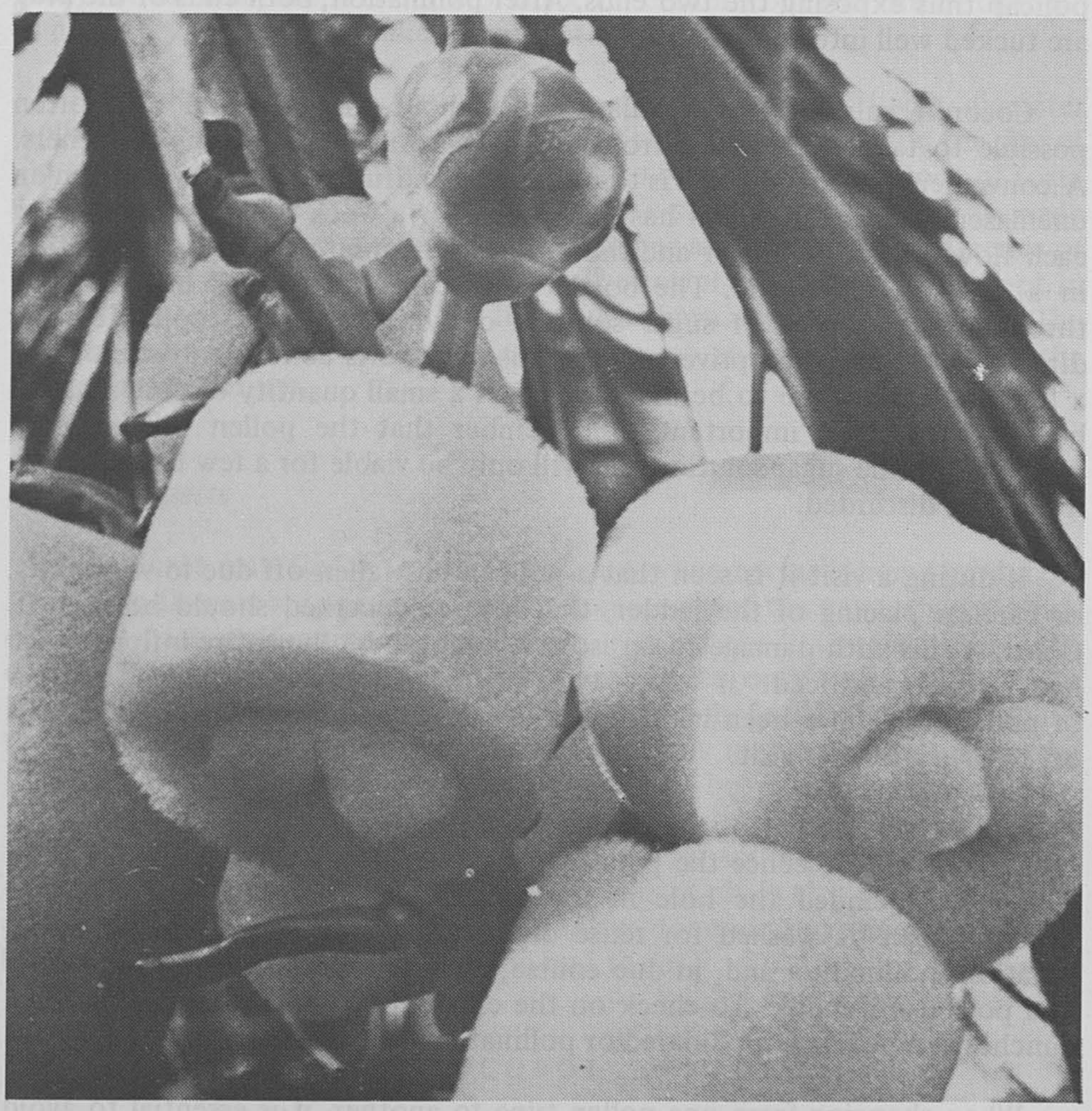


Figure 3. Exposed female flower becoming receptive.

For pollination it is convenient to collect pollen in advance and store it. In this way a fresh supply of pollen can be taken each day in a small, semiopaque vial, stoppered with a polyurethane policaps plug and kept out of the direct sun. When a receptive female flower is found, the plug is removed from the policap, and the pollen vial is shaken to deposit pollen on the end of its plug. This is then removed from the vial and pushed into the policap to bring the pollen in contact with the receptive stigma. The projecting end of the plug is tucked well into the policap to hold it firmly, and the plug that was removed from the policap now serves to close the vial and act as a pollen brush for the next receptive female flower. When there are many flowers on an inflorescence, they will not all be receptive at the same time, and second and third visits may have to be made. On these later visits, to avoid disturbing the pollinated female flowers, the different positions of the plugs serve to distinguish unpollinated from pollinated flowers. Before pollination the plug should be folded into a U-shape in the policap thus exposing the two ends. After pollination, both ends of the plug are tucked well into the policap.

Coconut palms flower regularly throughout the year and it is often possible to take fresh pollen from one palm to use immediately on others. A convenient way to do this is to pull off a handful of male flowers from an unemasculated bunch which has been open for a week or two and, cracking each flower between finger and thumb, drop them into a 10% sugar solution in a small plastic bottle. The bottle has a cap with a small hole or tube through which drops of sugar solution carrying suspended pollen can be directed onto each receptive stigma. This method is convenient where only a few pollinations are to be made or when a small quantity of pollen has to be extended. It is important to remember that the pollen will begin to germinate in the sugar solution and will only be viable for a few hours before it must be discarded.

If during a visit it is seen that a policap has fallen off due to wind, rats, or careless placing of the ladder, the flower concerned should be cut off. Contrast this with damage to an isolation bag where the entire inflorescence has to be sacrificed. If after two or three visits a sufficient number of pollinations have been made and a few flowers remain, these may be cut off to save a further visit.

At a later visit to the same palm to emasculate or pollinate the subsequent inflorescence the policaps may be removed. The developing fruit will have expanded the hole in the policap and it will be stiff with dry nectar. It can be washed for reuse or discarded. Records of emasculation, isolation, pollination and, in due course, of nuts reaped, can be made daily in a pocket notebook. To check on the emasculator's efficiency, occasional bunches can be left unpollinated or pollinated with dead pollen.

When changing from one pollen type to another, it is essential to avoid cross contamination. Hands, arms, and equipment may be safely sprayed

with 70% alcohol or a 10% solution of calcium hypochlorite (bleach), which will kill pollen. Some workers may also feel that the female flowers should be similarly treated before the policaps are put on but since pollen is only viable for a day or so, this should not be necessary when policaps are put on two weeks before females are receptive. However, if the bunch is being used for pollen collection, which is not done until the inflorescence has been open for one or two weeks, the later isolation allows a risk of pollen contamination and, therefore, requires sterilization, for which alcohol or bleach is quite suitable.

Making Policaps

Soft polyurethane foam is widely used commercially for packing and insulation and domestically for mattresses and furnishing and it can be cut easily. A suitable size is 5 cm x 5 cm x 7.5 cm long but this can be changed as necessary, perhaps to make use of factory off-cuts.

To make a hole in the foam any metal tube of suitable diameter (approximately 2–3 cm) can be used, the diameter depending on the size of the female flower of the particular variety to be isolated. The block of foam is compressed against the end of the tube (a suitable holder may be made from a can) and struck sharply with a hammer around the circumference of the tube, cutting the foam (*Figure 4*). The metal tube needs to be kept in good shape and smoothed with a file, but a sharp edge is not essential. The plug of foam removed is folded into a U-shape and replaced to make the policap ready for use.

Control of pests

Small ants may find a way into policaps when nectar is being produced. If no male flowers are present on any inflorescence of the palm, then the risk of accidental pollination is negligible. Nevertheless, to eliminate ants, cockroaches, and eryophid mites the policaps need only to be soaked in an insecticide such as chlordane and allowed to dry before use. Rats may also be attracted to the nectar and rats or squirrels may sometimes take the polyurethane for nesting purposes. They can be controlled by baiting.

The emasculator/pollinator can also be a source of trouble if he carelessly knocks off or damages maturing fruit. It is also possible that, if a long ladder is used in a young tree, damage done to the young spear leaves by the end of the ladder can cause the bud to rot.

THE MASCOPOL SYSTEM

The mascopol system, or mass controlled pollination in Jamaica, is essen-

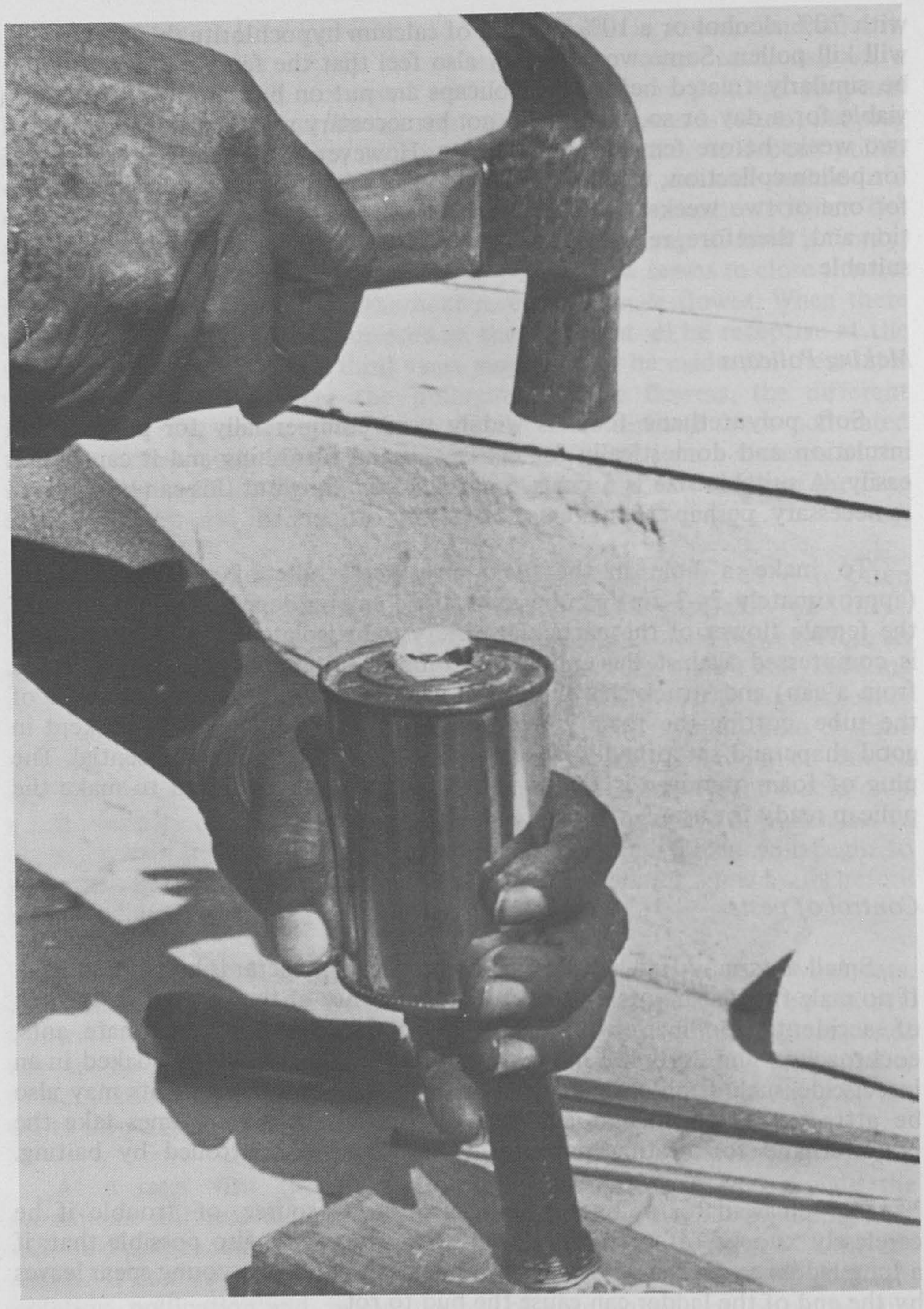


Figure 4. Making policaps.

tially the same as 'pollination assistée' in Ivory Coast. Hybrids are produced in commercial quantities by blowing or dusting pollen onto the receptive female flowers of some hundreds or thousands of palms daily (*Figure 5*).



Figure 5. Mascopol pollination. Photo by Wendy Hunt.

Isolation

Individual isolation of so many female flowers would be prohibitively expensive. Isolation is achieved by planting the seed garden in an area where no other coconuts grow or by surrounding it with a screen of foliage. This screen should be 200 to 300 meters wide, and it can consist of other tree crops or even emasculated coconut palms. This last method is less satisfactory

but because of the extensive nature of coconut plantings it may have to be commonly adopted. These emasculated guard rows should be pollinated with the same pollen being used in the seed garden, but unless suitable color markers are involved, the resulting fruit may be suitable only for copra (*see* color markers).

Emasculation

For the mascopol system, emasculation is done in the same way as described above for the policaps system. There is no need to remove twin or excess flowers as long as the male flowers around these are removed. Since the female flowers are not individually isolated, it is essential that emasculation be done efficiently so that no inflorescence is allowed to open and shed pollen and no single male flower is overlooked. One male flower produces thousands of grains of pollen. Although only some of the palms need to be emasculated on any one day, and the number depends on the time of year and the prevailing weather, all palms in the seed garden have to be inspected for six days out of seven. If done properly, no inflorescence should open on the seventh day. Allowance must also be made for working during public holidays. One man may be made responsible for about 400 six-year-old palms. Again, the exact number will vary with the season and also with the terrain over which ladders have to be carried.

The male flowers removed at emasculation must be disposed of. On sandy soil this can be done by burying them. Burning is difficult, because the material is fresh and cannot be dried before burning since pollen may be released. Bottomless steel drums with lids can be used. When full, the drum is dragged to one side to allow some of the decomposing flowers at the bottom to spill out. There must be enough drums to hold the male flowers long enough for them to decompose, and the lid must be kept in place at all times to prevent insects visiting and then carrying pollen back to the emasculated palms.

Pollination

At certain times of the year, one bunch is ready for emasculation when another on the same palm is just receptive. The emasculator can, therefore, be supplied with a hand pollen-blower with which to pollinate these. Otherwise, pollination is carried out as a separate operation by blowing a pollen: talc mixture (1:8 parts by weight) from a hand-held blower operated from the ground. If pollen is in short supply, then hand application of undiluted pollen to individual female flowers will give excellent fruit set, but it does involve increased labor costs. To produce a different F_1 hybrid combination it is best to prepare two to three weeks in advance by clearly marking newly emasculated inflorescences with colored ribbon or a splash of paint. One week before these marked inflorescences become receptive, all pollination

is discontinued. When the female flowers on these inflorescences become receptive, pollination is resumed using the new pollen parent.

