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Grain Sorghum in the Markham Valley

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Sorghum is a crop of increasing importance in Papua New Guinea because of its suitability for food for cattle, pigs and poultry. A feed mill in Lae now produces feed for pigs and poultry with an output of 1,500 *tons per year, so a reliable market exists for sorghum in the Markham Valley. Because of the increasing importance of sorghum, research work has commenced at the Agricultural Experiment Centre Bubia, near Lae.*

1. VARIETY TRIALS

IN the past, six different varieties have been grown commercially in the Markham Valley. No one variety has gained general acceptance. At present, some growers tend to prefer the pure line Alpha rather than hybrids, as the seed may be produced locally. The hybrids have to be imported from Australia, so the supply is less reliable. Three variety trials have been completed now, two at Mutsing and one at Mr J. Reid's plantation at Erap. Fourteen varieties have been compared. They include the six varieties previously grown in the valley, namely Dekalb's E57, Yate's NK220Y, Pioneer's Texas 608, Texas 610, 846 and Alpha and eight additional ones, Dekalb's X255, C44C, C42, X896, X897, E55e, X249 and Pioneer's Texas 626. All are hybrids except Alpha.

One of the main reasons for a poor yield in sorghum appears to be attack by the sorghum midge, and to a lesser extent by the sorghum head caterpillar. To minimize damage by these pests a variety must have two characteristics, firstly that the flower heads be open rather than compact and secondly that the flowering period be as short as possible.

In the case of the sorghum head caterpillar, a compact head makes a much safer home for the caterpillar than an open head. The food supply is closer and the caterpillar is much better protected from insecticide spray. A compact head will have a much higher humidity. When the grain is damaged, it is more prone to attack by fungus, and high humidity further encourages the growth of the fungus.

The advantages of a short flowering period with respect to minimizing midge damage are discussed in the next section.

In variety trials the problem of insect control is accentuated by the different flowering times of the varieties. Pests may build up in numbers on the early-flowering varieties and then attack the later-flowering varieties. All trials have been sprayed regularly in an attempt to minimize damage.

All trials received adequate nitrogen fertilizer.

Results of the three trials are given in the following tables. The 'time of heading' is the time when 50 per cent of the heads have emerged. Time of heading and time of maturity are each expressed as the number of days after sowing.

The *Mutsing wet season trial* was sown on 7th January, 1971. Rainfall recorded during the trial was 40 to 98 inches which was fairly evenly distributed. All hybrids gave better yields than Alpha but E57, Texas 608 and C44C were not much better.

The *Mutsing dry season trial* was sown on 13th May, 1971. Rainfall recorded during the trial was 5.17 inches. Only the hybrids X896, C42, Texas 626, Texas 610 and E55e gave significantly better yields than Alpha. All varieties had a flowering period of 12 days or less which would be considered acceptable to minimize midge damage.

The *Erap wet season trial* was sown on 26th March, 1971 at Mr J. Reid's property. Rainfall for the duration of the trial was 12.43 inches; 7.5 inches fell in April and this followed the very wet conditions of January, February and March (20 inches total rainfall). Although soil conditions were considered adequate at sowing time the continual rain in April led to waterlogging of the trial area on this poorly drained loam soil. This resulted in

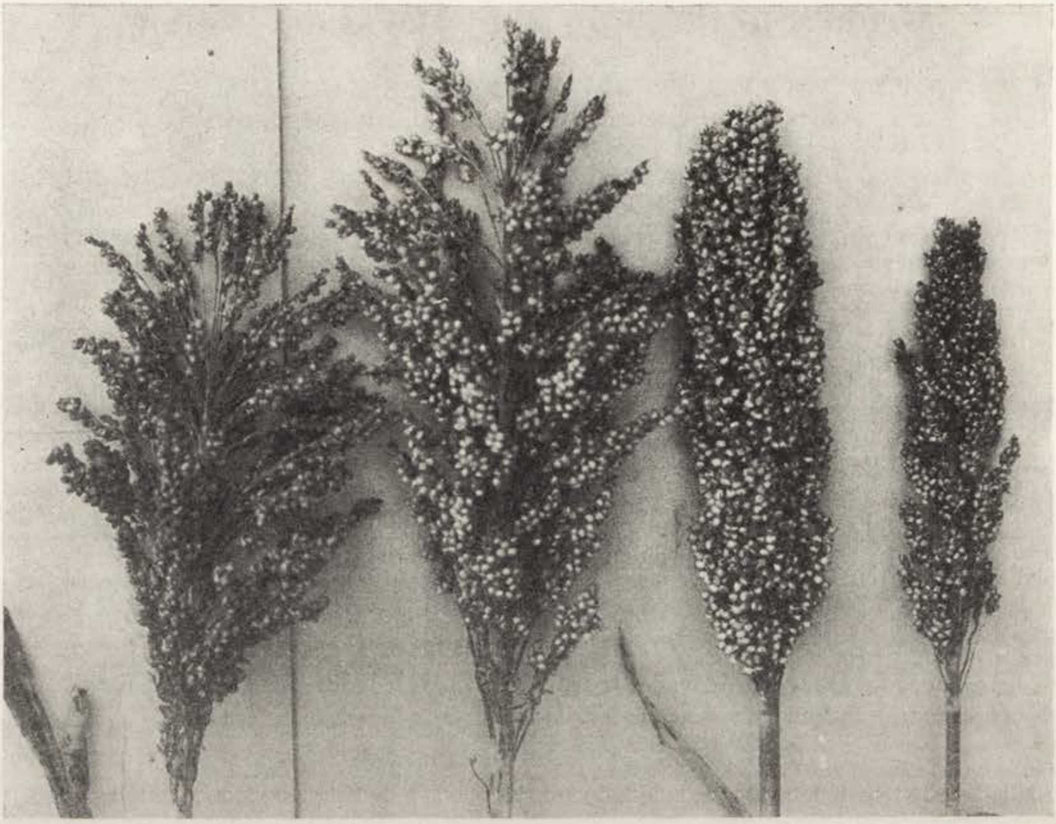

Plate I.—On the left are varieties X249 and E57, the open-headed type; on the right are Texas 610 and Alpha, compact-headed varieties

Table 1.—Results of Mutsing Wet Season Trial

Variety	(Days of Sowing) Time of Heading	Time of Maturity	Yield (lb/acre)	% Crude Protein Content of Grain	Head Type
X249	43	82	2950	9.8	Open
Texas 610	50	90	2950	10.2	Closed
X896	46	82	2800	9.7	Semi-open to open
NK 220Y	46	90	2800	10.2	Semi-open
Texas 626	49	90	2750	10.3	Closed
Pioneer 846	50	95	2750	9.8	Closed to semi-open
E55e	48	91	2600	8.1	Closed to semi-open
C42	45	91	2500	10.4	Semi-open
X255	49	95	2350	10.0	Semi-open to open
X897	46	82	2350	9.9	Semi-open to open
E57	49	95	2200	8.7	Open
Texas 608	50	90	2200	10.4	Closed to semi-open
C44C	50	95	2000	9.5	Semi-open
Alpha	51	90	1700	10.4	Semi-open

Table 2.—Mutsing Dry Season Trial

Variety	(Days of Sowing)		Yield (lb/acre)
	Time of Heading	Time of Maturity	
X896	41	82	2700
C42	48	92	2700
Texas 626	48	92	2600
Texas 610	49	92	2450
E55e	48	88	2400
X897	41	82	2150
E57	51	92	2100
Pioneer 846	53	92	2050
NK220Y	48	92	2000
Texas 608	49	88	1950
Alpha	48	88	1850

Table 3.—Erap Wet Season Trial

Variety	Yield (lb/acre)
Pioneer 846	425
X255	360
Texas 608	350
X897	315
Alpha	300
X896	260
Texas 626	250
E55e	235
Texas 610	195
NK220Y	190
C44C	175
C42	100
E57	55

retarded and uneven growth, prolonged flowering periods and severe insect damage. The time of heading for all varieties was very late, occurring at 80 to 90 days after sowing. Varieties were harvested at 116 and 123 days after sowing. Yields for all varieties were very low.

Variety evaluation will be a continuing process in the valley. A fourth trial will be completed at Markham Farming Co., Erap, in October, 1971. Five additional varieties have also been included in this trial. They are Dekalb's F64a and Pacific's 303, 007, 222 and Mini Milo I.

2. INSECT PEST CONTROL

More than a dozen species of insect pests on sorghum have been recorded in the Markham Valley since June, 1968. The most serious one is the sorghum midge (*Contarinia sorghicola*), which may be one of the most destructive insect pests of sorghum in the world. It has only recently been recorded in Papua New Guinea, although it has been known in other parts of the world for many years.

Midges attack only the flowering heads of the grain. The eggs are deposited within the flower and when the eggs develop into larvae, the larvae feed in the ovary, thus preventing the development of the seed. The full-grown larvae pupate in the eaten-out flower, and the adult midges emerge from the flower leaving their white pupal cases attached to the top of the seed coverings. They mate within a few minutes of emerging and the females start to lay eggs in half an hour. The adult midge lives only a day or two, during which time a female will lay up to 100 eggs. The adult midge is a small fly, smaller than a mosquito, and much harder to see. It has an orange abdomen and fine transparent wings.

Under the climatic conditions of this country, it seems that the midge breeds continuously all the year and passes many overlapping generations a year.

The whole life cycle lasts only 2 or 3 weeks, so if the flowering period of the sorghum is spread over many weeks, a few generations of midge could do a great deal of damage to the crop.

The time of sowing should therefore be as short as possible. If the seed is sown over a period of weeks, the flowering stage will spread over a similar time, which gives the conditions most suitable for a big increase in the midge population.

Suggestions for Control

1. Burn or plough in the remains of the crop after harvest. To prevent the survival of larvae and pupae, burning is recommended.

2. Obtain seed of uniform flowering open-headed variety.

3. Prepare a good seed bed by thorough cultivation to ensure even flowering.

4. Avoid planting near earlier-flowering sorghum or near any wild sorghum plants (such as *Sorghum nitidum*), which would act as alternate hosts for the midge until the main crop was ripe.

5. Plant the late-flowering variety up-wind of the earlier-flowering varieties, to limit the spread of adult midges.

6. Cut out early volunteer and ratoon sorghum. The cutting out must not be done at the time of the flowering of the main crop, however, as this would encourage the egg-laying adult midges to go to the sorghum crop.

7. Remove "out-of-season" flowering heads in the sorghum crop to prevent the midge getting established in the crop just before the flower heads emerge.

Chemical Control

Some farmers in the Markham Valley have sprayed their crop with DDT at intervals of 3 to 7 days during the heading stage.

Although sorghum is not produced for direct human consumption in this country, chemical control must be viewed with some caution because of the danger of pesticide residues being carried over into stock food and eventually into meat for human consumption. Cultural and mechanical control for midge is preferable. Furthermore, chemical control is expensive and is unlikely to be effective unless reasonable attention is given to the cultural methods described above.

3. WEED CONTROL IN GRAIN SORGHUM

The main weeds in sorghum in the Markham Valley are *Rottboellia exaltata* and *Brachiaria reptans* (both grasses) and the broadleaf weeds Tah Vine (*Boerhaavia erecta*), Tridax daisy (*Tridax procumbens*) and milkweed (*Euphorbia prunifolia*).

All weeds compete with the crop for nutrients and water and some also compete for light. Rottboellia grows taller than sorghum and is capable of smothering the crop if it becomes well established. When this happens, mechanical harvesting is often not possible. *Brachiaria reptans* is the main grass species encountered. This is a low-growing species so it does not compete for light, but it certainly competes for nutrients and moisture.

The broadleafed weeds and Brachiaria can be controlled with herbicides, but Rottboellia is best controlled by cultivation practices. This is because Rottboellia is very similar botanically to sorghum itself. Any chemical that kills Rottboellia is likely to kill the sorghum too.

So Rottboellia must be attacked in a different way. Its weaknesses are that its seeds are not easily distributed by natural means, and they only have a short dormancy period. It does however, produce many seeds (one estimate is 3,000 seeds per plant), so the best way to control it is to slash or hand-weed before the seeds are formed.

Although the seeds are not easily distributed by natural means, vehicles and agricultural implements can easily carry them. Growers must therefore ensure that road verges are kept clean and that machinery is thoroughly cleaned before moving it from an infected area.

