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The Papua and New Guinea

Agricultural Journal

Vol. 10 October, 1955 No. 2

SURVEY OF FISHING POTENTIALITIES OF THE CORAL SEA AND SOUTHERN AND EASTERN PAPUA IN 1955

A. M. RAPSON *

I.—*Introduction.*

SMALL motor boats and two vessels 60 feet in length, including Administration ships and a chartered boat from Australia, were used over a period of seven months to assess the fishing potentialities of the Coral Sea and Southern and Eastern Papua. As fishing at sea is seriously handicapped during the south-east season, sometimes for many days at a time, shore based tests from Port Moresby were carried out over a period of six weeks at Bootless Inlet in an attempt to replace part of the fishing effort at sea with work concentrated on shore which could be carried on independently of the weather.

II.—*Summary of Fishing Voyages.*

A period of six days was occupied fishing for bait about Port Moresby from Vabukori to Tatana and 500 lb. of bait sprats and anchovies were obtained; the following ten fishing voyages were made during the period February to August, 1955 :—

1.—1st-4th February—Fisherman's Island, beach netting and long line testing.

2.—15th-19th February—Hula Village, beach netting and long line tests.

3.—23rd-28th March—Port Moresby-Caution Bay and Idiha Island.

4.—31st March-12th April—Port Moresby via Gulf to Fly River Mouth returning via Bramble Cay and Portlock Reefs.

5.—18th-27th April—Port Moresby, Eastern Fields Reef and Daru returning via Fly River and off Yule Island.

6.—2nd-8th May—Port Moresby coastwise to Samarai.

7.—10th-18th May—Samarai, Milne Bay, Conflict Group, Kosmann and Uluma Reefs returning via Wari Island and Siriki Shoals.

8.—21st-26th May—Samarai, Wari Island, Shellard Ridge, Siriki Shoals, returning via Bremmer Island coastwise to Port Moresby.

9.—26th July - 2nd August — Off Kapa Kapa, tuna fishing tests 16 foot diesel motor boat.

10.—9th-12th August—Off Kapa Kapa and Gaile tuna fishing tests with 18 foot petrol driven vessel.

III.—*Trolling Results.*

The length of coast-line travelled, excluding off-shore reefs, is approximately 500 miles. Port Moresby lies slightly to the west of the mid point. In the following discussions of abundance the area is divided into five parts according to the different

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types of fishing water and principal areas are :—

1.—Port Moresby from Keppel Point to Yule Island.

2.—Gulf.

3.—Reefs of the Coral Sea.

4.—Central South Coast, and

5.—East of Samarai.

1.—*Port Moresby Area—Keppel Point to Yule Island*—

No spectacular catches of fish were made trolling in this area, although special efforts were made to catch inshore shoals of mackerel tuna, which with yellowfin and trevallies come inshore during the south-east season. Off Kapa Kapa a 16 foot diesel motor boat was not very effective, an 18 foot petrol-engined vessel was only slightly better on the figures given in Appendix I. However, partly because of poor weather conditions, over a three day period the catch from the petrol-engined vessel was less by 22 lb. than the smaller diesel-engined boat. These tests were carried out to determine the type of vessel most suitable for trolling from a larger vessel and for comparison with fishing by Kapa Kapa people who catch from three to nineteen fish per day per canoe, using small anchovies and bait chumming for tuna and trevallies. The average catch per canoe of about eight fish weighing 60 lb. compares favourably with the results from the two motor boats. Off Tupuselei to Pyramid Point also there are, at certain times, small shoals of fish, but the main run does not usually travel far west of Kapa Kapa or Gaile.

Off Yule Island.—Near the 100-fathom line best catches in this general area were made on a passage from the Gulf and if the area was systematically fished good results could be expected. Similarly off Idiha Island and the shoals to the west and north, there were indications that small schools of fish are to be found at the correct season.

Off the five general areas fished, the region from Keppel Point to Yule Island gave consistently the poorest results by all methods of fishing tested. This is at least partly because the Barrier Reef ends a few miles north of Idiha Island and the influence of the Gulf water bearing a different stock of fish has some effect.

2.—*Gulf Area*—

Trolling from Jokea to the Fly River Mouth from 1 to 20 miles off shore on the ship's course, produced for over 20 hours of trolling, 12 lb. of fish.

3.—*Reefs of the Coral Sea—Bramble Cay to East Cay*—

At *Bramble Cay*, a convenient anchorage in the south-western Gulf region, excellent catches of Spanish mackerel were made in February, 1948, and March, 1950, and Queensland fishing vessels have had good fishing there on numerous occasions; since then Bramble Cay yielded no fish at all on two visits in April, 1955, and only several fish were taken on the passage from Laxton Reef to Bramble Cay. Best results in the Coral Sea were obtained at Anchor Cay where 313 lb. of fish were taken in two hours, and at East Cay, although a greater quantity of fish was taken, the rate of catching was slower, 553 lb. of fish were taken in four hours.

Anchor Cay is a fair anchorage in south-east weather having on the north side an extensive shoal. At low tide there is a small area of reef exposed forming a crescent in which there is an extensive shoal area of sandy mud about 4 fathoms deep covered with eel grass with an area of sand only 30-40 yards in diameter which would be awash at high tide.

East Cay would be a satisfactory anchorage only in calm weather. There was no exposed sand cay seen at East Cay although extensive areas of reef were exposed, traversed by a shallow channel.

Portlock Reef.—Trolling over the reefs could not be satisfactorily accomplished as conditions were not favourable for cruising over uncharted reef, to the north-east of the most western reef, however, *en route* to Port Moresby, a few fish were taken. Results in Appendix I include trolling approaching from the west on the edge of the reefs; to the east sharks were a serious problem near the edge of the reef. Portlock Reef is an extensive area in which there are numerous shallow reefs. It is reported to have fair anchorages, although the western and north-western parts were trolled no satisfactory anchorage was found on the visits in April, 1955. The reefs are rather widely separated and some are sufficiently deep to be sailed

over without sighting except in good weather conditions. On the crossing estimated at the middle of the reef an unbroken chain of reef was seen to the south and small reefs were found at irregular intervals inside this area which formed a relatively calm area of sea. Fish were not taken except near the reefs and best results were obtained near the north-western boundary of the reef. An extensive lagoon without any visible entrance lies to the northern extremity of the reef area. Tides at the time were strong and sharks caused some damage, and gear was lost through strikes by big fish.

Eastern Fields.—The three reefs, East Cay, Portlock Reefs and Eastern Fields, form a series in which there is a change from small but compact reef over which there are depths of 3-5 fathoms to Portlock Reefs where there is an area of more scattered reef with shallow parts at the edges while a shallow lagoon in at least one case, had extremely precipitate margins in which the outer wall was almost perpendicular to a depth of 50 fathoms. No fish were taken approaching Eastern Fields reef in late evening, one shark was taken with a handline in 50 fathoms. However, crossing about the centre of the reef area two very large fish broke lines. It is considered that the greatest supply of fish nearest to Port Moresby is at Eastern Fields Reefs with Portlock Reef as the next best area. Although relatively small catches were made the fish are of greater size and with a well equipped ship good results would be obtained.

The fishing grounds of the Coral Sea could be worked for four to six months a year and to make regular fishing voyages would require a vessel of about 200 tons.

4.—*Central South Coast of Papua*—

Grange Island.—Inside the sunken barrier between Port Moresby and Samarai, European vessels have seldom taken many fish yet Native canoes, fishing in conditions which deter small coastal ships, are able to take fair quantities of troll fish. The reason appears to be that fish do not take lines readily under conditions in which vessels can steam close to the reef, whereas canoes in a fresh breeze can be managed better and with their shallow draft can, with greater safety, be navigated close to reefs. There are fair stocks of fish near the sunken barrier in a number of places but in six cruises from 1949 to 1955 only a few fish have been taken. Off Grange Island three Spanish mackerel were taken in 3 minutes, but no further strikes were obtained over a period of 40 minutes trolling about the reefs to the west and around the Island.

Off Mogubu comparable results were obtained and in a period of more than two hours only at infrequent intervals was a small mackerel obtained and in the passage from Mogubu to Fyfe Bay under fair weather conditions only slightly better results were obtained .

5.—*East of Samarai*—

A number of good fishing reefs lie within a few hours steam of Samarai. Most important of these tested in 1949 and 1950 were fished again and results were again found to be good. Greatest quantity of fish was taken over Emerald Shoal and Reef which is an extension of this shoal and not different in character or depth of water. Fish on this shoal were found only in patches with different schools of fish on various parts of the shoal. Small motor boats in fair weather should make good hauls on this reef which is quite extensive and fish were found over an area about 15 miles north and south and 20 miles east and west. On the Western Boundary there are isolated reefs separated by deep water from the main shoal, but generally the depth over the shoal is from 5-7 fathoms with extensive patches of white sand (where few fish are caught) lying between dark areas of reef on which the fish can hide.

On Kosmann Reef the fastest trolling rate of catch in the area was made in poor weather and although some losses were experienced through sharks, these were not serious. This reef is not so extensive as Emerald Reef and is estimated to extend approximately 9 miles to the north-west of Kosmann Island and about 6 miles wide near the island. Although there are shallow parts, it is generally deeper than Emerald Reef and there are depths of over 10 fathoms.

Principal reefs to the south-east of Samarai lie between Kosmann Island and Uluma Reef where on the inside of the sunken Barrier good catches may be made in isolated parts. On the passage to Uluma Reef, 30 lb. of fish per hour were taken. Although this was exceeded in the passage off Yule

Island, conditions were different and the isolated reefs east of Samarai are most productive and would, for short periods, yield results comparable to those obtained at Emerald Reefs.

