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TEI ABAL, M.H.A.

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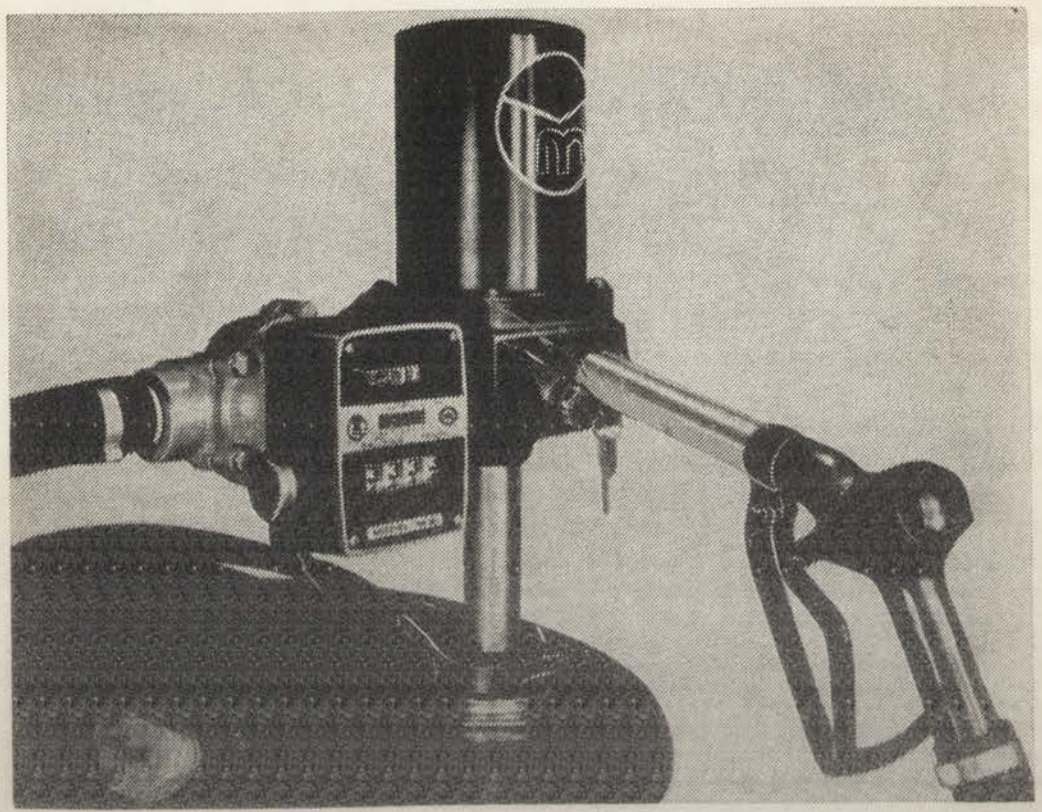

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(Photo: D.I.E.S.)

Harvest is a new part of D.A.S.F.'s extension work, aimed at assisting primary producers. More technical information, results of new research work, advice on economic aspects of primary production—these are the topics which will be covered in *Harvest.*

Primary producers in this country differ widely in their knowledge of the scientific aspects of agriculture. It is impossible to suit everybody's level of technical knowledge, and everybody's knowledge of English. The editorial policy for *Harvest* is therefore to aim at the middle—not too technical in ideas, not too complicated in language.

For those who want information at the academic level, results of research will still be published in the *Papua and New Guinea Agricultural Journal.* In the past this journal has attempted to cover both the research and the extension aspects of the Department's work. Now there will be two journals—closely linked, but separate.

I fully recognize the need for agricultural expansion in the Territory. We must find new crops, new methods to increase production and cut costs, new varieties to give better yields and better resistance to disease.

But all this will be useless if the information gained does not finally reach the people who can use it. *Harvest* is D.A.S.F.'s newest bridge across this gap.

TEI ABAL,
Ministerial Member for Agriculture, Stock and Fisheries.

Mr Alan Charles

Mr ALAN CHARLES, B.Sc. Agr. (Syd.), M.Sc. (Cantab.), Assistant Director of Research and Surveys, has left the Territory after seventeen years of service with my department. In that time, he has made a notable contribution to the agricultural development of the Territory.

In 1953, Mr Charles joined the department as Economic Botanist, a position he held until he became Chief of Division of Plant Industry after Mr Frank Henderson was appointed Director. In the administration of the division he has earned the reputation of being hardworking and decisive. He has shown that he is at home in any field of agricultural research, and under his guidance the research work of the department has expanded. Two new research stations have been opened, at Tambul and Kuk. The growth of the pyrethrum, tea and oil palm industries has been under his direction. It is mainly due to his enthusiasm and vision that the research work carried on by this department is the envy of the rest of the South Pacific area.

As a representative of the Administration in its negotiations with the World Bank and United Nations Development Programme, he has contributed to the overall expansion of agriculture in the Territory. He has exerted a strong influence on the department as a whole, and has at various times served as Acting Director.

Mr Charles' duties have required frequent attendance as Territory representative at overseas conferences, and at these he has established an international reputation for his excellent grasp of detail over a wide range of subjects. His ability to keep to the point is always appreciated.

It is not surprising, therefore, that he represented not only the Territory, but also Australia, at various conferences, notably those of the South-East Asia and Pacific Region Plant Protection Committee, the FAO Study Group on Oilseeds, Oils and Fats, and the Operations Board of the Rhinoceros Beetle Project.

Mr Charles has now joined the staff of CSIRO in Canberra. He leaves with the good wishes of all the members of my department.

TEI ABAL.

Advice on Rice

M. N. HUNTER, Agronomist, and C. S. LI, Entomologist,
Plant Industry Centre, Bubia, Morobe District

Dryland rice was grown commercially in the Markham Valley during the years 1950-1955, *but it was not successful. The climate and soil conditions were quite satisfactory, but two other problems arose. Firstly, the varieties of rice used were not suitable for the conditions, and secondly the seed used was contaminated with serious amounts of red rice (a weed rice species).*

In the past ten years, great progress has been made in the development of suitable high-yielding rice varieties for the tropics, so the agronomists at Bubia reconsidered the idea of growing dryland rice in the Markham Valley.

Varieties

TWO varieties were tried in the 1967-1968 season, Milfor (Plant Introduction No. NG6009) and B5580 (Plant Introduction No. NG6010). The results were most encouraging. Both varieties yielded well (2,800 lb grain per acre) and they both showed complete resistance to lodging (falling over at the heading stage).

Climate and Soil Conditions

The trials were then extended to other areas, with different climatic and soil conditions. Seven sites were selected in the Markham and Ramu River Valleys. The two varieties, Milfor and B5580 were planted with a sod seeder in both fertilized and unfertilized blocks. In addition, two variety trials were established testing five varieties including Milfor and B5580.

The yields obtained varied from 4,375 lb per acre on a fertilized block at Gusap to 77 lb per acre on a fertilized plot at Erap, where long dry periods delayed flowering and seriously affected yield.

Too much rain may harm rice by washing out the nutrients from the soil. Too much rain usually means too little sun, and this also will reduce the yield. Furthermore, continuous cloud cover may be associated with the occurrence of leaf spot and glume blotch.

Planting

Forty pounds of fully viable seed should be planted per acre at the onset of the wet season (December in the Markham Valley) as soon as there has been enough rain to moisten the soil thoroughly. Prior to planting, the seed should be treated with Agrosan or Ceresan as mentioned below.

Disease Caused by Fungi

Leaf spot and glume blotch caused by the fungus *Helminthosporium* may cause serious problems. The disease is transmitted with the seeds, but when it is established in a growing crop, it is spread by the wind rapidly and extensively.

Seed dressing with Agrosan or Ceresan is recommended and thorough mixing is needed so that the seed is well covered with the fungicide. A concrete mixer would achieve the best mixing.

Weed Control

The first weed control trial showed that propanil (Stam F34) would be suitable. It is important to notice, however, that propanil must be applied while the weeds are still young (within three weeks of planting). As the weeds get bigger and stronger, propanil is less effective.

Insect Control

Although 33 species of rice insect pests have been recorded in the Markham Valley, the main pest is the Rice Bug (*Leptocorisa* spp.) which damages the rice by sucking the milky juice of developing grains, thus preventing grain formation. The adults live for 24 to 120 days. They breed all year round and seven or eight overlapping generations may be expected per year. Recommendations for *Leptocorisa* control must at present be based on

Plate I.—Experimental rice block at Gusap with variety B 55880 on the right and Milfor on the left. Yields from the small plots harvested in B 5580 were equivalent to 4,300 lb of paddy rice to the acre

overseas results. Application of carbaryl or lindane (1 lb of active ingredient per acre) is recommended.

Purple Stem-Borer (*Sesamia inferens*) is another serious pest. This borer also breeds all the year round, and a new generation is produced about every eight weeks. Control measures are crop rotation, stubble destruction and application of diazinon granules. Recommended rate of application is 1 lb active ingredient per acre every three weeks during the rice growing stage.

Rice Leaf Rollers and Rice Leafhoppers are also serious pests in the Markham Valley. Control is achieved by eradication of wild grasses in the vicinity of the crop and the application of carbaryl or diazinon (1 lb active ingredient per acre).

Harvesting

Under ideal conditions B5580 will be ready to harvest 110 days from planting, while Milfor may take another 20 to 30 days to mature.

Although the grain in these varieties is held firmly on the head, it is better to harvest earlier than later. Owing to expansion and contraction pressures that are set up in the grain following rain, the longer it stays on the stalk after maturity the greater is the possibility of grain crack (or suncheck) occurring. Such cracking gives a sample that breaks easily in the milling stage and so is down-graded in quality.

Overseas recommendations are to harvest rice at a moisture content of 18 to 22 per cent (measured with a moisture meter). It should then be dried slowly (three days) with a blower system. Rapid drying (three hours) leads to cracking of the grain, so is to be avoided.

