

BULLETIN No. 19.

**Department of Agriculture,
Gold Coast.**

**Second Conference
of
West African Agricultural Officers.**

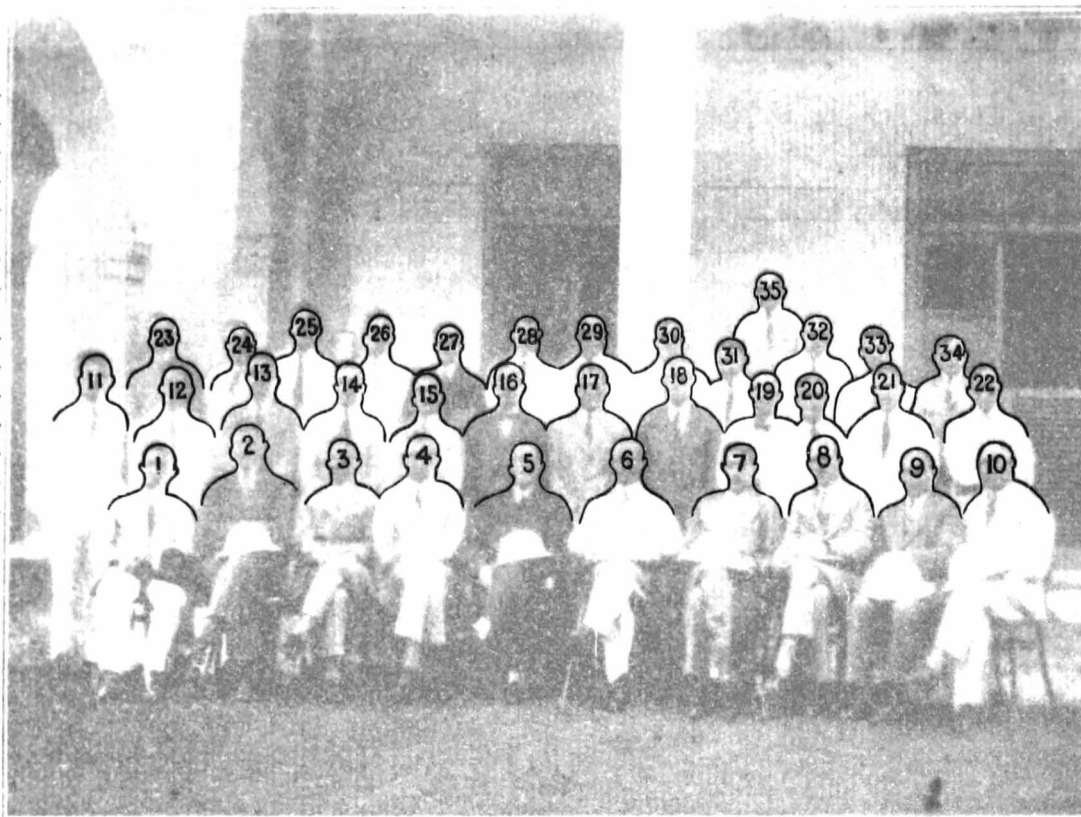
(Held in the Gold Coast, October, 1929.)

VOLUME I.

PROCEEDINGS.

1930.

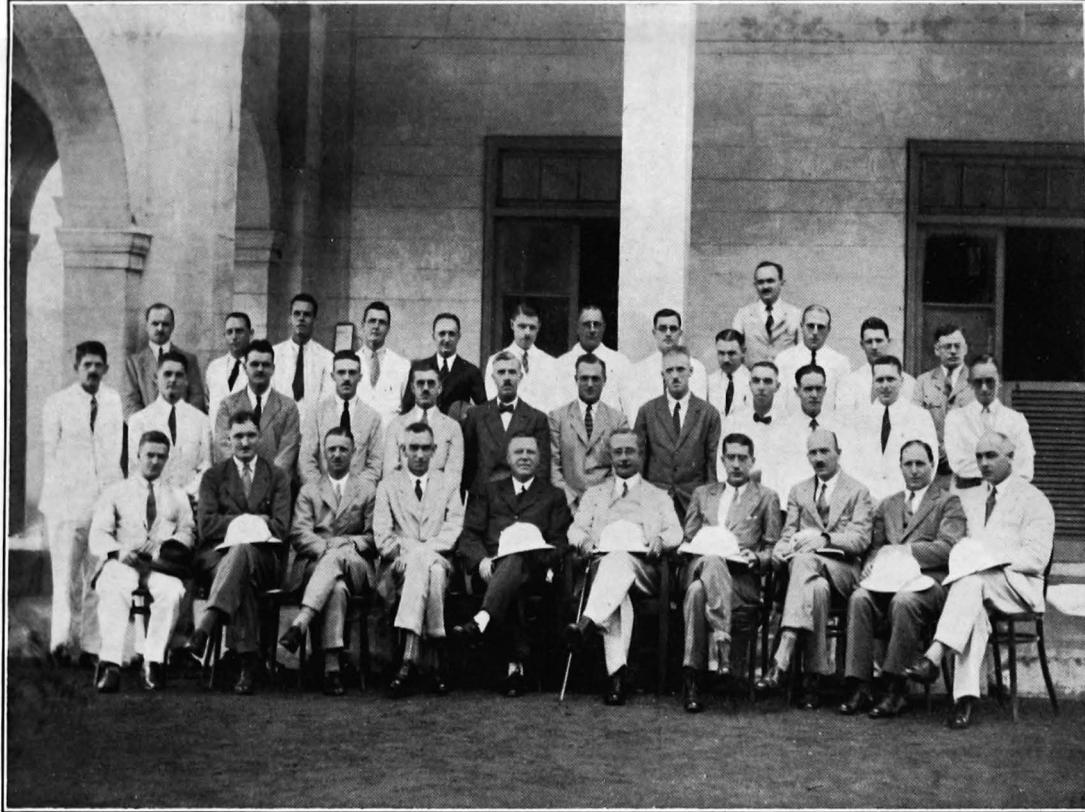
W. H. Beckett G.C.
 J. R. Mackie N.
 F. J. Martin S.L.
 H. C. Sampson Kew.
 F. A. Stockdale C.O.
 His Excellency Sir
 Ransford Slater G.C.
 O. T. Faulkner N.
 G. G. Auchinleck
 (Chairman) G.C.
 A. J. Findlay N.
 J. Pirie Gam.
 K. T. Hartley N.
 C. J. Lewin N.
 G. S. Cotterell G.C.
 W. B. Dowson N.
 J. M. Dunbar G.C.
 H. E. Green G.C.
 J. M. Wingate G.C.
 A. W. Paterson G.C.
 E. D. Hill G.C.
 E. Hargreaves S.L.



21 H. B. Waters G.C.
 22 A. S. Thomas G.C.
 23 Capt. G. Blackburne-
 Kane (P.S. to H.E.) G.C.
 24 H. W. Moor
 (Forestry) G.C.
 25 C. L. Skidmore G.C.
 26 J. C. Muir G.C.
 27 S. T. Phillips G.C.
 28 J. T. H. Stein G.C.
 29 F. Pyatt G.C.
 30 J. M. Ward G.C.
 31 G. C. Coull G.C.
 32 H. G. Poynter N.
 33 W. R. Hudson G.C.
 34 N. P. Chamney G.C.
 35 T. L. Williams G.C.

C.O. = Colonial Office.
 N. = Nigeria.
 G.C. = Gold Coast.
 S.L. = Sierra Leone.
 Gam. = Gambia.

SECOND CONFERENCE OF WEST AFRICAN AGRICULTURAL OFFICERS,
 — GOLD COAST. 1929.



[Photo by Holm.]

FOREWORD.

THE Second Conference of West African Agricultural Officers afforded to all delegates a valuable and appreciated opportunity for personal discussion of problems of development which face the four Colonies. While, in many cases, these problems differ from Colony to Colony in their technical aspects, the four Departments of Agriculture are on common ground in matters of function and aim. Each of the Departments exists for the sole purpose of increasing and intensifying the agricultural output of the Colony which it serves, and in this wide and difficult task the purely technical aspects are perhaps of less importance at the moment than questions of policy and methods of administration. Agricultural administration is still in the nascent stage in most tropical countries, and every means of interchange of opinion is of definite value.

The Conference was specially fortunate in having present as delegates from the United Kingdom, Mr. F. A. Stockdale, C.B.E., Adviser in Tropical Agriculture to the Colonial Office, and Mr. H. C. Sampson, C.I.E., from the Royal Botanic Gardens, Kew, who brought with them ripe experience of agricultural administration in other tropical countries. In addition, the Gold Coast Department of Agriculture had the privilege of meeting teams of brother officers from the other three Colonies, led by Mr. O. T. Faulkner, C.M.G., Dr. F. J. Martin and Mr. J. Pirie.

I am under obligations to members of the four Departments for help given in sessions of the Conference and at meetings of the various Committees in which much preliminary spade-work was done. To Mr. H. B. Waters I owe an additional debt for his help in editing the two Volumes of Proceedings and Papers in which the activities of the Conference are recorded.

G. AUCHINLECK,
DIRECTOR OF AGRICULTURE, GOLD COAST.
Chairman.

April, 1930.

VOLUME I.

CONFERENCE PROCEEDINGS.

CONTENTS.

PART A.—GENERAL SESSIONS.

AT ACCRA.

	PAGE
I. Address of His Excellency the Governor	I
II. The Colonial Advisory Council of Agriculture and Animal Health and the Imperial Agricultural Bureaux	2
III. Economic Botanical Work, Kew	4
IV. Field Experiments	4
V. Forestry in relation to Agriculture	6
VI. Imperial Agricultural Research Conference, 1932 ..	8

AT KUMASI.

VII. Economics of Cacao Farming	9
VIII. Forecasting the Cacao crop	13
IX. West African Oil Palm Industry	15
X. The Oil Palm at Calabar	16
XI. Palm Oil Factories	17
XII. Co-operative Societies	18

AT SEKONDI.

XIII. Inspection and Certification of Produce	20
XIV. Report and findings of Administrative Committee ..	25
XV. Reports and findings of Committees	25
XVI. Invitation to Sierra Leone for 1931	26
XVII. Adjournment	26

PART B.—CONFERENCE FINDINGS.

XVIII. General	27
XIX. Economic Botany.. .. .	30
XX. Agricultural Chemistry	34
XXI. Agricultural Economics	35

CONTENTS—*continued.*

PART B—CONFERENCE FINDINGS—*continued.*

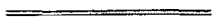
	PAGE
XXII. Agricultural Entomology	36
XXIII. Meteorology	41
XXIV. Produce Inspection and Certification	42
XXV. Statistics	43

PART C.—REPORTS OF COMMITTEES.

XXVI. Administrative Committee	45
XXVII. Economic Botany.. .. .	54
XXVIII. Agricultural Chemistry	60
XXIX. Agricultural Economics	63
XXX. Agricultural Entomology	64
XXXI. Meteorology	68
XXXII. Produce Inspection and Certification	75
XXXIII. Statistics	89

PART D.—APPENDICES.

A. List of Overseas Delegates	98
B. List of Representatives from the Gold Coast	98
C. List of Papers presented	100
D. Time Table and Itinerary	101



PART A.

GENERAL SESSIONS.

The six general sessions of the Conference were held as follows:—

ACCRA:

In the Council Chamber 17th October, 1929; Morning.

KUMASI:

At Cadbury Hall ... 22nd October, 1929; Morning.

Ditto 25th October, 1929; Morning.

SEKONDI:

At the Rest House ... 29th October, 1929; Afternoon.

Ditto 30th October, 1929; Morning.

Ditto 30th October, 1929; Afternoon.

At Accra.

I.—ADDRESS OF HIS EXCELLENCY THE GOVERNOR.

His Excellency the Governor, Sir Ransford Slater, presided.

In a brief opening address he welcomed the delegates from the sister Colonies and made special reference to the two distinguished visitors from home. Mr. Stockdale, he said, brought wide experience from various parts of the Empire, including Mauritius and Ceylon, and had come as the Secretary of State's Agricultural Adviser and representative of the newly-created Advisory Council. They might consider themselves fortunate in being the first of the Colonies to receive such a visit. Mr. Sampson came with the prestige of an ex-Director of one of the provinces of India, and as an Economic Botanist from Kew, and His Excellency took this opportunity of thanking both the Secretary of State for allowing Mr. Stockdale to attend, and the Director of the Royal Botanic Gardens, Kew, for sparing Mr. Sampson.

His Excellency said he would make no speech, on account of the numerous items in the agenda. Speaking if he might on behalf of the Governments of Nigeria, the Gold Coast, Sierra

Leone and the Gambia, he said that they realised the great responsibility in having under their charge twenty-five millions of people, most of whom derived their living from Agricultural pursuits, and, as finances would allow, each Government would, according to its ability, support proposals calculated to increase their prosperity. Speaking for the Government of the Gold Coast, he realised the first-class importance of the work in which the gentlemen before him were engaged and, so far as the finances of this Colony would allow, he could assure the Agriculture Service of a generous measure of support.

Mr. Auchinleck (Gold Coast) outlined the arrangements made for the Conference. General Sessions would be held in Accra, Kumasi and Sekondi, and much of the spade-work would be done by Committees. He felt confident that overseas delegates would welcome this opportunity of seeing the country, although it would involve considerable travelling for them.

His Excellency the Governor then invited Mr. Stockdale to address the delegates.

Mr. Stockdale replied, thanking His Excellency for the welcome extended to them, and, on behalf of all the visitors and delegates, thanking the Gold Coast Government for the very complete arrangements for their reception. He expressed his great satisfaction at meeting agricultural officers working in this part of the world. The Under-Secretary of State, he said, was personally interested in this Conference and would specially look forward to receiving complete reports.

II.—THE COLONIAL ADVISORY COUNCIL OF AGRICULTURE AND ANIMAL HEALTH AND THE IMPERIAL AGRICULTURAL BUREAUX.

Mr. Stockdale then proceeded to deal with his paper on the above subject. Recalling that the question of agricultural organisation had been considered by the Secretary of State for some time, he made reference to the outstanding features of the progress made in this reorganisation. He outlined the functions of the Colonial Council of Agriculture and directed attention to its work in connection with the training of Agricultural Officers, the scheme for Central Research Stations, and the dissemination of scientific and agricultural information. After referring to the proposed Unified Colonial Agricultural Service and the difficulties now receiving examination that had been encountered in its organisation, Mr. Stockdale gave an account of the newly constituted Imperial Agricultural Bureaux and concluded his address by reminding agricultural officers present of the significance of their work and of their obligations (to quote his own words) "not only

to ourselves but also to the services to which we belong and even more important to those millions of primary producers we are appointed to serve." (The full text of Mr. Stockdale's paper is published as Paper I, Bull. 20, Dep. Agr., Gold Coast.)

His Excellency expressed the indebtedness of those present to Mr. Stockdale for his lucid and adequate exposition of the objects of the Colonial Advisory Council of Agriculture and Animal Health, and stated that, if any doubt had existed in their minds as to the utility of the appointment of an Agricultural Adviser to the Secretary of State, this had now been dissipated. They were fortunate in having Mr. Stockdale from home to explain these matters. His Excellency then called upon Mr. Auchinleck to take the Chair, remarking that not only was his time fully taken up, but that also he felt that his presence there might hamper free discussion.

Mr. Auchinleck (Gold Coast) on behalf of the meeting thanked His Excellency for having attended. His Excellency then left the meeting.

Mr. Auchinleck then took the Chair and asked if there were any questions anyone would care to put to Mr. Stockdale.

Mr. Faulkner (Nigeria) said that although he was full of minor criticisms he would support Mr. Stockdale's schemes and felt assured that every one there would do so.

The Chairman said that he and the Gold Coast Department of Agriculture were entirely in favour of a Unified Agricultural Service. He had listened to Mr. Stockdale with interest, but there was one point to which he desired to call attention. The Service was called Unified. It was dangerous, he thought, to have two different kinds of men in it, and the proposed Service might too easily become a dual service with two classes of officers:—(1) agricultural officers, and (2) specialists. He felt that every man should first of all be an agricultural officer and then might specialise.

Mr. Stockdale thanked Mr. Faulkner and Mr. Auchinleck for their promises of personal support. When first asked to come to the Colonial Office he had hesitated to a certain extent as he had understood the full purport of the work. He felt, however, that it was up to him to accept the position offered, as by so doing he would have the opportunity of performing a useful service both in clarifying the position and in getting a system of value. He stated that without a Unified Agricultural Service he was convinced that they would not perform to the best that work of which they were capable. He would be pleased to hear any aspect of the matter and expressed the desire to learn and get officers' views as to how far and how fast the Committee might go ahead.

III.—ECONOMIC BOTANICAL WORK, KEW.

Mr. Sampson spoke on this subject. He pointed out that Kew had in the past played an important part in distributing plants of economic value and explained how in the future Kew could continue to give service to the Empire. He referred to another line of work relating to plant introduction, but concerned rather with the improvement of local agriculture by the introduction of varieties of staple crops. He said that Kew must be in close contact with the work of the Agricultural Departments of the Empire and stated that in many lines of work Kew has to depend on the co-operation of officers of the Agricultural Service. (The full text of *Mr. Sampson's* address is published as Paper II, Bull. 20, Dep. Agr., Gold Coast.)

The Chairman, in thanking *Mr. Sampson* for his speech, said he was glad of it for several reasons. Firstly, the post of *Mr. Sampson* was a new one and he had explained it effectively. The aspect of Kew with reference to Departments of Agriculture in the Tropics had changed and it had become a bureau about which they were all anxious to learn. *Mr. Sampson* had wide experience as an agricultural officer from both the field and administrative point of view. Kew was now agriculturally in right perspective with them and they in right perspective with Kew, and they promised him their hearty support.

Mr. Sampson then thanked the Chairman for giving him the opportunity of coming to West Africa and meeting men in the Agricultural Service in this part of the world. He hoped during the next two or three months to get to know all the men and their views in West Africa.

IV.—FIELD EXPERIMENTS.

Mr. Faulkner (Nigeria) had, he said, little to add to what he had said in the paper submitted by *Mr. Mackie* and himself (Paper III, Bull. 20, Dep. Agr., Gold Coast). The chief point was that different sets of conditions required different systems for dealing with them. The Nigerian system suited Nigeria and the "odds" by that method were easy to work out. The method of determining these odds was peculiar to that system and made use of several assumptions. These were known, and the figure arrived at erred on the right side. In agricultural experiments such small samples were used that any methods of calculating a standard error partook of the nature of a guess, and he gave as a parallel, the case of estimating the number of spades in the pack from a review of four cards taken systematically from that pack.

Dr. Martin (Sierra Leone) stated that he had previously read *Mr. Beckett's* paper, but he was no mathematician. He advocated the use of systematised plots as providing optical demonstrations.

