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Some aspects of agriculture on Tarawa Atoll, Gilbert Islands

by

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INTRODUCTION

The following paper is part of a report written in 1951 which has not previously been published. The writer spent three months on Tarawa taking part in the South Pacific Commission's project E.6, the economic development of coral atolls. The report of Dr. R. Catala,\* the leader of the S.P.C. team, has been published (Atoll Res. Bull. 59: 1957).

It had been intended to visit two or three other islands after completing investigations on Tarawa; but shortage of transport made it necessary to return to Fiji when an opportunity offered, before any other islands could be visited.

Work accomplished includes soil and water investigations, studies on the main crops\* (coconuts, Cyrtosperma, pandanus, etc.), observations on livestock, and some brief notes on tools and on native plants.\* Consideration was given to the establishment of a small agricultural station at Bikenibeu, near the site chosen for the King George V school.

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\* The published report by Dr. Catala incorporated parts of the observations made on Tarawa by Mr. Mason and treated some of the same subjects. To avoid costly duplication of material, some chapters of Mr. Mason's report are omitted from this Bulletin. The report of Dr. Catala also contains many photos which illustrate points brought out by Mr. Mason.--Ed.

## SOILS OF TARAWA

Since all the soils of Tarawa Atoll are derived from coral, there is no great variation. Hard coral rock outcrops in a few places, and in others there is little or no sand but many stones--for example, at Temaiku. In general, however, there is a layer of sand two to six feet deep above the underlying coral rock. Where soil has been developed, the commonest profile is a horizon of brown to dark brown sandy material high in organic matter and from 2 to 12 inches deep, overlying a pale brown horizon extending to between 12 and 30 inches; below this is coarse yellowish-white sand. This soil type has been named the Bikenibeu Sand ("B"); 17 profiles were examined and some are described below.

Two phases of this soil type were met fairly frequently. They are the Bikenibeu Sand Shallow Phase ("Bsh"), in which hard coral rock is found at 36 inches or less; and the Bikenibeu Sand Stony Phase ("Bst"), with a stony layer, often closely packed, usually at about twelve inches. Nine profiles of these two phases were examined.

The Eita Marine Marsh ("E") is a soil type in which extreme salinity inhibits plant growth. The type occurs infrequently in depressions behind the ocean and lagoon beaches.

The Mweang skeletal soil ("M") shows a dark-brown or black peaty sand in the upper layers, associated with large numbers of small stones, the soil occupying the interstices between the stones. Three profiles were examined, in separate areas. The dark-coloured soil, if sieved free from stones, is useful for gardening.

The fourth soil type is the Te Ribu loamy sand ("R"), which again was found in small isolated areas. The loamy sand characteristic of this soil type is found at a variable depth, never on the surface, although at Buota it was uncovered at the bottom of 'babai' pits. It is sufficiently plastic to be moulded in the fingers. This soil appears to be very poor, for the coconuts at Buota were few in number and were yellow with little fruit, and there was no grass. In the pits the 'babai' was poor and yellowish except for a few plants growing in a shaded place. Shade however was very limited. A similar condition, though not so pronounced, was seen near Buariki.

The rapid variation of soil type and the consequent impracticability of preparing soil maps is shown by figure 1, a plan giving the different types in the Bikenibeu area.

Apart from the exceptions mentioned above, there was little correlation between soil type and plant growth. No correlation was observed between production of coconuts and depth of dark soil except when the latter was less than two inches. On the other hand, profile No. 4 was from an area where the trees were distinctly above average, and it showed the horizons at 4 and 8 inches only, with maximum root development between 12 and 18 inches. The only places where fertility was markedly higher were on a deep dark-coloured soil at Buariki, where the rainfall is probably a little higher, and on Betio. Pre-war Betio is said to have been no different from the other islets, but now the difference is great.

A young coconut, not more than 5 years old but already starting to flower was typical of many. The creeper Ipomea pes-caprae was running riot in places. The increased fertility is the result of the intense disturbance of the ground by bombs and shells in 1944, and of the many thousands of Japanese buried there. Many plants not seen elsewhere flourish there despite the lack of shade. As a result of the bombardment, there were only about twenty mature coconut trees left on the whole islet after the war.

The underlying coral rock was not often reached in digging pits, but was quite frequently seen in village wells. (Profiles could not be taken since the sides are built up with stone). A very hard layer was reached in Well No. II at Bikenibeu at 99 inches. This appeared to be very thick, although several wells were seen where it was only 3 to 4 inches. Its porosity was shown by the water rising through it with the rising tide. A series of borings with a post-hold borer showed the varying depths in a cross section of the island east of the village of Bikenibeu. The rock is prominent at that place on both the lagoon and ocean shores. On the lagoon side of the island ('Tamrio') the depth was about 3 feet near to the road, twenty yards from the sea. Trees were bearing fairly well in all three places. Presumably the root system was sufficiently long to reach the deeper soil. (Many roots were encountered while digging well No. IV at Bikenibeu although no trees grew within 10 yards.)

Outcrops of rock occur near Eita village and on the small peninsula at Temaiku. No coconuts grew in the former place; but in the latter, fruit was produced to a limited extent even where there was 4 inches or less of sand over the rock. Presumably cracks exist. East of Abatao is an area of fairly hard stone, but a pit showed extensive coconut roots underneath, at 6 to 10 inches depth. This is not coral but appears to be a type of mudstone which has hardened on exposure.

