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EDITORIAL NOTES.

FOR some decades the policy of most countries has been to encourage the local production of staple commodities instead of relying on their importation. To-day, this policy is largely dictated by the international situation, which is restricting the free flow of trade from one country to another. In New Guinea, production for local consumption is small, most of the necessities of life being imported from Australia and overseas. The value of the foodstuffs imported into this Territory is about £300,000 per annum and the value of the foodstuffs of animal origin is approximately half this amount, made up as follows:—

	£
Meat	86,000
Dairy Produce	30,400
Fish	16,700
Bacon and Hams	9,900
Other Animal Foodstuffs	8,900

A diminution in the importation of any of these foodstuffs, particularly dairy produce, through increased local production is most desirable. In the case of dairy produce, local production is not only desirable economically, but necessary to maintain a high standard of health, for milk is the most valuable of all foods and it has been proved that in communities where there is not a good supply of cheap fresh milk, the health of the people is thereby impaired.

The production of milk in the tropics is a subject which has received much attention during recent years. The most fundamental of the many problems connected with it is that concerned with the establishment of breeds of dairy cattle which will live, thrive and produce payable quantities of milk under the severe climatic and environmental conditions existing in tropical countries. The introduction of European breeds into the tropics with a view to their final acclimatization is a practice which has met with little success. The first imported animals may be satisfactory, but successive generations bred in the tropics show progressive degeneration due to causes which have not been fully investigated. Repeated importations of new blood may retard this degeneration but are generally unsatisfactory. The development, by selection, of milking strains within some of the pure breeds of Indian cattle of the Zebu or Brahmin type has met with definite success and it has been stated, that in the proper handling of material available in Southern India, lies the solution to the problems of breeding dairy cattle for the tropics.

Nearly half a century ago, dairy cattle were first introduced into this Territory and although many died shortly after their importation, some survived and to-day their prodigy (over 20,000) are to be found in many coastal districts of the Territory. These cattle were mostly of the Jersey and Guernsey breed imported from Australia, although, it is on record, that occasional cows of the Bali, Zebu and Javanese breeds were also brought into the country. These cattle were imported for the joint purpose of milk production and to keep down grass on the plantations, thereby saving labour. As dairy cattle, they have degenerated pitifully, but they have adapted themselves to their environment and are in good health. Unfortunately, their milk yield is low but, as will be shown in the following article, this is partly the result of inadequate feeding. By proper feeding, selection and perhaps the introduction of new blood from sub-tropical countries, the milk yield could be increased and dairy herds of good grade built up.

The relation between dairying and the copra industry is most complex and before the present war the largest butter producing countries were also the largest margarine producers. This is partly because the by-product from the preparation of copra is an important supplementary fodder and this fodder can be utilized in increasing milk and hence butter production. For the same reason, a similar relation exists between the coco-nut and pig industries. Coco-nut meal or cake is an excellent pig food and in Guam fresh coco-nut meat has been successfully used for feeding growing pigs and brood sows on pasture. Both skim-milk and butter-milk would be excellent supplements to coco-nuts in swine feeding, for these dairy by-products are rich in calcium, phosphorus and proteins of the highest quality.

It is thus seen that there is a definite relation between the copra, dairy and pig industries and once one of these industries has been established, it is advantageous that the development of the other two should follow. Unfortunately, none of these industries has been fully developed in this Territory, although the time should not be far distant when we will be crushing our own copra and seeking the most economical means of disposing of the by-products.

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MILK PRODUCTION IN NEW GUINEA.

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Introduction.

There are no cattle indigenous to the Territory of New Guinea, but during the past forty or fifty years, particularly during the German occupation, cattle were introduced into many parts of the country. A search through old German records (Statistics, German New Guinea, 1916) has revealed that mostly cattle of the Jersey and Guernsey breeds were imported, and the colour and conformation of many of the existing cattle give definite support to this statement. Much care was taken over the importation of these cattle, and the Germans had a government station at Kieta (*Bulletin Imperial Institute*, 1915) for the breeding and distribution of superior types. These cattle have interbred and increased in numbers,[a] so that to-day large mixed herds are to be found on plantations in practically all coastal districts of the Territory. They are never housed and, except in occasional cases where the cattle have access to cover crop, their feed consists only of natural pasture. Nevertheless, they are in fair condition and remarkably free from disease.

The individual milk yield of these cows seldom averages much more than one quart a day at any stage of their lactation period, so that they are not worth milking, except in cases where planters milk three or four to supply their own household requirements. The mean yield per cow of fifteen herds on different plantations was only 1.1 quarts per day, which is even lower than the yield from the poor, inefficiently producing, native cows of Ceylon and South India (Bruce, 1922; Crawford, 1938, and Bunting and Marsh, 1934).

Less than four years ago, a small herd of pure-bred Friesian cattle was imported from Australia for the purpose of supplying fresh milk to Rabaul. This is the only herd, producing milk on a commercial basis, in the coastal districts of the Territory. The average daily milk yield of this herd throughout the year is about half a gallon per cow, although, in May, 1940, 28 cows thoroughly milked were only giving 12 gallons per day, but at that time several of the cows had their calves running with them during the day, so that the actual yield was slightly higher than this amount. The standard daily yield for a Friesian cow in a temperate climate is 3.2 gallons (Bulletin 52, Ministry for Agriculture and Fisheries, 1937), and the original cows in this herd were giving from three to four gallons a day before their importation.

Because of these low yields, dairy farming in New Guinea is a most unattractive proposition, and although there are many centres in which sufficient people live to support one or even more dairies, there are only three dairies selling milk in the whole of the Territory. One is situated near Rabaul, and two in the high inland mining town of Wau, where climatic conditions are more conducive to dairying, being quite different from those in the coastal districts of the Territory.

(*a*) In 1909, there were less than 1,000 cattle in New Guinea (Amtsblatt f. Neu-Guinea vom 15. Sept. 1909) and to-day about 21,000 have been accounted for (Report on Administration of Territory of New Guinea, 1938-39) and there are many more. The increase has been mostly a natural one.

The object of this investigation was to show that these low milk yields are largely the result of inadequate feeding, and to indicate how the yield could be improved.

Climatology.

To understand fully the circumstances surrounding this investigation, it is necessary to know something of the climatic conditions of the coastal districts of New Guinea, where practically all cattle are located.

The Mandated Territory of New Guinea is situated 141° to 156° east longitude, and approximately 0° to 8° south of the equator, and, except for the high inland areas of the Mainland, its climate is typically tropical in the narrowest sense of the word. On the smaller islands and along the coastal belts of the Mainland, New Britain, New Ireland and Bougainville Island, where most agriculture is practised, the climate is hot and humid. There are no distinct seasons, although more rain falls when the north-west monsoons prevail, from December to April, than during the remainder of the year. The average rainfall varies from 100 to 300 inches per annum. The mean temperature is approximately 82° F. at all periods of the year. The greatest difference between the highest and lowest barometer readings during the year seldom exceeds 10 millibars. From observations taken over a period of years at five main coastal weather stations, the average relative humidity was found to be 81 per cent. at 9 a.m., 75 per cent. at 3 p.m., and 88 per cent. at 9 p.m. The average soil temperatures, taken at a depth of 9 inches in the Botanic Gardens in Rabaul, were 84° F. at 9 a.m. and 85° F. at 3 p.m., and these readings seldom varied by more than about 4° F.

It is thus seen that the climate of the coastal districts is entirely lacking in the seasonal variations found in more temperate zones.

Composition and Properties of Milk.

Table I. gives the composition of 70 mixed milk samples from the pure-bred Friesian herd to which reference has already been made, and 42 from other mixed herds in the Territory.

TABLE I.—AVERAGE COMPOSITION OF NEW GUINEA MILK.

Herd.	Total Solids.	Fat.	Solids-not-fat.	Specific Gravity.
	Per cent.	Per cent.	Per cent.	
Friesian	13.13	4.82	8.31	1.0298
Mixed	13.56	6.28	7.27	1.0290

Methods of Analysis.—Specific gravity was determined with a Westphal balance and corrected for temperature using the author's equation (Hutchinson, 1940). Fat was estimated by Richmond's (1930, *a*) modification of the Roese Gottlieb method, total solids by the evaporation of 10 c.c. of milk and solids-not-fat by difference. Normally, if the fat content and specific gravity were known, the total solids and hence solids-not-fat could be calculated from Richmond's formula (1930, *b*), but it has not yet been shown that Richmond's formula holds equally well under tropical and temperate conditions; in fact, there is evidence to the contrary. Calculating total solids by Richmond's formula for milk from the Friesian and mixed herds, we have 6.18 and 7.94 per cent. respectively. These figures are much lower than those found by direct estimation.

Discussion of Results.—Comparing the figures given in Table I. with those given by Morrison (1938, *a*), Richmond (1930, *c*) and Davies (1939, *a*), it will be seen that the solids-not-fat content and the specific gravity of the New Guinea milk is low, while the fat content tends to be high. A high fat content is to be expected, for it will be shown later that the pastures in the coastal districts of New Guinea are rich in carbohydrates, and it has been proved (Mackintosh, 1938, *a*) that the fat of milk is largely formed from the carbohydrates supplied in the feed. Furthermore, many of the mixed herds contain Jersey and Guernsey blood, and these breeds of cattle are noted for giving milk of high fat content.

The low specific gravities are accounted for as follows: The melting point of butter fat is about 86° F., so that it is liquid when drawn from the cow and, under the atmospheric conditions prevailing in New Guinea, solidification takes place so slowly that it remains in the liquid state during the day it is drawn, generally solidifying in the evening. It has been shown (Richmond, 1930, *d*) that the specific gravity of butter fat in the liquid state is lower than when in the solid state; so that the specific gravity of milk, in which the butter fat is in the liquid state, will be lower than when the butter fat solidifies. The low solids-not-fat content of the milk would also lower the specific gravity slightly.

The low solids-not-fat content appears to be general for milk produced in the tropics. Wright (1916-22) has recorded normal values a little over 8 per cent. for the solids-not-fat content of milk produced near Suva, whilst Southall (cited by Blackie and Flemons, 1939) made a series of determinations on milk from local suppliers in Fiji, and his figures indicate a wide variation in solids-not-fat tending to an average of 8.3 per cent. Further work in Fiji, by Blackie and Flemons (1939), shows the mean solids-not-fat content of mixed milks collected over a period of one year to be 8.33 per cent. French and Raymond (1936) have indicated a similar state of affairs in Tanganyika, stating that over 25 per cent. of the grade cows regularly give milk which contains less than the arbitrary legal limit of 8.5 per cent. solids-not-fat. In Mauritius (Annual Report, Department of Agriculture, 1938), the mean solids-not-fat content of a large number of mixed milk samples collected at different periods of the year was 8.4 per cent. In the Philippines (*Handbook of Philippine Agriculture*, 1939, *a*), where a number of milk samples from cows of different breeds have been analysed, similar results were also obtained. The mean of four analyses of milk from Holstein cows gave a protein plus lactose content of 7.42 per cent., and 37 samples from half Nellore-half Holstein cows gave 7.52 per cent.

Low Solids-not-fat—Probable Causes.—This lowering of the solids-not-fat may be due to several causes. It may be a natural adjustment brought about by the physiological necessity of secreting a liquid lower in calorific value to suit the naturally smaller needs of a suckling in a warm climate or it may be due to disease or faulty nutrition. The first cause seems unlikely as the fat content tends to be high, although there is the possibility that this high fat content may be due to other causes of difficult physiological control, for the fat content of milk is more readily changed than the solids-not-fat. If the second cause is responsible, it could almost certainly be detected by analysis, for the solids-not-fat are usually altered in composition by digestive ailments and by disease (Bergema, 1919).

The results of the analyses of the solids-not-fat fractions of 25 milk samples are given in Table II. Protein was estimated by the method outlined by Davies

(1939, *b*); lactose by the Fehling's Solution method outlined by Richmond (1930, *e*) and chlorine by Massot and Lestra's (1936) third method.

Reference will be made later to the mixed herds from which samples 11 to 25 were collected, for it was on these herds that determinations of weight were made and it was the pastures upon which they were feeding which were analysed.

These figures are not abnormal, although the lactose content is perhaps low and the chloride content a little high. Davies (1939, *c*) gives the normal lactose content of milk as 4.8 per cent. He also gives the normal chloride content of morning milk as ranging from 81 to 90 mgms. per 100 ml. (Davies, 1938), and, for samples from Friesian herds known to be giving milk low in solids-not-fat, the

TABLE II.—COMPOSITION OF THE SOLIDS-NOT-FAT FRACTION OF NEW GUINEA MILK.

No.	Herd.	Protein.	Lactose.	Ash.	Chloride.	
		Per cent.	Per cent.	Per cent.	Per cent. Cl.	Per cent. NaCl.
1	Friesian	3.06	4.42	.67	.136	.224
2	,,	2.97	4.29	.68	.146	.241
3	,,	3.15	4.55	.70	.127	.209
4	,,	3.16	4.62	.71	.121	.199
5	,,	3.06	4.40	.68	.123	.203
6	,,	3.07	4.45	.69	.140	.231
7	,,	3.16	4.67	.70	.118	.194
8	,,	3.24	4.68	.72	.117	.193
9	,,	3.17	4.59	.71	.124	.204
10	,,	3.12	4.51	.69	.130	.214
Mean	..	3.12	..	..	..	..
11	Mixed	2.39	3.46	.56	.198	.327
12	,,	2.86	4.13	.64	.158	.261
13	,,	3.11	4.49	.69	.131	.216
14	,,	3.21	4.64	.71	.121	.200
15	,,	2.08	2.96	.46	.244	.402
16	,,	2.94	4.24	.65	.151	.249
17	,,	2.80	4.04	.62	.164	.270
18	,,	3.12	4.50	.69	.131	.216
19	,,	2.80	4.25	.68	.149	.246
20	,,	3.21	4.40	.69	.138	.228
21	,,	2.19	3.17	.50	.201	.331
22	,,	2.62	3.80	.58	.183	.302
23	,,	2.72	4.00	.59	.164	.270
24	,,	2.93	4.04	.67	.164	.270
25	,,	3.12	4.56	.70	.133	.219
Mean	..	2.81	..	..	..	..

mode of the frequency distribution was 110 to 120 mgms. per 100 ml. A low lactose content accompanied by a high chloride and ash content is generally considered as indicative of disease or of digestive ailments. Mathieu and Ferré (1914) have found that the lactose (grams per litre) plus the lactose equivalent of the chlorides as NaCl (NaCl × 11.9) in grams per litre does not fall below 70 in a normal milk. They have termed this figure the "*constant moléculaire simplifiée*", (c.m.s.). Koestler (1922) has suggested that the value 100 × per cent. Cl. ÷ per cent. lactose ("Koestler number") is of value in diagnosing milk from cows with diseased udders or otherwise giving abnormal milk. The value for normal milk is usually less than 2 and milk samples giving values above 3 may be regarded as abnormal, the latter value applying to milk containing .14 per cent. Cl and over. Computing the c.m.s. and Koestler number for the milk samples analysed, the results given in Table III. were obtained.

TABLE III.—C.M.S. AND KOESTLER NUMBER FOR NEW GUINEA MILK.

Friesian.			Mixed.		
No.	c.m.s.	Koestler No.	No.	c.m.s.	Koestler No.
1	70.9	3.1	11	73.5	5.72
2	71.6	3.4	12	72.4	3.82
3	70.4	2.8	13	70.6	2.92
4	69.9	2.6	14	70.2	2.61
5	68.2	2.8	15	77.4	8.24
6	72.0	3.1	16	72.0	3.56
7	69.8	2.5	17	72.5	4.06
8	69.8	2.5	18	70.7	2.91
9	70.2	2.7	19	71.8	3.51
10	70.6	2.9	20	71.1	3.13
			21	71.1	6.34
Mean	70.3	2.8	22	73.9	4.82
			23	72.1	4.10
			24	72.5	4.54
			25	71.7	2.92

Neither the c.m.s.'s nor the Koestler numbers for milk samples from the Friesian herd suggest that these cows were suffering from disease or digestive ailments, particularly as the ash content is low. The c.m.s.'s and Koestler numbers for samples 1, 2 and 6 are slightly above 3 and 70 respectively, but not appreciably high.

The milk samples from the mixed herds gave widely differing c.m.s.'s and Koestler numbers, the majority being abnormally high. The wide difference to be found in these figures is due no doubt to the fact that the samples were not from the bulked milk of herds of normal size, but generally from only three or four cows, so that individual variations might not have been completely eliminated. The reason for most of the figures being high is accounted for by the fact that the chloride content of the samples was correspondingly high. Davies (1932) has made detailed analyses of milk samples from healthy cows which were giving milk low in solids-not-fat and he found that the constituent mostly responsible for the deficiency was lactose and that invariably samples low in solids-not-fat and thus lactose are high in chlorides due to the fact that the maintenance of the osmotic pressure of the milk is affected by the substitution of ionized chlorides for lactose. Thus it is normal for these samples, low in solids-not-fat, and hence lactose, and high in chlorides to have high c.m.s.'s and Koestler numbers. This and the fact that the ash contents are low give no indication that these milk samples were from diseased cows or from cows suffering from digestive ailments.

The third possible cause will now be considered. In an excellent paper, "The Effect of Type of Feed on the Solids-not-fat Content of Milk", Roux, Murray and Schutte (1935) fed one group of six cows a heavy concentrate ration, a second group a heavy dry ration and a third group a heavy succulent ration.

The heavy concentrate ration maintained a higher level of production, a normal trend of solids-not-fat and a slow increase in percentage of butter fat with advance in lactation. The other rations appeared to have a depressing effect on the percentage of solids-not-fat and milk production dropped more rapidly and the percentage of butter fat increased to a greater extent than occurred in the heavy concentrate group.

During a period of three years, Cranfield (1927) studied variations in the solids-not-fat content of a herd of Shorthorn cows which frequently gave milk low in solids-not-fat. Feeding was found to be one factor which influenced the solids-not-fat content of the milk.

As a result of four years' investigation with a herd of cows, it has been shown (Trambics, 1938) that the percentage of solids-not-fat drops in summer months, the drop being more marked the severer the summer. It is considered that this drop is partly the result of a change in the sugar and protein content of the feed.

The results of these investigations indicate that poor feeding could be at least partly responsible for lowering the solids-not-fat content of milk. It will be shown presently, that the feed upon which New Guinea cows are feeding is often very low in nutritive value and it seems highly probable that these low figures for solids-not-fat are partly or wholly the result of faulty nutrition. In fact, it is probably for this reason that low solids-not-fat are more common in the tropics than in temperate climates, for in temperate climates pastures are, in general, more nutritive (see Table V.) and the practice of feeding concentrates is more common.

Factors Effecting Milk Yields.

Miscellaneous Factors.—The amount of milk a cow produces is effected much more readily and to a greater degree than its composition.. There are several factors which might be contributing towards low milk yields in New Guinea but, as will be shown presently, there is one factor which appears to greatly outweigh all others. It must be understood, however, that with the exception of the recently introduced Friesian herd, the cows are producing approximately as much milk as their dams which is probably their inherited capacity. After the introduction of the first cattle, each succeeding generation has probably produced a little less milk than the previous one, until a state of equilibrium has been reached in relation to their environment. Therefore, the low milk yields are the result of factors which have been operative over a number of cow-generations.

New Guinea cows are only milked once a day, in the early morning. An attempt was made to increase the production of the Friesian herd by milking twice daily, but the dairyman considered that the slight increase in yield was not sufficient to justify the extra labour involved.

The cattle are generally milked by natives, for most New Guinea cattle, with the exception of the Friesian herd, are too timid and frightened to be even approached by a white man. There is a possibility that the natives may not strip the cows as thoroughly as desirable, although the milk is generally high in fat and most fat is contained in the strippings (Van Slyke, 1908 and Eckles (—)).

The only complaint from which any of the cattle appear to be suffering is tick infestation, although they appear to be immune to tick fever. But ticks in New Guinea cattle are not common, although, unfortunately, they are spreading, and of the sixteen herds under observation during this investigation only one was found to be infected with them. Hence, although it is known that ticks do lower milk yields (Maynard, 1931), they are not responsible for low yields in the present instance.

For a cow in good health, the maximum yield is usually reached at 7 to 9 years of age but there is usually no marked decline in yield until she is about 12 years of age (Morrison, 1938, *b*). None of the cows under observation during investigation was more than 6 or 7 years of age.

If the weather is too hot for the comfort of the cows, it may cause a slight but decided reduction in yield, together with an increase in the fat content and other changes in the composition of the milk. Experiments have shown that such an effect is produced when cows are kept in an atmospheric temperature above 85° F. for more than 48 hours (Regan *et al.,* 1934). High humidities may also cause a drop in yield, high producing cows being more effected than low producers (Bender, 1928). The temperature in New Guinea frequently reaches 85° F. but remains there only for a relatively short time and, as the cows are all low producers, neither temperature nor humidity should effect milk yields to more than a small extent.

Cows imported into a tropical country are more susceptible to heat than those born there. In the case of exotic breeds, it has been shown (Bonsma *et al.,* 1940) that as soon as the atmospheric temperature rises above 80° F., it is accompanied by a rise in the body temperature and a considerable increase in the respiration count. The respiratory centre loses its normal function of controlling the rhymthmical movement of respiration, the breathing consequently becoming rapid, irregular and shallow. Such factors would almost certainly have a disturbing influence on the delicate mechanism of milk production, in the imported Friesian cows.

Dietary Factors.—During a preliminary investigation into the low milk yield of New Guinea cows, the herd of Friesian cattle was fed concentrates imported from Australia in addition to being grazed all day. The concentrate was mixed with chaffed elephant grass (*Pennisetum purpureum*) and the amount fed depended approximately upon the individual response of each animal. It was found that during a very short time, the milk yield could be increased more than 30 per cent. This suggested that the cause of the low milk yield was partly dietary. Consequently, it was decided to investigate the diet of these cows and this led to a determination being made of the nutritive value of the more common grasses and fodder crops found in the coastal districts of New Guinea.

Nutritive Value of Fodder Crops.—It is well known that different grasses and legumes vary widely in nutritive value. Even plants of the same species may vary considerably in composition depending upon their habitat and stage of maturity. For instance, immature grass is relatively high in protein and low in crude fibre. As the grass matures, the percentage of protein decreases and that of crude fibre increases. Hence, a pasture that grows considerably faster than it can be consumed, will soon have a stand of mature grass, high in fibre but low in nutritive value. In recent years, the work of Woodman and associates at Cambridge has emphasized the value of immature grass for feeding purposes and milk production.