Other important reefs were found in the vicinity of Wari Island, where, although there is a considerable Native fishing population, some good catches were made to the south near a large lagoon reef, and to the north at Ikalka and Bell Rock.

The most extensive reef bearing good stocks of fish is the Siriki Shoals which, while deeper and more crossed by channels than Emerald Reef, is similar to it in many respects and bears similar species of fish. Trolling with small motor boats over this area, which like Kosmann and Emerald Reefs, receives much protection from southerly weather by the Barrier Reef would be practicable for a large proportion of each year.

Bremer Island has not produced good results although it was previously reported to be a good fishing ground. Tests on three occasions yielded only about 60 lb. of fish for four hours trolling over reefs.

Principal trolling results show conclusively that there are few extensive relatively rich grounds with great lengths of coast-line bearing, at least inshore, quite small stocks which are caught only by special methods or under favourable weather conditions, viz., cloudy sky and a moderate sea. At the following places more than 100 lb. of fish were taken per hour :—

Anchor Cay	....	180 lb.
East Cay	....	138 lb.
Eastern Fields	....	112 lb.
Emerald Reef	....	114 lb.
Kosmann Reef	....	129 lb.

Of the areas where satisfactory trolling may be found the nearest produced 125 lb. of Spanish mackerel and yellowfin tuna in 1½ hours; concentrated fishing in the area may improve on this result. As this ground is only 60 miles from Port Moresby this class of fishing may be an economic possibility. Of the grounds mentioned above, the next nearest to Port Moresby is Eastern Fields Reef, 100 miles distant.

The only method by which the reefs east of Samarai could be economically fished would be for the catch to be loaded to refrigerated vessels trading to the Territory, for shipment to centres where supplies are needed.

Although trolling and chumming off Kapa Kapa produced few fish the shoals which come in to feed on the post-larval anchovy offer one of the greatest potential fisheries in southern Papua, and if further trolling methods do not produce better results, netting with mesh or beach nets may prove more satisfactory.

IV.—*Line Fishing.*

Handlines.—Testing of an area for handline fishing presents difficulties as commercial fishing grounds are usually developed in connection with economic needs. It was found most practicable during the survey to anchor at night wherever possible on a reef that might prove productive. In the Port Moresby area most satisfactory results were obtained in Idiha Island shoal, a sand and coral bank to the west of Idiha Island. Under rather unfavourable tide conditions, but using patu bait, 40 lb. of fish were taken during 2½ hours. Comparable reefs with similar species of fish are found off Tupuselei, the principal species being *Lutganus coatesi* (local name Siaro).

At Eastern Fields it was not possible to fish inside the lagoons, and at a depth of 50 fathoms, within a few yards of the reef, only one black-tip shark was taken. At Conflict Reef near Panassea 90 lb. mixed fish, including *Epinepelus, Lutjanus coatesi, L. ornatus* and *Lethrinus* were taken from motor boats and vessel in two hours.

Best results in Papua, in this and a previous survey, were made off Kosmann Reef where with handlines 210 lb. of fish were taken in 4 hours with three lines. Conditions were favourable, there being a small tide, and the bottom was relatively clear. The rise and fall in tide estimated for Port Moresby when this catch was made showed only 3 inches difference between high and low water.

Long lines.—Horizontal lines were tested in lengths up to 2 miles off Port Moresby, Hula Village, Jokea and Milne Bay. Sharks were taken to a depth of 15 fathoms. None, however at 35 fathoms, although at 15 fathoms in the same place, off Port Moresby, two sharks were caught. Results are given in Appendix II.

Horizontal long line fishing cannot be considered an economic possibility until the grounds are further prospected and a supply of first-class bait is available.

Two sets were made with vertical lines off Fisherman's Island and off Jokea; only one shark was taken. Milne Bay is an extensive area of relatively sheltered water. It undoubtedly has good stocks of fish but as in 1951, attacks by sharks damaged much long line used horizontally and made fishing quite unprofitable. In May, 1955, fifty hooks used on a line anchored in 80 fathoms, set diagonally and buoyed at the surface produced parts of the heads of two sharks estimated at 8 feet in length. Four hooks were lost and a cod 8 lb. in weight was taken. This is the only locality where fish other than sharks were taken on set lines.

In Milne Bay fish are not caught by the Native people for a considerable part of the south-east season, April to October, although parts of the bay are of sheltered water. Vertical lines in 80 to 100 fathoms may make a substantial contribution to their needs.

V.—*Fish Trap and Mesh Nets—Bootless Inlet.*

The need for a continuous supply of fish is frequently most obvious in otherwise prosperous communities where gluts of fish alternate with periods of scarcity. This is most marked in Port Moresby where Native fishing in the south-east season may practically cease for a week or ten days because of the weather conditions.

After preliminary fishing tests with nets and lines in Bootless Inlet in 1954 and 1955, a wire mesh fish trap was installed to the east of Dogura Village. One arm of the trap 150 yards long, was built to take the run-off from Bomana Creek where good quantities of mullet and small sharks are often taken. During the first nine days the trap was operated, catches were poor, but 280 lb. were taken on the tenth day in mesh nets used in association with the trap. Severe south-east winds broke part of the trap which was moved about 200 yards west to a more suitable site, with respect to the weather. An estuary rather wider than the Bomana River opens into the north-west corner of the Inlet (no fresh water runs in the watercourses entering Bootless Inlet in the south-east season).

Further catches in the mesh net, however, showed that they were superior to the wire mesh trap and in an operating period of fifteen days the daily catch of traps and mesh net amounted to 63 lb. bony fish and 10 lb. sharks and rays.

Principal difficulties were watching the trap and fishing every tide over a seven day period and keeping the small quantity of fish in good order. Lightly salting proved satisfactory over a 36-hour period but transport by motor truck proved too costly for the amount of fish produced.

A group of three Tupuselei Natives fished the traps and mesh nets for two weeks getting the fish to Port Moresby as best they were able. Value per man was stated to be approximately £3 per week. The fishing finally stopped because of other necessary seasonal work in the village and the trap was removed.

The information from the trap in Bootless Inlet suggests that in this region a trap is not sufficiently productive to be a success. Three inch mesh nets at this season take impressive quantities of fish and the method will be further tested. Most abundant species were the Hairback Herring *Nematalosa nasus*, Wolf Herring, *Chirocentrus dorab*, Leatherskins *Chirocentrus* and Mullet *Mugil*.

Netting.—Mesh netting, although profitable in the vicinity of Port Moresby, was not entirely successful in two other places tested; to the east and west of Red Scar Head small Spanish mackerel were taken; off Dedele Point a small variety of fish was taken. This class and size of net is more suitable for enclosed waters and beach seine nets are more satisfactory for exposed waters.

VI.—*Bait Fishing.*

For trolling, salt gar *Hemirhamphus* was used and best supplies nearest Port Moresby were obtained at Hula Village. Both *Hemirhamphus far.* the barred gar and *H. dussumieri* the striped gar were taken, the latter being most satisfactory for bait. Small quantities were also obtained at Fisherman's Island where there is a small sandy bay on the north-eastern corner.

In Port Moresby from Vabukori to Tatana, sprats *Dactylolepis* (Motu-patu)

come inshore during the south-east season and although they tend to jump over the cork line of the hauling net it was found that 1 inch mesh 9-ply used as a beach net effectively catches a large part of the shoal as the fish become meshed. A lift net has been successfully used to catch quantities in excess of 400 lb. in an hour. Anchovy *Engraulis* (Motu-herre) of a similar size are also caught in this way and are an excellent bait.

At Kapa Kapa "whitebait" also came close inshore, they may be caught in mosquito net or woven net of Native material. These fish which are advanced post larval anchovies *Engraulis* are too large to use as whitebait, European style. They vary in size from 2.1 to 2.7 inches in total length. The large head and the advanced post larval development showing a broad silvery band on each side of the body seriously detract from their appearance as whitebait for food. They are excellent bait for chumming but rather small for use on a hook.

Best results in bait fishing for 4-6 inch size fish have been found with a lift net in the shape of a truncated triangle using a small beach seine to drive the shoal over the broad side of the lift net.

VII.—*Canoes Versus Motor Boats.*

Three tests of Native canoes versus motor boats were observed. Two tests off Kapa Kapa to Gaile with a 16 foot motor boat powered with a 7-9 horse-power diesel proved about equal under fair weather conditions. A low-powered petrol engine in an 18 foot motor boat gave comparable results to the diesel-engined vessel. Some Natives with much experience on canoes experience difficulty in judging the weather conditions for small motor boats and it is significant that the larger canoes can be more effective fishing vessels than quite large motorized craft. On one part of the coast while motor vessels were sheltering from the weather some of the larger Native canoes were taken out fishing and made excellent catches. Shallow draft, manoeuvrability and fine sailing qualities, however, do not completely recompense for the loss of comfort of the crew, and such fishing even for Natives is limited to relatively short expeditions in the vicinity of villages.

In a further test with an outboard motor and dinghy it was found that for trolling, inboard engines are superior. During the south-east season it would not be desirable to use outboard motors even inside the reef on the south coast of Papua except for short periods of favourable weather. In the north-west season, however, there are considerable periods when outboards would prove of great assistance in developing fisheries and they will be of particular use in estuaries in enclosed waters.

VIII.—*Marketing of Fish.*

At the Koki Market prices of fish vary to some extent according to species, generally, however, small fish of average quality cost 2s. 6d. per lb. and larger from 1s. 6d. to 2s. per lb. This makes the cost on a basis of skinned fillets approximately 3s. 6d. a pound, a price comparable to that of imported fish. It is difficult to determine how much fish is sold in the Port Moresby Native Market where in the late afternoon, fish are on sale strung on poles. The number of poles varies with the weather and in bad conditions only two or three poles bearing twenty to forty pounds of small fish each may be displayed, whereas on days when fishing is good as many as eighteen to twenty poles may be displayed and the weight may vary from 80 lb. to 100 lb. per pole, most of the fish being more than 5 lb. in weight.