Soil samples collected in Tarawa and despatched to Suva for analysis were all ruined by sea water while in the hold of R.C.S. "Kiakia," together with most of the entomological specimens. The following ten analyses were made in Tarawa, using the 'La Motte' apparatus. (Table 1, p.4)

These samples were taken where the soil by its blackness or the coconuts by their fruit appeared above average.

Native names for different kinds of sand and soil are as follows:

Te Bike	Shore sand
Te Tano	Ordinary sandy soil
Te Bon, Te Bon Ro, Te Iarauri	Black soil, frequently found under 'Te Uri' (Guettarda)
Te Mweang	Light black soil which blows in the wind.
Te Ribu, Te Riburibu	Grey clayey soil. Worse than sand if water is salty.
Te Ririba	Outcrops of rock
Te Bokaboka	Mud in babai pits etc.

TABLE NO. 1

Soil Type	Profile No.	Depth in inches	Soil description	p H	Nitrate Nitrogen (p.p.m.)	K m.e per 100 gms	P <sub>2</sub> O <sub>5</sub>
M	29	0-12	Black peaty soil between stones	7.6	4	3.0	0.023
M	30	0-6	Representative sample of area	8.0	12	3.0	0.020
R	32	1-3	Brown, very sandy	8.2		2.5	0.003
	"	20-24	Dark brown former surface				
	"	60	Grey, clayey, slightly sticky	7.8			
B	8	0-8	Black, high organic matter	8.0		2.5	0.011
	"	8-18	Dark, less organic matter	8.2			
	"	84	Whitish coarse sand	8.2			
B	8	0-6	Representative sample of area	8.0	6	2.7	0.017
B	6	0-6	Dark brown sand	8.0	30	3.0	0.009

\* Author did not state what units the P<sub>2</sub>O<sub>5</sub> figures represent.--Ed.

Description of Soil Profiles

Soil types:	Bikenibeu sand	B
	Bikenibeu sand Shallow phase	BsL
	Bikenibeu sand Stony phase	Bst
	Eita marine marsh	E
	Te Mweang	M
	Te Ripu	R

No structure was observed in any of these soil types.

BIKENIBEU SAND  
(B)

Profile No. 6: Tabaongo,  $1\frac{1}{2}$  miles east of Bikenibeu wells

Surface: Coconuts with patches of Lepturus

1. 0 to 2 inches Dark brown sand, friable, organic-matter-stained, free draining, few roots, no stones.
2. 2 to 54 inches Pale brown sand, loose, no organic matter free draining, root development greatest between 6 and 18 inches with some to 36 inches. No stones.
3. 54 to 69 inches Pale yellow sand, loose, no organic matter free draining, no roots, coral fragments up to 2 inches in size.
4. 69 + inches Hard coral rock.  
Water rises to 66 inches at high water only.

This is the commonest type of profile. Considerable variation occurs in the extent of the horizons. Horizon 1 sometimes extends to 5 inches, while horizon 3 was sometimes met as high as 10 inches. Less developed profiles occur particularly near the beaches. Occasionally a buried former surface is met. In places where the coral rock was not reached by about 6 feet, further digging was prevented by water.

BIKENIBEU SAND, SHALLOW PHASE

(B sL)

Profile No. 18

Surface: Coconut palms, germinating nuts; fallen leaves, no grass.

1. 0 to 10 inches Brown sand, friable, organic-matter stained, free draining. Maximum root growth between 3 and 9 inches. No stones.
2. 10 to 20 inches Yellow coarse sand, loose, no organic-matter, free draining. Few roots, no stones.
3. 20 + inches Hard coral rock.

In other profiles horizon 1 varies from 2 to 12 inches and from brown to dark brown. In the other pits examined, the hard coral was struck at depths between 27 and 38 inches. It was too hard to be broken by crow-bar.

BIKENIBEU SAND, STONY PHASE

(B st)

Profile No. 25, 3/4 mile east of Bikenibeu.

Surface: Coconut palms rather yellow, yield fair to poor. No other vegetation.

1. 0 to 2 inches Brown sand, friable, organic-matter stained, free draining, few roots, no stones.
2. 2 to 15 inches Pale grey-brown sand, loose, no organic-matter, free draining, root development throughout; no stones.
3. 15 + inches Stones - irregular flat coral stones lying horizontally and too tightly packed to prise with spade without great difficulty.

The thickness of the stony layer is variable. In profile 26, at the old site of Eita village, a layer of flat very hard white smooth coral stones up to 12 inches long and  $1\frac{1}{2}$  inches thick occurs between 14 and 16 inches. Below this occurs a horizon of yellow and brown very coarse sand with few roots but with many stones.



EITA MARINE MARSH  
(E)

Profile No. 27: salt bog 22 yards inland from ocean beach, with high sand bank intervening. Due south of Te Bike island.

Surface: bare of vegetation; greenish-brown in colour.

1. 0 to 3 inches Pale grey sand
2. 0 to 10 inches Grey sand
3. 10 + Yellow coarse sand

Brackish water was struck at 7 inches but later it rose to 1 inch, and probably covers the surface at high water spring tides. Salt content very high - approximately 1.98% chloride. Typical of numbers of small isolated areas close to the sea where fluctuations of salty water associated with tidal rise and fall inhibits growth of vegetation.

TE MWEANG  
(M)

Profile No. 28, south of Taborio village.

Surface: Vegetation cover of coconuts, sparse Lepturus, and some shrubs. Ground surface comprises white coral pebbles.