Mr. Beckett (Gold Coast) said that certain objections to randomization had been dealt with in his own paper (Paper IV, Bull. 20, Dep. Agr., Gold Coast). Whether or not it was reasonable to use standard error in agricultural experiments with small samples, it was at least more reasonable to arrive at an estimate of that standard error by a random method, than by a systematic one.

The odds arrived at did not matter so much as the validity of those odds. It was better, he said, to have valid odds of 10—1, than odds however big which were rendered non-valid by the method of systematic sampling. He agreed with the difficulties of estimating the number of spades in the pack from four cards systematically selected, but he was sure that a better idea would be obtained if the four cards had been chosen at random, and he pointed out that the pack used was only one from the total number of packs available.

Randomization he suggested was misinterpreted. A Latin Square, for instance, was not random because the individual plots were scattered in a random arrangement, but because the complete square was selected at random from the total number of available Latin Squares. He had been associated with Mr. Engledow during his last leave and it was worthy of note that Mr. Engledow was increasingly using randomization.

The argument against the Fisherian method on the score of difficult mathematics did not hold good as he had actually trained native overseers at Asuansi to deal with the statistics, and he had found that they became proficient in a few months.

He had, he said, a great admiration of the Nigerian system—especially after seeing it working in the field when on a visit to a station in Northern Nigeria. At the same time he thought that the introduction of random selection would still further improve it, without any change in the field lay-out. The plots could still be in line.

Concluding, he stated that he was most impressed with one sentence in Mr. Faulkner's paper:—"We have found treatments and varieties, which our experiments have shown to be sound, are proved to be so by the readiness with which they are taken up by native farmers, and after all, this is the final test in West Africa."

That summed up the whole question, and any system where the above held good could be claimed to be perfect.

Mr. Faulkner (Nigeria) said that in some cases the Fisherian method was useful. Any estimate of standard error, based on a small sample, was liable to be so far from the truth that he could not feel that it was important whether one used a systematic or a

randomized arrangement. The random arrangement did not take advantage of the correlation between adjacent plots which generally existed.

Mr. Stockdale stated that the matter discussed was of great importance to them. *Mr. Faulkner*, he said, had given them a method which suited his conditions, but he had to admit that he personally lent towards randomization. He stated that they had made various tests in Ceylon dealing with annual crops, and it was their experience that they could use randomization effectively. In Ceylon they found they could train native officers to deal with the required statistics.

He stated that in dealing with permanent crops the system became much more difficult owing to the inherent individual nature of the trees. In Ceylon, prior to starting an experiment, they kept individual records of the trees of two to five years and then tried to establish a size of plot which would give a reasonable standard error. As *Mr. Faulkner* had stated, Rothamsted methods gave satisfactory results under Rothamsted conditions, but they felt that under the tea-growing conditions in Ceylon randomization was necessary as the land was undulating. He stated that he appreciated *Dr. Martin's* point of view, but he did feel that before the stage of demonstration was reached the stage of experimentation should come first. That was the main point. There was no one method, he said, suitable for all conditions.

The Chairman said that he realised the importance of the question—if only from the discussion which had taken place. It was, he thought, of vital importance to everyone in the Department, and although *Mr. Faulkner* was on the Administrative Committee he thought that he might be persuaded to meet the Sub-Committee on Statistics at some time. It was evident that there was no one method applicable to all conditions.

V.—FORESTRY IN RELATION TO AGRICULTURE.

The Chairman referred to the paper submitted to the Conference by *Mr. Gent*, Deputy Conservator of Forests, Gold Coast, who, he regretted to say, was unable to be present. *Mr. Moor*, however, who had also submitted a paper, was there and would speak on this subject. (See Papers VIII and IX, Bull. 20, Dep. Agr., Gold Coast.)

Mr. Moor (Gold Coast Forestry Department) stated that in the absence of *Mr. Gent* he wished to stress only a few points. In this Colony, Forestry was of assistance to Agriculture, and Forestry and Agriculture affected each other. The farmer, he said, was dependent on the forest for his supplies, but failed to realise the indirect influences which the forest brought to bear on his occupation. He said that in the United States of America

the existing expensive engineering works had failed to protect the farmer from the effects of excessive deforestation at river sources. The presence or absence of forest had an appreciable influence on local climatic factors. In this country they had only the one crop—cacao—and that an evergreen of the moist tropical forest belt. This was happiest in a forest environment, but in this country to grow the crop they merrily proceeded with haphazard deforestation. He stated that he used the word “haphazard” deliberately as no other word could adequately describe the lack of method. The result could be seen along the fringe of the cacao belt where they were killing the very crop that they were trying to foster.

All vegetation depended, he said, upon what foresters called “Quality of the Locality” or “Site Quality,” which was the resultant of all factors operating. When they saw one type of vegetation replacing another, as they did see in this country, the natural conclusion was that some change in the “quality” or component factors was taking place. The intrusive vegetation, said Mr. Moor, was always of a more xerophytic type and quite a few people believed that climatic factors were bringing about this change. Whatever might be the origin of this climatic change it was certainly being accelerated by excessive deforestation. The two main climatic factors influencing vegetation in this country were the Monsoon and Harmattan winds. The Monsoon wind was the primary source of rain moisture generally. The Harmattan was a dry wind, and the strength and duration of the Harmattan was a limiting factor as far as cacao and all evergreen vegetation was concerned.

Forests had both a local and a regional influence in mitigating the influence of the Harmattan, and it was upon this basis that they were trying to work out a system of forest reserves. For various reasons—the chief of which was perhaps the somewhat complicated system of land tenure—their success so far had amounted to only one-third of what they considered the minimum necessary. They hoped, however, to increase that proportion.

For the present they were not considering the questions of timber and forest produce, and as a Department they were, he thought, unique in that respect. A forester's first business was to manage and improve his forests.

However, with these forest reserves fulfilling the primary function—as he trusted they would do—this question would follow as a matter of course, and he hoped that in due time this country would benefit both directly and indirectly from its forests.

The Chairman stated that he thought the Department of Agriculture should be considered fortunate in being in a country where there existed another Department, which had as its duty the protection of agriculture rather than the exploitation of forests.

The Forestry Departments were out to protect the cultural areas by forest reserves, and, bearing in mind the land tenure and administrative difficulties in this country, it was very creditable that these reserves had been established on all the escarpments in the South West to protect the perennial crops of the country. He then enquired if there was any subject they desired to raise before the Conference broke up.

VI.—IMPERIAL AGRICULTURAL RESEARCH CONFERENCE.

Mr. Stockdale referred to a letter he had written on 20th September, 1929, the following extracts of which had been circulated to all delegates:—

.....
 " There is one other matter that I would like to bring up at the Conference if you can conveniently find time for a short discussion on it. It was raised at the meeting of the Colonial Advisory Council which was held yesterday and relates to the preliminary arrangements which should be made for the Imperial Agricultural Research Conference due to be held in Australia in the autumn of 1932. I would like your Conference to consider, if possible, what main subjects affecting tropical agriculture in general, and West Africa in particular, should be raised at the Imperial Agricultural Research Conference. If our present proposals materialise there will be a pre-Imperial Conference for tropical delegates in Ceylon en route to Australia, and it will there be decided as to which delegates shall represent the Colonial Empire in the different matters which will be discussed at the main Conference in Australia. It does, however, seem desirable that we should take advantage of your Conference in West Africa to consider in a preliminary manner what items should be recommended for inclusion in the Imperial Agricultural Research Conference agenda. We are similarly approaching the West Indies to take early action in this matter and I shall probably be writing to Ceylon and Malaya and to East Africa in due course on the subject."

He asked that the letter might form a subject for discussion by the various Committees in order that the present Conference might formulate material for inclusion in the agenda of the forthcoming Imperial Agricultural Research Conference in Australia. The delegates, he said, could then go to Australia not only with a knowledge of what their problems were, but with the determination to see them dealt with.

The Chairman confirmed *Mr. Stockdale's* remarks and declared the meeting closed.

At Kumasi.

VII.—ECONOMICS OF CACAO FARMING.

The Chairman (*Mr. Auchinleck*) opened the meeting by stating that the subjects for discussion were the West African Cacao Industry and the West African Oil-Palm Industry. Referring to the question of the Economics of Cacao Farming, he said there was some doubt as to the exact acreage of cacao farms in the Gold Coast. During the recent Plant Pests Campaign it was thought that the average acreage of farms was six acres. Mr. Miles, however, had worked the acreage out to be 4.6 acres. In the Western Province of Ashanti, officers had been stationed at gates on the road to check the amount of cacao which left the Province. Mr. Muir then surveyed the area and his estimate of the amount of cacao was very close to that obtained at the gates, *i.e.*, between 5,000 and 6,000 tons. It was then worked out that the average amount of cacao held by farmers in the Western Province of Ashanti was between 2.8 and 6.4 acres.

It was necessary to find out if a country run by peasant farmers was economically sound. The average yield of dry cacao on Agricultural Stations worked out at 5 cwts. per acre, therefore the average farmer, assuming that he had 4 acres of cacao, did not produce more than 1 ton of dry cacao per year, in other words, his income was approximately £20 per annum or £2 per month. This was less than the wages of domestic servants. It was therefore necessary to prove to the public that the industry was, or was not, stable. It would appear that the solution to the problem lay in increasing the size rather than the yield of farms.

In years of depression it was noticed that cacao grown some distance from the railway was not harvested. If the profits in cacao farming went down, it was probable that large areas would not be reaped. This would not happen were the land farmed by companies, as these would have to continue their business for the sake of shareholders. By the last statement he was not considering capitalistic tendencies in this country.

British West Africa was among the few tropical countries under European control the agriculture of which was practically entirely in the hands of native peasantry. For climatic and political reasons this condition of affairs would probably continue for many years to come. Large capitalized plantations, whether European or native, were not likely to come into existence.

The four Colonies they represented were very largely agricultural and, in the last analysis, most of the money raised for the support of the State by direct or indirect taxation came from agriculture. The income of the farmer was therefore a factor of paramount importance in any study of the financial status of one of these Colonies. His gross income depended on the area of land

he worked and the prices of the products grown and exported, while his net income available for taxation depended on the cost of production and the cost of his living.

In the case of the Gold Coast, they had no certain information as to the financial position of the farmer, though he was usually regarded as prosperous and the country as a wealthy one. Actually, the value of annual exports did not amount to more than £5 or £6 per head of the total population. The little evidence they had indicated that the average gross annual income of the cacao-farmer ranged about £20 to £30 (say, 4 acres yielding 20 cwts., worth, say, £24 locally).

It was possible that the average cacao-farm in the Gold Coast was too small. It would almost certainly be too small in the near future to satisfy the growing personal desires of the farmer and, in addition, provide him with a surplus for agricultural improvements. In addition, public needs were growing and more and more revenue was becoming necessary. An increase in the average area of cacao-farms, intensification of work and increased crop per acre, or a change to some other crop would probably become necessary, and in his choice the farmer could be influenced by the advice and action of Government.

We needed reliable figures. Figures of areas, of costings, of prices, of taxation, of yields. In other words, Departments should arrange for continuous and thorough study of the economics of peasant agriculture, and should compare the results with those normally occurring in a country of large plantations. We wanted to know whether a financially stable agricultural peasant-state could be built up in the tropics, and if so, how it could be built up. The question was not an easy one, and it had not yet been answered even in the case of advanced European countries.

This Conference could direct the attention of Governments to the importance of such studies. The Departments of Agriculture represented should arrange to carry out continuous investigations into local agricultural economics and to compare results with those of other countries. Such study should include a comparison of local figures of areas, costings, yields, and prices of major crops with those of other countries and investigations into the connection between these factors and the economic stability of the countries concerned.

Mr. Faulkner (Nigeria) said that the whole question was intimately connected with the price of food. In Nigeria, a man earning £2 per month was well off. It was important to discover how much food was grown locally and how much was imported. If the price of cacao decreased, so would the price of food. Plantations depended on imported food to a very much larger extent than did the native farmer who grew his own food.

Mr. Sampson agreed with *Mr. Faulkner*. He wanted to know if there were sufficient available cacao land to increase the size of the farms. He saw few food crops growing when travelling from Accra to Kumasi by train. He wished to point out that a cacao farmer did not have to work hard for his income of £20 per annum. This fact and the question of food crops must be taken into consideration when making investigations.

Dr. Martin (Sierra Leone) said that in Sierra Leone the ginger crop was regarded as the money-making part of farming and the food crops were grown to provide for the farmer's more general needs. If the price of ginger went down the farmer still had their food crops and did not suffer as a result. The same thing probably occurred in the Gold Coast with cacao.

Mr. Findlay (Nigeria) said that farmers were not dependent on cacao, as this crop was only used to supplement their income. If the farmer wanted money he would harvest his cacao, food crops being considered as ordinary revenue. In Nigeria, cacao was a supplementary crop. From observations made in the train from Accra he considered the standard of food crops lower in the Gold Coast than in Nigeria, as the majority of crops for sale were plantains and cocoyams which were produced by a poorer type of farmer than the one who farmed yams.

The Chairman pointed out that a great effort had been put into the cacao industry the last fifteen years which had put a great draft on the farmer. Food crops in the Gold Coast were certainly of a poor standard.

Mr. Stockdale asked if the plants were planted originally for the purpose of growing food crops or for cacao. In Sumatra the farmers made farms for growing food crops first and afterwards planted rubber.

Mr. Nicholas (Gold Coast) said that normally the farmer planted food crops first and the cacao was planted after the first crop had been taken off.

Mr. G. C. Coull (Gold Coast) agreed with *Mr. Nicholas*. He pointed out that clerks, lorry drivers, etc., also had cacao farms to supplement their ordinary income. He was of the opinion that cacao was being grown at the expense of food crops. The area of land surrounding most of the larger towns had been planted up with cacao with the result that the food crop farmer had to move away from the towns to find land on which to grow his produce.

Mr. Stockdale wished to know if the smallness of the farms was due to the land having been split up when the land was inherited. In the East, people often owned only fractions of an acre of land, as each farm was divided amongst the sons on the death of the owner.

The Chairman said that he did not think inheritance was a big factor in this country. Population was far less dense than in the East.

Mr. G. C. Coull (Gold Coast) said that the land on which the farms were situated was purchased. Each village had its "Stool-land" and any male could farm the land in that area. On the death of the owner the land reverted to the "Stool."

Mr. Mackie (Nigeria) said that it was very important to get to know the farmers round the Agricultural Stations, as this was by far the best way to gain information. It was not possible to get much out of the farmer by walking round the country without actually knowing the farmer personally.

Mr. R. Coull (Gold Coast) said that since he had been in Tamale he had found out with surprise how much the farmers knew about agriculture, and many of them had names for soil types.

Mr. Stockdale said that if the cacao farmer was replacing the food-crop farmer it might be necessary to start a food-crop industry with the specific purpose of feeding the cacao farmers and the urban population. If the production of cacao tended to decrease it would be necessary to find a high-yielding type of cacao, and also rejuvenate plantations by planting new trees to replace old worn-out ones. He had noticed a lot of poor cacao farms on either side of the railway line from Accra. The distribution of a high-yielding strains of cacao should be considered. If land available for new planting was getting scarce, then it would be necessary to increase the yield to keep up production.

The Chairman said that there was plenty of land left in the country which could be used for planting cacao. There was a big acreage of good land in the Western Province of the Colony, and farmers were slowly moving in this direction from the Central Province.

Mr. Nicholas (Gold Coast) said that areas of bad cacao were always to be observed along the railway and roads and this was due to thrips and *Sahlbergella* which always attacked cacao in exposed areas.

Mr. Stockdale said that he had also noticed a number of very good cacao farms beside the railway, and he considered that the good and bad areas might be due to varying soils conditions.

The Chairman said that some farms had been treated during the Plant Diseases and Pests Campaign and many of these were in better condition than those which had not been treated.

Mr. Parkes (Gold Coast) mentioned that during the Plant Diseases and Pests Campaign he noticed that while many of the farms had benefited by work done on them, others had been too poor to gain any benefit thereby.

The Chairman said that the discussions had been very interesting to all officers, but as time was limited he would like to leave the subject and discuss the question of forecasting the cacao crop.

VIII.—FORECASTING THE CACAO CROP.

Mr. Waters (Gold Coast) said that the paper "Forecasting the cacao crop" (Paper XIII, Bull. 20, Dep. Agr., Gold Coast) gave an account of the work done on this subject by members of the Gold Coast Department of Agriculture. This work might be regarded solely as a means of improving forecasts, but he wished to stress its value and usefulness more from the point of view of its providing new knowledge concerning the cacao tree. The forecaster wished to know the reason for any variation in yield or in production, in order that he might make use of this knowledge in future predictions, and had to consider every possible factor affecting production. This study therefore stimulated the worker to endeavour to find out more about the cacao tree and about the cacao industry. An example was the study of the correlation of the yield with rainfall. New information of this description was, he thought, likely to be of value not only for the issue of forecasts but also for the larger project of preserving and improving the cacao industry.

The paper fell into two parts. The first was concerned with the area under cacao in the Gold Coast; an estimate of this area was being made by means of surveys and by figures for rail and lorry shipments. The second part referred to the yield per acre, and under this heading could be mentioned particularly the decline in the yield of a cacao tree after its tenth year. The maximum yield was usually obtained when the tree was between eight and ten years of age, after which the yield declined for a few years and then reached a fairly constant level of annual production. Some of the fields at the Aburi Botanic Gardens had given very large yields for twenty years, but this was regarded as exceptional.

In the Gold Coast therefore large areas of young cacao were giving higher yields each year and large areas of old cacao were giving lower yields each year. There were areas which were being planted and areas which, due to unsuitable conditions, were going out of bearing. The forecaster had to appraise the relative effect of each of these; at present their combined effect still showed a tendency for production and export to increase.

With regard to the publication of the official forecasts there was no doubt that merchants appreciated and also put some reliance in them. He was of the opinion that forecasts were a great help to various branches of the community—railways, banks, merchants, etc. Government also could put early information as to crop prospects to good use, as apart from the direct return from

the crop—the export duty on cacao was then £1 3s. 4d. per ton—there was the indirect effect on the revenue from import duties. Government forecasts, being unbiassed and unprejudiced, helped to stabilise the price of cacao by reducing the number and effect of scares which arose from time to time as to the condition of the cacao crop. If Government gave regular and reliable estimates of the amount of cacao available, these scares would not have so great an effect on the market.

Mr. Faulkner (Nigeria) said that it required many years of careful work to arrive at definite figures of the yield of cacao in the various districts of the country. He was doubtful if it was worth the time and expense of forecasting the country's production of cacao if the variation from year to year was only slight. To do this accurately involved large expense. He was not prepared to do this in Nigeria unless this could be done thoroughly, and he did not consider the expense was justified.