For the broadleafed weeds and Brachiaria the weedicide atrazine (trade name: Gesaprim) seemed to offer good prospects. Three main field trials were therefore laid down. Each trial tested four rates of atrazine—1, 2, 3 and 4lbs of active ingredient per acre in comparison with a 'hand-weeded' control and a 'not hand-weeded' control. The time of application of the herbicide differed in each trial. In trial 1, the herbicide was sprayed on to bare ground after the crop had been sown but before either weeds or crop had emerged. In trial 2, the herbicide was sprayed on the growing crop when it had reached the 2 to 4 leaf stage, and in trial 3 when 4 to 6 leaves of the sorghum had appeared. The herbicide was applied as a blanket spray in 15 gallons of water to the acre. There was no evidence that the spray damaged the sorghum at all.

The sorghum variety used was Texas 610, and nitrogenous fertilizer was applied at planting at the rate of 40lb urea per acre. For each trial, conditions were ideal for spraying, with moist soil surface and follow-up rains to move the atrazine into the soil.

Results

Results of these trials were assessed in two ways—firstly by observing the effect of the herbicide applications on the weeds, and secondly by measuring the yield of grain under the different treatments.

Atrazine was very effective against the broadleafed weeds—Tah Vine, Tridax daisy and milkweed—even at the lowest rate of 1lb active ingredient per acre. At this low rate, atrazine was not effective against Brachiaria, but it was effective against it at 2lb per acre in trial 1 (pre-emergent spraying). It gave less control of Brachiaria in trials 2 and 3 when the weeds had become established before the atrazine was applied.

In trial 2 (spraying at the 2 to 4 leaf stage) atrazine was particularly effective in controlling milkweed, which completely smothered the untreated plots.

The effects on yield of the various treatments are set out in *Table* 4. From these figures it is clear that weed control at all stages of growth will increase the yield of grain. Hand-weeding was less effective than spraying in all three trials.

Table 4.—Yield responses of grain sorghum following the application of atrazine for weed control

Trial No.	Treatment	Average Yield of Grain (lb/acre)	% Increase in Yield*
1	Not hand-weeded	3800	0
	Hand-weeded	4200	11
	Atrazine 1	4800	26
	(lb a.i./acre) 2	5400	42
	3	5400	42
	4	5600	48
2	Not hand-weeded	2900	0
	Hand-weeded	4000	38
	Atrazine 1	4700	62
	(lb a.i./acre) 2	5000	73
	3	4700	62
	4	4900	69
3	Not hand-weeded	4800	0
	Hand-weeded	5500	15
	Atrazine 1	5800	21
	(lb a.i./acre) 2	5400	13
	3	5800	21
	4	5900	23

Trial No. 1 Herbicide applied before crop and weed emergence

2 Herbicide applied soon after crop and weed emergence (sorghum at 2 to 4 leaf stage)

3 Herbicide applied later after crop and weed emergence (sorghum at 4 to 6 leaf stage)

*Increase over 'not hand-weeded' control.

In trial 1, broadleaf control at 1lb active ingredient per acre increased the yield by 1,000lb per acre, a rise of 26 per cent. Brachiaria was not controlled at this rate, but was controlled at the higher rates of application. At 2lb active ingredient per acre, there was a further yield increase of 600lb per acre.

The biggest increases in yield were seen in trial 2 (early post-emergent spraying) where the yield increases of the sprayed crop over the unweeded crop were 60 to 70 per cent. This was due to the very high incidence of milkweed in the unweeded plots.

Trial 3 (late post-emergent spraying) showed that while spraying at this stage is beneficial, it is too late to achieve most effective control of the weeds. This would, of course, depend on the kind of weeds present. It is certainly too late for Brachiaria.

From these trials it is clear that atrazine is effective in controlling weeds, and it is now being used on several properties in the Markham Valley. The usual practice is to blanket-spray the bare ground immediately after sowing and to follow this up with spot-applications as necessary when weeds appear. The recommended rate is 1 lb active ingredient per acre.

If Brachiaria is a major weed species, a higher rate may be needed, but this may lead to problems of atrazine residues in the soil. The weedicide remains in the soil after the crop has been harvested and can cause trouble if a different crop is planted there in the next season.

For spot-spraying, other weedicides may be used against specific weeds. Thus if milkweed is the only weed present, MCPA (trade name: Methoxone) is effective and cheaper. 2,4-D amine (trade name: Ammoxone) is also effective over a narrower range of weeds.

CONCLUSION

Variety trials will need to continue for some time yet before firm recommendations can be made regarding the best sorghum variety for the Markham Valley, but the initial trials have clearly demonstrated that the best hybrids are capable of much higher yields than Alpha. Sorghum midge constitutes a serious problem in sorghum production and growers will have to practise crop hygiene and choose varieties and cultural methods that will ensure a short flowering period, so as to prevent rapid build-up of this pest. Atrazine can be very useful for weed control but *Rottboellia exaltata* is resistant to atrazine and will have to be controlled by cultural practices.

Skipjack Tuna in Papua New Guinea

M. MITCHELL, Fisheries Superintendent

Those of you who like to go fishing outside the reef will have come across a smallish tuna, about 4 *to* 10 *pounds in weight, which has distinct broad stripes along the belly. This is the skipjack tuna, or* Katsuwonus pelamis. *It is much sought after, since it is quite acceptable to most of the world's tuna eaters, and is also suitable for some traditional processes of curing in Japan.*

COMMERCIAL tunas of the world include albacore, yellowfin, big-eye, bluefin, and skipjack, with a miscellany of other species, many of which are only available in small quantities. Many of the tuna fleets of the world, especially Japanese and American, have been concentrating on oceanic yellowfin tuna. The resulting decline in fish population has caused some concern internationally, and catching quotas are recommended. It is a peculiar fact that whilst the Japanese are expert fishermen in most respects, they have never matched the Americans at yellowfin purse-seining but have concentrated on their own favourite method of longlining. Purse-seining consists of running a very large encircling net around a school of fish and then quickly closing the bottom of the net by means of a drawstring. Longlining, on the other hand, consists of paying out a very long length of main line (up to 30 miles at a time) from which hang baited hooks.

Tuna of the same species may differ in schooling and other habits according to their size and particular oceanic locality. This may determine the method of fishing attempted.

One of the drawbacks of oceanic longlining is the fact that this method is economical only with large fish. It will be appreciated that one hook will catch only one fish, the bigger the better, whereas an encircling net may catch so many more individuals. Purse-seining is, therefore, a much more efficient method of fishing.

With the population decline of larger tunas, especially yellowfin, and with world demand for fish rapidly growing, fishing nations of the world are looking further afield to exploit fresh stocks or new areas.

It is thought that in the Pacific Ocean there exist two main stocks of skipjack tuna and that these roam the ocean in separate swimming tracks, one in the eastern part and the other in the west. The western population, which concerns us, is thought to circle the ocean in a clockwise motion which brings it into Papua New Guinea waters at one stage of its travels. So now that the demand for skipjack tuna is increasing due to general world scarcity of fish, this area is attracting more attention.

Recently the Japanese have become very interested in exploring Papua New Guinea waters with a view to setting up a skipjack industry. Other countries, including Australia and America, have also shown some interest. Since a large amount of capital is required to set up a full-scale fishing and processing operation, it will be evident that exploratory fishing, on a 'no commitment' basis, is the first step. The Japanese attitude has been stimulated by the Australian-Japanese Fisheries and Trade Agreements, which encourage the setting up of joint-venture operations, especially in Papua New Guinea.

Consequently three Japanese fleets have arrived in our waters and have conducted skipjack fishing surveys under limited period permits, with encouraging results. Two purse-seine fleets are now exploring the Coral Sea area. Both have American interest and one has already become incorporated within Papua New Guinea.

Skipjack are smallish fish and it would not be an economical proposition to longline them, but purse-seining has not yet proved satisfactory. Luckily there is a traditional method much used in the industry. This is called the 'pole and live bait' method, or 'poling' for short. Briefly, the poling boats must first catch a supply of suitable small live bait before they proceed to the tuna grounds. As soon as feeding schools of tuna are sighted, the catcher boat moves in and live bait is thrown overboard. The tuna are attracted by the bait

Plate I.—Papua New Guinean trainees with Okinawan crew members aboard the *Tamoyoshi Maru* (Photo D.I.E.S.)

to the boat's side, where about 20 men are waiting with short bamboo poles to which are attached short lengths of strong nylon line. A feather 'jig' with a barbless hook is fastened to the line. The excited tuna strike at the lures as they dash in amongst the live bait. Provided the line is kept tight, the tuna cannot throw the hook, but once the line is slackened the fish throws the jig and the line can be immediately thrown back into the water. In practice many tuna do throw the jig whilst they are still flying through the air to land on board behind the fishermen. Those which have not already thrown the jig do so immediately they hit the deck. It can be seen that the fishing is fast and furious when things are going well.

At the same time, sprays of water are emitted from jets along the side of the boat and these tend to hide the fishermen from the fish as well as to excite the fish. Sometimes the tuna show undue caution and will not take a feather jig. On these occasions the fishermen have a special pole ready which has a plain hook on the end, which is baited with a live fish. As the tuna cannot throw these hooks like a jig, then the fish has to be caught as it flies towards the fisherman. The tuna is firmly tucked under one arm and quickly unhooked. With a quick twist of the body the fisherman throws the tuna behind him onto the deck. Whilst the whole method may seem somewhat amateurish by modern standards, in fact it is very efficient and up to 20 tons per fishing day may be boated. It is a young man's game and yet some quite elderly fishermen are involved. They are given the best and physically easiest fishing positions on the boat.

This method of poling tuna is exactly the same as used in Australia except that there larger fish may be encountered amongst the bluefin schools. With the larger fish two or even three poles may be used for the one fish, the lines being joined to one hook, of course. Experiments have been made with mechanical automatic tuna poles, which can fish unattended.

A form of tuna poling has been practised in Papua New Guinea for generations, but the gear has been primitive and the fishing done from canoes. There has been no incentive to progress above this level owing to lack of refrigerated transport to supply demands outside any particular area. The scene is now changing of course, and plans to involve local fishermen are under consideration. With the eradication of freezers at various points in Papua New Guinea, coupled with a growing awareness by shipping owners of the advantages of installing freezers, there is now every inducement to train our fishermen in modern techniques.

The Department of Agriculture, Stock and Fisheries has a Fisheries School at Madang. DASF employees and others wishing to specialize in fisheries work may go there for training. With the accent now on skipjack poling, arrangements were made to put a group of such trainees aboard a Japanese tuna boat and let them participate in the normal routine. The joint venture firm at Kavieng, Gollin Kyokuyo, volunteered to do this and six DASF trainees went to Kavieng for the experiment. Despite language difficulties and the general air of caution and unfamiliarity which surrounds such an exercise, the whole thing went off quite well. The first thing which emerged was that the food is simple, the living is hard and office hours don't exist.

Plate II.—Three tuna fly through the air to the catcher ship as the live bait is thrown out to sea (Photo D.I.E.S.)

Plate III.—Washing down the catch
(Photo D.I.E.S.)

The whole fishing operation cycle takes a complete 24 hours, beginning with catching the bait. In some cases the bait fish are collected on a reef by driving them into nets using a gang of swimmers. The more usual method of catching bait however, is by light attraction.

Boats using the light technique anchor at a suitable site before dark with a bait boat 50 feet astern of the catcher boat, attached to it by a rope. After dark, the bait boatman lowers a waterproof light down into the water. The light is powered by a diesel generator in the bait boat. The submerged lamp is brighter than any light above the water as the surface of the water reflects most of the light anyway. Small bait fish are attracted to the light so strongly that they do not leave it. After a while they are seen milling around the light in an orderly circle. About 4 a.m. a bell is rung aboard the the catcher and the crew all turn out to secure the bait. The crew have enjoyed about six hours' sleep, except for the bait boatman. He does not work during the day but takes the bait boat back to the mother ship.