These supplies give only the quantity of fish on display at one time. An average daily turnover during the south-east season could be based on seven poles bearing 400 to 500 pounds of fish and this probably represents about half the daily sales of fish including smoked fish at the Koki Market. It is reported that during a particularly good run of fish off Tupuselei in August, 1955, that 400 mackerel tuna were taken in one day and all were smoked and delivered to the Koki Market. The weight of these fish was estimated at 3,600 lb.

In July, 1954, a group of Tatana Natives organized commercial fishing to supply some Administration messes at Port Moresby. This effort produced, in a period of four months, until November, 6,242 pounds of fish and 870 dozen oysters. The fish was not all of good quality and the contract terminated

when it became known that the fish would be better used in the villages. The largest quantity delivered in one day was 680 lb. The price of the whole fish was approximately 1s. 6d. per lb.

The fish caught by the Division was disposed of as shown in Table 2, which includes mesh net caught fish and some bait fish. Some of the catch was unloaded at Samarai, transferred from the shore freezer and transported by refrigerated ship to Port Moresby, and after eight weeks in cool store reported to be in fair condition, being superior to imported fish. This test shows fairly conclusively that fish caught in the Territory and prepared by Natives under European supervision has a fair market. A small sample of this was sent to the Highlands where, however, thawing and re-freezing caused a considerable loss in quality.

Some tuna species which were kept for three months in a freezer were found to be in good condition but had suffered slight freezer-burn. Several samples of tuna, including yellowfin and dogtooth, were canned in association with a Native Co-operative Society. One sample of yellowfin in coconut cream proved to be quite a superior article being better than tuna in oil. Canned dogtooth tuna were inferior to yellowfin.

For a marketing test through Native Co-operatives, 60 lb. of fresh fish sold in about 30 minutes at a price of 1s. per lb. Shark and skate at 8d. per lb. sold last.

A small sample of tuna smoked hard Native style was sent from Kapa Kapa. This was cooked but not dried and had a safe keeping time of approximately 36 hours in Port Moresby conditions. The demand for this type of product, which is suitable for Native rations for labour lines and hospitals, exceeds the supply in the Native Market.

Smoking European style may have some advantages in eliminating slight losses. It is unlikely, however, that the demand from Native peoples would be appreciably improved. Salted fish for use in coastal areas, it is considered, would have only a limited sale. A test with salt and pyroligneous acid (liquid smoke) indicated that for the labour involved smoking over a fire would be preferable unless conditions were such as to necessitate transport before fired smoking could be completed.

Development of Fisheries.

Building of Japanese vessels was subsidized by the Japanese Government after the war for the development of fishing fleets. These have now reached considerable size and about 1,200 vessels exceeding 100 tons fish the eastern and southern Pacific as far as New Caledonia. These ships now have available to them information on the distribution of different species in the Pacific and Indian Oceans, and as a consequence, vessels of 100 tons capacity can be filled on these grounds in 25-30 days and sometimes less. The journey to and from the more distant fishing grounds, however, requires ten to twelve weeks and sometimes longer.

Vessels based in New Guinea employing Papuan or New Guinea Natives as crews under proper technical guidance should compete after a few years with these Japanese vessels. They have the advantage of port facilities and shore bases much closer to their fishing grounds and do not need to carry such large supplies of fuel and provisions. Fishing vessels based on Australia could not compete until a very high catch per day was achieved.

Native and European Industries.

European capital for development of edible fish industry as opposed to shell industry, will not be attracted until marketing and distribution in the Territory have been proved. Native organizations have an advantage in this respect that the vessels used by them could operate nearer Native villages than it would be advisable to allow European vessels to do. Off shore, at distances of 20 to 100 miles from main ports, there are extensive reefs which cannot be fished by Natives except under particularly favourable conditions and on some of these areas fish are abundant. It is considered, however, that a vessel of two hundred tons capacity would be required to work these reefs with any regularity and in any degree of comfort and safety; until crews can be trained using smaller vessels inshore ½-20 miles off the coast in the methods to be followed, fishing, except in a few uninhabited sheltered areas, will be the right of the Natives.

A large part of the south-east coast of Papua is not a rich fishing ground and it is probable that the Gulf fishing or reefs of

the Coral Sea will prove economic and more satisfactory than inside the Barrier Reef extending south-east and north-west from Port Moresby.

Except in the principal towns where there is a considerable European population and concentration of Native labour, large scale fishing is not likely to succeed unless the Administration and business firms are prepared to give assistance to the fishing industry by using locally caught fish for their Native staff. Natives in villages or in the towns have not the money to purchase very much fish based on European prices and Europeans even in the larger towns aften show a preference for imported fish. In Port Moresby alone, the European requirements for fresh fish may be stated at between 2,000 and 2,500 pounds per week. Native requirements, in addition to present Native supplies may exceed a further 5,000 lb. weekly. In a small town where there is a considerable demand for fish, a local retail store, supplied through the Native Co-operatives, sold (at a price approximately half that of the imported article) ten pounds of locally caught fish in two weeks. The balance of the fish supplied was used for Native labour.

To establish a fishing industry the most effective aims are to supply—

(*a*) the larger towns for European consumption;

(*b*) to the large companies and to the Administration for Native staff;

(*c*) Native Co-operatives which are able to sell small quantities in the larger towns where Native staffs are employed by Europeans.

As much knowledge of local conditions is necessary for successful fishing, the most satisfactory way in which an industry may be established would be for Native Co-operatives or European firms established in the Territory to organize vessels to fish the most highly productive areas and to establish pilot plants so that supplies of fish in excess of those which can be used fresh, may be smoked or canned. At least one fishing venture in New Guinea failed because of lack of attention to disposal of catch which was surplus to the local needs of fresh fish.

TABLE 1

RESUME OF FISH LANDED—FISHERY SURVEY, PAPUA
23rd March—16th May, 1955 (gutted weights)

Date	Locality	Sharks (lb.)	Tuna, Spanish Mackerel, etc. (lb.)
1. 4th-18th February, 23rd-29th March	Bootless Bay to Idia Island (long line) .... Red Scar Bay—Idia Island	450 260	 100
2. 31st March-10th April	Across Gulf to Bramble Cay and Portlock Reefs	....	260
3. 18th-27th April	Eastern Fields, Portlock Reefs to Daru, Fly River Mouth	....	840
4. 2nd-8th May	Port Moresby, east to Samarai	....	320
5. 10th-18th May	Milne Bay, Conflict and Emerald Reef and Siriki Shoals	....	2,041
6. 20th-26th May	Bell Rock, Shellard Ridge, Dumolins, return to Port Moresby	....	456
		710	4,017

TABLE 2

DISTRIBUTION OF FISH (excluding Sharks)
February to July 1955

—	Natives and Native Labour	Native Hospitals	European Hospital and Messes	Experimental
Port Moresby	610	750	1,560	200
Samarai	630	480	....	460
Rigo	260	....	....	....
Conflict Group	80	....	....	....
Daru	40	....	....	....
	1,620	1,230	1,560	660

APPENDIX I

TROLLING AND CHUMMING RECORD

Station	Date	Locality	Depth fathoms	Bottom	TIME			Tide	Catch—species and number of fish and weight in pounds	Remarks
					Shot	Finish	Total Time			
							H. M.			
1	24.3.55	Caution Bay to Idia Island	....	..	11.0 a.m.	12.20 p.m.	1 20	½ E.	1 yellowfin tuna (18)	Caught inside passage west of Island. Many surface shoals of fish.
	25.3.55		....	....	8.30 a.m.	4.30 p.m.	8 0	....	4 trevally (24), 1 pike (30), 1 trout (8)	
2	1.4.55	Off Yule Island	....	....	11 a.m.	1 p.m.	2 0	L.W.	2 mackerel (24), 1 pike (28), 1 turrum (20)	Near Island steaming to Cape Possession.
	27.4.55	Off Yule Island	....	....	10.30 a.m.	noon	1 30	½ F.	3 mackerel (47), 3 yellowfin tuna (74), 1 pike (4)	Off Island near 100 fathom line.
3	2.4.55 to 6.4.55	Cape Possession to Jokea to Panaroa to Fly River	....	....	....	....	18 40	....	1 golden trevally (6), 1 mackerel (3)	Close inshore about 7 fathom line all daylight steaming. Water usually showing evidence of fresh water from rivers.
4	22.4.55	Anchor Cay to East Cay	....	....	10.40 a.m.	12.35 p.m.	1 55	½ E.	25 mackerel (313)	Mackerel taken in small area off Anchor Cay. Fish taken over wide area includes 2 sharks 290 lb.
	8.4.55 to 9.4.55						4 0		5 mackerel (105), 9 turrum (92), 6 others (356)	
5	9.4.55	Portlock Reef	....	....	10.45 a.m.	3 p.m.	4 15	½ E.	3 mackerel (51), 3 turrum (59), others (65)	Some gear broken with sharks and large yellowfin tuna. Trolling over big area. Fish not taken where previous catches made.
	21.4.55	Portlock Reef	....	....	10.30 a.m.	11.20 a.m.	- 40	½ E.	1 tuna (18), 1 pike (18)	
6	20.4.55	Eastern Fields	....	....	6.30 a.m.	9.15 a.m.	2 45	H.W.	5 tuna (265), others (45)	Crossing reef fish taken only near shoal areas. Lost two lines with big fish.
7	5.5.55	Off Grange Island	....	....	11.5 a.m.	12.20 p.m.	1 15	¼ E.	3 mackerel (48)	3 fish taken in 3 minutes. None others taken in 1¼ hours. Trolling about Island.
8	6.5.55	Off Mogubu to Fyfe Bay	....	....	8.20 a.m.	10.40 a.m.	2 20	¼ E.	4 mackerel (21), pike (9)	Water calm, clear and fish jumping.
	7.5.55		....	....	7.35 a.m.	12.10 p.m.	4 35	½ E.	5 mackerel (40), 2 jobfish (17), trevallies (36)	Weather cloudy.
9	13.5.55	Emerald Reef	....	....	1.40 p.m.	5.10 p.m.	3 30	H.W.	1 mackerel (18), coral trout (20), 2 jobfish (13), 6 trevallies (82), tuna (7)	Fish take line on this reef mainly before 9.30 a.m. and after 5.30 p.m.
	14.5.55	Emerald Reef	....	....	7.45 a.m.	10.15 a.m.	2 30	½ E.	4 mackerel (34), 7 tuna (171), 3 red bass (19), 1 coral trout (16), 1 trevally (10), 2 pike (8)	