1. 0 to 14+inches Black highly organic sand occupying the interstices between the closely packed stones, free draining, roots throughout, extremely stony.

The highly-packed stones make digging almost impossible. One pit near Abatao, however, penetrated the upper horizons and reached off-white sand with many larger stones at 18 inches.

It would appear that the reason for the striking accumulation of organic matter in this soil type is that all root growth is confined to the very small volume of soil between the stones; thus the continuing addition of organic matter to the soil balances the losses through oxidation.

TE RIFU  
(R)

Profile No. 32: near Buota

Surface: Coconuts unhealthy in appearance, yellowish and with few nuts. No grass cover. Cyperus, Sida, Pandanus, Scaevola occur close by, Guettarda scrub being dominant at this spot.

1. 0 to 10 inches      Dark, nearly black loamy sand, friable, organic-matter stained, few roots, no stones.
2. 10 to 30 inches    Grey fine sandy loam, slightly sticky when wet, no organic matter, no roots, no stones.
3. 30 + inches        Mixed coral fragments.

WATER

Water is very frequently the limiting factor for growth. The rainfall is extraordinarily variable.\* In 1930, 138.52 inches fell, 29 inches being in November. (These figures are by courtesy of the New Zealand Meteorological Service and the Gilbert and Ellice Administration.) In 1950 a total of 15.38 inches fell in twelve months - 2.94 inches in the first seven months. (Rainfall is high in the northern islands and lower in the south; in 1950 Beru, one of the southern islands, received 9.68 inches.) The mean for Tarawa over 16 years is 64.19 inches per annum. Naturally last year's drought (1950) killed off numbers of coconuts in poor environments such as on sand spits or on small islands. It seems remarkable that anything could stay alive.

Ground-water can be obtained anywhere that a hole can be dug to a depth of from five to ten feet, depending on the height of the land. Drinking water is obtained from wells of low salinity. It appears that the level of well water varies only slightly with conditions of rainfall but no definite data could be obtained on this subject. (A recording device was designed but was not completed before leaving.) There is a very pronounced rise and fall of ground-water due to the effect of the tides. Naturally the movement is greatest close to the beach and least in the centre of the island. Nine wells were dug at Bikenibeu on a line at right angles to the beaches, to give a transverse section of the land, and the levels in these were recorded over a 36 hour period. Graphs from the data obtained are shown in Figure 2. Since all nine could not be plotted on the same axes, the first five and the last four are given separately. The sites of the wells are shown in Figure 3; well No. 1 is nearest to the ocean beach, and well No. 9 is on the lagoon tidal sand flats. The graphs are plotted about a common mean, and show clearly how the movement decreased from No. 1 to No. 5 and increases again from No. 6 to No. 9 though with less regularity. It is also clearly shown

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\* Rainfall tables are included in Atoll Res. Bull. 60: 1957, by M.-H. Sacht.--Ed.