The catcher boat has a net stowed along one side which is termed a 'stick held dip net'. The sticks are fat bamboos, several of which are lashed together to form pieces about 40 feet long. One piece which is floated parallel to the ship's side is held out by two more pieces, one at each end. The whole looks like soccer goalposts lying on the water. From the crossbar piece a curtain of very fine mesh net is hung and weights attached to the bottom of it to ensure that is hangs vertically in the water. To the bottom of the net, several ropes are attached, which are led to the side of the catcher boat. When all is ready, the bait boat is slowly pulled inside the floating bamboos, still with the light suspended below, and bringing with it all the bait which has collected there. Thus the bait boat, light and bait fish are all eventually positioned between the bait net and the side of the catcher boat. At a signal the crew heave up the ropes and pull the net up so that the bait and bait boat are enclosed completely. The bait boat then moves slowly out and is manoeuvred over the side of the bait net without letting the bait get away. A weak light is then suspended over the bait in the net to encourage them to mill in an orderly fashion and not damage themselves against the net. The bait is very easily damaged and is handled with great care at all times. The side pieces of the bamboo 'goalposts' are then drawn onto the catcher boat and the net is pursed up into a small area. The bait is bailed out in buckets of water, and then gently lowered into wet-wells on the catcher boat. Sea water circulates through the wet-wells as the bait would soon die without constant circulation of oxygenated water.

By this time daylight has come and the catcher boat can get on its way to the fishing grounds. A minimum of 30 buckets of bait is required for a day's fishing but anything from 75 to 150 may be carried and used. The catcher then puts to sea and fishes as described previously. About 2 p.m. the catcher returns to the mother ship and unloads, takes a breather and gets under way again about

4 p.m. This is repeated seven days a week barring bad weather. The fishermen have about one free day per month.

Our trainees were apparently fascinated by the whole business, which was quite strange to them. There were men from Popondetta, Daru, Samarai, Lae, Buin and Manus in this group. Despite forebodings about food, there was no trouble with rice and raw fish or whatever was served up. The tinned meat remained unopened. Catching fish was, however, considered more important than meals; the skipper once took up into a school of tuna just as rice was being served and we had all squatted down with our chopsticks. Food went untouched while we got stuck into the tuna. That's the way of it.

The crews of the catcher boats are Okinawans. The work is hard and the living conditions are most spartan. Our trainees slept, when they could sleep, between decks on the engine room level, on bare boards. Luckily the main engine was stopped at night, otherwise it would have been too hot down below. The headroom where we slept was about three feet so that it was unwise to sit up quickly when the bell rang early in the morning. Likewise the minute hatch through which one had to struggle to get out of the place was about three feet by two feet. It was hard to find with sleep-filled eyes.

The first trainees have now completed their course and have been posted to fisheries stations in Papua New Guinea. We hope that they will pass on what they have learnt, and thus stimulate interest which will benefit both the people and the country.

Plate IV.—The catch is transferred from the catcher ship to the mother ship for freezing and dispatch (Photo M. Mitchell)

Shade, Spacing and Fertilizing of Cocoa in Papua New Guinea

P. N. BYRNE, Agronomist-in-Charge, L.A.E.S., Keravat, East New Britain

Shade, spacing and fertilizing are the three major agronomic practices of importance to good cocoa yields. While there is a marked interaction between these, they will be discussed mainly as individual factors. Effective pest and disease control are equally important and should be given as much attention as agronomic practices.

THIS article deals mainly with sole planted cocoa as most agronomic trials have been carried out on this type of planting. However, on the whole, results are also applicable to cocoa interplanted to coconuts. The two main points to remember when applying these practices to interplanted cocoa are—

(*a*) Coconuts do provide shade so that interplanted cocoa will respond to various treatments in much the same way as sole cocoa under other types of shade.

(*b*) The dual cropping system, coconuts/cocoa is very demanding on soil nutrients and under these conditions one is committed to fertilizing by the time the cocoa is mature, if not sooner, if reasonable levels of cocoa and copra production are to be maintained. This applies particularly if all shade additional to coconuts is removed.

SHADE

While it is possible to establish cocoa without shade, its use is traditional. This tradition has very sound practical bases. Shade simulates the natural environment for cocoa, which is an under-storey forest tree.

Young seedlings make best growth under fairly heavy shade conditions but the cocoa tree's requirements for shade decrease as it develops. Opposed to this, shade at the same time tends to get more dense so that it is necessary to keep removing or trimming shade to meet the cocoa's need for increasing light. This aspect will be discussed in more detail later.

Cocoa can be planted using thinned out forest to provide shade but this has disadvantages, particularly in many areas of Papua New Guinea where insect pests occur, e.g., the cacao weevil borer (*Pantorhytes* spp.) The felling and burning of forest trees is a major factor in keeping some pests out or, at least, under reasonable control. For this reason only planted shade is recommended and discussed in this article.

Shade trees should be planted on a systematic pattern keeping in mind the final pattern of permanent shade trees. This gives a uniform shade and also helps considerably in shade control or manipulation.

Shade also has an important function, particularly in the early stages before cocoa forms a canopy, of suppressing grass and regrowth thus saving on maintenance and reducing competition for nutrients.

Generally speaking, shade should be fairly heavy when cocoa is planted. It is thinned out as the cocoa develops so that by the time the cocoa trees at normal spacing start to ramify there are, for example three Leucaena trees to each cocoa tree. It should be progressively thinned from then on, so that by the time the cocoa has formed a complete canopy, there is one Leucaena tree to each two cocoa trees, and eventually one well-developed Leucaena tree to each four cocoa trees. Other species of shade trees are thinned to give the equivalent cover. It may be necessary to modify this recommendation according to growth of both shade and cocoa trees.

Figure 1 shows suggested planting and thinning patterns for cocoa planted at 12ft triangular spacing and using Leucaena as shade. Further thinning will depend on local conditions, whether or not it is intended to use fertilizer, pest and disease situation, subsequent growth of shade trees, etc.

The importance of shade control is highlighted by results of trials carried out at Keravat. In general, the less mature cocoa is shaded,

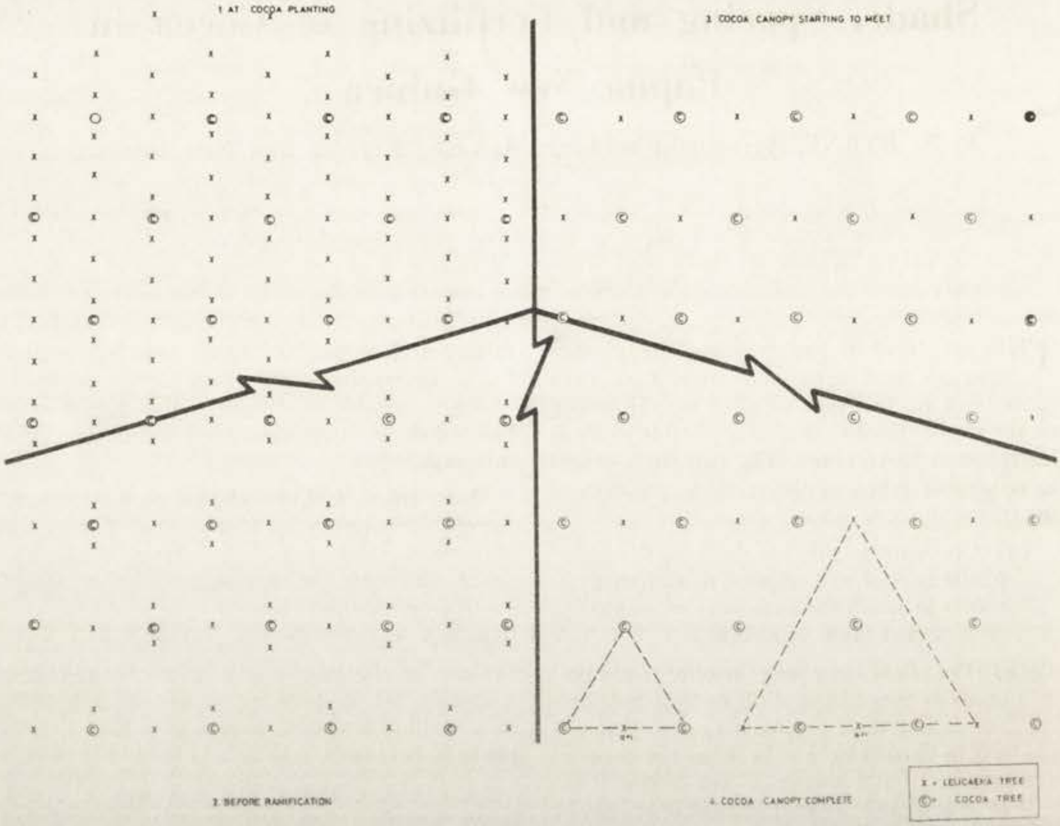

Figure 1.—Planting and thinning pattern for sole cocoa planted at 12 ft triangular spacing and using Leucaena shade. Further thinning would consist of removing alternate Leucaena trees in each line so that these are then on a 30 ft triangular spacing. Less drastic thinning on block edges is recommended as this could assist in keeping down infestation of pests such as the cocoa web moth (*Pansepta teleturga*)

the greater the production. In the main trial (KTC 2) there were four levels of shade:—

Nil shade: No Leucaena.

Quarter normal shade: One large Leucaena tree to four cocoa trees

Half normal shade: One large Leucaena tree to two cocoa trees

Normal shade: One large Leucaena tree to each cocoa tree

Cocoa was planted at 15ft on the triangle. However, shade was relatively old and very well developed so that in effect the quarter normal shade (shade trees on 30ft triangle) gave about as much shade as one Leucaena shade tree to four cocoa trees at 12ft spacing (shade trees at 24 ft triangular spacing).

Results for period 1959-60 to 1963-64 are given in *Table* 1 and these are shown graphically in *Figure* 2.

Table 1.—**Yields in lb of dry cocoa per acre obtained by using an arbitrary conversion factor of eleven pods per pound of cocoa**

Year	Nil Shade	¼ Normal Shade	½ Normal Shade	Normal Shade
1959-60	1729	1576	1331	1043
1960-61	1381	1176	974	799
1961-62	1288	1167	943	831
1962-63	1645	1400	1127	982
1963-64	1047	1240	926	887
Mean	1418	1312	1060	908
Ratio cocoa/ Leucaena tree	Nil	4:1	2:1	1:1

Table 1 gives support for the recommendation of thinning out eventually to one Leucaena

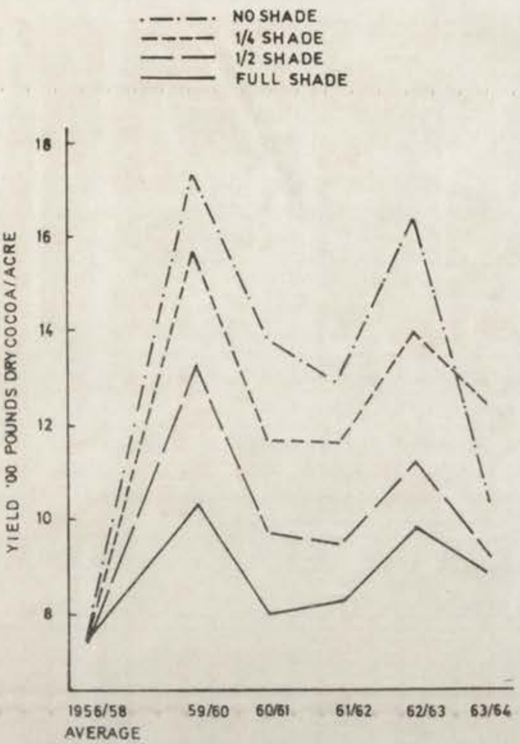

Figure 2.—Graph showing yields in lb dry cocoa per acre at 4 shade levels (Trial KTC 2). Cocoa planted at 15 ft triangular spacing and Leucaena shade

tree to each four cocoa trees under normal conditions. Further response to complete shade removal could be anticipated but this would be recommended only if it is intended eventually to use fertilizers where this will not accentuate problems of pests and diseases and where soil and climatic conditions are suitable.

With drastic reduction or complete removal of shade, conditions become much more favourable for build-up of some insect pests particularly *Pansepta* (cocoa web moth) and *Pantorhytes*. In the case of *Pansepta* early recognition and treatment by cutting out and burning infected branches will keep this pest under control but emphasis must be on early recognition and treatment. Where *Pantorhytes* are present shade removal will be dependent on the seriousness of the infestation and probably response of *Pantorhytes* to shade removal in the particular area. The advice of entomologists should be sought if you are not sure how *Pantorhytes* are likely to respond to shade removal.

Some of the shades in use are discussed below.

Coconuts

For new coconut plantings a 30 feet triangular spacing is recommended. A closer spacing will give a too dense shade and consequently this will depress cocoa yields. With fertilizing, which is almost inevitable with interplanted coconuts/cocoa, coconut fronds will be larger and more luxuriant and this will result in greater shading and further affect yields.