10	15.5.55	Emerald Reef	....	....	6.40 a.m.	12.20 p.m.	5	40	E.	4 tuna (63), 10 mackerel (124), 3 pike (24), 16 jobfish (117), 3 red bass (18), 3 trevally (22)	Although the reef is extensive fish are taken on only a limited area.
11	15.5.55	Kosmann Reef	....	....	2.45 p.m.	5.10 p.m.	2	25	H.W.	2 mackerel (24), 1 tuna (12), 1 pike (6)	Sky cloudy and heavy. Fish not taking lures.
	16.5.55				8 a.m.	9.20 a.m.	1	20	½ E.	3 mackerel (45), 3 red bass (19), tuna (13), 2 jobfish (17), coral trout (12), others (66)	Serious trouble with sharks, which took 2 fish and broke gear.
12		Kosmann Reef to Uluma Reef	....	....	12.30 p.m.	4.30 p.m.	4	0	H.W.	5 mackerel (77), 1 jobfish (11), 7 others (45)	Sky clear, sea calm. Fish not biting although passage steamed very close to reefs.
13	17.5.55	Siriki Shoals	....	....	7 a.m.	9.30 a.m.	2	30	½ E.	13 mackerel (168), 4 jobfish (27), 1 tuna (8)	On two days fishing in rough weather 23rd and 24th May over parts of this area no fish were taken.
		Wari Island									
		Ika Ika	....	....	9.30 a.m.	12.30 p.m.	3	0	¾ E.	3 mackerel (59), 12 jobfish (110), 1 pike (21)	
		Bell Rock									
14	23.3.55	Port Moresby to Caution Bay	....	....	2.45 p.m.	4.30 p.m.	1	45	¼ F.	1 spotted trevally (7)	Steamed on ship passage.
	31.3.55	to Keppel Point	....	....	8.30 a.m.	1.30 p.m.	5	0	¼ E.	1 blue trevally (7), coral trout (8)	
	26.5.55		....	....	9 a.m.	6 p.m.	9	0	....	1 wahoo (59), pike (8), dolphin (18)	Steamed straight course off Tupuselei.
15	27.7.55 to 29.7.55	Kapa Kapa	....	....	....	....	8	0	....	2 northern bluefin (18), 1 mackerel tuna (5), 1 yellowfin (8), 1 mackerel (1)	Duck feather lures and plastic jigs. Tuna feeding on anchovy, many surfacing but few took troll lines.
16	27.7.55	Kapa Kapa	....	....	7 a.m.	9.30 a.m.	7	30	½ E.	3 northern bluefin (25)	Chumming with anchovies and with anchovies on 3 and 5/0 hooks with 8 inch wire trace and nylon line. Calm morning, choppy sea in afternoon.
					noon	5 p.m.			½ F.	3 mackerel tuna (18) 1 turrum (5)	
17	28.7.55	Kapa Kapa	....	....	noon	2.30 p.m.	2	30	L.W.	3 nothern bluefin (24) 3 mackeral tuna (12), 1 morwong (*Plectorhynchus*) (4)	Chumming anchovy bait as 27.7.55. Large sharks took some fish. Choppy sea.
18	29.7.55	Kapa Kapa	....	....	11 a.m.	5 p.m.	6	0	L.W. to H.W.	1 northern bluefin (9), 3 mackerel tuna (20)	40 lb. anchovy used in chumming in 6 hours, lost many fish with sharks.
19	10.8.55	Kapa Kapa	....	....	5.45 a.m.	9.30 a.m.	3	45	L.W.	3 mackerel tuna (26), 6 northern bluefin (51), 1 mackerel (3)	Period of 1 hour chumming omitted no catch. Fish taken on troll lines.
20	12.8.55	Gaile	....	....	8 a.m.	11 a.m.	3	0	¾ E.	3 northern bluefin (24), 1 mackerel tuna (10), 2 mackerel (8), 1 trevally (5)	Includes 1 hour chumming for 18 lb. fish.

APPENDIX II

LINE FISHING RECORD HORIZONTAL LINES

Station	Date	Locality	Depth of Line fathoms	Bottom depth fathoms	TIME Shot	TIME Finish	TIME Total Time H. M.	Tide	Catch	Remarks
1	3.2.55	5 miles off Fisherman's Is.	15	400	11.20 a.m.	11.30 a.m.	2 10	½ F.	2 sharks for 8 hooks, 200 and 60 lb.	Line drifted strongly, travelled about 3 miles although tide not at spring rising 2 feet 6 inches.
2	17.2.55	1 mile off reef Hula Village Hood Point	15	200	9.30 a.m.	10.30 a.m.	1 0	½ E.	1 shark for 15 hooks, 400 lb.	Fresh south-east wind so lines hauled early.
3	24.3.55	8 miles off Idia Island	35	800	4.10 p.m.				No catch for 100 hooks	Miscellaneous bait, including 8 hooks with salted garfish. Remainder fresh gar and other fish.
4	28.3.55	½ mile south of north end Fisherman's Island	15	150 hard bottom	2.30 p.m.	6.15 p.m.	3 45	½ E.	2 sharks for 40 hooks and 1 swimmer mangrove crab. Sharks total 260 lb.	Line drifted strongly and travelled about 3 miles. Tide rise 2 feet 4 inches. Sharks easily handled by long line.
5	2.4.55	3 miles off Jokea Gulf of Papua	15	80 soft mud	11.15 a.m.	4.30 p.m.	5 15	H.W. to ½ E.	4 sharks, black-tip and similar species. 47 lb. 40 hooks	Bait mainly *Trachinocephalus* (Grinner). Line drifted at right angles to set in very soft mud. Only a few baits taken.
6	10.5.55 to 11.5.55	Head of Milne Bay	80 to surface	80 mud	5.5 p.m.	11 a.m.	17 55		1 Epinephalus 8 lb. 2 shark remains, 1 jaw bone and part of head	Bait *Selar crumenophthalmus*. Line left overnight not satisfactory. Epinephalus had not been on line very long. A considerable tangle of line on bottom section which had possibly caught severel Epinephalus all taken by sharks.
7	12.5.55	Head of Milne Bay	35	80 mud	8.30 a.m.	9.12 a.m.	42		20 hooks set. 1 bait and hook taken	Bait *Selar crumenophthalmus*. Results suggest that anchored vertical lines in Milne Bay with 20 to 50 hooks would be best for trials.
						VERTICAL LINES				
8	28.3.55	½ mile south of Fisherman's Is. Port Moresby	150	hard	1.45 p.m.	4 p.m.	2 15	½ E.	Nil. No baits taken	Baits possibly not satisfactory. 2 sharks were taken at 40 fathoms with horizontal line.
9	2.4.55	Off Jokea, Gulf of Papua	17	mud	12.15 p.m.	4 p.m.	3 45	H.W. to ½ E.	1 shark 3 lb. All baits taken from 2 lines with 12 hooks	Bait not satisfactory. Natives fish here with handlines evidently on the mud.

THE VEGETATIVE PROPAGATION OF *COFFEA ARABICA L.*

A. J. H. VAN HAAREN *

INTRODUCTION

THE importance of vegetative propagation in a number of tropic plantation crops is well known. The earliest work on the vegetative propagation of coffee was carried out in Java some sixty years ago, and suitable methods have been established there. However, it is necessary to confirm such results under local conditions and trials of various methods for the vegetative propagation of coffee were commenced at the Highlands Agricultural Experiment Station, Aiyura, in July, 1955. The aim was to develop successful techniques for vegetative propagation as a tool to be used in the breeding and selection programme. Whether the development of a practical method of vegetative propagation will have a direct applicability in plantation practice is at present uncertain.

Methods.

Three methods of vegetative propagation have been tried, namely :—

(1) Cuttings;
(2) Grafting;
(3) Budding.

Considerable success has been obtained with cuttings and grafts, but budding, although carried out successfully in other countries, has so far been unsuccessful at Aiyura.

1.—*Propagation by Means of Cuttings.*—

Experiments have demonstrated that coffee can be propagated at Aiyura by means of cuttings without the use of glass covered propagators, thus obviating the initial costs of cement, sawn timber and glass. Such propagators did, in the few trials conducted with them, lead to a small increase in the rapidity of striking cuttings, but this initial advantage was quickly lost. Excellent results were obtained with the simplest locally available materials, as will be described below.

(1) *Types of Cuttings.*—Cuttings from plagiotropic branches (laterals) give bushes of abnormal form in which the growth is flattened and insufficiently upright. Only cuttings from the orthotropic branches, generally known as suckers or watershoots, will give bushes of normal form, and they have thus been used exclusively in these studies.

Cuttings of various lengths and consisting of two or more internodes were used experimentally, but in these trials the longer cuttings did not give better results than single internodes. Only when the internodes are short (less than 2½ inches) is the use of two internodes advocated. The length of single internode cuttings varies from about 2½ inches to 5 inches. The use of single internodes, of course, permits the maximum increase of the material available which is most important in a plant improvement programme where the availability of material may limit the proper replication of treatments.