REAPING SEED

Coconut fruit does not mature until 11–15 months from pollination, depending on cultivar and season. Apart from the inflorescence branchlets that were shortened or removed during emasculation, the pollinated inflorescences look no different from normal bunches nor do the reaped fruit (seednuts) look any different. It is not until germination and subsequent growth that hybrids can be recognized (*see* color markers below). On the first sign of the fruit maturing, when they begin to loose their fresh color and turn dry brown, the policaps-pollinated nuts should be carefully reaped by hand, marked according to the tag on the bunch, and set in nursery beds similarly identified. Mixing of seed or young plants can lead to confusion that will undo all the careful work of the pollinator a year before. Mascopol nuts can be reaped by the bunch instead of individually since they will all be of one type. However, when changing from one hybrid to another, as indicated by the marked bunches (*see* above), care should be taken to see that the bunches marked differently are set separately.

CHOICE OF PARENTS

On the basis of present knowledge, the most suitable F_1 hybrids will be those resulting from a cross between selected dwarf and tall parents, since these will combine the precocity and high nut number of the dwarf with the larger nut size and robustness of the tall. If the 'Malayan Dwarf' is used, then the hybrid will have some resistance to lethal yellowing disease, the level depending upon the male parent.

Color markers

Accidental self-pollination, or pollen contamination due to inefficient isolation, could possibly go unnoticed for five years or more until the presumed hybrid plants come into bearing. Fortunately, this can be largely prevented by making use of the knowledge of color inheritance when choosing parent palms. The colors referred to can be identified on leaf stalks of seedlings and mature palms and on developing fruit, and are shades of yellow, red, green, and bronze, which can be easily distinguished with a little practice. The dwarf is either yellow, red, or green, and the tall is either green or bronze (the exceptions to this general rule need not confuse us here).

In crosses involving two different colors, one color predominates in the hybrid as shown in *Table 1*.

TABLE 1. COLOR INHERITANCE IN HYBRID SEEDLINGS OF COCONUT (SIMPLIFIED)

Seed Parent	*Pollen Parent*				
	Yellow	*Red*	*Green*	*Bronze*	
Yellow	Yellow	Red	Green	Bronze	*Hybrid Seedlings*
Red	Red	Red	Green	Bronze	
Green	Green	Green	Green	Bronze	
Bronze	Bronze	Bronze	Bronze	Bronze	

The table is simplified in so far as it does not take into account the fact that all colors except yellow can be either homozygous, *i.e.* they breed true for the particular color, or heterozygous, *i.e.* they produce plants mainly one color but with a proportion of one of the other colors. Intermediate shades are also found. For the purposes of this introduction to coconut hybridization, it is sufficient that either the yellow or red dwarf forms be chosen whenever possible as the seed parent. In this way, seedlings produced by accidental self-pollination or contamination from other dwarfs can be distinguished from dwarf X tall hybrids as soon as they germinate in the nursery. Green dwarf is less satisfactory as a seed parent, because confusion may arise if hybrids are likely to be green as a result of the pollen parent color. Contamination from neighbouring tall varieties, if these are not the same as the tall pollen parent that is being used, *will not* be recognizable in the nursery so that close attention must be given to effective isolation in such situations.

Other advantages are gained from using a dwarf seed parent, because it comes into bearing early, does not grow out of reach as quickly, and is capable of producing a high number of nuts.

In contrast to the advantages of the dwarf as a seed parent, the greatest disadvantage of using the tall as a seed parent is simply that seed from all pollinations, whether legitimate hybrids, contamination from foreign pollen, or accidental self-pollination, will germinate to show the dominant tall color and no selection will be possible in the nursery.

Apart from F_1 hybrid production, breeding work may involve crossing tall X tall or dwarf X dwarf where color inheritance cannot always be of assistance. In such cases, it is possible only to ensure that all operations are carried out as carefully as possible.

HANDLING POLLEN

Male flower collection

When the inflorescence opens naturally most of the many male flowers

are not mature. Each day, over a period of two to three weeks, some open, shed pollen and fall off. One or two weeks after the inflorescence opens, when about a quarter of the male flowers have fallen, most of the remaining male flowers are sufficiently mature to give viable pollen. The branchlets carrying the male flowers are cut off, and the flowers stripped from the stalks. If the palm is not being used for policaps hybridization, there is no need to remove all the male flowers, and fruitset on these nonisolated, partially emasculated bunches is not reduced and may be enhanced.

For policaps hybridization, palms may be treated individually, in which case the male flowers from one inflorescence are put into individual labelled bags. For mascopol hybridization, male flowers from selected individuals of any one cultivar are bulked.

Flower drying

Pollen is readily released by drying the male flowers, which may be left on a bench at room temperature for some days, put in an oven or a specially constructed drying room at 40° C for 24–40 hours, or in a fluid-bed dryer at 40–60° C for three or four hours. The method chosen will depend upon the facilities available and the location of the pollen parents in relation to the place the flowers are to be processed or to where the pollen is to be used. It is essential to keep a flow of dry air passing over or through a thin layer of flowers. The flowers may be given an initial cracking to expose the drop of nectar secreted at the base of the anthers and are then dried for the appropriate period. After drying, they are sieved, cracked a second time, and sieved again. This method will get an amount of pollen equivalent to 1.5 to 2.5% of the fresh weight of the flowers with a viability of around 40%.

Pollen Storage

Once collected, pollen can either be used immediately or stored in a closed container for a few weeks in a refrigerator or a few months in a deep freeze. Longer-term storage at room temperature following vacuum freeze-drying is also possible.

Pollen Viability

Whether or not pollen has been stored, it is wise to test its viability before use. This can be done by preparing a culture medium composed of sugar, unflavoured gelatin and distilled water (in the proportions by weight 2:7:20) mixed in a container which in turn is put in a pan of boiling water to dissolve the gelatin. The thinnest possible layer of jelly is poured, while still hot, into clean petri dishes, which are immediately covered to retain the condensation. When the jelly is cool, pollen is lightly dusted on it from a

small brush and the lid replaced. After incubation for 1–5 hours at 30° C, germination can be observed under a low-power microscope. Pollen which germinates poorly is discarded. This technique is simple to follow and satisfactory for routine pollination work. It can be refined, and accurate counts may be made if desired. Sterility of glassware etc., as in a pathology laboratory, is of minor importance since pollen will naturally carry spores of saprophytic fungi that will contaminate the whole germination medium if, for instance, it is left overnight. Sometimes poor viability is due to the loss of humidity above the pollen or to contamination of the glassware by detergent.

The biggest contamination risk in all work with pollen is from other pollen and it is essential to avoid mixing different lots. Care must be taken to label the flower bags and the pollen containers. Only one lot of pollen should be opened for use at any one time, and the cleaning of hands, arms, equipment, and surfaces with 70% alcohol between dealing with different lots of pollen is essential.

ATTENTION

Neither the policaps nor the mascopol systems can eliminate operator error. Should there be any doubt about the parent palms used, the pollen collected, the efficiency of emasculation or pollination, or the legitimacy of the subsequent palms produced, the only safe procedure is to abandon the doubtful material.

ACKNOWLEDGEMENT

This practical guide to coconut hybridization draws freely on the publications of other coconut breeders whose work is gratefully acknowledged. The specific information about the policaps and mascopol systems is published by permission of the Coconut Industry Board, Jamaica.

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Use of glyphosate for selective control of Paspalum conjugatum and Ottochloa nodosa in established legume cover crops *

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At 0.33 lb ae/ac. glyphosate is effective in controlling the grasses, Ottochloa nodosa and Paspalum conjugatum but is relatively safe to established Pueraria phaseoloides, a legume cover crop. Therefore, it is possible to maintain the purity of legume cover crops by using glyphosate.

The majority of the large planting organizations in Malaysia have a policy of establishing and maintaining legume cover crops during the immature stages of rubber and oil palm planting. One of the reasons for establishing legumes is that it provides a good source of nutrients, particularly nitrogen (Watson, Wong & Narayanan, 1964). At the same time, the legumes help to reduce soil erosion and minimise the invasion of weeds.

The usual method of maintaining legumes requires frequent handweeding. Most of the time, with shortage of labour or delays in weeding due to wet weather, many grasses and particularly *Ottochloa nodosa* and *Paspalum conjugatum* invade these legumes. It is thus difficult for estate managers to maintain pure legume cover crops. At certain stages of grasses infestation, it is not practical to handweed as it requires more money than the estate has budgetted for.

The objective of this paper is to present results showing how glyphosate can be successfully used to selectively remove grasses such as *Paspalum conjugatum* and *Ottochloa nodosa* from established legumes.

MATERIALS AND METHODS

The weedicide used is Roundup®, a liquid formulation containing 3.0 lb (acid equivalent) of glyphosate per US gallon.

A complete randomised block design of 3 replications of 6 treatments per trial site; *i.e.*, control, 0.25 lb, 0.33 lb, 0.5 lb, 0.75 lb, and 1 lb a.e. glyphosate per blanket acre sprayed over several locations in Peninsular Malaysia.

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*Paper presented at the 6th Asian Weed Science Society Conference, Jakarta, Indonesia, 1977.

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Four sites were chosen. Two from very young rubber areas (18 month old) and two from very young oil palm areas (9 month old). The average relative composition of *Pueraria phaseoloides* (legume) to grasses varied from 35%–49% legume and 51%–65% grasses consisting mainly of *Paspalum conjugatum* and *Ottochloa nodosa.* The shade over the legume grass mixtures varied from 0–10 percent.

The plot size was 0.2 acre per replication in 2 trials, and 1.5 acres per replication in the other 2 trials.

All spraying was done using an ordinary 4 gallon knapsack sprayer fitted with a 5/64 in.orifice diameter polijet. Volume of water used was 40 gallons per blanket acre.

The spraying was done on 4 days at the rate of one trial per day when the weather was fine, to reduce the likelihood that rain would affect the sprays applied. All the trials were sprayed in late April and early May of 1976.

Visual observations of proportion and density of legumes to weeds were carried at 0, 30, 60, 90, 120, 150 days after application of glyphosate for all treatments except the control where observation was carried out at 0 day and 150 days only.

RESULTS

Effect of various rates of Glyphosate on the grasses – Paspalum conjugatum and Ottochloa nodosa (*Table 1*) – glyphosate 0.25 lb/ac. gave very poor control of grasses. The percent grass coverage was reduced from 57% to 31% at 30 days after treatment but subsequently it regenerated to 54% coverage at 150 days. Glyphosate at 0.33 lb/ac. was slow acting (*Table 1*). It required 150 days for the percent presence of grasses to be reduced from 51% to 7% During the first 90 days after application glyphosate at 0.5 lb reduced the percentage of grasses from 65% to 6%. Glyphosate at 0.75 lb gave almost the same result as the 0.5 lb rate.

During the first 30 days after application of glyphosate at 1 lb/ac., the grasses were reduced from 50% to 0% (*Table 1*). There was no regeneration of grasses at 120 days after application.

In the control plot, the average grass coverage was 65% at 0 day and 70% at the end of 150 days.

Observations on Pueraria phaseoloides (*legume cover crop*) (*Table 1*) – glyphosate at 0.25 lb/ac. did not damage the legume at all. The percent presence of the legumes did not drop below the 42% level observed at the beginning of the trial. Glyphosate at 0.33 lb/ac. caused initial slight damage

TABLE 1. AVERAGE % PRESENCE OF LEGUME AND GRASSES

Treatment	*Average % grasses (Paspalum conjugatum & Ottochloa nodosa)*						*Average % legumes (Pueraria phaseoloides)*					
Days after treatment	0	30	60	90	120	150	0	30	60	90	120	150
Glyphosate 0.25 lb	57	31	41	54	54	54	42	46	50	57	49	46
Glyphosate 0.33 lb	51	18	15	11	9	7	49	34	41	64	80	79
Glyphosate 0.5 lb	65	23	11	6	6	4	35	28	41	60	78	86
Glyphosate 0.75 lb	64	26	9	5	9	6	36	26	56	72	84	90
Glyphosate 0.1 lb	50	0	0	0	0	2	50	15	10	15	40	45
Control	65	–	–	–	–	70	35	–	–	–	–	30

to the legume. The reduction in legume coverage was from 49% to 34% at 30 days. Subsequently, percent presence was 79%–80% at 120–150 days. The same basic trend was observed for the 0.5 and 0.75 lb/ac. of glyphosate applied.

Glyphosate at 1 lb/ac. was very damaging to the legumes. The percentage legume dropped from 50% at the start of the trial to 15% at 30 days and there was no recovery until 120 days.

In the control plot the percent presence of legumes were initially at 35% and at 150 days it was reduced to 30% coverage.

DISCUSSION

Practical application

From the data obtained, when glyphosate at 0.33 lb, 0.5 lb and 0.75 lb/ac. was blanket sprayed over an area of a mixture of legume and the grasses *Paspalum conjugatum* and *Ottochloa nodosa,* initially up to 30 days after spraying both the amount of legume and grasses were reduced. Subsequently, the percentage of grasses continued to decrease while the legume started to regenerate. In the absence of competition from the grasses, the final coverage of the legume cover crop was significantly higher than what was initially observed at the time of spraying. The end result was that the areas which started with a mixture of legume and grasses ended up with almost pure legume. It appears that glyphosate at 0.33 lb/ac. would be a suitable dosage. It ensures adequate safety to the legume cover crop plus consistent grass control (*Figure 1*).

The most important finding from this project is that glyphosate at 0.33 lb/ac. can selectively remove the major grasses *Paspalum conjugatum* and *Ottochloa nodosa* growing within established *Pueraria phaseoloides* legume cover crop in rubber and oil palm plantations in Malaysia. This can be put into practise to simplify legume cover crop management. The practical effects are illustrated in (*Figure 1*). There appears to be some advantages derived from this method of applying glyphosate on legume grass mixture. The result obtained could reduce the concern of handweeding of grasses especially *Paspalum conjugatum* and *Ottochloa nodosa.* It can also be used for rehabilitation of legumes being invaded by these two grasses (Plate 1, 2, 3).

The data indicate that glyphosate can be applied at 0.25 lb to 0.75 lb/ac. over 9–18 months after planting legume where the shades over the legume is 0–10%. The dosage for practical application appears to be 0.33 lb/ac. which can give consistency in the control of *Ottochloa nodosa* and *Paspalum conjugatum* mixed with the legume. A certain amount of initial scorching of legume within 15–45 days after application should be expected.