In most cases the shade provided by coconuts is not adequate for establishing cocoa and this can be overcome by either planting additional shade or the use of fertilizer. The latter has definite advantages provided maintenance is consistent and of a high standard.

It should be noted that new and well-maintained coconut plantings must be 3 to 4 years old before interplanting cocoa, otherwise the cocoa, which grows rapidly in the early stages, will out-compete coconuts for light. Coconut losses will be high and survivors will be retarded, except on road edges, etc.

Leucaena leucocephala (*syn.* L. glauca)

This is the most widely used shade for cocoa in Papua New Guinea. As a shade it is almost ideal but has two main disadvantages—

(*a*) Seedling regrowth can become a major problem when shade is not properly managed or where there are heavy losses of cocoa allowing penetration of sunlight to the ground and encouraging germination of Leucaena seed.

(*b*) Leucaena is a host for some of the leaf eating caterpillars, e.g., in Popondetta the moth of *Tiracola plagiata* (army worm) lays its eggs on the leaves of Leucaena. These hatch out and the small larvae or caterpillars later descend on to the cocoa tree and cause serious damage. Where army worm and certain other caterpillars are found, Leucaena is not recommended.

Leucaena can be established either by sowing seed directly into the field or by transplanting seedlings. The latter has advantages in shade control as it allows planting on a systematic pattern.

The most common cause of poor take of Leucaena seedlings is planting too deep and failure to firm-in at planting. Leucaena seedlings, at least as thick as one's little finger, are

Plate I.—Sole seedling cocoa planted at double 12 ft triangular spacing under Leucaena shade. This is a dieback area and double spacing has been used to compensate for possible high loss of seedlings

either pulled out or the main root cut 4 to 6 inches below soil surface. The side roots are trimmed off and the tap root, if still remaining, is cut back to 4 to 6 inches and the whole topped back to 3 to 4 feet. When planting, the original collar should be no more than 1 to 2 inches below ground level. Leucaena stakes can be used but losses can be very high and therefore they are not usually recommended.

Gliricidia maculata

While this is used overseas, it has only recently been seriously considered for use in Papua New Guinea to replace Leucaena. The entomologists have found that army worm will not feed on it. Further advantages of Gliricidia are that it does not seed in the lowlands and it will stand heavy cutting back which, in fact, is necessary to maintain it as a satisfactory shade.

Gliricidia is brittle and susceptible to wind damage. Its growth habit is often straggly but this can be kept in control by judicious pruning.

Hardwood cuttings from 1½ to 6ft long are used. These must be well firmed-in when planted.

Other Permanent Shade Trees

These include Albizia, Casuarina, Erythrina, etc., which have their uses under certain conditions.

Temporary Shade Plants

A number of these have been recommended and used over the years. These include *Crotalaria anagyroides*, *Tephrosia* spp., *Flemingia congesta*, etc.

N.B. The above recommendations are based on Gazelle Peninsula conditions. It may be necessary to modify for other areas. For example, less shade would be recommended for Buin which has more cloud cover.

Plate II.—Clonal cocoa (cuttings) planted under Gliricidia shade

SPACING

Current recommendation based on trials is a 12 feet triangular spacing for sole-planted seedling cocoa. For sole-planted clonal cocoa (cuttings) this should be modified slightly to give a close hedge spacing to make the stand more accessible for machinery. For interplanted coconuts/cocoa, recommendations are based on experience and observation only.

Spacing recommendations for various types of planting material and conditions are given below.

Sole Seedling Cocoa

Twelve-feet triangular spacing is recommended. This is a planting density of 348 trees per acre. There may be slight advantages in planting at a slightly closer spacing.

Seedling spacing trials at Keravat indicated that for the first 3 years of bearing a 12ft triangular spacing gave better yields per acre than a 15ft triangular spacing. In one trial (KTC 4) yields of dry cocoa per acre during the first 3 years of bearing were 2,404lb for the 12ft spacing and 2,118lb for the 15ft spacing. This is a difference of 13.5 per cent. However, there were no significant yield differences between these two spacings in subsequent years, but both spacings continued to out-yield wider spacings. Results of this trial are given in *Table* 2.

Table 2.—Yields in lb dry cocoa per acre for five different triangular spacings. Seed planted at stake in 1965. Dieback affected this stand of cocoa to such an extent that only yields up to the end of 1963 are reported

	Triangular Spacing				
Year	12 ft (348)	15 ft (224)	17 ft 2 in. (174)	20 ft (126)	24 ft (87)
To Dec					
1960	507	342	300	222	201
1961	696	636	375	441	478
1962	1201	1140	1046	684	804
1963	1499	1473	1365	952	867

(....) Trees per acre

It is possible that a slightly closer spacing may be the optimum. The only experimental evidence under our conditions is that an 8ft triangular spacing is too close. Thus all that can be said is that the optimum triangular spacing for sole seedling cocoa lies somewhere between 8ft and 12ft but probably near 12ft.

Wide hedge spacings for seedling and clonal cocoa have been tried at Keravat but it was found that the cocoa canopy took a long time to cover the space between hedges, resulting in increased maintenance and grass competition. The same applied to wide triangular spacing trials: closer spaced cocoa formed a complete canopy sooner than the wider spacings.

Where New Guinea cocoa dieback occurs, planting at double 12ft triangular spacing is a wise precaution in anticipation of heavier losses than under normal conditions. A double 12ft triangular spacing is in actual fact a 10.4ft x 6ft rectangular spacing. This will require a modification of shade planting pattern. Should there be a high percentage of survivors it may be necessary to thin out the cocoa stand to reduce inter-tree competition to reasonable levels. Thinning out excess trees is far easier than planting at normal spacing and later having to replace losses.

Sole Clonal Cocoa (Cuttings)

A cutting is actually a cocoa tree without a trunk with branches coming out at ground level. Thus the canopy is that much closer to the ground and hampers movement between lines. To overcome this problem a modified hedge spacing is recommended. This modification is essential to allow relatively free movement through the cocoa stands, particularly if tractor-mounted machinery is used for spraying, fertilizing, etc., or even motorized knapsack sprayers. This applies even more when clones are relatively young.

Spacing between hedges must be a compromise between being wide enough for easy access but close enough to ensure that the canopy fairly rapidly covers the space between hedges. This saves on maintenance, reduces grass competition and ensures that shade can be thinned at about the normal time. It is considered that a spacing of 15ft between hedges will meet these requirements.

Trials on spacing between clones within hedges are to be conducted. These will include the following spacings: 12ft (242 trees/acre), 10ft (290 trees/acre) and 8½ft (343 trees/acre). The wider spacing probably will result in lowered yields for the first 2 or 3 years of bearing but this will be offset, in part at least, by the lower capital outlay for planting material. Rooted clonal cuttings at present are being sold at Keravat for ten cents each.

In areas where dieback occurs, double spacing to allow for losses, as recommended for seedlings, is not necessary. Dieback resistance in selected clones is more uniform than in seedlings and, due to their growth habit, they are better able to withstand pruning out of dieback infections.

Interplanted Cocoa/Coconuts

The advantages of a 30ft triangular spacing for coconuts have already been mentioned.

It is recommended that cocoa, both seedlings and clones, be planted in a single line

Plate III.—Seedling cocoa interplanted to coconuts showing strip in cocoa planting line maintained in a weed-free condition midway between coconut rows and also in the coconut lines. This is preferred to planting two lines of cocoa between coconut lines. This pattern gives better access for machinery (spraying, grass cutting, etc.) and the cocoa trees are further away from the palms, thus lessening chances of damage from falling fronds and nuts.

Recommended planting distance between cocoa trees in the line midway between coconut lines is 10ft. In the coconut lines two positions are planted to cocoa between each two coconut positions, e.g., with coconuts at 30ft triangular spacing cocoa would be planted:— coconut palm—10ft space—cocoa tree —10ft space—cocoa tree—10ft space— coconut palm and so on (see *Figure* 3).

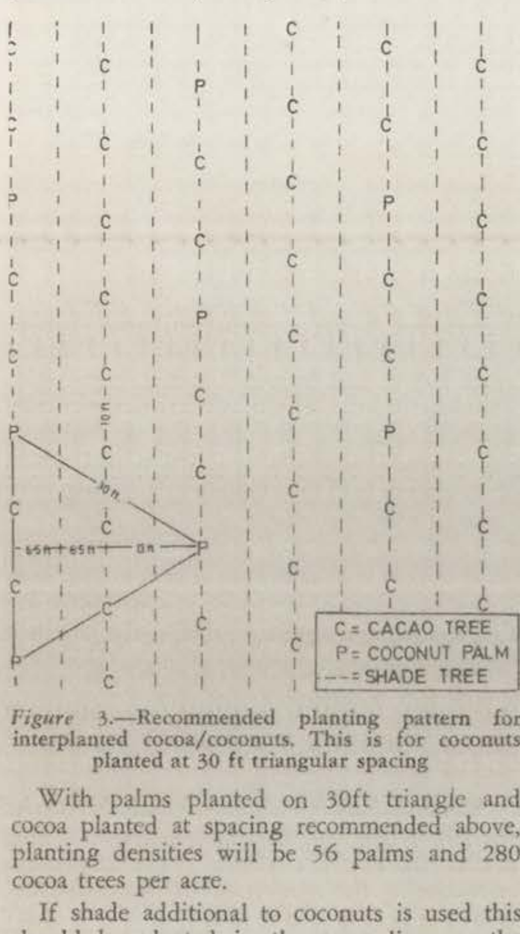

Figure 3.—Recommended planting pattern for interplanted cocoa/coconuts. This is for coconuts planted at 30 ft triangular spacing

With palms planted on 30ft triangle and cocoa planted at spacing recommended above, planting densities will be 56 palms and 280 cocoa trees per acre.

If shade additional to coconuts is used this should be planted in the same lines as the cocoa; additional lines midway between cocoa lines may be planted. Where coconuts are at 30ft triangular spacing the former will give shade lines 13ft apart and the latter 6½ft apart.

Reference to *Figure* 3 shows spacing recommended where coconuts are planted on 30ft triangle. Basically the same pattern would be followed for other spacings but distance between cocoa lines would vary according to coconut spacing. Spacing between cocoa trees would remain at 10ft, but the distance between coconuts and cocoa trees in the cocoa lines would have to be varied.

FERTILIZERS FOR COCOA

Nitrogenous fertilizers under conditions of little or no shade and in some areas, potash, are the only fertilizers to which cocoa in Papua New Guinea has shown a general economic response. Phosphate deficiency has occurred in a few areas while other deficiencies, particularly iron, zinc and copper, do occur to some extent. There have been a few isolated cases of sulphur deficiency in cocoa, but cocoa is apparently very efficient in taking up sulphur from the soil. Some of the so-called responses by cocoa to sulphur have been indirect ones; mainly cocoa shade (Leucaena) has responded and this in turn has benefited young cocoa.

While areas where, and conditions under which, responses to various fertilizers can be expected are fairly well defined, there are occasions when a more positive assessment is required. This situation is catered for by the soil and leaf analysis service supplied by the Department. Samples for analysis can be taken by the owner or manager provided correct sampling techniques are followed and full information relating to samples is supplied. Unless both of these requirements are met, results of analyses and interpretation of results can be grossly misleading and even very costly.

Instructions for sampling and details of information required will be supplied by the Department on request.

Nitrogenous Fertilizers

Under conditions of heavy shade a response to nitrogen is unlikely, but under little or no shade a response can be expected. One trial quoted to support this statement is the Shade x Spacing x Fertilizer Trial (KTC 3) carried out at Keravat.

Shade was removed progressively from the no shade treatment during 1953-54. By 1957-58 the initial boost to yields from shade removal appeared to have been lost and at this stage a fertilizer treatment was superimposed using urea initially at the rate of 224lb per acre (10oz per tree at 12ft spacing and 15oz per tree at 15ft spacing) and changed in December to 4lb/tree/year in four applications.

There was no response to fertilizer under shade but a marked one under no shade. This resulted in a 37 per cent yield increase. Yields for period 1959-60 to 1963-64 are summarized in *Table* 3.

***Table* 3.—KTC 3 mean yields of lb dry cocoa per acre. Yields for 12 and 15 ft triangular spacing combined**

	Not Shaded	Shaded
Fertilized	1671	1224
Not fertilized	1272	1217

These were converted from pods per acre to lb dry cocoa per acre using an arbitrary conversion factor of 11 pods per pound dry cocoa.