Generally speaking, the whole of the length of a watershoot is suitable for making into cuttings, with the exception of the top two internodes plus the terminal bud. Sometimes success will be obtained with this immature terminal growth, but results are variable. Great differences were not found in the rooting capacity between various parts of the watershoot. This is contrary to the findings of Roelofsen and Coolhaas (1) in Java, who found that " cuttings from young parts of a sucker survive and root better than cuttings from older parts, the terminal cuttings always being most successful ". Typical results using cuttings of different ages are given in Table I. Hormone treatment was used in some instances, but the pattern of behaviour was unaffected.

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TABLE I.—Influence of Age of Cutting on Root Formation

Cutting Material	No. of Cuttings	Number of rooted cuttings per treatment							
		* Hort. 1/100		Hort. 1/200		Hort. 1/300		Control	
		weeks		weeks		weeks		weeks	
		12	16	12	16	12	16	12	16
Two top internodes and terminal bud (two intern. cutting)	10	0	0	0	0	0	0	0	0
3rd Internode †	10	0	6	3	9	0	5	4	9
4th Internode †	10	6	10	1	10	2	10	3	7
5th Internode †	10	0	10	3	10	1	10	8	9
Single intern. Yellow, turning brown	10	3	6	1	9	2	9	2	9
Single intern. Brown wood	10	0	10	4	6	1	9	2	7

* Hortomone A, a proprietary hormone preparation for inducing root formation.
† Greenwood single Internode Cuttings.

Some of the terminal cuttings did root eventually but they were extremely slow in coming away and did not tolerate unfavourable conditions. The older brown wood cuttings were generally slower to form roots than those taken from the younger wood, but over a longer period the differences almost entirely disappeared. For practical purposes it is considered that any part of the watershoot except the tip is equally valuable for cuttings.

In taking cuttings it was found that results were better when the two leaves of the cutting were retained complete than when they were reduced. Whether the cut was made just above or below the node, or whether made with a pair of secateurs or a sharp knife was found to be immaterial. Consequently the quickest and most economical method, viz., cutting with secateurs just above the node, was adopted as standard practice. The impression was gained that making the cuts with secateurs and thus slightly damaging the tissues had a stimulating effect upon the root formation, but on the other hand the tissue damage also increased slightly the danger of root rot.

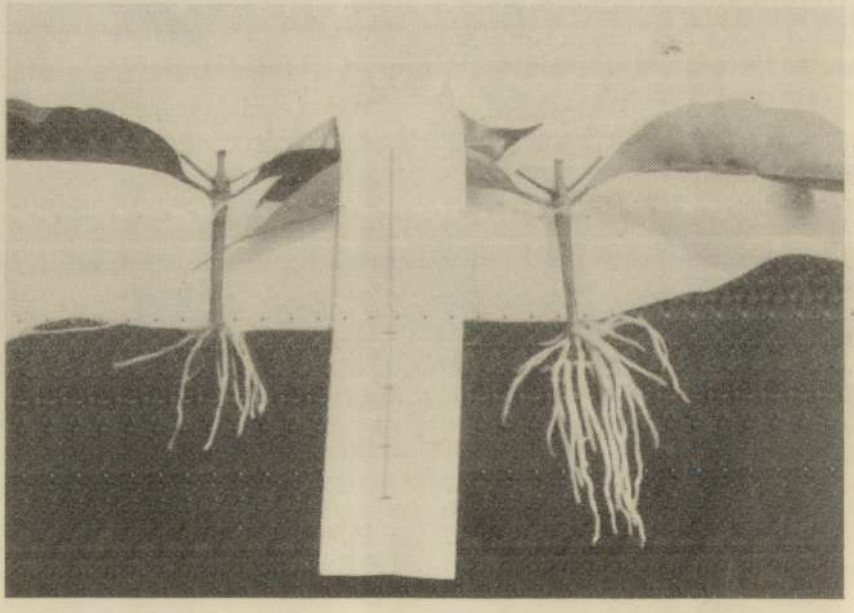


Fig. 1.—Effect of Hortomone A on rooting. Left—control. Right—treated. Age of cuttings—12 weeks.

(2) *The use of hormones*—The proprietary preparation Hortomone A was the only root inducing hormone preparation tried. It was generally found that Hortomone A did encourage early root formation, this being well illustrated by Figure I. However, the initial advantage was lost after a time, and from about the sixteenth week there was no difference between the percentage of successful strikes and vigour of treated and untreated cuttings. Nor was there any significant difference between Hortomone A at a concentration of 1:100 and 1:300. Some results with hormone pretreatment have been given in Table I and further results are presented in Table II. In every instance the cuttings were allowed to stand overnight (about 17 hours) in the hormone solution.

TABLE II.—Effect of Hortomone A Treatment of Coffee Cuttings

Treatment	Date Planted	No. of Cuttings	Alive Not Rooted		Rooted		Dead	
			12 weeks	16 weeks	12 weeks	16 weeks	12 weeks	16 weeks
Hortomone A 1 : 100	21.12.55	50	33	18	14	29	3	3
Nil	21.12.55	50	36	15	9	30	5	5
Hortomone A 1 : 100	5.10.55	40	31	9	9	31	0	0
Hortomone A 1 : 150	5.10.55	40	30	7	9	32	1	1
Hortomone A 1 : 200	5.10.55	40	34	8	6	30	0	2
Hortomone A 1 : 250	5.10.55	40	30	8	9	31	1	1
Nil	5.10.55	40	24	7	13	30	3	3

Under Aiyura conditions, therefore, there seems to be no advantage using hormone treatment, except possibly in the case of clones which do not produce roots readily or when very old mature wood is used for cuttings. Other hormone preparations may be more effective than Hortomone A, but they have not been studied as results with no treatment at all were entirely satisfactory.

(3) *Ecological Factors.*—

(*a*) *Light.*—Light is a most important factor in striking cuttings successfully. The secret of successful propagation is to keep the leaves alive and healthy and root formation will eventually follow. Herbaceous cuttings usually have only small amounts of stored auxin and cannot survive and form roots on their stored reserves only. Their successful propagation thus depends on the continuation of the normal assimilation processes by their leaves in the presence of light. Under tropical conditions however, the ratio between assimilation and respiration is often unfavourable. High night temperatures with consequent increased respiration require increased assimilation, which in turn depends on more sunlight; however if sunlight is increased too much, excessive transpiration and leaf burning follow. To summarize, " the whole question of retaining the leaves on the cutting depends on whether the cutting assimilates more during the daytime than it respires during the night " (2). It is sometimes necessary to use glass-covered propagators to obtain sufficient control of these factors, but under Highland conditions this has not been necessary.

At Aiyura it has always been necessary to use some shade; when cuttings were exposed to full daylight they quickly lost their leaves and died, even when frequently wetted using a knapsack spray. After considerable trial and error, the best results have been obtained during the dry season with a light intensity of 30 per cent.-40 per cent. of that of normal daylight, ranging up to 80 per cent.-85 per cent. of normal intensity during the wet season. It is a matter of experience under any particular set of conditions as to what amount of shade is required for the best results. The increased humidity and lower temperature of the medium probably affect propagation during the wet season, but it is believed that the reduced number of hours of sunshine per day is the most important variable. The adverse effect of over-heavy shade during the wet season is well illustrated in Table III. All measurements of light intensity were made with an ordinary photographic exposure meter.

TABLE III.—Influence of Light Intensity Upon Root Formation. Planted 21.12.55.

Treatment	Number of Cuttings	Alive Not Rooted		Rooted		Dead	
		12 weeks	16 weeks	12 weeks	16 weeks	12 weeks	16 weeks
Light intensity 30 per cent.-40 per cent. of daylight	100	44	34	2	12	54	54
Light intensity 80 per cent-85 per cent. of daylight	100	69	33	23	59	8	8

The simplest and cheapest form of shade used was a heavy cover of ferns, little more than 12 inches from the ground, which is illustrated in Figure 2. However, this shade reduced the light to 30 per cent.-40 per cent. of normal intensity, and was satisfactory only during the dry season. During the wet season, bamboo blinds, 3 feet-4 feet above ground-level (illustrated in Figures 3 and 4), have proved to be satisfactory, and they permit up to 80 per cent. to 85 per cent. of the normal light to enter. The use of these bamboo blinds throughout the year is satisfactory as they can be supplemented by additional shade when necessary, but for large scale propagation it would be more economical to carry out the operation during the dry season, using fern shade only.

(*b*) *Humidity.*—Humidity is most important in the successful propagation of cuttings and the objective has been to maintain as high a humidity as practicable at all times, in order to reduce transpiration. Excessive transpiration leads to wilting, followed by loss of the leaves and death of the cutting. At the same time, care must be taken that not too much water is applied to the rooting medium or waterlogging and rotting of the cuttings will follow. The technique adopted in these trials was to give a quick wetting with a fine spray, at hourly intervals from 8.00 a.m. to 5.00 p.m. on fine warm days, with decreasing frequency on overcast days. However, at times the application of moisture to the soil was excessive and rotting did occur although this trouble could be avoided by the use of pure sand as a rooting medium. This medium had other disadvantages, as will be shown in a later section.

Under the relatively uncontrolled conditions of experimentation at Aiyura, the correct maintenance of humidity is primarily a matter of experience and the judgment of the propagator.