FIGURE NO. 1

**SOIL TYPES**  
*IN THE*  
**BIKENIBEU AREA.**

**A**

			B			
			8			
B	B	BS	R	R	B	
3	2	23	34	33	1	
			R			
			32			
B						
4						

**B**

		B 24			
		R 30			
		BS 25			
		B 5			

**C**

BSH	BSH	BSH	B	B	BSH
19	20	21	6	7	22

B : *BIKENIBEU SAND*  
 BS: .. .. *STONEY PHASE*  
 BSH: .. .. *SHALLOW PHASE*  
 R: *TE RIPU CLAYEY SAND*

*NUMBERS REFER TO PROFILES.*

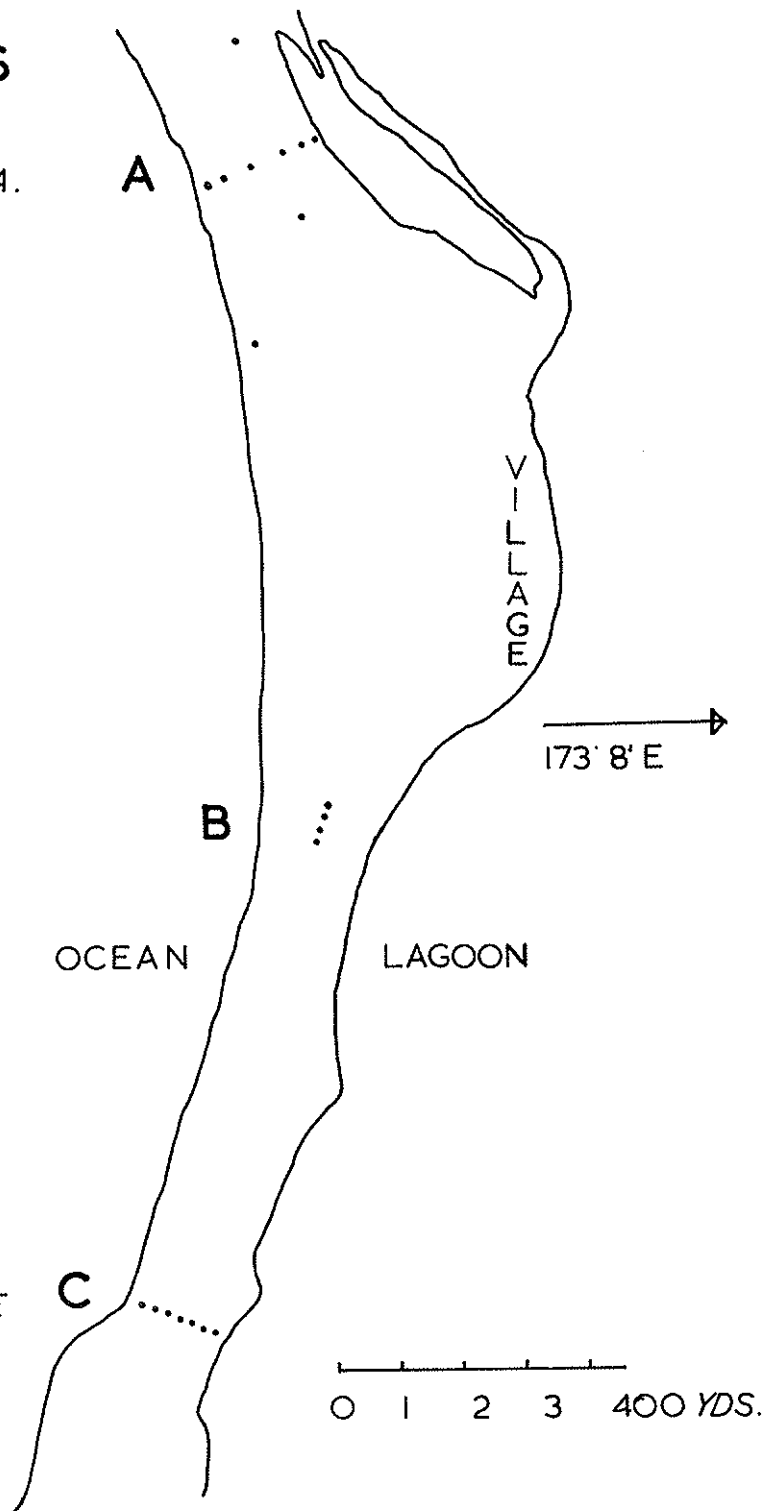




FIGURE No. 3

# SALINITY OF WATER

NEAR  
BIKENIBEU.