The Chairman said that if forecasting was attempted it must be done accurately, otherwise damage would be done to the country. As far as this country was concerned, betting on the year's production of cacao in the country must be attempted. Fluctuations in market-prices were sometimes great, and this was due to lack of official forecasts. He would like to ask *Mr. Waters* if he really considered that forecasts were necessary.

Mr. Waters (Gold Coast) thought that the effort made by the Gold Coast Department of Agriculture to improve cacao forecasts was a good thing at the present time, but he regarded the work more from the point of view of its value to the Department than from the point of view of the value of the forecasts themselves. With regard to the point, raised by *Mr. Faulkner*, that it was not worth while trying to forecast year to year variations, as these variations were comparatively slight, he thought that a slight variation in the production of cacao made a big difference in the price. Slight over-production in the world's market usually made the price considerably lower.

Mr. Faulkner (Nigeria) remarked that merchants had rather inexact notions with regard to the increase in production of cacao. They imagined that production might increase as much as 25 per cent. in one year, whereas it was a very gradual rise, as it was in the Gold Coast.

Mr. Findlay (Nigeria) said that forecasts were popular with merchants as they saved them (the merchants) from having to make their own reports to their London Office. Forecasts were of real value if they were really reliable and the public appreciated this fact. Certain sections in cacao reports were often magnified and the information abused. He did not recommend the use of forecasts unless they were of real value to the public and the Government.

Mr. Lewin (Nigeria) said that the production of cacao in the Gold Coast and Nigeria had gone on very smoothly, following the lines of a curve. By extending this curve it appeared to be a reasonable deduction that the production of cacao in the Gold Coast would not exceed 240,000 tons.

The Chairman said that as the subject of forecasting had been fully discussed, he would like to ask *Dr. Martin* if he had any points to raise in connection with his paper on Oil Palms in Sierra Leone. (Paper XVIII, Bull. 20, Dep. Agr., Gold Coast.)

IX.—WEST AFRICAN OIL PALM INDUSTRY.

Dr. Martin (Sierra Leone) said that the oil palms in the Gold Coast contained a smaller percentage of oil than those in Nigeria, and that those in Sierra Leone contained a smaller percentage still. The type of fruit in Sierra Leone was also poorer than that of Nigeria and the Gold Coast, and the palms were more scattered than those of Southern Nigeria. The industry in Sierra Leone was simply a kernel one, no oil being extracted from the pericarp. He was uncertain whether it was better to improve the local variety of oil palm by selection or by importing new varieties from other countries. To increase the revenue it was necessary to increase the output of kernels. This could be done either by giving the natives some incentive to increase their product or by the introduction of machinery to save labour. Some good was being done by increasing transport facilities. The palms were not cultivated, the fruits being picked up in the forest. In times of taxation, or when their house rent came due, the natives went into the forest and picked up the nuts which lay rotting under the trees.

The Chairman thought that few people realised that the industry in Sierra Leone was only a kernel one and not like that of Nigeria, which was the most important industry in the country. In the Gold Coast the oil palm belt extended close to the coastal line where cacao did not do well. It was not a very important industry in the Gold Coast, the main idea being to harvest the nuts and obtain oil from the pericarp.

Mr. Sampson asked *Dr. Martin* if it were essential to have uniformity of nuts in Sierra Leone, and could he give any information on nut-cracking machines.

Dr. Martin (Sierra Leone) said uniformity of nuts was not essential as without this they still had definite value. The best nut-cracking machine he had found was the Knox, but this was not strong enough to stand up to the rough treatment by the natives. When this machine was working it did its work well, only a few nuts remaining unbroken which did not greatly matter. Only the chiefs had enough money to buy these machines and when that happened the people would not make use of the machines.

Mr. Faulkner (Nigeria) said that he had not found any machine which was really efficient owing to lack of uniformity of the nuts. A large number of nuts remained unbroken and these had to be taken out and broken by hand.

Mr. Stockdale suggested that Government might help the farmer by giving him facilities to buy the machine on the hire-purchase system, to which *Mr. Faulkner* remarked that he hoped to do something in this matter shortly.

X.—THE OIL PALM AT CALABAR.

Mr. Lewin (Nigeria) drew attention to certain important points in the paper tabled by *Mr. Smith*. (Paper XVI, Bull. 20, Dep. Agr., Gold Coast.) He said that the paper was unique in that it gave for the first time a definition of the thin-shelled type which apparently had genetic significance and also that it contained suggestions, tentative, it was true, as to the mode of inheritance of certain important fruit characters. The thin-shelled type when self-fertilised would always produce thin-shelled progeny if *Mr. Smith's* hypothesis was correct. There was no direct evidence as to whether the mantled and green-fruited characters were dominant or recessive, but the comparative rarity of the types suggested the latter. The Calabar records showed that yields equalling those reported from Sumatra should be obtained from plantations situated in the typical oil palm belts of Southern Nigeria.

In breeding-work the question would arise as to which was the most profitable type. He had hoped to produce figures which would indicate the type which seemed most promising in Southern Nigeria, but was unable to do so at this stage. It seemed likely, however, that the most paying type for Nigeria would not necessarily be the best for the Gold Coast and particularly for Sierra Leone. The Conference had been told that there appeared to be a progressive decrease from East to West in the oil content of indigenous palms in the West African Colonies and it seemed to him likely that climate was the limiting factor in oil production in the more Western Colonies. If this were the case Sierra Leone should concentrate on selection within the thick-shelled type for high kernel yield.

He was struck by the very high proportion of low-yielding palms in the Calabar plots. It was hoped that these might be eliminated to some extent by breeding, but time would show whether or not this hope would be fulfilled. In the meantime, in the establishment of plantations and in the thinning of the oil-palm groves, a means of detecting low yielders at an early age would be of the greater value. They could not afford to wait for twelve or fifteen years before cutting out an unsatisfactory tree, yet

at present they could be by no means certain that a palm was definitely a low yielder until some such time had elapsed. He suggested that a study of sex-ratios of individual palms might be of value in this respect, and also that attempts should be made to correlate yield with some vegetative character.

Finally, he did not wish it to be thought that he considered that oil palm breeding was the prop which would support the West African Industry against Eastern competition. The economical utilisation of the vast existing resources in Sierra Leone was of far greater importance. In Nigeria the invention of a cheap and satisfactory hand-press would do far more for the industry than the isolation of the finest strain of oil palm in the world.

Mr. Stockdale raised the question of the poor type of oil palm in Sierra Leone. There were also poor types as well as exceedingly good types in Nigeria. Would not the introduction of good types from Nigeria to Sierra Leone be successful?

Mr. Lewin (Nigeria) doubted if the introduction of, say, the Deli type would be successful in Sierra Leone, especially with regard to the progeny. Later, *Mr. Lewin* said that it was quite possible that the better types would be successful for the original plantation, but it was more than likely that the progeny would deteriorate.

Mr. Faulkner (Nigeria) thought that the difference in types was chiefly a question of climate, and particularly of rainfall. On the other hand, it seemed that the introduction of Calabar types to Benin would prove successful. This suggested that there were therefore two factors—variety and climate.

Dr. Martin (Sierra Leone) said that the climate in Sierra Leone was similar to that found in part of Southern Nigeria. He thought that the better types found in Southern Nigeria would also do well in Sierra Leone, and already there was some support for this belief.

The Chairman thought that it was probably not a climatic question, as the climate was wet in Calabar, dry in the Gold Coast, and wet in Sierra Leone. Oil-palms thrive in all three countries, but their quality did not vary directly with rainfall.

XI.—PALM OIL FACTORIES.

The Chairman then explained the Gold Coast Oil-Palm Subsidy Scheme. He outlined its history and stated that the final scheme was a compromise between schemes formulated by the Niger Company and by the Gold Coast Department of Agriculture.

The question of the position of the existing Oil Palm Plantation and Factory at Butre was then raised, and the working of this project was explained by the Chairman and *Mr. G. C. Coull*. It was pointed out that delegates would have an opportunity of visiting Butre during their visit to Sekondi.

Mr. Faulkner (Nigeria) then explained the scheme of working of two companies which for some years had been running factories in Nigeria, and asked that the matter should be treated as confidential.

Mr. Stockdale said that it was a matter of general experience that with a factory it was essential to have a limited area under the company's own control, in order to stabilise both prices and the quality of the product.

The Chairman said that, as in Nigeria so in the Gold Coast, there had been difficulty in leasing land for plantation purposes already with regard to the sisal plantation, and there probably would be further difficulty in connection with Messrs. Rose's Lime Juice Factory.

Mr. Faulkner (Nigeria) said that the factories experienced the greatest difficulty in competing with the prices which a native farmer could obtain locally for his own extracted oil and kernels.

Mr. Stockdale considered that the probable course of events would be for some means to be found for an increased local consumption.

The Chairman pointed out that the only year the Butre Plantation proved really successful was when the oil was sold locally in the Gold Coast, being transported even as far as to Kumasi.

Mr. Sampson raised the question of the oil palm farmers also owning cacao. Another difficulty was that child and woman labour is used in local production, but cannot be used on a plantation scale.

The question of establishing the proposed oil palm factory at Bissa was raised, and *Mr. G. C. Coull* (Gold Coast) explained that the chief difficulty would probably be that it would work in direct competition with the local cacao industry.

XII.—CO-OPERATIVE SOCIETIES.

The Chairman briefly opened the discussion.

Mr. Faulkner (Nigeria) said that Co-operative Societies, similar to those on the Gold Coast, were not needed in Nigeria at present, and this would hold until such time as the farmer changed his system of farming or preparation of products. Meanwhile,

Nigeria was interested in the Gold Coast scheme and eager to obtain information on the subject against the time when Co-operative Societies would be needed there.

The Chairman said that there was not such an urgent need for Co-operative Societies here as there was in India, for instance. The scheme was originated following an outcry from a group of rather influential people—lawyers, etc.—complaining of the cacao farmers' financial straits. There was also general dissatisfaction regarding the difference in price between what the farmer received and the merchant received. In order to alleviate matters, among other things a new Land Bank was proposed. Then Government met the merchants and they agreed to give advanced prices for better quality produce, and this formed the principle on which the Gold Coast Societies worked.

Mr. Findlay (Nigeria), referring to the credit side of these societies, understood that advances could be made on cacao brought into store. He asked if advances could be made on a standing crop, as in Nigeria there was a demand for advances for labour.

The Chairman said that such was the intention in the Gold Coast when the societies were functioning fully.

Mr. G. C. Coull (Gold Coast) explained the present brokers' system of buying cacao, whereby brokers advance say 5s. on every load of cacao promised. Frequently this was all that the farmer got. This was the chief thing that Co-operative Societies would defeat. He said that the ideal visualised certainly was to have enough capital to advance on the standing crop as well as to pay out immediately when the cacao came in.

The Chairman gave figures showing the successful working of the Atsamanso Society last season.

Mr. Mackie (Nigeria) mentioned that the premium for quality was much higher in Nigeria.

The Chairman said that this was probably due to the much lower standard of the ordinary exported cacao in Nigeria.

Mr. Stockdale said that it appeared obvious that the lines on which to work were to keep the numbers of members in each society low, and then to finance them entirely. But to do this the members must be strictly loyal: Co-operative Societies at home had failed time and again through disloyalty. He explained the Credit Sheet System of working of societies in Ceylon, whereby each member had a credit sheet made up, which included, as nearly as could possibly be arrived at, all his assets of whatever nature. The society was then empowered to advance him money up to one-eighth of the amount shown on his credit sheet. This Credit Sheet System appeared to be working very well, and they had

found very little trouble indeed in ascertaining members' assets. Referring to other aspects of the Ceylon Societies, he said that some societies had gone three years before being registered, because they appeared to be not fully educated up to co-operation ideals, and from among them had sprung many of the best societies in Ceylon.

Mr. Mackie (Nigeria) suggested that these societies might be induced to pledge themselves to grow a certain amount of food-stuffs and so tide themselves over the break between the main seasons.

The Chairman said that this was approaching something which he would greatly regret to see, viz., dual-purpose societies.

Before the meeting was adjourned *Mr. Stockdale* thanked those of the members of the Conference at Kumasi who had contributed to the success of the Conference and comfort of the visitors.

At Sekondi.

The Chair was taken by the Honourable, the Director of Agriculture, Gold Coast, *Mr. G. G. Auchinleck*, who opened the session by welcoming the Honourable, the Provincial Commissioner for the Western Province of the Colony, *Mr. H. E. G. Bartlett*, to the Conference.

The Commissioner, Western Province, thanked the Chairman for inviting him to the meeting and welcomed the visiting delegates, especially those from the United Kingdom. He stressed the value of the social side of such Conferences and the value of getting to know each other personally.

He said that the Western Province of the Colony was rich in possibilities for agricultural development. He hoped that when the delegates left they would have pleasant memories of the Province, and he was sure their work would be of great benefit to all the Colonies concerned.

XIII.—INSPECTION AND CERTIFICATION OF PRODUCE.

(See Papers X, XI and XII, Bull. 20, Dep. Agr., Gold Coast.)

The Chairman, in opening the discussion on this subject, explained that in 1927 a bill for compulsory Inspection of Produce for the Gold Coast was drawn up but was withdrawn later in the same year on account of opposition from the merchants and chiefs. In place of this, a system of voluntary inspection was started and during the last year all shipments were examined and reported

upon. Much information had been gathered as to the causes of various defects, and these results had been published, principally in the 1928 Year Book. The work was now proceeding smoothly and the reports served as bases for various financial transactions, for instance: (a) Advances from Banks; (b) Forward Contracts for American Shipments; (c) Insurance of Consignments. In fact, the work had proceeded so well that it was hoped that compulsory measures would not be needed.

Although the standards for the American market had been raised, that for the European market had not altered, and there had been no marked improvement in the quality of the cacao exported during the two years of voluntary inspection.

Compulsory certification in the Gold Coast would be faced with two main difficulties: (1) If it were carried out at the ports there might be delay in shipment and consequently it would be opposed; (2) if it were carried out up-country a large staff would be required, entailing great expense. A third method would be by the institution of co-operative societies pledged to produce cacao of a high standard. The opinion of delegates from Colonies using compulsory inspection was requested on this point.

He drew the attention of the Conference to the report of the Committee on the Inspection and Certification of Export Produce, and asked the meeting to consider its findings. He regretted that the Gold Coast was the only Colony represented on this Committee.

Mr. Stockdale requested further information from the delegates from Sierra Leone and Nigeria regarding prosecutions under Produce Inspection Ordinances. He said that he himself was loth to use prosecution, and preferred educative methods, and asked if the latter had preceded compulsion.

Dr. Martin (Sierra Leone) replied that propaganda had preceded compulsory inspection and that the native producers themselves were not prosecuted. The merchants knew that if they bought inferior produce they must clean it before it could be exported. Inspection was confined to materials prepared for shipment, therefore the merchants were given sufficient opportunity to clean the kernels. For five or six months each year river transport was not possible, therefore the merchant kept his kernels in a main store for some time. The produce was inspected before it entered this store and again before shipment.

Mr. Findlay (Nigeria) stated that the regulations applied equally to the exporter, middleman or producer, but the last named was seldom prosecuted. In practice the system had been quite successful, for the producers had raised their standard. Most prosecutions had been directed against the middleman, on account

of deliberate attempt to evade the regulations. Proceedings were seldom taken against the exporter and then only in cases of gross carelessness. Ample warning was given to all before the regulations were brought into operation, also no proceedings were taken for some time afterwards.

Mr. Stockdale enquired as to the number of prosecutions each year.

Mr. Faulkner (Nigeria) explained that in Nigeria there were about twelve each month and fines ranging from 5s. to £10.

Dr. Martin (Sierra Leone) stated that in Sierra Leone there were about eighty per annum, and that the fines were more severe.

Mr. Pirie (Gambia) said that in the Gambia, all the onus was on the buyer, but the producer was showing so much ingenuity in adulteration that it was probable that the regulations might be extended to include him. The chief adulterant in groundnuts was sand, but as a result of legislation the average of impurities had dropped from 15 per cent. to 2 per cent.

Mr. Faulkner (Nigeria) stated that, in Nigeria, when defects were discovered, both the middleman and the merchant concerned were liable to prosecution, but the onus usually was taken by the former since he escaped with a small fine. The three main types of defects to be considered were :—(a) The presence of an excessive percentage of shell in palm kernels; (b) Dampness in cacao beans (if wet beans were transported they were spoiled even if dried subsequently), hence it was an offence to carry wet beans except from farm to house; (c) Deliberate adulteration of palm oil with potash and the wetting of kernels.

Mr. Stockdale asked how the farmer was made to realise the necessity of a high standard of produce.

Mr. Faulkner (Nigeria) replied that the middleman was made to realise that it was not in his interest to buy inferior produce.

Dr. Martin (Sierra Leone) explained that the prosecution of natives was often difficult since they were usually illiterates and did not understand the law; moreover, they were poor and lived in remote places, whereas the middleman could understand the regulations and could bring pressure to bear by giving lower prices for low grade produce.

Mr. Stockdale asked whether this did not give too much power to the middleman.

Dr. Martin (Sierra Leone) replied that this was not so owing to keen competition between the buyers.

The Chairman asked whether there had been any opposition to the Ordinance, and *Dr. Martin* (Sierra Leone) stated their experience had been to the contrary, the merchants having asked for an extension of up-country certification.

The Chairman stated that there was general opposition to the compulsory certification in the Gold Coast, but that during last year the Keta Chamber of Commerce had asked for certification of copra, offering to pay 2s. 6d. per ton for this service. This request could not be granted on account of previous opposition to compulsory certification, although it would have been comparatively easy to establish a scheme for copra as this industry was a small one compared with cacao.

Mr. Faulkner (Nigeria) remarked that in Nigeria there were many grades of middlemen and in some places they were also producers, therefore the regulations were framed to include both middleman and producer.

Mr. Findlay (Nigeria) explained that if the produce offered for sale was not up to standard, the producer was not immediately prosecuted, but was instructed how to clean or dry his produce, and was warned against repetition of his offence. Therefore it was only in flagrant cases of adulteration that summary action was taken. It seemed to him that the opposition in the Gold Coast was due principally to the merchants who feared that Government would exercise too much control over trade. In view of the fact that the cacao areas in this country were concentrated, the organisation of inspection should be comparatively easy, and with so large an export a small cess should provide sufficient revenue to cover the cost of inspection.

The Chairman stated that *Mr. Findlay* was correct with regard to the merchants' opposition on the ground of interference. Two years ago there was little knowledge of the causes of defective cacao, and at that time merchants feared that legislation would be ill-advised. Recent investigations had provided information on these points, so that now opposition was due to two main causes, the undue Government control, and to political matters. Inspections initiated by Chiefs' Councils had proved quite inefficient owing to the low grade of cacao which was approved. He then drew the attention of the Conference to the graphs in *Mr. Culham's* paper*, which showed that no marked improvement in quality of cacao exported had taken place since the initiation of the voluntary inspection scheme.