A moisture content of 13.5 per cent is ideal for milling purposes, but at levels of 13 per cent and below, there seems to be less insect activity and less chance of the development of mustiness in the grain due to fungal growth.

On a village scale it would probably be advisable to harvest at 17 per cent and sun-dry to 13 to 14 per cent before storage.

In a mechanised industry, rice is harvested with a header which cuts, threshes and winnows the grain before augering it into a truck

Plate II.—Bad lodging following heavy rain in a crop of E 1 at the flowering stage. The melon in the foreground is resting on the ground

which transports the rice to the storage shed. Machines used for this operation vary in price from $1600 to $16,000; naturally the capability of the machine varies with the price.

Milling Qualities

Samples of all varieties of rice grown were sent to the Administration rice mill at Madang.

Percentages of brown rice recovered ranged from 66 to 78 per cent with an average for all varieties of 72 per cent. White rice ranged from 62 per cent to 70 per cent with an average for all varieties of 65 per cent.

On the whole, the hulling process was quite satisfactory as there was no grain breakage for any variety. Grain breakage did occur in the pearling operation, especially in IR8.

Acceptability Trials

Acceptability trials were conducted at Igam Barracks near Lae. The soldiers were given small samples of nine different varieties of brown rice, cooked in the usual way (small water volume). The consensus of opinion was that the newly introduced varieties were neither better nor worse than the rice bought at a local store.

Plate III.—Helminthosporium leaf spotting on leaves of IR 8 rice variety

Crocodiles

M. C. DOWNES, Animal Ecologist

The Wildlife Ecology Section was formed in January 1968 when Mr Max Downes was appointed first Animal Ecologist. The Wildlife Laboratory is at 8-Mile, Port Moresby (next to the Moitaka Cattle Station) and there are subsidiary field stations for crocodile research at Lake Murray and for deer research at Wando. Both of these research stations are in the Western District of Papua.

The Section is concerned with all forms of wildlife, though its activities are at present focused on two main items—crocodiles and deer.

IN recent years there has been a serious decline in the income obtained from the sale of crocodile skins in Papua and New Guinea. Although there were more people than ever hunting crocodiles, the total sales dropped from $1,000,000 in 1965-1966 to $500,000 two years later. The growth of young crocodiles was just not keeping pace with the slaughter.

For many people in Papua, this meant that their major source of income was vanishing. The request to the House of Assembly to do something about the situation came from the crocodile hunters themselves.

The House asked the Wildlife Ecology Section to study the problem and suggest what sort of law would best help the crocodile hunters. After a lot of work, the Section came to the conclusion that the best way to increase the crocodile population would be to reduce the heavy killing of the breeding crocodiles. If many more of these could be saved, they would breed each year and produce more young crocodiles.

The House of Assembly accepted this recommendation and passed a law forbidding the sale of large crocodiles (exceeding 20 in. width which corresponds to a length of 8 to 9 ft). The law does not say that big crocodiles must not be killed; it says that the skins of big crocodiles must not be sold. The control of the situation, therefore, revolves around the traders as much as the hunters, and those engaged in these activities must have a licence to do so, whether they are hunters, buyers, buyers' agents, or exporters. Details of licences are given at the end of this article. This law does not apply in the East and West Sepik and Madang Districts, but it is an offence to send skins over 20 in. in width from other parts of the Territory into these districts.

Many people are puzzled by the fact that it is the big crocodiles, not the small ones, which are protected. A female salt water crocodile may be as much as 15 years old before she starts to look after the eggs she lays. She lays about 30 to 60 eggs per year. Not many of these eggs ever develop into adult crocodiles. Throughout the fifteen years, natural enemies as well as crocodile hunters prevent the crocodile population increasing. And when at last crocodiles do reach adulthood and start to breed, they are just the size the hunters want.

In other words, most young crocodiles are going to die before they reach breeding age anyway, whether hunters kill them or not. Birds like eating crocodile eggs, and wild pigs and big crocodiles like eating young crocodiles. But when the crocodile reaches adult size and it is contributing to the future crocodile population, then its chief enemy is man. So laws were needed to protect the crocodiles.

For some people, crocodiles are killed for food and for traditional purposes. It is not intended to prevent these practices, so the laws concentrate on the sale of skins, not on the killing of the reptiles.

The inevitable effect of the law is to reduce the income of hunters and traders, but this is only a temporary setback. There are two other alternatives: either a complete ban on hunting for 5 to 10 years to restore the population balance, or no ban at all, resulting in practically all crocodiles disappearing within five years.

Crocodile Farming

To many people it seems that the solution to the problem of dwindling crocodile population is "crocodile farming". It seems easy enough. Just catch some adult crocodiles and keep them in ponds—with a good fence around to stop the crocodiles getting out or any crocodile enemies getting in. In due course they will produce eggs and these can be looked after so carefully that practically all of them, instead of just a few, reach adulthood and they themselves start to breed. Sell as many as you can and make your fortune.

It sounds easy—but is it? Instead of finding their own food, these crocodiles would have to be fed. Fences would have to be very strong, and staff would be needed to feed the animals, check the supply of water to the pens and maintain the fences. There is not enough evidence yet to say whether this would be a paying proposition, but experience overseas suggests that it would not be. Even starting with eggs found in nests in the swamps is not at all hopeful.

The best commercial proposition seems to be the rearing of small crocodiles 12 to 18 in. in length captured in the wild and kept in small enclosed ponds until they are big enough to sell. This would take two or three years. Such animals would still need daily attention, and a cheap source of protein food would be needed to ensure good growth. Fish, prawn heads, or abattoir offal would be suitable food.

It is debatable whether this kind of farming would be an economic proposition but the Gauwi Local Government Council in the East Sepik District is experimenting. Pens have been constructed at Pagwi and some crocodiles have been installed.

Plate I.—Young crocodiles in pens being fed pieces of shark (Photo: D.I.E.S.)

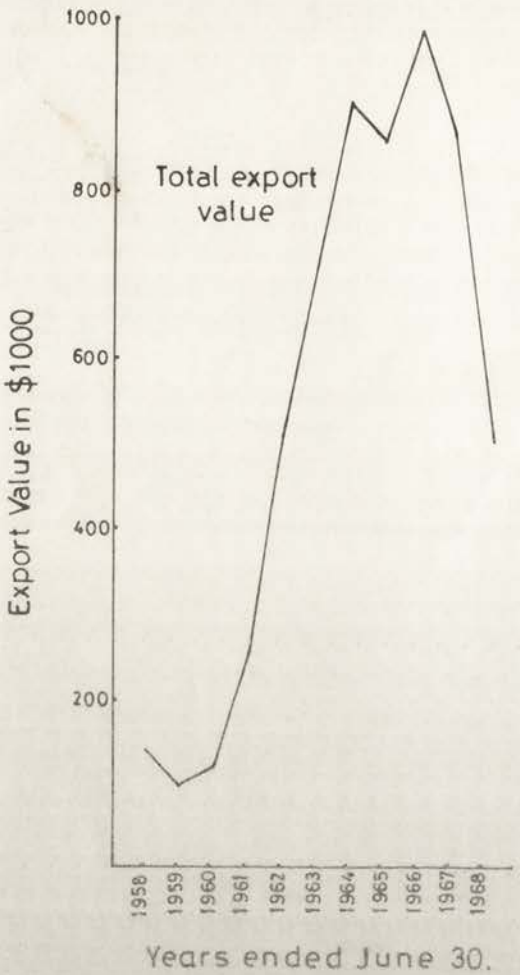


Figure 1.—Value of crocodile skins exported from the Territory of Papua and New Guinea 1958-1968

The construction and maintenance of the pens is very simple. The fences are made of native materials, 3 ft high with a 1 ft horizontal overhang on the inside to prevent small crocodiles climbing out. The pen area is about 20 ft x 25 ft and is half in shade and half in sun. The pond water is about 10 ft x 10 ft and 1 ft deep. The pond should be filled up daily and emptied and cleaned out each month.

Only crocodiles about the same size should be kept in the same pen. Crocodiles more than one foot different in size should be housed separately with animals the same size. The number which can be accommodated in any pen depends on the care with which the water is changed and the way they are fed.

The Gauwi Local Government Council is to be commended for its enterprise in initiating this experimental work.

Crocodile Hunter's Licence

1. A Crocodile Hunter's Licence costing $5 per year is required to hunt crocodiles for selling skins as a business.
2. Persons who have lived more than seven years in the Territory do not require a Crocodile Hunter's Licence.
3. Only persons who have lived more than two years in the Territory are allowed to hunt crocodiles for selling skins as a business. "Hunting" includes any method of catching such as shooting, netting or hooking.

Crocodile Buyer's Licence

1. Every person who buys crocodiles or crocodile skins must possess a Crocodile Buyer's Licence costing $10 per year. The buyer must have lived more than two years in the Territory to obtain a licence.
2. The crocodile buyer must keep a record of crocodile skins bought, giving details of the size and the kind of skin (freshwater or saltwater). Every three months he must send this information to the Department of Agriculture, Stock and Fisheries. For this he must fill in a special form obtainable from the District Rural Development Office.
3. The crocodile buyer must never have in his possession any crocodile skins which are bigger than 20 in. in width. This applies to all of the Territory of Papua and New Guinea except the East and West Sepik and Madang Districts.
4. A person who buys crocodile skins on behalf of someone else must have his own personal Buyer's Licence.

Crocodile Exporter's Licence

1. Persons who export crocodile skins must have a Crocodile Exporter's Licence costing $100 per year.
2. A permit to export crocodile skins showing the size of each skin in the consignment must be obtained from the Department of Agriculture, Stock and Fisheries before crocodile skins can be exported.
3. If an exporter or his agent personally buys skins within the Territory he must also have a Crocodile Buyer's Licence.
4. A crocodile exporter or his agent must not have in his possession any skin greater than 20 in. in width except in the East and West Sepik and Madang Districts.