In New Guinea, particularly on plantations along the coastal belts, there are extensive areas of green, succulent and apparently nutritious pastures. Because of the climatic conditions, there is no period of maximum growth, but plants are growing rapidly all through the year and consequently these pastures consist of a high proportion of mature grass. Cattle do not graze these pastures indiscriminately but generally seek the younger grass, of which there is only a very limited amount. This necessitates their covering extensive areas each day.

On plantations the grass is cut periodically, but it commences growing immediately and within a very short time reaches maturity again. If there are cattle on the plantation, it is probable that they will not have availed themselves of the opportunity of grazing on the freshly cut areas, for most tropical cattle are of a very nervous and timid disposition and generally migrate to those parts of the plantation where there is least activity and excitement. It would be too expensive to enclose the cattle within fenced areas, for timber is frequently scarce and the areas would have to be large and the fences substantial.

Samples of the more common grasses and sedges of which New Guinea pastures are composed have been collected and analysed. These samples were divided into mature and immature samples. By mature grass is meant grass at or past the flowering stage and by immature grass is meant young grass which is sufficiently high to be easily grazed, but which shows no sign of flowering. Each sample analysed was taken from a number of pooled samples collected from one locality, although, in some cases, it was not possible to collect corresponding mature and immature samples from the same locality.

Sixteen samples of mixed pastures were also collected and analysed, but, as has already been pointed out, whenever possible, cattle eat only the immature grass. They also show preference for certain grasses. For instance, they will never eat Kunai (*Imperata arundinacea*), no matter how young and succulent it may be, if there are other grasses available. Thurston grass (*Paspalum conjugatum*), is perhaps the most common pasture grass in the Territory and on some plantations it is the only grass. Couch grass (*Cynodon dactylon*) is relished by cattle and is plentiful around Rabaul, although comparatively rare in other parts of the Territory. Because of these facts, samples of the more nutritious and succulent portions of these sixteen pastures were also collected and analysed for moisture, crude protein and digestible crude protein. These unavoidably contained some mature grass but they were very similar to those eaten by the cow. They were not cut, but plucked by hand in order to simulate a cow's method of grazing.

All estimations were made in duplicate on the fresh samples, 5 grams being taken for each determination. Crude protein, which was estimated in preference to true protein for reasons to be given later, is nitrogen $\times$ 6.25. Crude fibre was estimated by the method given in Allen's *Commercial Organic Analysis* (1937). The ether-soluble extract was determined in a Soxhlet extractor, moisture in a hot air oven at 105° C. and sugar and starch (or nitrogen-free extract), were computed by difference. The results of these analyses are presented in Tables IV. and VI.

TABLE IV.—COMPOSITION OF NEW GUINEA PASTURES, GRASSES AND SEDGES.

Common Name.	Scientific Name.	Water.	Crude Fibre.	Sugar and Starch.	Crude Protein.	Eth. Sol. Extract.	Ash.	Nature of Specimen.	No. of Analyses.
		%	%	%	%	%	%		
Kunai ..	*Imperata arundinacea* ..	61	14.8	19.7	1.3	0.4	2.8	Immature ..	3
		48	18.4	29.0	0.8	0.3	3.5	Mature	3
Thurston ..	*Paspalum conjugatum* ..	82	4.9	7.0	3.2	0.7	2.2	Immature ..	3
		74	7.4	14.4	1.5	0.4	2.3	Mature	3
Nut ..	*Cyperus rotundus* ..	78	6.5	10.5	2.4	0.2	2.4	Immature ..	3
		67	10.4	17.9	1.9	0.2	2.6	Mature	3
Love or Seedy	*Chrysopogon aciculatus* ..	69	9.0	15.2	3.4	0.4	3.0	Immature ..	3
		61	13.3	20.7	1.8	0.2	3.0	Mature	3
Couch ..	*Cynodon dactylon* ..	66	10.2	16.7	3.5	0.5	3.1	Immature ..	2
		57	12.5	23.7	3.0	0.3	3.5	Mature	2
Elephant ..	*Pennisetum purpureum* ..	89	4.6	2.9	1.2	0.5	1.8	1 ft. high.. ..	1
		86	7.0	4.2	0.7	0.5	1.6	4 ft. high.. ..	1
		62	13.2	21.8	0.5	0.3	2.2	16 ft. high (mature)	1
Karapai ..	*Pennisetum macrostachyum*	81	7.2	6.8	2.3	0.4	2.3	Immature ..	3
		75	12.6	8.4	1.2	0.3	2.5	Mature	3
Pasture ..	.. .. ..	70	10.3	15.4	1.4	0.4	2.5	Mixed	16
		(As percentage of dry matter)							
		..	34.3	51.3	4.7	1.3	8.3	Mixed	16

In order to compare the results given in these tables with figures for pastures growing in temperate climates, Table V. has been compiled. This table gives the chemical composition of a number of mixed pastures used for the grazing of dairy cattle in some of the more prominent milk-producing countries.

Comparing the figures in Tables IV. and VI. with those in Table V., it is seen that the protein content of New Guinea pastures, when the whole pasture is sampled, is appallingly low. When mostly the younger portions of the pastures are sampled the protein content is nearly double and, considering New Guinea pastures are unimproved natural pastures, for the most part growing on loose, easily leached soil, it is considered that these results would probably be in good agreement with results obtained for pastures growing under similar conditions in temperate climates. The ash and ether-soluble extract are also low; there is no appreciable difference in the starch and sugar content and the fibre content is, in general, higher. These differences are largely accounted for by the fact that the samples contained a high proportion of mature grass.

Pasture Digestibility.—A chemical analysis is not in itself sufficient for the determination of the nutritive value of a feed. The proportion of the feed which is digestible is also required to be known.

When the digestibility of a feed is determined biologically it is generally assumed that the whole of the dung consists of undigested food. This is incorrect, for faeces always contain metabolic waste products. Attempts have been made to

TABLE V.—COMPOSITION OF PASTURES IN TEMPERATE CLIMATES.

Country.	Season.	Water.	Crude Protein.	Crude Fibre.	Sugar and Starch.	Ash.	Ether Extract.	No. of Estimations.	Reference.
		%	%	%	%	%	%		
				(Results expressed as percentage of green matter.)					
Australia ..	Summer	..	9.87	..	..	..	..	19	Hutchinson (1939, a)
South Africa ..	Summer	..	7.0–9.0	..	..	..	..	..	du Toit *et al.* (1940)
South Africa ..	Winter	..	3.3–4.0	..	..	..	..	..	du Toit *et al.* (1940)
America ..	..	74.2	4.7	5.3	12.0	3.2	0.7	86	Newlander *et al.* (1933)
America ..	..	71.3	5.7	6.4	12.8	2.7	1.1	262	Morrison (1938, *c*)
America ..	..	69.8	4.7	6.5	14.5	3.7	0.8	40	Morrison (1938, *c*)
South America	..	75.6	3.7	6.5	10.8	2.6	0.8	179	Morrison (1938, *c*)
				(Results expressed as percentage of dry matter.)					
South Australia	..	..	8.0	29.6	51.4	9.5	1.6	...	Davies *et al.* (1934)
England ..	Spring	..	11.3	24.0	53.6	8.3	2.8	35	Moon (1939)
England ..	Winter	..	13.4	28.3	49.6	6.0	2.7	14	Thomas and Boyns (1936)
Canada ..	..	5.3	14.7	24.3	..	..	..	..	Crampton (1934)
America ..	..	..	17.5	23.4	46.5	8.3	4.9	..	Woodward (—)

determine the amount of metabolic residue in the faeces by feeding a nitrogen deficient ration. Kellner (1880), working with herbivora, suggested a value of .4 gram of nitrogen per 100 grams of organic matter digested. Pfeiffer (1883-87) carried out a number of experiments with pigs and the figures he obtained agreed with Kellner's value for herbivora. However, it has since been shown (Ashton, 1936; Morgen *et al.*, 1914, and Mitchell and Hamilton, 1929) that a definite figure cannot be accepted for the metabolic nitrogen of all rations for the figure varies with different feeds fed in different ways, nevertheless Pfeiffer (*loc. cit.*) concluded from his experiments that the nitrogenous products of metabolism must be taken into account in determining the protein digestibility in animal experiments.

Efforts to determine the digestibility of a food *in vitro* have been successful in the case of protein. This has been effected by artificial digestion in acid gastric juice and has served to determine the total protein which is digestible. Such determinations, however, tend to measure the true digestibility in the digestive tract rather than the effective digestibility as measured by animals.

Pfeiffer (*loc. cit.*) carried out experiments to determine the crude protein digestibility of certain feeding stuffs (1) with animals, (2) by artificial digestion and (3) with the value obtained in the animal experiment corrected for the nitrogen-containing metabolic residues. There was excellent agreement between the values obtained in the artificial digestion and the values obtained in the animal trials when corrected for the metabolic residue in the faeces. More recently (Watson and Horton, 1936), a ration of artificially dried grass was fed at the plane of nutrition to six sheep. The digestibility coefficients obtained by the different methods were:—

Animal experiments uncorrected for metabolic residues ..	63.30
Animal experiments corrected for metabolic residues ..	76.24
Artificial digestion	76.95

This also shows excellent agreement between figures obtained by the last two methods.

The main objection to the artificial methods is that the digestibility of certain protein constituents encased in very tough or fibrous cells is included in the determination, whereas, in actual practice, this protein may pass through the animal undigested.

In New Guinea there are two animals available for digestibility trials, the cow and the goat, but climatic conditions, insect pests, and the temperament of the New Guinea cows and goats do not permit digestibility trials being carried out satisfactorily and with the necessary accuracy. Hence, in the present instance, it was considered that more reliable results could be obtained by an *in vitro* method rather than a biological method carried out under such unfavorable conditions. The method chosen was that recently employed by Schwarze (1937) in determining the amount of digestible protein in lucerne plants and various seeds. The digestion was carried out with pepsin-hydrochloric acid and pancreatin-soda mixtures.

Figures giving the amount of digestible crude protein in the more nutritious portions of the sixteen previously mentioned pastures are included in Table VI. The average amount of digestible crude protein in the first fifteen samples was 1.65 per cent. and for the sixteenth sample, which was collected from the pasture upon which the Friesian herd was grazing, 1.66 per cent.

It is interesting to compare the average figure for digestible crude protein given in Table VI. with figures for pastures in more temperate climates. For this purpose Table VII. has been compiled. It must be remembered, however, that, although the results were obtained from the most nutritious portions of the pastures, they were natural, unimproved pastures containing no introduced grasses or legumes of high nutritive value, whereas the English and American figures were probably for improved pastures.

TABLE VI.—PARTIAL ANALYSES OF THE MORE NUTRITIOUS PORTIONS OF NEW GUINEA PASTURES.

No.	Moisture.	Crude Protein.	Digestible Crude Protein.	
			Per cent. Fresh wt.	Per cent. Dry wt.
	Per cent.	Per cent.		
1	79	3.1	2.33	..
2	75	2.5	2.03	..
3	69	2.0	1.46	..
4	72	1.8	1.31	..
5	74	2.1	1.55	..
6	76	3.5	2.70	..
7	68	1.9	1.31	..
8	71	2.9	2.03	..
9	67	1.4	0.91	..
10	74	2.1	1.49	..
11	78	2.2	1.56	..
12	69	2.0	1.44	..
13	66	1.7	1.19	..
14	72	2.2	1.58	..
15	78	2.4	1.90	..
Mean	73	2.3	1.65	6.1
16	76	2.6	1.66	6.9
Mean of all results ..	73	2.3	1.65	6.1

From these results it is seen that the digestible crude protein content of New Guinea pastures is low, although approximately the same as for the best Queensland pastures. However, if the results for Queensland and New Guinea pastures were exactly comparable, it is probable that the New Guinea figure would be lower. By comparing values for the best pasture in each country, it is interesting to note that the digestible crude protein content appears to increase as the climate becomes more temperate. The reason for this may be that pasture improvement is practically unknown in tropical countries and is not as common in sub-tropical as in temperate climates.

TABLE VII.—DIGESTIBLE CRUDE PROTEIN CONTENT OF PASTURES.

Country.	Climate.	Digestible Crude Protein.	Remarks.	Reference.
		Per cent.		
New Guinea	Tropical ..	1.65	Young	This investigation
Queensland	Sub-tropical ...	1.6	Best	Brünnich (1926)
United States of America (southern)	Sub-trop.-temp.	2.6	Fertile	Morrison (1938, *d*)
United States of America ..	Temperate ..	3.3	Poor to fair ..	Morrison (1938, *d*)
United States of America	Temperate ..	4.4	Fertile	Morrison (1938, *d*)
England	Temp.–cold ..	2.2*	Extensively grazed	Mackintosh (1938, *b*)
England	Temp.–cold ..	4.4*	Closely grazed ..	Mackintosh (1938, *b*)

* Calculated.

Weight of Cows.—Suitable scales for weighing the cattle were not available so that their weights had to be determined indirectly.

Kendrick and Parker (1936) have compiled a table for estimating the live weights of dairy cattle from heart-girth measurements based on a study of 1,721 actual weights and heart-girth measurements of Holstein and Jersey cattle. A similar table has also been compiled by Ragsdale and Brody (1935) in which the estimated live weights for a given heart-girth are somewhat lower than those given by Kendrick and Parker (*loc. cit.*). Other methods of live-weight estimation have been suggested in the *Queensland Agricultural Journal* (1910), by Singh (1933), and by Dmitrochenko (1926).

Morrison (1938, *e*), in his standard work *Feeds and Feeding,* recommends the method of Kendrick and Parker (*loc. cit.*) for estimating live weight of dairy cattle and this method undoubtedly has advantages over the other methods. The live weights of sixteen groups of New Guinea cows from whom milk was obtained are given in Table VIII. In general, each group of cattle measured was typical of the whole herd.

New Guinea cows vary in size somewhat although, generally speaking, they are small, being about the size of a small Jersey cow. There are indications that the first importations were probably larger for, when the Friesian cows were imported from Australia almost four years ago, they were healthy and of normal size but the offspring of these cows have apparently ceased growing at less than 900 lb. live weight.

TABLE VIII.—LIVE WEIGHTS OF TYPICAL NEW GUINEA MILCH COWS.

No.	Mean Heart-girth Measurement.	Mean computed Live Weight.	Numer of Cattle. measured.
	inches.	lb.	
1	62	700	4
2	60	637	4
3	55	501	4
4	59	607	20
5	70	987	4
6	57	552	2
7	65	800	3
8	63	732	3
9	66	835	2
10	67	871	5
11	64	760	4
12	59	607	6
13	62	700	3
14	65	800	4
15	58	579	5
Mean	62	711	..
16	68	910	17

Pasture Consumption per Cow.—This may be determined by comparing the yield of clippings obtained from a grazed area immediately after the grazing trial with the clippings from a similar ungrazed check area, or, it may be determined by feeding a known weight of pasture to a cow in an enclosure, weighing the unconsumed portion at the expiration of a certain time and computing the feed consumed by difference. There are disadvantages to both methods. In the former, the assumption must be made that the grazed and check areas are identical and, unless an elaborate experiment is planned, this assumption may be far from the truth. While in the latter, a cow, which readily submits to stall feeding, would almost certainly consume more pasture if the pasture were already cut, than if the cow had to expend additional energy in grazing it. In this investigation, the latter method was chosen, for there was neither the necessary grass-cutting machine, nor experimental paddocks available with which to carry out estimations by the first method.

The feeding trials were conducted with the assistance of Brother Wochner at the Vunapope Catholic Mission at Kokopo where there is a herd of about nine hundred cattle, twenty of which are milked daily. These cows were quite typical of the majority of New Guinea cows and the daily milk yield averaged about 1 quart per cow. The cows were only milked once a day.

Before satisfactory results were obtained a considerable amount of preliminary experimentation was found necessary. After the first trial, it was found that even approximate values for the normal amount of pasture consumed during a given period could not be satisfactorily determined. Young pasture which had been obtained from areas in which the cows frequently grazed, was stall-fed to selected cows, but within a very short time after it had been plucked, and before it could be consumed by the cow, the pasture lost its freshness and became limp and dead in colour and the cows would not eat it.

It is a common habit in New Guinea to feed cows whilst milking them and it has been found that they relish fresh young bananas, in fact, the cows are loath to leave their stalls while any banana still remains in the feeding box. This allowed determinations to be made of an upper limit to the amount of feed, and hence dry matter, which cows will consume in 24 hours. By an upper limit is not necessarily meant the maximum amount of feed which the cows will consume in 24 hours but an amount which is in excess of that usually consumed by a cow on pasture during this period.

For the second preliminary experiment two cows each weighing about 700 lb. were chosen. In the early morning these cows were milked, and hand fed as usual and then instead of being turned out into the plantation to graze they were allowed to remain in their stalls for 24 hours, being fed from time to time throughout the day weighed quantities of fresh feed consisting of one part by weight of pasture and two parts by weight of freshly cut bananas. At dusk sufficient feed was fed to last until morning, and at the expiration of 24 hours the unconsumed feed was weighed. The cows had access to a common feeding box and were fed water *ad libitum*. The amount of feed consumed per cow was a little less than 50 lb.

During the trial, the stall fed cows had access to feed during the whole 24 hours and they appeared to take full advantage of it, whereas, if they had been turned out to graze, as usual, they would have been driven some distance before any feed was available and even then, considerable areas would have been covered during the course of the day in order to collect but small amounts of feed. In the heat of the day, the cows usually rest in the shade of any trees which might be nearby, thus losing more grazing time.

Having the above information upon which to work, a more accurate feeding test was then conducted. For this another two cows each weighing 710 lb. (heart-girth 62 inches) were chosen. They were stall fed as in the preliminary experiment with feed consisting of one part by weight of fresh young pasture and two parts by weight of bananas, the mixture having a moisture content of 79 per cent. The feed consumption is given in Table IX., the results being in good agreement with those previously obtained.

A similar experiment, in which chaffed young elephant grass (96 per cent.) and bran (4 per cent.) were fed instead of bananas and pasture, was later conducted with two Friesian cows weighing 910 lb. (heart-girth 68 inches) and the results are also given in Table IX. These cows would not eat the pasture-banana mixture.

TABLE IX.—DAILY FEED CONSUMPTION PER COW.

Experiment.	Fresh Feed consumed.	Moisture Content of Feed.	Dry Matter consumed.
	lb.	Per cent.	lb.
First (cows 710 lb.) ..	45	79	9.5
Second (cows 910 lb.) ..	124	89	13.6

In comparison with food consumption figures for dairy cows in temperate climates (Woodward, 1936) these figures are very low. This is probably due to the scarcity of palatable and nutritious feed, although, it is not to be expected that these animals would be large eaters, for they would then be too susceptible to overheating in a country where atmospheric temperatures are so high.

Digestible Crude Protein Consumption.—From the results of the preceding section and those given in Table VI we have—

	lb.
Amount of dry matter consumed per day by a cow weighing 710 lb.	< 9.5
∴ Amount of digestible crude protein consumed daily ..	$< \frac{6.1 \times 9.5}{100}$
	< .58
Amount of dry matter consumed per day by a Friesian cow weighing 910 lb...	< 13.6
∴ Amount of digestible crude protein consumed daily	$< \frac{6.9 \times 13.6}{100}$
	< .94

Protein Requirements.—Protein requirements for dairy cows have not been determined for cows living under tropical conditions. In the tropics, there is less loss of body-heat due to radiation and conduction than in a colder climate. Hence, slightly smaller amounts of digestible nutrients, particularly fat and carbohydrate, may be required, but it is doubtful whether, in the case of protein, the difference would be sufficiently large to be of practical significance.

In addition to the true proteins, other nitrogenous compounds of a less complex character also occur in feeds in relatively small quantities. These are generally grouped with true protein under the term crude protein.

Some investigators have expressed their results in terms of digestible crude protein, some as digestible true protein and, in 1924, a Departmental Committee of the Ministry of Agriculture and Fisheries in England advocated expressing protein requirements in terms of "protein equivalent", which is the percentage digestible true protein plus one half the difference between the percentage of digestible crude and digestible pure protein.[a]

The lack of justification for stating protein requirements in terms of digestible true protein is emphasized by Forbes (1924), who states that, "The true protein of a feed does not contain all its amino acid fraction, while the crude protein contains all—and much else—some of related character—and some not related. All things considered, the writer favours the continuance of the crude protein standard in the literature of animal production." Morrison (*loc. cit.*) in his standard work, *Feeds and Feeding,* expresses results in terms of digestible crude protein in preference to digestible true protein, the reason for his choice being that "there may be as great a difference in nutritive value between two pure proteins, as there may be between a crude protein and the mixture of these simpler compounds occurring in common foods." McCandlish (1938, *a*), after discussing the best units in which to express protein requirements in feeding standards, sums up by saying, ". . . it appears probable that there is more justification for a feeding standard being based on digestible crude protein rather than on true protein."

The non-protein nitrogenous compounds may be divided into two portions, one consisting of amino acids and their derivations, and the other of simpler nitrogenous compounds. There is no doubt that the amino acids and their derivations contribute towards the protein value of the feed, and it has been pointed out by Mitchell and Hamilton (1929) that the simpler nitrogenous compounds, though probably of no use to carnivorous or omnivorous animals, may perhaps be of some value to ruminants, and their possible value to ruminants is set forth in a paper by McCandlish (1938, *b*.).

In view of these facts, it is concluded that there is more justification for protein requirements being expressed in terms of digestible crude protein than digestible true protein, and because of the small differences to be generally found between digestible crude and digestible true protein and the consideration given above, there appears to be little justification for the term "protein equivalent."

In Table X are given the more recent figures obtained by various investigators for the digestible crude protein maintenance requirements per 1000 lbs. live weight. Where results were expressed in terms of digestible true protein, the conversion was effected by use of the factor 1.2, and protein equivalent was converted by using the factor $\frac{12}{11}$.

(*a*) The relationship between digestible crude protein (C), digestible true or pure protein (T) and protein equivalent (E) may be obtained as follows:—

According to Armsby (1917) .. .. $5C = 6T$

$\therefore C = 1.2T$

And by definition .. .. $E = T + \frac{C-T}{2}$

$= \frac{11C}{12}$

TABLE X.—DIGESTIBLE PROTEIN REQUIREMENTS FOR MAINTENANCE.