Mr. Faulkner (Nigeria) said that in Nigeria there were Advisory Committees which included representatives of the

* This paper, at the request of the Accra Chamber of Commerce, was not published.

merchants and these committees framed inspection regulations. Such committees were most useful in that they inspired confidence, and complaints were submitted to them and not to the Government.

The Chairman stated that after the withdrawal of the ordinance for compulsory inspection of produce a Cacao Advisory Committee was formed in the Gold Coast. This committee was not a success and rejected several proposals, including Port Inspection and Co-operative Societies. It sanctioned investigational work at three centres for six months, but would not permit the publication of any figures. He suggested that haste in presenting the scheme was the cause of the opposition encountered. He again asked the Conference to explore the possibilities of a co-operative system.

Mr. Findlay (Nigeria) stated that he could see no reason why Gold Coast cacao should not deteriorate, since the merchants paid a flat rate for all qualities; consequently, the producer had no incentive to prepare higher grade cacao.

The Chairman replied that this argument had already been brought forward by producers, but, in fact, existing Co-operative Societies had cut out the intermediate charges between the producer and the merchant, and in some cases produce had obtained a premium for high quality.

Mr. Faulkner (Nigeria) asked whether it was probable that the present small percentage of producers, who obtain a higher price for their cacao, would increase.

The Chairman replied that this was already evident and hoped that in time all the produce would be marketed through Co-operative Societies. In reply to Mr. Faulkner's question as to the personnel required for such a scheme, the Chairman said that his estimate was 29 officers (5 accountants and 24 superintendents, each of the latter to be in charge of ten secondaries); a secondary would consist of ten primaries each producing approximately 400 tons of cacao. Mention of secondaries had not been made in the Co-operative Society Ordinance on account of the opposition which this idea might provoke.

Mr. Sampson suggested that, as the movement grew, the premium for cacao produced by the societies would become less, hence there would be less inducement for others to join, and perhaps the scheme would kill itself.

The Chairman said that the centralisation of 240,000 tons of cacao would facilitate the buying operations of the merchants to such an extent as to make them desirous of retaining the system. He requested Captain Wingate to express his opinion on the subject of Inspection.

Captain Wingate (Gold Coast) said that the voluntary system had been working for two years at great expense, chiefly for the benefit of the merchant, and the time had come for compulsory certification to be introduced, preferably at up-country centres, where it would cause less disorganisation of cacao traffic than at the Ports.

Further discussions on the Inspection and Certification of Produce took place in General Sessions when the report of the Committee on this subject was considered. An account of these discussions will be found in this volume as addenda to the minutes of the Committee (Section XXXII).

XIV.—REPORT AND FINDINGS OF ADMINISTRATIVE COMMITTEE.

The resolutions or findings of the Administrative Committee were next considered.

The proposal for a Professional Association of Agricultural Workers was fully discussed. An account of this discussion will be found under this heading in Section XXVI in this volume, and the resolution, made by the Conference, is recorded as FINDING No. 1.

Recommendations for the readjustment of salary scale for officers of Departments of Agriculture were also discussed and slight amendments suggested and accepted. See FINDING No. 3.

The remaining recommendations of the Administrative Committee were not discussed. See Sections XVIII and XXVI in this volume.

A resolution on the subject of Senior Posts in the Departments of Agriculture in the Gold Coast, Sierra Leone and Gambia, was put forward and passed by the Conference. See FINDING No. 4.

XV.—REPORTS AND FINDINGS OF COMMITTEES.

The resolutions or findings of the Committees were then submitted *serialim* to the Conference. Each finding was read out and discussed, and was either accepted, amended or rejected. The recommendations of the Conference in regard to these findings, together with an account of major discussions that took place in General Sessions at Sekondi, are reported in this volume as addenda to the minutes of the "REPORTS OF COMMITTEES." In addition, the findings passed by the Conference have, for convenience of reference, been extracted and printed separately under the heading of "CONFERENCE FINDINGS."

The statement below is a list of these Committees supplemented by references to the relevant pages herein :—

Committee.	Proceedings of Committee and consideration of its findings in General Sessions.		Findings adopted by the Conference.	
	Section.	Page.	Section.	Page.
Economic Botany	XXVII.	54	XIX.	30
Agricultural Chemistry	XXVIII.	60	XX.	34
Agricultural Economics	XXIX.	63	XXI.	35
Agricultural Entomology	XXX.	64	XXII.	36
Meteorology	XXXI.	68	XXIII.	41
Produce Inspection and Certification	XXXII.	75	XXIV.	42
Statistics	XXXIII.	89	XXV.	43

XVI.—INVITATION TO SIERRA LEONE FOR 1931.

On behalf of the Government of Sierra Leone, *Dr. Martin* extended a cordial invitation to the other West African Colonies to send delegates to the next West African Agricultural Conference, to be held in Sierra Leone in 1931. He regretted that the number of visiting delegates would have to be limited to ten or twelve: he presumed that October would be a suitable month.

The Chairman on behalf of the Conference thanked the Sierra Leone Government for the invitation, which he accepted. The general feeling of the Conference was that the best time would be either March or October, preferably the latter.

XVII.—ADJOURNMENT.

Mr. Stockdale on behalf of the visitors thanked the Gold Coast Department of Agriculture for all the arrangements that had been made for their reception and comfort. The preliminary work had enabled the Conference to deal effectively with a large volume of business, and the visiting delegates were under a great obligation to the Department of Agriculture for the trouble that had been taken on their behalf.

The Chairman thanked the visitors for what had been said. The preliminary spade work had been of as much benefit to the Gold Coast Department as it had been to the visiting delegates, and the visits of *Mr. Stockdale*, *Mr. Sampson* and of the teams from other Colonies had done immense good to the Gold Coast.

He declared the Conference adjourned *sine die*.

PART B.

CONFERENCE FINDINGS.

The resolutions or findings given under this heading are those which the Conference accepted or supported. All were drafted by the Committees (with the exception of Conference Finding No. 4) and were considered by the full Conference in General Sessions.

In the case of Committee Findings receiving amendment in General Sessions, the wording is recorded here in its final form.

The circumstances under which each finding was accepted may be found by reference in this volume to Part C., Reports of Committees, Sections XXVI to XXXIII, where will also be found the text of those Committee Findings which were not passed as Conference Findings.

XVIII.—GENERAL FINDINGS.

CONFERENCE FINDING No. 1.

PROFESSIONAL ASSOCIATION OF AGRICULTURAL WORKERS.

This Conference desires to place on record its opinion that the time has arrived for the formation of an Association within the Empire of professional workers in agriculture and allied sciences and suggests that steps be taken to ascertain the feasibility of the formation of such an Association with a view to having the matter placed on the agenda of the next Imperial Agricultural Conference to be held in Australia.

CONFERENCE FINDING No. 2.

OIL PALM INVESTIGATIONS.

The existing oil palm industries in the several West African Colonies are so variable and present so many local problems both of a botanical and economic nature that detailed local investigation is an essential preliminary for its ultimate improvement. Such investigations should lead to the development of the existing local oil palm industry and should also show whether local varieties or types fulfil its needs.

The Conference considers that in view of the existence of numerous heavy oil-bearing types in Southern Nigeria, that country offers the best scope for the development of such types and the trials being or to be made with these in other Colonies should form a part of the work of local departments.

CONFERENCE FINDING No. 3.

READJUSTMENT OF SALARY SCALE FOR OFFICERS IN DEPARTMENTS OF AGRICULTURE.

The resolution was made that :—

(a) A more uniform initial salary be established for all permanent officers of the senior staff of West African Departments of Agriculture.

(b) The three years waiting period on the time scale for agricultural officers be abolished in view of the fact that all officers are required to possess high academic qualifications in addition to practical experience, or in the case of specialists, special training, in addition to two years post-graduate work provided under the Scholarship Scheme.

(c) An initial salary of £510 in Scale C is considered to be the minimum which would enable West African Departments of Agriculture to secure, in competition with institutions in the United Kingdom, the type of officers required for their services.

(d) Officers in receipt of a salary of less than £510 should, if the proposed alteration in initial salaries is effected, be raised to that figure and should retain their departmental seniority.

(e) A Selection Grade for officers whose duties are specialised is needed for West African Departments of Agriculture and becomes an essential corollary to the unification of initial salaries proposed above. The numbers and salaries in this selection grade should be such as to balance the administrative grade posts which tend to be filled chiefly by agriculturists.

(f) Provision should be made where necessary for appointments by the Secretary of State to the service at any appropriate point in the salary scale, but such appointments should be limited to those cases where a greater degree of experience is demanded or is possessed by the candidates for appointment. Such higher initial salary should not necessarily carry seniority with it.

CONFERENCE FINDING No. 4.

SENIOR POSTS IN GOLD COAST, SIERRA LEONE AND GAMBIA.

The Conference realises that the scales of pay laid down for the West African Agricultural Service, when this was reorganised, met in a great measure the then situation as far as the long grade is concerned. It considers, however, that the time has arrived when the number of senior posts at higher scales of pay should be increased, not only to relieve the directors of some of their increasing duties, but to provide that contentment in the service which is essential to efficiency.

The Conference directs attention to the small number of posts senior to Scale C in the Gold Coast, Sierra Leone and Gambia. The number of posts is limited at present to 3 among some 70 trained officers, and this is considered to be inadequate for the needs of the Departments of Agriculture in the above Colonies and if not rectified will hamper recruitment of officers to them.

CONFERENCE FINDING No. 5.

CONFERENCES OF DIRECTORS OF AGRICULTURE.

(Administrative Committee's proposal):—

The Colonial Advisory Council of Agriculture and Animal Health should be asked (i) to arrange for the discussion of matters bearing upon agricultural development in the Colonies, and (ii) to consider whether some of them could be brought before the Colonial Agricultural Conference, which it was proposed to hold in Ceylon in 1932, or whether it would be preferable to arrange for special Conferences of Directors of Agriculture to deal with such matters.

CONFERENCE FINDING No. 6.

WITCHBROOM DISEASE OF CACAO.

(Administrative Committee's proposal):—

(a) Directors of Agriculture should take action at once to provide against the possible introduction of this disease into the British West African Colonies from the West Indies or from the South American Mainland.

(b) The Colonial Office should take up the matter with the French, Portuguese and Spanish Governments with a view to a similar action being taken in their West African Colonies.

CONFERENCE FINDING No. 7.

MEMORANDUM ENTITLED "SOIL SURVEY OF THOSE PARTS OF TROPICAL AFRICA ASSOCIATED WITH THE EMPIRE."

(Administrative Committee's proposal):—

(a) The suggestions contained therein are acceptable to, and workable by, West African Departments of Agriculture.

(b) It would be preferable for the Bureau of Soil Science to refer to work of the kind proposed in the memorandum as "Investigations of Soils," rather than as "Soil Surveys."

(c) With reference to paragraph 3 of the memorandum, it is considered that it is desirable for the Bureau to give some indication, as early as possible, as to the minimum determinations necessary to enable a suitable classification of the soils to be made.

(d) Finally, the Committee wishes to suggest that the Bureau takes steps to bring this matter up at the next International Soil Congress with a view to obtaining general uniformity in soil work in all parts of Tropical Africa.

CONFERENCE FINDING No. 8.

SECOND IMPERIAL AGRICULTURAL CONFERENCE—AUSTRALIA, 1932.

(Administrative Committee's proposal):—

The subjects for reference to the Imperial Conference should include:—

1. Formation at Kew of a Bureau of Economic Botany.

2. Organisation of plant quarantine services for the Tropical Colonies.

3. Extension of the scope of the Empire Marketing Board to include Marketing of Empire products:—

(a) In all countries within the Empire.

(b) In countries outside the Empire.

4. Consideration of the most effective methods of extension work of Departments of Agriculture amongst tropical peasantry.

See also CONFERENCE FINDINGS NOS. 1, 5, 27 and 54.

XIX.—ECONOMIC BOTANY.

CONFERENCE FINDING No. 9.

BREEDING HIGH-YIELDING TYPES OF CACAO.

(Botanical Committee's proposal):—

The problem in the Gold Coast is complicated by the fact that a large proportion of the land suitable for cacao is already

under this crop, and that more will be planted before a high-yielding strain is evolved. However, the work would be of value in supplying material both for new plantations and for the replacement of poor yielding trees on existing farms. The relationship of this problem to West African Colonies in general is discussed under CONFERENCE FINDING No. 17.

CONFERENCE FINDING No. 10.

COTTON STAINER.

The Conference recommends the adoption of the following measures (proposed by the Botanical Committee) in areas where the cotton stainer is a serious pest:—

- (a) The exclusion of American cotton.
- (b) The evasion of the period of maximum stainer infestation by the isolation of strains which produce the bulk of their crop late in the season.
- (c) The uprooting, if feasible, of all cotton plants at the beginning of April.

It considers that the problem is of such magnitude that considerable localised investigation work is necessary and that time of planting tests should be inaugurated in different areas.

The destruction of alternative food plants is considered wholly impracticable, and further, the opinion is expressed that attempts to breed unpalatable strains are unlikely to be profitable.

Staple Asiatic cottons might be given trials on a small scale: such introductions could be made with perfect safety provided that the usual measures of seed fumigation were observed.

CONFERENCE FINDING No. 11.

ASEXUAL PROPAGATION OF PERENNIAL CROPS.

The Committee discussed this question in relation to the following crops:—

- (a) Cacao;
- (b) Coffee;
- (c) Cola;

and made the following proposals which the Conference adopted.

(a) *Cacao*.—It was decided that asexual propagation of this crop is at present a matter of considerable importance especially in the Gold Coast.

The Gold Coast Agricultural Department is experimenting with the following methods of asexual propagation :—

1. Budding.
2. Grafting.
3. Cuttings.
4. Root-wiring.
5. Layering.
6. Marcotting.

It seems that budding on two-year old wood will be the method of the greatest practical importance.

It was considered that the anatomy and physiology of wound-response and the relationship of stock and scion should be investigated as it is probable that such investigation will solve the problem of vegetative propagation.

(b) *Coffee*.—The increasing importance of this crop in the Gold Coast indicates that it would be desirable to evolve methods for the propagation of high-yielding strains.

(c) *Cola*.—It is possible that the asexual reproduction of *Cola* will be studied in Nigeria in the near future.

It is suggested that the investigation of the first two problems should be undertaken in the Gold Coast where they are of considerable local importance.

CONFERENCE FINDING No. 12.

INTENSITY OF LIGHT IN PLANTATIONS.

The Conference is of the opinion that the methods of measuring light intensity, as described by R. A. Taylor and by W. R. G. Atkins and H. W. Poole, merit trial in cacao and oil palm plantations.

CONFERENCE FINDING No. 13.

SHEA.

The Committee considered the memorandum on this subject tabled by Mr. T. Lloyd Williams, and was of the opinion that no botanical work on this crop by local Departments of Agriculture is at present justified. The Conference approved of the finding.

CONFERENCE FINDING No. 14.

FOOD CROPS.

In the opinion of the Conference the collection and cultivation of local food crops should be undertaken by officers in charge of experiment stations. If, in the future, there arose the desirability for selection work on these crops, information on such varieties would thus be available.

CONFERENCE FINDING No. 15.

OIL PALM VARIETAL PLOTS.

The Oil Palm varietal plots (and particularly the newly established plantations in Sierra Leone) form valuable material for botanical investigation. The Conference is of the opinion that local strains raised by selection would be of more value to the Colony concerned.

CONFERENCE FINDING No. 16.

LOCAL GRASSES.

The Conference considers that the study of local grasses is at present justified only in connection with schemes for the encouragement of mixed farming. Co-ordination of effort is hardly feasible and individual action must be taken by the Colonies if and when the desirability of and opportunity for such work arises.

CONFERENCE FINDING No. 17.

CO-ORDINATION OF BOTANICAL EFFORT.

(Proposals of the Botanical Committee adopted by the Conference):—

The Committee has carefully considered the desirability of the concentration on specific problems by certain Departments. It is of the opinion that the Gold Coast should undertake investigations into the cacao problems of a botanical nature which are common to the Colonies, and, for reasons which follow, should be the centre for selection work on this crop. In return, oil palm investigations in which botanists are concerned should be mainly relegated to Nigeria and Sierra Leone.

1. *Cacao*.—While the Committee is opposed, on general grounds, to the complete segregation of selection work on a crop in any one Colony, it is felt that cacao presents an exceptional case for the following reasons:—

(a) The production and distribution of high-yielding strains even if possible is not a problem of crucial importance in West Africa.

(b) The environmental limits within which cacao will thrive at all are so narrow that it is felt that the distribution to other Colonies in West Africa of improved strains isolated in typical Gold Coast cacao areas would, at least, be more likely to be of value in this case than in that of crops with a wider range of distribution.

(c) Nigeria and Sierra Leone have no satisfactory plantations on which individual tree records have been maintained. From certain Gold Coast plantations such records extending over a period of fifteen years are available.

The Committee assumes that no emphasis is necessary as to the desirability of relegating to the Gold Coast other botanical problems of cacao.

2. *Oil Palm*.—While ideally each Colony should undertake its own investigation and selection work on this crop independently, it is felt that if the Gold Coast assumes the burden of cacao investigations it should be relieved, as far as possible, of oil palm work.

Selection work should form the main item in the Gold Coast botanical programme, for this crop and investigational work should be subservient to that on cacao.

In order that the Gold Coast may reap the maximum benefit from the results of investigations elsewhere, the Committee considers that overlapping of the botanical oil palm programmes of Nigeria and Sierra Leone is not only unwasteful but desirable, and it is confident that Nigeria and Sierra Leone should both prosecute selection work.

The Committee is definitely opposed to the suggestion for a central West African Station for Oil Palm research in whatever Colony such a station might be situated.

XX.—AGRICULTURAL CHEMISTRY.

CONFERENCE FINDING No. 18.

SOIL INVESTIGATIONS.

The Committee's proposal was adopted that the Circular on Soil Investigations recently issued by the Imperial Bureau of Soil Science be regarded as acceptable to Departments of Agriculture in West Africa and that results of analyses carried out locally be forwarded to the Bureau of Soil Science through the Directors of Agriculture.

CONFERENCE FINDING No. 19.

MECHANICAL ANALYSIS OF SOILS.

The Committee's proposals was adopted that the existing classification of soil particles in mechanical analysis be abandoned in favour of that approved by the International Soil Science Congress in Washington in 1927.

CONFERENCE FINDING No. 20.

SOIL MAPS.