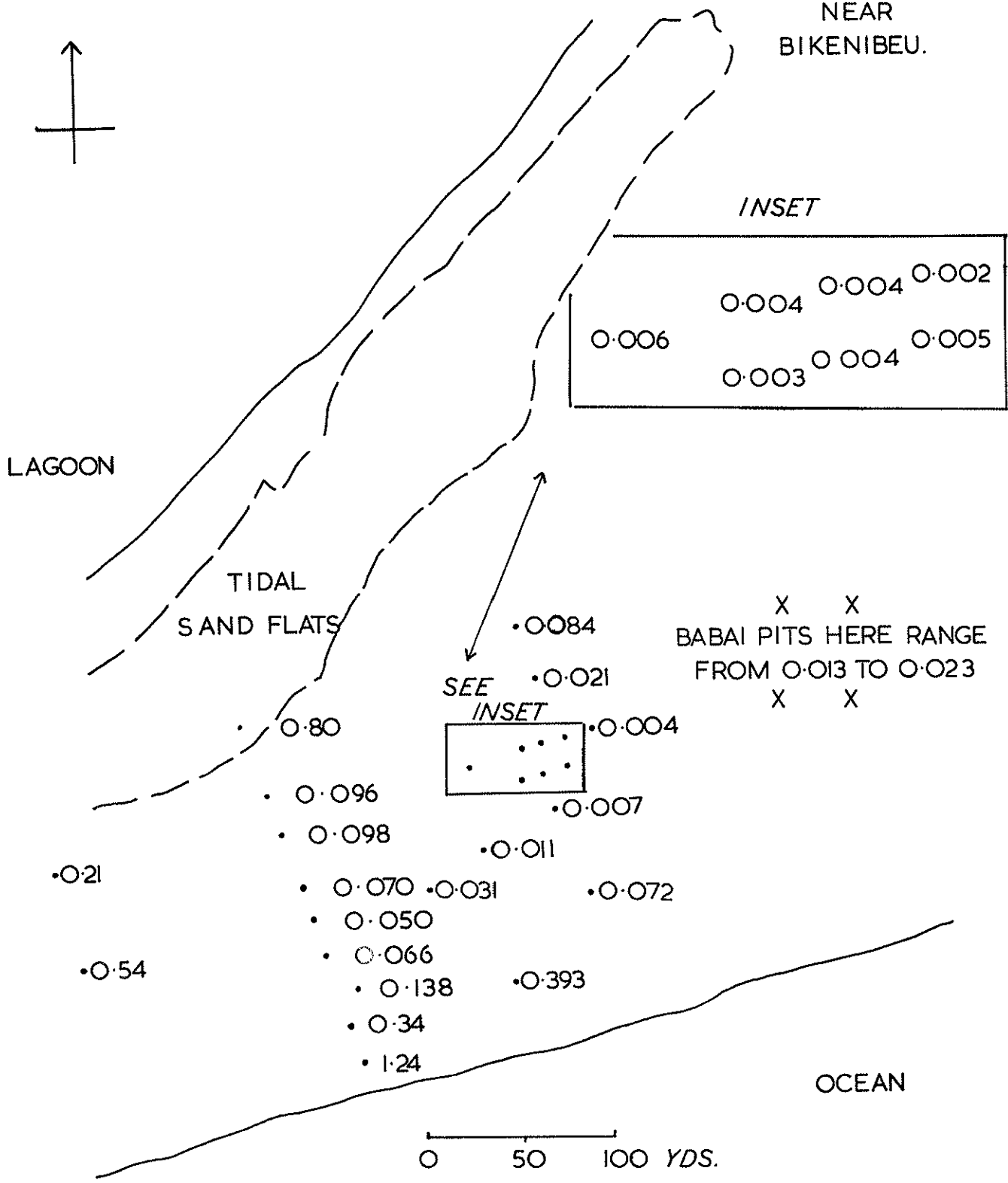
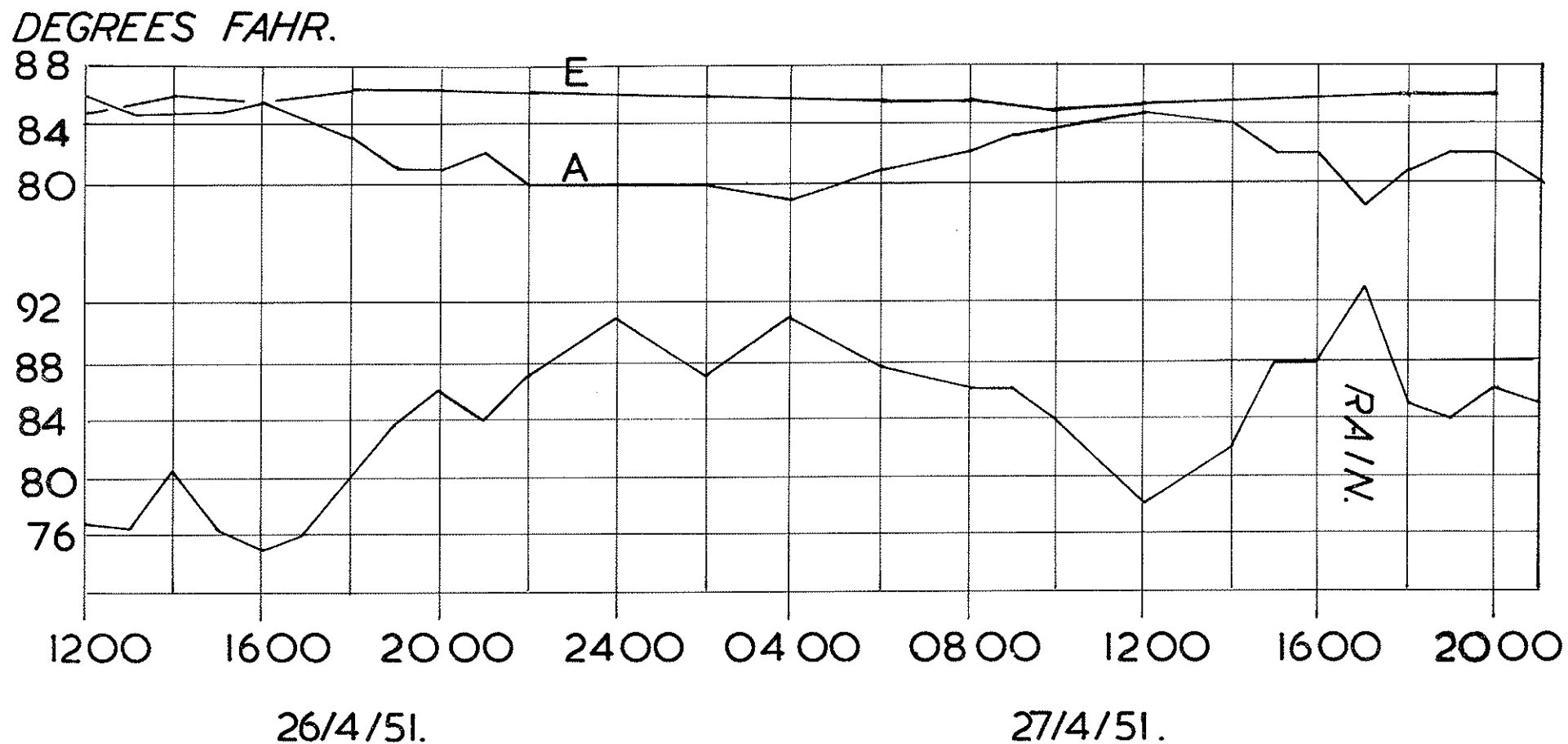


FIGURE No 4

# AIR & EARTH TEMPERATURES AND RELATIVE HUMIDITY.



that the central wells reach their maxima and minima one and half to two hours later than the one nearest to the beach, although there are some peculiar irregularities.

There is a very great variation in the salinity of ground water even within a short distance. Figure 3 shows the salinity (expressed as percentage of chloride) in a number of samples near Bikenibeu. The analysis was carried out by silver chloride titration. In little over 100 yards in a transverse direction, salinity fell from 1.24 percent to 0.066 percent Cl. This decrease of salinity from the beaches to the centre of the island is normal. Variations also occur in a longitudinal direction for example, from 0.070 percent to 0.011 percent in two hundred yards. Water from well No. 3, having a salinity of 0.138 percent Cl was unfit for drinking or washing. Well No. 5, at 0.050, was all right for washing, but unpleasant to drink, while water from the best source, 0.002 percent Cl, was indistinguishable from fresh water. Most wells are presumably sited by guess; and a preliminary survey would obviously be of great value when a new one is to be built.

Salinity also varies with time, due to rainfall and evaporation. Wells which are normally sweet became brackish in the drought of 1950. The following table shows the variation of one well at intervals of a few days, with the amount of rain recorded in the intervening periods.