Exempt Districts

These laws do not apply to crocodiles caught in the East Sepik, West Sepik and Madang Districts, where crocodiles exceeding 20 in. in width may be sold and exported. BUT skins must not be transported from other parts of the Territory into these districts.

Plate II.—Pens may be constructed of timber and wire, or bush materials. The overhang prevents the crocodiles escaping

New Coffee Varieties

There are many different kinds (races) of coffee rust, and no one type of coffee is resistant to all the coffee rust races. It is desirable to have growing in the Territory many different types of coffee with resistance to difference races of rust. So back in 1961 *the Department started to import seed of various types of rust-resistant coffee. These varieties have since been grown to obtain sufficient seed for agronomic trials. These trials will study such characteristics as yield and adaptability to soil, climate and management techniques.*

IT is not known, of course, what race will be present if an outbreak of coffee rust does occur here at some future date, but these importations mean that some material resistant to that race may be available, unless a completely new rust race occurs.

The first agronomic trial was started in 1968, using a total of 17 different varieties. These varieties originated from India, Tanzania and Ethiopia, but were obtained from the United States Department of Agriculture or from Portugal, which is one of the foremost countries in research on coffee rust. Four dwarf varieties of considerable commercial interest obtained from U.S.A. were also included in the trial, and several varieties established already in the Territory were added for comparison.

All varieties are being fertilized on a "little and often" basis of 2 oz of complete fertilizer each 2 months until they are well established in bearing.

Two pruning systems have been applied to all the varieties:—

(*a*) Agobiada pruning with four leaders;

(*b*) Growth as unpruned single stem bushes for a number of years, then conversion to multiple stem by stumping.

Plate I.—Caturra Dwarf variety showing heavy bearing

Temporary shade was initially provided by *Crotalaria,* but was removed after 18 months and the trial is now unshaded.

It is too early yet to have any reliable information on yields.

The performance of the dwarf varieties will be followed with particular interest. There are three varieties, Caturra (red fruit), Caturra Amarello (yellow fruit) and Mundo Novo (yellow fruit). Information from overseas indicates that they will all be high-yielding at close spacing. As the bushes are still growing, it is difficult to decide yet just how "dwarf" they are going to be, but one difference between these varieties and conventional varieties is already quite apparent. The primary and secondary lateral branches grow much closer together, so that the whole bush is quite compact. Those that have started bearing are bearing heavily (see photo).

Some of these varieties are also being tested at Goroka and Korn Farm (near Mount Hagen).

A further seven varieties with resistance to some rust races were obtained from the same sources. These varieties originated in Kenya, Tanzania, Ethiopia and India. They arrived too late for the first trial, so they will be included in a second trial now being established at Aiyura, with Arusha and Bourbon standards for comparison.

Results of these agronomic trials will be reported as soon as possible.

Invitation to Authors

ARTICLES may be submitted for publication by authors within and outside the Department of Agriculture, Stock and Fisheries. Manuscripts should be typed with double-spacing, on one side of the paper only. There is no minimum length for articles, but authors should aim at a length of 1,500 to 2,000 words (roughly six pages of foolscap, double-spaced typing). Articles exceeding eight pages will probably be heavily pruned, or will be returned to the author for rewriting.

Photographs and diagrams should be included where applicable. Black and white photographs should be 6 in. x 8 in. in size, with a glossy finish. Negatives will be accepted if prints cannot be obtained. If black and white photos are not available, coloured slides may be submitted to see if black and white prints can be made from them.

The level of language used should be standard English with a minimum of technical terms. Technical words may be used, but should be explained the first time they are mentioned.

The purpose of *Harvest* is to pass on technical information of practical value to the primary producer, and all articles should be written with this end in view. All the activities of D.A.S.F. are suitable subjects for articles.

All articles are submitted to the Editorial Committee for approval before publishing. The Committee consists of the three Assistant Directors and the Chief Agricultural Economist. The Committee may request another officer to check the accuracy of the information given.

Fifteen Years of Fertilizer Trials in Coconuts, Cocoa and Coffee

Arthur E. CHARLES

This paper was presented by Mr A. E. Charles, Chief Agronomist, at the ANZAAS Congress, Port Moresby, in August, 1970. Mr Charles emphasized that he was reviewing the work of a large number of officers of the Department of Agriculture, Stock and Fisheries.

THE programme for fertilizer trials by the Department of Agriculture in Papua and New Guinea was started in the mid-fifties by the late Mr Frank Henderson with a firm direction that the purpose was economic. It was not enough to demonstrate that crop plants would respond to fertilizer; the trials had to show that the use of fertilizers would bring increased profits. This provision demanded a fair standard of precision in trials, sufficient size for reliable estimation of per acre yields, and siting of trials on areas representative of extensive plantings of the crop. On several occasions, field trials have been preceded by extensive surveys aimed at identifying problems and selecting suitable sites. The programme began at a time when the Department's chemical services were in their infancy and early trials were diagnostic : they aimed to show whether all the major and minor nutrients were adequately supplied. More detailed studies followed to learn more of the quantities of additional nutrients needed. Nowadays most of our field trials study rates and methods of application of a few nutrients already identified as deficient, either in earlier field trials or by soil and foliar analysis.

Trials in coconuts, cocoa and coffee present a number of problems not shared by trials in temperate crops. One of the greatest problems is yield recording. The temperate zone agronomist can usually get his yield recording over in a period of a few weeks or make a yield estimate at a single inspection of a tree. Coconuts, however, produce all the year round—a new fruit bunch ripens approximately once a month on each palm. Our records are generally based on estimates of nut numbers made by inspection with binoculars twice a year. This permits us to place trials on properties where problems occur, without our having to ask the managers to keep yield records which are more detailed than they require themselves. Cocoa crops mature in "flushes" but some pods are harvested throughout the year, and timing of flushes is somewhat variable. We have found no alternative to recording yields at each of 12 to 15 harvests per year, which means it is impractical to do much work outside our own experiment stations. Coffee likewise produces some crop all the year round: although there is usually one main flush producing 75 per cent of annual yield, this may be spread over a period as long as six months. We have to record yields over 10 to 12 harvests per year and have had to restrict trials to our own stations. The number of recordings forces the agronomist to rely heavily on field workers and also generates a heavy load of arithmetic. These factors severely restrict the number of trials to be handled.

A second problem lies in the area occupied by field trials. Genetic variability is high, so one cannot work with fewer than 30 to 50 trees per treatment. Coconuts are mostly planted at 56 per acre; a 16 tree plot with a single guard row therefore occupies two thirds of an acre and the simplest trial covers 10 acres. Within this area variability may be formidable. Cocoa presents similar problems on a reduced scale, being planted at 220 to 350 trees per acre. Coffee, at 600 to 1,200 trees per acre, does not have this problem, but it has others. For example, coffee is unusually sensitive to impeded drainage; even minor variations in drainage can cause big differences in yield. To ensure that different treatment responses are not just due to chance, each treatment in a coffee trial has to be repeated more times than with most crops.

Temperate zone workers no doubt think of tropical plant growth as exceptionally fast, yet some tropical crops are depressingly slow. The

coconut takes 6 to 7 years to start bearing; its fruit takes 12 months from pollination to maturity. Coffee cherries take 9 to 10 months to mature and cocoa pods 5 to 6 months. Thus yield responses tend to be slow. The effect of a fertilizer application may not appear until more than eighteen months later.

As in other perennial crops, biennial bearing can be a problem. Coconut is not particularly prone to this and cocoa less so than many temperate orchard crops. Coffee shows full biennial tendencies and in some situations yield in one year may be two to three times as great as in the succeeding year. In coffee trials at Aiyura, we have coffee on drained swamp soil showing marked biennialism while nearby coffee of similar age and treatment but on a different soil shows no such pattern. One or two of our trials have been complicated by certain plots getting out of phase with others, so that treatment contrasts may reverse in alternate years. Coffee sometimes bears so heavily in the peak year that the tree loses its leaves at the end of the cropping season. Usually it stages a remarkable recovery and, after a year's rest, bounces back for another massive yield; but should unfavourable conditions follow the defoliation, the trees may die, playing havoc with field trial analyses.

Those are some of the problems. Some of them can be overcome by mathematical analysis, comparing yields before and after treatment.

Coconuts

Coconut fertilizer trials began in 1955 in New Ireland where large acreages showed severely declining yields, while appreciable areas had been abandoned. A soil survey showed that almost all palms were on coral-derived clayloam soils, with the decline most evident on older, acid, generally deep, yellow-brown soils. Younger, neutral, generally shallow red-brown soils with free coral in the profile usually supported healthy productive palms. Following a survey by an agronomist, comprehensive diagnostic trials were put down on both soil types. The trial on the older soils demonstrated a response to potassium with an increased copra yield giving a profitable, though not exciting, return. The trial failed to show appreciable response to any other nutrient and the trial on the younger soils did not demonstrate response to any nutrient. Yield response was not evident till the second year after fertilizing and did not reach a maximum until the third year. Subsequent detailed trials with potash have shown better response from broadcasting fertilizer over a larger area rather than a small ring round each palm; as good or better response from two-yearly rather than annual application; increase in nut size as well as nut number; marked growth response in young seedlings; and better response (on at least some sites) to potassium sulphate than potassium chloride. In all trials pretreatment yield records were made and proved very useful in reducing error variance. Most New Ireland plantations are now using potash as a standard practice.

A survey of Papuan plantations in 1956 showed the most important soils to be base saturated alluvial loams and black sands. A trial on a loam gave an indication of potash response but not at an economic level. A more recent trial on a site where leaf analyses showed very low potassium levels has given an economic response. A trial on a black sand where palms were yellow produced the rather odd result of no response attributable to any individual nutrient but a notable improvement in colour of all palms in the fertilizer trial block. This may have been due to poaching between treatments but more probably was a sulphur response, as most fertilizers were sulphates and subsequent experience confirms that the yellowing was typical of sulphur deficiency.