The Committee's proposal was adopted that soil maps be constructed for all experimental stations and the districts around them where possible. It was thought that by this means a knowledge of soil types and their response to cultivation will be obtained and that this knowledge should prove extremely valuable to the departments generally.

CONFERENCE FINDING No. 21.

LATERITIC SOIL WORK IN SIERRA LEONE.

The Conference is of opinion that means should be explored by the Advisory Council of Agriculture and Animal Health whereby a continuation of the investigational work started in Sierra Leone into problems of lateritic soils should be ensured for the benefit of West African Colonies as a whole.

XXI.—AGRICULTURAL ECONOMICS.

CONFERENCE FINDING No. 22.

STUDY OF AGRICULTURAL ECONOMICS.

The Sub-Committee's opinion was accepted that there is a definite necessity for the study of Agricultural Economics in the West African Colonies.

CONFERENCE FINDING No. 23.

FACTORS AFFECTING AGRICULTURAL INDUSTRIES.

The Committee's proposal was adopted that the first step to be taken is the study of the factors affecting the development or decline of Agricultural Industries in the area under consideration. This would include the consideration of the relation of the local habits and customs and the communal or village system to agricultural operations.

CONFERENCE FINDING No. 24.

PEASANT FARMER.

The Committee's proposal was adopted that there is need for investigation into the economic position of the peasant farmer. This investigation would yield valuable data concerning the economic stability of the country. The present "test" Co-operative Societies in the Gold Coast afforded an excellent means of approach to this subject and should be continued.

CONFERENCE FINDING No. 25.

MARKETING AND FINANCING.

The Committee's opinion was accepted that the producer's present methods of marketing are unsatisfactory and that as no suitable organisations for financing the peasant farmer are available it would appear that there is definite need for the formulation of methods of meeting these difficulties. It was suggested that a system of Co-operative Societies was likely to afford a possible solution.

CONFERENCE FINDING No. 26.

LAND TENURE.

The Committee's proposal was adopted that the systems of land tenure should be kept in view during the course of economic investigations.

CONFERENCE FINDING No. 27.

SECOND IMPERIAL AGRICULTURAL CONFERENCE.

The Conference considers that the study of Agricultural Economics is of great importance, and that a discussion of it should form part of the proceedings of the Second Imperial Agricultural Conference.

XXII.—AGRICULTURAL ENTOMOLOGY.

CONFERENCE FINDING No. 28.

IMPERIAL ENTOMOLOGICAL CONFERENCES.

The Conference considers that each Colony should be represented at Imperial Entomological Conferences by Entomologists whenever possible.

CONFERENCE FINDING No. 29.

HANDBOOK ON LOCAL CROP PESTS.

The Committee's proposal was adopted that books on local crop pests were urgently needed, and that they should be restricted to economic plants and pests.

The books should include :—

- (a) Illustration of all major and minor pests.
- (b) Life-histories and habits.
- (c) Food plants.

(d) References, if any, to occurrence of same species and allied species in other countries.

(e) Controls, if any, and conditions favourable to increase.

CONFERENCE FINDING No. 30.

ARTIFICIAL DISTRIBUTION OF EUPHORUS.

The Committee's opinion was accepted that this work is necessary, but being at present in a purely experimental stage, should be undertaken in the Gold Coast, where the problem of *Sahlbergella* control is of major importance.

It was further decided that the preparation of plans and estimates for the above is a matter which requires early attention.

CONFERENCE FINDING No. 31.

SHELTER BELT TRIALS FOR SAHLBERGELLA CONTROL.

The Conference is of opinion that wind breaks are necessary in all cacao farms. The opinion was expressed that these windbreaks should take the form of hedges at least 30 feet high round individual farms, and in particular on farms whose edges have been exposed owing to food crop clearings; extension of existing cacao farms and the construction of roads, railways, etc.

Shelter belts around selected fields should be planted by the Departments of Agriculture to test their effects on this pest.

CONFERENCE FINDING No. 32.

MANURIAL AND CULTIVATION TRIALS FOR SAHLBERGELLA CONTROL.

(Proposals of the Entomological Committee adopted by the Conference):—

This Committee considers that experiments in manuring and cultivation are of value as a means of *Sahlbergella* control.

It has been found in other West African cacao producing countries that manuring is of value in throwing off *Sahlbergella* attack.

Work following Andrews' lines on control of tea *Helopeltis* in India has been commenced.

As *Sahlbergella* attack is most prevalent on alluvial soils, drainage is also an important factor.

This Committee recommends that in view of the importance of cacao in West Africa, definite information on the cultural requirements of this crop be made available.

CONFERENCE FINDING No. 33.

COTTON-STAINER CONTROL.

The subject of the control of the cotton-stainer in Togoland has been treated in full in Departmental Bulletin No. 12 (Gold Coast) and the Committee's proposal was adopted that the methods of control outlined therein should be investigated. *See also* CONFERENCE FINDING No. 10.

CONFERENCE FINDING No. 34.

FRUIT-PIERCING LEPIDOPTERA ON CITRUS.

(Proposals of the Entomological Committee adopted by the Conference):—

In view of the possibility of the establishment of a Citrus industry and the fact that fruit-piercing *Lepidoptera* constitute a serious limiting factor, it is necessary that facilities be provided for early investigation of these pests.

Primary study should be devoted to the food plants of the larvæ which are at present unknown. To enable this to be carried out, increased staff is essential in addition to the assistance of a botanist.

As most wild plants have native names which are known by the majority of Africans, a publication giving systematic and native names would be of immense assistance in studying this and other entomological problems. This publication should be regularly added to as further information becomes available.

CONFERENCE FINDING No. 35.

CONTROL OF COLA WEEVIL AND FLY.

(Proposals of the Entomological Committee adopted by the Conference):—

The chief source of infection is from fallen fruits which have previously been attacked by the Cola fruit fly.

Unopened fruits are never attacked.

Owing to the prolific egg-laying power of the weevil and short life-history, once a heap of nuts is infected, damage proceeds at an enormous rate.

Methods of control :—

A.—Alteration in methods of collection.

It has been found that weevil-attack very rarely occurs if, when pods are harvested, only the unbroken fruits are selected and removed from the neighbourhood before being broken.

In the Gold Coast the Cola tree grows wild, but its fruit is naturally the property of someone, there being no unowned land in the forest belt owing to the communal method of land tenure.

The practice is to sell the unharvested fruits to Hausa and Northern Territories merchants. The fruits are harvested by them. The fruits are then broken open under the actual tree and packed up for transit.

Almost complete control of the weevil could be obtained by removal of the fruits from the vicinity of the trees before breaking open.

B.—Control of the Cola Fruit Fly.

This would result in fewer fruits falling prematurely and therefore less weevil infestation on the ground. It is, however, impractical in this country to control the fly particularly in view of the fact that the actual number of fruits attacked is small.

C.—Control in Store.

(a) Storage in liquids—if a suitable liquid is found for storage this will obviate repeated sorting of loads and changing of packing materials.

(b) Fumigation of nuts has been experimented with. There is some indication that an effective treatment of this nature may be evolved.

(c) Proper and clean storage is essential.

D.—Natural Enemies.

(i) One parasite only has been obtained. There is no chance of expecting to increase its population.

(ii) The entomogenous fungus, *Beauveria*, commonly attacks the adult weevils, but it has been determined that oviposition is invariably completed before death. This method of control is therefore valueless.

CONFERENCE FINDING No. 36.

MOTH AND WEEVIL IN STORED CACAO.

The Conference is of opinion that the following are possible methods of control:—

(a) Infection occurs during drying, the most susceptible cacao being that which is semi-dried.

(b) Sound drying—in countries where artificial drying is resorted to, weevil and moth are not considered pests. The results of experimental work in the Gold Coast have shown that, when sun-drying is resorted to, the method of drying on concrete platforms is the best. (See table within Section XXX, Item 10).

(c) Sound storage in dry and well ventilated sheds with platforms raised above ground level.

(d) Fumigation at ports.

(e) Artificial drying.

CONFERENCE FINDING No. 37.

PLANT PESTS ORDINANCES.

The Committee's opinion was accepted that except for provision against the importation of specific insects no insect pest can be scheduled.

That if an Ordinance for the protection of standing cacao is considered necessary, it should be confined to cultural requirements.

In this connection the findings of the Mycological Conference were likely to be worth study.

CONFERENCE FINDING No. 38.

AFFINITIES OF LOCAL CROP PESTS.

The Committee's opinion was accepted that the classification of very closely related forms of insects is not entirely satisfactory, but that this subject is not suitable for discussion at the present Conference.

CONFERENCE FINDING No. 39.

ARTIFICIAL CONTROL OF INSECT PESTS.

It is recognised by this Conference that artificial methods of control of insect pests are in demand in Sierra Leone and the Gold Coast.

It is considered that where applications are received from farmers for artificial methods of control of insect pests, in general it is sound that payment shall be made by the farmers concerned for such treatment.

XXIII.—METEOROLOGY.**CONFERENCE FINDING No. 40.****METEOROLOGICAL STATIONS.**

The Committee's opinion was accepted that in each Colony one first class station, under a fully qualified officer of the Department of Agriculture, is necessary and that sufficient lower order stations should be in operation to ensure adequate services for agricultural purposes.

CONFERENCE FINDING No. 41.**INTERCHANGE OF RECORDS.**

The Committee's proposal was adopted advocating the regular interchange of detailed meteorological information between Governments of British and Foreign Colonies in West Africa in order that joint problems may be adequately studied for the benefit of agriculture in the countries concerned.

CONFERENCE FINDING No. 42.**CLIMATE FACTORS AND PRINCIPAL CROPS.**

The Committee's proposal was adopted that investigation into the major meteorological factors controlling the principal perennial crop in each Colony in West Africa is desirable.

CONFERENCE FINDING No. 43.**CROP FORECASTS.**

The Committee's opinion was accepted that exact meteorological data from a wide area are essential factors towards accurate crop forecasts.

CONFERENCE FINDING No. 44.**METEOROLOGY IN WEST AFRICA.**

(Proposals adopted by the Conference):—

(a) The collection and publication of meteorological records in West Africa should be the business of Agricultural Departments.

(b) Provision should be made for maintenance of accurate up-to-date records and reports should be telegraphed to the headquarters daily.

(c) The Colonies should agree upon standard methods of recording.

(d) Phenological relationships merit investigation in West Africa.

XXIV.—INSPECTION AND CERTIFICATION OF EXPORT PRODUCE.

CONFERENCE FINDING No. 45.

COMPULSORY INSPECTION.

This Conference, taking cognisance of the system already established in certain other West African Colonies, supports the resolution of the Sub-Committee (to the effect that a compulsory system of inspection is essential in order substantially to improve the quality of West Africa exported produce) but feels that in order to make a compulsory system of inspection successful, it is essential that provision be made for:—

- (a) Advisory Committees largely of nominated members.
- (b) Expenses to be met by a cess on exports.
- (c) Some up-country extension of compulsory inspection.

CONFERENCE FINDING No. 46.

MARKET STANDARDS; INSURANCE; ADVANCE CONTRACTS.

The Committee's opinion was accepted that the examination and certification or sealing of produce for export has definite relationship to (a) market standards; (b) insurance; and (c) advance contracts, and that this relationship was conducive to the improvement in quality of the produce and tends to facilitate market operations.

CONFERENCE FINDING No. 47.

MARKET STANDARDS OF CACAO.

The Conference considers that the market standards for West African cacao are lacking in uniformity and clarity of definition, and strongly advocates that in collaboration with manufacturers and merchants an attempt be made to secure clearer definition of grade.

CONFERENCE FINDING No. 48.

QUALITY GRADES FOR PRODUCE.

The Conference feels that a conference should be held in Nigeria attended by representatives of Inspectorates of each Colony having as its object the unification of produce quality grades in British West Africa.

CONFERENCE FINDING No. 49.

STORAGE INVESTIGATIONS.

Considering the importance of storage and the problems attached thereto, the Conference recommends that investigational work be carried out in the near future by all Departments of Agriculture concerned, and that there should be an interchange of all results from such investigations.

CONFERENCE FINDING No. 50.

GO-DOWN, RAIL AND SHIP STORAGE.

The Conference is of the opinion that considerable investigational work is necessary to raise the standard of go-down, rail and ship storage in the interest of West African produce.

CONFERENCE FINDING No. 51.

SAMPLING METHODS FOR PALM KERNELS.

In the absence of a generally accepted system the Gold Coast Department of Agriculture has adopted a certain form of sampling and analysis in order to bring about a substantial improvement in the quality of palm kernels. The Conference recommends that the question of standardisation of methods of sampling be investigated at the proposed Inspectorate meeting in Nigeria.

CONFERENCE FINDING No. 52.

COLA MARKETING.

(Proposals of Produce Inspection Committee adopted by the Conference):—

In view of conflicting evidence on the loss in heaping, marketing and transport, more information is required on the organisation, packing and grading of cola.

Before any system of grading can be devised, investigation is required on the period that elapses between the storage of fresh, good-conditioned nuts and the appearance of such defects as mould and weevil attack.

XXV.—STATISTICS.

CONFERENCE FINDING No. 53.

AGRICULTURAL STATISTICS.

The Conference is of opinion that Departments of Agriculture should have some organisation for the collection, analysis and presentation in a concise form of statistics vital to agriculture, such as total production and distribution of crops, yields, prices, etc.

CONFERENCE FINDING No. 54.

AERIAL SURVEYS.

The Conference considers that aerial surveys are at present impracticable locally, but the subject should be brought up at the Australian Conference in 1932, and also the question of an Imperial Fund for studying the value of aerial surveys for determining the areas under crops in the tropics.

CONFERENCE FINDING No. 55.

SAMPLING METHODS.

The Committee's proposals were adopted that data as to the applicability of sampling methods to local conditions are required, and the method of taking statistics on selected farms should be encouraged.

CONFERENCE FINDING No. 56.

PUBLICATION OF CACAO STATISTICS.

The Conference recommends that steps be taken to regularise cacao statistics, and the possibility be explored of the regular publication of cacao statistics in some English periodical.

CONFERENCE FINDING No. 57.

OXFORD ECONOMIC SURVEYS.

The usefulness of the Oxford survey methods as means of collecting statistics of peasant and crop economics is appreciated by the Conference.

It is understood that the collection of such statistics is one of the duties of an agricultural officer, and is carried out to some extent by the extension work of stations in Nigeria.

CONFERENCE FINDING No. 58.

WORLD AGRICULTURAL CENSUS.

The Conference supports the opinion of the Committee that apart from Blue Book information, little can be done, as estimates of acreage such as could be made would not be sufficiently reliable to merit their inclusion in the return.

PART C.

REPORTS OF COMMITTEES.

Under this heading will be found the reports of the Administrative Committee and of the Sub-Committees on Botany, Chemistry, Economics, Entomology, Inspection of Produce, and Statistics. It was found not to be possible to have Sub-Committees for Agricultural Education, Irrigation, Fruit Export and Mycology, as originally intended.

Each Committee dealt with the items on a prepared agenda-paper and in some cases added further items. Under each item will be found (i) any memorandum or paper on the subject submitted to the Committee, (ii) an account of any discussion in Committee, (iii) the Committee's findings on the subject, (iv) an account of any discussion in General Sessions, and (v) the findings of the Conference in regard to that item. Where the memorandum, paper or finding is printed elsewhere in the Conference Bulletins (i.e., Vols. I and II, Bull. Nos. 19 and 20, Dep. Agr., Gold Coast) a reference only is given.

XXVI.—ADMINISTRATIVE COMMITTEE.

I.—PROFESSIONAL ASSOCIATION OF AGRICULTURAL WORKERS.

Mr. Auchinleck submitted the following resolution and memorandum giving his views on the subject :—

This Conference wishes to place on record with Departments of Agriculture of British countries their opinion that there should be founded a professional Association of Agricultural Officers of the Empire.

The membership of the Association should include :—

- (a) Any officer of a Department of Agriculture in a British country who is desirous of joining the Association.
- (b) Honorary associates elected by the general body.

The major objects of the Association should be :—

- (1) Consideration of any matter affecting the efficiency of prestige of its associates.
- (2) Consolidating into one profession all officers engaged in development of agriculture of a British country.
- (3) Accumulating evidence as to the nature of the preliminary academic and the further specialized training necessary for candidates intended for the staff of British Departments of Agriculture, and

(4) Studying the functions of Government with respect to the devising and effecting of policies for safeguarding and developing agriculture.

In order to effect consolidation of the profession, the Association should emphasize :—

(a) The necessity for a sound preliminary training in farming technique and in agricultural economics of all candidates for staffs of Departments of Agriculture;

(b) The importance of investigation into local farming methods and economics as preliminaries to the formulation of any local policy of agricultural development, and

(c) The necessity of intensifying and extending the investigational or research facilities of Departments of Agriculture in all lines bearing upon the welfare and development of local agriculture.

The Conference asks that West African Governments lay this resolution before the Secretary of State for the Colonies for consideration and for transmission to other British Governments.

The Administrative Committee, while not agreeing with these proposals in their entirety, supported the idea of an Association. It was agreed to debate the subject in General Sessions.

In General Sessions, the *Chairman* (Mr. Auchinleck) said that the suggestion for an Association had first been put forward in the Gold Coast by Mr. Beckett at a Staff Conference at Asuansi some years previously. He thought that such an Association could include all professional workers in agriculture, and suggested that steps should be taken to test the feasibility of this proposal in order that recommendations might be brought before the next Imperial Agricultural Conference.

Mr. Beckett (Gold Coast) considered that membership should not be restricted to officers of Agricultural Departments but should be confined to those possessing definite qualifications laid down by the Association, thereby raising the status of its members to that of a recognised profession.

Mr. Lewin (Nigeria) feared an Association might approximate to a Trade Union.

The Chairman explained that the type of Association he had in mind was comparable to the Association of Forestry Officers.

Mr. Lewin (Nigeria), referring to the *Chairman's* memorandum, suggested that all details might be left entirely to the Second Imperial Agricultural Conference where all Colonies and Dominions would be represented and not solely those of West Africa.

The *Chairman* feared that the scheme would not receive adequate consideration at the Imperial Conference unless definite recommendations had been previously made.

Mr. Faulkner (Nigeria) proposed that the aim of the Association should be to include professional workers in agriculture and allied sciences. It should not be an examining body, but recognise certain qualifications for membership.

Mr. Stockdale was of the opinion that a general resolution should be put before the Imperial Conference, since it was a matter for the whole Empire—Great Britain, Dominions and the Colonies.

A resolution was then put to the Conference and passed as CONFERENCE FINDING NO. 1.

2.—ESTABLISHMENT OF A CENTRE FOR OIL PALM INVESTIGATION IN SIERRA LEONE.