Authority.	Date.	Protein Requirements.	Result in Terms of Digestible Crude Protein.
		lb.	lb.
Eckles	1913	.5 true	.6
Haecker	1914	.7 crude	.7
Armsby	1917	.5 true	.6
Hills *et al.*	1922	.6 crude	.6
Buschmann	1923	.45 true	.54
Hansson	1926	.5 true	.6
Möllgaard	1929	.45 true	.54
Morrison(*f*)	1938	.6 crude	.6
Forbes and Kriss ..	1931	.6 crude	.6
Mackintosh(*c*)	1938	.6 Prot. equiv.	.65

In Table X, the majority of figures indicate that for maintenance, a cow weighing 1,000 lb. requires approximately .6 lb. of digestible crude protein daily. During the latter stage of pregnancy, a cow would probably need considerably more than this amount, so that, when dealing with a mixed herd in which there are cows at all stages of pregnancy, slightly more digestible crude protein would be required.

In the tropics, it is possible that protein requirements may be slightly less, for reasons already indicated. On the other hand, there is the possibility that New Guinea cows, which are naturally inclined to be careless in their habits, may not utilize their feed as efficiently as cows in temperate climates, although there are no real grounds for such a supposition. Taking all these factors into account, it seems reasonable to conclude that for maintenance, milch cows in New Guinea require approximately .6 lb. of digestible crude protein per 1,000 lb. of live weight daily.

It has been found that maintenance requirements are more closely proportional to body surface than live weight. The reason for this is that the body loses most of its heat by radiation and conduction from the skin surface, and this loss is proportional to the area of that surface. Also, the weights of the most active tissues of the body, in animals of different sizes, is more closely proportional to the surface of their bodies than to their live weights. Taking these factors into consideration, it has been deduced that if .6 lb. of digestible crude protein per 1000 lb. live weight is required daily, then cows weighing 910 and 710 lb. would require approximately .55 and .45 lb. respectively (Morrison, 1938, *g*).

During recent years, much experimental work has been carried out on the subject of protein requirements for production. Protein requirements for production are generally expressed as so many lbs. of digestible crude protein per 10 lb. of milk containing a certain fat content. No information is given as to the protein content of the milk, for, generally, the results are intended for incorporation in feeding standards where the quality of the milk is judged according to its fat content. The protein content of milk may vary from 3.05 to 3.85 per cent. (Davies, 1939, *d*), and although equations have been obtained connecting the fat and protein content of milk (Kahlenberg and Voris, 1931, and Ohio Station Bulletin 446, 1930), the results obtained are unsatisfactory. Hence, most experiments planned to determine protein requirements for production are of little value in determining the number of units of digestible crude protein required to produce one unit of milk protein.

Hills *et al.* (1922), conducting extensive investigations over a period of 13 years, found that cows produced satisfactorily on rations providing 1.26 to 1.46 times as much digestible crude protein as there was protein in milk. As the result of an extensive review of literature published by investigators working in American experiment stations, Morrison (1938, *h*) concluded that, in addition to maintenance needs, a cow required 1.25 times as much digestible crude protein as there is protein in the milk. This is confirmed by McCandlish in Scotland (1938, *c*).

Thus it seems fairly well established, that in addition to the protein allowance for maintenance, approximately 1.25 times as much digestible crude protein as there is protein in the milk is also required. Cows of high productive capacity need more than this amount, although it is claimed that when amounts greater than 1.60 times the amount of protein in the milk are fed, the production is not increased appreciably (Morrison, 1938, *i*).

In New Guinea, the possibility is that a larger and not a smaller amount of protein may be required for production, for as already mentioned, cows may not be able to utilize their feed as efficiently as they would under temperate conditions. Nevertheless, it seems reasonable to conclude that at least 1.25 times as much digestible crude protein as there is protein in the milk would be required for production purposes.

Protein available for Production.—If the amount of digestible crude protein required for maintenance is subtracted from the maximum amount of digestible crude protein which is likely to be consumed in a day, the resulting amount represents the maximum amount of digestible crude protein which is available for production thus,

For the mixed herds	.58 — .45 lb.
	= .13 lb.
For the Friesian herd	.94 — .55 lb.
	= .39 lb.

Now the average amount of protein in New Guinea milk, as given in Table II., is

For the mixed herds	2.81 per cent., or
	.281 lb. per 10 lb. of milk.
For the Friesian herd	3.12 per cent., or
	.312 lb. per 10 lb. of milk.

and the amounts of digestible crude protein required to produce 10 lb. of milk of the above protein content are

For the mixed herds .. .. .. $\frac{5 \times .281 \text{ lb.}}{4}$

= .351 lb.

For the Friesian herd .. .. .. $\frac{5 \times .312 \text{ lb.}}{4}$

= .390 lb.

so that, the maximum amount of milk which the protein intake of these cows permits them to secrete is

For the mixed herds . . . . . . $\frac{.13 \text{ lb.}}{.0351}$

$= \frac{.13}{.0351 \times 2.58}$ quarts.

$=$ 1.4 quarts.

For the Friesian herd . . . . . . $\frac{.39 \text{ lb.}}{.0390}$

$= \frac{.39}{.0390 \times 2.58}$ quarts.

$=$ 3.9 quarts.

and considering the assumptions made, these figures are in good agreement with actual fact. Actual production figures are lower than the above figures, which is to be expected, for the above figures are based on high consumption figures and on results for digestible crude protein which were determined on the most nutritious portions of the pastures which were not always available to the cows. Nevertheless, it indicates that cows in New Guinea are producing approximately as much milk as their protein, and hence, feed consumption, permits and, although there may be other factors influencing their yield, this dietary factor is paramount.

Improving Milk Production.

To improve milk production in New Guinea, it is necessary to improve the milk producing qualities of the cattle and to provide them with a good supply of a more nutritious feed.

Because of their low feed consumption, the cattle need a supply of feed even higher in nutritive value (particularly protein) than that usually fed in temperate climates. By keeping the cattle within fenced areas their grazing could be so regulated that the pastures never reached maturity. This would provide the cows with a slightly more nutritious feed but the initial expense and upkeep of wooden fences would prohibit their use on many plantations. The most satisfactory solution to the problem would be to improve the pastures by the introduction of plants of high nutritive value.

The improvement of the cattle can be brought about by the introduction of new blood or by selection, that is, by the castration of inferior males and the selection of only the best females for breeding purposes. However, it would be no use endeavouring to improve the cattle by either of these means until legumes or other plants of high nutritive value have been first established in the Territory.

Tropical Fodder Plants.

Much scientific investigation has centred around the problem of finding a suitable legume that will grow under tropical conditions. Legumes are more valuable than grasses for they are richer in protein and also carry the all-important nitrogen into the soil. Unfortunately, lucerne, subterranean clover and many other valuable legumes which grow in temperate climates cannot be grown successfully in the tropics but there is no reason to believe that there are not other plants of equal nutritive value indigenous to the tropics.

Both in the *Handbook of Philippine Agriculture* (1939, *b.*) and in the *Bulletin of the Imperial Institute* (1939), special reference has been made to *Centrosema pubescens* as a forage crop. The plant is claimed to be relished by cattle and to be high in protein. In tropical America, Hawaii, Mauritius, Madagascar and many other countries, *Leucaena glauca* has been used for many years as a fodder. It is excellent for cattle but has a depilatory effect on horses. Both these legumes have been growing in the Territory for a number of years, having been first introduced as a cover crop and shade respectively. *C. pubescens,* and to a less degree, *L. glauca,* give a slightly disagreeable odour to milk if the cows have been feeding on them up to the time of milking. This may be remedied by taking the cows off the feed for about four hours before being milked.

The *Bulletin of the Imperial Institute* (1927) also contained a brief note on the possibility of growing *Pueraria thunbergiana* as a fodder crop. This legume was introduced into New Guinea several years ago as a cover crop and is to be found growing on some plantations. Information on varieties and methods of cultivation is to be found in a paper by Calvino (1937).

Preliminary tests over the last three or four years at the Fitzroyvale Plant Introduction Station in Queensland have revealed the promising growth of the legume *Stylosanthes guyannensis*—vernacular name "Trifolio"—from Brazil. McTaggart (1937) has described its growth habit, palatability, soil and climatic requirements and strain selection. *Stylosanthes sundaica* [(a)] (Townsville lucerne), a small legume found in the neighbourhood of Townsville, in North Queensland, has also been receiving some attention of late as a tropical legume. Both these plants have been recently introduced into the Territory where they are doing very well. The former has a high proportion of stalk and few leaves.

Wester (1924) claims that *Vigna marina* (Silani), a perennial vine growing in the Philippines, is two and three times as nutritious as green lucerne and cowpeas respectively. This vine is of very common occurrence in the coastal districts of New Guinea, its local name being "Beach Bean".

Burkill (1935) states that in parts of Java where cattle breeding is important *Sesbania grandiflora* (Agati) is much planted. The cattle eat the leaves, which are said to increase the milk yield. A saponin is said to be present but it appears to be harmless. This plant has recently been introduced into New Guinea and is growing in the Botanic Gardens.

On several occasions, mention has been made in the *Queensland Agricultural Journal* of *Alysicarpus vaginalis* as a fodder plant. This plant is to be found growing in many parts of New Guinea where it grows to a height of about two feet.

Desmodium heterophyllum (Japanese clover) grows well in the British Solomon Islands where it is considered an excellent cattle feed. Recently, it was introduced into the Territory and it is growing profusely on a plantation near Kokopo and in the Botanic Gardens.

(a) In the *Queensland Agricultural Journal*, this plant is also referred to as *S. mucronata* and *S. procumbens.*

The leaves and stalks of Peanut (*Arachis hypogaea*), Kau Kau (*Ipomoea batatas*), Velvet Bean (*Mucuna deeringiana*), Mauritius Bean (*Mucuna aterrima*) and Cowpea (*Vigna sesquipedalis*) plants are other crops which have been suggested as good fodder crops and which are already growing in the Territory.

All these plants and, in addition, paw paw (*Carica papaya*), sweet cassava (*Manihot utilissima*) and banana (*Musa sp.*) leaves have been analysed and the results are given in Table XI. These results will now be discussed, paying particular attention to protein contents.

The analyses of the first seven plants in Table XI. show them to be good sources of protein. *Leucaena glauca* has the highest protein content but is only of value as a fodder when less than three months old, for after this, it becomes woody and ultimately grows into a tree from 20 to 30 feet high. It ratoons well, but, unless allowed to grow to maturity, does not reseed. It would be an excellent soiling crop, but could not be fed to cows within four hours of milking because of feed-taint. This is a distinct drawback.

Sesbania grandiflora resembles *Leucaena glauca* in many respects both having a pinnate leaf. Unless frequently cut it also grows into a tree about twenty feet in height. Both the young and the mature plants have comparatively few leaves and even in its young stages the plant is rather woody. The latter reason probably accounts for the fact that in Java, only the young leaves are fed to cattle. It would be a very laborious task picking sufficient leaves each day for a dairy herd. *Manihot utilissima, Alysicarpus vaginalis, Desmodium triflorum* and *Centrosema pubescens* each have approximately the same protein content. The sweet variety of *Manihot utilissima,* when very young, is promising as a fodder. It is relished by goats, although the author has no knowledge of its being fed to cattle. *A. vaginalis* and *D. triflorum* are to be found growing in many parts of the Territory but they are not eaten by either cattle or goats if there is more palatable feed available. This is probably due to their dry woody nature. *C. pubescens* is grown on many plantations as a cover crop and is relished by cattle. However, it could not form part of a mixed pasture for it is a very rampant grower and would very soon shade out grasses and other constituents of the pasture. Furthermore, it causes an obnoxious feed-taint if fed within four or five hours of milking. *Desmodium heterophyllum* comes next in protein content, and is promising as a pasture constituent in pastures growing only a few inches high, although it is not a very succulent feed. The *Stylosanthes spp.* and *Pueraria thunbergiana* are also good sources of protein although not outstanding.

These analyses give valuable information on the composition of a number of legumes and other plants which have been suggested or are being used for the feeding of cattle in tropical countries. Valuable as some of these plants are as sources of protein, they would be of little value in improving existing pastures for they would either shade out all existing grasses, need constant attention or have some other draw-back. The ideal legume would be one which has a high protein content, is succulent and palatable, grows to a height of about 2 feet (so that it will not be hidden or overgrown by tall grasses), ratoons well and reseeds itself. None of these plants possessed all or most of these qualities. Because of this, attention was next turned to certain indigenous legumes which had come under notice.

TABLE XI.—ANALYSES OF PROMISING FODDER PLANTS.

Common Name.	Scientific Name.	Water.	Crude Fibre.	Sugar and Starch.	Crude Protein.	Eth. Sol. Extract.	Ash.	Nature of Specimen.	No. of Analyses.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
..	*Leucaena glauca* ..	70	7.7	13.1	6.8	.5	1.9	Stalks and leaves; immature plant	1
..	*Leucaena glauca* ..	64	10.6	17.7	4.5	.3	2.9	Leaves; mature plant	1
Agata ..	*Sesbania grandiflora* ..	77	4.2	11.5	4.7	.7	2.9	Leaves; mature plant	1
Cassava (sweet) ..	*Manihot utilissima* ..	77	8.3	7.4	4.5	.6	2.2	Leaves; immature plant ..	1
..	*Alysicarpus vaginalis* ..	67	16.5	9.3	4.4	.3	2.5	Stalks and leaves; plant flowering	1
Centrosema ..	*Centrosema pubescens* ..	79	8.0	6.2	4.4	.3	2.1	Stalks and leaves; immature plant	1
Clover ..	*Desmodium triflorum* ..	71	8.9	13.4	4.4	.5	1.8	Stalks and leaves; immature plant	1
Japanese clover ..	*Desmodium heterophyllum*	72	10.4	10.9	4.0	.5	2.2	Stalks and leaves; immature plant	1
Townsville lucerne	*Stylosanthes sundaica* ..	81	6.7	6.7	3.3	.3	2.0	Leaves and stalks; immature plant	1
Trifolio ..	*Stylosanthes guyannensis*	74	7.3	13.0	3.2	.2	2.3	Stalks and leaves; immature plant	1
Trifolio ..	*Stylosanthes guyannensis*	74	7.3	13.0	3.2	.2	2.3	Stalks and leaves; immature plant	1
..	*Pueraria thunbergiana* ..	83	6.8	4.8	3.1	.3	2.0	Stalks and leaves; immature plant	1
Velvet bean ..	*Mucuna deeringiana* ..	82	5.5	7.0	2.9	.6	2.0	Stalks and leaves; immature plant	1
Mauritius bean ..	*Mucana aterrima* ..	80	6.5	8.1	2.8	.5	2.1	Stalks and leaves; immature plant	1
Beach bean ..	*Vigna marina*	89	2.2	4.6	2.5	.6	1.3	Leaves and stalks: immature plant	1
Banana ..	*Musa* sp.	82	7.1	5.8	2.4	.4	2.3	Leaves; immature plant ..	2
Peanut ..	*Arachis hypogaea* ..	91	2.6	2.3	2.2	.8	1.1	Stalks and leaves; immature plant	2
Peanut ..	*Arachis hypogaea* ..	88	4.7	3.5	1.8	.6	1.4	Stalks and leaves; mature plant ..	2
Cowpea ..	*Vigna sesquipedalis* ..	79	6.7	9.1	2.0	.4	2.8	Leaves and stalks; immature plant	1
Kau kau ..	*Ipomoea batatas* ..	85	3.8	6.4	1.8	.5	2.5	Stalks and leaves; immature plant	2
Paw paw ..	*Carica papaya*	80	6.3	9.1	1.1	.5	3.0	Stalks and leaves; mature plant ..	2

There were four legumes indigenous to the Territory which, from casual observation, appeared to possess many of the above-mentioned qualities. The results of their analyses are given in Table XII. The first plant will be described in detail later. *D. polycarpum* was found growing on the Mainland and, in appearance, it greatly resembles *D. tortuosum*. *I. endecaphylla* was a small creeping plant found on New Britain and New Ireland. There was some doubt as to whether this plant was truly indigenous. *G. tenuiflora* was discovered on the Mainland, and in appearance it greatly resembles a small *Centrosema pubescens*. Seeds of these four legumes were collected and grown in experimental plots in the Botanic Gardens.

TABLE XII.—COMPOSITIONS OF PROMISING FODDER PLANTS.

Scientific Name.	Water.	Crude Fibre.	Sugar and Starch.	Crude Protein.	Eth. Sol. Extract.	Ash.	Nature of Specimen.	No. of Analyses.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.		
Desmondium tortuosum	72	9.9	10.3	4.8	.7	2.3	Immature ..	7
	50	15.6	28.4	2.7	.5	2.8	Full maturity	6
Indigofera endecaphylla	74	7.8	11.1	4.3	.7	2.1	Immature ..	1
	69	12.9	11.4	4.0	.6	2.1	Mature ..	1
Galactia tenuiflora ..	78	9.8	5.1	4.3	.9	2.5	Immature ..	1
	72	11.0	9.3	3.7	.7	2.7	Mature ..	1
Desmodium polycarpum	79	9.1	5.0	4.0	.7	2.2	Immature ..	1
	74	12.8	7.0	3.2	.6	2.4	Mature ..	1

Desmodium tortuosum.*—Of the plants mentioned in Table XII. *D. tortuosum* has the highest protein content, and was found to be superior to the other plants in several respects.

This legume was first discovered growing on New Hanover, but it has since been found on New Ireland, New Britain, and the Duke of York Islands. It is known as "koako" by the natives of the Duke of York Islands, who claim that the plant has a medicinal value. It is relished at all stages of growth by both cattle and goats.

Normally, the plant grows to a height of about 2 ft. 6 in., although plants over 5 feet were noticed growing under the shade of an embankment. It appears to grow well on almost any type of soil, and photographs 1 and 2 show the mature plants, under similar climatic conditions, growing on a heavy clay soil and on a poor light volcanic soil, respectively. If anything, the clay soil seems to favour a lower and more dense growth. When cut, the plant ratoons well, and photographs 3 and 4 were taken of plants having ratooned for the first and second time respectively. In the Botanic Gardens, there are plants which have ratooned for the fifth time and are still as healthy as ever, although after the fourth ratoon the ratio of stalk to leaf began to increase and the plants did not grow to their former heights. Photographs 5 and 6 were taken two and eight weeks, respectively, after sowing the seed. The plant generally reaches maturity in less than two months and reseeds of its own accord.

* The plant was first named *D. stipulaceum*, by which name it has been referred to in certain departmental reports. Recently Mr. W. D. Francis, of the Botanic Museum and Herbarium in Brisbane, identified the plant definitely as *D. tortuosum*.

Five of the more important minor constituents of koako have been determined and the results are given in Table XIII.

TABLE XIII.—MINOR CONSTITUENTS OF KOAKO.

Constituent.	Immature Plant.	Mature Plant.
Calcium	.239 per cent.	.224 per cent.
Phosphorus	.124 per cent.	.084 per cent.
Iron	.0090 per cent.	.0082 per cent.
Carotene	180 mgms./kg.	210 mgs./kg.
Vitamin C	.33 per cent.	.24 per cent.

Calcium, phosphorus and iron were estimated by methods similar to those previously described for milk (Hutchinson, 1939, *b*). The carotene content of the plant was estimated by the method developed by Bolin and Khalapur (1938). The carotenoids of plants usually consist chiefly of β-carotene with small admixtures of α-carotene and cryptoxanthine (Fixsen and Roscoe, 1937-38, *a*, and Morton, 1940). Since .6 microgram of β-carotene has a vitamin A potency of approximately 1 international unit a rough conversion of carotene into international units of vitamin A could be made by multiplying the carotene content in micrograms by 1.6. Vitamin C was estimated in an acqueous extract by titration with 2 : 6 dichlorphenolindophenol after the removal of colouring and reducing substances with mercuric acetate and hydrogen sulphide.

It is interesting to compare the results obtained for immature koako with those obtained by different workers for young lucerne, the "king of all fodders".

TABLE XIV.—COMPOSITIONS OF KOAKO AND LUCERNE.

Constituent.	Koako.	Lucerne.	Reference.
Water	72 per cent.	82.4 per cent.	Fox and Wilson (—)
Crude protein	4.8 per cent.	6.2 per cent.	Fox and Wilson (—)
Digestible crude protein ..	3.8 per cent.	3.2–4.0 per cent.	Morrison (1938, *j*)
Ether Sol. Extract ..	.7 per cent.	.6 per cent.	Fox and Wilson (—)
Sugar and starch.. ..	10.7 per cent.	6.4 per cent.	Fox and Wilson (—)
Crude fibre	9.9 per cent.	2.4 per cent.	Fox and Wilson (—)
Ash	2.3 per cent.	2.2 per cent.	Fox and Wilson (—)
Calcium..	.239 per cent.	.385 per cent.	Fox and Wilson (—)
Phosphorus	.124 per cent.	.11 per cent.	Fox and Wilson (—)
Iron	.0090 per cent.	.0083 per cent.	Fox and Wilson (—)
Carotene..	180 mgs./kg.	90-400 mgms./kg.	Fixen and Rosecoe (1937–38, *b*)
Vitamin C	.33 per cent.	.07–.38 per cent.	Fixsen and Roscoe (1937–38, *b*)

Excluding crude fibre, koako contains a higher percentage of dry matter than lucerne, the excess being mostly composed of sugar and starch. The crude protein content of lucerne is higher than that of koako, but the results are not exactly comparable. Crude protein was estimated in the lucerne plant when 3–5 in. in height while the results for koako were obtained from a number of samples collected at all stages of growth up to the budding stage. From the results of Table XV., however, it is seen that the crude protein content of very young koako would be nearer 6 than 5 per cent. The ether soluble extract, the ash, phosphorus and iron contents are higher in koako than in lucerne, but calcium is considerably lower. The vitamin A and C content of koako compare very favorably with that of lucerne.

Before drawing final conclusions from this comparison, it should be remembered that the koako chosen for analysis was not any particular strain chosen for its high nutritive value, nor did it receive particular attention, such as the application of fertilizers, during its cultivation. If only the best strains of koako high in nutritive value were cultivated and the soil upon which they were growing was kept well watered and, if necessary, fertilized, koako might rank as high in nutritive value as lucerne.

Table XV. gives the crude protein content and the yield per acre of the plant at different stages of growth. Figures for yield were obtained from a small experimental plot consisting of three rows of koaka, 20 feet long and 2 feet apart, the density of planting working out at 300,000 plants per acre. The multiplication of corresponding pairs of figures gives the yield of crude protein at each stage of growth.

TABLE XV.—PROTEIN CONTENT AND YIELD PER ACRE OF KOAKO.