Considering other fertilizer trials, a lower rate of fertilizing may have given as good an economic response. In one trial (KTC 9) urea was applied at two rates (1 and 4lb per tree per year) and two frequencies (6 and 3 monthly). This trial is being carried out on a stand of mature cocoa interplanted to coconuts in an area which has been badly infected by New Guinea cocoa dieback, hence low yields, but even so increased yields from fertilizing are worthwhile. Results are given in *Table* 4.

***Table* 4.—KTC 9. The yields have not been corrected for pretreatment effects**

Treatment	lb dry cocoa/acre per year	Percentage of Control
Controls (no fertilizer)	585	100
6 monthly application: 1lb urea/tree/year	804	137
6 monthly application: 4lb urea/tree/year	873	149
3 monthly application: 1lb urea/tree/year	878	150
3 monthly application: 4lb urea/tree/year	972	166

The important point of this trial is that ¼lb urea every 3 months gave as good a yield response as 2lb urea every 6 months. Taking cost of urea and its application into account the 'little and often' rate would give a better net return. Whether or not 1lb urea per tree every 3 months would give a better net return would largely depend on cocoa prices. However, there is a suggestion that 4lb of urea per year may be excessive and in the long term result in lowered yields. This effect has not been proven but heavy rates of urea should be used with caution.

Based on the above, recommendations for nitrogenous fertilizers are for ¼ to ½lb urea per tree or its equivalent in other fertilizers applied every three months (i.e., 1 to 2lbs urea/tree/year).

The rate will depend on spacing, e.g., the lower rate (1 lb per year) is for a 12ft triangular spacing and the higher rate for an older type of interplanted cocoa. On the other hand it may be advisable to double up the rates for the initial and even second application where trees are obviously very nitrogen deficient.

The above recommendation applies only under conditions of little or no shade.

Where shade is completely removed or drastically reduced there will be initial boost to yields but this will probably disappear after a few years. While fertilizing will give a further boost, it is not necessary for the first couple of years but should be used later if high yields are to be maintained. However, complete shade removal would be recommended only when it is intended eventually to fertilize and where it would not lead to complications already mentioned in the section on shade.

Recommendations are for urea or its equivalent. Urea contains 46 per cent nitrogen compared to 21 per cent in ammonium sulphate; i.e., ammonium sulphate has slightly less than half the nitrogen content of urea. However, for all practical purposes it is applied at double the rate of urea. Nitro-potash containing 20 per cent nitrogen is also applied at double the rate of urea.

The initial effect of urea on a soil is to raise the pH of the soil for a short duration. This results from its conversion into ammonium carbonate by the enzyme urease. Once nitrification (i.e., conversion to nitrate form) processes commence, urea, like ammonium sulphate, then induces an acidification of the soil to which it is added (i.e., it lowers the pH). Prolonged use of urea fertilizer does not depress the pH of a soil to the same extent as sulphate of ammonia.

There are differences between fertilizers in losses due to leaching, volatilisation, etc., availability to the plant and effects on other soil nutrients. However, this has not been studied in cocoa under Papua New Guinea conditions.

Relative costs of nitrogenous fertilizer are based on the landed (on the plantation) cost per unit of nitrogen. For example urea at $92 per ton costs $2 per unit but ammonium sulphate at $67 per ton costs $3.19 per unit. At these prices urea would be the cheapest source of nitrogen.

Sulphur

Cocoa apparently is very efficient in taking up sulphur and only a few confirmed cases of sulphur deficiency in cocoa have been reported, mainly in young cocoa. On the other hand some shade trees are very susceptible to sulphur deficiency, e.g., Leucaena which will be very retarded and thus fail to provide adequate shade for young cocoa.

Despite the claim that cocoa is not very sensitive to low levels of soil sulphur, it is considered a wise precaution to substitute ammonium sulphate (A.S.) or ammonium sulphate nitrate (A.S.N.) for urea for occasional dressing in areas known to be sulphur deficient. In these areas A.S. or A.S.N. should be substituted in one application out of four.

If sulphur deficiency is present, the use of urea will accentuate the effects of this deficiency unless it is corrected by the above recommendation.

Potash

Papua New Guinea's coral-derived, mature clay loams are amongst the known potash deficient soils and are one of the major soil groups on which cocoa is grown. These soils occur on New Ireland, south coast of New Britain, etc. Response to potash by cocoa grown on these soils has been obtained under conditions of shade ranging from heavy to nil.

Cocoa fertilizer trials on these soils have not been running long enough to make any but tentative recommendations. However, it would appear that under conditions of little or no shade, nitrogen will accentuate a potash deficiency. Therefore the potash deficiency will have to be corrected before a response to nitrogen can be expected. Recommendation for potash on coral-derived mature clay loams for mature trees is $\frac{3}{4}$ to $1\frac{1}{2}$ lb muriate of potash (KCl) per tree per year in a single dressing, the amount depending on spacing.

Fertilizing Coconuts in an Interplanted Coconuts/Cocoa Stand

The economics of applying nitrogenous fertilizers to coconuts is doubtful, but they do benefit from nitrogen applied to interplanted cocoa. On the other hand, there have been marked responses to both potash and sulphur where these deficiencies occur.

In interplanted stands where potash or sulphur (or both) are deficient, separate fertilizer programmes are required for both crops rather than a combined programme.

An article by Mr J. Sumbak recently published in *The Papua New Guinea Agricultural Journal*, Vol. 22 No. 2, gives recommendations for fertilizing coconut palms.

Establishing Interplanted Cocoa Without Shade Additional to Coconuts

This can be successfully carried out provided ground maintenance is of high standard and use is made of fertilizers to compensate for high light intensities.

Maintenance consists of keeping the immediate area around cocoa seedlings weed-free. In actual practice this is best done by maintaining a weed-free strip 3 to 4ft wide in the cocoa lines in preference to ring-weeding.

Recommended rates for fertilizing young inter-planted cocoa are given in *Table* 5. It should be noted that in potash deficient areas it may be necessary to apply muriate of potash at these rates to sole cocoa planted under shade, particularly if the area has been used for gardening or other cropping.

Applying Fertilizers to Cocoa

Young seedlings should not require any special ground maintenance before fertilizing as it should be kept clean weeded at all times. Fertilizer should be scratched in around seedlings and cuttings up to 12 months old, taking care that fertilizer does not come in contact with the seedling.

Application of fertilizers to older trees should be preceded by close cutting of grass, if present. Exposing soil by removing leaf litter is not

Table 5.—Fertilizer rates for interplanted cocoa grown without shade additional to coconuts

Age of Cocoa	Fertilizer Rates: Urea per Tree	Fertilizer Rates: Muriate of Potash per Tree (2)	Remarks
3 months	½oz(1)	2oz	Cuttings and seedlings from nursery taken as 3 months old when field planted
6 months	½oz	—	
9 months	½oz	—	
12 months	1oz(1)	4oz	
15 months	1oz	—	
18 months	1oz	—	
21 months	2oz	—	
24 months	2oz(1)	4oz	
27 months	2oz	—	
30 months	2oz	—	
33 months	3oz	—	
36 months	3oz(1)	—	
39 months	3oz	½lb	
42 months	3oz	—	
45 months	4oz	—	
48 months	4oz(1)	¾lb	
Thereafter(3)	4 to 8oz	—	Every three months
Thereafter(3)	—	¾ to 1½	Every twelve months

(1) In areas of sulphur deficiency substitute ammonium sulphate or ammonium sulphate nitrate at double the above rates.

(2) Applies to areas where potash deficiencies occur.

(3) Rates will depend on number of cocoa trees to the area.

recommended. This can expose surface roots resulting in damage and is too labour-consuming.

After the tree ramifies, apply fertilizer uniformly to area covered by the canopy but again do not allow fertilizer to come in contact with tree. Once a complete canopy is formed, or nearly formed, fertilizer should be applied evenly over the whole block.

It is emphasised that fertilizers should be applied uniformly to the area covered by the canopy. It should not be applied in a narrow band or a heap as this will result in root damage and poor uptake.

Once the cocoa canopy is well developed tractor-drawn fertilizer spreaders, where they can be used, give good distribution and uniform application.

Interaction Between Shade, Spacing and Fertilizing

There is no doubt that there is an interaction between shade, spacing and fertilizing. No single trial to tie up these three factors has been completed under our conditions. The only trial laid down for this purpose was so severely affected by dieback that it had to be abandoned.

Taking into account the various trials already mentioned, reports on overseas research and personal observations, one cannot help but come to the conclusion that maximum yields per acre will be obtained by a combination of—

(*a*) close spacing within the limits already discussed;

(*b*) under light shade or no shade conditions once the cocoa canopy meets; and

(*c*) fertilizing according to soil type. Nitrogenous fertilizers certainly are essential eventually to maintain yields after shade has been drastically thinned or removed while 3-monthly application has been superior to 6-monthly application.

There are pitfalls associated with shade removal, as already mentioned, such as build-up of *Pansepta* and *Pantorhytes* infestations and where cocoa dieback occurs. If there is an awareness of these pitfalls and precautions are taken accordingly, cocoa can be expected to give good yields under these conditions.

Cocoa Planting Techniques

JOHN KOUTA KONIMOR, Final Year Student, Vudal Agricultural College*

Over recent years it has become common practice to use plastic bags for the germination of seedlings in the nursery. In the Gazelle Peninsula the plastic bags give the added advantage of protection from the Giant Snail. Germination in the bag, however, causes a distortion of the roots which may be a severe disadvantage.

A study of the use of plastic bags in cocoa nurseries was made by John Kouta Konimor, a final year student at Vudal Agricultural College.

MOST agricultural extension officers recommend the use of plastic bags for cocoa at the nursery stage, especially in the Gazelle Peninsula, where the Giant Snail (*Achatina fulica*) causes extra trouble in nursery practice. At the time of planting out in the field the bottom of the plastic bag is cut off and the entire contents, seedling and soil, are placed into the prepared hole. The soil around the roots is not disturbed so the roots are not damaged during the transplanting. Because of this lessening of transplanting shock, it is possible to transplant when the seedling is older. At the later time it is easier to select the best plants and weed out those showing poor growth. The later time of transplanting also means a reduction in field maintenance costs. If a seedling is planted out in the field at an early stage it will be greatly in danger of being smothered by weeds. So clean-weeding will be necessary until the seedling has become well established. If transplanting is delayed, it will be a shorter time before the need for weeding is past.

In spite of these advantages however, the root system of the cocoa tree does not always establish well since the bag inhibits its growth. This is not immediately apparent but it is noticeable that trees aged 2 to 4 years which started life in bags are more likely to fall down during high winds or earthquakes than trees grown from seeds planted at stake. The distortion of roots caused by the bags probably gives rise to points of weakness in the root system.

*At Vudal Agricultural College, each final year student has his own research project. Much useful information comes to light through these. This is the first of these reports to be published in *Harvest*. Others will appear from time to time. Mr Konimor is now at Mosa Plantation, West New Britain.

To test this theory an area of approximately ¼ acre was divided into two halves.

In one half cocoa seeds were planted out at stake, the spacing being 6ft on the triangle. At the same time a large number of seeds were planted in plastic bags in the nursery.

After 3 months 12 seedlings were transplanted from the plastic bags into the second half of the area. At the same time 12 seedlings planted in the field and 12 seedlings from the bags were pulled up and examined for root straightness. These seedlings were not replanted.

Plate I.—Seed planted at stake in the field—development of roots 8 months after planting

Table 1.—Root distortion after 8 months

	Root Condition							
	Straight		Slightly Twisted		Badly Twisted		Average Height of Plant Above Ground	Average Depth of Roots
	No.	per cent	No.	per cent	No.	per cent	Inches	Inches
Planted at stake	38	82	6	12	3	6	26.1	38.4
Transplanted from plastic bag								
5.2.1970	—	—	4	33	8	67	27.6	21.8
2.3.1970	—	—	1	8	11	92	26.4	19.9
6.4.1970	—	—	2	16	10	84	25.8	19.5
5.5.1970	—	—	1	8	11	92	25.6	17.4

These practices were repeated at 4, 5 and 6 months after the initial planting. At 8 months all the seedlings were pulled up and examined for root straightness.

The photographs and table give the results of the trials.

The photographs were all taken 8 months after the trial commenced. They show the straight roots of the seedlings planted at stake in the field and the distorted roots of those transplanted from plastic bags. *Table* 1 gives the final results after 8 months.