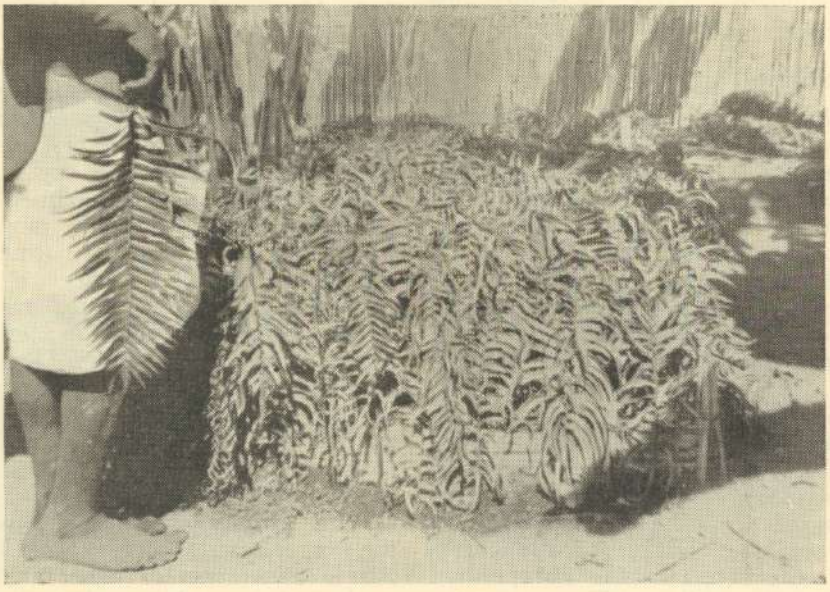
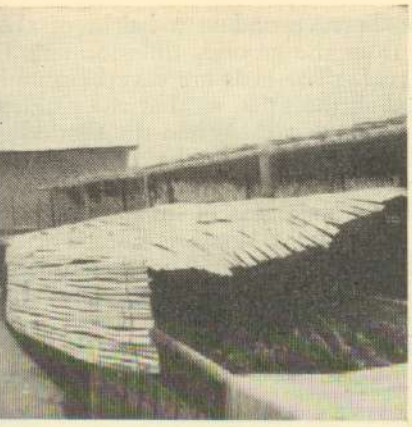


Fig. 2.—Heavy fern cover over propagator.



ig. 3.—Bamboo blind in down position.

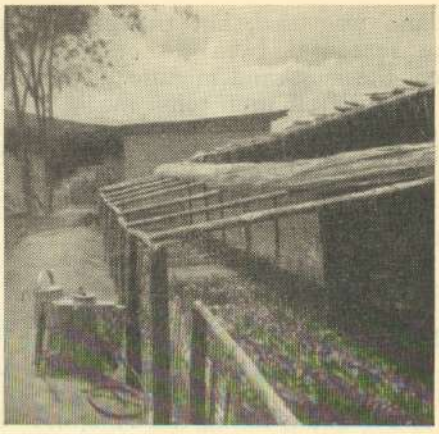


Fig. 4.—Propagator with bamboo blind rolled up.

) *Temperature.*—The maximum tem-ture for coffee propagation is said to 8° F. (31° C.). Under Highland con-ns this is very rarely reached. Although optimum temperature appears to be een 79° F. and 84° F. (26° C. and C.), very good results were obtained at ra with an average day temperature of F. (22° C.) and an average range from F. (12° C.) to 78° F. (25° C.). No erature control was possible so that a comparison of results at different temperatures could not be made.

(*d*) *Media.*—A number of rooting media was tried including coarse sand, fine sand, sawdust, local soil, moss and sand and mixtures of soil and sand and sawdust and sand in various proportions. Fine sand was unsatisfactory as it consolidated unduly after a period, and its use was soon abandoned.

Typical results with a number of media are given in Table IV.

TABLE IV.—Results Using a Range of Rooting Media

Rooting Medium	No. of Cuttings	Planted 9.9.55				Planted 29.12.55			
		Rooted		Dead		Rooted		Dead	
		12 weeks	16 weeks	12 weeks	16 weeks	12 weeks	16 weeks	12 weeks	16 weeks
soil (sifted)	40	7	20	15	15	5	13	22	22
(coarse)	40	6	32	0	0	0	13	0	0
ust (well rotted)	40	5	15	2	2	1	7	2	2
and coarse sand 1 : 1	40	21	34	1	1	15	34	1	1
and coarse sand 1 : 1	40	12	31	3	3	9	30	3	3
ust and coarse sand 1 : 1	40	12	35	0	0	3	21	2	2

ell-rotted sawdust, although generally ded as one of the best rooting media, disappointing results in these trials. ings transplanted from 100 per cent. lust in the propagation beds to 100 per local soil in the nursery beds also red more of a set-back than cuttings splanted from other media.

medium consisting of coarse sand and in equal proportions gave outstanding lts with regard to percentage of rooted cuttings as well as further growth after transplanting. This medium is not really practical although of experimental interest, but it would seem to indicate the desirability of the addition of humic materials to any medium. A rooting medium consisting of one part of local soil and one part coarse river sand, thoroughly mixed, has been adopted as the standard medium for the practical propagation of cuttings. Not only was the strike obtained very good when this

medium was used, but transplanting was more successful from no other medium except the moss-sand mixture. Transplanting to local soil from some media such as pure sawdust and pure sand caused serious set-backs and heavy losses; at least two transplantings are necessary to graded media so that the change of environment will not be too sudden.

(4) *Season.*—The best time of the year for successful propagation of coffee cuttings under Aiyura conditions seems to be the dry season, and especially the months July-October. It is easier to control light intensity and humidity during these months. The months December-April are least favourable, and many dead cuttings were found during these months; root formation also tended to be slower. At times during the wet season, light intensity is too low and there is too much moisture for good soil aeration. It is assumed that these are the factors mainly responsible for the greater difficulty of striking cuttings during the wet season.

(5) *Technique.*—The propagation beds at Aiyura are 4 feet wide and of various lengths, built up at the sides which are supported with flattened bamboo, and filled with the rooting medium to a depth of 10 inches-12 inches.

Suckers are collected early in the morning and the laterals developing from the leaf axils are reduced to half an inch in length. Cuttings are made as described previously and planted immediately or else allowed to fall into a bucket of water if there will be some time lag before planting out. This process is always carried out under shade. Planting is done by pushing the cuttings into the medium right up to their leaves with spacings of 5 inches between rows and 2 inches within rows. Whether the cuttings are planted vertically or at an angle has not affected the results. If planting be done during dry weather, the beds should be thoroughly moistened and cloudy days are preferred for setting out new beds of cuttings.

After the cuttings are planted, the shade is built above the beds, being either of bush ferns or bamboo blinds as already stated. To make the fern shade, the fronds are placed in lines between the cuttings and bent over, breaking the midrib, all in the same direction and at a height of about 1 foot from the ground, thus forming a tile-like roof. The beds are covered completely including the sides, so that the cuttings are not visible at all. When the shade is close to the ground as is the case with ferns, evaporation is at a minimum and an even level of humidity is maintained. The ferns dry up and the shade is automatically reduced gradually as time passes. When bamboo blinds are used, a supporting structure must be built from bush timber, at the required height (3 feet-4 feet) from the ground.

If weeding is necessary it should be carried out by partly removing the shade and replacing it as the work proceeds; weeding should be done on cloudy days.

(6) *Observations and Results,*—Root formation seldom takes place in less than 8 weeks and usually commences between the 10th and 16th week. Some cuttings do still take after the 16th week. During the more favourable times of the year an average of 25 per cent. of rooted cuttings can be expected after 12 weeks, 75 per cent. after 16 weeks, and up to 90 per cent.-95 per cent. if the remaining cuttings are left a few weeks longer. During the less favourable times of the year the precentages may be down to 10 per cent. to 15 per cent. and 50 per cent. to 60 per cent. after 12 and 16 weeks respectively.

New growth from the buds in the leaf axils usually commences just after 6 weeks, and will average 4 inches in length after 4 months, 6 inches after 6 months, and 10 inches after 9 months. The average length of roots at the same ages are 2 inches, 5 inches and 8 inches respectively. Compared with seedlings of the same age, cuttings are usually somewhat better developed (See Figuree 5*a* and 5*b*).

As shown in Figure 5*a*, the plants grown from cuttings do not develop a tap-root system like seedlings, nor do their main roots correspond entirely to the lateral roots of seedlings. Cuttings develop several main roots with a mass of fibrous roots which give the impression of a modified tap-root system. The absence of a tap-root does not appear to be a disadvantage, although subsequent growth, yield, etc., will have to be observed over a long period before this contention can be maintained with confidence. The

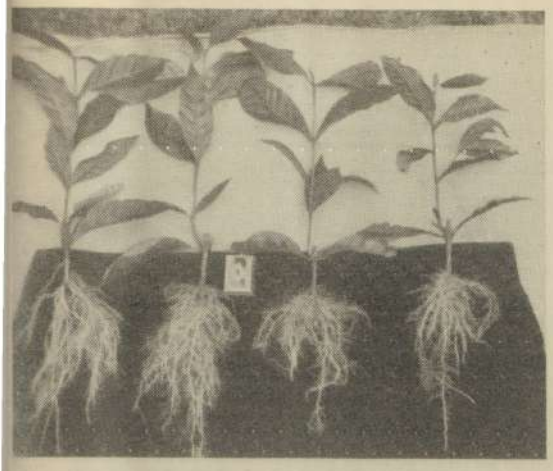


Fig. 5a.—Cuttings at 8½ months (made 13.7.55).