Stage of Growth.	Yield per acre.	Crude Protein.	Crude Protein Yield per acre.
	lb.	Per cent.	lb.
Quarter mature (6 inches) ..	1,320	4.96	65.47
Half mature (12 inches) ..	2,360	4.83	113.99
Three-quarters mature (18 inches)	3,150	4.48	141.12
Budding	3,660	3.45	126.27
Mature	3,510	2.48	87.05

If the yield of crude protein is plotted against stage of maturity, Figure 1 is obtained. From this figure, it is seen that the largest yield of crude protein for a given area is obtained by feeding the plant immediately before the budding stage. Of course, the younger the koako is grazed the higher is its nutritive value but it has less bulk in its younger stages and, in order to grow sufficient to feed a herd, it would be necessary to have extensive areas growing so that, after a certain area had been grazed, sufficient time would elapse for the plant to make fresh growth, before grazing it again. The yields per acre of first and second ratoons were found to be approximately 4,500 and 6,210 lb. respectively.

On a dry matter basis, the crude protein content of immature koako is approximately 17.1 per cent. and the digestible crude protein is 13.6 per cent., whilst the crude protein content of young New Guinea pasture is 8.5 per cent. and the digestible crude protein is 6.1 per cent. Consider a pasture consisting of 90 per cent. immature koako by weight and 10 per cent. young pasture. This pasture would have a digestible crude protein content of 12.85 per cent. on a dry matter basis. Young koako is relished by cattle and it is reasonable to assume that, if unrestricted, a New Guinea cow weighing 710 lb. would consume approximately 9.5 lb. dry weight daily and a Friesian cow weighing 910 lb., 13.6 lb. (from

Table IX.), so that the daily protein digestion of these cows would be 1.22 and 1.75 lb. respectively. Deducting protein requirements for maintenance and computing as before, it is seen that this amount of protein would be sufficient for the daily production of nine and twelve quarts of milk per cow for the mixed and Friesian herds, respectively. In the case of the mixed herds, the figure is

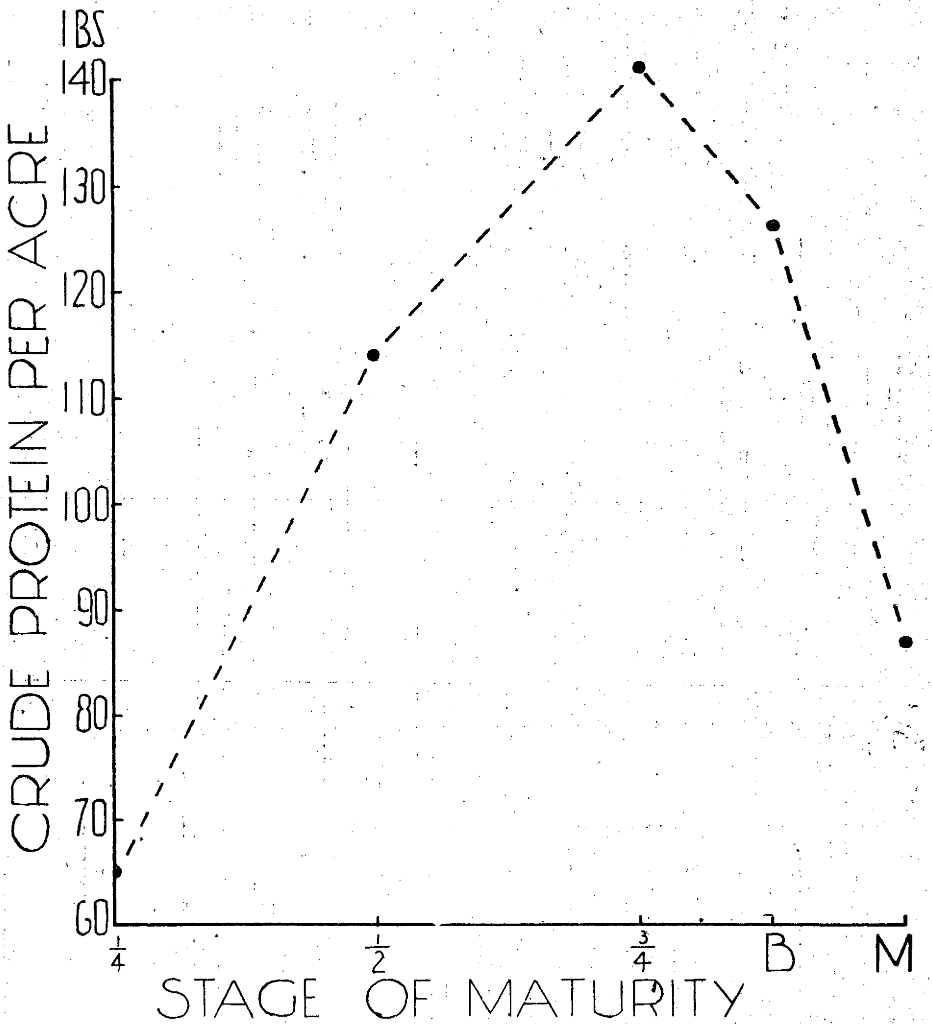

Figure 1.

over six times the yield computed previously and nine times the actual yield, and in the case of the Friesian herd, it is over three times the computed yield and six times the actual yield. These figures could be further increased by the addition of concentrates to the daily ration. Because of the numerous assumptions inherent in the above calculations, the results can only be considered as rough approximations.

It is not considered that koako is the ideal legume for New Guinea conditions, nor that it is superior to all other legumes growing in the Territory, but it possesses distinct advantages over the other legumes considered during this investigation. It is of easy cultivation, palatable, has a high protein content and would be a valuable asset to existing pastures.

As already emphasized, the milk yield of the common New Guinea cow cannot be improved by feeding alone. It is necessary that the herds should be improved by the introduction of new blood or by selection, but this improvement cannot be permanently achieved unless the cows are also given a more nutritious feed, which can be best supplied by feeding the cows on pasture containing a high proportion of a legume such as koako.

Summary.

A number of mixed milk samples collected from a Friesian and other mixed herds in the Territory of New Guinea have been analysed. The fat content was found to be high, while the solids-not-fat and specific gravities were low. The solids-not-fat portions of twenty-five milk samples were analysed and the Koestler number and "*constant moleculaire simplifiée*" computed. These results led to the conclusion that the cause of the low solids-not-fat was probably the result of inadequate feeding.

The milk yield of New Guinea cows is extremely low but it has been shown that it is as high as the protein consumption of the cows permits. To arrive at this conclusion, a number of pastures were analysed for digestible crude protein and the weight and daily feed consumption of a number of cows determined.

Numerous fodder crops have been analysed and the results discussed, paying particular attention to protein contents. *Desmodium tortuosum,* which is indigenous to the Territory, was shown to have great possibilities as a tropical fodder crop. Its composition is compared with that of lucerne.

Acknowledgments.

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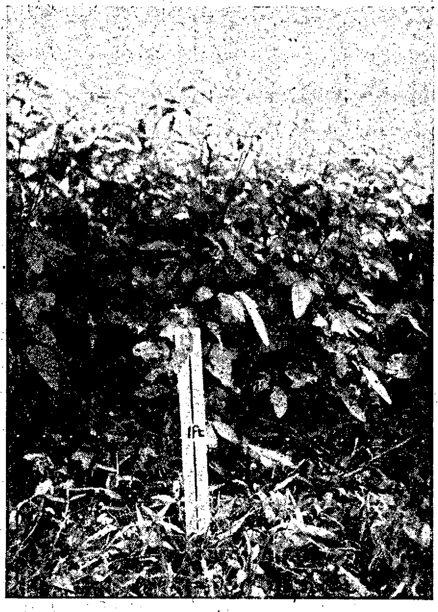

Figure 1.—*D. tortuosum* growing on heavy clay soil.

Figure 2.—*D. tortuosum* growing on light volcanic soil.

Figure 3.—*D. tortuosum*, first ratoon.

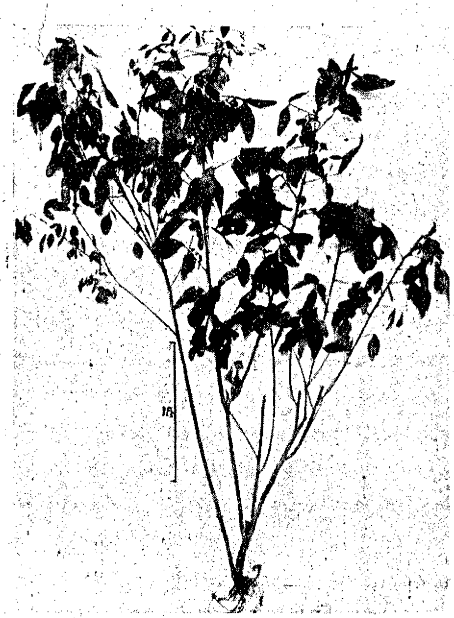

Figure 4.—*D. tortuosum*, second ratoon.

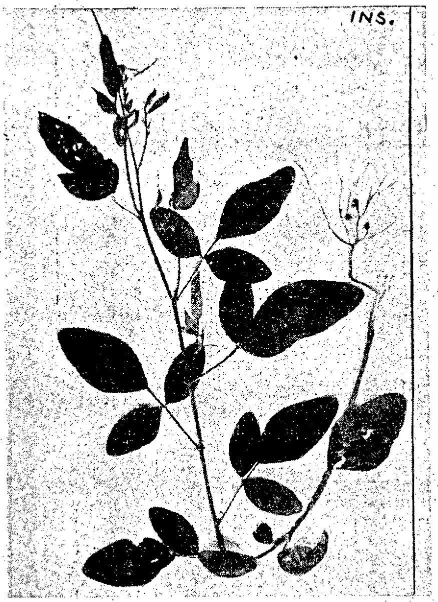

Figure5.—Mature *D. torfuosum*, eight weeks old.

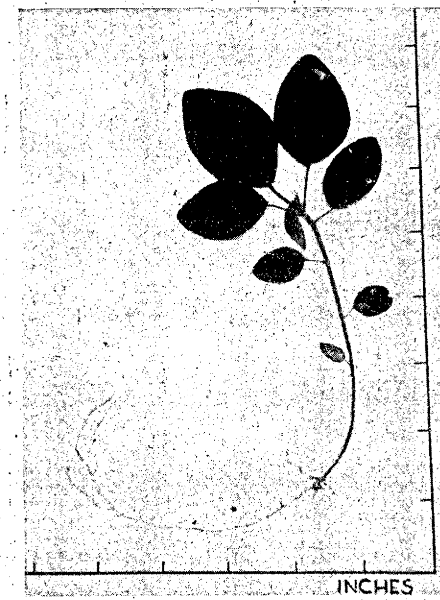

Figure 6.—Young *D. tortuosum*, two weeks old.

A herd of typical New Guinea cattle.

A pure-bred Friesian herd in New Guinea.

(Photographs by Chee Hoi Meen.)

PIG NOTES.

By G. F. Gee, H.D.A.*

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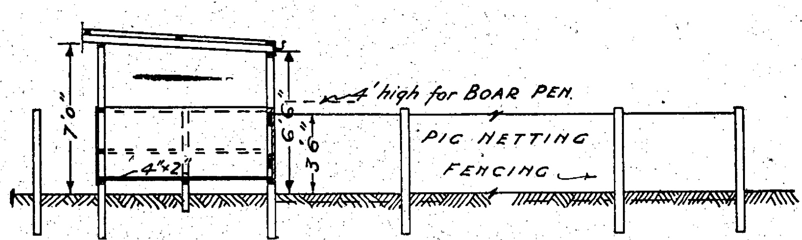
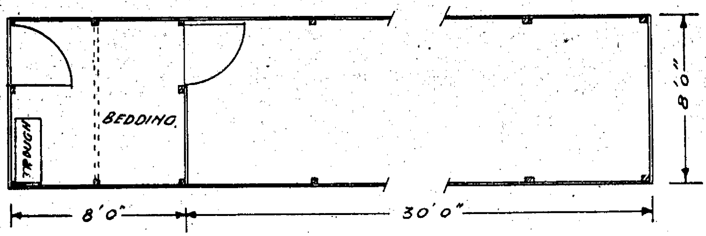
A Small Piggery.

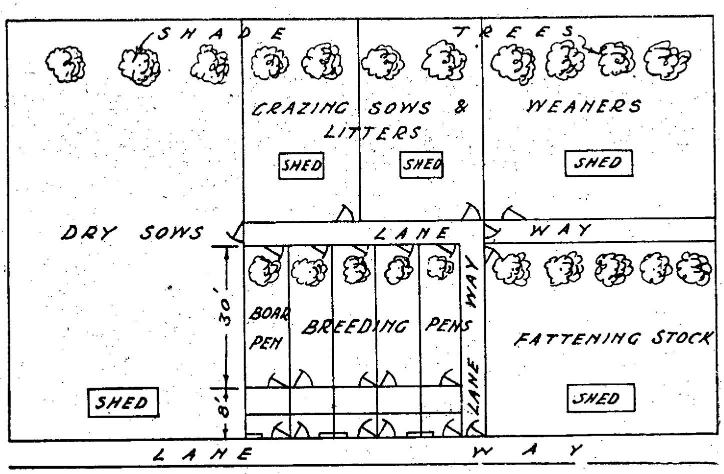
In the accompanying figure is given the layout for a small piggery suitable for New Guinea conditions. It will be seen that the plan allows for future expansion. The advantage of this layout is that the stock are moved from one



SECTION



BREEDING PEN (ENLARGED)



LAYOUT

* Formerly Assistant Piggery Instructor, Hawkesbury Agricultural College.

paddock to the next, in rotation, as they grow. The dry sows are near the boar pen, which will make it easier to detect sows on heat, and they are also near at hand to be placed with the boar, when ready for service.

If the roof of the sleeping pens is made to cover a passage-way 3 feet wide in front, it will facilitate the feeding of the stock in wet weather besides giving the pens more protection from the weather. A laneway around the breeding pens allows pigs to be drafted and shifted with little trouble. Shade trees are necessary in each paddock, and a wallow would be an advantage, but this must be properly constructed. A mud hole in the paddock is worse than useless and is a source of infection for kidney worms and other parasites. The floor of the shelter sheds should be raised from ground level and should be of timber. In the breeding pens, a wooden sleeping platform of preferably 4 inches by 2 inches hardwood is necessary, as chills, paralysis and other illnesses can usually be traced to the pigs sleeping on damp ground or concrete floors. Once a young pig has received a setback from a chill, it is almost useless to attempt to fatten him, and he might just as well be killed off.

Breeds.

For all ordinary purposes, the best breed for this climate is the Berkshire, and this breed will rapidly improve local stock. If, however, an attempt is to be made to produce bacon pigs, then another breed will have to be considered, as the Berkshire is much too fat for good bacon. The Tamworth, or the Tamworth Berkshire cross, would be best if bacon is to be the main consideration, but care should be taken in the type of Tamworth boar chosen for this purpose.

Pigs from five months to a year old could be successfully introduced to this Territory with very little trouble. A boar cannot be properly selected until he is approaching six months old, and, of course, if a sow is being introduced, to farrow after her arrival, she will be almost a year old, for she would be ten months old before being mated.

Bacon Curing.

In this Territory, bacon could not be successfully cured unless refrigeration were employed. The ideal temperature is 40° – 45° F., and should never exceed 60° F. A planter may cure a little bacon and be perfectly satisfied with the result, but it would probably not keep for any time. Where refrigeration is possible, there is no reason why bacon curing should not be a successful industry in this Territory. Temperature is a most important factor in bacon curing.

A good recipe for pickling is as follows—

50 gallons clean water
160 lb. fine salt
16 lb. brown sugar
16 lb. saltpetre
1½ lb. all spice (ground)

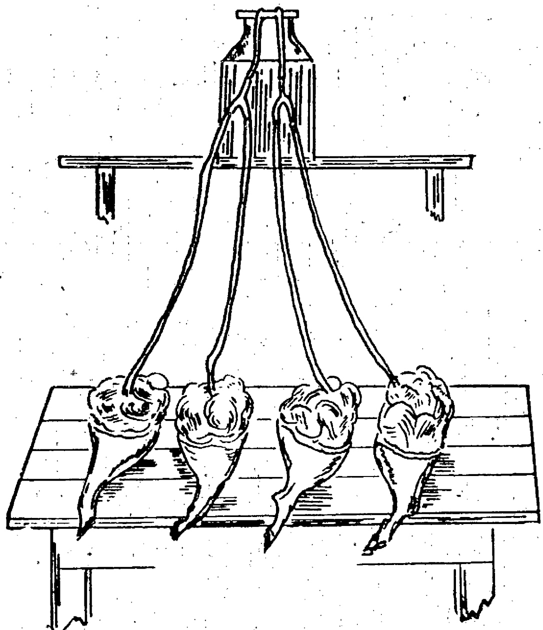
This is sufficient for about 700 lb. of meat. The procedure is as follows:—Boil water, then add salt, sugar and saltpetre. The allspice, which has been tied in a calico bag, is allowed to float in the mixture. This is boiled for one hour, and any frothy matter rising to the surface is skimmed off. The solution is then allowed to cool to room temperature before using. Each piece of meat is now pumped with the pickling solution which has been made up to 100 per cent. solution by the addition of more salt. This density is taken with a salinometer. Too much pressure should not be used during pumping, for it tears the meat. The pickle is pumped along the bone into the synovial sacs and pockets. The meat is now placed in the pickling solution and, if necessary, clean pieces of hardwood are used to keep it well covered. This method of pickling requires a needle and pump, but if these are not available a good system, as outlined in the *Handbook of Philippine Agriculture,* is as follows:—

"One or two days before killing, prepare the following ingredients for every 100 kilograms of meat to be cured.

Common salt	24.00 kgm.
Sugar	3.00
Saltpetre (potassium nitrate)	0.75
Total	27.75 kgm.

"Dissolve the above mixture in clean water to make 100 liters of solution (brine). This may be sterilized by boiling. After straining, let it stand to cool and to allow the precipitate to settle down. The precipitate is discarded by decanting. If only four legs weighing 20 kilograms are to be cured, 20 per cent. of the above formula is sufficient.

"Secure a glass tubing, with one end drawn to a fine point. Insert the pointed end into the artery of each leg.



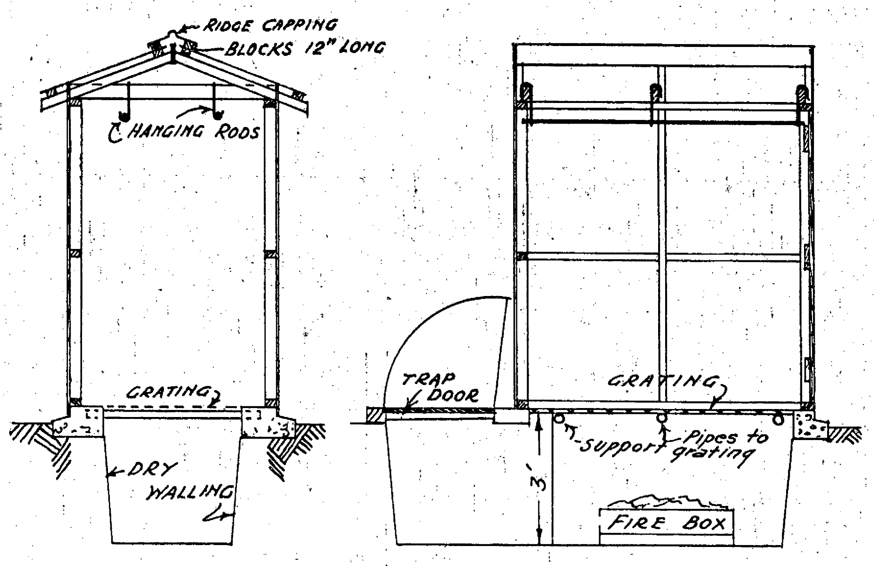
"For each leg weighing 5 kilograms, use a jar containing 5 liters of brine. The brine is siphoned into the leg by means of a rubber tubing, and allowed to flow into the leg for 18 to 24 hours. During the first two or three hours, the flow should be at high pressure to dilate the arteries and to detect any leakage, which is stopped by clamping or ligating. High pressure is obtained by placing the jar high (see illustration).

"The next day the rubber tubing is disconnected. A quantity of the curing ingredients, undissolved, is gently rubbed against the surface of the leg. The meat should be covered with a box to keep out the flies and the light. More of the curing mixture is again applied on the third day. The leg is turned over every other day.

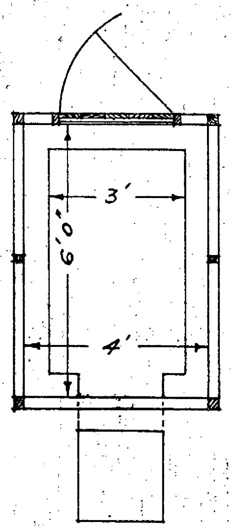
"On the sixth day, any excess salt is washed off carefully. The leg in the smokehouse is hung to drip.

"Drying and smoking is started on the seventh day. A fire is built on the floor of the smokehouse, and smoking is continued for a week or until the ham has assumed the colour and firmness desired."

Sketch Plan of Smokehouse.



CROSS SECTION LONGITUDINAL SECTION



PLAN

Where only one or two pigs are being smoked at a time, an old 600 or 800-gallon galvanized tank makes a good smokehouse. The top of the tank is cut out, and battens, on which the meat is placed, are put across the top. A hardwood sawdust fire, about three inches deep, is made in the bottom of the tank, and the whole covered with bags or a tarpaulin. Direct heat should be prevented from reaching any meat that may be hanging over the fire, by placing a piece of galvanized iron over the fire on loose columns of bricks. If direct heat reaches the bacon, the fat will melt, and with it go part of the flavour of the meat. The smoke-room temperature should never be more than 90° F.

If something more elaborate than the tank is desired for a smoke-room, then a room about 4 feet by 6 feet, built over a 3-ft. pit and extending outside the building, with a trap-door fitted, is recommended. A ventilator is fitted to the trap-door to control combustion. This type of smoke-room is shown in the accompanying plan.

NOTES ON THE PREPARATION OF "GAPLEK" FROM CASSAVA (TAPIOCA) ROOTS.

Great success has attended the use of "Gaplek" as a partial substitute for rice in the Netherland East Indies, and the following information on the method adopted in Java for its preparation from cassava (tapioca) roots has been supplied by the Director of Commerce at Buitenzorg.

The roots of the tapioca are first pared and then split lengthwise into four parts, which are again cut into three or four pieces, 3, 4 or 5 inches long and 1½ to 2 inches thick, according to the size of the roots. These pieces are dried in a natural way, i.e., by exposing them for five or six days or longer, if necessary, to the sun and, as they contain a large percentage of water, the loss in weight is considerable. Three tons of fresh roots are necessary to obtain one ton of the dried product.

When required for food the Gaplek is converted into flour. Two and a half katies (1 katie = 1⅓ lb.) a day are sufficient for a family of five persons. Usually one gantang (= 1 gallon) of Gaplek is pounded in an ordinary rice mortar. The pulverised mass is then winnowed to separate the flour from the coarse root fibres. This flour can be used in the same way as pounded rice or maize.