Of the plants grown from seeds planted out directly in the field 82 per cent had straight roots, 12 per cent had slightly twisted roots and 6 per cent had badly twisted roots. By contrast, there were no straight roots amongst the seedlings transplanted from plastic bags and more than two-thirds of the seedlings had roots which were badly twisted.

The twisted root system did not seem to affect the height of the plant above ground after 8 months but it certainly did affect the depth of the roots. The straight roots penetrated to an average depth of 38.4 inches whereas the twisted roots reached only to about half that depth. Thus the seedlings grown from direct planting of seed have deeper, stronger tap roots and thus are better able to absorb water and nutrients from the soil and are better able to stand against a high wind or during an earthquake.

Before a decision is made to use plastic bags therefore, the disadvantages shown up by the project should be weighed against the advantages mentioned earlier.

Plate II.—Development of roots in an 8-months old seedling—transplanted after 3 months in a plastic bag with a subsequent 5 months in the field

Plate III.—Development of roots in an 8-months old seedling transplanted after 6 months in a plastic bag with a subsequent period of 2 months in the field

Natural Product Evaluation in Papua New Guinea

M. J. PRICE, Natural Products Chemist

A variety of plants producing essences, spices or perfumes have been introduced into Papua New Guinea to check the possibilities of new industries. Most of the early investigations were concerned with how the plants would grow but more emphasis is now being placed on combined field and laboratory studies to aid the early evaluation of an introduction. It is easy to see whether a plant is growing well or not, but this is not the only important factor. A plant may be growing very well, but if it is not producing the right amounts of the right kind of spice or oil, it is useless. So the laboratory studies are a vital part of assessing the value of these newly-introduced crops. This article explains the chemist's role in natural product evaluation. It outlines the types of apparatus used to study the major crops at present under consideration and gives descriptions of the use of the chemical and electronic equipment in a natural products laboratory.

THE terms "essential oil" and "oleo-resin" may be defined as follows:—

"Essential oil"—any group of volatile oils which give to plants their characteristic odours and are used in making perfumes and flavours. An essential oil is usually a very complex mixture of chemical compounds.

"Oleo-resin"—a natural mixture of an essential oil and a non-volatile resin. The non-volatile resin may contain important taste principles.

Examination of Plants Producing Essential Oil

Gum trees (*Eucalyptus* sp.), Ti trees (*Melaleuca* sp.), Japanese mint (*Mentha arvensis* var. *piperascens*) and Sweet Basil (*Ocimum basilicum*) are all examples of essential oil producing plants. In the first two examples the oil is produced in the leaves while in the latter examples, it is present in both leaves and flowers.

It is convenient to use Japanese mint as an example of essential oil plants as some studies have been made of this species in Papua New Guinea. With essential oil producing plants it is generally necessary to harvest at a particular stage of growth, usually related to floral development to obtain the maximum oil yield and optimum oil quality.

In the case of the mint, the most important component of the oil is menthol. The chemist must therefore analyse the plant to determine—

1. How much oil is there in the leaves of the mint plant?
2. How much menthol is there in the oil?

The percentage of essential oil in the leaves may be determined in the laboratory by a process known as steam distillation. In the apparatus used, the finely divided plant material is boiled with water and the steam produced carries the essential oil over into the cooling condenser. Here the steam is condensed to water and, as water and oil do not mix, the lighter oil floats on the surface of the water in the measuring section of the apparatus. After a certain time the distillation is stopped and the oil cooled and measured.

By distilling the plant material at various stages of growth, the chemist can construct a graph of the development of the oil in the plant with time.

The samples of oil obtained by the above process at different stages of plant growth can then be analysed to answer the second question, "How much menthol (and other components) is there in the oil?" The Gas Liquid Chromatograph is an instrument used extensively in essential oil research to obtain information about the composition of the oils. The information obtained from the apparatus is in the form of a graph which can be analysed to give information as to the type and concentration of the compounds present in the essential oil.

By analysing oils produced at different stages of plant growth, the chemist can construct a graph of menthol percentage in *Mentha arvensis* oil with time. Both the percentage oil and menthol in oil percentage may be put onto the one graph and the optimum harvest time is then readily ascertained. Such a graph construction is shown in *Figure* 1.

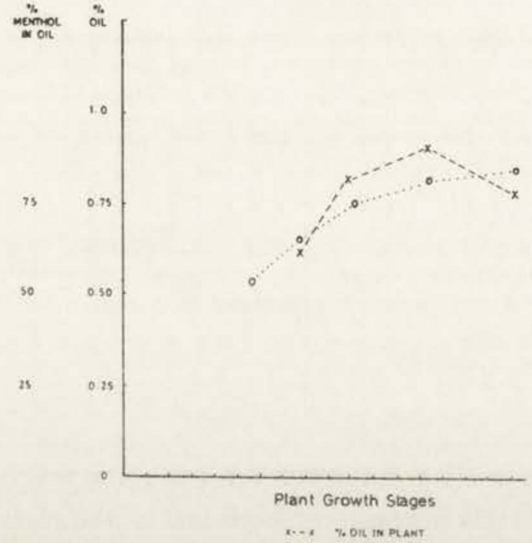

Figure 1.—Graph showing the variation of the percentage of menthol in the oil and the percentage of oil in the plant as the plant grows

In the field, essential oils are distilled from the plant on a much larger scale. A typical apparatus is shown in outline in *Figure* 2. The actual distillation time may vary considerably depending on the material being processed.

The chemical work done so far has indicated that a high quality mint oil may be obtained from the mint plants growing at the Lowlands Agricultural Experiment Station, Keravat. The amount of oil in the plants, and the amount of menthol in the oil, are both satisfactory. Agronomic trials to check on the yields per acre are now proceeding at Keravat.

Examination of Oleo-resin Producing Plants

Ginger (*Zingiber officinale*), Pepper (*Piper nigrum*), Nutmeg (*Myristica fragrans*) and Vanilla (*Vanilla tahitensis*) are species that are usually extracted by solvents. The residue remaining after the removal of the extracting solvent, by gentle heating under reduced pressure, is termed the oleo-resin. The oleo-resin is not soluble in water. Pepper, a commonly used household spice, is extracted commercially for its oleo-resin, both the quantity and composition of this extract being very important.

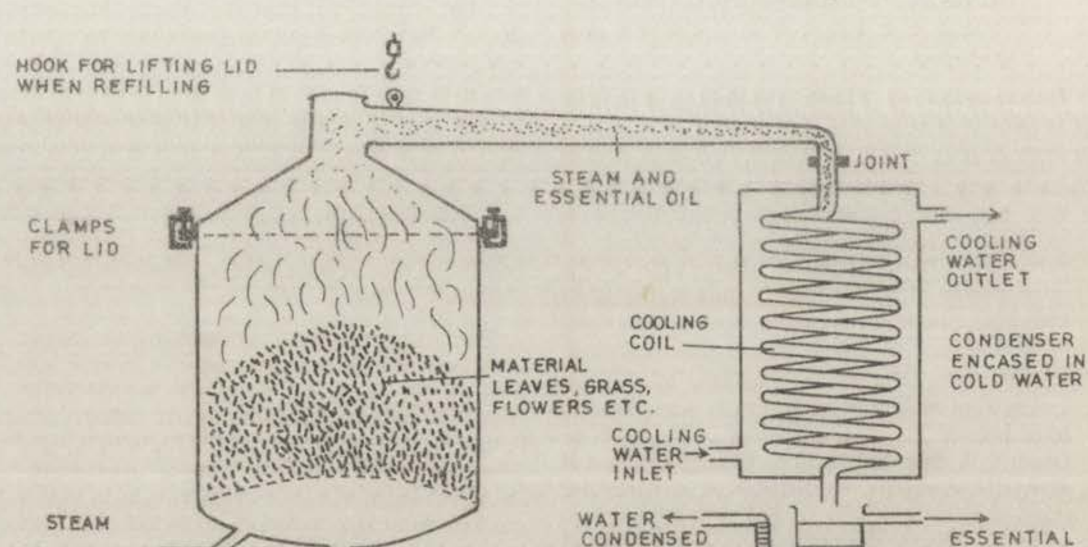

Figure 2.—Steam distillation apparatus

The laboratory apparatus used for solvent extraction studies is illustrated in *Figure* 3. The material to be extracted is finely divided and placed in compartment A, the solvent to be used for extraction is placed into the boiling flask B. On heating, solvent vapours rise through the bypass tube C and are condensed to liquid in the condenser D. The liquid percolates through the material, in the extraction compartment, removing the solvent soluble oleo-resin. The solvent oleo-resin solution automatically siphons back into the boiling flask B via siphon tube E. Only the solvent is vaporized by boiling so that the process is one of removal of oleo-resin from the material in compartment A and concentration in the boiling flask. It is then a relatively easy procedure to remove the solvent completely from the boiling flask leaving behind only the oleo-resin which can be weighed and its percentage in the original pepper calculated.

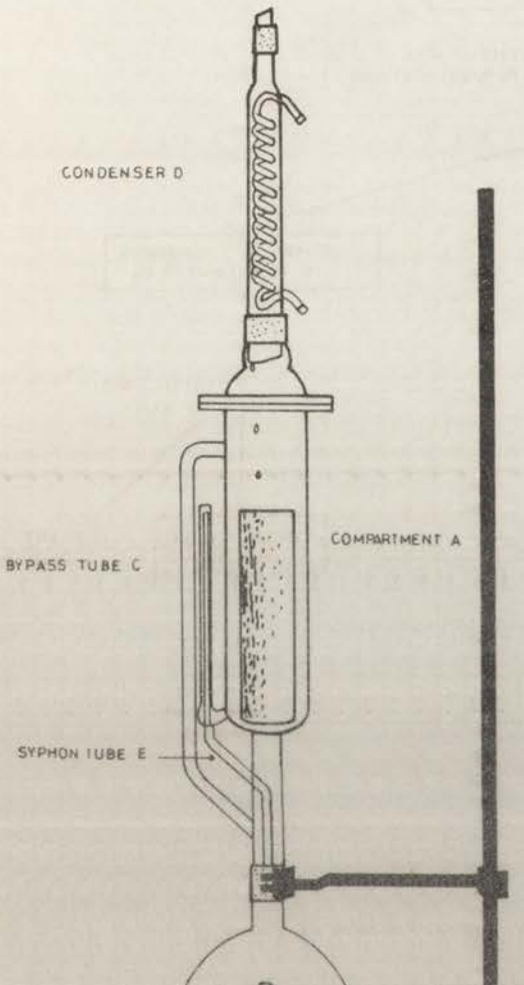

Figure 3.—The laboratory apparatus for extracting oleo-resins from plant material

An important constituent in pepper oleo-resin is piperine. This compound is responsible for the pungency or sharp flavour of pepper. The chemist analyses the oleo-resin for piperine percentage and may thus compare different varieties and different processing techniques used for pepper production.

Industrial extractions are carried out on a large scale. Despite the size of industrial extraction processes, extremely careful control of the operation is exercised to ensure the oleo-resin is not affected by excessive temperature.

Examination of Miscellaneous Samples

The procedures discussed above are all very clear cut since we are examining a known plant species.

Investigation of the usefulness of a plant species that has not been previously examined is a more complicated matter.

The number of compounds that occur in plant materials is of course very large but the compound categories which have been found to be commercially useful are fortunately much smaller.

By a procedure of extraction and examination of the extracts recovered under different conditions the chemist can fairly quickly confirm the presence or absence of certain classes of compounds in the particular plant he is confronted with. Such a scheme is illustrated by *Figure* 4. It can be seen from this diagram that a few reasonably simple extraction procedures followed by the use of chemical spot tests and colour reactions can indicate the presence of some very important classes of plant compounds. Steroids, saponins and alkaloids are important groups of drugs used in medicine. Terpenes are present in essential oils and tannins are a group of compounds used in the leather industry.

The chemist engaged in natural product research has a challenging and interesting role to play in the evaluation of many plant species. The challenge arises when new species are investigated. The interest comes when the laboratory results are applied in the agronomic handling of the crop.