The above trials confirmed economic responses to potash, known from overseas work to be a vital nutrient for coconuts. Pioneer work by our chemists has shown widespread incidence of sulphur deficiency in Papua and New Guinea. Replicated trials on seedling coconuts in pumice soils in the Rabaul area have shown major growth response to sulphur and especially to sulphur plus nitrogen, while urea on its own proved virtually lethal. Recent trials on palms on high pH alluvials in the Markham Valley have shown yield response to nitrogen plus sulphur, but it has not yet been clearly established that the responses are economic.

Cocoa

A comprehensive trial on cocoa under standard Leucaena shade at our cocoa station, Keravat, in 1955, produced evidence only of slight response to nitrogen. About that time, results were coming in from overseas showing that much greater fertilizer responses could be

expected in unshaded cocoa; and local trials were showing that shade removal gave increased yields without serious tree deterioration. Our subsequent fertilizer work has been either based on unshaded or lightly shaded cocoa or has specifically studied shade/nitrogen interactions. Trials in New Britain have shown major and very profitable response to nitrogen on unshaded cocoa but little response under standard shade. The need for nitrogen is recognized by growers and its use is standard in most areas. A trial on cocoa growing under coconuts on a pumice soil has shown much greater response to four applications per year (F4) than to two (F2); yields in 1969 to ratios of 1 and 4 lb urea per tree were in the following proportions:—

Control	100
N1F2	135
N4F2	150
N1F4	172
N4F4	187

Response to nitrogen, at least in the early stages, has shown up almost entirely as an increase in pod production about six months after fertilizer application. In the first year, using a low rate of nitrogen, the response was clearly present but quite ephemeral. It was several years before fertilized trees showed consistently better yield than controls and even after ten years the main effect of six-monthly fertilizer application comes in the seasonal flushes, with yield falling back near control levels in the intervals between flushes. However, three-monthly fertilizer has given yield increases remaining more consistently above control levels. It appears that the cocoa tree tailors the size of its flush crops to the amount of nitrogen available.

Most of our cocoa trials have been with nitrogen. In the trial for which results are quoted above, superphosphate was included as a factor for several years but no response was obtained. In New Ireland, cocoa interplanted in a coconut trial block showed a growth response to potassium but yields were not recorded.

Coffee

Because coffee yields more than cocoa (up to 1 ton dry beans per acre compared with seldom more than half a ton for cocoa) it tends to exhaust the soil more rapidly, while its high value ($750 per ton) makes the economics of fertilizing very much more favourable than for coconuts. Many growers use rates as high as ½ ton compound fertilizer per acre per year.

Coffee is grown on a variety of soil types and as it has not been possible to put in trials off our stations, our approach has been to demonstrate the levels of yield increase likely to be obtained and to use our station trials to provide information on the nutrient content of leaves associated with deficiency and response. We have demonstrated yield increases of as much as 100 per cent with nitrogen and potash, even on shaded coffee. In one trial response to muriate of potash has increased at rates up to 4 cwt per acre, while in unshaded coffee we have response to nitrogen increasing proportionately up to 4 cwt per acre of sulphate of ammonia, indicating that the optimum could be appreciably higher. Like cocoa, coffee tends to yield more and respond more to fertilizer in the absence of shade and our only demonstration of phosphorus response (and that quite small) has been on unshaded coffee. An interesting feature of the trial concerned has been that the fertilizing has induced biennial bearing and fertilized plots give all their response in alternate years with sometimes lower yield than controls in the "off" year. This no doubt indicates some other limiting factor, very likely moisture, although possibly boron or zinc. Recent trials, which have not run long enough to give clear yield trends, show visual response to soil applied borax and a small early yield increase; and an early yield increase with magnesium on plots which have been fertilized with potash for many years. A zinc sulphate spray treatment in a trial at Aiyura showed a dramatic yield decline to one third of the yield of unsprayed plots. The spray apparently caused fruit shedding, possibly because it had not been neutralized. A surprising feature was that foliage was not injured and there was a definite amelioration of deficiency symptoms on treated trees. As in other crops, sulphur deficiency appears to be very patchy in incidence—one tree may die from it while a tree 30 ft away remains healthy and productive. This makes demonstration of sulphur response difficult, but strong indications of response in more than one trial, coupled with chemical evidence, leave no doubt that there have been genuine yield increases due to sulphur.

Cardamom

G. St. J. BREAY,

Western Highlands District

In the search for new crops for Papua and New Guinea, considerable attention has been given to the spice crops. One such crop is cardamom, which grows very satisfactorily in the altitude range of 2,000 *to* 3,500 *ft above sea-level. A rainfall of* 100 *to* 125 *in. per year is required and a temperature bewteen* 56° *and* 80°*F.*

AS a cash crop, cardamom has the great advantage that little processing needs to be done before marketing. The seeds are not removed from the pod. The whole pod is dried in a dark curing house or kiln so that the green colour of the pod is retained. The first crop (admittedly a small one) is obtained only 18 months after planting out, and three years after the nursery is first established. Weeding is necessary in the first year only, so this does not add to regular production costs. The nursery work needs careful management however, and skill is required to decide when the pods are ripe for picking.

The true cardamom of commerce (*Elettaria cardamomum* Maton) belongs to the same family as ginger, Zingiberaceae, and it looks like ginger, with thick clumps of stems bearing large leaves which grow to a height of 8 to 10 ft. As with ginger, the stems multiply from a

(Photo: D.I.E.S.)

Plate I.—Cardamon in first nursery ready for transplanting to second nursery

Plate II.—Cardamon in second nursery ready for planting out (Photo: D.I.E.S.)

thick underground bulb (known technically as a rhizome). The flowering stems or panicles grow separately from the rhizome and are 2 to 4 ft long. The flowers appear on a short secondary panicle off the main panicle. The egg-shaped capsules or pods which form after flowering contain from 15 to 20 highly flavoured or aromatic black seeds. An aromatic oil can be extracted from the seeds.

The two main Indian varieties of cardamom are known as Mysore, with erect growing panicles, and the Malabar variety with panicles which creep along the ground. There is also the Ceylon variety with erect panicles. The Ceylon variety is larger than the Indian varieties and it will grow at lower elevations.

The Indian varieties grow best at an altitude range between 2,500 and 4,000 ft above sea-level. Cardamoms will grow at a higher elevation than 4,000 ft but they take longer to come into bearing.

Soils

Cardamoms grow best on reasonably flat land with good drainage. The soil should be rich in humus. Stiff clay soils are unsuitable. Banks of streams sheltered from high winds are also suitable for the crop. Exposed ridges should be avoided.

Propagation

Cardamoms can be cultivated both by splits and seeds. Growth from splits is more rapid and selection from high yielding clumps is possible. Seed is used when splits are not obtainable and when a large and rapid expansion of an area is required.

Nursery

Seed beds require careful preparation. The soil to a depth of 3 inches should be heat-treated to destroy all insects and seeds of weeds. The soil, if possible, should contain

2/3rd leaf mould and 1/3rd sand. Beds are made 3½ ft wide and raised about 1 ft above ground.

In New Guinea where regular rain showers are experienced, dark overhead rain-proof shade should be erected about 3 to 4 ft over the germinating beds and the beds should be lightly watered regularly. The surface soil should be kept slightly damp. Excessive rain or hand-watering will cause erosion of the soil and the seeds will be washed away. The edge of the seed beds should be sprayed or dusted with an insecticide to prevent ants taking away the seeds. Two per cent Chlordane (1 fluid oz of 80 per cent concentrate in 2 pints of water) is suggested for this. The seed is spread evenly over the bed, and soil or sand to a depth of ¼ in. is spread over the seed. The top soil should be firmed with the palm of the hand after sowing the seed.

Depending on the air and soil temperature, seed can take from 36 days to 6 months to germinate. There are about 50,000 seeds to a pound and a 30 per cent germination can be considered satisfactory.

(Photo: D.I.E.S.)

Plate III.—The first flower-head emerges from the ground 2 to 2½ years after germination, when the plant is about 6 ft high

Seedlings can be transplanted if they are removed with care from the germinating bed when two pairs of leaves have formed or when the seedlings are 3 in. high.

First Nursery Transplant

The nursery beds should be 4½ ft in width. At least the top 2 to 3 in. of soil should be rich in humus. Seedlings should be transplanted 6 x 6 in. apart. Overhead shade must be erected over the beds at a height of about 5 ft from the ground. The top shade should permit rain water to percolate through to the beds. About 30 per cent sunlight only should be allowed to penetrate through the top shade.

Seedlings must not be planted deep in the soil. The surface soil must be covered with leaves, grass, or sawdust after the seedlings have been planted so that soil does not creep up the stems of the seedlings and cause them to "damp off" (rot at the base).

Secondary Nursery

The beds are prepared in the same way as the first nursery. When the plants are 9 in. high in the first nursery, every alternate plant may be removed and planted in the second nursery at a spacing of 1 ft x 1 ft. When the plants in the first and second nurseries are 2 ft high, they may be transferred to a permanent position in the plantation, provided the plantation is in an area which receives regular rain showers. If rainfall is restricted to seasons, the plants should remain in the second nursery until they are 2½ ft high.

Permanent Planting

Cardamoms may be spaced at a distance of 7 to 10 ft apart depending on the type of soil and depth of humus. The greater the depth of humus the closer can be the planting.

Prior to planting, holes 18 in. x 18 in. x 9 in. deep must be dug. It is preferable to leave the holes open for at least three weeks. The excavated soil should be returned to the holes, and compost or well-rotted manure added to the soil, if available. Additional soil from the top side of the hole may be scraped into the hole. One or two seedlings, or one large rhizome, may be planted in the centre of the hole. Care should be taken not to plant the seedlings or rhizomes too deep in the soil. Plants more than 1½ ft high should be tied

(Photo: D.I.E.S.)