For daily use as a foodstuff the flour is spread out in a tray, then kneaded with water and afterwards steamed in the same way as rice. The cooked mass is somewhat glandular and can be eaten in the same way as boiled rice, with or without vegetables and condiments.

If a certain amount of rice is available, it is advisable, instead of finishing all the rice first and afterwards using Gaplek, to mix rice and Gaplek flour in equal quantities and steam until thoroughly cooked.

AGRICULTURAL EXPORTATION IN NEW GUINEA.

The Report to the Council of the League of Nations on the Administration of the Territory of New Guinea for the year ending 30th June, 1939, has now been published. Certain portions, which are of particular interest to planters, are reproduced in this article.

In Table I., the quantities and values of all exports during 1938-39 are presented. Copra was the largest single agricultural export and Table II. shows the countries to which it was shipped.

The commencement of the present war concludes a period in the development of this Territory which began during the Great War and it is interesting to review the agricultural exports during this period. The major exports are tabulated in Table III. In addition, a shipment of coco-nut fibre was exported last year, small quantities of galip nuts were exported during 1933-34, 1935-36 and 1936-37; in 1931-32, 1932-33 and 1933-34 some Massoia bark and Massoia bark oil were exported; in 1932-33 a little coco-nut oil and in 1923-24 small quantities of cotton and cotton seeds were among the exports.

From Table III., it is seen that the major exports have been copra and cocoa, each having been exported consistently since 1915.

Figure I. shows diagrammatically the amount of cocoa exported during the period 1915-16 to 1938-39. By drawing a smooth curve through all the points plotted, a better idea of the general trend of the exportation is obtained. It is seen that the exportation slowly decreased until 1929-30 when the amount of cocoa exported was only 58 tons. After this date, exportation rose steadily, and with increasing rate of increase, and last year, the amount of cocoa exported was 56 tons greater than the year previous and nearly double what it has been for any other year.

The general trend of copra exportation is shown by the broken-line curve in Figure II. It is only this general trend which is of value, for the annual variations in exportation are more the result of an irregular shipping service, than a sudden change in production. Figure II. cannot be easily interpreted by casual observation, but it can be readily interpreted after mathematical analysis. Let y be the exportation in tons and x the number of years since the termination of the Great War (i.e. 1918-19 = 1, 1919-20 = 2, etc.) then it can be shown that,

$$y = 5.8x^3 - 316x^2 + 7300x + 5640 \qquad (1)$$

and by giving x any value from 1 to 21, a value for y is obtained which gives the approximate exportation for that year.

Differentiating (1) twice we have,

$$\frac{dy}{dx} = 17.4x^2 - 632x + 7300 \qquad (2)$$

and

$$\frac{d^2y}{dx^2} = 34.8x - 632 \qquad (3)$$

For any value of x, $\frac{dy}{dx}$ is equal to the slope of the curve of the corresponding point or, in other words, the rate of exportation at that point. When $\frac{d^2y}{dx^2} = 0$, that is, when $x = 18$, there is a point of inflection on the graph. This means that the portion of the curve from 1918-19 to 1935-36 is concave downwards and the rate of increase of exportation is decreasing, while from 1935-36 to 1938-39 the curve is concave upwards and the rate of increase of exportation is increasing. Now, if in equation (2), x is given every value from 1 to 21, 21 values of $\frac{dy}{dx}$ are obtained, that is, 21 values for the rate of increase of exportation, and it is seen that these figures decrease from 6685 when $x = 1$ to 1562 when $x = 18$ and increase from 1573 when $x = 19$ to 1701 when $x = 21$. From this it is seen that the decreasing rate of increase of exportation immediately after the Great War was much greater than the present increasing rate of increase of exportation.

This decreasing rate of increase in the exportation is interpreted as being the result of a decreased rate of increase in production of earlier planted properties, particularly, the large areas planted by the Germans before the Great War.

The recent increasing rate of increase in exportation is probably due to areas coming into full bearing which were planted after the taking over of expropriated properties, the yields from these properties more than compensating for the falling off of the earlier planted properties.—*R.C.H.*

TABLE I.—TOTAL EXPORTS DURING 1938-39.

Article.	Quantity.	Value.	Article.	Quantity.	Value.
	Tons.	£			£
Copra	73,345	727,949	Shell (marine) ..	176 tons	10,560
Desiccated coconut	1,590	69,960	Trepang ..	27 tons	2,025
Copra refuse ..	114	570	Gold	400,672 oz.	2,129,263
Cocoa beans ..	235	6,580	Tortoiseshell ..	89 lb.	89
Coffee beans ..	38	843	Timber (logs) ..	1,718,916 sq. ft.	6,544
Coco-nuts ..	259	1,554	Timber (sawn) ..	31,986 sq. ft.	367
Peanuts ..	7	105			
Rubber ..	54	4,050			
Coco-nut fibre ..	38	190			
Total ..	.. ..	811,801	Total ..	.. ..	2,148,848

TABLE II.—COUNTRIES TO WHICH COPRA WAS EXPORTED DURING 1938-39.

Country.	Quantity.	Value.
	Tons.	£
United Kingdom	33,921	336,666
European ports	12,167	120,757
Australia	9,068	90,000
Sweden	8,017	79,569
Germany	3,207	31,829
Spain	2,293	22,758
China	1,478	14,669
Holland	1,255	12,456
France	624	6,193
Denmark	600	5,955
Caroline Islands	444	4,407
Japan	271	2,690

TABLE III.—MAJOR AGRICULTURAL EXPORTS FOR THE PERIOD 1915 TO 1939.

Year.	Copra.		Copra Refuse.		Desiccated Coco-nut.		Coco-nuts.		Peanuts.		Ivory Nuts.		Cocoa Beans.		Coffee Beans.		Rubber.	
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
1915–16	11,062	161,119	..	..	..	..	..	..	..	..	..	109	186	9,005	..	..	..	1,720
1916–17	18,582	267,277	..	..	..	..	..	..	..	..	..	93	..	8,664	..	..	..	5,304
1917–18	19,708	369,837	..	..	..	..	..	..	..	..	..	180	144	11,159	..	..	..	1,673
1918–19	14,886	244,314	..	..	..	..	..	..	..	..	..	333	112	8,464	..	..	..	1,196
1919–20	22,708	745,057	..	..	..	..	..	..	..	..	..	271	140	15,530	..	..	..	1,104
1920–21	23,735	644,045	..	..	..	..	..	..	..	..	..	531	133	9,105	..	..	29	2,900
1921–22	25,894	474,110	..	..	..	..	..	..	..	..	..	..	152	9,465	..	..	..	..
1922–23	32,648	619,715	..	..	..	..	..	..	..	..	17	336	83	3,734	..	..	..	..
1923–24	34,974	686,519	..	..	..	..	..	..	..	..	16	192	70	3,602	..	..	..	..
1924–25	39,151	815,938	..	..	..	..	..	..	..	..	27	312	135	6,949	..	..	..	..
1925–26	45,806	1,016,930	..	..	..	..	..	..	..	..	28	456	113	6,510	..	..	..	..
1926–27	47,613	849,852	..	..	..	..	..	..	..	..	9	152	65	3,500	..	..	..	..
1927–28	65,285	1,176,040	..	..	..	..	..	..	..	..	..	..	73	3,859	..	..	..	..
1928–29	60,435	933,769	..	..	26	1,456	..	..	..	..	17	153	72	3,816	..	..	..	..
1929–30	63,832	864,358	..	..	192	8,640	..	..	..	..	9	77	58	3,074	..	..	..	..
1930–31	62,303	716,543	..	..	941	37,640	..	..	..	..	8	75	64	3,200	..	..	..	..
1931–32	59,452	618,298	..	..	1,282	64,100	..	..	..	..	56	280	102	3,060	..	..	..	..
1932–33	59,040	543,906	191	1,876	1,335	73,452	81	567	..	..	17	131	65	2,292	..	..	..	..
1933–34	62,270	283,329	392	3,528	1,463	81,562	76	532	1	21	73	566	98	3,479	..	..	..	..
1934–35	56,251	361,413	1,112	5,282	1,611	45,080	107	321	25	467	24	186	95	3,479	5	450	..	..
1935–36	66,684	761,309	557	5,013	1,647	65,880	198	594	35	653	69	552	127	3,810	11	880	..	..
1936–37	76,409	1,231,309	443	4,430	1,632	86,930	71	710	15	225	59	767	132	6,600	51	4,100	..	..
1937–38	73,716	847,734	402	1,759	1,579	73,423	147	882	4	84	18	162	179	4,475	41	1,025	4	242
1938–39	73,345	727,949	114	570	1,590	69,960	259	1,554	7	105	..	..	235	6,580	38	843	54	4,050

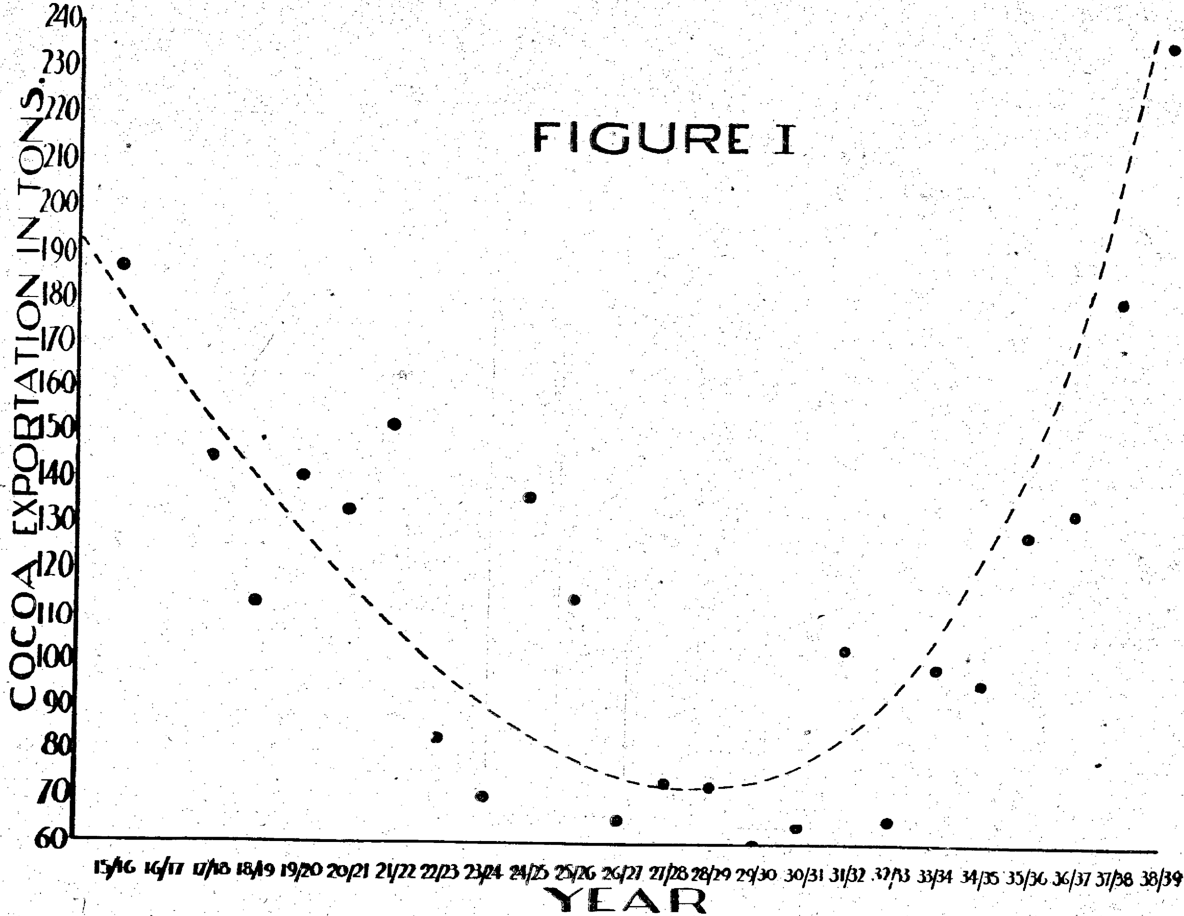

COCOA EXPORTATION IN TONS.
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
15/16 16/17 17/18 18/19 19/20 20/21 21/22 22/23 23/24 24/25 25/26 26/27 27/28 28/29 29/30 30/31 31/32 32/33 33/34 34/35 35/36 36/37 37/38 38/39
YEAR

FIGURE I

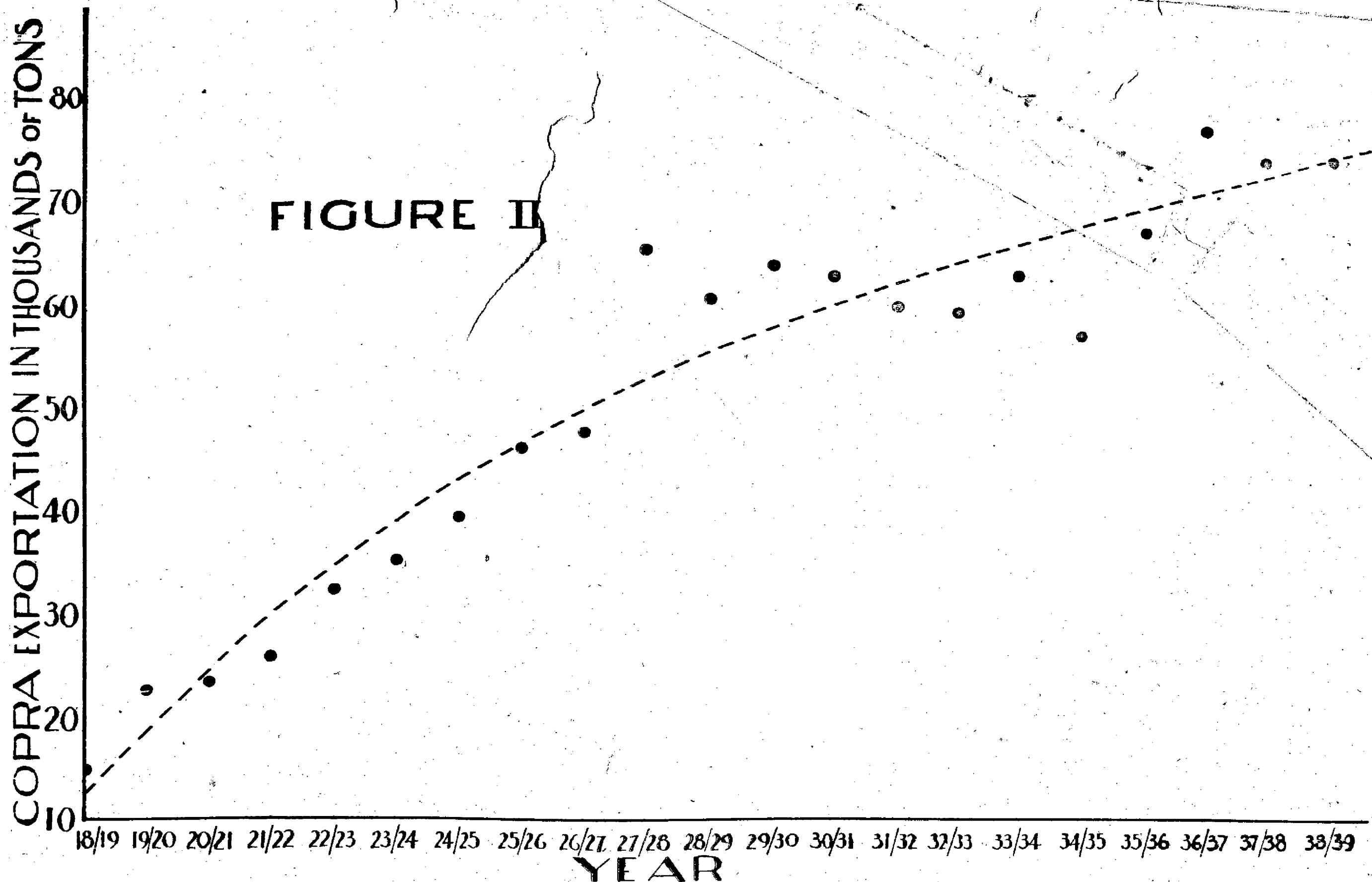

COPRA EXPORTATION IN THOUSANDS OF TONS
10
20
30
40
50
60
70
80
18/19 19/20 20/21 21/22 22/23 23/24 24/25 25/26 26/27 27/28 28/29 29/30 30/31 31/32 32/33 33/34 34/35 35/36 36/37 37/38 38/39
YEAR

FIGURE II

THE CULTIVATION OF NATIVE FOOD CROPS.

By E. C. Green, *A.I.C.T.A. (Trin.), H.D.A.*

Demonstration Plantation, Keravat.

1. Taro.

Taro cultivation, especially of the native varieties, is a most important part of native food production, for taro is, by far, the most commonly cultivated of all native foods. There are two kinds of taro cultivated in this Territory—*Colocasio* spp. and *Xanthosoma* spp. The former embrace the commonly cultivated types which are generally referred to as "native taro", and the latter the Kong-kong type.

In this Territory there is a large number of varieties of native taro, probably many hundreds, and during the past five years no less than 67 varieties have been tested at the Demonstration Plantation at Keravat. As far as the writer is aware, there are only two varieties of Kong-kong taro, one a green stem and the other a blue stem, although it has been reported that a red stem variety is grown in the Talasea District.

Native Taro.

Soil.—Native taro requires a well-drained soil rich in organic matter, for it will not produce on badly drained, impoverished soils. In native gardens the site generally selected is rising ground, or hillsides, wherever possible, and wet or swampy areas are always carefully avoided.

Preparation of the Land.—Taro land should, even where virgin ground is to be planted (i.e., following clearing), be hoed to a depth of 6 to 9 inches, and in heavy soils the ground should be worked down as finely as possible. This hoeing prior to planting assists drainage and aeration, and experiments at Keravat have shown it to give a great improvement in yield.

Planting.—The land should be lined and the taro planted in rows 2 feet apart, with a space of 2 feet to 2 ft. 6 in. between the plants in the row. Either suckers or tops (i.e., the extreme top of the tuber, plus the stem) are used as planting material, and these are planted in holes 9 inches deep. The holes are quickly made by means of a pointed stick about 6 feet long and 3 inches in diameter, and as taro grows upwards and not downwards it is essential that attention be paid to the depth of the hole. Shallow holes result in the tuber being formed and developed above ground, where it does not attain normal size, becomes very susceptible to beetle attack, and in many instances rots before reaching maturity.

The sucker or top is placed in the hole and the hole covered in with soil to a depth of 3 or 4 inches, the top portion of the hole remains open and gradually fills as the crop grows. The soil covering the sucker or top should not be pressed down around the plant.

After Cultivation.—Weed and grass growth is controlled until the plants have made sufficient growth to form a complete canopy over the soil. In some districts of New Guinea it is the practice to reduce the number of suckers that are formed around the plant from time to time, but this is not necessary, and results at Keravat have not shown any significant differences in yield.

Harvesting.—The period to maturity depends on the variety, and is usually between six and nine months after planting. The plant is generally considered as having reached maturity when the leaves (except the very young ones) are dry or badly spotted, and the top of the tuber is firm and brown in colour.

The yield per acre varies according to the variety, method of cultivation and planting. Taro grown on suitable land, and planted at the proper depth, should produce at least 5 tons of edible tubers per acre.

Kong-Kong Taro.

Soil.—Soil suitable for the cultivation of native taro is also suitable for Kong-kong taro; in fact, Kong-kong taro is more intolerant of wet soil than native taro.

Preparation of the Land.—The preparation of the land is the same as for native taro.

Planting.—Kong-kong taro should be planted in rows four feet apart, with the plants spaced four feet apart in the rows. The planting material consists of suckers, parent stem, or sections of the parent stem containing a number of "eyes" in each section. Holes at least 9 to 12 inches deep must be made if suckers or parent stems are planted, and if cut sections of the parent stem are used, then the holes should be no more than 4 inches deep, otherwise the sections rot.

Large, deep holes are necessary for Kong-kong taro cultivation, because the edible portion of the plant comprises the suckers, which are produced in radial formation around the parent stem. When cut sections are planted in the shallow holes it is necessary to "hill up" the crop before the formation of the suckers.

After Cultivation.—Grass and weed growth must be controlled until the plants have formed a canopy, which is usually about two months after planting in the case of suckers and parent stems, and some four months after planting cut sections. Where cut sections have been used for planting, hilling up is carried out in the fourth or fifth month.

Harvesting.—Kong-kong taro is ready for harvest about nine months after planting, in the case of suckers or parent stems, and twelve months after the planting of cut sections. However, it is not necessary, as in the case of native taro, to harvest Kong-kong immediately it is mature; in fact, higher yields are generally obtained between twelve and fifteen months, and even as high as eighteen months after planting.

There are two methods of harvesting, the whole plant can be removed from the ground and the edible suckers taken from the parent stem, or the soil can be removed from around the parent in order to expose the suckers which are harvested, and the soil hilled up again around the parent. This latter method of harvest cannot be recommended for general practice, as Kong-kong taro, like all other roots crops, is a heavy feeder, and to grow two crops in succession on the one area of land would materially affect the soil for future crops; further, experiments at Keravat have shown that this second or ratoon crop is much smaller than the main crop.

Kong-kong taro is a heavy producer, recorded yields of more than 15 tons per acre have been obtained on many occasions at Keravat, and an average of 10 tons per acre has been obtained during the past four years.

In comparing Native taro and Kong-kong taro, it might be stated that Kong-kong taro yields more than native taro, does not deteriorate if allowed to remain in the ground for months after maturity, is not so susceptible to beetle attack, and after removal from the ground will store for at least a week longer. On the other hand, native taro is quicker maturing, more palatable to the native, can be used as native food continuously without the native becoming tired of it, and surplus stems and suckers are less trouble to remove and destroy.

2. Sweet Potatoes.

The sweet potato is grown throughout the tropics and also to some extent in non-tropical countries.

Soil.—Sweet potatoes need a fairly loose, well-drained soil; heavy or wet soils produce very small crops, and the tubers are of poor quality.

Preparation of the Land, Lining.—There are two methods of preparing the land for sweet potato cultivation, namely, ridges and hills. The ridging system consists of making long, continuous ridges, whilst the hill system is one in which single or individual hills are made.

It is important to note that in each method the ridges or hills must be large; low ridges or small hills produce only small crops, as the tubers do not get a chance to reach full size, their growth being stopped by the hard ground under the hills or ridges.