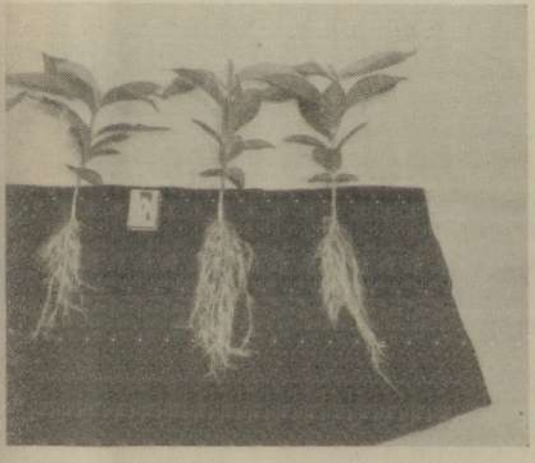


Fig. 5b.—Seedlings at 8½ months (sown 6.7.55).

absence of a tap-root may even prove to be an advantage where the water table is on the high side.

The initial spacing of 5 inches by 2 inches is not sufficient to permit development of the cutting to the stage where it may be transplanted directly into the field. The practice adopted has been to leave the cuttings in the propagating beds for 4 months and then transplant them to a nursery at a spacing of 6 inches by 6 inches, where they are left for a further 4 months before they are transferred to the field. Alternatively, satisfactory results may be obtained by planting the cuttings originally at 6 inches by 6 inches and leaving them in the original propagation beds for 8 months before transferring them directly to the field. This latter method, however, is prodigal of the use of the special rooting medium; it is more difficult to control humidity with the wider spacing; and finally, rejection of badly rooted specimens at the time of transplanting cannot be performed.

2.—*Propagation by Grafting.*—

Although practically all methods of grafting have been attempted in the main coffee growing countries of the world, it is apparent from the work of others that the cleft or wedge graft has proved most successful. At Aiyura, cleft, saddle, whip (or splice) and side grafting were carried out and cleft grafting was most successful. As it is also the simplest of these methods, it has been adopted as the standard technique at Aiyura. Typical cleft grafts are shown in Figures 6, 7 and 8. Experiments have been carried out

Fig. 6.—Cleft graft 10 weeks old.

to determine under what circumstances cleft grafting can be used with maximum success under local conditions. The factors studied, which will be dealt with separately, include type of stock, height of grafting, type of scion wood, type of graft cover, time of

Fig. 7.—Cleft graft 15 weeks old.

Fig. 8.—Cleft graft 8½ months old.

removal of cover and tying material and seasonal influences.

(1) *Type of Stock.*—Most workers agree that the best stocks are seedlings of 1-2 years of age. The only seedlings available at Aiyura at the commencement of these experiments were 18-20 months old, spaced at 15 inches by 15 inches under normal nursery shade. Their stem diameters at ground level varied from 1 cm.-2 cm. Although this stock was considered somewhat too old, the stem diameter at grafting height being rather too great and the bark tissues too rough, all the trials had perforce to be carried out on this stock. The ideal stock has a diameter of 7 mm.-9 mm. (pencil thickness) grafting height and at Aiyura this size is attained at an age of 12-14 months.

(2) *Height of Grafting.*—In the Philippines the stock is cut back to a height of 12 inches from the ground, in Tanganyika to 8 inches, and in Java the height is usually about 6 inches. Presuming that about 8 mm. is the optimum stock diameter at grafting height, the optimum height depends on the age and thickness of the stock. With twelve months old seedlings the optimum thickness is usually found at 4 inches-6 inches from ground-level. The older the seedling stock, the higher the best grafting height will be. The operator will also regulate the height of grafting according to the thickness of the scion which is ideally of the same diameter as the stock; it may be thinner but should not be thicker as good results will not be obtained if some of the cambial surfaces of the scion are exposed.

As grafts should not be implanted too high on the stock, the use of stock seedlings of the right age is important.

(3) *Type of Scion Wood.*—Orthotropic branches (watershoots or suckers) have always been used for scions, except for a few plagiotropic scions used experimentally, for the same reason as the former have been used exclusively for cuttings—plagiotropic scions will not produce a tree of normal form. A few grafts from plagiotropic branches (laterals) are being grown on to see what the growth and bearing habits will be like.

Hard green wood was grafted more successfully than brown wood and all scions are now selected from the middle sections

of watershoots (preferably of pencil thickness), discarding the soft top portion and the old brown wood. Length of scions is 2 inches-5 inches.

It was found that scions with leaves reduced to 1/3 to 1/4 of their length gave better results than those on which the leaves were left complete. Scions with all leaves completely removed also gave excellent results. There was some indication that it might be better merely to reduce the leaves thus in the wet season, but to remove them entirely when grafting during the dry season.

(4) *Type of Graft Cover.*—To prevent the graft from drying out some kind of graft cover has usually been found necessary as coffee scions seem to be particularly susceptible to dry conditions.

As binding material only raffia has been used and it is entirely satisfactory. As graft covers the following were tried :—

(*a*) Grafting wax;

(*b*) Moist spaghnum moss tied around the graft;

(*c*) A cylindrical cover of a length of banana leaf sheath around the graft;

(*d*) "Colgraft"—a proprietary grafting compound;

(*e*) Waxed paper bags covering the graft.

Colgraft proved to be the most effective and has the additional advantage of ease of application as it can readily be painted with a brush over the tying material and exposed cut surfaces.

(5) *Removal of Cover and Tying Material.*—The period elapsing between grafting and the removal of the cover and tying material varies from 3-4 weeks to 2 or 3 months in different countries. It was found at Aiyura that the removal of the cover and tying material after 3 and 6 weeks respectively, or even after 6 and 9 weeks, often spoiled an apparently successful graft. When the tying material was removed at less than 9 weeks the scion often came away from the stock unless a firm union had already taken place, which of course led to the death of the scion. According to observations at Aiyura, a union seldom takes place in less than 12 weeks and the binding which holds the scion in intimate contact with the stock should not be removed before that time. When Colgraft is used as the cover material, it is removed at the same time as the raffia as they cannot be removed separately. In any case it is not necessary to remove the Colgraft apart from that which comes away with the raffia. It is now the standard practice at Aiyura not to remove the cover and tying material until it is evident that a union has taken place. This varies as a rule from 12 to 16 weeks after the grafting operation. The binding material can be left even longer than this, but as it causes constriction when the point of union starts to swell, it must then be removed, or damage will ensue.

(6) *Seasonal Influences.*—The right time of the year for the most successful grafting of coffee is a problem which can be solved only by trial and error over a prolonged period. It has been stated by overseas workers (6) that "the difference between 100 per cent. take and complete failure may be brought about by only two months difference in the time of grafting". In general, unduly wet conditions or hot dry conditions are less favourable than warm, moist weather, and according to the literature, grafting should be carried out for preference when the tree begins active growth after rest, but before the sap flow becomes too free.

There are as yet insufficient data to be able to state the best time of the year for grafting at Aiyura, but results so far indicate that, under local conditions, grafting can be carried out at any season. The average result obtained has been a final take of 60 per cent. The best result was a 75 per cent. take with grafts made in the second half of November, which confirms the conclusion of other workers that grafting should preferably be carried out when the tree begins active growth after a period of rest, but before the sap flow becomes too free. However, seasonal influences are by no means the ouly factors influencing success and a final strike of over 90 per cent. or under 50 per cent. at any time of the year is not surprising in coffee grafting.

(7) *Other Factors.*—It is, of course, obvious that grafting should always be carried out under shade and never in direct sunlight. There is little exact knowledge about the physiological factors affecting grafting but the condition of the stock and scion wood are likely to affect the results. Little

is known of the interactions which may occur between stocks and scions or of the compatibility of Arabica varieties.

(8) *Grafting of Cuttings.*—The possibility of grafting newly made cuttings has also been investigated. Such a technique, if successfully developed, could be used to save time and hasten progress in the study of clonal stocks.

During September and October, 1955, several attempts to graft freshly taken cuttings were made with varying success. Final takes of 10 per cent. and 20 per cent. were obtained in two trials. The technique could probably be improved, but it is the opinion of the writer that a final take of about 50 per cent. is the best that could be expected. The successfully grafted cuttings developed new shoots and grew normally, although their growth was considerably slower than that of scions grafted on one year old seedling stock (See Figure 9 and cf. Figures 6, 7, 8).

Fig. 9.—Successfully grafted cuttings at the age of 6 months.

Summary and Conclusions.

Investigations carried out at Aiyura in 1955 have led to the development of two successful methods of vegetative propagation of Arabica coffee, which is an important step in the testing of the mother trees which form the basis of the coffee improvement programme. Only the simplest and most readily available materials have been used. The successful technique may be summarized as follows :—

1.—*Cuttings.*—

(1) *Cutting Wood.*—Single internode cuttings with the cut made just above the node from any portion of a watershoot except the top two internodes and the growing tip. Leaves left entire.

(2) *Hormones.*—Hortomone A had no permanently advantageous effect.

(3) *Rooting Medium.*—A mixture of equal parts of local top soil and coarse sand.

(4) *Shade.*—Light intensity under shade should should vary from 30 per cent.-40 per cent. of normal in the dry season to 80 per cent.-85 per cent. in the wet season.

(5) *Humidity.*—Spray hourly with a fine mist in dry weather and less often during wet weather.

(6) *Season.*—Best results in the dry season.

2.—*Cleft Grafts.*—

(1) *Stock.*—1-2 year old seedlings. Stem diameter at grafting height preferably 7 mm.-9 mm.

(2) *Scions.*—Middle section of watershoots (hard green wood), preferably of same thickness as stock, but may be thinner, length of scion 2 inches-5 inches, length of actual wedge 1½ inches-2 inches, scion leaves entirely removed or cut back to ¼ of their length.

(3) *Grafting Height.*—Preferably about 6 inches from ground-level but should be regulated according to thickness of stock and scion.

(4) *Tying Material.*—Raffia.

(5) *Graft Cover.*—" Colgraft ".

(6) *Removal of Covering and Tying Material.*—12 weeks after grafting or later if no evidence of union at 12 weeks.