Plate IV.—A close-up of the same flower-head as in *Plate* III.

to a stake. The surface soil around the plants should be covered with leaves to avoid soil erosion and provide additional plant food.

Field Preparation

(*a*) *Draining.* This is not necessary unless it is noticed that water remains on the surface after rain. Drains 2 ft deep will be sufficient to allow the water to run off.

(*b*) *Shade.* Cardamoms grow best under virgin jungle shade with a touching canopy of trees at least 30 ft high. Low shade trees, such as *Leucaena,* or *Erythrina,* are inadequate for cardamoms. All that is required in virgin jungle is to clear the undergrowth and excessive small trees, leaving the large top canopy of trees.

(*c*) *Weeding.* In the first year after planting, the area should be kept free of weeds. Very little weeding is necessary from the second year onwards. A single rhizome will produce as many as twenty stems or more. These stems gradually die and are replaced by new ones. Some removal of dry leaves from the clumps is necessary from the second year onwards.

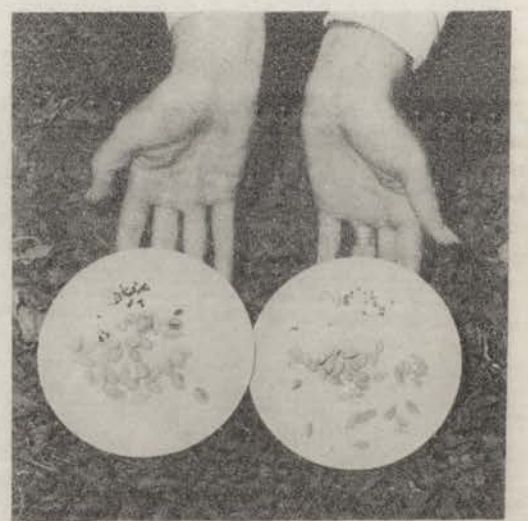
Cropping

The first crop is produced in about one and a half years after planting out, or about three years from seed. The first crop is generally a small one, followed in the second year by a large crop. Thereafter, the crop fluctuates according to weather conditions during the year. Replanting is desirable after 12 years.

Cardamoms require light showery weather for good growth. Periods of ten days without rain during the cropping months will help to hasten ripening. Flowers do not appear together, hence the pods do not ripen at one time. Picking is usually undertaken every month over a period of six months.

Gathering

Pods should be gathered before they turn yellow. To determine whether a pod is ripe or half ripe requires skill, which is only gained after prolonged experience. Ripe pods will break away from the panicle with slight pressure by the fingers. Cutting pods with scissors is not necessary and is a slow and costly process.



(Photo: D.I.E.S.)

Plate V.—The pods of Malabar variety (left) are wider, and the seeds are darker, than those of Mysore variety (right)

If pods are over-ripe, there is a tendency for them to split open when the drying process takes place.

Curing

As far as possible the original green colour of the pod should be retained after the drying process has been completed. It is therefore best to cure cardamoms in a shed with the use of artificial heat. The simplest method of drying is to pass heat from a stove through a flue in a shed, raising the temperature of the air in the shed to 120°F. The pods are sufficiently dry when they contain about 10 per cent of moisture. Excessive heat or too quick drying will cause the pods to split.

Sun drying will bleach the pods or turn them yellow. Sun-dried cardamoms will fetch a lower price than kiln dried green cardamoms.

Preparation for Sale

When the drying process has been completed, the flower petals and stalk on the pods have to be removed. This can be done by rubbing the pods over a No. 18 wire mesh. Sorting into grades by using perforated metal sheets of varying sizes is usually necessary for export. All splits are removed by hand and sold separately. The crop is packed in wooden boxes lined with plastic or in jute bags with an inner lining of plastic.

Pests of Cardamon

The two main pests of cardamom are the hairy caterpillars which eat the leaves, and thrips, which enter the flowers and cause a shrinking of the pods, leaving a corky scar on the outside of the pod. This detracts from its value. Depending on the length of time to harvest, either DDT or carbaryl spray is suggested for control of these insects. DDT should not be used within 30 days of harvest. A dilution of 0.1 per cent may be prepared by adding 2 fluid oz of 25 per cent concentrate to 3 gallons of water. Carbaryl (Sevin^{R}, Septene^{R}, Resistox^{R}) can be used up to three days before harvest. A 0.15 per cent dilution is prepared by dissolving 1 oz of 80 per cent wettable powder in 3 gallons of water.

Pigs will destroy the clumps and eat the rhizomes. Precautions must be taken against pigs entering the plantation.

Market Prices

The chief growers of cardamom at present are India and Guatemala. Most of their crop is exported to the countries of the Middle East.

As there is virtually no cardamom being exported from the Territory yet, it is not possible to give reliable figures on economic returns; it is not known how the Territory products would compare with overseas grades. Prices quoted in London during 1970 have ranged from 46/6 Sterling per lb to 39s. per lb (Aust. $4.99 to $4.18) for Ceylon No. 1 grade, and from 46s. to 24s. per lb (Aust. $4.93 to $2.57) for Indian No. 1 grade. The prices have fluctuated quite considerably over the last five years, with high prices in 1966, a drop to less than 20s. in 1967 and 1968, rising again to a high peak in early 1970.

The demand for spices is fairly stable in higher income countries. In Eastern countries, however, spices are an important part of the daily diet, and consumption is expected to increase with improved standards of living. Overall demand may be considered to be rather stable at present, but tending to expand in the future.

Basic Data

1 lb fresh fruit contains an average of 780 pods.

10 lb fresh pods produces 2½ lb of seed.

1 lb of pods contains about 50,000 seeds of which about 30 per cent will germinate.

Planting distance—7 ft x 7 ft = 889 to 10 ft x 10 ft = 436 plants per acre.

Time to come into bearing—3 years from seed (small crop only—full crop after 4 years).

One man can pick 8 to 10 lb of pods per day.

One well-grown healthy cardamom plant produces up to ½ lb dry pods per year.

One acre of cardamoms averages 150 lb/acre in the fourth year.

One acre of cardamoms averages 200 to 300 lb in the fifth year.

By good selection of high-yielding rhizomes, crops above 300 lb per acre could be obtained.

Foot and Mouth Disease

P. R. HARVEY,

Assistant Director, Animal Industry Division

Foot and Mouth Disease is one of the most infectious of all animal diseases. It is distributed widely throughout the world, with Oceania, North America and the British Isles currently being classified as free. The closest focus of infection to New Guinea is Java. The lesser Sunda Islands to the west of Java and West Irian are, fortunately, free.

FOOT and Mouth Disease affects all cloven footed animals, occasionally other species such as the hedgehog and the coypu, and exceptionally man himself. The disease causes distinctive blisters on the tongue, lips, udder, genital organs and skin between the claws of the feet. These blisters soon rupture leaving a raw surface which heals in about 3 to 4 weeks. Animals become lame, are loath to walk, and may salivate profusely with strings of saliva hanging from the lips.

Except occasionally in young animals, there is not a high mortality in Foot and Mouth Disease. The main economic effect of the disease on livestock industries is the serious loss of production. Affected animals show a marked loss of appetite, a rapid fall in body condition, a drop of milk production and may take many months to recover. In a fully susceptible animal population such as in New Guinea, the disease will spread very rapidly with all animals in a herd becoming affected in a short space of time.

The virus causing Foot and Mouth Disease is one of the most resistant known, and may survive for a number of years in frozen meat and for several months on contaminated material and equipment. Infection can spread rapidly by the movement of animals and birds, milk, milk products, biological products, semen, wind, contaminated packing materials, hay, fodder, clothing, footwear, vehicles and equipment.

Control Measures

The control of Foot and Mouth Disease in countries free of the disease is generally based on the complete slaughter of all stock on all affected farms. The cost of eradication under these circumstances can be extremely high; for instance, in the recent United Kingdom outbreak, direct costs amounted to $70,000,000 and indirect costs between $140,000,000 and $300,000,000. Nevertheless, it is considered cheaper to eradicate by slaughter than to bear the high annual costs of vaccination.

In countries where the disease is endemic, control is usually achieved by vaccination. This does, of course, depend on the sophistication of the veterinary services, the availability of vaccines and the control exercised over the animal population. Vaccination is hampered by the presence of seven major virus types and over 50 different sub-types, with vaccine against one sub-type not necessarily conferring any immunity against other sub-types. In all cases control is assisted by movement restrictions, the quarantine of infected and "in contact" properties and the disinfection of premises.

Quarantine Regulations

Papua and New Guinea is fortunate in having one of the healthiest livestock populations in the world. This favourable health situation has been largely brought about by stringent quarantine requirements which govern the entry of animals and animal products.

Returning travellers and tourists have a responsibility to ensure that they make correct declarations for quarantine and do not inadvertently bring a disease into the country with them which could end up by costing the country many millions of dollars. For continued freedom it is essential that quarantine be both understood and supported by the public. It is general for shoes to be disinfected if travellers have been on farms in countries where the disease exists. This is done at the airport or wharf and takes only a few minutes. It does not inconvenience the traveller at all.

Plate I.—A ruptured blister on a steer's tongue, showing the ragged appearance of the broken skin. Two pieces of skin have been removed and laid on the animal's upper lip. There is extensive separation of the skin from the tissue beneath

Plate II.—A pig's foot showing blisters as white areas at the junction of horn and skin. Where the blister has ruptured the typical raw base is visible

Action for an Outbreak

As a second line of defence the Department has a comprehensive action plan to deal with Foot and Mouth outbreaks. If Foot and Mouth is suspected, rapid notification and investigation are the keys to control. All suspected cases must immediately be reported to the nearest Veterinary Officer or Livestock Officer who has been instructed to investigate without delay. As an interim precaution no stock or animal products should be moved off the suspect property; human movement should be restricted and animals moved away from boundary fences.