The ridges or hills are spaced 4–5 feet apart and made as high as possible. At a 4-5 feet spacing the ridges or hills should be about 2 feet above ground level, and by previously hoeing the land to a depth of 9 inches, the depth of loosened soil in which the crop is to be grown is about 2 ft. 9 in. The importance of a previous turning of the soil to a depth of at least 9 inches must not be forgotten, as this allows for a maximum depth of well-worked soil in which the tubers can grow and develop.

Planting Material.—The best planting material consists of runners, or slips, or "ropes", as they are called here; these runners may be described as the vine of the plant. Runners for planting should always be taken from a bearing crop, or from an area that has been dug up and in which a certain number of tubers have been allowed to remain in the soil to provide runners. The use of runners from such sources ensures that the runners are always strong and healthy.

Planting.—Having gathered the runners, or slips, or ropes, they should be cut into lengths about 2 feet long; two or three of these short cuttings are then placed together, bent in the middle, and this central elbow, containing at least two nodes or eyes to each cutting, is planted about 6 inches deep in the soil.

Where ridges are used the cuttings are spaced about 2 ft. 6 in. apart along the top of the ridge, and on each side of the ridge about 1 foot above the ground. Where hills are used the cuttings are planted at the top of the hill and in about five or six places around the sides. The reason why some cuttings are planted low down in the ridges or hills provides for a certain amount of the crop being obtained in the space between the ridges or hills.

After Cultivation.—Weed and grass control is maintained until the runners have grown and are effectively covering the ground.

Harvesting.—The period of maturity varies according to the variety, but is generally between five and seven months. A purple fleshed variety in cultivation at Keravat can be harvested at 4½ months, although if allowed to remain until 6–7 months old the yield is almost double.

Sweet potato varieties, such as "Keravat Purple" and "Keravat White", can remain in the ground up to the end of the eighth or ninth month after planting without any serious loss in yield. Soft varieties, however, like the red-skinned yellow flesh type grown in many parts of New Guinea, must be harvested soon after maturity.

After harvest the tops should be removed and burnt, also tubers or pieces of tuber which are overlooked at the time of harvest should be dug out from time to time as they germinate. The removal of the entire crop, both tubers and vines after harvest is important in the control of the sweet potato weevil. Should planting be needed from a harvested area, then only a small section sufficient for requirements should be allowed to remain.

Yields.—The main factors affecting yield are—

1. Loose friable soil.
2. Type of planting material.
3. Large ridges or hills.
4. Allowing the crops to become fully mature.

Yields at Keravat during the year 1939 average between 7–9 tons per acre, but improved methods of cultivation adopted after experimentation towards the end of 1939, have resulted in maximum yields of up to 17¾ tons per acre being obtained, and average yields of 10–12 tons. Improvement in cultivation consisted of proper spacing, use of the correct planting material, control as far as possible of the sweet potato weevil, complete control of the sweet potato caterpillar by the giant toad (*Bufo marinus*), making of large hills, and allowing the crop to reach full maturity before harvest.

After harvest, sweet potato tubers may be stored up to ten days, providing that the skin of the tuber has not been damaged.

3. Yam.

The types of yams cultivated in the Territory of New Guinea may be divided into three groups, namely—

1. Common Yam.
2. Taitu Yam.
3. Mammee Yam.

The common yam is easily recognized by the leaf which is long and pointed, and by the thick, angular stem. The tubers are of varying shapes and the skin of the tuber may be white, cream, or red, the flesh of the tuber may be white, cream, or purple.

The Taitu yam, so called in the Territory because, under this name, the type was introduced from the Trobriand Islands. The leaf of the Taitu yam is best described as "heart shaped", the stem is round and may be smooth or covered with thorns. Three varieties are in cultivation here and the tubers are so characteristic that they are easily known from both the common yam and the mammee yam. The Taitu tuber is oval or pear-shaped, the oval type is either very hairy (that is, entirely covered with a dense coarse mat of small rootlets), or has a large number of short hard spines up to ½ inch long; the pear-shaped type is most characteristic, the upper half, which corresponds to the neck, is covered with short sharp spines, whilst the lower half or bulbous portion is entirely smooth.

The mammee yam has heart-shaped leaves, round stems, which may be smooth or thorny, and in this respect resembles the Taitu yam. However, the similarity ends here. The mammee tuber is very much smaller, is smooth or covered with fine, soft, rootlets, and grows in clusters of as many as 40 small or medium-sized tubers. The flesh of the tuber may be white or purple.

Soil.—The yam requires a loose, well-drained soil containing a fairly high percentage of organic matter. If planted in heavy, wet, or badly drained soil, the parent tuber of "set" generally rots and dies before the vines have an opportunity to become established. Should favorable weather follow planting the vines become established quickly; but they die once the soil becomes too wet, and any small tubers that have formed rot away.

Preparation of the Land and Lining.—There are three methods of preparing the land for yams, namely—

1. Hills raised above the surface of the ground.
2. Deep holes in which loose surface soil has been thrown and a hill about 1 foot high built up over the hole.
3. Long ridges raised well above the surface of the ground.

Native yam cultivators usually adopt methods Nos. 1 and 2, chiefly because they grow their yams in conjunction with other food crops such as taro, bananas, ibeka, etc., and the hills or holes can be dotted around amongst the other crops. Other reasons for the use of these methods by the native are that in coral or stony country where good, deep soil is scarce, holes can be dug between the coral or rocks and a crop obtained, also in some districts the long tuber type of yam is grown and high hills or holes allow for maximum growth.

Experience at the Demonstration Plantation, Keravat, shows that when yams are grown as a sole crop, long high ridges are best. When making the ridges it is essential that they be as large and as high as possible, the land should be previously hoed to a depth of at least 9 inches, and by spacing the ridges 4 to 5 feet apart the completed ridges should be at least 2 feet above ground level with another 9 inches of tilled surface soil beneath. Thus there is about 2 ft. 9 in. of well-tilled, friable soil in which the yam can grow and develop. In districts of high rainfall, the top of the ridge should be flattened out to minimize as much as possible washing down of the soil and so lowering the height of the ridge and exposing the parent tuber or "set". This flattening out also allows for protection against heavy storms until the vines have grown and produced a protective covering.

Should single hills or hole and hill methods be used, then the hills should be made as high as possible. The hole and hill system is not recommended at any time unless the long type of yam is to be cultivated, also from the aspect of plantation native food production and cultivation, the hole and hill method is not so economic as the ridge method.

In the hill system two "sets" may be planted, and in the ridge system the "sets" are planted at intervals of 3 feet along the top of the ridge. The hills are spaced 4 feet apart from centre to centre.

Planting.—The material used for planting is known as a "set", and consists of either a section of cut tuber, or the top of the tuber, or a full tuber.

At harvest all damaged tubers are set aside for immediate consumption, whilst the undamaged tubers are stored in a well-ventilated place and allowed to "cure". During the curing process the crop should be carefully inspected and material selected for planting so that all tubers not needed for the next season's crop can be eaten.

The plant tubers are allowed to germinate, and when the shoot has reached a length of about 3 feet the tuber is ready for planting. Once the time for planting arrives these shoots are cut back until they are about 6 inches long and contain two or three nodes, and in the case of large tubers the germinated portion plus a section of the tuber is cut off and planted. The balance of the tuber can be eaten or the cut end rubbed in ashes, and the tuber returned to storage for further germination. With mammees the tubers are usually too small for cutting and are thus planted whole, whilst in the case of the Taitu yam the medium sized tubers are planted whole, and the large tubers are cut. In many of the common yam varieties, especially the "cluster" types further germination occurs when the cut yam is returned to storage; with Taitu yam, however, a second day germination does not readily occur.

The native cultivator usually retains all small tubers for planting, and when planting is carried out he uses two or three, or even more, "sets" at each planting point. This idea is quite wrong, especially in the case of mammees, Taitu yam, and "cluster" types of the common yam. Experiments during the past two years at Keravat have proved beyond doubt that small tubers produce much smaller crops than medium-sized tubers or the cut-off top section of a large tuber. Furthermore, the proportion of small and very small tubers obtained from plants raised from small "tuber sets" is far in excess of those obtained from medium or large "tuber sets".

After Cultivation.—At all time during the growth of the crop any soil washed down must be replaced to prevent exposure of the tubers.

In the case of the common yam and the Taitu yam it is essential that the crop be "staked". Once the vines have reached a length of 3 to 4 feet it is time to "stake". Cut bush timber in lengths about 6 feet long, 2 inches in diameter, and sharpen one end. Insert the stakes strongly in the ground near the base of each vine, and attach long sticks parallel to the ground and about 5 feet above so that fence is made, and the vines as they grow are able to trail up the stakes and along the central stick.

A series of experiments conducted at Keravat showed that with mammees, the extra yield obtained from staked plants was so small that staking was uneconomic, on the other hand, "staked" Taitu yam showed an increased yield of more than 30 per cent.

The hills and ridges, also the spaces between, must be kept free of grass and weed growth.

Harvesting.—The period of maturity varies according to the type from nine to eleven months, and the crop is ready for harvest when the leaves turn brown and drop off or are covered with brown spots and the bottom of the tuber has become hard.

Recently recorded yields from bulk plantings at Keravat were 9 tons per acre from Taitu yam, and 8 tons per acre from mammees.

TOBACCO CURING.*

By F. W. Winckley,

Department of Science and Agriculture, Jamaica.

Curing.

After the plants have been cut and hung up in pairs on the rails to dry, one must wait from 35 to 50 days before the leaves and their stems are perfectly dry. The time for drying may differ greatly, as it depends on the weather. If the weather is cold and damp, it is best to keep charcoal fires burning between the several rooms in the barn to keep the air circulating as much as possible. A damp, clammy atmosphere in a barn will cause the tobacco to sweat and great care must be taken to prevent this taking place, as once sweating starts it is difficult to prevent it from going through the whole barn and so spoiling all the tobacco. If one has sunny days, it is best to hang the affected rails out in the sun for a few hours to check the sweating. On fine days, the barn should be open to air as much as possible during the day, so that it is best to have shutters made at either end of the barn to allow of their being opened and ensuring a good current of air going through the barn. After cutting the green tobacco and hanging it on the rails, it is sometimes worth while putting the rails outside in the sun for a short time, or in a place out in the open with not too much sun for a couple of days, to allow the plants to quail properly and also to prevent sweating and to hasten on the drying process. The rails should not be left out in the rain. The idea is to get the plants as free from moisture as possible before hanging them up in the barn, thus keeping the interior of the barn as free from moisture as possible.

When the tobacco leaves are quite dry and their stems are dry right up to where they join the main plant stalk, one can start stripping. The early morning is the right time to start taking the pairs of plants from the rails. About 24 pairs to a rail 12 feet long are usual, so when taking down, string up 12 pairs together, lift off the rail and place in a cool spot on the floor of the "press," or place where the fermenting is to take place, and cover over with sacking or banana matting. That is, from each rail make two big bundles of plants. When the necessary quantity has been taken down, start making a "stick press," that is, the bundles of plants with their dried leaves still hanging to them are placed in a staple with their heads or tops towards the centre and the stalk end, by which they have been hanging, outwards. This ensures that all the leaves are inside the staple or press, and as they have been taken down in the early morning they are supple and will remain so until the stripping begins. Do not keep the plants in this press more than a night or two, but start stripping as soon as possible, as fermentation will start and it is better not to ferment the tobacco while the plant stalks are still green, otherwise the leaves soak up so much moisture that it is difficult to get them dry again. When the leaves are stripped, it is better to grade for length at once, if possible, and then make them into heads of 40 to 45 leaves. These heads should be kept covered as much as possible to keep them supple, otherwise they will dry out, and be difficult to ferment properly. When a good quantity of heads is ready, they should be stapled together in a pile (pilon) from 5 feet by 5 feet to 9 feet by 9 feet and 5 feet high. Naturally, the size of the pilon

* Reprint of Tobacco Circular No. 4, Department of Science and Agriculture, Jamaica.

depends on the quantity. When about 3 feet high, a hollow bamboo large enough to allow a thermometer to pass easily down its centre, should be placed on the layer of tobacco in the pilon. One end of the bamboo is in the middle of the pilon, and the other end sticks out 6 inches from the side of the pilon. A straight bamboo of about 1½ inches in diameter should be used and the partition between the hollow joints should be cut out with a chisel. To do this a small opening about 3 inches long and ¾ inch wide must be made at one side of the bamboo. These openings are also necessary to allow the heat from the tobacco to reach the thermometer, which must be put down the bamboo to the centre of the pilon. It is best to tie the thermometer to a strip of bamboo which can easily be pulled up or pushed down the hollow bamboo. The bulb end of the thermometer must be nearest the centre of the pilon. Then continue stapling the tobacco on top of the bamboo until the required height of 5 feet is reached. Then insert the thermometer, and cover the pilon with sacking or matting. The fermentation will start almost the first day, and every morning the thermometer must be read and a note kept of the reading. The fermentation can go on until a temperature of 130° F. has been reached, but it must not be allowed to go higher, so if one sees that it is likely to go higher in the night, the pilon must be opened up that day and turned. All the tobacco forming the sides of the pilon, two or three layers from the top and bottom, have not had any heat, so this tobacco must be put aside and later on when rebuilding the staple or pilon, it must be put in the middle, to be sure that it gets its fair share of fermentation. Turning a pilon must be done as quickly as possible, so that as little heat as possible is lost. Pilons should be built on plank floors, so it is best to have one compartment in the barn with a wooden floor raised at least 6 inches from the ground, and also the sides should be of boards or wattle plastered with mud. The method of stapling or stacking the heads of tobacco leaves is quite simple. First start a row outside completing the full size of the pilon, then about 3 inches inside this row start another row, the heads always being outwards and the tips of the leaves inwards. When these two outside rows are completed, start stapling across with the heads pointing outwards and go on doing this, making the straight rows about 3 inches apart, until the centre of the pilon is reached. Then start at the other side doing the same thing until the whole of the first layer is complete. Start the second and succeeding layers the same way and the cross rows as well, so that the pilon is composed of so many layers of tobacco, built up to 5 feet high.

Barns or Tobacco Houses.

These should be built of wooden posts with wattled sides and thatched roofs. All interior wood not coming in contact with the ground may be of softer woods, although the cross-pieces, upon which the bars or rails are to rest, must be strong, as the weight of the green plants is fairly heavy.

It has always been said that one room per acre is sufficient, but with more modern methods of cultivation and consequently better sized plants, it is safer to have two rooms to the acre, and so have plenty of room to space the rails properly and dry the tobacco more quickly. The size of a barn for one acre should be then 33 feet by 27 feet by 24 feet high at the ridge pole, and 9 feet high at the plate (i.e., outside posts). The length of 33 feet is made up as follows: 3 feet, 12 feet, 3 feet, 12 feet, 3 feet. The 3-ft. spaces are walk-ways to enable one to move freely between the rooms when moving the rails. The 12-ft. spaces are the rooms, where the tobacco is to hang. In breadth, the rooms are 27 feet with a centre walk-way of 3 feet. On every row of posts across the breadth of the barn, cross-pieces must be put up at 3-ft. intervals, upon which the bamboo rails are to hang. The ends of the barns may be thatched to within 6 feet of the ground, that is, as far as the wattling, and two or three shutters, which can easily be opened or closed as required, should be made in the side thatching. For each room 125 to 130 bamboo rails are required, so for one acre, 300 bamboo rails are more than enough. The extra rails are always handy in case of breakages and if the crop is extra large. With large-sized plants it is best to space them at 1-ft. intervals on the rails; in this case 125 rails per room are necessary and these will hold 6,000 plants. One corner must be set aside to make room for a watchman and the "press", wherein the tobacco will be stored for fermentation, as explained previously.

PRODUCER GAS UNITS.

Apart from their importance in a time of national emergency, producer gas units cost so little to run that they are considered a sound investment at all times.

The making of producer gas consists essentially in drawing air through a bed of red-hot charcoal and in the following article in this issue, a clear and simple explanation of the use of producer gas for all types of road-transport vehicles is given.

Charcoal, for the production of producer gas, is usually made by completely carbonizing pieces of hardwood. Charcoal made from coco-nut shells has not been used to any extent, although it is being tested by a prominent firm in Rabaul with very satisfactory results.

Following the article on "Producer Gas" in this issue is an article on the preparation of high-grade charcoal from coco-nut shell. Wood charcoal is prepared in a similar manner.

From exhaustive tests, carried out in New South Wales, it has been found that two very suitable producer gas units are those manufactured by the following companies, from whom full particulars may be obtained:—

Harkness and Hillier, 155 Parramatta-road, Fivedock, New South Wales, and

The Powell Gas Producers (Aust.) Ltd., 142 Parramatta-road, Camperdown, New South Wales.

In reply to recent inquiries, these units were quoted as follows:—

The H. and H. Producer Gas Units—

	£	s.	d.
Truck unit, less sales tax	85	0	0
Trailer unit, for attachment to cars	135	0	0
Chassis trailer fitting	1	10	0
	136	10	0

The Powell Gas Producer Unit—

	£	s	d.
Type A (suitable for engines up to 27 h.p. and load up to 4 tons)	85	0	0
Less fitting charges	10	0	0
	75	0	0

	£	s	d.
Type B (suitable for trucks over 27 h.p. and loads of 5 tons and over	94	0	0
Less fitting charges	10	0	0
	84	0	0

In supplying these units to New Guinea, they would be accompanied by plans and descriptive matter enabling them to be installed locally.—*R.C.H.*

PRODUCER GAS.*

Fundamentals.

The making of producer gas consists essentially of drawing a limited quantity of air through a bed of red hot fuel (coal, coke, charcoal, wood, &c.).

If a container is filled with charcoal and ignited it can be fanned to a glowing mass by supplying an abundance of air to the fuel. If now the amount of air supplied to the heated bed of charcoal is reduced, there will be a quantity of charcoal at a sufficiently high temperature to combine with oxygen readily, but for which insufficient oxygen is available. The combustion of the carbon, which is the principal element of charcoal, will be incomplete, and a gas, carbon monoxide (CO), will be formed. This gas is capable of burning to carbon dioxide (CO_2) when mixed with more air and again ignited. Consequently, if a gas producer be arranged with a limited supply of air, the hot charcoal will combine with less oxygen than it would in an ordinary open fire thus forming a combustible gas which can be burned elsewhere. Hot carbon possesses another ability; it is able to dissociate the elements of water or steam to give hydrogen and oxygen. The hydrogen remains free, but the oxygen combines with carbon to give carbon monoxide. This reaction is also used in a gas producer.

It is simplest to assume that in a gas producer the first reaction is to form carbon dioxide, which is then reduced to monoxide, but whatever the case may be the results are the same and may be set out as below.

(1) $C + O_2 \rightarrow CO_2$

(2) $CO_2 + C \rightarrow 2CO$

(3) $H_2O + C \rightarrow H_2 + CO$

C = Carbon
O = Oxygen
H = Hydrogen
CO = Carbon Monoxide
CO_2 = Carbon Dioxide
H_2O = Water

The first reaction (1) is that which normally takes place in an open fire. The second (2) and third (3) will only take place at a high temperature in the absence of oxygen, and it will be seen that the first and second could be combined as follows without altering the result.

(4) $2C + O_2 \rightarrow 2CO$.

The reaction (4) or (1) and (2) combined, gives off heat (is exothermic) and this heat is used to maintain the temperature of the fuel bed and to bring about the reaction (3) which absorbs heat (is endothermic). A balance must be set up between the heat evolved in reaction (4) and that absorbed in (3) so that the temperature of the fire does not fall, consequently the amount of steam or water admitted to a gas producer must be carefully controlled. For Australian conditions the admission of steam is considered to be very desirable as the hydrogen evolved improves the quality of the producer gas. Further, oxygen obtained from steam is not mixed with nitrogen or other diluents as in the case of atmospheric oxygen used in reaction (1), thus a greater concentration of combustible gases is developed.

* Reprint of Pamphlet No. 4, New South Wales Forestry Commission, Division of Wood Technology.

In brief, the essentials to making producer gas are—A hot bed of fuel in a suitable container and through which a limited amount of air may be drawn together with a controlled supply of water or steam. The result will be the generation of a mixture of gases: Nitrogen, hydrogen, carbon monoxide, and a small percentage of impurities. This is the mixture known as producer gas. Such a gas, when mixed with the right proportion of air, can be exploded in an internal combustion engine in exactly the same way as an air-petrol mixture.

Quite a large number of producers have been evolved in an endeavour to obtain the best possible gas with any particular fuel. The principle is the same in every case. Designers try to procure a gas which burns with great heat (high calorific value) and then to deliver this gas to the engine, free from any tar, soot, dust or other solid matter and cooled to the temperature of the surrounding air, or lower if possible.

Producer Furnaces.

Furnaces have been constructed in a great variety of shapes and sizes. The older types were almost invariably lined with fire-brick or similar material. This lining frequently led to trouble as it was affected by vibration, and it has survived only in stationary plants. In vehicular plants it has been found possible to so arrange the air inlet and the gas outlet in the furnace that the container is protected by an envelope of charcoal which surrounds the fire and through which little or no air passes. The charcoal actually acts as an insulator for its own casing. Special precautions in design have to be made at the point where the air enters the fire, as high temperatures are invariably met at such points.

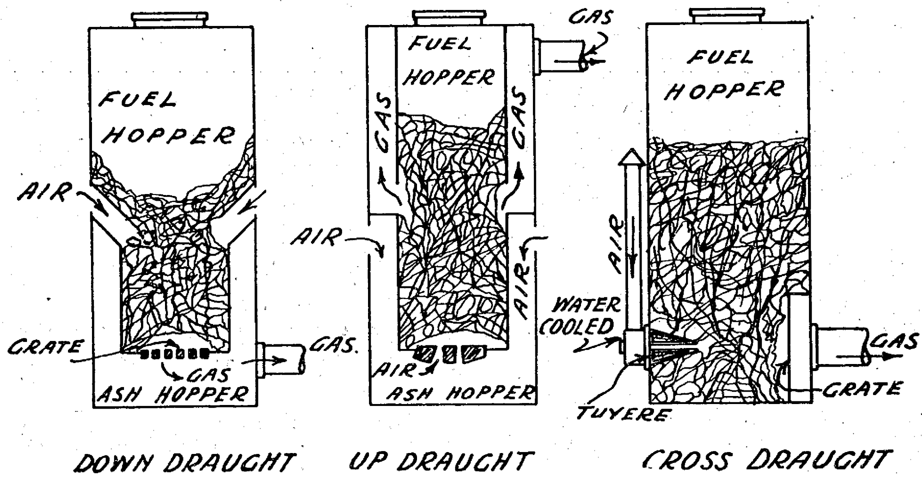
Furnaces may be divided into three types according to the direction of the draught in them, i.e., down draught, up draught, and cross draught. The first type is not normally used for charcoal plants and needs no particular explanation. In the up draught producers air is admitted at the bottom of the furnace through a grate, and considerable ingenuity has been displayed on the part of designers in making a grate which will withstand the high temperatures at this point. The furnaces are usually surrounded by a false shell which acts as an ash hopper, and the air supplied to the furnace is pre-heated in the space between the furnace and false shell. Steam is also generated in this space from a "drip feed" of water supplied to it. Gas is drawn off at the top of the furnace and passes on to the cleaning process which will be discussed later.