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INDIGENOUS VERSUS INTRODUCED VEGETABLES IN THE VILLAGE DIETARY

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MANY seeds of European vegetables are being distributed amongst the Native people of Papua and New Guinea to plant in their gardens. This is done in order to introduce more variety into their meals. Whilst some of these vegetables are good nutritionally and could considerably improve the diet of the people, it must be borne in mind that in many areas indigenous plants already growing and being eaten are superior in food value to the introduced kinds. The following table will indicate this.

Food 100 gm. Edible portion	Calories	Protein gm.	Calcium mgm.	Iron mgm.	Vitamin A I.U.	Thiamin mgm.	Ascorbic Acid mgm.	Botanical Name
Pit Pit *	38	4.1	10	....	....	....	21	*Saccharum edule.*
Shoots of Palm *	19	1.9	550	....	....	....	14	*Archontophoenix* sp.
Shoots of Grass *	25	1.6	7	....	....	....	8	*Panicum palmarum.*
Aibika *	45	5.7	580	3.0 approximately	13,000 approximately	0.15	118	*Hibiscus abelmoschus.*
Pumpkin tips *	26	3.8	80			0.15	18	*Cucurbita maxima.*
Taro Leaf *	43	4.1	310			0.15	16	*Colocasia antiquorum.*
Amaranthus *	6	3.5	267	3.9	6,090	0.08	80	*Amaranthus* spp.
Purslane (Pig Weed) *	21	1.7	103	3.6	2,550	0.03	25	*Portulaca oleracea.*
Lettuce †	15	1.2	22	0.5	440	0.04	8	*Lactuca sativa.*
Cabbage †	24	1.4	40	1.0	240	0.06	50	*Brassica oleracea.*
Chinese Cabbage †	14	1.5	186	1.0	2,800	0.08	45	*Brassica chinensis.*
Tomato †	22	0.9	130	0.2	400	0.06	22	*Lycopersicum esculentum.*
Cucumber †	2	1.0	5	0.1	0	0.01	2	*Cucumis sativus.*
Carrots †	9	0.2	12	0.2	6,237	0.02	1	*Daucus carota.*
Choko †	8	0.2	3	0.1	5	0.05	4	*Sechium edule.*
Radish †	4	0.2	6	0.3	0	0.03	5	*Raphanus sativus.*
Turnip †	5	0.1	11	0.1	0	0.07	5	*Brassica rapa.*
Spring Onion †	37	1.0	30	0.4	250	0.03	15	*Allium cepa.*
Treefern *	43	5.5	....	....	....	0.15	26	*Alsophila* sp.
Wild Mulberry leaves (Burua) *	57	2.9	300	....	....	0.15	49	*Morus* sp.

* Indigenous. † Introduced.

Greens.—

The importance of green leaves in the diet of the Native people is frequently overlooked. In most areas it is the custom for green leaves to be eaten daily in considerable amounts. They form an important part of the diet for the following reasons.

1. Most of the Native people are infested with parasites which deplete the body of iron, therefore foods rich in iron are important for the health of these people. Most of the indigenous green leaves are rich in iron.

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2. In areas where the staple foods are taro, yam, tapioca or banana, green leaves play an important part in the diet by supplying Vitamin A and ascorbic acid as well as calcium and iron.

3. In areas where sago is the staple diet green leaves can supply all the nutriments which are commonly found in the other staple vegetables but are deficient in sago. Adequate green leaves of a high nutritive value are essential to the health of the people in sago eating areas.

4. In Highland areas the people obtain adequate Vitamin A, thiamin and ascorbic acid from the staple sweet potato. Signs of calcium deficiency have been noted in these areas away from the coast where betel-nut and lime are not eaten. The main source of calcium for these people comes from green leaves, which also supply extra iron and protein.

5. It is well known that the main deficiency in the diet of the people of this country is a deficiency of protein. In many areas the greater part of the protein intake of the people comes from vegetable sources. The indigenous green leaves have a higher protein content than most other vegetables excepting legumes and cereals. Considering the quantity of green leaves that are eaten they do add something to the small protein intake of the people. Proteins are comprised of varying numbers of amino acids. Only proteins from animal sources contain all the amino acids essential for growth of body maintenance. Vegetable proteins contain some but not all of the essential amino acids. If a diet containing a number of different vegetables is eaten all the essential amino acids can be obtained. Most of the indigenous greens have not been analysed for amino acid content but it is believed that they do contain essential amino acids which are lacking in the staple vegetables and so when these greens are eaten with the staple vegetable, the proteins of both can be utilized to better advantage. In this way greens play an important part in the protein intake of the people.

It will be noted that all leaves of a dark green colour are superior in iron calcium and Vitamin A to those of a light green colour and most of the indigenous greens are higher in protein content than imported varieties, consequently plants such as aibika, pumpkin tips, taro leaves and amaranthus which are grown and eaten in most areas should not be supplanted by the inferior imported plants such as English cabbage and lettuce. This could happen as the people become more sophisticated if they are encouraged to grow the new vegetables and the old ones are given no recognition. They will then tend to think that the indigenous plants are of no importance. I have seen this happening about Lae and Port Moresby. In other areas I have seen the European vegetables grown and wasted because the people do not care to eat them and they have no sale for them. Where garden space is short and the nutrition is poor, as in some areas of Chimbu, the vegetables that will give the highest yield and the best nutritive value should be encouraged. There is not much point in the people growing English cabbage, lettuce, cucumber and radish, etc., where there is no sale for them to Europeans.

In some areas many of these European vegetables are grown for sale to Native hospitals and labour lines. It would be better to encourage the production of more indigenous vegetables for this purpose.

There are many other varieties of indigenous greens such as ferns and fig leaves and sweet potato leaves eaten by the Native people which are equally as nutritious as the varieties mentioned.

Legumes.—

The following list shows the protein content per 100 gm. of the mature seed of some varieties of legumes :—

Winged beans	35 gm.
Soya bean	35 gm.
Cow bean	24 gm.
Lima bean	20 gm.
French bean	24 gm.
Green gram	22 gm.
Peanut	23 gm.

To overcome the deficiency of protein in the diet of the people throughout Papua and New Guinea certain types of beans have been introduced in some areas with limited success. It will be noted from the above figures that apart from soya beans, winged beans (*Psophocarpus tetragonolobus*) have a higher protein content than any of the other legumes. Winged beans are indigenous to the country, and are grown both in high-

land and lowland areas. They are popular, the leaves and the tuberous root as well as the green beans in the pod, and the mature beans are eaten. In areas where these beans flourish would it not be better to encourage larger crops of wing beans, perhaps by distributing more seeds, rather than try to introduce new varieties of beans which are not so nutritious and a taste for which has to be acquired.

In most areas it is the custom of the people to eat mature beans but not dried beans. The mature beans would have somewhere about the same nutritive value as the soaked dried beans and a great deal more nutriment than the immature green beans in the pod, such as french beans as eaten by Europeans.

It would perhaps be an advantage to encourage the people to dry and store some of their beans, then they could be eaten on days when fresh beans are not available, thus a continuity of the protein intake could be assured. However, this cannot be done unless the people have containers in which to soak and cook the beans and even then they must be taught how to soak and cook them before they will be bothered using them in this way.

Peanuts are always popular. They can be an important source of protein in the diet of the people. They are usually eaten raw. They are better assimilated, however, if they are cooked before eating them. It has been found that peanuts with a low oil content, such as Virginia Bunch, are better tolerated by young children than those varieties with a higher oil content.

Fruit.—

In many areas where sweet potato is not the staple food there is a deficiency of ascorbic acid especially amongst the infants and small children. Fruits such as papaw, ripe mango, fivecorner, citrus fruits and pineapple are the richest source of ascorbic acid. Insufficient of these fruits are cultivated. Occasionally mango trees are planted around a village, mainly for shade; and, sometimes, there are a few citrus trees. The fruits of these trees are seasonal, therefore other fruits should also be planted about the village or in the gardens so that a continuous supply of fruit can be maintained. Papaws, which bear throughout the year, should be grown more frequently. Too often they are not planted. The papaws obtained are gathered from trees which have seeded themselves, consequently there is insufficient fruit for the needs of the people. Pineapples are also a good source of Vitamin C and more should be grown for home consumption.

Conclusion.—

Greens are very important in the diet of the Native people. Indigenous greens have a higher nutritive value than imported ones. More native greens should be encouraged to be grown rather than introduce new varieties of inferior nutritive quality.

Indigenous winged beans have a very high protein content. The variety which gives the best yield should be determined and seeds of this variety of winged bean distributed widely throughout the Territory.

Soya beans will sometimes flourish in areas which are unsuitable for winged beans, such as in some highland areas over 6,500 feet. Soya bean seeds should be distributed in these areas with instructions for them to be used when mature. Only in areas where cooking containers are available can the use of dried beans be encouraged with success.

Only peanuts with low oil content such as Virginia Bunch should be distributed in areas where they are to be used for local consumption. In areas where peanuts of a high oil content are grown for sale outside the Territory, or for local oil extraction, some Virginia Bunch or other low oil content peanut should be distributed with instructions for them to be used for the feeding of infants and small children.

Papaws are a rich source of Vitamin C. The trees are hardy. The fruit is not seasonal, it is obtainable at all times of the year. The people should be encouraged to plant more papaw trees and be instructed to feed papaw to their babies and small children daily.

The majority of imported vegetables should be distributed only in areas where they can be sold for European consumption.

More native vegetables and less European vegetables should be grown for sale to Native hospitals and labour lines.

The following vegetables and fruits are suitable for general distribution :—

Winged beans.
Soya beans and other varieties, and peas, according to the suitability of the area for the crop.
Peanuts (preferably Virginia Bunch).
Tomatoes.
Pineapple.
Citrus fruits.
Papaw.
Pumpkin.
Corn.
Improved varieties of indigenous greens.
Peppers and spring onions for flavouring.