Dr. Martin had submitted a paper on this subject, viz., "Need for further research facilities in West Africa. Proposal for a Research Station for oil palms and lateritic soils." (Paper No. VI in Vol. II; Bull. No. 20, Dep. Agr., Gold Coast.)

The following remarks were submitted by *the Chairman* :—

There is a growing tendency to provide for agricultural investigation, or research to give the more fashionable name, by means of special institutions or schemes operated independently of Colonial Departments of Agriculture.

Recent examples of this tendency include the recommendations of Lord Lovat's Committee for establishing a chain of Central Research Stations, the proposals for a West African Soil Survey, and plans for a Development Scheme of Cacao Research at the Imperial College, Trinidad. In 1926, a proposal was put forward in the Gold Coast for a Research Institute which should handle the total investigational work of the Colony, thus conferring benefits impartially on Agriculture, Forestry, Medicine and Veterinary. Somewhat older examples are the research schemes for Rubber, Tea and Coconuts now operated in some of the Eastern Colonies.

There can be little doubt in the minds of members of this Conference that under existing conditions certain advantages accompany the segregation of some lines of agricultural research in special institutions. Under the conditions in which Departments of Agriculture now exist, continuous and whole-time research cannot easily be sustained. Long-range problems can be attacked by special institutions without criticism from a public accustomed to require immediate results from a Department of Agriculture. Finally, certain problems, the solution of which is not the specific responsibility of any one department or not fairly chargeable to any one Colony, may be referred to a special institution.

It is, however, a certainty that Departments of Agriculture will be hampered in their growth, or weakened by premature and general segregation of investigational work in special institutions. None of the four West African Colonies would find it easy now to provide adequately for Departments of Agriculture and special institutions simultaneously, and none of them has yet an adequately developed Department of Agriculture. The

financial danger, too, is small in comparison with that which would arise through weakening the efficiency and prestige of Departments of Agriculture by minimising their investigational functions.

If there is one fact which, more than any other, has been learnt during the past half-century of trial, it is the futility of establishing Departments of Agriculture on any other basis than that of investigation or research. Investigation is their prime function, and instruction, advice and administration rest on this. Economics, land tenure, meteorology, behaviour of soils, plant pests and diseases, the behaviour of new crops must all be explored before we can give advice with any degree of confidence. And it is essential that these explorations should be made by the departments and not by external bodies, if the efficiency, unity, prestige and public responsibility of the departments are to be maintained. Investigation must be in the bones of every officer, but in addition must be part of the basic organisation of the departments.

The four Governments to which we belong have given very clear indications of their willingness, in fact anxiety, to establish sound policies of agricultural development. Up to the present, they have not been clearly advised as to the most effective types of organisation for evolving and operating sound policies, although there are an embarrassing number of proposals from which to select. This state of uncertainty is not conducive to good work or steady development of our departments, and one of the duties of this Conference should be to give as clear an expression of opinion as possible on the question.

To simplify the outlook, we can consider two extreme types of organisation. A finished scheme would no doubt lie somewhere between the two, but for the moment it is profitable to regard them separately. In the one type, applicable to an advanced country which has decentralized its policy or has not felt the necessity of centralizing it, agricultural knowledge is obtained and disseminated by means of an array of specialist research institutions linked to one another and to the public by no official bond. Of this type the United Kingdom, which so far has no Department of Agriculture as the term is understood elsewhere, offers probably the best known example. To the passing observer, it seems doubtful whether the system can for very much longer remain unaltered there. Some central Government organisation for co-ordinating and constructing a policy for the country seems necessary now in order to restore agriculture to a condition of efficiency and prosperity.

The other type of organisation has been adopted in all other English-speaking or British-controlled countries. Canada, Australia, New Zealand, South Africa, India, the United States, and all Crown Colonies and Protectorates have established Departments of Agriculture, that is, Government Departments responsible to the Administration and the public for obtaining and disseminating exact knowledge on which sound policy may be based. In the best and most effective types, facilities for obtaining knowledge, or in other words research facilities, form part of the organisation of the department.

In West Africa, we began with the department type of organisation, as is natural in undeveloped countries in which Government must assume greater responsibilities. After forty years, these Departments of Agriculture have not yet attained the efficiency, prestige and standing of other Government Departments, and we in this Conference should endeavour to ascertain the reason for this. The most obvious explanation, the true one, is that the investigational or research aspect of the departments has not been developed. We have laid down machinery for carrying out a policy, but have omitted to provide fuel for it. Perhaps it is truer to say that until

recently funds were not available for purchasing fuel. Now that the provision of facilities for agricultural research is contemplated, it is assumed that they should be established independently of our departments. We have allowed Departments of Agriculture to be accepted frankly as non-investigational organisations, or at any rate as unlikely to carry out efficient research.

This idea has been allowed to go very far. We have only recently partly escaped from a plan whereby we should have been endowed with a Colonial Agricultural Service from which all officers of Departments of Agriculture would have been excluded, a service composed exclusively of specialists in four pure lines working in Central Research Stations. We can hardly be accused of precipitate haste if we take the opportunity now of indicating what is necessary in order to obtain efficient Departments of Agriculture and to establish sanity of outlook in and on the profession of agricultural science.

The question on which we have to advise is largely one of order and method of development. The first step necessary to West Africa is centralization of responsibility and authority in matters concerning agriculture. Just as in education, forestry, medicine, or law, one local department is recognised as the responsible adviser and is progressively fitted with facilities for ensuring sound advice, so for agriculture we must have one authority. The directed amassing of exact information must go hand in hand with the directed use of the information, and development proceed by progressive growth of the central unit.

Two dangers have to be avoided. The profession of agricultural science cannot be resolved into an agglomeration of "pure-line" specialists, any more than the medical profession can be resolved into water-tight associations of zoologists, anatomists, druggists and botanists. Secondly, a development policy cannot be devised or operated by a dual organisation, the one purely executive, the other purely investigational. One department and one profession must be the aim, and that nucleus can be progressively fitted with facilities for specialized examination of the problems of agriculture.

The procedure now indicated is that this Conference should submit to their Governments, and through them to the Colonial Agricultural Council, resolutions embodying their findings on this matter.

The members of the Administrative Committee were in agreement with and realized the value of the work done in Sierra Leone, but the feeling generally was against the suggestion for a special institution in Sierra Leone for investigation on the oil palm, as this work is now being carried out in Nigeria where the crop is of great economic importance.

Mr. Faulkner (Nigeria) undertook to forward a statement on the investigational work that has already been done, also what is intended to be done in the future with reference to oil palms in Nigeria.

Mr. Stockdale suggested and the Committee agreed that the Director of Agriculture, Gold Coast, should prepare a draft resolution on this question to be considered later.

In General Sessions the subject was not debated, but the Conference recommendations were recorded as CONFERENCE FINDINGS Nos. 2 and 21.

3.—READJUSTMENT OF SALARY SCALE FOR OFFICERS IN DEPARTMENTS OF AGRICULTURE.

The Director of Agriculture, Gold Coast, proposed the following resolution :—

The Administrative Committee of the Second West African Agricultural Conference—

Records the opinion that administration of West African Departments of Agriculture cannot be carried on with the degree of efficiency necessary and desired by Directors unless the initial salaries of all European officers on the permanent staff are the same.

Notes that in Departments of Agriculture outside of Africa the initial salary of laboratory officers does not differ from that of other agricultural officers.

Notes that the first West African Agricultural Conference in 1927 recognised that the qualification and training of other agricultural officers should not be inferior to those of laboratory officers and recommended that the initial salary of the former be raised to that of the latter.

Recommended that a common initial salary be established for all officers of the permanent European staff of each Department of Agriculture in West Africa.

This resolution received general agreement from the members of the Committee. An alternative resolution was drafted for discussion at General Sessions.

In General Sessions, *Mr. Lewin* (Nigeria) maintained that, if the initial salaries of all officers were to be equalised, so also should their ultimate prospects. This was approved and the resolution was finally passed by the Conference as CONFERENCE FINDING NO. 3.

4.—CONFERENCES OF DIRECTORS OF AGRICULTURE.

The Director of Agriculture, Gold Coast, brought forward the question of the general consideration of policies of agricultural development in the Colonies, and suggested that arrangements be made for Conferences to deal with administrative questions affecting agricultural policy. He submitted the following list of types of subjects that required consideration :—

A.—Matters concerning the Agricultural Service.

Status and training of Officers of the Service.

Training and employment of Natives of the country by Departments of Agriculture.

Professional Association of Agricultural Officers.

B.—*Questions concerning the Administration of Departments of Agriculture in the Colonies.*

Government's functions in Agricultural Policy.
 Organisation of specialist work in Departments of Agriculture.
 Department's functions in long-range research.
 Relations with External Specialist Institutions.

C.—*Relations of Departments of Agriculture with their Public.*

Functions of local Advisory Agricultural Bodies.
 Publication of investigational results.

D.—*Economic Questions affecting Welfare and Development of Agriculture in the Colonies.*

Provision for study of Economic Factors.
 Applications of Methods of Co-operative Finance.
 Agricultural Development in relation to problems of labour and land tenure.

E.—*Tropical Products of the Empire in the World's Markets.*

Functions of Government Trade Bureaux.
 Limits of special Advertisement Campaigns.
 Effects and uses of Exhibitions.
 Producers' Associations.

F.—*Improvement of the quality of Tropical Produce.*

Functions of Government.
 Market standards in the Empire.

G.—*Development of New Agricultural Industries among a Native Peasantry.*

Devices for stimulation.
 The Economic Aspect.

H.—*Other Questions affecting the work of Colonial Departments of Agriculture.*

Functions of Departments in Agricultural Education.
 Ordinances for Controlling Crop Pests and Diseases.
 Boundaries between Agricultural and Veterinary Departments.
 Methods of Experimentation in use.

After discussion it was agreed that the Colonial Advisory Council of Agriculture and Animal Health should be asked to arrange for the discussion of subjects of this nature and consider whether some of them could be brought before the Colonial Agricultural Conference, which it was proposed to hold in Ceylon in 1932, or whether it was preferable to arrange for a special Conference to deal with such matters.

In General Sessions it was explained that, while the proposals of the Chairman had not been entirely supported by the Administrative Committee, the suggestion relating to Conferences of Directors of Agriculture to consider matters of administrative policy had received general support. The resolution is recorded as CONFERENCE FINDING No. 5

5.—WITCHBROOM DISEASE OF CACAO.

The Committee's findings under this head are recorded as CONFERENCE FINDING NO. 6.

6.—MEMORANDUM ENTITLED "SOIL SURVEY OF THOSE PARTS OF TROPICAL AFRICA ASSOCIATED WITH THE EMPIRE."

This memorandum, issued by the Bureau of Soil Science, was as follows:—

I. In 1927 a memorandum of the soil survey of those parts of Tropical Africa associated with the Empire was drawn up by Sir John Russell and circulated by the Colonial Office to the Governments concerned, who have now adopted the general principles contained therein. This circular is in amplification of Sir John Russell's memorandum and of the note entitled "Preliminary Soil Map of the Empire" issued from the Bureau on September 10th, 1929. In developing the soil survey, the principle to be adopted is to use all possible opportunities for collecting information which are afforded by the routine work of agricultural chemists in collaboration with the district staffs of the agricultural and other departments.

In this way the following material should rapidly become available:—

(a) Observations on the nature of the surface soil with notes on the profile where a natural exposure is encountered.

(b) First-foot samples taken in connection with the above and depth samples from the natural exposures.

(c) Depth samples and profile observations to a depth of four or six feet taken from places where no natural exposures occur, the intervals between the holes being such as is prescribed by practical circumstances or local requirements.

(d) The results of the physical and chemical examinations of the above samples in the laboratory.

II. *Field observations.*—It is suggested that at each place where a surface observation is made, the following information should be recorded:—

(a) The exact locality on a map.

(b) The geological formation.

(c) The natural vegetation.

(d) The colour and general description of the soil.

(e) The topography.

(f) Drainage.

(g) Notes on climate for the area.

Where a natural exposure occurs or a deep hole is made, notes on the profile should be added, and if pocket testing equipment for pH and calcium carbonate is carried, this can be with advantage used and the results recorded. In taking depth samples two methods are available. The first is to use a soil auger, this having the advantage that little labour is required and the whole operation carried out very quickly. The other method is to arrange beforehand for the excavation of holes four to six feet deep. This allows of a much more satisfactory examination of the profile, the more accurate taking of samples and much less expenditure of time by the skilled observer. Circumstances will, of course, dictate as to which method is to be used.

III. *Examination of Samples.*—The laboratory examination of soils was dealt with somewhat fully at the last West African Conference and the methods provisionally selected for adoption are contained in a report

of the chemical committee prepared by Dr. F. J. Martin. In view of the difference of opinion which exists as to the best methods of carrying out certain determinations, it is difficult for the Bureau of Soil Science to endorse any particular method at present. Neither in the West African nor in the East African group is a uniform set of methods in use, but until certain difficulties are cleared up, it appears inadvisable to ask any laboratory to change the method in use in which it has confidence.

IV. *Collation of Results.*—It is suggested that the results of the field observations and analyses should be forwarded to this Bureau at the end of each year in order that progress reports can be compiled on a uniform basis. Where determinations are desired which cannot be carried out locally, the Bureau will endeavour to arrange for the examination to be made in this country. This might apply, for example, to the petrographical identification of the mineral constituents of the coarse fractions; and to a complete mineral analysis of clay fractions from samples taken in colonies where limitations of staff preclude the carrying out of such determinations. The Bureau would endeavour, with the advice of local investigators, to map all the soils described on as uniform a basis as possible and to establish the identity of soil series occurring in different countries. Such reports would be circulated to all the Governments concerned for criticism by their technical officers before publication.

The Committee's findings under this head are recorded as CONFERENCE FINDING NO. 7.

7.—SECOND IMPERIAL AGRICULTURAL CONFERENCE—AUSTRALIA—1932.

The preliminary findings of the Committee under this head are recorded as CONFERENCE FINDING NO. 8. Attention is also drawn to CONFERENCE FINDINGS NOS. 1, 5, 27 and 54,

8.—RELATIONS WITH BUREAUX.

The Director of Agriculture, Gold Coast, put forward the following resolution:—

The Administrative Committee of the Second West African Agricultural Conference—

Wishes to place on record the opinion that definite harm to the unity and efficiency of West African Departments of Agriculture will result if correspondence between Imperial Bureaux and specialist officers of those departments be permitted to extend beyond matters of scientific technique.

Points out that the work of specialist officers of those departments forms part of the general policy of agricultural development for which the Directors of Agriculture in West Africa are responsible to their Governments.

Points out that in the case of West African Colonies the Imperial Bureaux are subsidized by Government in order that specialist knowledge may be available to Directors of Agriculture in devising and effecting sound policies of agricultural development.

Suggests that paragraphs 10, 11 and 12 of Memorandum 1 of May, 1929, on Imperial Agricultural Bureaux be replaced by the following in so far as West African Colonies are concerned:—

“ 10. *The Director of Agriculture in each Colony shall be official correspondent of his department and Government with each Bureau.*”

“ 11. *Any officer on his staff may be delegated by the Director of Agriculture as his official representative for correspondence with any Bureau, and will be required by the Director of Agriculture to keep the Bureau fully informed of local matters relating to the science concerned.*”

“ 12. *The Director of Agriculture in each Colony shall keep Bureaux fully informed of the needs of his department in each of the sciences concerned, and shall refer to the Bureaux suggestions regarding work which the Colony requires.*”

Asks that a copy of any letter written by an Imperial Bureau to an officer of one of those departments be sent simultaneously to the Director of Agriculture concerned.

Mr. Faulkner suggested the substitution of the following for paragraphs 11 and 12:—

“ The Director of Agriculture should—

(a) allow latitude to specialists to correspond direct about minutiae of their subject: responsibility on the specialist.

(b) consult specialists and forward their views, especially if opposed to his own.”

XXVII.—ECONOMIC BOTANY.

The Committee consisted of the following members:—

- T. Lloyd Williams (Gold Coast),
- C. J. Lewin (Nigeria),
- S. T. Phillips (Gold Coast),
- A. S. Thomas (Gold Coast).

1.—BREEDING HIGH-YIELDING TYPES OF CACAO.

The Committee's finding was passed by the Conference as CONFERENCE FINDING No. 9.

2.—SUMMARY OF RESULTS OF COTTON TRIALS IN GOLD COAST.

(a) TOGOLAND; (b) NORTHERN TERRITORIES.

The following summary of the results of cotton trials in the Gold Coast was tabled for the information of the Committee:—

A.—IN THE NORTHERN TERRITORIES.

(a) The following is extracted from a manuscript paper by *Captain G. C. Coull*, “The Cotton Industry in the Northern Territories.”

1. In 1909 the Tamale Agricultural Station was opened and cotton was grown there experimentally until the year 1919-20.

2. Various varieties of seed were grown and selections made. The results were as follows:—

Seed.	1912-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20
Black Rattler unmanured	143	85	171	67	65	123	175	182
Black Rattler manured . .	140	90	192	245	225	240	312	320
Selection 1	—	—	—	38	128	160	34	136
„ 2	—	—	—	64	204	169	104	304
„ 3	—	—	—	373	53	51	54	290
„ 4	—	—	—	258	224	256	136	120
„ 5	—	—	—	243	136	144	68	—

3. The highest yield obtained was 512 lbs. per acre from a $\frac{1}{4}$ -acre manured plot of Upland cotton. From 1920 no cotton was grown experimentally.

4. The British Cotton Growing Association was engaged from July, 1910, till March, 1916, in carrying out propaganda among the natives, distributing seed, buying and ginning. They closed down in 1916 owing to insufficient supplies being offered.

5. In 1925 cotton development was again decided upon and a cotton ginnery erected at Tamale.

(b) 1926-1927 Season.—Propaganda was carried on by the Agricultural Department and seed distributed free to the natives within a 50 mile radius of Tamale, 8 tons 13 cwts. being so distributed. The yield was very poor—information not being available as to the exact figure, and also, owing to a variety of non-agricultural causes, a considerable portion of the seed was either not sown or the harvested cotton not brought to the ginnery to be purchased. At the Agricultural Station, Tamale, 40 acres were planted with Allen seed. The yield was very poor, being 18.9 lbs. of seed cotton per acre, due partly to abnormal heavy rains during the planting season.

(c) 1927-28 Season.—40 acres were again planted with cotton on Tamale Experiment Station with Allen seed, which proved to be very mixed. The highest yield was 55 lbs. of seed cotton per acre and the average 23.4 lbs. Selection was carried out and seven plants finally selected for further trial. Three varieties of native cotton (for description of these see Howes 1926 Year-book) were planted. Two failed entirely and Gumanli only gave a yield of 11 lbs. per acre. One of these plants was selected with a view to hybridisation.