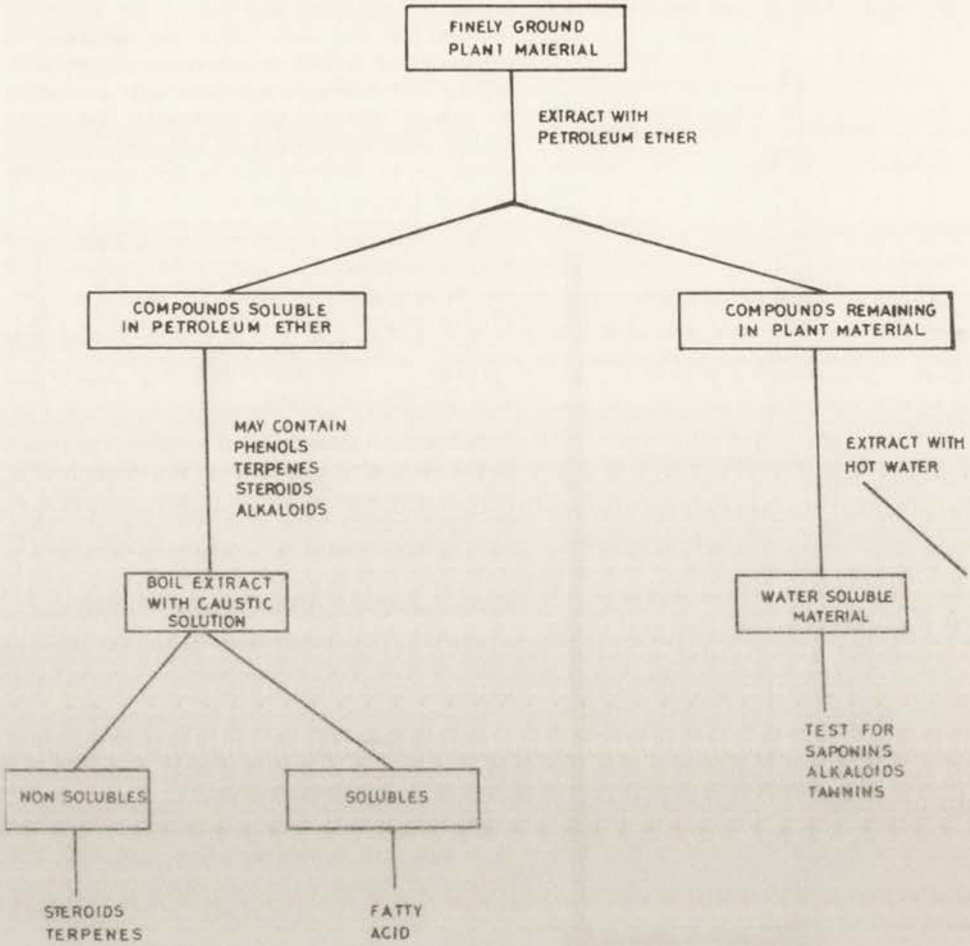

Figure 4.—Scheme for analyzing natural products in plants

The Use of Polythene Bags in the Coconut Nursery

H. GALLASCH, Agronomist,

Lowlands Agricultural Experiment Station, Keravat

Using polythene bags for seedlings in nurseries for oil palm, cocoa and coffee has been common practice for some years, but the practice has not been adopted for coconuts, presumably because the nut was considered too large. Work done by Foale in the British Solomons prompted further work at the Agricultural Station at Keravat in New Britain.

MOST of the advantages of the polybag system come from the fact that the plant can be left to develop in the bag to a much bigger size than it could be in the nursery. Transplanting is always a time of setback for the young plant and the later it is, the more serious is the setback. Growers may choose to plant out at the 2 to 4 leaf stage, to minimize this setback. Planting at a later stage means that the root system is much more fully developed and suffers greater damage on transplanting. With the bag system, the roots are not damaged at all in transplanting, as the soil surrounding the roots is transplanted as well and the plant is less disturbed.

A further advantage of planting out at a later stage lies in lower field maintenance costs. Seedlings planted out at, say, 3 months, suffer severe competition from weeds, and the Department's recommendation is therefore that the ground should be clean-weeded around the palms until they are at least 18 months old. The longer the seedling remains in the bag, the shorter will be the time it needs weeding in the field.

In many ways the delay in planting out gives better control over the young plants. If there is a dry spell, it is possible to hand-water in the nursery, but this is not practicable once the plants are out in the field. The same argument applies to the application of fertilizer. It is much less trouble to do it while the plants are still in the nursery.

If the soil on the site of the nursery is not satisfactory, soil may be obtained from any other source. Under normal nursery practice, there is always the danger of a build-up of pests and diseases in the soil. With the use of polybags, the soil is planted out with the seedling, so there is no opportunity for such a pest development. The closer proximity of the plants in the polybags in the nursery may mean that a disease, once introduced, is more easily transmitted than in the field, but it is also much easier to apply control measures if the seedlings are close together.

A further advantage of the later planting time is that a better selection of plants can be made. Under the normal nursery practice, seedlings are planted out at the 4 to 6 leaf stage so selection of seedlings must be made at that time. If final selection can be delayed until a later stage, the chance of making a better choice is increased.

The only obvious disadvantage of the polybag system is the cost of the bag, but this is more than compensated for by the reduction of labour costs for weeding. The bag must be a thick durable plastic, and because of the size of the coconut, it must be at least 15 in wide and 20 in high. Such a bag holds about 40 lb of soil, so the plastic needs to be strong. It also needs to withstand weathering in the field, so a light-weight plastic is not satisfactory. Plastic of 500 gauge is necessary. Black plastic is more durable than clear, because of its resistance to ultra-violet light.

A bag that is 15 in wide when empty is 9 in in diameter when filled with soil. It is more convenient to germinate the nut in a vertical position instead of the usual horizontal position.

Trial at Keravat

In the trial at Keravat, the treatments were—

1. Nuts horizontal, 2-leaf transplant—Normal nursery practice.
2. Nuts horizontal, 7-leaf transplant—Normal nursery practice.

Plate I.—Seedling palms about 11 months old in polybags

3. Nuts upright, 2-leaf transplant—Normal nursery practice.
4. Nuts upright, 7-leaf transplant—Normal nursery practice.
5. Nuts in small polybags transplanted at the age of $11\frac{1}{2}$ months.
6. Nuts in large polybags transplanted at the age of 14 months.

The sizes of the bags were 15 in x 20 in and 18 in x 24 in.

These treatments allowed the following comparisons to be made:—

A. Between nursery transplanted seedlings and polybag seedlings.

B. Between seedling transplants at 2-leaf and 7-leaf stages.

C. Between nuts placed horizontally and vertically.

D. Between large and small bags.

E. Between nuts transplanted and remaining in the nursery.

F. The effectiveness of seedling selection at 2-leaf and 7-leaf stage.

Results

1. Four months after transplanting the last treatment, there was no significant difference in height between any of the six treatments.

2. There was a transplanting shock suffered by seedlings at both the 2-leaf and 7-leaf stages, this being greater at the 7-leaf stage, but after 18 months there was no significant difference in development between the treatments.

3. There was no difference between nuts planted horizontally or vertically.

4. Seedlings selected at the 2-leaf stage showed a greater degree of variability in height (due to poorer selection), particularly with regard to more slowly growing plants.

This was offset, however, by the fact that transplanting at the 7-leaf stage apparently made plants more susceptible to disease and to waterlogging, resulting in more deaths after transplanting.

5. There was much greater early development of roots in the polybag nursery compared with the field nursery.

6. Small polybags were quite effective for up to $11\frac{1}{2}$ months, the larger bags being useful for a somewhat longer period.

7. Field maintenance costs were reduced by the later planting out.

Practical Details

Selected seed nuts are placed in an upright position in a pre-nursery and allowed to germinate. When the developing shoot is about 8 to 12 inches high, a selection of all the healthy and vigorous seedlings is made and these are transplanted to polybags. At this stage virtually no roots will have emerged through the husk. A further selection can be made after about 3 weeks and any reject seedlings should then be destroyed. Generally about 60 per cent of the nuts are selected for planting in the polybag nursery.

The bag is first filled with a good loam and the nut, surrounded by soil, fills the upper half of the bag. The lower half of the bag has drainage holes $\frac{1}{4}$ in in diameter and about 2 in apart. The surface of the soil should be covered with mulch to reduce loss of moisture. Even with this mulch, moisture is lost from the polybag more easily than from the normal nursery bed, so the seedlings should be watered during dry periods. Fertilizer should be added after 5 months to maintain vigorous growth. Mulch should be replaced as required and all weeds should be removed promptly.

Plate II.—Seedling palms germinated in polybags show greater development of roots, and no loss of roots during transplanting

Planting Out

When the plants are ready for transplanting at 9 to 11 months, a final selection can be made and any slow-growing seedlings rejected. A hole is dug, just large enough to take the seedling with its soil. The bottom of the bag is cut off with a knife, removing the bottom inch of soil also, with the matted roots at the bottom of the bag. The plant with its soil is then placed in the hole and the bag is slit and peeled off. Planting out should be done during overcast conditions while the soil is still damp from previous rain.

Availability of Bags

These polybags are the same as those used in oil palm nurseries. They are available from local commercial suppliers, as well as from overseas firms.

Quarantine Booklet

The last thing we want to do in Papua New Guinea is to import other people's troubles; we have enough of our own. So we don't want Foot and Mouth Disease, or Swine Fever, or Rice Blast, or Tea Blister Blight, or Blue Mould of Tobacco. We didn't want Coffee Rust either, but somehow it got in. Thanks to prompt action by DASF staff, it was eradicated before it had spead very far. It it had reached the main coffee growing areas of the highlands we would have had a major economic crisis.

Nobody deliberately intends to bring in these diseases, but it is easy to do it in all innocence. So DASF has recently issued a booklet entitled *Animal and Plant Quarantine in Papua New Guinea—A Guide for Importers*. It gives a brief outline of quarantine regulations concerning specific plants and animals, including timber, straw packing and animal products such as lard and bristles.

The booklet indicates which items may be imported without restriction, which require a permit, and which are totally prohibited. Conditions surrounding the issue of permits are given.

Copies of the booklet may be obtained from DASF offices at each district headquarters, from all DASF Quarantine Officers, and from the Collector of Customs in each port throughout Papua New Guinea. In Port Moresby copies are also available at Jackson's Airport (DASF Quarantine Officer) and at DASF Headquarters, Konedobu from the reception desk.

Compost for Subsistence Farmers, Agricultural Nurseries, Vegetable Projects and Potting Media

D. P. FRANKLIN, Regional Training Officer, Highlands Region

In many areas, the use of compost on the farm will greatly improve soil structure, soil fertility and, in consequence, crop yields. Subsistence gardens may become overcropped for a variety of reasons, and unless soil fertility is maintained at a satisfactory level, deterioration in crop yields will occur and a cycle of 'time hungry': harvest of immature gardens and replanting of old gardens takes place.

A compost heap in every subsistence garden will do much to prevent this situation.

What is 'Compost'?

Compost is the name given by gardeners for vegetable matter which has been rotted by bacterial action to form a dark brown or black, friable, peaty material. Good compost is virtually odourless, damp to the touch and falls apart in crumbs when handled.

What material to use

The basic principle is that only young, leafy plants and grasses or succulent fruit and vegetable waste, such as coffee pulp, should be selected. Diseased plant materials should not be used.

1. *Grasses*

Young Elephant grass, Guinea grass, Ischaemum, Setaria, Molasses, Para or any other leafy grass. Kunai grass and mature grasses with woody stems will not compost readily.

2. *Legumes*

Most pasture and vegetable legumes are ideal. Old pea and bean vines are good. It does not matter if some soil adheres to the roots.

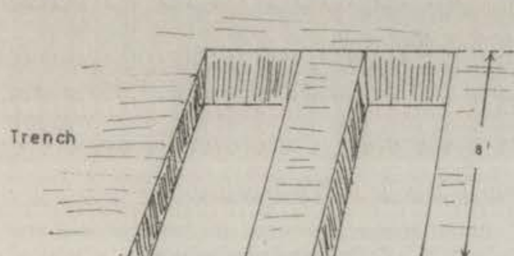

Figure 1.—Trenches for making compost

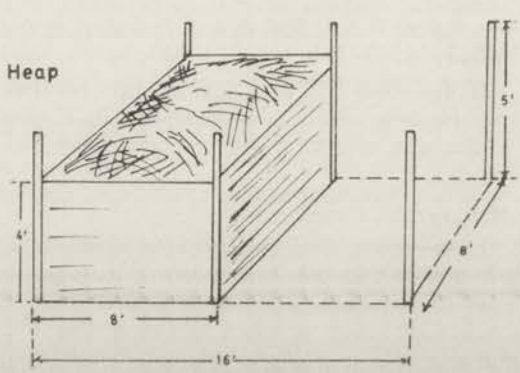

Figure 2.—Compost heap

3. *Vegetable waste*

All vegetable waste from the family kitchen—kaukau and potato peelings, cabbage leaves, carrot tops, etc., and garden residues—kaukau vine, peanut waste, etc.