Plate 1. Mixture of legumes and grasses before application of glyphosate



Plate 2. The initial injury of scorching of legumes at 30 days after application of glyphosate



Plate 3. This area ended up with almost pure legumes at 120 days after application of glyphosate

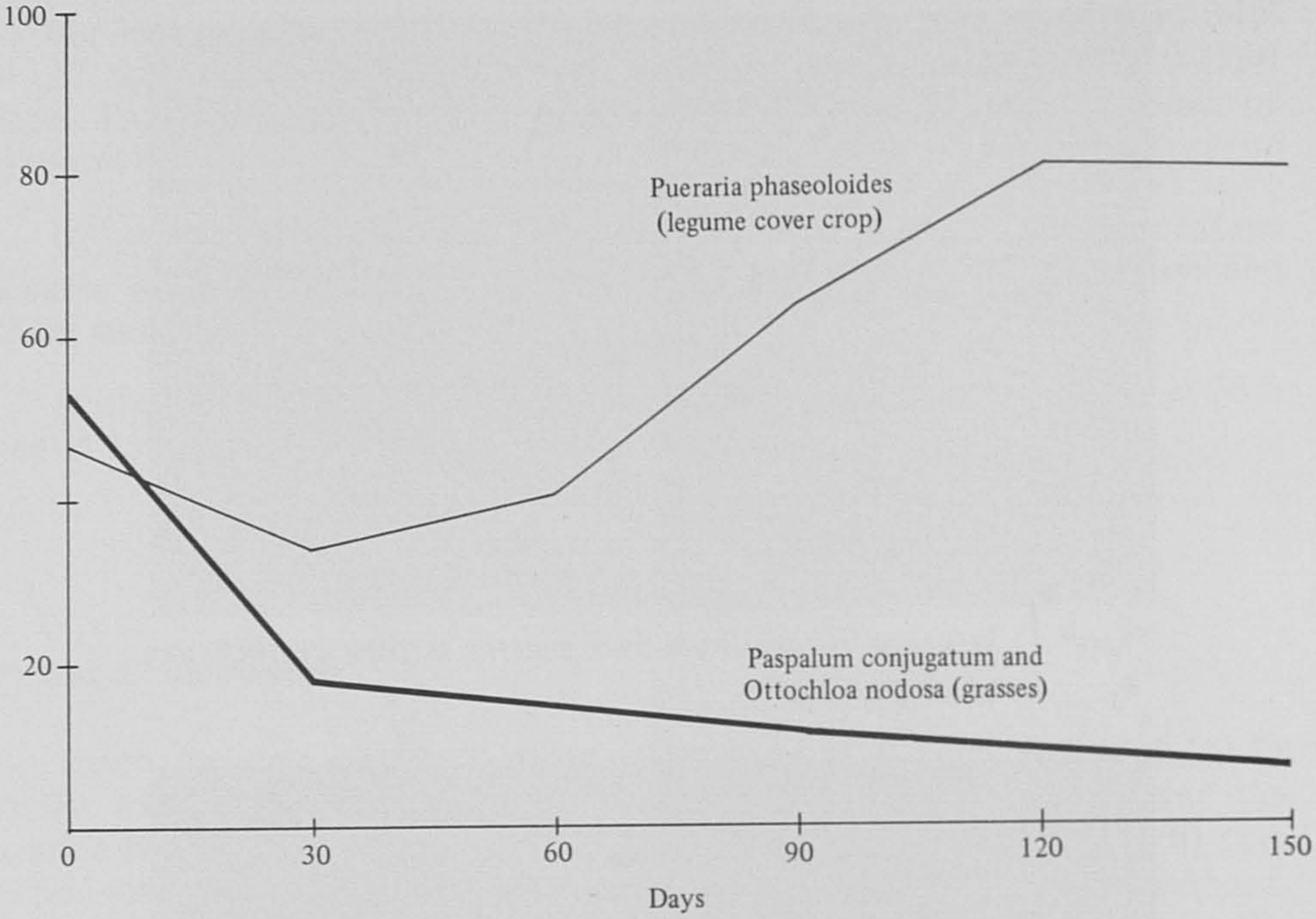


Figure 1. Effect of glyphosate 0.33 lb/ac.

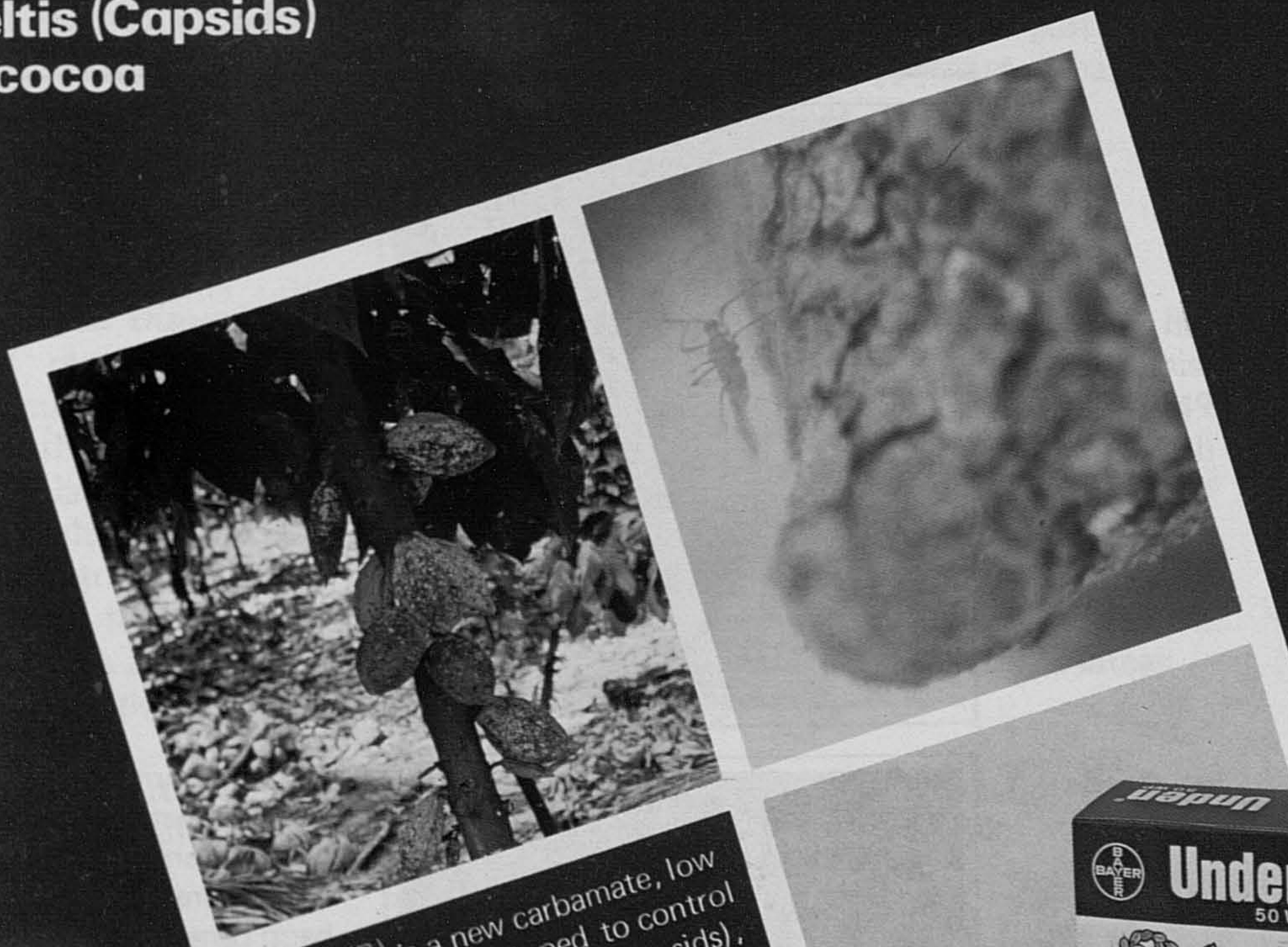
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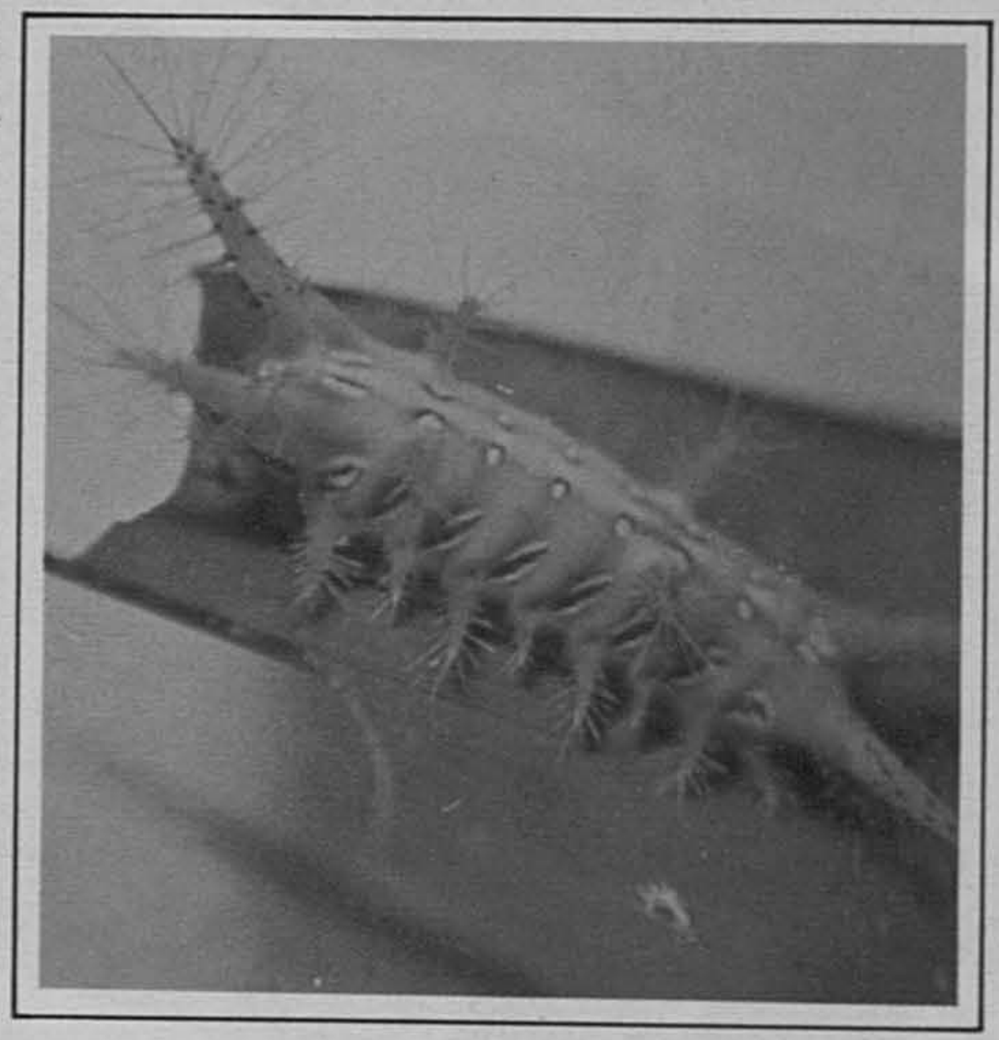
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Agricultural aviation*

D. MCLEOD

Since at least 1924, aircraft have been used in a wide variety of tasks and in many countries of the world in the service of agriculture. Agricultural aircraft have a vital role to play in solving the problem of feeding the people of the world.

This paper is not a scientific treatise, but an attempt to describe the significance of agricultural aviation world-wide, to deal more particularly with its application in New Zealand and to suggest that, perhaps, it has more to contribute to Malaysian agriculture than is generally recognised.

TASKS OF THE AGRICULTURAL AIRCRAFT

A search through such information as we have in our company library has not revealed when agricultural aviation – the use of aircraft to assist agriculture on a commercial basis – began. In New Zealand, it was 1949 but this was long preceded in the USA where the first experiments with aeroplane application of insecticides by the United States Department of Agriculture, Bureau of Entomology, at the Cotton Insecticide Research Laboratory, Tallulah, Louisiana, were followed by the first commercial dusting for cotton insect control at Heathman, Mississippi, in September 1924 (A History of Mississippi Agricultural Aviation – Calhoun Dunnan – early 1950s).

What are the ways in which aircraft – and I include helicopters – can assist agriculture? Perhaps, the following random examples will be of interest.

(1) It was found in the Sudan when spraying cotton, that either aerial or ground methods were equally successful, but to spray the area in the required time of 10 days required 25–30 aircraft as opposed to 300 tractor sprayers (Abdoun, 1971).

(2) Aerial application of Urea solution on rice and wheat in India, increased yields 15% and 31% respectively (Rajat, 1971).

(3) The yields from 720 000 acres of rice in Java which was aerially fertilised, then protected from stem borer insects by aircraft applied insecticide, was 50% – 100% higher than the untreated control areas (Joyce, 1970).

(4) An epidemic of sugar cane leaf hoppers in India in 1968 was successfully controlled by aerial spraying (Bhatia, 1972).

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*Paper presented at the ISP Conference on Estate Engineering & Mechanization 1975.

(5) Aerial seeding of wheat, rye and barley is carried out annually on 40 – 50 000 acres in East Germany (Heymann & Bernhardt, 1973).

(6) In Spain, insects in olive trees were controlled with a ULV spray of one pint per acre giving a mortality rate of 93 – 97 percent (Lopez-Villalta, 1973).

(7) During 1972, a total of 220 million acres were treated from the air in the USSR (Anon. (1), 1974).

(8) ULV sprays are used in Nicaragua to control Mediterranean fruit flies in coffee (Rhode, 1972).

(9) In England and Wales, about 36 000 tons of potatoes are lost to slug damage each year. An aircraft spreading slug pellets at a rate of 14 lb per acre has now been proved to provide effective control (Anon. (2), 1973).

(10) Cherry fruit in Bulgaria have been protected from the air against fungus diseases, fruit fly and aphids (Wassey, 1971).

(11) A total of 181 200 acres were treated by a fleet of 17 aircraft in Holland during 1970 (Kerssen, 1970).

(12) In California, 90% of the 333 000 acre rice crop is treated from the air. Aircraft seed and fertilise the crop, then apply herbicides and insecticides (Brazelton, 1972).

(13) Aircraft in Austria achieved a 100% kill on Pine Sawfly using three-quarter pint per acre (Schmutzenhofer, 1971).

(14) An effective control for tsetse fly was demonstrated when an area of 600 square miles in Zambia was sprayed five times, at three weekly intervals, using two-fifths oz of chemical per acre each time (Park, 1972).

(15) Locusts, which can eat their own body weight in food each day, have been estimated to devour between 30 000 tons and 100 000 tons of vegetation per day (UNESCO Courier Feb. 1972 page 9), when swarming. These swarms can be destroyed with aerial application of insecticide at ULV rates of one ounce or less per acre (Carleton, 1969).

(16) Estimates of aircraft numbers in use and annual area treated, prepared by the International Agricultural Aviation Centre during 1971/72 from questionnaires, returns and literature surveys, are:-

	Aircraft engaged in agricultural aviation	*Area treated annually (hectares)*
Europe (including USSR)	9 500	90 000 000
America (North and South)	8 700	60 000 000
Asia	950	9 500 000
Oceania	650	8 400 000
Africa	300	3 500 000
Total	20 100	171 400 000

(Anon. (3), 1973).