Propaganda and free seed-distribution was again carried on over the same area—5 tons 5 cwts. being distributed—but results were again very poor, largely owing to non-agricultural causes.

Five native plots were measured and the yields taken. The highest gave 62.1 lbs. of seed cotton per acre and the lowest 13.7.

(d) 1928-29 Season.—93 acres of cotton was grown at Tamale Experiment Station, six varieties on a field scale. The highest yield was 98 lbs. per acre from a 5-acre block of Ishan and the lowest 14 lbs. per acre from a 5-acre block of Allen. The mean yield over the whole Station was 40 lbs. per acre.

Breeding and selection work was carried out on an extensive scale. Distribution of seed was again carried out and a bonus of 10/- per acre given for a good stand of cotton. 5,578 lbs. of seed were distributed and 351.7 acres were grown. Yields varied from 116 lbs. to 8 lbs. to the acre, the former yield being on a farm of 15 acres. The average was 35 lbs. of seed cotton per acre.

The report on Northern Territories Cotton Development for 1928-9 season is tabled.

Conclusions.—Continued low yields over a number of years are the main feature of the history of cotton trials in the Northern Territories.

Future Plans.—(I)—Breeding and selection work is in hand on a large scale, and this work has now progressed to the extent that in the forthcoming season an idea as to whether any materially increased yield will result should be obtained.

(II)—Many new varieties are being tried out this season, mainly of American types. Next season some of the better types of Indian varieties will be tried out.

(III)—Soil conditions and their effect on the low yields are at present being investigated by the Agricultural Chemist.

(IV)—The incidence of pests and diseases is under investigation.

(V)—Expansion of tillage and manurial trials at Tamale Experiment Station.

(VI)—Small trial plots are being laid down in other parts of the Northern Territories.

B.—TOGOLAND.

There is a well-established minor industry in Togoland, which was started in 1900. By the year 1907, 1,205 bales (of 550 pounds) were exported from the whole of Togoland.

Most of the cotton now goes over the French border, and in 1924, 323,999 lbs. was so exported. The industry is now on a considerably smaller scale, as the cultivation of food crops is now more profitable.

The variety mainly grown in Togoland is Sonko (*Gossypium peruvianum*) (1). This cotton resembles Ishan very closely. In parts of Togoland a cotton very similar in appearance to Sonko, but with a kidney type of seed, is grown. The department is gradually succeeding in stopping the cultivation of this variety.

The yields of cotton at the two Experiment Stations at Abor and Kpedsu (both now closed down) are given below :—

Station.	Year.	Variety.	Yield of seed cotton lbs. per acre.
Kpedsu	1923-24	Sonko	110
	1924-25	Sonko	131
	do..	Kadean yingba	187
	1925-26	Sonko	226
	do.	[Kadean yingba	340
Abor	1925-26	Sonko	140

The cotton work was then transferred to Kpeve Experimental Station, and on an area of 10 acres the yields in the 1927-28 season were:—

Sonko 180 lbs. of seed cotton per acre.

Ishan 219 „ „ „ „ „ „

A comprehensive series of trials was laid down in 1928-29, including tests on new varieties, investigations on tillage, spacing, time of planting, etc., and this is being repeated this season.

Mr. G. S. Cotterell, whilst investigating the incidence of the cotton stainer in Togoland (2), laid down sample plots on native farms in various areas, and has kindly supplied the following figures:—

The yields are from $\frac{1}{4}$ -acre plots chosen to be as representative as possible.

Ve Deme 716 lbs. of seed cotton per acre (a pure stand).

Ve Hoeme 460 lbs. of seed cotton per acre (after a mixed food crop had already been harvested the same season).

REFERENCES.

- (1) Howes, F. N. Paper No. XVIII, 1926 Year-book, Gold Coast.
- (2) Cotterell, G. S. Bulletin No. 12, Department of Agriculture, Gold Coast.

3.—BREEDING COTTON-TYPES RESISTANT TO COTTON STAINER.

In General Sessions, *Mr. Faulkner* called attention to the magnitude of this work which was irrespective of the magnitude of the crop, and *Mr. Lewin* stressed the fact that selection of improved strains must be done in the districts where the cotton was to be grown. After slight amendment the findings of the Sub-Committee were adopted by the Conference as CONFERENCE FINDING No. 10.

4.—ASEXUAL PROPAGATION OF PERENNIAL CROPS.

The findings of the Sub-Committee on this subject were passed by the Conference as CONFERENCE FINDING No. 11.

5.—MEASUREMENT OF AMOUNT AND INTENSITY OF LIGHT IN CACAO AND OIL PALM PLANTATIONS AT DIFFERENT PLANTING-DISTANCES: FORMULATION OF PLANS FOR.

The Committee has perused a paper entitled "An indirect method of measuring the amount of foliage on different blocks of trees," by R. A. Taylor—Tropical Agriculturist, Vol. 73, No. 1, 1929, and is of the opinion that this method is well worthy of trial as a means of measuring light intensity in cacao and oil palm plantations.

In General Sessions, *Mr. Stockdale* called attention to a paper read at the recent Meteorological Conference, setting forth more refined methods than those hitherto described. This paper was "Methods for the photo-electric and photo-chemical measurement of daylight," by W. R. G. Atkins and H. H. Poole, published in

Volume II, Papers and Discussions, Agricultural Section, Conference of Empire Meteorologists, 1929 (H.M. Stationery Office). A resolution was adopted as CONFERENCE FINDING No. 12.

6.—OBJECTS OF THE SHEA PLOT AT YENDI, GOLD COAST.

Mr. Williams submitted the following memorandum to the Committee :—

The Shea Plot at Yendi is 23 acres in extent. The country around Yendi has a large number of shea trees, and this area has been taken from the bush, all other trees cut out and a pure stand of shea established.

The area has been divided into plots upon which the effects of the following treatments are being tried—burning, green manuring, hoeing, and no cultivation at all.

A considerable amount is known about the anatomy and morphology of *Butyrospermum Parkii*—mainly written by the French—but practically nothing about it as a commercial crop. Hence the shea plot at Yendi has been laid down in order to investigate :—

(i) Yields per tree and per acre.

(ii) How these yields are affected by the cultural operations mentioned above.

(iii) To investigate the question of whether there are distinct varieties of *Butyrospermum Parkii*.

This question is of importance as regards the unsaponifiable matter in the fat, for it has been suggested that certain types may contain only a very small percentage of this substance. Trees with varied leaf and fruit characters have been marked and seed from these trees has been planted in order to see if they come true to type. Specimens have been taken to Kew and the question of the existence of distinct varieties has been discussed. Both the writer and Mr. Hutchinson, of Kew, are of the opinion that there are no definite botanical varieties.

(iv) The period from germination to fruiting and the amount of fruit to be expected from trees of different ages.

Individual yields of a certain number of trees are being taken in this connection.

It is considered that there is no need for any further botanical work to be carried out on shea, for

(a) It is a very slow growing tree.

(b) The yield per tree is very low, so that, leaving out all questions of transport, etc., it is quite certain that shea will not be planted on a plantation scale, and hence there is no need for selection work to be carried out on this crop.

The Conference approved of the Committee's findings on the subject of shea. These are recorded as CONFERENCE FINDING No. 13.

7.—ESTABLISHING STANDARD COLLECTIONS OF LOCAL FOOD CROPS FOR SELECTION WORK ON EXPERIMENT STATIONS.

The Sub-Committee's suggestion on this subject was approved by the Conference as CONFERENCE FINDING No. 14.

8.—STATEMENT OF WORK ON OIL PALM SELECTION IN GOLD COAST AND ANY RECOMMENDATIONS FOR MODIFICATION OF THE WORK.

The statement is published as Paper No. XIX of the Conference Papers (Paper XIX, Bull. 20, Dep. Agr., Gold Coast).

The findings of the Committee on this subject are embodied in item 13 of the records of this Committee.

9.—THE OIL-PALM VARIETAL PLOTS IN SIERRA LEONE—VALUE AS CENTRES FOR BOTANICAL AND SELECTION WORK.

The Committee's findings were passed by the Conference as CONFERENCE FINDING No. 15, after the original wording had been considerably altered.

10.—REGULATIONS FOR CONTROLLING IMPORTATION OF PLANTS—GOLD COAST.

The Committee considered the regulations at present in force and decided to make no recommendation.

In General Sessions, *Mr. Stockdale* proposed that the regulations at present in force in Trinidad and Tobago should be studied as a model if alterations were contemplated.

11.—PROPOSALS FOR STUDY OF LOCAL GRASSES (FODDER VALUE, ECOLOGY, CARE OF PASTURES, CULTIVATION OF FODDERS).

The Committee's findings were approved by the Conference as CONFERENCE FINDING No. 16.

12.—REPRESENTATION OF DEPARTMENTS OF AGRICULTURE, WEST AFRICA, AT THE WORLD'S BOTANICAL CONGRESS, 1930.

The Committee understands that *Mr. Lewin* has already been nominated as Nigerian delegate to the World's Botanical Congress, 1930, and is of the opinion that, in view of the importance of this assembly and since convenient opportunity for representation may not recur for many years, a botanist should be nominated as the Gold Coast delegate.

In General Sessions, *the Chairman* sanctioned the findings on behalf of the Gold Coast Department of Agriculture.

13.—CO-ORDINATION OF BOTANICAL EFFORT.

The Committee's recommendations were fully discussed by the Conference and ratified as CONFERENCE FINDING No. 17.

XXVIII.—AGRICULTURAL CHEMISTRY.

This Sub-Committee consisted of the following members:—

- F. J. Martin, Sierra Leone.
- K. T. Hartley, Nigeria.
- R. Coull, Gold Coast.
- H. B. Waters, Gold Coast (present at first sitting).

1.—RESOLUTIONS OF CHEMICAL COMMITTEE, FIRST WEST AFRICAN AGRICULTURAL CONFERENCE, 1927.

The Committee reviewed the question of Soil Investigations in West Africa and were of the opinion that the circular recently forwarded by the Bureau of Soil Science may be regarded as acceptable to the Departments of Agriculture in West Africa.

2.—METHODS OF SOIL-SAMPLING AND ANALYSIS RECOMMENDED BY CHEMICAL COMMITTEE OF FIRST WEST AFRICAN AGRICULTURAL CONFERENCE, 1927.

The Committee reviewed the methods of analysis recommended at the last Conference and were agreed that they should stand with the exception of the classification of soil particles in mechanical analysis. It is recommended that the classification accepted by the International Soil Science Congress should be used.

3.—GEOLOGICAL BASIS FOR SOIL SURVEY WORK.

The Committee was of the opinion that a geological basis was unsuitable as a basis for soil survey in tropical countries on account of the very great effects of temperature and rainfall on formation of soil types.

4.—SOIL MAPS FOR EXPERIMENT STATIONS.

Soil maps for experimental stations should prove of great value and the determinations agreed upon for general soil survey work should always be made. Any other determinations depend upon the problems to be investigated at individual stations and should be decided by the officers concerned, e.g., salts and their nature on irrigation stations, nitrogen, phosphorus and potassium determinations for fertiliser trials. The Committee considers that work of

this type would result in the setting up of standard types of soil whose response to cultivation is known. It would then be possible in the case of unknown soils whose profiles and laboratory characteristics agree with standard types to make reasonably valid inferences as to their behaviour on cultivation.

5.—ADSORPTION OF BASES BY LOCAL SOILS.

The Committee was of the opinion that work on adsorption of bases by local soils might be of value and should be undertaken if it appears that it would assist in the solution of specific agricultural problems.

6.—WATER-TABLE MAPS, LATERAL EFFECT OF DRAINS ON MOISTURE, TEST-WELLS AND BORINGS.

Information with regard to the water-table and degree of moisture in soils is very valuable, but methods of measuring lateral effects of drains and deciding on what test-wells and borings are necessary would depend on local conditions.

7.—COMPOSITION OF DRAINAGE WATERS ISSUING FROM CULTIVATED FIELDS.

The Committee discussed various methods of obtaining samples of drainage waters and decided that properly constructed lysimeters would be necessary. The Committee hesitated to formulate any general plan and expressed the view that these should only be constructed when some definite agricultural problem renders it necessary to obtain information as to losses by leaching.

8.—VALUE OF REGULAR ANALYSIS OF RAIN-WATER.

The Committee could see no immediate application of the results of the regular analysis of rain-water.

9.—FOOD VALUES OF LOCAL FODDER-GRASSES.

The Committee understands that this matter is now being investigated by the Veterinary Departments of the Gold Coast and Nigeria and considers it unnecessary to formulate any specific plans.

10.—COMPOSITION OF THE MILK OF LOCAL BREEDS OF CATTLE.

11.—HCN-CONTENT OF LOCAL CASSAVAS.

12.—ALKALOID CONTENT OF COFFEE VARIETIES.

- 13.—COMPOSITION OF PALM-SAP.
- 14.—NATURE AND AMOUNT OF UNSAPONIFIABLE MATTER IN SHEA FAT.
- 15.—CHEMICAL CONTROL OF MILLING: (a) LIMES, (b) RICE, (c) SHEA FAT, (d) OIL PALM FRUIT.
- 16.—ADCO TRIALS WITH SISAL-WASTE, PERICARP-FIBRE, DRIED LEAVES, ETC.

The Committee agrees that the problems indicated in items 10 to 16 are of great interest and should be undertaken as the need for information arises. Various methods of attacking these problems were discussed in detail, but it was considered that the working out of the necessary plans for any individual investigation is essentially a matter for the local Department concerned.

- 17.—INDICATOR PROPERTIES OF CACAO-RED.

The Committee was unaware of any information with respect to the indicator properties of cacao-red which could be utilised in connection with the work of the Inspectorate.

- 18.—ORDINANCE FOR CONTROLLING THE QUALITY OF FERTILISERS IMPORTED INTO WEST AFRICA.

The Committee submits the following outlines of an Ordinance for controlling the quality of fertilisers imported into West Africa, but wishes to record that in their opinion the time has not arrived when such an Ordinance is necessary.

Definition.—Fertiliser; any substance offered for sale for the purpose of application to the soil to increase the yield of crops.

Provisions:—

(a) Prohibition of import or sale of fertilisers unless accompanied by a statement of the percentage of each of the constituents potassium oxide, phosphoric anhydride and nitrogen.

(b) Power to Governor to appoint persons as inspectors of fertilisers.

(c) Power to Inspectors to take samples of fertilisers imported or offered for sale. Samples to be divided into three equal parts and bottled and sealed. One sample to be sent to analyst, one given to vendor and one retained by inspector.

(d) Any person importing or selling a fertiliser which is found on analysis to be deficient by more than 5 per cent. of the declared percentage of any constituent shall be liable to prosecution.

(e) Penalties under (a) and (d).

(f) Power to Governor in Council to make orders and in particular to specify methods for sampling and analysis.

In connection with Items 1 to 18 above, the Committee formulated resolutions for the consideration of the Conference. These were passed in General Sessions as CONFERENCE FINDINGS Nos. 18, 19 and 20.

19.—LATERITIC SOILS.

After discussion of the paper laid on the table the Committee was of the opinion that further information about lateritic soils was desirable, but thought that work on fundamental problems would not normally be undertaken by local Agricultural Departments. It is suggested that the Conference should consider the necessity for such work and the means by which staff and facilities can be provided.

In General Sessions, *the Chairman* complimented Dr. Martin on his work on lateritic soils which he considered to have many important bearings on agricultural practice and which therefore fell within the province of Departments of Agriculture. *Dr. Martin* replied that routine departmental work precluded adequate attention to this subject. A resolution was then passed by the Conference as CONFERENCE FINDING No. 21.

XXIX.—AGRICULTURAL ECONOMICS.

Present:

Mr. A. W. Paterson, Gold Coast.

Mr. H. G. Poynter, Nigeria.

Mr. J. M. Dunbar, Gold Coast.

Mr. F. Pyatt, Gold Coast.

"Agriculture" has been very ably defined by Sir Henry Rew, K.C.B., as "the utilization of the natural fertility of the soil for production of commodities serviceable to man." Agricultural economics is the study of the business side of agriculture and is concerned with WHY rather than HOW a crop is grown.

The majority of the failures of schemes of agricultural development can be definitely traced to lack of knowledge and appreciation of local conditions, customs and habits rather than to any deficiency of technical knowledge.

The recommendations of the Committee were submitted to the Conference and were approved as CONFERENCE FINDINGS Nos. 22, 23, 24, 25 and 26.

A further resolution was put forward by the Economics Committee with regard to the Imperial Agricultural Conference, 1932 :—

This Conference considers the subject of Agricultural Economics is of growing importance and that the possible need for the establishment of an Imperial Bureau should be borne in mind.

In General Sessions, *Mr. Stockdale* stated that at the last Imperial Agricultural Conference this subject was discussed and it was decided that the study of Agricultural Economics was not sufficiently advanced to merit the formation of an Imperial Bureau. *Mr. Faulkner* said that the results so far obtained were not applicable to a system of peasant industry, and so were of little value to Nigeria.

Mr. Stockdale suggested an amendment which was passed as CONFERENCE FINDING No. 27.

XXX.—AGRICULTURAL ENTOMOLOGY.

The Committee consisted of :—

Mr. G. S. Cotterell, Gold Coast.

Mr. E. Hargreaves, Sierra Leone.

The Committee very much regretted the absence of a Nigerian Entomologist as a representative to this Conference.

I.—CONSIDERATION OF RESOLUTIONS CONCERNING AGRICULTURAL ENTOMOLOGY PASSED BY THE FIRST WEST AFRICAN AGRICULTURAL CONFERENCE, 1927.

Resolution 2 at 1927 Conference.

Mr. G. S. Cotterell was commissioned to visit Fernando Póo and San Thomé. The tour was extended to include the cacao producing areas of the Belgian Congo.

Conclusions reached are embodied in a paper on the table. (Paper No. XIV in Vol. II; Bull. No. 20, Dep. Agr., Gold Coast).

Resolution 3 at 1927 Conference.

Co-operation has been established.

In General Sessions, *Mr. Cotterell* outlined his visit to Fernando Póo and San Thomé and the results accruing therefrom.

2.—REPRESENTATION OF WEST AFRICAN DEPARTMENTS OF AGRICULTURE AT THIRD IMPERIAL ENTOMOLOGICAL CONFERENCE.

(a) Para. 3 of the Secretary of State's Despatch to His Excellency the Governor dated 22nd March, 1929, states:—

“The experience of the previous two Conferences has proved that such meetings of members of the entomological services in all parts of the Empire are of the utmost value, and the Managing Committee of the Bureau are anxious that the Conference to be held in 1930 shall be as successful as its predecessors. I feel sure that you will agree as to the many useful purposes which these meetings can fulfil, and I trust that your Government will find it possible to accept this invitation to be represented.”