The control of the disease in the Territory would depend on its distribution when first diagnosed. If the disease was limited eradication through slaughter would be attempted and compensation would be paid to the owners of slaughtered animals. If, on the other hand, the disease was distributed more widely and present in the native pig population, a vaccination policy may have to be followed. In either case the presence of Foot and Mouth Disease would severely disrupt the livestock industries.

Remember, prompt reporting means prompt control.

Pyrethrum Marc for Pigs

PYRETHRUM marc is the residue left after pyrethrum flowers have been treated with solvent to extract the insecticide. When dried, marc is a dark brown meal, having a protein content of about 13 per cent and a carbohydrate content of about 43 per cent. It is readily available in the Mount Hagen area, and some owners have been using it as an ingredient in pig rations.

To test its value as a pig food, Mr George Malynicz, Veterinary Officer (Pig Production) carried out some trials recently at the Tropical Pig Breeding and Research Centre, Goroka.

Three groups of pure-bred Berkshire pigs were fed a standard ration based on milled sorghum and protein supplement. Group I was fed only the standard ration. For Group II, 10 per cent of the standard ration was replaced by marc of an equivalent protein value, and for Group III, 25 per cent of the ration was replaced by marc of equivalent protein value.

The pigs were group-fed, with food and water in adequate supply, and were weighed at weekly intervals.

Over the whole period of the trial, 140 days, the average gains in weight were as follows:—

Group I .... 133 lbs;

Group II .... 114 lbs; and

Group III .... 85 lbs.

For Group I the average consumption of food was over 4 lb per day, whereas for the other groups it was only 3.5 lb per day. Spillage of food from troughs was heaviest in Group III. From the colour of the feed remaining in the trough next morning, it was apparent that, despite thorough mixing, the pigs were selecting the standard ration and deliberately leaving the pyrethrum marc.

Although this trial could be considered only as preliminary in nature, the trends are clear. Introducing marc into a ration of equal protein concentration results in reduced feed intake and reduced growth. Technically, therefore, the decision to include pyrethrum marc would appear inadvisable.

Barramundi Tagging Programme

Maureen A. WRIGHT

Fisheries scientists at the Department of Agriculture, Stock and Fisheries are concerned at rumours in the fishing industry that barramundi are being "fished out". Some fishermen have claimed that their catch rates are declining around Daru where fishing pressure is heavy. Barramundi have been taken in fewer numbers in Lake Murray during recent years, and this has also caused some anxiety in the industry. These fears may be groundless, according to a visiting specialist from the World Bank, Mr C. Beever, who visited the area during June, 1968. In fact, it may well be that the barramundi stocks could stand a much greater fishing pressure. In March, 1970 the Department began an intensive study of the barramundi and the barramundi fishing industry. The biology, life history and population dynamics of this fish will be studied to enable the Department to recommend a management programme for this important industry.

Tagging

INITIALLY, biologists will concentrate on tagging barramundi in the fishing areas. Fish are collected in set gill nets and seine nets, weighed and measured, then a tag is fixed to the gill plate and the fish is released. Several years ago, fisheries officers released three to four hundred tagged barramundi around Daru, but none of these tags was ever recovered. In the present programme many more fish will be tagged, and over several years biologists hope that several hundred tagged fish will be recaptured. A target of 1,000 tagged fish has been set for the first year, and in the next three to four years about 4,000 fish will be tagged.

Fisheries officers have talked about the tagging programme in radio interviews, and posters in English, Pidgin and Motu have been circulated. The fisherman is asked to measure any tagged fish he catches, remove the tag and take it to the nearest D.A.S.F. officer or mission. He will be given 50c for every tag he brings, provided he gives the following information:—

(i) Where the fish was caught;

(ii) The time and day the fish was caught;

(iii) How it was caught; and

(iv) How long it was.

Only the tag has to be given to the agricultural officer; the fisherman keeps the fish.

This information will show how far the fish has travelled since it was released, and how much it has grown.

Tagged fish are being released mainly around Daru, where the main part of the commercial fishery is, but tagging operations will be extended to fishing areas all along the coast.

At the same time, commercial fishermen are being asked to supply data on their total catch. From the proportion of tagged fish occurring in the catch, researchers will be able to estimate the size of the barramundi population, and the fishing mortality. Sampling tests by field officers will supplement data from commercial catch returns.

Under the present fishing regulations, there are no controls on commercial barramundi-fishing activities. There are no limits on the quantity of fish which may be taken, or how or where they may be caught. There are no size restrictions, nor are there any limits on the duration of the fishing season. The question researchers have to answer is, are sufficient numbers of barramundi escaping from the fishermen and other predators to maintain breeding stocks? If not, some regulation will be necessary.

Biologists need much more information about the barramundi before they can recommend adequate management measures. It is very important to know where and when the fish breeds, and if necessary to limit fishing pressure during part of the breeding season.

Plate I.—Special pliers are used to attach the tag to the gills of the fish (Photo: D.I.E.S.)

Biological Studies

An earlier study of the barramundi in T.P.N.G. gave a considerable amount of general information. It was found that—

(i) in the Territory, the species is restricted to rivers discharging into the southern coastal plains of Papua. The Fly River and its tributaries carry the largest stocks;

(ii) Barramundi live in the rivers and freshwater lagoons and swamps for most of the year, and make their way to the sea, presumably to spawn, in the wet season, October to March. Other small runs occur at other seasons, possibly related to rain in the catchment areas, and possibly also to migrations of prawns; and

(iii) the fish which can be caught in the upper reaches of the rivers in the dry season are not of the same high eating quality as the sea run fish. Freshwater barramundi contain a large amount of fat and the flesh has a distinct muddy or earthy flavour. The fatty tissue disappears when the fish migrate towards the sea.

Detailed information on the breeding biology will be collected during the present

Plate II.—Young barramundi with tag attached (Photo: D.I.E.S.)

programme. The reproductive organs of fish will be examined throughout the year, to determine the breeding season. It may be possible to correlate breeding season with environmental factors, particularly rainfall and river heights. The reproductive organs from fish of different sizes are being examined to determine at what length the barramundi is sexually mature, and also what length classes actually spawn. Fecundity of different length classes will be estimated. Some estimate of the number of times an individual fish breeds during its lifetime is also required. Breeding behaviour will be studied both in the field and in laboratory tests.

Pond Culture and Introductions

Because of its good eating quality and fast growth rate, the barramundi might be a good species for pond culture in the Territory. A thriving barramundi pond-culture industry is already in existence in Thailand. The main experimental work of the laboratory will involve keeping and rearing barramundi. Biologists will try to breed barramundi in experimental tanks. The possibility of large-scale pond culturing of barramundi in the Territory will be investigated.

River systems which do not support a barramundi population at present, particularly the Sepik and Ramu, will be studied to determine whether barramundi could be successfully introduced.

Not Enough Sun

INSUFFICIENT sunshine may be the reason that coconuts do not do well in south-west Bougainville. This is reported by Mr J. H. Sumbak, Agronomist at the Lowlands Agricultural Experiment Station, Keravat, in the December issue of the *Papua and New Guinea Agricultural Journal*. The coconut palms in this area show a very slow development, tardiness in bearing and very poor nut production. The palms look poor—they are characterized by upright fronds, few spathes and even fewer nuts.

Mr Sumbak investigated the nutritional status of the palms, and concluded that the cause of poor growth was not a nutrient problem. Other trees with a lower requirement for sunshine, such as cacao and Leucaena, grow well, suggesting that there is little wrong with the nutrient supply in the soil.

In this area, patricularly away from the coast, there is a heavy and continuous cloud cover most of the day. The amount of bright sunshine is often less than two hours a day. Sunshine recordings from Buin were very much lower than for other areas, such as Kerivat, Aropa and Tigak, where palms do well. Although other factors such as poor planting material, pests and diseases could contribute to poor growth, it seems probable that the area is unsuitable for coconut and oil palm production because there is not enough sunshine for these crops.

Geese

Robart W. ROBARTSON,

Project Manager, Southern Highlands District

At present there is no commercial production of geese in the Territory, but there are definite possibilities. From a few weeks old, geese can live entirely on grass, so they would be suitable for most of the Territory. An acre of good land will graze up to forty geese, and the production could be as much as $500 per acre per year. This is allowing for a survival rate of only four goslings per goose per year, selling at $5 per head.

GEESE live longer than other forms of poultry. The female can be used for breeding until she is fifteen years old. Geese are more intelligent, grow faster and are hardier than fowls, turkeys or ducks.

Three breeds of geese seem to offer the best possibilities for the Territory. They are Toulouse, Embden and Chinese.

1. *Toulouse* are a heavy breed of goose originating in France. The weight is 30 lb for the gander and 20 lb for the goose.

2. *Embden* comes from Germany, and is slightly lighter than the Toulouse. It is considered the best bird for meat. The weight is 18 to 20 lb for the gander and 16 to 18 lb for the goose.

3. *Chinese* geese can be white or brown, although only the brown is known in Australia. This breed seems to offer the best prospects of surviving in the tropical climate.

Housing

Geese do not need special housing as long as they have shelter from rain and sun. If there are no trees for shade, a kunai lean-to can be provided. It is worthwhile spending some time and effort on providing satisfactory housing, otherwise the geese tend to make their nests and lay their eggs outside, and the eggs may be lost to the owner.

Stock Selection

Breeding stock should be chosen on their expected ability for meat production, egg size and number of eggs produced per season. Stock for breeding purposes should be selected from second year eggs, as it has been found that fertility and hatchability are lower for first year eggs.

Handling

Geese should always be caught by the neck, as the legs are easily broken. Catching geese can be very difficult, and can cause injury to the catcher. The birds have powerful wings, and can strike hard. They can also inflict nasty scratches with their feet. The safest way to catch a goose is to use a hooked wire.