In the maintenance of up draught producers it is necessary to see that air is admitted through only the proper air inlet and that all doors, inspection holes, and filling holes are securely closed and sealed. The grate must be kept free of clinker as this seriously hampers the operation of the producer. Makers usually provide the necessary tools for this work, and it should be attended to at regular intervals depending on the quality of the fuel used.

In the cross draught producers the air is let into the furnace through special openings in the side of the casing. In most cases only one air inlet or tuyere is provided, and in all cases special arrangements have to be made to cool the tuyere. Some makers provide water cooling, either in conjunction with the engine-cooling system or by means of a separate water tank connected to the tuyere and operating on a thermosyphon system. Some tuyeres are cooled by the air supply to the producer, which passes round a tortuous path through the tuyere on its way into the furnace. Either steam or water is admitted with the air as it enters the furnace, and means of controlling the rate of water supply are provided.

Gas is drawn off to the cleaning system through a grate or grill on the side of the furnace opposite the tuyere, and a second grate or similar device is usually provided below the path of the gas in the furnace for the ash and clinker. As in the case of up draft producers, it is essential to see that air enters the producer only at the correct point or points and that all other openings are sealed. Clinker removal is necessary as in up draught furnaces.

THREE TYPES OF FURNACES SHOWN DIAGRAMMATICALLY.



Cleaning System.

When the gas leaves the furnace it carries with it particles of dust, soot, ashes, fine charcoal, etc., and it is essential that these impurities should not be allowed to reach the engine. The gas must, therefore, pass through a series of scrubbers or cleaners.

Many types of scrubber have been used by different makers, and only the most successful will be described here.

With stationary plants the practice is to use a large cylinder filled with coke or similar material as a scrubber. The gas passes from the producer upwards through the coke with which it mingles intimately and a shower of water is passed downwards through the scrubber. The coke and running water combine to clean and cool the gas very effectively.

For vehicular work the weight of the equipment is of great importance and so the coke and water scrubber has had to be discarded and replaced by dry scrubbers and dust traps. With a number of designs the gas passes straight into the dust trap and there baffles are placed to cause the heavier particles to be deposited. In another type of trap the gas passes through baffles in which the openings are shaped to impart a swirling motion to the gas, and the heavier particles are separated by centrifugal action to the outer portion of the scrubber. They then fall to the bottom of the vessel where they collect and can be removed at regular intervals.

Filters are also considerably used as gas cleaners. Pads for these filters have been made of many materials such as wood wool, metal wool, sisal, hair felt, etc., and they are usually packed into trays or cages to facilitate cleaning. In some cases the pads are soaked in oil or water, and in others they are dry. The filters must be regularly cleaned and the pads washed so that their effectiveness is not impaired. In many cases the pad material has to be teased from time to time to prevent its becoming so tightly packed as to impede the passage of the gas.

Various oil scrubbers are also used as a final stage, in the cleaning process. In some the gas actually passes through the oil, the inlet being submerged in the liquid. Another type depends on the splashing of the oil on to plates over which the gas passes. The success of such scrubbers depends on the regular changing of the oil and on maintaining the oil at the correct level.

Coolers.

It is of the greatest importance that the gas should be cooled to as low a temperature as possible before entering the engine. Adequate cooling ensures that the gas delivered to the engine is at its maximum density, giving the greatest charge (by weight) for the cylinders. Some makers have provided special coolers for this purpose in the form of radiators or nests of pipes through which the gas passes and so placed that they are cooled by the air as the vehicle moves. A separate cooler is not always necessary if the scrubbers afford ample cooling, but it can usually be classed as highly desirable. Coolers should not require any attention apart from occasional inspection to see that no soot is accumulating.

Fan or Blowers.

With some producer equipments it is usual to supply a fan or blower to be operated by hand in order to heat the furnace before starting. The fans are very similar to those used on the blacksmiths' forges and need no description. Other makers depend on the engine to supply the draught for starting the fire and start the engine on petrol. This method of starting will be dealt with later, but it should be noted here that on every producer which is not equipped with a fan provision should be made for the temporary connection of one for testing purposes. This can be done by fitting a tee-piece in the gas line just before the line reaches the mixing valve (see below). The branch of the tee should be extended to a convenient position and there closed with a blank flange. Such an arrangement would allow a fan to be connected, and in the event of starting difficulties, would enable the gas to be tested and the resistance in the gas line ascertained.

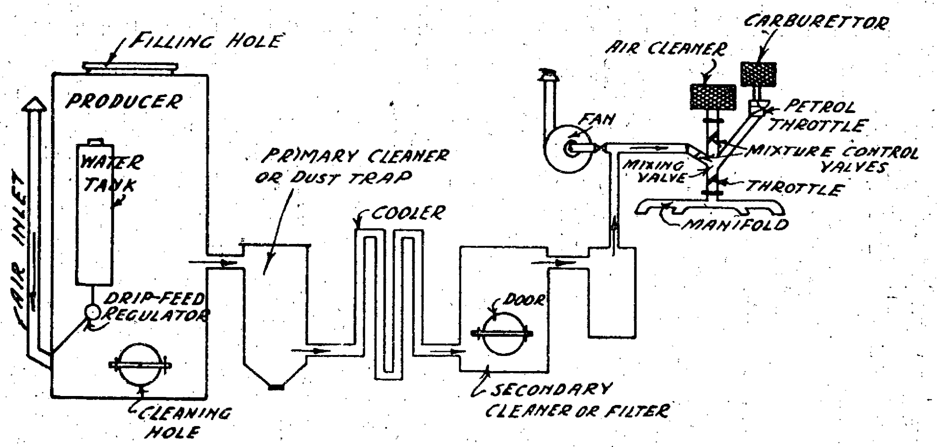
Mixing Valves.

On a producer gas engine the mixing valve takes the place of the carburettor on the petrol engine. In essence, it consists of a " Y " piece with a butterfly valve in each branch and a throttle valve in the stem. The gas line coming from the cleaning system is connected to one branch, and the other branch is coupled to the air cleaner or left open to the air. By varying the position of the two butterfly valves the ratio of gas to air can be adjusted to the best position at any time, according to the performance of the engine. It is, therefore, usual to couple the two valves together with levers and bring a control into the driver's cabin on a vehicle.

The throttle valve is of the usual type and is connected by levers to the driver's cabin in just the same way as the accelerator is connected to the throttle of the carburettor in the ordinary vehicle.

Where a converted vehicle is to be started on petrol it is also necessary to retain the entire petrol system. This means that an inlet system consisting of the induction pipe, carburettor and mixing valve have to be re-arranged so that either gas or petrol can be admitted as necessary, and although the location of the parts may vary considerably it is the equivalent of adding a third branch to the Y-piece and connecting the carburettor to this branch.

Diagram of a Typical Producer Gas Equipment Showing Sequence of Operations.



Starting up with Blower.

In a producer plant fitted with a blower the starting-up process consists of igniting the fuel bed with a kerosene wick or similar arrangement, and then operating the blower until the producer has reached a temperature high enough to make gas. Care must be taken to see that all the valves at the mixing box are closed, so that the blower does not merely draw air back from the engine. When the gas is ready the mixing valves are set to correct positions and the engine started in exactly the same way as a petrol vehicle.

Starting on Petrol.

On vehicles without a blower the engine is started on petrol, with all mixing valves closed and the producer ignited. With the engine running at a fair speed the gas valve is opened a little to set up a draught in the furnace. The temperature of the furnace rises; gradually gas is produced and the controls are manipulated so that the engine gets more and more gas and less petrol until the petrol throttle can be closed right off and the vehicle driven on gas. The process of changing from petrol to gas requires a little practice, but after a time it should be found possible to make the change with the vehicle in motion.

Once the vehicle is settled down on gas the petrol is turned off and gas is used entirely. It should be noted that the tap for turning off the petrol should be placed in a convenient position between the petrol pump and the carburettor, and that it is advisable to have the petrol pump overhauled at the time of conversion of the vehicle.

Most users prefer to get their vehicle running on gas before they start the water feed to the producer, and this may be considered good practice, as it facilitates raising the furnace temperature.

Operation.

Once the plant is changed over to producer gas, the driving of the vehicle is in every way similar to that of a petrol vehicle. Plants have been built to give a range up to 200 miles on one filling of fuel, depending on the fuel, but an average figure of 100 miles between fuel recharging is more usual. The plant in most cases has to be stopped for refuelling, and in opening up the hot furnace some care is needed, as the hopper is likely to be filled with gas, which promptly burns. The resulting flames are too short-lived to be dangerous, but can be very unpleasant.

Maintenance.

The routine maintenance of the ordinary petrol vehicle has been reduced to an absolute minimum in recent years. A little more trouble has to be taken in attending to a producer gas vehicle, but this is only to be expected, and the success of any vehicle depends to a large extent on the care exercised by the user. The important points are set out below:—

1. The furnace must be regularly cleaned out to remove all clinker or ash.
2. The scrubbers must be emptied and inspected regularly.
3. Filter pads must be washed as required.
4. Oil scrubbers must be recharged.
5. All joints in the gas line must be kept absolutely air tight, so that air enters the system only at two points, i.e., at the air inlet to the furnace and at the mixing valve. The importance of this point cannot be over-stressed, and supplies of spare jointing material should always be on hand.
6. Supplies of clean water for cooling the tuyere and feeding to the producer must be maintained.
7. The usual maintenance required for a petrol vehicle should be given to a producer gas vehicle.

The time involved in the additional work required to maintain a producer gas vehicle will vary with the fuel quality and the capacity of the scrubbers. A reasonable estimate for a vehicle working a full day would be about ten minutes each day and an extra thirty minutes once a week. These figures should not be exceeded with plants at present available.

Choice of Fuel.

Producer gas users are advised to be careful in the selection of the fuel for their units. The idea that "anything will do" is a misguided one and often leads to trouble. Experiments indicate that any sound timber can be successfully converted into charcoal, but hardwoods are probably the best. The important points are as follows:—.

1. The charcoal should be free from any unburnt portions of wood or bark.
2. The charcoal should be evenly graded with a minimum of fines. (Suggested size, ½ in. to 1½ in. mesh.)
3. A charcoal with good mechanical strength and giving a metallic ring is preferable.
4. The greatest care should be taken to avoid sand or earthy impurities in the fuel, as these impurities form clinker in the furnaces. Clinker presents by far the greatest problem to be overcome in the furnace, and it can be largely avoided by using only fuel free from the above impurities.

Suitability of Vehicles.

Any petrol engine can be converted to run on producer gas. Whether the conversion will be satisfactory or not depends to a large extent on the power reserve of the engine in regard to the work performed on petrol. A definite loss of power is unavoidable, and with engines of low compression ratio, this may be as high as 40 per cent. The loss may be reduced to about 20 per cent. by increasing the compression ratio to 7 to 1, or the power loss can in some cases be completely overcome by boring out the cylinders and fitting larger pistons.

For vehicle work the power loss is often not of vital importance, as modern vehicles have fairly high compression ratios and ample power reserves. The only effects of the conversion are: A reduction in speed on hills, in acceleration, and possibly in absolute maximum speed. It follows that many vehicles could be converted to producer gas without seriously reducing their utility. On account of the necessity of maintaining a high furnace temperature, it may generally be stated that the larger the vehicle and the more uniform the load on the engine the better the results will be, as under these circumstances a more effective current of air passes through the producer.

Ignition System.

The ignition system of petrol vehicles is quite suitable for producer gas, except that arrangements must be made to increase the angle of advance of the spark when running on producer gas. Angles of advance up to 45 deg. before top dead centre have been found satisfactory, but the correct position varies with each engine and must be found by adjustment in each case.

Precautions.

All users of producer gas should remember that the gas contains carbon monoxide, which is highly poisonous and difficult to detect. There is no fear of the gas harming anyone during the normal running of a producer gas vehicle, as there is never a positive pressure in the gas line. Nevertheless, care should be exercised whenever the system is opened up for cleaning of scrubbers, &c., to avoid breathing the gas.

When an equipment is provided with a blower, the greatest care should be exercised to see that the blower is not operated in a closed room or shed, and that wherever it is operated the outlet or exhaust from the fan is not inhaled. The handle of the blower should always be removed so that the uninitiated cannot do any harm either to themselves or others.

COCO-NUT OIL AS LIQUID FUEL.

At the Vunapope Catholic Mission, situated at Kokopo in New Britain, coco-nut oil is being used as a liquid fuel. It is running a 30 h.p. H.M.G. two-stroke semi-diesel engine. The engine runs well and pulls a full load. Combustion appears to be complete, for there is no sign of smoke from the exhaust. The only trouble so far experienced was that after about fourteen hours' running, the fuel pump and injector valves began to stick and had to be taken down and cleaned.

Planters are invited to submit suggestions for the improvement of the GAZETTE.

Appreciation of the GAZETTE *can be shown by lending it to your friends.*

VEGETATIVE PROPAGATION IN TROPICAL PLANTATIONS.*

The Imperial Bureau of Horticulture and Plantation Crops, East Malling, has issued Technical Communication 13 on this subject by G. St. Clair Fielden and R. J. Garner. It deals with the vegetative propagation of some 55 plantation crops, and follows a previous communication (issued in 1936) dealing with the vegetative propagation of some 100 fruit varieties grown in the tropics and sub-tropics. The help of technical experts has been invoked for adequate treatment of such major crops as rubber, coffee, cacao, &c., while the foreign literature has been thoroughly combed for details of propagation of the less familiar, but nevertheless important, crops. One feature of the previous work, which commended it also to workers in temperate regions, is retained and considerably enlarged, namely, the section devoted to methods used in vegetative propagation. The descriptions are supported by simple, clear, line drawings of some seventeen types of graft and seven types of budding commonly used in vegetative propagation. Tropical workers will also be glad of the illustrated detail of the construction of loosely woven potting baskets which have been found so useful a substitute for pots in nursery work in the tropics. For those who wish to study originals, a list of references immediately follows the discussion on the propagation of each particular crop.

* *Nature*, No. 3690, 20th July, 1940.

COCO-NUT SHELL CHARCOAL.*

By Dr. Reginald Child, B.Sc., Ph.D. (Lond.), F.I.C.

Coco-nut Research Scheme, Ceylon.

1. Introduction.

Coco-nut shell charcoal is one of the best absorbents for gases, &c., which accounts for its well-known use in gas masks and also for certain industrial operations. Before it can be used for this purpose, however, it has to undergo a technical process known as "Activation". Coco-nut shell charcoal as prepared on the estate and as exported has very little absorbing power. Purchasers of such charcoal require it to reach certain standards of quality and in particular to be free from contaminants which make the activation process more difficult. The most likely common faults of locally produced charcoal are—

(i) Too much moisture.

(ii) Not sufficiently burned, which means loss to the manufacturer of activated charcoal, as the under-burned charcoal has to be carbonized or if used causes trouble in the activating plant.

(iii) Too much sand or earthy matter.

(iv) Containing salt through using brackish water in cooling off.

Purchasers usually buy on specifications controlling these faults and typical standards are given below.

It is the purpose of this article to describe the preparation of coco-nut shell charcoal by the ordinary simple method and to show how to avoid the above and other faults so as to produce charcoal up to the usual specifications. The writer has examined a large number of locally made samples and finds that with ordinary care there is no difficulty in producing a satisfactory product.

2. Charcoal Making.

The process of making charcoal is merely the burning of shells in a limited supply of air, so that they do not burn away to ash as in a copra fire-pit, but are carbonized. The only trick of the process is to get conditions right so that the shells are carbonized to just the right degree, i.e. burned enough but not too much.

Kiln.—The kiln in which the shells are burned may be anything from a simple hole in the ground to expensive steel and brickwork patent kilns. Actually patent kilns are not in use in Ceylon. On non-friable soils, a simple pit serves well enough, but it is obviously difficult in sandy soils to prevent the charcoal becoming mixed with sand unless a brick-lined pit be used.

The shape and size of the pit may vary. The diagram† shows types, actually in use, of various depths. Firebricks are preferable for the lining, but ordinary local bricks stand up for a considerable time and mud mortar is said to be more satisfactory than cement. As far as shape is concerned, circular pits narrower at the top than bottom such as *A*, or bottle-shaped such as *B*, are preferable, as the firing is more easily controlled.

The shells used should be dry, clean and free from adhering fibres of husk.

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* Reprint from *Coco-nut Industries*, Vol. 4, No. 2, p. 77, 1940.

† The diagram has been adopted from that given in F. C. Cooke's *Investigations on Coco-nuts and Coco-nut Products* (1932) with the omission of the simple unbricked pit and the addition of commercial type of pit (*a*) used on everal Ceylon estates.

Procedure.—In the pit of type *A* and *B* in the diagram a fire of shells is started at the bottom of the pit; more shells are added to this until these too are well alight; then more shells and so on until the pit is completely charged, the fire being allowed to burn up before each new addition. When the full charge is well burning the fire may be damped down by sprinking water. The glowing mass is then covered to exclude air, but space is allowed for the large volume of smoke to escape.

For covering, green fronds, damp turf and soil may serve. If old corrugated sheets are available, these are used as first coverings to prevent contamination with soil, which may be placed on top.

The time taken for charging will naturally vary with the size of the pit. Some operators prefer slow charging. By this method the first fire is started and the pit covered, *A* with its circular steel cover of $\frac{1}{4}$ in. mild steel fitted with handles or *B* with galvanized sheeting. Smothered carbonization is allowed to proceed for some time before the next addition of shells, after which carbonization is again controlled by replacing the cover and so on until the pit is full. This may take, with a pit of the dimensions of *B*, up to 6 or 7 days. This slow procedure, which does not require water cooling, is said to give better uniform well-burned charcoal than the more rapid procedure described above.

It is hardly possible to give precise directions for either procedure. Some practice is required to get exactly right conditions. If the combustion is too much smothered and carbonizaiton is incomplete, a mass of woody half-burned charcoal results. If, on the other hand, the burning is not smothered enough, there is a poor yield of charcoal and it is brittle and thin.

When the pit is full the slow burning proceeds while much acid smoke is given off. During this process, the pit (as described above) is covered except for sufficient space for a smoke outlet. It is not usually possible to open the pit until the third day. When the pit is opened the mass of charcoal may catch fire and it is sometimes therefore necessary to sprinkle with water to cool off.

C is a large pit which is filled with shells which are then fired by kerosene poured down the central bamboo. The author has not seen this in operation, but does not consider that it has any particular merit.

In places with a high water table it may be necessary to use an above-ground kiln, such as *D* in diagram. This kiln is charged with shells, which are fired. When the shells are burning well, the fire hole is blocked, and air regulated by air holes at the top.

Sorting and Bagging.—The good pieces of charcoal are sorted out from the bulk; any unburned shells or under-burned pieces are put aside and used in starting the burning of the next charge.

Since accidents have occurred both on land and sea through stocks or cargoes of charcoal becoming ignited, it is now made a condition of shipment that charcoal shall be exposed freely to the air for at least 14 days before packing or bagging. It is packed in stout gunny bags holding a hundredweight (twelve to the shipping ton).

The crude charcoal contains sufficient acidic products to cause deterioration of bags on prolonged storage. This indicates that bulk storage is preferable in cases where immediate shipment is not possible. Such storage would have to be in dry godowns or warehouses. This extra handling may also cause the production of a large percentage of small pieces and dust.

3. Yield.

The weight of charcoal obtained should be just under 30 per cent. of the weight of the original shells. The weight of shells varies considerably, and in fact goes parallel with the out-turn of copra. The weight of a 1,000 shells may vary from as low as 280 lb. to as much as 400 lb. but is nearly always about a quarter of the weight of the husked nuts. Thus after a drought, when nuts are small and out-turns of copra are poor, shells will also be thin and light.

The following is a rough guide to what may be expected:—

Out-turn of copra.	Weight of 1,000 shells.	Number of shells to a ton.	Number of shells to make a ton of charcoal.
	lb.		
1,000	437½	5,120	17,650
1,100	400	5,600	19,300
1,200	365	6,140	21,200
1,300	337	6,650	23,000
1,400	312½	7,170	24,700

Twenty thousand whole shells to a ton of charcoal is a usual working average. The heaviest and thickest shells give the best charcoal.

4. Quality.

Good charcoal should be uniformly black in colour, and free from dirt due to husk. Broken edges should show a shiny black surface, and a characteristic sharp fracture. When dropped on a stone floor good pieces give a clear ring; badly burned pieces give a dull sound. Over-burned pieces are very thin and brittle; they are not favoured for inclusion in samples for export, as they easily go to dust.

Other faults of bad charcoal have been enumerated above, and buyers' specifications are based on avoiding these. Individual firms have slightly different specifications, but the following are nearly always required:—

(i) *Size.*—It is usually stipulated that not more than 5 per cent. shall pass a ¼ in. mesh sieve. Some firms have more stingent specifications indicating what percentage shall pass or be retained on a series of graduated sieves.

(ii) *Ash Content.*—A limit of 2 per cent. is usually imposed. An ash content of over 2 per cent. almost always indicates contamination with sand or soil. Clean good charcoal averages about 1.8 per cent. of ash, which is largely potash salts derived from the shells themselves. A tolerance of only 0.2 per cent., or 2 parts per thousand, is thus allowed for sand, &c., from outside. The necessity for care in seeing that no sand or soil is allowed to contaminate the charcoal is thus obvious.

Chloride Content.—One firm imposes a limit for chloride of 1.0 mg. per gm. A figure over this indicates the presence of salt, as when salt or brackish water is used for damping the fires and in cooling off. This should never be used, but only fresh water.

(iii) *Moisture.*—Different firms have different specifications for limit allowed for moisture. Five per cent. is usual, though some allow up to 10 per cent. It is not uncommon for unscrupulous local makers to damp the charcoal too much, so as to increase its weight for sale. This is easily detected and is bad business in the long run, as a prejudice is created in the buyers' minds against the particular seller practising it.

(iv.) *Volatile Matter.*—This is an arbitrary figure, and different firms have different standards. A usual limit is 15 per cent., that is, the sample when heated under certain fixed standard conditions shall not lose more than 15 per cent. of its weight. A content of volatile matter over this limit indicates under-burning, which is a fairly common fault.