Crops treated by aircraft or helicopters include:-

Grapes in France
Wheat, citrus, cotton, pine forests, cork oaks, rice and olives in Spain
Olives in Greece
Wheat, cotton, rice, sugar-beet and dates in Iran
Rice in Japan
Rice and coconut palms in Indonesia
Millet, cotton, wheat and corn in South Africa
Cotton and rice in Egypt and Sudan
Cotton in Brazil and Colombia and Central America.

THE AGRICULTURAL AIRCRAFT AND THE WORLD FOOD PROBLEM

The problems of producing on this planet sufficient food to feed the present population and of increasing that production to cope with the anticipated population increase have been well canvassed and are known even in countries where obesity is a national disease.

About 500 million of the 3.9 thousand million people now living on earth suffer from malnutrition and more than 1.5 thousand million are on an unbalanced or inadequate diet.

This situation will become worse from year to year and end in catastrophe unless every possible effort is made to increase food production faster than the world's population is increasing. Six to six and a half thousand million people will have to be fed and clothed by the year 2000.

If the overall state of nutrition, which is bad enough already, is not to get worse still, food production must be increased by 35% in the next few years and only a 50% increase will produce any noticeable improvement. However, this will be possible only if the countries capable of development

increase their agricultural production by 80% during the same period.

In these circumstances, it seems incomprehensible that even today more than one third of the potential annual world harvest is destroyed by pests, plant diseases and weeds – a loss which certainly costs us more than 75 thousand million dollars. This figure of 75 thousand million dollars is equivalent to the value of the world's grain harvest (calculated according to producer prices) which is about 65 thousand million dollars together with the world's potato crop which is about 10 thousand million dollars.

This means that pests, plant diseases and weeds deprive mankind of food worth more than the value of the entire crop of wheat, rye, barley, oats, maize, millet, rice and potatoes.

These figures cover only the losses incurred up to the time of the harvest. They do not include damage during storage which adds up to another enormous sum.

These frightening results were obtained during a recent study in which all cost over-estimates were avoided and losses were assessed so cautiously that in doubtful cases no unjustifiably high estimates of damage could be made. The figures were worked out for approximately 60 of the most important plant species cultivated in the world, and probably represent the minimum loss.

Rice cultivation presents a particularly dismaying picture. Rice is the basic diet of the larger part of mankind and in particular of those peoples who already have difficulty in obtaining enough to eat.

The figures speak for themselves: the average world crop amounts now to around 22.5 quintals of rice per hectare.

This mean value, however, does not show how greatly the harvest varies in different areas of cultivation.

Australia achieves the best yield with 64.4 quintals per hectare.

Japan holds the record among Asiatic nations with 58.5 quintals per hectare; South Korea harvests 45.9 quintals per hectare, and Sri Lanka (Ceylon) 21.9 quintals per hectare. India possesses more than 36 million hectares of land on which rice is grown, that is, nearly 30 percent of the entire rice-growing area of the world, but India's share of the world's rice crop is only some 20 percent. In some African countries the yield hardly amounts to five quintals per hectare.

It can be shown that these unsatisfactory yields are partly due to the fact that a large part of the crop falls victim to infestation with pests and plant diseases, and to competition by weeds and useless grasses. In India for

instance, about 77 million tons are lost, the actual harvest amounting to about 59 million tons.

This means that 57 percent of the crop which might now be harvested – without additional irrigation, manuring or mechanisation – is lost. This quantity would be sufficient to provide each one of about 570 million Indians with an additional 135 kg of rice per annum or 370 g per head per day.

By far the greatest part of these losses could be avoided. It is not Utopian to assert that they could be reduced to a mere fraction of their present volume with the methods of modern crop protection already available. Japan has proved this.

The annual losses (in million tons) include: wheat 86, rye 6, barley 129, oats 16, maize 121, millet 46, potatoes 129, sugar-beet 69, sugar-cane 566, vegetables 78, fruit 21, citrus fruit 7, grapes 28, coffee 2.6, cotton 5. The list can be extended to show that more than a third of the crop which might be harvested is destroyed by various pests.

It is, however, quite impossible to estimate the value of crops which are saved from destruction by modern methods of crop protection. In many areas where fruit, including citrus fruit and grapes, vegetables, cotton, potatoes, and sugar-beet are now grown economically, this could not be done without crop protection. Nor is it conceivable that grain could be grown nowadays without first dressing the seed.

For a number of years chemical crop protection has been the subject of discussion. We should now accept that it is one of the most effective weapons we have against hunger which is still one of the gravest threats to mankind.

Undoubtedly not 50 – 60% but far more than 80% of all humanity would go short of food today were it not for modern methods of crop protection (Anon. (4)).

I believe, that because of the speed with which they can treat large areas, their ability to fly over crops where wheeled vehicles often cannot be used because of the nature of the terrain or, if used, will cause crop damage and the economics they offer, the agricultural aeroplanes and helicopters have a very significant role to play in combating the world food shortage.

AGRICULTURAL AVIATION IN NEW ZEALAND

To pursue in more detail the practical application of agricultural aviation, the benefits gained and some economic implications, I must rely on my own experience as manager of the largest such operation in New Zealand.

New Zealand depends on agriculture to produce 80 – 85% of its export income and this comes principally from sheep and cattle grazed year round on open pastures. The success of this activity depends on the ability to grow grass.

Most New Zealand soils in their original state had low phospate fertility containing about 200 to 400 kg of total inorganic P per ha. in the top 10 cm layer. Without the addition of P these soils could supply only 5 to 6 kg P per ha per annum, which was adequate for the sustenance of very low producing species, supporting approximately 4 ewe equivalents per ha. The introduction of new high producing species necessitated a much higher soil P supply, which had to be increased tenfold in order to increase the pasture production approximately fivefold. Consequently, heavy applications of P fertilisers had to be used initially (700-1. 100 kg per ha (5½ to 9 cwt per acre) super-phosphate) in order to increase the soil P status above the 'fertility barrier' and enable satisfactory establishment of rye-grass-white clover associations (Karlovsky, 1975).

Endeavours to establish satisfactory pastures met with limited success until we had available reliable tested and certified grasses – particularly perennial ryegrass, the dominant grass in much of our pasture and white clover. Application of phosphatic fertilisers promotes clover growth which, in turn, combined with a full return of cheap dung and urine from the grazing animals to the pasture, provides abundant nitrogen for the prolific growth of grasses.

Much of New Zealand's pasture lands lie in hill country inaccessible to wheeled vehicles and prior to the advent of the agricultural aircraft fertiliser was transported out by horse and spread manually. This was expensive, involving the employment, housing and feeding of contractors over a considerable period of time. Neither was it always efficient. Supervision of the type of labour available for this sort of work was a problem and it was not uncommon to find bags of fertiliser in a gully where they had been dumped to ease the task of spreading. It is interesting to hear of similar problems in some of your fertiliser applications in Malaysia.

Trials with a converted Grumman Avenger torpedo bomber indicated the possibility that aircraft may provide a solution to fertiliser spreading problems. War time pilots invested their limited savings in the purchase and conversion of De Havilland DH89 Tiger Moths which, having become surplus as wartime trainers, were available at bargain prices. Kiwi ingenuity attacked the problem of getting fertiliser from bags on the ground and later from bulk stock piles into the aircraft hopper. Limited capital budgets encouraged the commissioning of some ancient vehicles to which were attached a variety of loading devices that would have had Heath Robinson looking to his laurels.

This opened the way to the successful farming of larger areas of hill country and aerial topdressing as the process is called in New Zealand,

contributed very substantially to an increase in fertiliser usage from 1 million tons in 1949 to 2 million tons in 1969. In turn, this was the major factor in an increase in livestock units over the same period from 52.7 million to 94.4 million. The country's herds of sheep, dairy cows and cattle increased 28.7 times faster in the 20 years following the advent of aerial topdressing than they had in the 20 years before the aeroplane became a farm tool.

I doubt that New Zealanders, in general, or even the many farmers that were transported from poverty to prosperity realise or have recognised the remarkable contribution a modest force of agricultural aircraft and a relatively small band of dedicated people have made to the prosperity of their country.

Forty-three point seven percent of the fertiliser sold in New Zealand is now applied by aircraft but the aircraft's role is not restricted to fertiliser spreading. Seeding new pastures or over sowing was, perhaps, of greater significance in earlier years than it is now. Rabbits had become such a problem in some parts of New Zealand that they posed a real threat to farming. Distribution of poisoned baits using aircraft plus strict control measures largely eradicated this problem and returned to pasture thousands of acres that were barren.

While aircraft had been used in other countries for crop spraying well before they were used for fertiliser distribution in New Zealand, the New Zealand experience was different in that their initial and major role was the distribution of fertiliser in country too difficult for wheeled vehicles, whereas in other countries the initial and major use appears to be spraying crops in reasonably easy terrain. Cropping in New Zealand is for local use, not export, and accordingly is not as significant as in many countries. Aircraft are, however, used quite extensively for crop spraying, spraying weeds in pastures, particularly thistles, and forestry work. The latter involves dessication of natural cover prior to replanting, release spraying following planting to control weed competition, some fertilising and spraying for a fungus disease. This work has assumed increasing importance with the growth of New Zealand's man-made pine forest industry.

ECONOMIC CONSIDERATIONS IN NEW ZEALAND

Fertiliser application in New Zealand is generally at rates of 200 lb – 300 lb per acre. This means that it takes little time to distribute the load by comparison with the time taken to load, take off, fly to the dropping area, return to the airstrip and land. The average would be 30 seconds to 45 seconds sowing of a 4-min turn round.

On ultra low volume spraying, it is possible to carry a load that will take longer to distribute than the aircraft's endurance – you run out of fuel before you run out of chemical. Obviously, in this situation, time taken for

loading, flying to the dropping area and returning for another load, can be a very small percentage of the dropping time and one can tolerate a much longer haul from airstrip to dropping area than can be tolerated when a heavy application rate is involved. In practice, we consider it desirable for a sortie not to exceed one hour in the interests of avoiding pilot fatigue.

Swathe width for the material dropped can be influenced, and increased swathe width reduces sowing time. Where a heavy application rate is involved, any such gain is not likely to be significant unless more than two passes are involved, because it affects only a small percentage of the total sortie time. There is the further difficulty of influencing spreading characteristics when there is a heavy rate of discharge from the aircraft hopper mouth. Substantial force will be required and can usually be obtained only at the expense of engine performance if engine driven accessories are used – at the expense of aircraft performance if devices are attached to the aircraft fuselage and at the expense of payload in both cases.

In the case of ULV applications at say ounces per acre increasing the swathe width can result in a very considerable increase in acres sown per hour and, hence, reduce costs per acre.

In the New Zealand fertilising application, the obvious area to attack was not the sowing time, but the balance of the sortie time and the following factors have been significant in this.

Aircraft

Increased payload increases the sowing time without any increase in the other factors assuming no loss in performance. Improved performance can also be significant, particularly when climb from the airstrip to the sowing area is involved.

The Tiger Moth proved that aircraft could do the job and light aircraft never designed for this purpose were adapted to it, such as the Cessna 180 and 185, Piper PA18 and De Havilland Beaver. Agricultural aviation developed worldwide encouraging aircraft manufacturers to produce aircraft designed specifically for the purpose such as the Cessna Ag-Wagon, Piper Pawnee, Snow, later to become the Rockwell Thrush Commander, the Grumman Ag-Cat, the Fletcher and the Australian Airtruk.

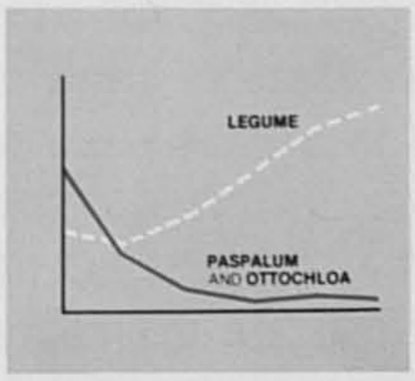
Manufacturers were invited to submit designs for an agricultural aircraft to suit the New Zealand requirement and replace the Tiger Moth. In response to this invitation, the Percival E9 made a brief appearance and the Auster Agricola is used still by one operator, but unquestionably the successful aircraft was the Fletcher, initially built in USA but now made in New Zealand.

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The Fletcher was first imported into New Zealand in 1955 as a 225 hp 1 680 lb payload aircraft – quite an improvement on the Tiger Moth's 560 pounds. Performance with this load was restricted but improved by installing 260 hp and then 300 hp engines. Now, the aircraft comes equipped with a 400 hp engine and carries a 2 400 lb payload. This latest 33 1/3% increase in payload has resulted in a 25% improvement in productivity. This, in turn, has reduced the 653 hours per annum required to achieve break even operations with a 300 hp engine to 493 hours per annum. It is quite amazing and speaks volumes for the strength originally incorporated that the aircraft has been capable of such exceptional development without major airframe modifications.

In fact, two Fletcher aircraft have been further developed – one by the installation of a Pratt & Whitney PT6 A-20 turbo prop derated to 500 hp and the other fitted with a Garrett Air Research rated at 680 hp. Both these aircraft were specially modified and no production tooling exists for their reproduction. They were built prior to the 400 hp installation which has substantially bridged the gap from the 300 hp version to the performance available from these turbo prop aircraft.

It seems that if we wish to go beyond 400 hp and use current production engines, we will have to move into turbine power; however, these engines are approximately four times as expensive, and a turbo prop Fletcher would probably cost as much as two 400 hp Fletchers. Whether such a high cost can be justified depends primarily on the additional payload that can be carried and a design study indicates the probability that such an increase may be possible.

In 1955, we placed in service a Douglas Dakota CA7B fitted with a hopper holding 11 000 lb of fertiliser. About 12 of these are currently operating in New Zealand. Originally, it was thought that they would perform the dual roles of transport and spreading and operate economically up to 50 miles radius from airfields. They have proved useful in servicing off-shore islands, where there is high country to be fertilised reasonably close to an airfield, where light aircraft airstrips are hard to find close to the work, or where road access considerably exceeds the distance by air. As with all agricultural aircraft operating on high application rates, the closer to the airstrip the area to be treated is the better are the economics. Under normal conditions, transport by air is much more expensive than by road taking into account the limits on aircraft utilization, imposed by weather conditions on our type of operation.

Large aircraft can have a place and DC7s were being used in Canada to combat bud worm in forests.

Loading

With 15 operations per hour, loading time can become significant and this was recognised at an early stage. Bulk fertiliser soon replaced bags and a hydraulically activated loading bucket suspended on folding booms was built out over the front axle of a conventional truck. Next, tractors were introduced with similar loading equipment over the front – a cab for the driver and a large concrete counter weight suspended at the rear. These worked well on the airstrip, but lost too much time moving from airstrip to airstrip and we have reverted to trucks but with the loading equipment suspended over the rear end of the chassis and with a second cab and driving position built over the rear axle and facing to the rear. For loading, the driver uses the rear cab and on the road the conventional cab. Between the cabs, we fit a 600 gallon aviation fuel tank. Pilots and drivers return to their home base each night leaving the loader on the airstrip.