Mating

Geese will select their mates from about 15 weeks of age. If flock mating is allowed, there is the danger of brother and sister attachments; this inbreeding gives weak offspring resulting in a higher mortality rate. It is better, therefore, to separate the geese from the ganders as early as possible so that no attachments can develop before those arranged by the owner.

While the geese and gander are separated, it is advisable to house the gander in a small cage where he can keep an eye on his brood. If selected birds are put together and their behaviour watched for a few weeks, it will soon be apparent if the members of the group are compatible. This will be especially apparent at feeding time.

At times a gander shows a preference for one or two of his mates. This can indicate that mating will not be general. To test a gander's fondness of the females, it is advisable to remove one female at a time. If the gander shows indifference on the removal of one of the birds, it is almost certain that the gander will not mate with this female. Hence there will be fewer fertile eggs.

It is usual practice in Australia to mate three females to each gander.

Plate I.—Geese on pasture

Natural Incubation

The heavier breeds of Toulouse and Embden have not given any indication yet that they will be of any importance in the future of the industry here in the Territory. Toulouse, although few in number, have not bred successfully. Embden have laid a few eggs but appear to be just as disappointing as Toulouse.

If eggs are kept prior to setting, they should be kept in cool conditions (50 to 60°F.) and 60 to 70 per cent relative humidity. They should be turned over regularly, and should not be kept longer than seven days.

In Australia, it is common practice to use muscovy ducks for incubation, but it has been found here that local native hens are better as they tend to sit tighter. Geese themselves will cover up to 16 eggs (as against the hen's coverage of four) but it is not advisable to allow a goose to lay and then brood her own eggs. Goose eggs lose their hatching potential quickly, so they should be removed and given to other birds to incubate.

Goose eggs need higher humidity to incubate them than other eggs. If the humidity is not correct in the nest when incubation is starting the embryo will die.

Artificial Incubation

The artificial incubation of eggs is possible for the entire period of incubation if temperature and humidity are carefully controlled. Temperature should be 99½°F. with relative humidity 65 to 70 per cent for the first 26 days, and 75 to 80 per cent for the remainder. Eggs should be turned over 3 times daily up to 26 days. For the inexperienced owner, however, it is safer to start the eggs under a hen or muscovy duck for a fortnight, before transfer to the incubator. By exchanging eggs and finishing them in the incubator, the one bird can be used to start three or four times the quantity of eggs that she would normally incubate.

It has been found that eggs incubated in a hot air incubator need sprinkling with warm water three times per day, and from the twenty-fourth day they can be immersed in warm water for about a minute each day. This can be kept up until the eggs pip.

Brooding

Goslings are possibly the easiest of the poultry breeds to brood. They can be brooded artificially under a brooder or naturally by

hen, duck or goose. If the mother goose is used for brooding, there is always the possibility of the goose injuring the goslings with her big feet and extra weight.

Goslings require some shade, and must have a dry place to sleep. Until their legs become strong, they should be kept in a confined area, preferably grassed, as they will soon begin to graze. At the age of four to five days they will begin pulling at growing grass and weeds.

Feeding and Watering

From one day old, goslings should be fed a little green feed. Finely chopped lettuce, or milk thistle can be fed four or five times per day. Any soft grasses can be fed, chopped up, but they must be fresh. Any good chicken mixture, preferably starter crumbles, can be fed until the fourth week. If the grazing is good, the chicken food can then be limited to one feed per day.

Goslings are noted for their rapid growth rate and can be ready for killing for the table at twelve weeks. There will be some ganders that are not required for breeding and can be sold for table use. Goslings which are raised for killing should be kept on good grazing and fed with the prepared food three times a day. They should be given enough food to be eaten at the time, with none left over.

Clean fresh water is essential at all stages of growth, and should always be available to the goslings. They should not have enough water to swim in until they are 6 to 8 weeks old. From hatching they should have water only deep enough to get their bills in, and at about a week, water deep enough to get their heads in. This helps to keep the nasal tract clear, and so helps to guard against infection and disease.

If goslings are confined, grit should be provided. Coarse river sand is satisfactory for this.

Plate II.—Hatching in a forced draught incubator

Plate III.—Sex identification by a physical examination for the presence of the bird's penis

Sex Identification

It is difficult to identify the sexes of goslings. The same method as used for identifying chickens can be used, but this is not recommended as the inexperienced person can cause damage to the sexual organs.

With geese of the same age, the gander is generally slightly larger, with a longer neck. The cry of the gander is high, while the cry of the goose is harsh.

If the geese are mating, or the female is laying, it is an easy matter to take note of the goose while she is on the nest. Later she can be caught and marked. This is, however, a time-consuming method.

The best method is a physical examination of the sex organs of mature birds. In the case of a male bird, the penis may be exposed by pressure around the vent. The left hand is placed below the vent, and a slight pressure is directed downwards. With the right hand pressure is brought to bear above the vent, thus exposing the penis if the bird is a gander. It is best not to attempt such an examination until the birds are at least twenty weeks old.

Import Requirements

Air freighting of goose eggs from suppliers in Australia is the simplest way of obtaining geese, as the mortality rate of day-old goslings is very high. An import permit must first be obtained from:

Chief Quarantine Officer (Animals),
Department of Agriculture, Stock and Fisheries,
Konedobu.

The eggs must come from an approved hatchery in Australia, where the birds have all been tested by a veterinary surgeon for pullorum disease and have been found to be free from the disease.

Approval to import adult geese will not be granted.

The assistance of the N.S.W. Department of Agriculture in supplying the photographs is gratefully acknowledged.

Cultivation Practices with Sweet Potato

A. J. KIMBER, Agronomist,

Highlands Agricultural Experiment Station,

Aiyura, Eastern Highlands District

A summary of a paper by A. J. Kimber presented at the Second International Symposium on Tropical Root and Tuber Crops, held at the University of Hawaii, August, 1970.

SWEET POTATO (*Ipomoea batatas*) is the major crop of subsistence gardeners in the Highlands and is also important as a cash crop, particularly for rations for plantation and Administration workers. Work has been carried out at the Highlands Agricultural Experiment Station, Aiyura, to determine whether some cultivation techniques are superior to others, irrespective of the variety of sweet potato used and of soil variations and climate differences in the Highlands.

Three different soil types were used, typical of soils used in the Highlands for sweet potato cultivation. Seven different cultivation treatments were included. Within each row, cuttings were planted 15 inches apart.

Treatments

1. Flat land, with cuttings planted in rows 25 in. apart.

2. Small ridges, 6 in. high and 25 in. apart. Cuttings were planted along the ridges.

3. Intermediate-sized ridges, 9 in. high and 25 in. wide at the base. Distance between the centres of ridges was 42 in. Cuttings were planted in two rows 18 in. apart.

4. Large ridges 9 in. high and 30 in. wide, flat on top with angled sides. These were formed by combining alternate ridges of Treatment 2 above. The distance between the centres of the ridges was 50 in.

5. Small mounds 6 in. high and 27 in. in diameter. These were formed from the small ridges of Treatment 2 above. Two cuttings were planted per mound.

6. Intermediate-sized mounds, made from the ridges of Treatment 3 above. Height of each mound was 9 in. and diameter 30 in. Three cuttings were planted per mound.

7. Large mounds 10 in. high and 34 in. in diameter. Four cuttings were planted per mound.

Four trials were laid down, using the varieties Merikan, Serenta, Gonimi, Naveto and Yamandi. The following treatments were used:

Trial No.	Treatments
1	1, 2, 4, 5, 7
2	2, 4, 5, 7
3	All treatments
4	All treatments

Tubers were harvested after 7 to 9 months.

Results

The results are tabulated in order of decreasing yield of marketable tubers in each trial (*Table* 1). All tubers harvested were weighed and sorted according to size. Those 4 in. or more long and 2 in. or more wide were counted as being marketable. Smaller ones were considered to be stock-feed and were not included in the yield figures given.

Although there were some minor differences in the relative response of varieties between treatments, on the whole all varieties used responded similarly to the various treatments and for this reason, varieties are not shown in the table. In other words, the result depended on the treatment, not on the varieties used.

Throughout the trials, the flat land yields were always lowest, so there is no doubt that mounding or ridging is worth the trouble.

In all trials, mounds gave higher yields than ridges of comparable size and in three of the four trials, large mounds gave bigger yields than small mounds. The exception was in

Table 1.—Yields of Marketable Tuber (in lb per acre)

Trial 1			Trial 2		
Treatment No.	Treatment		Treatment No.	Treatment	
5	small mounds	21435	7	large mounds	13982
7	large mounds	15866	5	small mounds	13430
2	small ridges	15412	4	large ridges	13206
4	large ridges	13191	2	small ridges	9674
1	flat land	11087			

Trial 3			Trial 4		
Treatment No.	Treatment		Treatment No.	Treatment	
7	large mounds	11347	7	large mounds	7278
5	small mounds	8937	6	intermediate mounds	5251
4	large ridges	8312	5	small mounds	5339
6	intermediate mounds	8234	4	large ridges	5283
2	small ridges	8044	3	intermediate ridges	4010
3	intermediate ridges	6839	2	small ridges	3290
1	flat land	6498	1	flat land	1239

Trial 1 in which small mounds gave better results than large mounds or ridges. Among the mound treatments therefore, large mounds generally seemed to yield more, but where soil structure and drainage are ideal as in the first trial, small mounds may be superior, possibly because of the more even spacing which they give for an equivalent plant density. It must be admitted, however, that conditions of ideal soil structure and drainage are not common in the Highlands.