5. Costs..

The price of charcoal and of shells fluctuates considerably, and it would be of little value to quote prices in this article.

In purchasing shells for charcoal making, care must be taken to have some idea of their out-turn or to buy on weight rather than by the number. As mentioned above, it may require anything from 17 to 24,000 shells to make a ton of charcoal, according to the out-turns of the nuts. Just as much care is, in fact, necessary, as in buying nuts for copra or desiccated coco-nuts, as charcoal out-turns vary in the same manner as copra and desiccated coco-nuts out-turns.

6. By-products.

Brief mention may be made of the nature of the products lost in the smoke—some 70 per cent. of the weight of the shells. If, instead of being burned in pits, shells are fired in ovens or retorts heated from outside, and the vapours given off condensed, there are obtained from 100 lb. shells, besides about 34 lb. charcoal left in the retort, some 40 lb. of a crude acid, known as pyroligneous acid, and about 5 lb. of tar. The pyroligneous acid contains 10 to 12 per cent. of acetic acid, and from the tar can be obtained carbolic acid and creosote. The working-up of these products are technical operations not suitable for small-scale working.

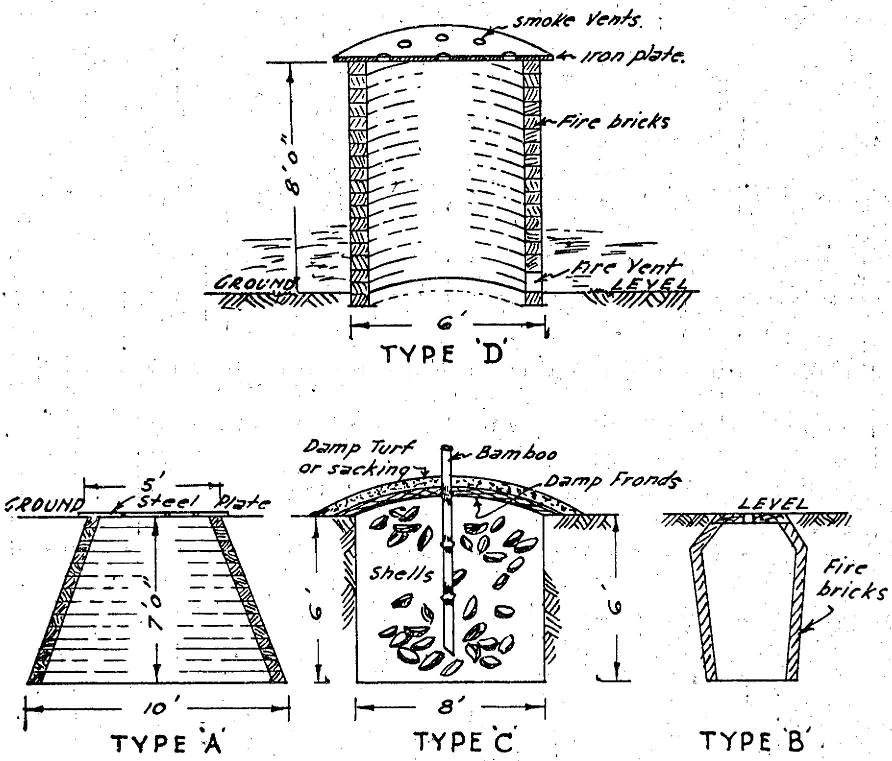
7. Conclusion.

It appears likely that the demand for charcoal will be maintained at a good level whilst war conditions continue.

Where copra is dried in ordinary Ceylon kilns, however, not more than 300 shells are left over for charcoal making from every 1,000 nuts cured. This will doubtless give an impetus to the use of other types of kiln burning butt-ends, &c.,

and also, where practicable, to sun-drying. In very dry weather it is possible to effect considerable economy of shells by reducing the number of kiln firings and increasing the number of sun-dryings.

Types of Charcoal Kilns.



CHEMICAL NOTES.

A recent enquiry led to the antiscorbutic value of the juice of the common New Guinea "moolie" or lime being determined. The average figure for the analyses of the juice of five moolies from different sources was 28 milligrams of ascorbic acid (vitamin C) per 100 cubic centimetres, which is in good agreement with figures obtained for limes in temperate climates.

Approximately 2.5 milligrams of ascorbic acid per day will protect a baby from scurvy, and in case the diet of the baby does not contain this amount it is customary to supplement it with orange juice. It has been found that Australian orange juice may contain from 29 to 74 milligrams of ascorbic acid per 100 cubic centimetres, so that, three teaspoons of moolie juice are equal, in antiscorbutic value, to one teaspoon of good Australian orange juice or three teaspoons of juice from a poor orange.

The addition of sugar to the moolie juice does not lower its antiscorbutic value.

MANURIAL EXPERIMENTS FOR PLANTERS.

As a plantation is not a scientific institute, but a commercial enterprise, the planter cannot be expected to carry out experimental work, with the view of promoting scientific knowledge in general. It must be left, therefore, to the experiment station to carry out the research work necessary to solve the new problems which continually arise.

With regard to fertilizer problems, it is not necessary for the planter to undertake any research work to find out the general requirements of the plant. Experiment stations showed long ago that every plant requires certain amounts of nitrogen, phosphorus and potash, and that fertilizers which contain these elements must be supplied, if they are not already present in the soil in sufficient and available quantities.

What the experiment station cannot do, however, is to adapt the general results of its investigations to the specific conditions of different planations. This problem can only be solved by the planter himself. Within this restricted sphere, therefore, he cannot avoid some small amount of scientific work, if he wishes to apply the results of science to his own endeavours, a proceeding which is becoming more and more necessary if good results are to be obtained.

If the planter wishes to carry out practical manurial experiments, the following two conditions must be carefully observed, namely:—

(*a*) The experiment must be simple, to ensure that it be carried out in a proper manner under the difficult conditions of actual practice.

(*b*) The experiment must be laid out in such a way that the results can be relied upon, i.e., that any increase in the yield must be due to the manuring, and not to any casual outside factors.

To comply with the first condition, it is essential that the planter restrict himself when laying out the scheme of his experiment, and that he does not aspire to solve too many questions at one time. It is best to attempt to answer only one question at a time. If, for example, a planter wants information as to the elements required by his soil, he should lay out the experiment with the sole object of solving this question.

Scientific research work in, and practical experience of, more advanced countries have shown that the best dressing is one which returns to the soil all the chief elements, which are taken out of the soil by the crop; and these are nitrogen, phosphorus, potassium and possibly also calcium. If, therefore, a planter wishes to know whether it will pay him to make use of artificial fertilizers, he should lay out an experiment which will enable him to compare two plots, one of which is a check plot, receiving no manure, and the other a plot receiving a complete manure. The two plots must be equal in every respect, size, situation, aspect, composition and condition of the soil, humidity, previous treatment and manuring. The only difference between these plots ought to be that one has been fertilized. In Table 1, plot 1 remains unmanured as a check plot; plot NPK receives a complete dressing with artificial fertilizers.

TABLE 1.—PLAN OF FERTILIZER EXPERIMENT.

Plot. 1	Plot 2
	N.P.K.
Unmanured	Full dressing with nitrogen, phosphoric acid and potash

To calculate the profit from this manuring, the planter has only to weigh the yield from each plot and so obtain the increase due to the complete dressing. By deducting the cost of the manure applied from the value of the increased yield, he will arrive at the net profit to be gained by manuring.

The next question to be solved is, which particular plant foods are especially wanted. Such an experiment should be laid out according to Table 2. Here, to the plots 1 and 2 are added three plots, on each of which in turn one element of plant food has been omitted. Thus plot 3 receives the same amounts of nitrogen and phosphoric acid as plot 2, potash, however, being omitted. It must be here emphasized, that the dressing with nitrogen and phosphoric acid should be exactly the same on both plots. If, for example, nitrogen be given on one plot in the form of nitrate of soda, it must be given in the same form to the other plot; not in the form of nitrate of soda on one plot and in the form of

TABLE 2.—WAGNER SCHEME FOR FERTILIZER EXPERIMENTS.

Plot 1	Plot 2	Plot 3
	NPK	NP
Unmanured	Full dressing with nitrogen, phosphoric acid and potash	One-sided dressing with nitrogen and phosphoric acid without potash

Plot 4	Plot 5
PK	NK
One-sided dressing with phosphoric acid and potash without nitrogen	One-sided dressing with nitrogen potash without phosphoric acid

sulphate of ammonia on the other. In the latter case one would not be able to say exactly whether any difference in the results of the two plots was to be attributed to the different forms in which the nitrogen was given, or to the additional potash given to the one.

Only when this dressing of potash is the sole difference between the two plots, can one conclude that the difference in results is a consequence of the potash dressing. The same applies to plots 4 and 5, a comparison between plot 2 and 4 showing the effect of nitrogen and a comparison between plots 2 and 5 showing the effect of phosphoric acid.

As the use of nitrogen and phosphoric acid is already well and widely known, the planter will in most cases be already well informed about their necessity. The problem which remains for him to solve will be whether a complete manuring which provides also potash is more advantageous than the one-sided manuring perhaps formerly in vogue.

Such an experiment could be laid in the simplified manner of Table 3, where a comparison between O and NPK will show the effect of a complete manuring and a comparison of NPK and NP the effect due to potash alone.

Now it may be argued, that the scheme suggested here is unnecessarily complicated and that the problem could be solved in the much simpler way, unmanured against potash, i.e. by comparing a check plot receiving no fertiliser with one receiving only a potash dressing.

If we look through the literature we find many records of manurial experiments where this incorrect method has been adopted. In other cases we find experiments where planters, who were accustomed to a dressing of nitrogen alone, tried to solve the phosphoric acid and potash questions by such a scheme as comparing nitrogen with nitrogen and phosphoric acid, or nitrogen with nitrogen and potash respectively. Such trials are in no way reliable, because they ignore Liebig's law of minimum by which the development and growth of the plant is governed. Liebig proved that the development of the plant is limited by that plant food of which, in relation to the demand of the plant, the least quantity is available in the soil.

If in a certain soil, nitrogen is the weakest link, then an addition of phosphoric acid and potash, that is a strengthening of the other links, can have no effect, because growth is limited by the nitrogen which is in the minimum. In such a case a dressing of potash alone would have no effect and a trial according to one of the aforesaid schemes would lead to the wrong conclusion that potash on such a soil had no effect at all. That this is so, would be proved if we laid out an experiment according to the scheme of Table 3.

TABLE 3.—CORRECT PLAN OF A POTASH EXPERIMENT.

Plot 1	Plot 2	Plot 3
	NPK	NP
Unmanured	Full dressing with nitrogen phosphoric acid and potash	One-sided dressing with nitrogen and phosphoric acid without potash

In that method, the soil has a sufficiency of nitrogen and phosphoric acid so that the potash is enabled to show its full effect, and to show whether it be possible to augment the crop more by adding potash than is possible by one-sided manuring with nitrogen and phosphoric acid alone.

A similar mistake would be made by comparing a nitrogen plot with another plot receiving nitrogen and potash. (Table 4.) If in this case phosphoric acid be a limiting factor, allowing the combination of nitrogen and potash to act only to a certain degree, it is evident that the dressing of potash can show no effect at all. Only when a complete manure is given, i.e. one containing nitrogen, phosphoric acid and potash, can reliable and conclusive results be obtained.

TABLE 4.—FAULTY PLANS OF POTASH EXPERIMENT.

Plot 1 Unmanured	Plot 2 One-sided dressing with potash
Plot 1 Nitrogen alone	Plot 2 Nitrogen and potash

Another method of experiment which in some cases has been tried is to give to one plot say 2 cwt. of a nitrogenous manure, and 2 cwt. of a phosphatic manure; whereas to another plot is given only 1 cwt. of a nitrogenous manure, 1 cwt. of a phosphatic manure and in addition 2 cwts. of a potassic manure, presuming that the potash can replace part of the nitrogen and phosphoric acid. This idea is wrong, because each element plays a different part in the life of the plant and cannot be substituted by any other element. These elementary experiments will not only give the planter an indication as to what elements are necessary, but will also give him an idea of the quantities and in what forms they are required.

The form in which an element should be given is best determined by a special experiment. If the planter wants to know whether sulphate of ammonia or nitrate of soda be more suitable for his crop, he should compare two plots one of which has received in addition to phosphoric acid and potash, nitrogen in the form of sulphate of ammonia, whereas the other one has received the same amount of nitrogen in the form of nitrate of soda. Another point, which must be kept in mind, is that in such experiments the planter should employ only manures which have been proved by science and practice to be free of noxious substances. Sulphate of potash is to be recommended for experimental work, since this salt has no bad effect even on such very sensitive plants as tobacco and sugar cane.

Muriate of potash is also a very pure salt and may be employed for many crops. Because of its high chlorine content, however, its use is not to be recommended for sugar cane or tobacco; and even for tea or cocoa, preference should be given to the sulphate. A practice not to be recommended either, is the use of impure potash manures, e.g. crude salts, tobacco ash or sugar cane ash, because these contain accessory substances, the effect of which on tropical plants is not yet fully known but is probably harmful. In laying out manurial experiments, these impure salts should be avoided, as they may give inconclusive and misleading results.

The main source of error in manurial experiments, however, is to be found in the inequalities of the soil over the experimental area, even though one may try to choose as uniform an area as possible. To find a sufficiently large area free from these soil inequalities is impossible, so it may happen that the plot receiving a dressing of potash may be poorer than that receiving no potash and consequently, although the potash has in fact had an effect, this improvement will not be shown. In order to correct these differences and to obviate their influence on the results a certain number of control plots should be laid out which, as in a chess-board, should be evenly distributed over the whole field. If this be not possible, at least one control plot should be allowed.

TABLE 5.—EXPERIMENT WITH CONTROL PLOTS.

Plot 1 Unmanured	Plot 2 Complete manure
Plot 3 Complete manure	Plot 4 Unmanured

If the results of the unmanured plots are uniform, whereas the results of the manured plots show a variation, then with every probability this difference may be attributed to the effect of the various manurings. The greater number of control plots, however, the surer will the results be.

The experimental stations of Java, where excellent scientific work is done, even go so far as to lay out ten or twelve control plots. For practical purposes this number would be excessive, because the laying out of experiments would then be far too difficult and complicated for the planter. For practical purposes three control plots are deemed sufficient.

An exact potash experiment could therefore be laid out after the manner shown in Table 6.

TABLE 6.—POTASH EXPERIMENT WITH THREE CONTROL PLOTS.

1 O	2 NP	3 NPK
4 NPK	5 O	6 NP
7 NP	8 NPK	9 O

For field crops each plot should be about 1/40 acre (= 121 sq. yards). Then from the results of the equally manured plots, the increases resulting from the various other manurings can be calculated. If the variations between the control plots are not great, the average results of the other plots will permit of reliable conclusions. In any case, one should calculate the average yield of every kind of manuring from yields of the various control plots. For example, if plots 2, 6 and 7 gave yields of 1,000 lb., 1,020 lb. and 1,061 lb., the average of these plots (NP) would be (1,000 + 1,020 + 1,061) ÷ 3 = 1,027 lb., the differences between the average and the several different yields are respectively — 27, — 7 and + 34 lb. If we then find that plots 3, 4 and 8 had respective yields 1,179 lb., 1,201 lb. and 1,160 lb., corresponding to an average of 1,180 lb., the variations of the single plots in comparison to the average yield are 1, 21 and 20 lb. The difference between the two average yields of NP and NPK then is calculated as 153 lb. In view of the irregular distribution of the different control plots throughout the field, this difference should be put down to the potash, as it cannot be due to the variations in soil, because the variations between equally manured plots are far smaller.

For scientific purposes, another and more exact calculation of the average variation based, on the law of probability, is generally adopted, but for practical purposes our method, which is much less complicated, is sufficient.

In dealing with permanent crops, the inequalities of the soil can be eliminated by another method. In the year previous to the experiment, the plots are laid out, the soil if left unmanured and the average yields of the various plots are determined and recorded. The variation between these plots will not be very great, if care has been taken to choose a field where the soil is as even as possible all over.

In the second year, the trials of the various manures may be commenced and their effects on the yields noted. In comparing the results of the second year, the difference between the plots, as found in the first year, should be taken in account. By such a method, a truer estimate of the effect of a certain manuring may be obtained. The disadvantage is that one must wait an extra year before any results are known, and further, that the influence of the weather cannot be eliminated in this way.

Manurial experiments very often require much patience, because perennial crops do not as a rule show any beneficial results in the first year of treatment. For example, the effect of potash may be diminished by the fact that the soil in its hunger for potash may absorb the first application so greedily, that the plant benefits little. Furthermore, in contrast to nitrogen, phosphoric acid and potash will in the first year only have the effect of promoting the vigour of the plant and the growth of wood, so that only later will these elements show their effects directly upon the yield. If only for these reasons, then it is to be recommended that potash manurial experiments should always be extended over a number of years, because even where negative results are shown in the first year, planters may be sure that at the end of several years potash will prove itself a great and valuable ally in the production of the production of remunerative crops.

In spite of all the care and precautions which are taken to obtain conclusive results, it is not always possible to get precise experimental data on special questions. In such cases, the planter finds himself in a dilemma; he must either spend money on a fertilizer without being assured that his soil requires it, or he must omit some plant-food without the satisfaction of knowing that his soil does not need it. Generally the latter choice will be the more dangerous, because he then loses any chance of obtaining a crop increase which a fertilizer dressing might eventually have yielded him.

This uncertainty of experimental work has its explanation in the fact, that the planter is not dealing with a dead mechanism, but with a living organism subjected to all the incalculable influences of nature, and one which cannot be expected to react so promptly to the experimental factors, as would be the case with an experiment in the laboratory.

Experimental work in the plantation, therefore, must always be left to the personal judgment of the planter upon whose knowledge and energy depends the success of the plantation.

The planter, who is well acquainted with the nature of the soil, and the requirements of his plantation, is in a position to learn very much more from the results of experiments, even though they are not quite conclusive, than the other who lacks this knowledge and who relies only upon the figures themselves.—[*Rewritten from a pamphlet by Jacob and Coyle. R.C.H.*]

ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE, PAPUA, FOR THE YEAR 1939-40.

During the six months preceding June, 1939, the local selling price of copra rose to a value not unremunerative to the producer which led coco-nut planters to believe that the year 1939-40 might possibly be a good one. In the first half of the year, this view was further strengthened by the fact that overseas vessels called in July, November and December and lifted all the produce on hand for which the producers received a fairly satisfactory price, particularly for hot-air grade which in November and December realized £10 3s. 3d. per ton net, the gross figure being £12 7s. 6d. (London market price).

During the latter half of the year, however, and up to the time of writing, no copra carrying vessels have called and there is now little or no space for storing copra at either Port Moresby or Samarai with the result that at the moment, the product is unsaleable and the industry in a precarious position. In fact, the situation is so grave that the Commonwealth Government has intimated that some measure of assistance to planters is being considered but no indication has yet been received as to the form it will take, although it is confidently assumed that it will be sufficient to relieve the anxiety of growers, particularly those who rely on this product only.

The comparatively high market price for rubber ruling during the year stimulated planters to take up further land in new parts of the Territory suitable for its cultivation.

During the month of May, 1940, an opportunity was taken to canvass planters for the purpose of ascertaining the position of the rubber industry in the Territory, details of which are as follows:—

Number of producing plantations	23
Area under cultivation	14,494 acres
Area planted with rubber	12,964 „
Area being tapped	7,904 „

The annual production of the tappable area is estimated at 3,009,379 lb.

Taking the above figures as a guide the average yield per acre is 380 lb. but this figure is rather misleading as some plantations produce as much as 500 to 520 lb. per acre, whilst in an isolated instance the yield is given at 1,428 lb. This latter yield may appear somewhat fantastic although it is true and the explanation is that the trees on this particular area are very old and have not been tapped for many years.

At the close of the year the market price (Australian Currency) for the various grades of rubber was as follows:—

No. 1 Smoked Sheet	14.035d. per lb.
„ 2 „ „	13.248d. „ „
Clippings	13.248d. „ „
Scrap	10.666d. „ „

The cost of production and marketing, including interest on capital invested is estimated at 7.5d. per lb.

It is pleasing to note that a number of areas have been taken up in the Port Moresby District for market gardening, both for private use and commercial purposes. The Territory and more particularly Port Moresby has long felt the want of a plentiful supply of fresh fruit and vegetables and there seems to be no reason why the same cannot be successfully grown in the Laloki River District, which is close to the township, and marketed at a profit to the grower.

Agricultural exports for the year were as follows:—

Mangrove Bark	268¾ tons
Desiccated Coco-nut	1875½ ,,
Coffee Beans	77¼ ,,
Copra	6656¾ ,,
Gum	62 ,,
Rubber	1345¾ ,,
Grain	196½ Bushels
Timber	67,299 super-feet

REVIEW.

A report, "Manurial Experiments on Cocoa in Trinidad and Tobago", by F. J. Pound, Ph.D., B.Sc., Department of Agriculture, Trinidad and Tobago, has just come to hand. The report, comprising 102 pages presents results of fertilizer trials on various cocoa soils in Trinidad and Tobago. As some of these soils correspond roughly to soil types found in New Guinea, much of the information contained in this report is of interest to cocoa planters here. In the "Summary and Recommendations for Manuring existing Cocoa" it is stated—

It has been emphasised here again that fertilising must be looked upon as an operation like pruning and draining, which may not pay off the capital expense involved in the year during which the work is done, but in which the good effects are seen long after. It is probable that, like pruning and draining, efficiency can be obtained by a small annual upkeep once the initial capital expense has been incurred.

The problem at the present time is twofold: manuring to increase yields from the existing tree population, and secondly the building up of soil fertility of suitable areas in readiness for a more efficient population to come.

Upon application, interested planters will be forwarded extracts of this report if the type of soil upon which they are growing cocoa, has been dealt with therein.—*Ed.*

In a recent bulletin (*Planters' Bulletin,* No. 9, 1940), issued by the Rubber Research Institute of Malaya, information is given on the manuring of rubber trees.

Striking increases in growth and yield were obtained by the regular application of a complete manure to rubber trees of the Dunlop Malayan Estates Ltd., when they were brought into tapping ten years ago, being then seven years old. The increased yield over comparable unmanured trees was 30 per cent. or 200 lb. per acre.

The question of whether nitrogen alone would produce adequate results is still unsettled, and for the moment the inclusion of phosphate and a little potash is recommended by the Rubber Research Institute.

By Authority: L. F. Johnston, Commonwealth Government Printer, Canberra.