A very smooth and fast loading operation is thus achieved with the loader already moving into the aircraft as it stops the fertiliser dropping into the aircraft hopper and the aircraft moving off the moment the loader is clear again. A ton of fertiliser is loaded into the aircraft in about 15 seconds from the time the aircraft stops in front of the loader to the time it moves off again fully laden.

Airstrips

Location of the airstrip to the sowing area obviously has a major effect on the sortie time and, hence, the cost of spreading. In our own operation, 90% of the work is within a two mile radius of the airstrip and would involve no climb in excess of 300 feet. Airstrips are sited along ridges usually with a marked slope – up to a one in four grade. We truck fertiliser uphill and fly it downhill. This means building access roads into the airstrips and often this can prove quite expensive as the airstrip site is likely to be less accessible than if a flat site in a valley floor had been selected.

These access roads pose many problems as frequently they cannot be used in wet weather, cutting off our fertiliser supplies and sometimes leaving our loader stranded at the airstrip. Fertiliser transport units have increased in size, demanding a better standard of access roading and increased maintenance costs.

Our requirements for an airstrip specify a length of 1 800 ft and width of 130 feet at sea level, however, the length required increases as altitude increases by 120 ft at 500 ft increase in altitude. On the other hand, length requirements reduce as incline increases by 3 ft for each one foot drop over the length of the airstrip. In fact, pilots prefer sloping airstrips where there is a drop off the end. Frequently, it may be necessary to maintain power on landing to climb up the airstrip to the flat loading area.

It is estimated that there are 12 000 farm airstrips in New Zealand and construction costs including roading would average $2 000 per airstrip.

A well consolidated loading area is desirable as the loader is moving backwards and forwards over the same piece of ground, particularly if the storage bin is provided on the airstrip, and moving over uneven ground with a ton of fertiliser in the bucket with booms extended throws a severe strain on the equipment and risks the bucket striking the aircraft if a loader wheel drops into a rut at the crucial moment.

We have always endeavoured to encourage the construction of concrete floored weather proof fertiliser storage bins on airstrips, but this facility exists on probably not more than 15 percent of our airstrips.

There have been moves over the last two years by our Pilots Union to insist on bins in the interests of safety. If fertiliser is not dumped on a consolidated surface, there is the risk of the loader bucket picking up clods of turf which, when loaded into the hopper, may clog the hopper mouth preventing the pilot from dumping his load in an emergency. The same risk arises with wet fertiliser, quite apart from the difficulty of properly spreading it.

Our aircraft can, in favourable conditions, spread fertiliser much faster than transport operators usually cart it which means that if we are not to waste valuable good weather we must have plenty of fertiliser out on airstrips ahead of the aircraft. If there are no adequate storage facilities on airstrips then there is the risk of the fertiliser becoming wet if it rains and even the meteorologists cannot accurately predict that. As the transport decision is frequently left in our hands – 'you order the fertiliser out when you are ready for it', we are left with the judgement of whether to order it out and risk the penalties of wet fertiliser or defer it and risk running out of fertiliser in good flying conditions. The solution is adequate fertiliser storage at the airstrip, but this can cost $2 000 for a 50-ton storage bin.

It is important for an aircraft to take off into the prevailing wind and the objective is to be able to operate it up to a wind component of 15 mph which is usually the maximum that can be tolerated for sowing fertiliser. Any restrictions on operations imposed by the airstrip will be a restriction on utilization or may mean reducing the load carried which will either reduce the operator's return per hour flown or increase the cost per acre to the farmer depending on the system of pricing. Airstrip restrictions may be inadequate length or width obstructions in the take off path or rough surface (we expect to be able to drive a car down the airstrip at 40 mph). There is a difference in the ability of different aircraft to handle a particular set of circumstances and in this respect the rugged nosewheel configuration of the Fletcher enables it to land in wind conditions that could not be tolerated by tail wheel aircraft and to handle more adequately and with less damage to the airstrip rough or wet surfaces.

Reference has already been made to the influence of pricing systems on airstrips. We commenced with a concept of an airstrip every 6 miles giving a 3-mile radius of operations from each airstrip and with a fixed charge for all sowing up to that radius. Competitors came in with an hourly rate charge and if farmers could see a saving in costs sufficient over a reasonable period of time to cover the cost of constructing an airstrip and had the capital to do so, then a further airstrip would soon appear.

The hourly rate system (the time charged does not include ferrying the aircraft from its base to the airstrip and back), led to a rapid increase in airstrip construction and it is noticeable today that there are more airstrips and a lower average sowing cost in those areas having an hourly rate system of charging than in those using a ton/mile rate, *i.e.*, a charge per ton related to the distance of the sowing area from the airstrip. Probably, this is due more to the ton/mile system not penalising longer haul work in proportion to the additional cost involved or, under the stress of competition, it is more likely to break down and for operators to start using elastic rulers.

A further advantage of the hourly rate system is that it leaves the farmer with a financial interest in the state of his airstrip since a rough surface may result in lighter loads being carried.

The success of these measures is revealed by the fact that by 1974 the average price per ton for sowing was the same as in 1954, but farm costs had increased an average of 88.7 percent over the same period. If aerial spreading costs were excluded then the increase in other costs would be even greater.

Of prime importance in costs is utilization – the hours flown productively per year. The preceding paragraphs discuss ways of getting more out of each hour flown, but the real key is the total hours flown. Factors that affect this are:-

(1) Weather conditions prevailing

(2) Seasonal nature of work available

(3) Aircraft type – some will continue to handle difficult conditions when others cannot and, again, breakdowns occur more frequently with some types than others

(4) Airstrips – an airstrip that can only be operated in perfect conditions can prove very expensive to the operator

(5) Pilots – ability to handle difficult conditions or fly long hours varies

(6) Regulations – may limit the hours that can be flown in any one day – week – month or year

(7) Maintenance standards – The objective should be to eliminate breakdowns in the field, as generally they are discovered only when the equipment is operating which, in most cases, will be when conditions are suitable for spreading operations. The time taken to carry out maintenance checks or overhauls is important and is one of the handicaps of a small workshop with limited manpower as opposed to a larger workshop, although there is a limit on the number of men that can usefully work on a aircraft at the one time. Good stocks of spares and components is a further factor

(8) Safety – Accidents are always bad business and can be kept to a minimum by proper training, regular flight checks and good supervision.

Another important cost that can be overlooked is the incidence of unproductive flying. We endeavour to ascertain from the farmer conditions at the airstrip before leaving base, but this is not always possible nor is the information received always reliable. Not all farmers or their wives appreciate a telephone call at dawn. Every effort needs to be made to organise a work programme so that the aircraft and loader progress from airstrip to airstrip with a minimum of dead flying. When the pressure is really on it is easy – but costly – to slip into a fire brigade approach rushing from place to place regardless of distance to soothe the client making the loudest angry noises.

Reducing the application rate per acre produces obvious economies in distribution costs, apart from the economies of reducing the quantity of material to be handled. Aircraft payload becomes of less significance and airstrips can be more widely spaced. Aircraft speed may increase in importance and it becomes more practical and important to improve distribution patterns and more rewarding to increase swathe width. These considerations led to the development of ultra low volume spraying (usually defined as application rates of ½ gallon per acre or less). As this brings us down to distributing neat chemical more care is necessary to avoid drift, leaking hoppers or equipment and the pilot will become very sensitive about dumping his load in an emergency. As airstrips need not be so close to the treatment area the risk of damage to third party's property is increased if the equipment is defective – accordingly, greater care to ensure that it is not is essential.

HELICOPTERS IN NEW ZEALAND

So far, my remarks have been confined to fixed wing aircraft and I should like now to refer to those fascinating machines described as helicopters. In New Zealand, they are used only for liquid spraying as far as agricultural work is concerned.

As compared with fixed wing aircraft, they have the following advantages:—

(1) No airstrip required

(2) Can usually operate from the area to be treated

(3) Faster turns on to a reciprocal heading

(4) More manoeuvrable in a confined area

(5) Downwash from the rotors is often claimed to give better penetration

(6) Slower spraying speed and manoeuvrability should give more accurate results.

On the other hand, fixed wing aircraft appear to win out in respect of:—

(1) Lower operating costs – at least 25% in New Zealand

(2) Greater payload – up over 100%

(3) Higher speed – up 100%.

These comparisons are based on 400 hp Fletchers and Hiller 12Es as operated by our company.

In practice, we find that each produces equally satisfactory results except where 'spot' as opposed to 'blanket' spraying is required or on small confined areas where helicopters are more satisfactory. In New Zealand, they operate for similar prices per acre treated, but the helicopter's advantages produce the best returns per hour flown on heavy application rates.

So far, light turbine helicopters have been little used in New Zealand on agricultural work, but their use in USA in this role appears to be developing. They cost three times as much as a piston engined helicopter for a 75% increase in payload. Our cost estimates indicate that a slightly higher price per acre would be required for a turbine powered helicopter as compared with our current piston engined machines. It may well be that a turbine helicopter may have more work available to it in other fields when not engaged in agricultural work than a piston engined machine because of its greater lifting ability, greater speed and greater passenger carrying capacity.

In USA large helicopters are used for the distribution of solids and liquids, particularly over forests, and still larger machines are used to haul logs from forests where only selective, as opposed to clear felling, is permitted. In New Zealand, clear felling is practised, but there is interest in

the use of larger helicopters on forestry spraying. This would be justified on the reduction in forestry staff required to monitor the operation rather than the ability of such a helicopter to operate for a lower price per acre.

OPPORTUNITIES FOR AGRICULTURAL AVIATION IN MALAYSIA

The agricultural aircraft and helicopter have established themselves in many countries as vital tools in the fight to increase food production. It seems that the very countries that most need to increase food production are the countries where the agricultural aircraft has yet to make its true contribution. To change from ancient labour intensive to modern mechanised forms of agriculture does have drastic implications for the traditional farmer, but surely any solution is better than famine. Particularly, where there are large new development projects, there is the opportunity to prove the advantages of modern technology. I foresee a rapid growth in agricultural aviation from the Middle East through to south-east Asia.

Where does Malaysia fit in this pattern? It would be presumptuous of me on such a brief acquaintance with your exciting country to be dogmatic and the thoughts that follow are more in the nature of tentative impressions.

At first sight, it is certainly surprising to find that in a country so deeply involved in agriculture there has not developed sufficient demand for agricultural aviation services to support an organisation specialising in this work. There is considerable interest in Indonesia, Thailand, Philippines, Pakistan, Bangladesh, India, Iraq, Iran, and Egypt that I know of.

Such enquiries as I have made indicate that much of your agriculture involves substantial plantations orientated to tree crops that are fortunately relatively free of insect and disease problems. Fertilising, and such problems as you have, are coped with by use of tractor equipment or by utilising the availability of relatively low cost labour.

I am aware that there has been a limited use of a helicopter on rubber tree defoliation to combat secondary leaf fall and trials have been carried out on weed control in sugar cane. I believe some limited work has been carried out on aerial spraying and fertilising using a Piper Pawnee and our own company sent an aircraft to Malaysia to investigate the possibility of aerial pollination of oil palm.

I doubt that this work gives you any real appreciation of the capabilities of a fully utilised specialist agricultural aviation service using up-to-date equipment.

Another aspect of Malaysian agriculture and possibly the area where the aircraft can make the greatest immediate contribution would seem to be

food crops – particularly rice. It would be quite impractical for any operator to deal with a multitude of small land holders and some form of collective farming would be necessary to co-ordinate planting, fertilising, spraying and harvesting programmes to market the produce – pay for contractor services and pay out to individual farmers, who should be in the happy situation of receiving more for doing less. It sounds great in theory, but one can appreciate the many human problems involved. Nevertheless, it is one way of realising the desire to increase food production and I am sure your government is very well aware of it.

It seems to me to be a question of *when* do you want an agricultural aviation service rather than *if* you want it. I gather that in some areas, labour is not plentiful and that the fertiliser distribution achieved is not always as planned. As the areas under cultivation increase, the risk of infestation from new and, perhaps, less well-managed crops may increase. You would seem to be terribly vulnerable to a major outbreak.

I have the impression that many of you would welcome the establishment of an experienced well-equipped agricultural aviation service in Malaysia, but if you really want it then you will need to give some tangible encouragement, as an operator cannot live on good wishes alone. It would need only a small percentage of your fertilising and spraying work – in the short term it may cost you a little more – on the other hand you may well find that improved results more than justify the increased cost.

CONCLUSION

In the long term, agricultural aviation will play an important role in Malaysia, and you will need it.