Economic Results

Since there is more work involved in building mounds than ridges, an analysis of costs was made. At present rural wage levels, it was found that the extra cost of mounding instead of ridging was $13 per acre. At a net return of 1 cent per lb for marketable tubers, an additional 1300 lb per acre would need to be obtained and sold to justify the extra expense of mounding. At a net return of 0.75 cents and 0.50 cents, an increase of 1733 lb and 2600 lb per acre respectively would be required.

Tables 2A and 2B give comparisons of financial returns for large mounds as against large ridges and small mounds as against small ridges. At a net return of 1 cent per lb, the two tables show that in six cases out of eight the extra expense of mounding was justified and in the remaining two cases the difference was only marginal. Where the net return falls to 0.75 cents per lb, there still seems to be an overall advantage in mounding, but at 0.5 cents per lb on the whole there is little or no justification.

The main advantage of ridges over mounds lies in their convenience in commercial production and for this reason some large-scale producers would prefer them.

Table 2A

	Trial 1	Trial 2	Trial 3	Trial 4
Large mounds yield (lb)	15866	13982	11347	7278
Large ridges yield (lb)	13191	13206	8312	5283
Gain in production due to mounding (lb)	2675	776	3035	1995
Gain in money due to mounding @ 1c	$26.75	$7.76	$30.35	$19.95
@ 0.75 cents	$20.07	$5.97	$22.77	$14.97
@ 0.5 cents	$13.38	$3.88	$15.18	$9.98
Less extra cost of mounding	$13.00	$13.00	$13.00	$13.00
Net gain @ 1c	$13.75	—$5.24	$17.35	$6.95
@ 0.75c	$7.07	—$7.03	$9.77	$1.97
@ 0.50c	$0.38	—$9.12	$2.18	—$3.02

Table 2B

	Trial 1	Trial 2	Trial 3	Trial 4
Small mounds yield (lb)	21435	13430	8937	5339
Small ridges yield (lb)	15421	9674	8044	3290
Gain in production due to mounding (lb)	6014	3756	893	2049
Gain in money due to mounding @ 1c	$60.14	$37.56	$8.93	$20.49
@ 0.75 cents	$45.10	$28.17	$6.72	$15.37
@ 0.50 cents	$30.07	$18.78	$4.47	$10.25
Less extra cost of mounding	$13.00	$13.00	$13.00	$13.00
Net gain @ 1c	$47.14	$24.56	—$4.07	$7.40
@ 0.75c	$32.10	$15.17	—$6.28	$2.37
@ 0.50c	$17.07	$3.78	—$8.53	—$2.75

Crown - of - Thorns Starfish

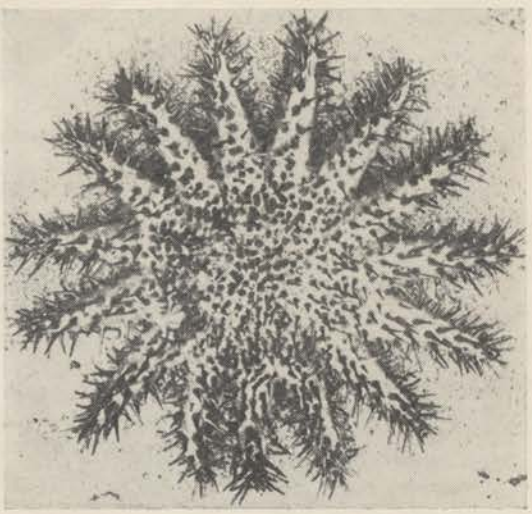
THE Crown-of-thorns starfish in Papua and New Guinea has been featured recently in various news items. Fisheries officers of the Department of Agriculture, Stock and Fisheries have conducted surveys in various parts of the Territory and in addition interested members of the public have been asked to supply information about its distribution on coral reefs.

Mr Rex Pyne, Marine Biologist in charge of this investigation, said recently that the evidence collected so far does not indicate that coral reefs and thus indigenous fishing grounds are being destroyed. Nowhere in the Territory is there evidence of the starfish having reached plague proportions. The starfish is widespread on the shallow inshore reefs throughout Papua and New Guinea, but only present in numbers of normal concentration or less (five starfish sighted in one hour's diving). There are many areas in Papua and New Guinea where no starfish have been found. Mr Pyne added that two unconfirmed reports had been received of reefs having been devastated several years ago by Crown-of-thorns starfish, and that there were indications that the starfish had been present in Territory waters for a very long time.

In recent years, a vast amount of time and money has been spent by both American and Australian marine research institutions on a study of the biology of the Crown-of-thorns starfish and effective methods of eradication.

The Territory survey is still proceeding, and reports of sightings are welcome. Information regarding the absence of the starfish on reefs is equally welcome. Reports should be addressed to:—

The Director,
Department of Agriculture, Stock and Fisheries,
Konedobu, T.P.N.G.



(Photo: D.I.E.S.)

Plate I.—Crown-of-thorns starfish.

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How KARMEX† helps you run your Coffee Plantation more profitably.

By eliminating weeds, which compete with the coffee for soil nutrients, Karmex allows for more economical use of fertilizers. So costs are lowered. So profits increase. And that's not all Karmex does!

Karmex keeps killing weeds longer. Unlike other dessicant type weedicides Karmex has a **residual action.** It keeps on killing weeds for up to 6 months after spraying. This **reduces costs** . . . because it eliminates the need for frequent re-treatments. In time, costs reduce even further because the amount of Karmex needed becomes progressively less.

Karmex aids picking. Because Karmex kills almost all weed and grass species found in coffee plantations . . . even stopping such perennial grasses as couch from taking over . . . the ground is left clear and clean. This aids picking; and pickers can be more easily supervised.

Karmex is easy to apply. Kill off existing top growth (either mechanically or with a dessicant) and spray Karmex on to clean ground. Mix Karmex with 40 gallons of water (per acre) and apply at the rate of 4 lbs. per acre. For subsequent treatments, spray on Karmex at the rate of 2 lbs. per acre every 6 months, or as necessary. If new growth is present at time of spraying, add NONIDET WK to the mixture at the rate of ½ a gallon to 100 gallons of spray mixture.

Act now! Your local Shell Depot or Agent can supply **Karmex†, Nonidet* WK** and a full range of chemicals. See him before it's too late! before weeds get a stranglehold on profits.

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Collins & Leahy — Kundiawa
Shell Company (Pacific Islands) Ltd; or Burns Philp (N.G.) Ltd. — Goroka.
Booij Bros. — Kianantu
Wau Valley Motors — Wau
Shell Company (Pacific Islands) Ltd., P.O. Box 169, Port Moresby

Shell Chemicals

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A Coffee Plantation at Banz, Western Highlands. 5 months after initial application of Karmex to a heavy infestation of couch grass

SC704/SP1-10P

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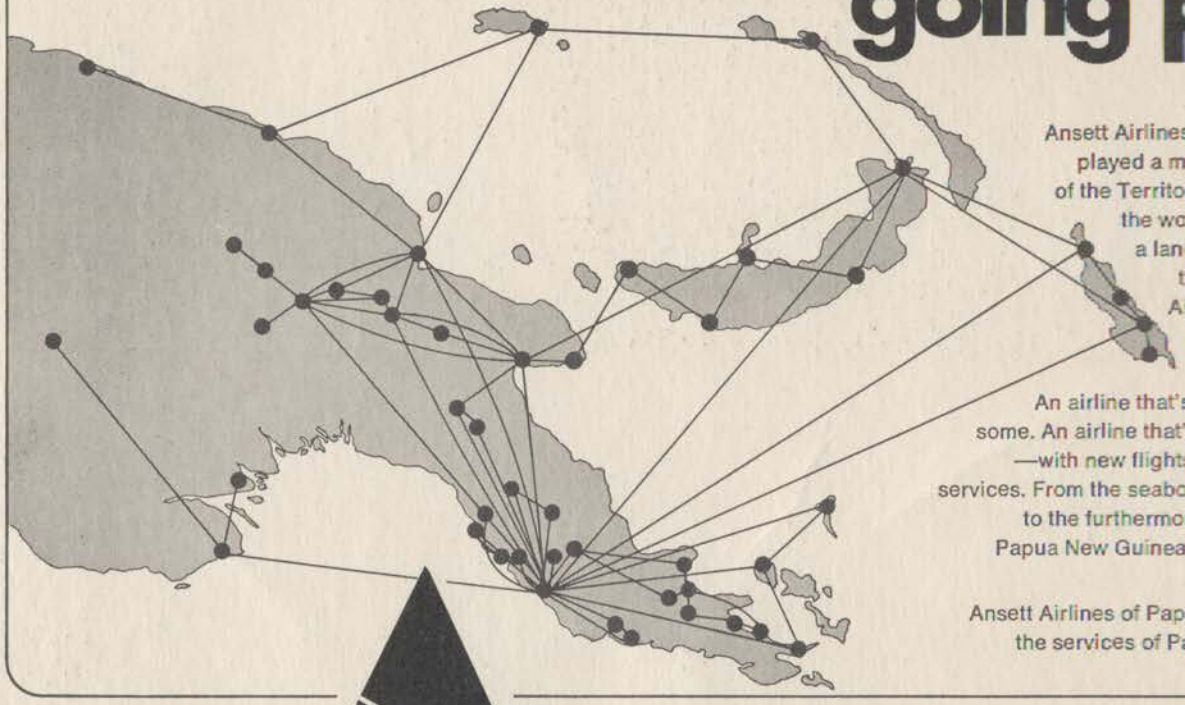

Ansett Airlines of Papua New Guinea have played a major role in the development of the Territory. Air transport has brought the world to Papua New Guinea. In a land where skyways have made the present possible—Ansett Airlines of Papua New Guinea are proud to be the airline that's really going places.

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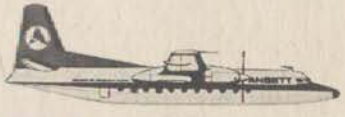
Ansett Airlines of Papua New Guinea also operate the services of Papuan Air Transport Pty. Ltd.



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