4. *Fruit waste*

Citrus, papaw, banana and pineapple skins may be mixed with the above.

Method of Making

Compost can be made in two ways—

1. Below the ground in trenches (*Figure* 1).

2. Above the ground in heaps (*Figure* 2).

In areas where drainage is a problem, compost must be made in heaps above the ground.

It is essential to realize that the compost heap is not just a rubbish dump in the corner of the garden. The latter can become a breeding ground for flies, garden pests and disease.

Size of Heap or Trench

The sizes recommended for a subsistence farmer and for general use are as follows:—

Heaps: 8ft x 8ft x 4ft high
Trenches: 8ft x 2ft deep

For the best results, compost heaps or trenches should be completely filled by ten days from the start of operations.

Marking Out

For each 8ft x 8ft compost heap, mark out an area of 8ft x 16ft on level, well-drained ground. Grass, if growing, should be removed.

Six stakes, 5ft x 1½in are set at each corner where the compost heap is to be made, and later to be turned, as shown in the diagram (*Figure* 2).

If the ground is well drained, two trenches may be dug side by side as shown in *Figure* 2. An area of 10ft x 8ft is required for two trenches.

Making the Compost

Layers of composting material 6 to 8in thick are applied daily until the heap is 4ft high or until the trench is filled to 2ft above ground level. Care must be taken to ensure that the outside 'wall' is well stacked and consolidated before the centre is filled to a slightly convex shape. Failure to build the outside properly will allow heat and valuable gases to escape, thus impairing the efficiency of the composting process and lowering the plant food value of the final product.

Use of a 'Starter'

The success or failure of the heap to properly compost is related to the presence of the correct bacteria. The addition of a 'starter' will accelerate the compost process by assisting the rapid multiplication of bacteria.

Types of Starter

A. *Organic* (of animal or plant origin)

1. *Animal Manure*

For each 6 to 8in layer of plant material, spread a 1in layer of unprocessed animal manure—cow, pig or poultry (somewhat less of the latter).

2. *Animal Residue*

Apply 4oz of animal residue—meat meal, fish meal, dried blood, etc., per square yard of compost heap, i.e., approx. 1¾lb per 6in layer on an 8ft x 8ft heap.

3. *Compost*

Apply compost which has been made previously at the rate of 5lb per square yard on each 6in layer, i.e., approximately 35lb on an 8ft x 8ft heap.

4. *Nightsoil*

Apply one bucketful of nightsoil per 6in layer of plant material. It is important to spread nightsoil only to within 18 inches of the outside of the heap in order to avoid offensive smell and fly nuisance.

While nightsoil, properly composted, is pathogenically safe, it is aesthetically objectionable to many local farmers, who will refuse to eat crops grown in ground to which it has been added. This reservation does not apply where this compost is to be used in cash crop nurseries, for which it is excellent.

B. *Inorganic* (of mineral origin)

1. *Compound NPK Fertilizer*

Apply at the rate of 3oz per square yard.

2. *Sulphate of Ammonia*

Apply at the rate of 2oz per square yard.

3. *Proprietary Compost Starter*

Follow the maker's directions (e.g., Hortico No. 1.)

Notes on Starters

1. Starters must be evenly spread over the surface of each layer of the heap. Inorganic fertilizer starters must be dissolved in water at the rate of 1oz to 2 gallons of water.

2. All starters must be applied first and then covered with the day's layer of compost material.

3. The addition of lime or woodash in small quantities will assist to promote the alkaline conditions which are required in the heap.

4. If available, small quantities of fertilizer such as superphosphate, sulphate of potash, Solubor, etc., may be added and these will improve the chemical value of the compost.

Measurement of Temperature

Initial temperatures in the heap should rise to 180 deg F. A sharpened pole may be pushed into the side of the heap, and when withdrawn to check the temperature, it should not be too hot to be held in the hand.

Moisture Control

It is essential that the heap remains moist throughout the composting period and up to the time of use. If it is too dry no fermentation will take place—if it is too wet the plant material will become rotten and soluble nutrients will be leached.

In areas where rainfall exceeds 70in per annum or where heavy tropical storms are experienced, the heap should be covered with a waterproof material, e.g., plastic sheeting. Where sun temperatures are high, it may be necessary to water the outside of an uncovered heap occasionally and to provide rough shade over the heap.

Turning the Heap

One month after the heap is completed, it should be turned on to the adjacent 8ft x 8ft site (or trench). This will facilitate even fermentation. If necessary, water should be sprinkled during the turning operation. It will be found that the heap settles to a smaller size after turning. The temperature pole is then replaced in the side of the heap.

Further turning is carried out at monthly intervals until after approximately 130 days, as follows, when the compost is ready for use:—

Building the heap—10 days
First turn—30 days later
Second turn—30 days later
Third turn—30 days later
—30 days later ready for use
Total time taken—130 days

Protection from Animals

A protecting fence must be constructed round the heap or trench in order to keep out animals and poultry.

Rate of Application of Compost

Apply made compost to the garden at the rate of one bucketful per square yard. Apply two bucketfuls to each 4ft diameter kaukau mound. Make sure that the compost is dug in to a depth of 4 to 6 inches.

Benefits from the Use of Compost

The value of compost lies not in its chemical analysis, which is approximately 1 per cent N, 1 per cent K_2O, 0.5 per cent P_2O_5, but in its physical and organic properties—

1. As a soil conditioner; and
2. As a source of humus.

After compost is added to the soil, clays become less stiff and sandy soils are rendered more water-retentive. The humus content slowly breaks down to form valuable plant food. The quality and quantity of crops grown in ground to which compost has been added will be improved and soil fertility levels will have been maintained.

TOO MUCH PROTEIN IN PIG RATIONS CAN CAUSE POOR GROWTH

RECENTLY in the Highlands, a commercial pig farmer had problems with his weaned pigs which did not appear to be growing as well as they should. The pigs seemed to be well looked after and there did not appear to be any sickness in the herd, but they were still not growing as well as could be expected. It was decided that the feed rations which the farmer used could bear investigation.

Twenty-two of his pigs were divided into four groups. Two groups were kept at his piggery and two groups were brought to the DASF piggery at Goroka. One group in each place was fed on the farmer's rations and the other groups were given DASF rations. The pigs were weighed every week. At the end of the 50-day experiment it was found that the two groups which had received the DASF rations had grown more quickly than those on the farmer's rations. One reason why they grew more quickly was because they ate more of the DASF ration.

Investigation of the farmer's ration showed that he was using 23 per cent protein, while the recommended ration for weaned pigs is 18 per cent protein. It seems that the farmer's ration had too much protein in it. Since then he has reduced his protein to 18 per cent by increasing the amount of crushed sorghum in his mixture, with the result that his pigs are now growing well.

While it is known that protein is essential for growth, it is now apparent that too much protein retards as much as too little.

G. L. MALYNICZ,

Senior Veterinary Officer,

Tropical Pig Breeding and Research Centre,
Goroka.

Letters to the Editor

VASCULAR-STREAK DIEBACK OF COCOA

I would like the opportunity, through *Harvest*, of congratulating Mr Keane, Professor Flentje and Professor Lamb on the research programme which has led to the publication of their paper *Vascular-Streak Dieback of Cocoa in Papua New Guinea* (University of Papua and New Guinea, Department of Biology, Occasional Papers: No. 1). This paper records the isolation of a previously unknown fungus, *Oncobasidium theobromae*, from dieback-infected cocoa branches and reports results of experiments which indicate this fungus to be the cause of this serious cocoa disease. The identification of the causal organism is of great significance in the fight against the disease. It is very pleasing that the University team plans to continue its research programme and we look forward to further advances in dieback control.

However, I think it desirable at this time to emphasize to cocoa growers and DASF staff that, for the present, the finding does not lead to any significant change in the recommendations for dieback control but does reinforce those recommendations. The paper itself notes that the knowledge that disease may be spread by spores produced on diseased branches strengthens the existing recommendation for pruning out of infections. The fact that, under wet conditions, fungus fruitbodies on pieces of stem cut from diseased branches shed spores for up to three successive nights afterwards confirms the need to remove and destroy prunings. Confirmation that the fungus grows ahead of visible streaking in the cocoa branch also strengthens the recommendation that infected branches be pruned off 1 to 2 feet beyond the limit of internal streaking.

It is an obvious inference that, as the disease is spread by fungus spores falling onto young growth, infection might be prevented by protecting young growth with fungicide spray. However, it is unlikely that this would be practical or economic because of the constant production of new flushes of growth which would require a very high frequency of spraying to maintain a fungicide cover, especially under conditions of high rainfall. This Department has been carrying out fungicide trials for some years and has not found any significant effect of fungicide sprays on the incidence of infection. Nor have trials with systemic fungicides shown any consistent reduction in number of infections on treated trees as compared with untreated.

Recommendations

Our recommendations for dieback control therefore remain as before:

1. Inspection of seedling, young and bearing cocoa as frequently as possible by the owner or a disease team trained to locate early symptoms of infection.
2. Immediate removal and destruction of infected seedlings and resowing of any vacant positions.
3. In older cocoa, pruning off infected branches 1 *to* 2 *feet below the lowest internal streaking,* immediate removal and destruction of the prunings.

When making new plantings, dieback resistant clones or seed from resistant parents should be used. Keravat distributes rooted cuttings of 16 clones which have been selected as good producers with desirable growth habits, pod characters, etc., as well as showing lower than average levels of dieback infection in field plantings at Keravat. It is important that any planting should comprise a mixture of several clones because of the danger of individual clones proving susceptible to a new pest or disease or unfavourable conditions. It must be stressed, also, that the dieback resistant clones are not immune to the disease and growers must still follow the inspection and pruning practices described above.

G. K. GRAHAM,
A/Assistant Director Research and Surveys.

This plantation shows the benefit of applying Shell Weedkiller B80 for shade thinning.

Shade thinning made easy!

How Shell Weedkiller B80* works 6 ways as a hormone poison to save time and money on coffee plantations

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2. Shell Weedkiller B80 is better than conventional axe stumping. Less labour units are required per acre to thin the same amount of shade.

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4. Shell Weedkiller B80 lessens the risk of falling Leucaena damage in cacao as is occasioned in axe thinning. The poles may be left to rot where they stand...or removed when dry for firewood.

5. Shell Weedkiller B80 is economical. The cost for materials is in the region of 15 cents per acre depending on the amount of shade treated and the size of the shade.

6. Shell Weedkiller B80 is safe. It is non-toxic to humans and livestock...yet remains poisonous to shade trees.

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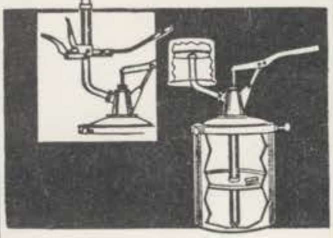

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GREASING ACCESSORIES

Snap-on small buttonhead coupler.
Snap-on giant buttonhead coupler.
Snap-on right angle coupler.
Snap-on 12" flexible hose coupler.
Snap-on 8" rigid extension tube.
Snap-on Zerk coupler.

QUART STROKE 44 GAL. DRUM PUMP

World's fastest—empties a drum in less than 3 minutes. Easy "rowing" action minimises fatigue. Any liquid up to viscosity SAE 50. 8 ft. hose. Trouble-free.

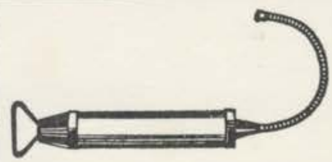
GEAR OIL PUMPS

Handy to fill sumps direct from the drum. Useful, too, for engine oil in the field. Very easy pumping.

4 or 5 gall.

12½ gall.

44 gall.



SUCTION GUN

Fill or empty sumps rapidly. One pint stroke. Flexible nozzle reaches bottom of 5 gall. pails.

ALL-PURPOSE DRUM PUMPS

Dispense kerosene, oil, disinfectant, etc., at 6 gallons per minute.

44 gall. with 6' hose, nozzle, bung opener

44 gall. with bung opener

12½ gall. with bung opener and non-drip nozzle

4 or 5 gall.

"BURNS PHILP (NEW GUINEA) LTD."