TABLE NO. 2

Variation of salinity in well No. 6 at Bikenibeu		
Date	Percentage Chloride	Rainfall between analyses (in inches)
April 26	0.054	
1951 28	0.047	0.965
30	0.044	0.375
May 1	0.025	0.16
4	0.029	0.76
8	0.024	1.72
9	0.024	0.14
12	0.028	0.01

The extent of the variation appears to vary from place to place, shown by Table No. 3 which gives the analyses of the nine wells on two different days. The tendency appears to be for the most saline wells to fluctuate most.

TABLE NO. 3

Salinity of the Bikenibeu wells on two dates  
(expressed as percentage of chloride)

Well No.	Date of Sampling:		Percentage Reduction:
	6-April-51	12-May-51	
1	0.93	0.526	43.4
2	0.42	0.288	31.4
3	0.15	0.163	- 8.6
4	0.054	0.040	25.9
5	0.073	0.070	4.1
6	0.070	0.028	60.0
7	0.104	0.068	34.6
8	0.105	0.076	27.6
9	0.585	0.208	64.4

Plants differ very greatly in their tolerance of salinity, mangrove obviously being the most tolerant since it grows in sea water. "Te Ngea" (Pemphis acidula), a saltbush with very hard wood, grows very close to the water, mainly on the lagoon shore, and the two shrubs "Te Mao" (Scaevola sericea) and "Te Ren" (Tournefortia argentea) grow everywhere, even on the beach crest on the ocean side where they are exposed to salt spray. "Te Uri", another shrub or small tree (Guettarda speciosa) is slightly less tolerant, as dead plants can frequently be seen on the beach crest; however, many seemingly-dead trees sprout again from the base of the trunk. "Te Itai" (Calophyllum inophyllum) is a hard wood often growing close to the water on the lagoon shore. Coconuts and Pandanus both grow fairly close to the sea but not as close as any of the foregoing plants. As mentioned earlier, many coconuts growing on small islets or on narrow promontaries were killed in the 1950 drought. At Bikenibeu, healthy coconuts were growing on the ocean side of the first well which on analysis after a fairly dry period showed 1.24 per cent of chloride. Table No. 2 however, shows that this high figure is not constant. The first effect of severe drought is to reduce the size of the young leaves of coconut palms growing under hard conditions; this results in a typical



flat-topped appearance. Trees were seen at Temaiku which had been severely affected and which were just starting to grow normally again.

Introduced flowering trees and others are frequently seen in the villages, which are all on the lagoon side. For example, at Marenanuka, Frangipani and Oleander were growing and flowering on a somewhat restricted scale, setting few seeds. These trees were near a well in which the water contained 0.042 per cent of chloride, a fairly low figure. Breadfruit trees in the same area were healthy, though in most villages individual trees here and there had been killed off by drought.

#### GARDENING EXPERIMENTS

With the exception of kumala (sweet potato) cultivation, such as at Buota and Betio (in occasional patches) gardening is confined to Europeans, who frequently bring soil into the Colony and grow plants in drums with some success. Selected black soil also gives good results especially if enriched with compost; but the effect of added organic matter such as leaves, manure, and fish offal appears to be confined to the first or first two crops only. Excellent tomatoes, China cabbage, English cabbage and water melons were seen on such selected soil (grown by Mr. Carter at Bonriki). Lettuce can also be grown. Frequent watering with good water is of course necessary. Pumpkins will grow in ordinary good soil. A climbing bean (*Dolichos lablab*) at Betio was seen which spread over the roof of a house, yielding well; but another at Bonriki in prepared soil suffered severely from chlorosis and yielded no fruit.

Seeds were taken from Fiji in the hope of establishing a leguminous cover but results were disappointing. In the first nursery, a good site was selected by Dr. Catala to the west of the Bikinibeu house and natural conditions were observed - no watering or manuring was given, but the rainfall after sowing was good.

Sown 24 March 1951:

Leucaena glauca - 'vaivai' - grew rapidly at first, slowing down later - 3 to 4 inches in two months. Slight paleness shown after one month. Likely to persist.

Centrosema pubescens - Never advanced beyond cotyledonary leaves.

Calopogonium mucunoides - First true leaves were yellow and soon died, the cotyledons persisting for some time before dying.

Sown 27 March 1951:

Cajanus indicus - Pigeon Pea - Died after producing two or three leaves. One only still persisted after two months.

Desmanthus virgatus - Appeared yellow and grew extremely slowly.

Pueraria phaseoloides - Hawaiian Puero - 4 or 5 seedlings only. Given soil from near Puero roots at Sigatoka Agricultural Station, Fiji. One grew very well until checked by the attack of a leaf-cutting bee; the others small but of a fairly good colour. Hopeful.

Stylosanthes guianensis - Growth stopped after 1 to 2 inches. Yellow.

Panicum maximum - Guinea grass from Sigatoka Agricultural Station. A few plants germinated after a month and had reached 2 inches by June.

P. maximum var. coloratum - Purple Guinea. Grew rather better than the common guinea grass, but neither is expected to survive.

Sorghum verticelliflorum - Kavirondo Sorghum. Whitish yellow - stopped growth at 6 inches.

Canavalia ensiformis - Sword bean. Rapid growth after germination followed by dying-off of the growing point in every plant except one.

Rice Bean - yellow leaves, but still growing after 5 weeks. (Very thickly planted). Growth appeared to be stopping at 2 inches.