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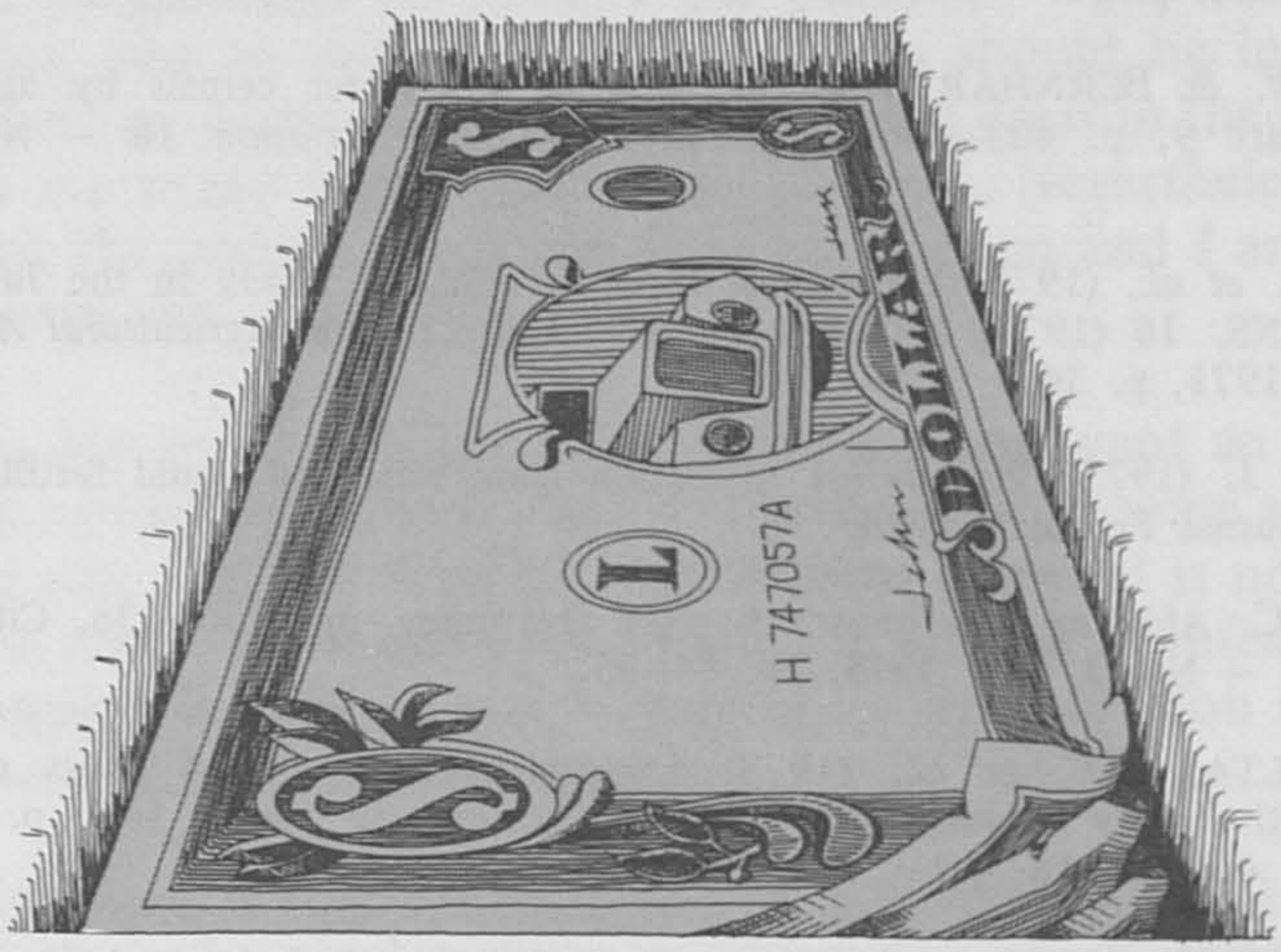
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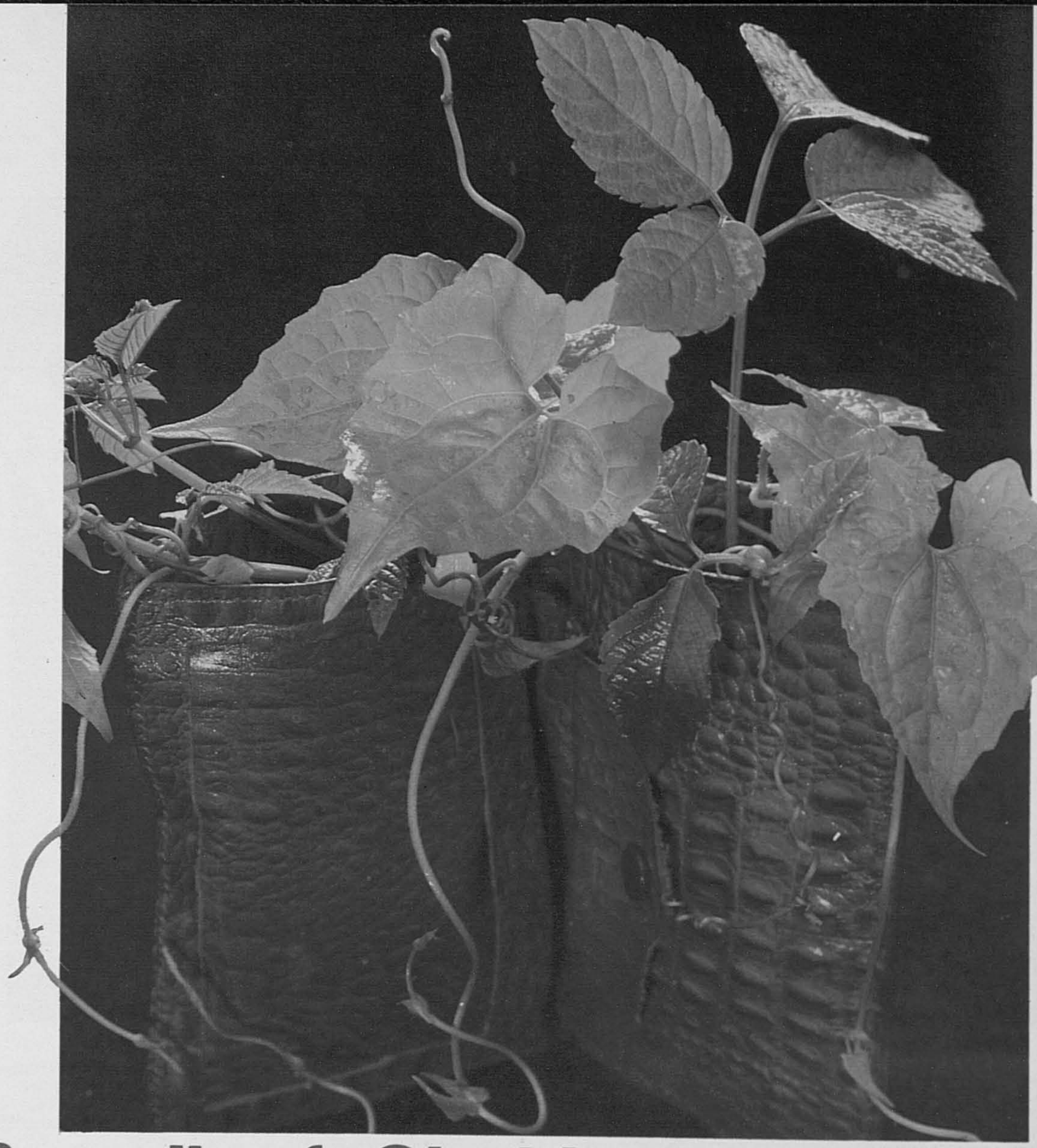
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MESPF Chairman's review*

The main objective of the Fund during 1977 was to increase income and reduce the deficit. This expectation was happily realised both in terms of growth and income. Since November, 1977 all withdrawing members received their full credits – first time since 1974 – and in order to ensure that this feature will continue, changes are being formulated to the Ordinance and Rules, the relevancy of which will be discussed later.

This report deals with all aspects of the activities of the Fund, and is suitably captioned for easy reference.

Income

Income rose to $7.312 million compared with $6.142 million in 1976. The bulk of the increase of $1.17 million is attributable to higher dividends received from investments in Commodity shares.

Dividends

Although, there is an increase in income, the dividend credited to members accounts is the same as last year – 3½% for the first half year and a similar rate for the second half, thus making a total of 7% for the year. However, in real terms such dividend is in excess of 7% as both the members contributions amounting to $3.888 million received during the first half of the year and dividend of $3.123 million credited to members accounts on June 30, 1977 were entitled to dividend of 3½% paid on December 31, 1977.

Investments

An analysis of investments and return of income is found on page 11. Investments continued to be confined to the following categories:

(i) Government securities.

(ii) Term Deposits including short and call

(iii) Equity participation.

Government securities

The market value of Government securities as opposed to acquisition

*Reproduced from MESPF Annual Report with kind permission from Chairman, MESPF.

values showed an appreciation of $1.087 million. In 1975, the unrealised loss on such Government securities was 10.06% of market value. These securities bear a coupon ranging from 5½% to 7½% with a life span of a few months to 15 years. During the year the Board took the opportunity to participate in syndicated loans which carry higher interest rates and repayments are guaranteed by the Government.

Term deposits

Deposits placed with the approved Banks amounted 32% of the total assets of the fund. The Board considered it prudent to maintain liquidity despite the poor return, as the Bank rate did slide from 7½% to 6½% during the year. Banks were known to be in surfeit of money and there was a period when deposits were not sought after. The Board wish to thank those Banks who not only accepted and renewed the fund's deposits but also extended certain concessions.

All surplus cash remained fully invested either in term, short or call deposits with inter banks. The latter placements earned interest at rate close to term deposits.

Earnings in respect of deposits fell to 6.77% compared with 7.76% obtained in 1976 and there is no indication that interest rates will rise in the foreseeable future. The Board is conscious of the situation and alternative avenues are being explored, as deposits can provide only limited protection against erosion of real values by inflation.

Equity portfolios

The performance shown on page 12 clearly illustrates the prevailing trend 44% of the Fund's money remained invested in the equity market. The $30 million alloted to two Portfolio Managers appreciated to $39 million in 30 months to 31.12.1977. This reflects a growth of 30% which can be considered highly satisfactory.

Income returned by the portfolios in the form of dividends and interest was $4.2 million, a return of 9.68%, compared with $3 million or 8.28% in 1976.

At the beginning of the year the total Portfolios as per Schedule II, had a market value of $36.5 million but at December 31, 1977 the value appreciated to $43.2 million. The growth achieved during the year is 18.36%, and has enabled the Board to reduce most of the deficit, brought forward from the previous years.

I do not wish to burden the members with the Portfolio Managers reviews for the year. Suffice it to say, that the Board's decision to introduce competitive portfolio management in July, 1975 has indeed proved prudent. The Portfolios have now operated over a period of 30 months up to December 31, 1977 and during this period, members of the Board have had ample opportunity to match their wits with the professional managers, during monthly meetings when portfolio performance is reviewed.

There seems hardly any exact science to portfolio management. The performance of portfolios managed by professional should, in my opinion, surpass the index, but this is not always the case and the Board is however conscious of the limitations that are imposed as a result of imponderables that do arise from time to time.

Deficit

This needs some explanation in view of my earlier comment that the Fund is solvent.

The deficit of $2.3 million shown in the Trustees' report arises as a result of crediting members accounts with the 3½% dividend on the last day of the year, the credit of $3.2 million, which is the cost of the dividend at December 31, 1977 correspondingly increased the members' fund by a similar amount.

Withdrawing members are entitled to the proportionate value of the Fund as at the date of departure and for the purposes of valuation the current income received to date is represented in current assets without any reciprocal adjustment made to members accounts.

However, to partly offset the above stated deficit there is an appreciation of $1.1 million in Government securities. This is not reflected in the valuation as the rules specifically state the 'The Board shall revalue all investments other than Government securities.' If the growth in Government securities is taken into account the deficit could be reduced to $1.2 million.

The rules are being amended and it is the intention of the Board, to pay all withdrawing members 100% of their credits without any deduction whatsoever.

Deceased members

A service to the deceased members has now been introduced. It has been the practice in the past, that when a member's demise is reported, his credit is automatically transferred to Deceased Members Account. The balance on this account as at December 31, 1977 is $860 367 of which $806 462 is

invested to earn income. Claims sometime, take months and years to finalise before payment can be effected and until such time the members credits earned no income. The Board see little justification for continuing such a practice and opened trust savings accounts for each of the deceased members so that, at the time of settlement the beneficiary not only draws the original credit but also interest earned up to that date.

Reform

The object of reform is to provide a greater opportunity of increasing the members benefits and to fortify the Fund against erosion. As the saying goes 'A journey of 1 000 miles begins with the first step.' The Board has taken that first step in recommending amendments:

(a) To the MESP Fund Ordinance, 1947

(b) MESP Fund rules and

(c) Setting up its own Secretariat.

Before I discuss the import of the proposed changes, I think it appropriate to acquaint the members with a brief resume I made recently to the Rubber Producers Council, regarding the necessity for recommending the amendments to the Ordinance and Rules of the Fund.

> 'The Rubber Producers Council may wish to know the necessity for recommending the changes to the Ordinance and the Rules of MESP Fund.
>
> In recent years the Fund has experienced mixed fortunes but the situation has turned for the better. The Fund is now 100 per cent solvent and members now withdrawing receive their full credit.
>
> When the Sterling was devalued for the second time in November, 1967 by some 14.25% the members balances were devalued by 5% followed by dividend restraint. The Board then took the decision to liquidate the Sterling investments and re-invest the proceeds in the equity market.
>
> The equity portfolio so created appreciated substantially to such an extent, that at end of 1972, members accounts were credited with a 25% bonus in addition to restoring the cut previously made.
>
> At the end of 1972, the Board felt the need for someone to manage the investments of the Fund. A Merchant Banker was appointed as Investment Manager from January, 1973, but the years that followed were generally disastrous years for investments the world over. This necessitated the members' accounts being devalued to bring them in line

with the value of the assets of the Fund. The frequent devaluation became an embarrassment and a change was then made affecting the credits of members withdrawing from 1975.

The Board became increasingly concerned with the frequent criticism of members though no member really lost any money after taking into account the bonus payment. Nevertheless, the Board took steps to revamp the investment strategy which involved the Board members in decision making and gaining their commitments to the objective of the Fund. This has been a success.

> In addition, Messrs. Harris Graham & Partners, a firm of Employees Benefit Consultants were engaged to report on the MESP Fund. They submitted a series of reports and as a result of their recommendations the Board decided to amend and modify the Ordinance and Rules which have remained almost unaltered since the inception of the Fund in 1947. Whilst deliberating the Harris Graham reports, the Board also considered carefully whether the Fund should continue as a distinct and separate Fund or seek to integrate itself with the Employees Provident Fund. It is the general consensus of opinion of the Board and further supported by the view of the Consultants that the members would stand to benefit more if the MESP Fund continues as a separate and distinct Fund.'

I will now endeavour to explain the salient changes as follows:-

(a) *An act to amend the ordinance, 1947*

(i) The bill seeks to update the Ordinance where it refers to aspects which are hardly relevant to the present day realities, as it was drafted some 30 years ago with little or no change since.

(ii) Further, it seeks to widen the investment powers of the Board, and would include housing loans to members, within the rules and regulations laid down from time to time by the Director-General of Inland Revenue.

(b) *Amendments to rules*

(i) Rules recommended for change are mostly those that require to be up-dated and to conform with the rules of the Employees Provident Fund.

Rule : 20

At present contributions are collected monthly by employers but remitted quarterly. The amendment makes the remittance monthly. The reason for this is obvious.

(iii) Rules : 30, 31, 44 and 46

Under these revamped rules the members are guaranteed their credits. Until recently, the Fund has been in deficit and the members withdrawing received only a proportionate value of the assets which are revalued monthly.

(iv) Rule : 33

The Significance of the amendments is that the life assurance policies already taken out by members will continue in force but no member may, in future, take out a life assurance policy assigned to the Board. In lieu of life assurance, the Board is to introduce a Death Benefit Scheme which is similar to that of the Employees Provident Fund.

Members will, of course, be notified of the details of the amendments once they are approved by the relevant Authorities and gazetted.

(c) *Own Secretariat*

(i) The Board after careful consideration decided to establish the Fund's own Secretariat. This is to enable the Board to modernise records, systems of administration and to formulate a more coherent policy. The Fund has grown in stature and its resources today exceeds $100 million. It is envisaged that the Fund should assume a more independent and positive role in the future.

Messrs. Peat, Marwick, Mitchell & Co., have been the Secretaries and Treasurers of the Fund from its very inception, 30 years ago. This is indeed a long time and they have carried out their assignments in a most satisfactory manner. We are most grateful to them. My special thanks goes to their Sr. Partner, Mr. David Bloom, whose counsel in times of need has been invaluable.

(ii) *New secretary*

The Board has engaged Mr. Heng Ji Keng, BEc. Hons., M. Comm., A.C.A., A.C.I.S., as Secretary. He until recently was a Senior Lecturer in Accountancy with a University. He will assume duty on May 1, 1978.

(iii)*New office:*

The new office of the Fund will be situated at 15th Floor, UMBC Building, Jalan Sultan Sulaiman, P.O. Box 1089, Kuala Lumpur. 01-02.