Pawpaws and water melon were also sown for the sake of comparison; the pawpaws made slow growth but the melon seedlings died off.

Later sowings by Dr. Catala on 24 April 1951 were also disappointing.

A second nursery was made to the east of the house at Bikinibeu and different treatments applied. Calopo, Vaivai, Pigeon Pea and Kavirodono Sorghum were sown in 4 parallel beds which were divided into 8 sections by divisions at right angles to the lengths of the beds. Soil from corresponding legume roots in Fiji was applied to half of the plots of each of the three legumes.

Each group of 4 plots was then given 4 treatments as follows:

- (1) an NPK mixture: sulphate of ammonia, muriate of potash and super phosphate;
- (2) a solution of trace elements, including iron, manganese, magnesium, copper, zinc, molybdenum and boron;
- (3) Coconut meal. Application of this was delayed until early May as a result of its being misplaced on the ship.
- (4) Control.

The seeds were sown thinly and the seedlings were watered twice in their early stages.

The legume soil benefitted the Pigeon Pea but not the other legumes. Where it was applied, the Pigeon Pea had reached 2 feet and was still growing at the end of May, although attacked by the leaf eating bee. The untreated plants had mainly died out.

The NPK manures gave no effect.

The trace elements gave a slight response on the Kavirondo Sorghum - slightly better growth with a better colour.

The coconut meal had insufficient time to give results by the end of May

The calopo in this nursery reached the 2nd and 3rd leaf stages, but these leaves were very pale. The Leucaena grew as in the first nursery. The Pigeon Pea looked as if it might reach maturity where it had received a sprinkling of soil. The Kavirondo Sorghum was a better colour than in the first nursery but was decidedly yellow. However, it appeared to be still growing at 8 to 10 inches.

The results obtained from the nurseries are mainly negative but are nevertheless very interesting. It remains to be seen whether the Leucaena will become established. Greater response to the trace elements had been anticipated. The delayed application of coconut meal was unfortunate because it seems likely that it may have considerable effect over a period of time.

#### LIVESTOCK

Pigs are kept by the majority of householders in the villages. Most of the pens, which are usually just behind the village, are simply four pieces of Airstrip matting forming a square. Higher walls of two sections are not usual. The alternative to these iron strips is a wall of interlaced coconut trunks. Pens are usually in the shade; shelter is usually provided (by plaited coconut leaf) if they are in the open.

The pigs are of varied breeding; the only definite statement that can be made is that no Tamworth influence was seen. All are small. This is not entirely due to nutritional deficiencies as a boar imported from Fiji and his offspring are noticeably bigger than average. The most frequent type is a porker weighing up to 200 lbs. at a year or so; but unfortunately no details could be gathered as no pigs of known age were found. The people simply do not know. Interest in breeding is very low; boars were seen which were no more than 50 lbs. in weight - little runts not much bigger than a decent-sized weaner. On the other hand, a son of the Fiji-bred boar mentioned above (which was imported by the Catholic Mission at Teaoarsereke 4 years ago), was seen at Buariki. This pig was about 2 years old, well grown and much above the average for Tarawa. It was recently castrated because it got out of its pen and caused trouble; so it is now being fattened up. It was less trouble to castrate it than to make a strong pen. When the people in this village were asked if, supposing a good boar was available, they would pay one shilling service fee, they suggested giving half the litter at birth to the owner of the boar instead.

Litter sizes appear to be very small and the average number reared is probably only about three. Nutrition is almost certainly the limiting factor. Feeding does not vary greatly; indeed, it cannot, so limited are the foods. They comprise coconuts, herbs, and fish bones. Two to five coconuts are fed either once or twice a day. The common method is to feed once a day, giving water in the evening. The two small herbs 'Te Mtea' and 'Te Wao' (Portulaca lutea and Sesuvium portulacastrum) are commonly gathered by the children. Both are plentiful. Grass and babai leaves may

also be given, and possibly 'Te Bero' (Ficus sp.). Some people give toddy - presumably what is left over from their personal requirements.

Emaciated pigs were seen which were neglected by their owners and not fed regularly. Also one gilt was seen which had the same food as another, neighbouring, fat sow, but apparently this one could not digest coconut, and so was very thin. The gilt was little more than 50 lbs. and had one pig of about 25 lbs. The fat sow had had three litters; six in the first all died in a week, nine in the second all died in five days, and one was reared out of seven in the third litter.

In Eita village there were 12 gilts and sows, 2 boars, 10 weaners and porkers, and about 6 young pigs running loose. In Bikinibeu there were 18 gilts and sows, 2 boars, 9 weaners and porkers, and about 14 young pigs. (Both villages have populations of 124).

Paralysis of the hind quarters was seen in one sow, which had full use of its forelegs. One sow was seen with a swelling of the udder. Slow growth of some pigs was presumed to be due to worms. Lice were reported but not seen.

The listlessness of the people regarding pig husbandry and the unavailability of feeding stuffs to give a balanced ration combine to make significant improvement in pork production unlikely.

#### POULTRY

The majority of birds run loose in the villages, but sometimes fowl runs are seen, made of 'Te Ba' (coconut mid-ribs, which are 8 to 10 feet long). There is a great variation in breed and size, ranging from well-bred Rhode Island Reds kept by various European houses on Bairiki (such as the Residency), down to bush fowls weighing only a pound or two. Occasionally good looking birds are seen in the villages, and some birds live wild in the bush.