Prospect

It would be presumptuous of me to speak as an expert. I believe that the development of the Fund has yet to reach maturity and sophistication. Nevertheless considering the relatively short history, it may be said that the Fund is performing remarkably well. A study of the Fund now and three years ago would reveal the depth and maturity it had achieved over this short span of time.

CONCLUSION

I have now served as Chairman for two years. Members will, I believe, feel that satisfactory growth and increased income has been achieved. This substantial progress is due to the untiring efforts of the Trustees, Secretaries and Advisors who have spent many hours deliberating the various issues in connection with the Fund at regular and special meetings. I am indeed grateful to them, all of whom have made their contribution to the further development of the Fund.

Again, I extend my very warm thanks to my colleagues on the Board, and look forward to their continued support and advice and finally to the members for their trust and understanding.

V.D. NAIR, FISP
Chairman

May 12, 1978.

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Dwarfs

MYD	–	(Malayan Yellow Dwarf)
MRD	–	(Malayan Red Dwarf)

Seednuts from selected mother palms.

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Further information can be obtained from:-

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HIGHLANDS RESEARCH UNIT
P.O. BOX 209, KELANG
SELANGOR.

Tel. No. 03-312144/312228

OR

THE MANAGER,
TORKINGTON ESTATE,
SABAK BERNAM,
SELANGOR.

Tel. No. 05-634208

Spray-on fungicides for Pink Disease lose out to the rain...





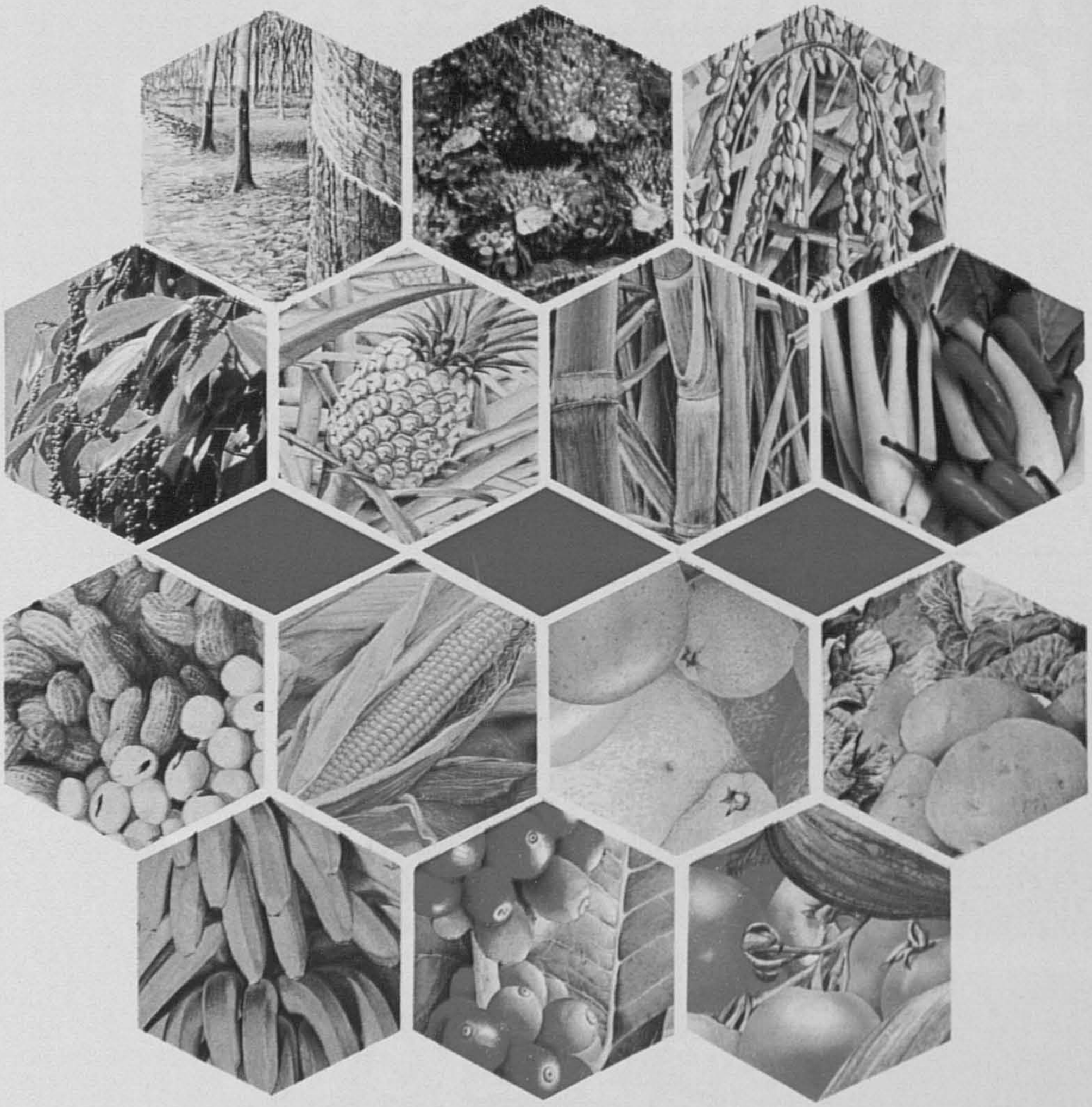
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The monthly crop

Fire precaution. The recent fire at Bernam Perak Estate in Teluk Anson, in which more than 900 acres of oil palm were destroyed by fire in 11 days, must have increased the awareness of oil palm estate owners on the urgent-need for suitable fire precautions in their estates. According to reports, the highly combustible nature of the peat soil allowed the flames to burn their way through to the fibrous tree trunks, thus increasing the difficulty of putting off the fire.

The danger of fire spreading to neighbouring estates and destroying vast acreage of crops is very real and loss can mount up to several million ringgit. In view of this threat, it is hoped that estate owners will improve and increase measures to prevent and control the destruction by fire.

Concession tours. One of the first services the Koperasi Sentiasa Maju is able to provide members is to assist them with their travel arrangements by air whether it be within the country or overseas. If any member of ISP or Koperasi is to avail of this service there will be no reason to be disappointed.

We are also hoping to organise short holidays to neighbouring countries and you will be hearing further on this from time to time.

An International Cashew Symposium is being jointly organised by the Indian Council of Agricultural Research, International Society for Horticultural Sciences and Indian Society for Plantation Crops from March 12 – 15, 1979 to be held at Cochin in south-west India.

This is the first time an International Symposium is being organised on this important economic plant. The topics to be covered will include Botany, Physiology, Crop Improvements, Vegetative Propagation, Agronomy, Plant Nutrition, Entomology, Pathology, Processing and Technology of this crop.

Pre- and post-Symposium tours of cashew plantations, research and processing centres, and sight-seeing in and around Cochin are also being planned.

Planters, scientists and others interested in attending and or presenting papers are invited to write to the following address:–

The Secretariat,
International Cashew Symposium (ICS),
Central Plantation Crops Research Institute,
Kasaragod 670 124,
Cannanore District,
Kerala, India.

The closing date for submission of abstracts is October 31, 1978.

Assistance for rubber smallholders. The Rubber Industry Smallholders Development Authority (RISDA) is inviting rubber smallholders to submit applications, by December 31, for next year's replanting scheme for rubber and other crops. The latter includes coconut, coffee, local fruits, padi, pine-apple, sago, oil palm, bananas, tea, clove, nutmeg, crops for animal feed, orchid, sugar cane, ginger, pepper and cocoa. RISDA will be conducting a campaign on the benefits of the replanting scheme and the method of application.

According to the new land development programme, smallholders having seven acres or less, of rubber land on or before December 31, 1970 will be helped to develop the existing land to the maximum of five acres. Smallholders with less than an acre of rubber land on or before December 31, 1970 will also be assisted to develop their land.

The Planter

A number of back issues published in 1976 and 1977 are being sought by some of our readers. Anyone willing to part with their copies are kindly requested to communicate with:-

The Editor/Manager,
The Planter,
P.O. Box 262,
Kuala Lumpur, 01–02.

"Sandy's Spice"

A.A. SANDOSHAM

MIXED SPICES

I am often called upon to entertain the guests at parties with some spicy stories. The trouble is with advancing age I find I have little spice left in me. Besides, my self assurance as a story-teller had a rude shock the other day at the Long Bar of the Selangor Club. Surrounded by the usual buddies with a glass of beer in the hand swapping stories I asked them if they had heard the new story of mine. They wanted to know if it was funny. I said, "Yes". "Then we haven't heard it" they replied. To think that during all these years they have been laughing at my jokes, not because my friends thought they were funny, but because they were being polite!

I am told it is enough if I speak for ten minutes. That reminds me of a speaker who said he had been given ten minutes to address them. "I have so much to say, I don't know where to begin." A wag from the back of the hall shouted, "Why don't you start at the 9th minute?" That's what I will do; I shall be brief.

The story I had in mind was that of little Mitchell who ran in looking for the mother saying he had had a fall and has hurt his forehead. Realising he wanted sympathy the mother made a big fuss of it, wiped off the sand from the forehead and kissed him there. He was appeased and ran off to play. A while later he returned to the mother crying and complaining that he had a thorn in his finger. Again the mother fussed over it, brushed off the thorn and sucked his finger and sent him off happy. Mitchell returned a third time saying he had a prick on his prick and demanded the same treatment. "Get away you little rascal," said the mother, "You are growing up more and more like your father every day!"

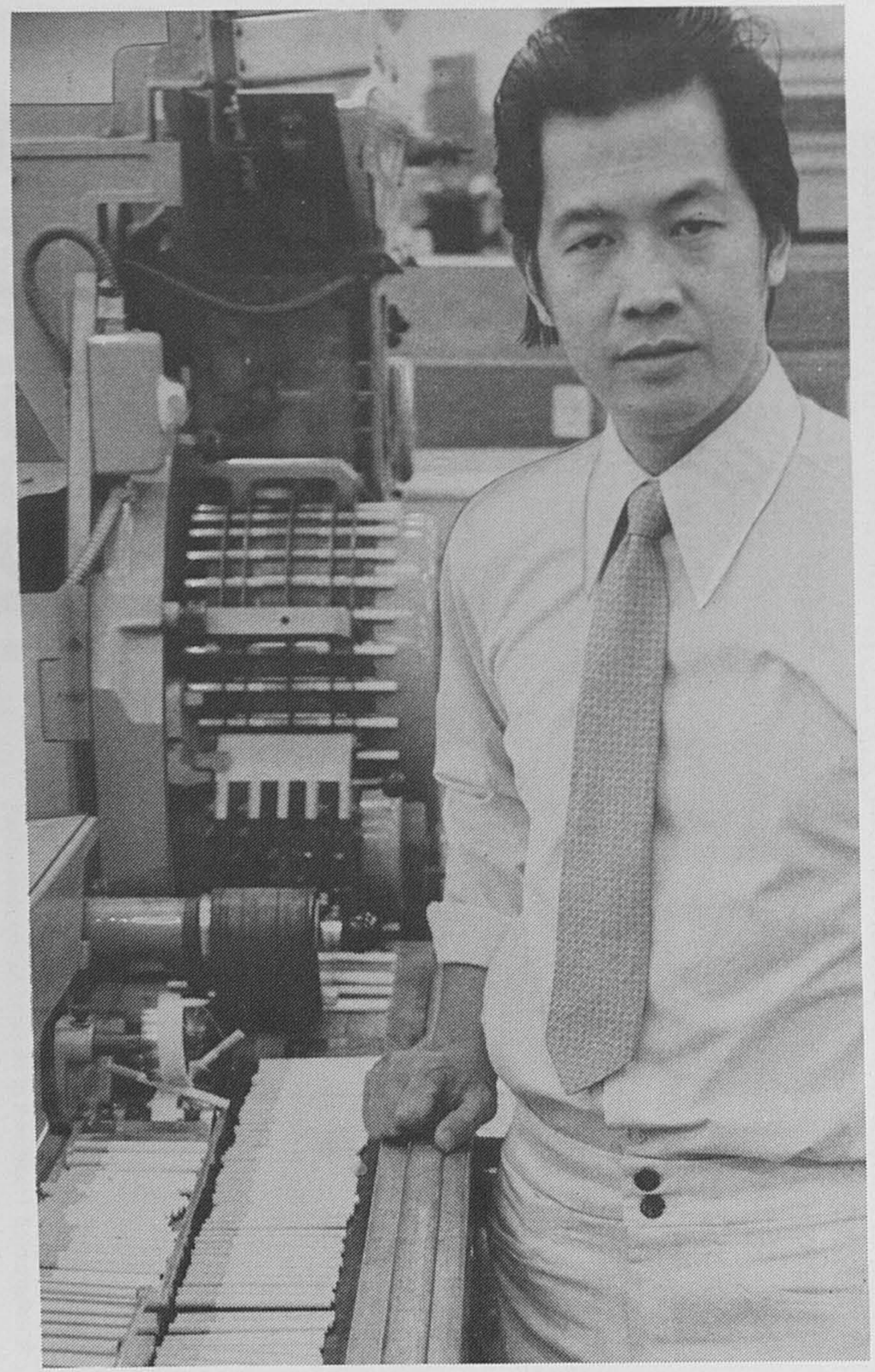
Such aberrant sex deviations are not altogether uncommon. I was told that some men treat their wives like their gramaphone records. They play one side first and turn it over and play the other side.

This is a well known practice among members of a certain community and when a mother learnt that her daughter wanted to marry one of them she put her foot down. But since the daughter was insistent she gave in but made the daughter promise that if ever her husband turned her over she should pack up her bag and baggage and return home the very next morning. Nothing happened for a couple of years. Then one morning the daughter arrived home to her mother with her bag and baggage. The old lady was very angry and took up the phone and gave a blowing-up to her son-in-law. He said, "Madame, let me explain. We have been married for nearly two years and we thought it was time we had a child. So, I turned her over!"

It seems one young fellow was inclined towards homosexualism. His friend was worried and ultimately prevailed upon him to give up this dirty habit as he might grow up into a 'queer'. To take him away from the temptation offered by his continuing to stay with his buddies in town, he took the young fellow away to the countryside for a couple of weeks. On the way they stopped at a hotel for a drink. There the young fellow was attracted by a handsome page boy in a smart uniform. He kept following him with his eyes all the time and then called the page boy, gave him two shillings and told him, "Go to that window, lean over and see if my car is there?" His friend intervened. He said, "You promised me to turn over a new leaf." "Yes, but I must get to the bottom of the page before I can turn over the leaf."

A lady had three daughters one of whom married an American, another an Italian and the third a Frenchman. The mother was anxious to know how the daughters were faring and so in the middle of the night she sneaked up to the door of the room of one couple and put her ear to the key hole and listened. The American was playing some pop music on a record player and dancing with the bride. She listened in the next room and heard the Italian serenading the bride singing an aria from the Italian operas. At the Frenchman's room she could hear nothing at all. So she put her eye to the key hole and found they were silent because their mouths were full. They had obviously become members of "Club 69".

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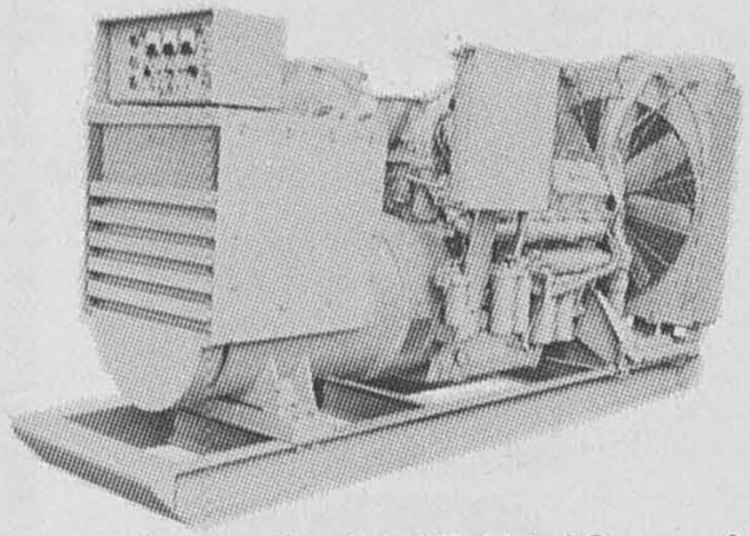
Mr. David Ch'ng, Manufacturing Manager
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Social and Personal

Marriages

Congratulations to:

BAVANI – VISWANATHAN : K Bavani, M A d/o G S Sankar AISP (Life member ISP) to N Viswanathan, M E s/o Narayanan Nair on June 19, 1978 at Hotel Ashoka, Madras.

FAWZI – HASNAH : Fawzi Ahmad to Hasnah Hassan on Saturday, June 10, 1978.

Examination Successes

Estate Practice (Cocoa)
March 22, 1978

Rosely bin Kusip	(Selangor)	Passed
P. Jayaraman	(North West Malaysia)	Passed

Returned from leave

3491 Macpherson, D A, AMBIM AISP, Segamat Estate, P O Box 501, Segamat, Johore.

Change of address

6181 Azam Shah bin Mohd Shuhaily, Boontong Estates Sdn Bhd, Thye Lye Division, Gurun, Kedah.

6294 Ab Razak bin Idris, Elmina Estate, Sungei Buloh, Selangor.

5945 Alias bin Omar, Batu Lintang Estate, Serdang, Kedah.

4685 Bamford, B P, Lepan Kabu Estate, Kuala Krai, Kelantan.

4229 Brindley, K, Bukit Paloh Estate, P O Box 107, Paloh, Johore.

4477 Brown, T P, NDA AISP, Dusun Durian Estate, Banting, Selangor.

6013 Cheng Hup Siang, Kuala Gris Estate, Kuala Krai, Kelantan.

6650 Chow Boon Liong, Felda Lepar Utara I, c/o Felda Kg New Zealand, Kuantan, Pahang.

6719 Chiong Tan Lee, Senai Estate, P O Box 103, Senai, Johore.

4204 Campbell, T J, AMBIM, Sagil Estate, P O Box 504, Tangkak, Johore.

6723 Chong Seong Hoe, The United Malacca Rubber Estates Bhd, Gelang Patah Division, Gelang Patah, Johore.

5009 Chok Mong Hoo MDA AISP, Batu Lintang Estate, Serdang, Kedah.

5636 Chong Kem Yee AISP, Sungei Buloh Estate, Bukit Rotan, Selangor.

6599 Chiang Keng Leong, Tebong Estate, Tebong, Malacca.

5607 Ding Hong Sing, Andrew, AISP., Kerilla Estate, Temangan, Kelantan.

5369 Goh Boon Peng, CEP Niyor Estate, P O Box 514, Kluang, Johore.

6785 Goh Tee Meng, The United Malacca Rubber Estates Bhd, Batu Anam Division, Batu Anam, Segamat, Johore.

6768 Gunasekaran s/o V Uthiradam, Bukit Benut Estate, Kluang, Johore.

3751 Holland, K C, Riverside Estate, P O Box 1, Sungei Patani, Kedah.

4199 Hodgson, G A, AISP, Temburong Estate, Bangar, Brunei.

5157 Ibrahim bin Haji Hassan Raof, Sabrang Estate, Teluk Anson, Perak.

5293 Joshua, M A, Bukit Kledek Estate, Jasin, Malacca.

5720 John, T A, St. Helier Estate, Bahau, Negri Sembilan.

6507 Khoo Lian Hong, Senawang Estate, Sungei Gadut, Negri Sembilan.

4335 Knight, V E, PJK., 1PR No. 7, Jalan Ipoh, Kota Lama Kira, Kuala Kangsar, Perak.

5638 Kugarajah, S, Diamond Jubilee Estate, Jasin, Malacca.

6750 Kutty, Kannan, Lambak Elaeis Estate, Kluang, Johore.

5108 Koh Tian Soo, Segamat Estate, Segamat, Johore.

6350 Lee, Andrew, Rompin Group Estate, Rompin via Gemas, Negri Sembilan.

5431 Lim Hean Peang, Patrick, Windsor Estae, Ulu Sapetang, Taiping, Perak.

6077 Lim Chin Hock, c/o Asian Institute of Management, M C C, P O Box 898, Makati, Metro Manila, Philippines.

5116 Loh Kwan Peng, Sungei Rengam Estate, P O Box 207, Batu Tiga, Selangor.

3331 McIntosh, J B, MBE FISP., Greenland House, Castletown, Caithness, Scotland.

6608 Mohd Yusoff bin Hj Musa, Majlis Daerah Buloh Kasap, Segamat, Johore.

6338 Mohamed Daud bin Mohamed, Middleton Estate, Rompin via Gemas, Negri Sembilan.

6095 Mohd Nizar bin Mohd Zahari, Sungei Palas Estate. P O Box 40, Tanah Rata, Cameron Highlands, Pahang.

5274 Nair, P S N, Plot No. 2271, 10th Main Road, Annanagar, Madras 600040, India.

5863 Pereira, J R, Ulu Yam Estate, Rawang, Selangor.

6809 Rubio, Diego C. (Dr), Paracrevea Borracha Vegetal S A., Granja Marathon, Caixa Postal 445, Belem, Para, Brasil.

5465 Raj, V G Varath, Malaya Estate, Selama, Perak.

5895 Rosely bin Kusip, Bukit Cheraka Estate, Jeram, Selangor.

5164 Su Tuang Ping, Linz (M) Sdn Bhd, Room 5, 1st Floor, Tan Chong Building, 274 Victoria Street, Penang.

4677 Sen, J M, Chamek Estate, P O Box 505, Kluang, Johore.

6551 Salleh bin Haji Aki, Pelam Estate, Kulim, Kedah.

4771 Santheran, K, AISP, Siliau Estate, Siliau, Negri Sembilan.

4992 Sivarajah, A, Semenyih Estate, Semenyih, Selangor.

5569 Tan Miang Hang AISP, Sungei Rawang Estate, Sepang, Selangor.

5148 Thong Kin Sin, Noel, Selborne Estate, Padang Tengku, Kuala Lipis, Pahang.

5320 Tan Han Chee, Kuala Pertang Estate, Kuala Krai, Kelantan.

5560 Tan Seng Yeang, Pinji Estate, Lahat, Perak.

5346 Tay Seng Pang AISP, Kuala Hau Estate, Temangan, Kelantan.

6754 Tio Poh Hock, Chin Teck Plantations Bhd, No. 70 Jalan Sultan, Segamat, Johore.

6183 Tay Kim Puan, CEP Rengam Estate, P O Box 106, Rengam, Johore.

5315 Tan Keng Hean, 29 Jalan Perlis, Penang.

5541 Viswanathan, A, Mantin Estate, Mantin, Negri Sembilan.

6102 Vettiveloo, R, Anak Kulim Estate, Kulim, Kedah.

6401 Wong Kia Hai, No 26 Jalan Abu Bakar, Paloh, Johore.

5135 Wong Tang Kah, Bukit Badak Estate, Layang Layang, Johore.

5083 Watt Yiew Fye, Sungei Samak Estate, Ulu Bernam, Perak.

5313 Yeoh Oon Tit AISP, Damansara Estate, Batu Tiga, Selangor.

5603 Yow San Yong, Albert, Sungei Sabaling Estate, Bahau, Negri Sembilan.

4829 Zakaria bin Othman (Haji), Ulu Papan Estate, P O Box 66, Kota Tinggi, Johore.

New members

6932 Chan Yew Mun, No 179 Main Road, Sungei Siput, Perak.

6933 Cheong Kai Hoe, Lanadron Group Estate, Panchor, Muar, Johore.

6934 Too Hye Fang, United Malacca Rubber Estates, Malaka Pinda Division, Alor Gajah, Malacca.

6935 Rockey, S, Victoria Estate, Padang Serai, Kedah.

6936 Manokaram, S, Bradwall Estate, Siliau, Negri Sembilan.

6937 Teh Chong Lay, BAL Estates Sdn Bhd, Scientific Department, P O Box 135, Tawau, Sabah.

6938 Jelani, A, B 1742 Taman Pertama, Kuantan, Pahang.

6939 Ahmad bin Haji Sulaiman, Labu Estate, Labu, Negri Sembilan.

6940 Nair, Gopi Nath, Viswanathan Plantations, P O Box 52, Kota Tinggi, Johore.

6941 Choong Siew Ming, Jabor Valley Palm Oil Mill, Kuantan, Pahang.

6942 Bolong bin Yacho, Giram Estate, P O Box 19, Kunak, Tawau, Sabah.

6943 Bagah, James B, Giram Estate, P O Box 19, Kunak, Tawau, Sabah.

6944 Iskandar Ahmad, Ladang Koko Yayasan Tun Fuad & Tun Razak, P O Box 502, Tawau, Sabah.

6945 Kamal bin Ahmad Milatu, Taiping Rubber Plantations, Trong, Perak.

6946 Vijayan a/l M N Karunakaran Nair, Tampin Linggi Estate, Rantau, Negri Sembilan.

6947 Ramlee bin Karim (Dr), Asean Chemical Fertilizer Sdn Bhd, Bt 5½ Jalan Kuala Kedah, Alor Setar, Kedah.

6948 Wong Leong, Murphy, P O Box 502, Tawau, Sabah.

6949 McGuire, M P, Ladang Bukit Cheraka, P O Box 202, Jeram, Selangor.

6950 Boniface Panyon Ak Maji, Sabah Softwoods Sdn Bhd, P O Box 137, Tawau, Sabah.

6951 Lee Yin Kim, Paul, Sabah Softwoods Sdn Bhd, P O Box 137, Tawau, Sabah.

6952 Tai Soon Hong, Rubber Research Institute of Malaysia, P O Box 503, Kota Tinggi, Johore.

6953 Haridass s/o M G Nair, Blenheim Estate, Teluk Anson, Perak.

Rejoined

5139 Catto, A D, Asean Chemical Fertilizer Sdn Bhd, Bilik 1.21 Tingkat 1, Angkasa Raya, Jalan Ampang, Kuala Lumpur.

4865 Lee Kim Tin, Sabah Softwoods Sdn Bhd, P O Box 137, Tawau, Sabah.

Resigned

5667 Ong Kwee Seng (S Trengganu/E Pahang)

6487 Yeong Voon Ng (Lower Perak)

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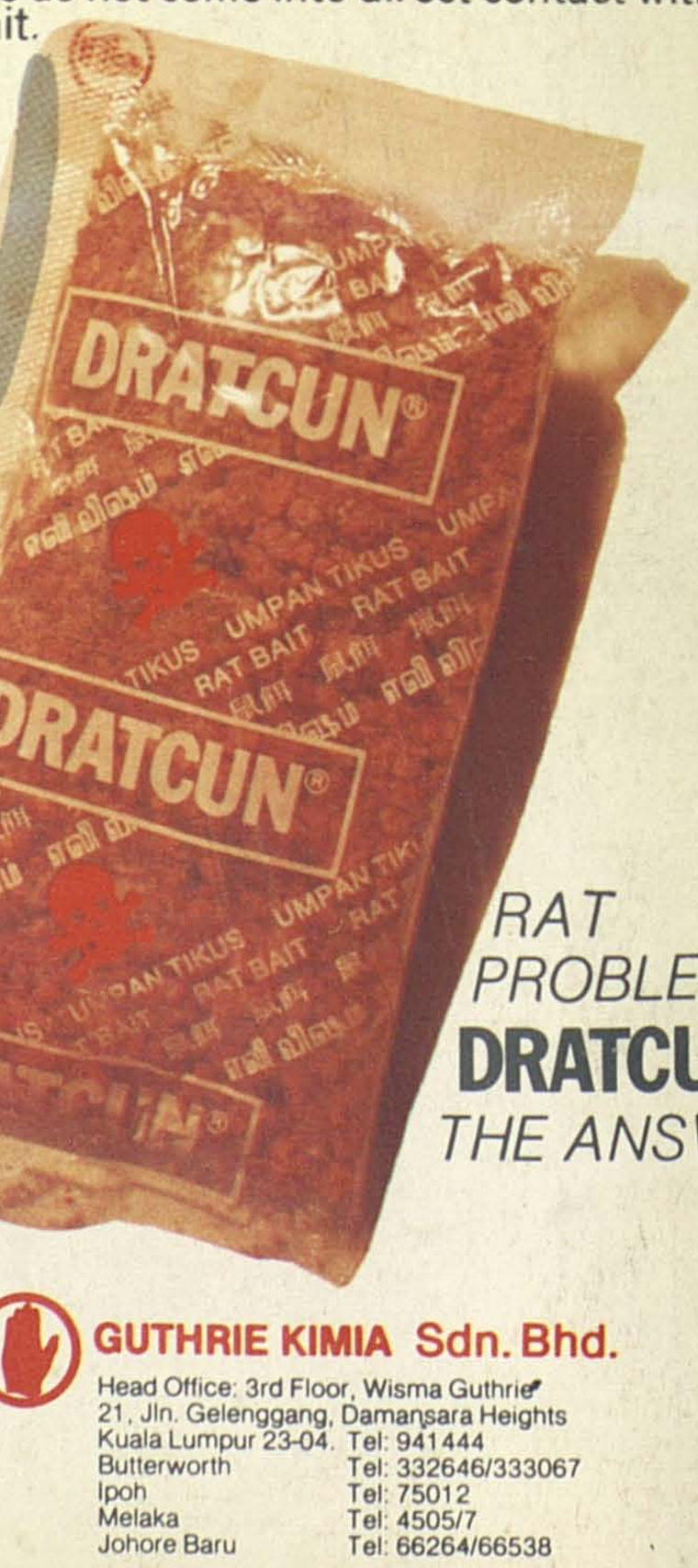
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