Their food is mainly coconuts, with what else they can forage. At the mission at Teoraereke, a big increase in egg production following the feeding of fish was mentioned. This indicates that considerable increases in poultry production should not be difficult to achieve.

Ducks are not very common, but some Muscovies were seen, one with a very good brood of ducklings.

No geese were seen.

#### TOOLS

Tools used in agriculture are very few and very simple. For cutting the many coconut roots which are in the soil everywhere, a spade with a circular blade is preferred. The blade is flat, and about 6 inches in diameter. The handle is commonly 5 feet of 3/4 inch pipe, which gives momentum to a cutting stroke. This spade, 'Te Rereba', is mainly used for digging or extending 'babai' pits.

Just as a Fijian is not often without his cane knife, so a Gilbertese usually has a machete type of knife, which is used for opening drinking nuts, cutting copra, and so on.

A mallet, 'Te Ikuiku' is made out of 'Te Ngea', a hard wood shrub (Pemphis acidula). Such mallets are used for beating flat the mid-ribs of pandanus leaves.

Other domestic tools are coconut scrapers (similar to those in Fiji) and scrapers for pandanus fruit. There are of course various articles for fishing, ranging from canoes down to fishhooks.

#### IMPROVEMENTS POSSIBLE IN THE NATIVE AGRICULTURE AND PROBLEMS REQUIRING FURTHER INVESTIGATION

The subjects requiring investigation are divisible into the problem of increasing exports, which means increasing copra production ; and the problem of increasing food production in order to provide for the increasing population, to lessen the dependence on overseas supplies, and to give a more varied diet..

An immediate improvement is possible in the quality of copra by reducing the interval between cutting and drying, and by taking more care during drying. At present, the coconut owners spend a day cutting copra and bring the wet copra back to the village for drying next day - an interval of up to 24 hours. To produce white copra, this interval should be reduced to less than 4 hours. To prevent contamination with sand and dirt, and to speed the drying process, drying trays should be erected above ground level, and should be provided with movable covers of galvanised iron or other rain-proof material.

The use of hot-air driers, for the production of good quality copra even in rainy weather, should be investigated. However, care is needed to prevent a trade developing in green copra between growers and Co-operative Societies, as this would inevitably cause delayed drying and consequent reduction in quality.

To encourage the production of better quality copra it will be necessary to introduce a grading system\* coupled with reasonable price differentials between grades. Particular attention should be paid to thorough drying of copra. Encouragement of half-nut copra (obtained by husking prior to splitting, instead of by extraction using a knife) would result in less fragmentation and less dust, and probably higher oil content; but a longer drying period is needed. Finally, quality should not be lost during storage by allowing insect infestations to develop; a routine spraying of the sheds is recommended.

Management of the coconut groves could with certainty be improved by weeding the bushes and germinating nuts, by removal of aged and non-producing palms, and by a prohibition on burning within the groves.

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\* Copra grading was instituted in 1957.

It is highly probable that increased yields would also result from selective thinning in most places, and by the establishment of a leguminous ground cover; but these should be investigated before being advocated on a wide scale. The cover crops Calopo and Centro were unsuccessful at Bikenibeu but the beach pea Vigna marina, which flourishes on Funafuti is more likely to be suitable. There is insufficient evidence on which to base a firm recommendation for optimum spacing, but it appears that ten yards is too wide and gives insufficient ground shade. Eight yards triangular planting is tentatively suggested.

Very considerable losses occur in certain places through delayed collection and incomplete collection of nuts, resulting in partial or total losses through germination of the nuts. This problem is economic rather than agricultural, and is related to the problem of better utilization of land held by absentee owners. A possibility worth investigation is the alteration of the export tax on copra into a land tax. This is considered possible since an overwhelming proportion of the land is used for coconut production. It would be necessary either for the tax rate to vary with the year's productivity, which depends on the rainfall or that there should be a flat rate with a reduction in drought years. It might also be necessary to reduce the rate in infertile areas.

The most important long-term measure in improving the crop lies in better planting of better nuts on unplanted land. No areas were seen on Tarawa which require felling and replanting, and it is not known if this would be justified on other islands. Selection of seed nuts of good shape from high yielding trees followed by rigorous selection of seedlings would not be difficult to carry out, but does not appear to have been thought of.

Recent figures for copra produced by the Gilbertese may be mentioned here. They are from the Colony copra Board's Annual Report for the year ending 31st March, 1958:

1951	1952	1953	1954	1955	1956 (drought)
4,019	3,956	7,705	5,770	7,180	2,900 tons.

It is certain that more 'babai' could be grown, mainly by greater attention to the existing area. Yields under different methods of management require study. For example, the pig manure is all wasted. The legume Gliricidia grows on Betio and Bairiki and could possibly be grown round the banks of pits, and used for mulching together with the pig manure. Varietal differences such as salt toleration, rate of growth, and yield are unknown. A comparison of the yields of Colocasia and the two main Cyrtosperma varieties 'Te Katutu' and 'Te Ikaraoi' over different intervals of time would be very interesting. Finally, a method is required to encourage the sale of 'babai' through the Co-operative Society to the people on Bairiki and Betio.

A point scarcely agricultural yet not out of place here concerns the use which might be made of mangrove; considerable protection could be given to the road where it crosses between islets by judicious planting of seedlings. The first stage of land reclamation on the lagoon shore could be construction of fish ponds, their banks being protected by mangrove.