(b) Recommendation of the Imperial Agricultural Research Conference, October, 1927 (para. 215 of the Report), reads as follows:—

“215. QUINQUENNIAL CONFERENCE.

“In view of the importance of obtaining adequate representation of entomologists at the Quinquennial Conference of Entomologists of the Empire arranged by the Imperial Bureau of Entomology, this Committee very strongly recommend that each entomological service in the Empire should be represented by an entomologist at every such Conference.”

The Committee strongly upholds the above recommendations.

The following resolution was made by the Committee:—

“This Committee considers that each Colony should be represented at Imperial Entomological Conference by Entomologists.”

In General Sessions, the words “whenever possible” were added and the resolution adopted by the Conference as CONFERENCE FINDING No. 28.

3.—NEED FOR EARLY PREPARATION BY EACH DEPARTMENT OF A HANDBOOK ON LOCAL CROP PESTS.

The Committee's findings were passed by the Conference as CONFERENCE FINDING No. 29.

4.—PREPARATION OF PLANS AND ESTIMATES FOR A BREEDING LABORATORY FOR ARTIFICIAL DISTRIBUTION OF EUPHORUS IN THE GOLD COAST.

The Committee's opinions were passed by the Conference as CONFERENCE FINDING No. 30.

In General Sessions, *Mr. Cotterell* explained that a start had been made on this problem in the Gold Coast, but the work had been purely experimental. *Mr. Stockdale* said that he hoped that too much expense would not be incurred until the possibilities of control by cultural methods had been fully explored. *The Chairman* stated that the agricultural aspects of the question had been considered and that *Mr. Cotterell's* experiments were on a modest scale.

5.—TEST WINDBREAKS FOR CONTROL OF SAHLBERGELLA ON GOLD COAST CACAO FARMS.

The Committee's recommendations were approved by the Conference as CONFERENCE FINDING No. 31.

6.—PROPOSALS FOR TESTS BY THE DEPARTMENTS OF METHODS OF MANURING AND CULTIVATION AS MEANS OF SAHLBERGELLA CONTROL.

In General Sessions, *Mr. Stockdale* stated that, as certain trees appeared to bear some kind of resistance to attack, the propagation of this type of tree merited investigation. He also questioned the efficacy of any particular type of manure as a control of *Sahlbergella*, and suggested that special mention of potash should be deleted from the Committee's finding. This was done and the resolution passed as CONFERENCE FINDING No. 32.

7.—FORMATION OF PROPOSALS FOR THE CONTROL OF COTTON-STAINER IN TOGOLAND.

The Committee's remarks were approved by the Conference as CONFERENCE FINDING No. 33.

8.—STUDY OF LIFE-HISTORIES OF ACHAEA AND OTHREIS—PROPOSALS FOR AN EARLY PROVISION OF FACILITIES FOR.

In General Sessions, *Mr. Cotterell*, in reply to a question from *Mr. Stockdale*, stated that the fruit-moths had been observed in almost every citrus-producing area of the Colony. *Mr. Hargreaves* mentioned that these pests had been reported in Sierra Leone.

The Committee's findings were approved by the Conference as CONFERENCE FINDING No. 34.

9.—MEMORANDUM ON POSSIBLE METHODS OF CONTROLLING THE COLA WEEVIL.

The Committee's memorandum was approved by the Conference and recorded as CONFERENCE FINDING No. 35.

10.—MEMORANDUM ON POSSIBLE METHODS OF PREVENTING MOTH AND WEEVIL IN STORED CACAO.

The Committee's findings were approved by the Conference and recorded as CONFERENCE FINDING No. 36. The table referred to in that finding is given on page 67.

ADULT WEEVIL INFESTATION OF DRYING CACAO.

	Mean weight of Samples	No. of Samples	Mean No. of Adult Weevils caught.										Remarks.
			1st day.	2nd day.	3rd day.	4th day.	5th day.	6th day.	7th day.	8th day.	9th day.	10th day.	
ABURI DISTRICT.													
Mat Platforms	97 lbs.	10	0.7	3.0	4.7	2.7	4.7	3.8	3.4	2.5	3.0	2.0	
Wooden Trays	30 "	1	1.0	3.0	0.0	0.0	0.0	17.0	13.0	3.0	0.0	0.0	
Concrete Platforms ..	28 "	2	0.0	0.0	0.0	0.0	—	—	—	—	—	—	Removed as dry after 4 days.
Iron Sheets	20 "	1	2.0	1.0	0.0	0.0	—	—	—	—	—	—	do.
KROBO DISTRICT.													
Mat Platforms	308 lbs.	5	0.0	9.2	14.8	15.6	8.8	—	—	—	—	—	Removed as dry after 5 days.
Sliding Trays (Model Fermentary)..	207 "	5	0.0	1.6	1.4	4.8	3.2	2.2	3.3	0.5	0.2	0.0	
Concrete Platforms ..	270 "	5	0.0	0.0	0.0	0.0	0.0	0.0	—	—	—	—	Removed as dry after 6 days.

11.—CRITICISM AND PROPOSALS FOR IMPROVEMENT OF THE GOLD COAST PLANT PESTS ORDINANCE.

The Committee's recommendations were approved and recorded as CONFERENCE FINDING No. 37.

12.—GAPS IN KNOWLEDGE OF AFFINITIES OF LOCAL CROP PESTS—
FORMULATION OF PROPOSALS FOR FILLING.

The Committee's resolution on this subject was adopted by the Conference as CONFERENCE FINDING No. 38.

13.—VALUE OF ARTIFICIAL CONTROL OF INSECT PESTS IN WEST AFRICA.

In General Sessions, the Committee's resolution was fully discussed and largely reworded. It was finally accepted as CONFERENCE FINDING No. 39.

XXXI.—METEOROLOGY.

This Sub-Committee was composed of the following delegates :—

Mr. N. P. Chamney (Gold Coast).

Mr. H. W. Moor (Gold Coast).

Mr. W. B. Dowson (Nigeria).

Mr. J. T. H. Stein (Gold Coast).

An agenda paper containing sixteen items had been prepared and the Committee proceeded to deal with them in order.

1.—PROPOSALS FOR DISTRIBUTION OF STATIONS OF VARIOUS ORDERS IN BRITISH WEST AFRICA.

Mr. Chamney pointed out that at the Conference of Empire Meteorologists in London (August, 1929) first-class stations for the Gambia and Sierra Leone were proposed in connection with airship routes and that the appointment of a meteorological officer to Nigeria was contemplated. This would lead to the establishment of a first-class station there. With regard to the Gold Coast, the station at Accra is already nearly of that order and with little cost could be made so.

In General Sessions, *Mr. Faulkner* (Nigeria) emphasized that records from all stations must be reliable, and suggested that, in order to obviate delays in the collection of records and correction

of errors, a telegraphic system should be substituted for the postal service. *The Chairman* mentioned that telegraphic methods were employed in the Gold Coast.

The Committee's resolution was passed by the Conference as CONFERENCE FINDING No. 40.

2.—INTERCHANGE OF INFORMATION WITH NEIGHBOURING FOREIGN COLONIES.

Mr. Chamney pointed out the difficulties which had been experienced in obtaining information in the past.

In General Sessions, *Dr. Martin* (Sierra Leone) pointed out the difficulty in Sierra Leone and the Gambia of providing staff adequate for this work. *The Chairman* remarked that of all meteorological records those of rainfall are generally of vital importance.

The Committee's resolution was passed by the Conference as CONFERENCE FINDING No. 41.

3.—PROPOSALS RE INVESTIGATIONS NEEDED INTO CORRELATION BETWEEN CLIMATIC FACTORS AND CROPS IN BRITISH WEST AFRICA.

The influence of the climate on crops growth was discussed and it was agreed that very little was definitely known about this subject with regard to tropical crops. The Committee passed the following resolution for submission to the Conference:—

“That determination of all meteorological factors controlling crop production in West Africa is essential.”

In General Sessions, *the Chairman* remarked that this programme was very wide and suggested that the resolution be amended to deal only with the major perennial crop of each Colony. This amendment was adopted by the Conference as CONFERENCE FINDING No. 42, but *Mr. Lewin* maintained that all the proposals of the Meteorological Sub-Committee were too ambitious and would entail undue diversion from normal work. *Mr. Stockdale* questioned the value of a mass of meteorological statistics of which few had a direct bearing on farming practice. He suggested that records should be made to throw light on particular problems, as, for example, humidity in relation to cacao cultivation in the Gold Coast. *The Chairman* stated that there was a definite lack of meteorological data in the Gold Coast, but asked the visiting delegates to indicate any parts of the resolutions which were distasteful to them.

4.—EXPLORATION OF POSSIBILITY OF CROP WEATHER FORECASTS.

The basis of crop weather forecast systems in the United Kingdom and United States was explained and such investigation as had been carried out on the Gold Coast was outlined. The Committee decided that in the absence of full information with regard to Item 3 above it was not possible in the time allotted to make a programme of investigation.

In General Sessions, *Mr. Sampson* said that in his experience headquarters of departments were often situated in positions not typical of the area they surveyed, therefore the meteorological records collected at head offices did not give a true picture of the climatic conditions of those areas. *The Chairman* observed that in the Gold Coast meteorological factors had been found to enter into almost every branch of departmental work.

The Committee's resolution was passed by the Conference as CONFERENCE FINDING No. 43.

5.—FURTHER INVESTIGATIONS ON CORRELATION BETWEEN HUMIDITY IN AIR AND MOISTURE IN PRODUCE.

Past work by Messrs. Scott and Dade was tabled and discussed and the investigation undertaken in Takoradi sheds was outlined. The necessity for dealing with cola and copra was emphasized and attention was paid to the diminution in market value of crops, notably copra, which suffered in appearance even though no damage might be done to the product.

The Committee passed the following resolution for submission to the Conference :—

“ That, to safeguard the quality of produce for export, this Committee advocates early commencement of work on the determination of the amount of moisture which in each product may be considered the damage-point with regard to mould.”

In General Sessions, *the Chairman* drew attention to the work of Messrs. Dade and Scott in connection with the relation of moisture in cacao to the humidity of the atmosphere.

Mr. Faulkner submitted the following omnibus resolution—to cover all the findings of the Meteorological Sub-Committee :—

(a) That the collection and publication of meteorological records in West Africa should be the business of the Agricultural Departments.

(b) That provision be made for maintenance of accurate up-to-date records and that reports should be telegraphed to the headquarters daily.

(c) That the Colonies agree upon standard methods of recording.

(d) That phenological relationships merit investigation in West Africa.

The Chairman asked that delegates would consider the remaining resolutions of the Meteorological Committee one by one. Mr. Faulkner's resolution was passed by the Conference and recorded as CONFERENCE FINDING No. 44.

6.—PROPOSALS FOR ANNUAL PREPARATION AND ISSUE OF WEST AFRICAN WEATHER MAPS.

The most important of these was shown to be that of "isohyets" and it was agreed that problems of safeguarding cacao areas from encroachment by savannah was bound up in production of such maps. The study of the weather conditions of these Colonies would be much easier and of greater value when their relation to the whole was worked out.

The Committee passed the following resolution for submission to the Conference :—

"That the preparation of West African weather maps for agricultural purposes be commenced at once by collaboration between agricultural officers concerned with meteorological work in each Colony."

The Conference allowed this resolution to stand as a finding of the Sub-Committee.

7.—CONSIDERATION OF THE FEASIBILITY OF OBTAINING HIGH ALTITUDE WIND RECORDS.

The methods of obtaining these records were explained by *Mr. Chamney*, but the Committee were of opinion that in view of the limited funds available there were more urgent matters requiring attention. They considered that the question was not urgent from an agricultural standpoint.

The Conference allowed this to stand as a finding of the Sub-Committee.

8.—OUTLINES OF INVESTIGATIONS INTO THE DETERMINATION OF EFFECTIVE RAINFALL.

A memorandum giving outlines of the work done on this subject by various investigators was tabled. A lengthy discussion ensued and, while it was agreed that most of the formulæ advocated were quite inadequate in that they did not take all the factors

into consideration, yet the cost and time employed in adequately studying the question would not be justified. The problem was one for scientific institutions rather than for local Departments of Agriculture. They considered that the "degree of wetness" gave a sufficiently accurate picture for practical purposes.

The following resolution was made by the Committee :—

"That, in view of the fact that total figures for rainfall are not a sufficiently accurate indication of the effect of that rain, investigations should be undertaken, where practicable, to find the value of the variables governing this effect."

The Conference allowed this resolution to stand as a finding of the Sub-Committee.

9.—INVESTIGATIONS INTO FACTORS CONTROLLING SUDDEN WEATHER FLUCTUATIONS ON THE GOLD COAST.

The variability of the incidence of the Harmattan with regard to the fact that this is governed by a fixed phenomenon, i.e., the "passage" of the sun, was discussed, but no explanation could be offered. The knowledge available with regard to the incidence and forecasting of tornados and line-squalls was detailed and it was found that the main line of investigation was a wider area of wind records.

The Committee framed the following resolution for submission to the Conference :—

"That this Committee recommends wind records to be taken at certain points in the Northern districts of the Colonies to determine the variation in levels of the N.E. and S.W. wind zones."

The Conference allowed this resolution to stand as a finding of the Sub-Committee.

10.—MAJOR METEOROLOGICAL FACTORS GOVERNING THE DISTRIBUTION OF LOCAL PLANT DISEASE—PROGRAMME OF INVESTIGATION.

The meteorological factors concerned were outlined in a memorandum taken from a paper read by C. E. Forster at the Conference of Empire Meteorologists. The Committee, however, felt that, in the absence of any mycologist at the Conference, the question of a programme of investigation could not be dealt with.

The Committee passed the following resolution for the consideration of the Conference:—

“ That collaboration between agricultural meteorologists and mycologists is highly desirable and provision of appropriate instruments at required points should be part of the former officers' duties.”

This resolution was not passed by the Conference, as it was considered that this subject had been covered by Mr. Faulkner's omnibus resolution (given under Item 5).

11.—THE HYGROSCOPICITY OF RAW PRODUCE IN RELATION TO THE ATMOSPHERE.

Mr. Chamney pointed out that this had been dealt with partly under Item 5, but that he had purposely divorced the question of the relation of humidity in the air to storage of produce from that of its relation to produce in the course of preparation. The Committee then discussed the question of adequate drying of produce in some detail especially in regard to correlation between hours of sunshine and quality of resulting produce. The rate of drying appeared to be of prime importance in regard to appearance of the product and mould content.

The Committee passed the following resolution for submission to the Conference:—

“ That the meteorological factors concerned in the drying of produce for export be studied and the optimum conditions found for each crop.”

This resolution was not passed by the Conference, as it was considered that this subject had been adequately dealt with under Item 5.

12.—ARRANGEMENTS PROPOSED FOR ENSURING EXACTITUDE OF METEOROLOGICAL OBSERVATIONS.

Outlined proposals were submitted by *Mr. Chamney* and discussed at length.

The Committee passed the following resolution for the consideration of the Conference:—

“ That this Committee advocates uniformity of exposure of instruments, periodic inspection of stations by a qualified officer and a supply of duplicate instruments at each station to ensure continuous and exact records.”

The Conference did not pass this resolution, as it was considered that the subject had been covered by Mr. Faulkner's omnibus resolution (given under Item 5).

13.—PROBLEMS OF LOCAL METEOROLOGY AWAITING SOLUTION.

Problems awaiting solution in the Gold Coast were submitted, but the Committee did not feel justified in attempting solution.

The Committee framed the following resolution for the consideration of the Conference :—

“ That local problems of meteorology can best be solved by collaboration between officers concerned.”

The Conference allowed this resolution to stand as a finding of the Sub-Committee.

14.—DISCUSSION ON THE EFFECT OF CLIMATIC FACTORS ON THE CHARACTERISTICS OF SOIL.

A summary taken from a paper by *Dr. Martin* submitted to the Conference of Empire Meteorologists was tabled and discussed. It was suggested that, as a certain amount of work was now being done on soils in West Africa, correlation between meteorological factors and soil characteristics in various parts of West Africa was necessary.

The Committee framed the following resolution for the consideration of the Conference :—

“ That accurate meteorological data should be provided to assist soil workers dealing with agricultural problems in the tropics.”

This resolution was not passed by the Conference, as it was deemed to be covered by Mr. Faulkner's omnibus resolution (given under Item 5).

15.—METHODS OF MODIFICATION OF CLIMATE BY LOCALIZED ARTIFICIAL DEVICES.

The question of shade trees, wind-breaks and afforestation were dealt with in regard to modifying the effect of insolation, wind and rainfall. The Committee considered the deforestation of West Africa by the system of shifting cultivation of primary importance and discussed this aspect at length.

The Committee framed the following resolution for the consideration of the Conference :—

“ That this Committee regards with apprehension the diminution of areas under forest in West Africa and advocates the closest study of the change in meteorological conditions with a view to suggesting protective measures.”

The Conference allowed this resolution to stand as a finding of the Sub-Committee.

16.—CO-ORDINATION OF EMPIRE METEOROLOGY BY MEANS OF THE BUREAU SYSTEM.

The following resolution passed at the Conference of Empire Meteorologists on this subject was read and discussed :—

BUREAU OF AGRICULTURAL METEOROLOGY.

“ The Conference has very carefully considered the question of the establishment of a Clearing Station for information on methods and results of agricultural meteorological work. The following existing bureaux already, or will shortly, centralise information regarding the problems of the agricultural meteorological research worker, so far as their respective sciences are concerned, viz., the Imperial Bureaux of Soil Science, Animal Nutrition, Animal Health, Animal Genetics, Entomology, Mycology, Plant Genetics (both general and herbage crops), Agricultural Parasitology and Fruit Production. The bulk of agricultural meteorological research work is probably covered by these bureaux.

At the same time, it would be very convenient if all the information on the subject could be focussed at some one centre. Such centralisation of information with subsequent distribution would be useful both to the agricultural meteorological research worker and also to the worker in pure meteorology, but especially to the latter.

With a view to obtaining experience which will prove useful as a guide to the Imperial Agricultural Research Conference of 1932 in considering the question, this Conference would be glad if the Ministry of Agriculture and Fisheries could develop the work it is already doing in this connection, and could obtain from the existing bureaux and from other sources, information on the methods and results of agricultural meteorological research, and could issue this information regularly to workers in agricultural science and pure meteorological science throughout the Empire.

This recommendation should not be taken as in any way pre-judging the issue for the Imperial Agricultural Research Conference of 1932.”

The Committee framed the following resolution for the consideration of the Conference :—

“ That this Committee endorses the recommendation of the Conference of Empire Meteorologists, 1929, relative to the establishment of a Bureau of Agricultural Meteorology.”

This resolution was allowed to stand by the Conference as an opinion of the Sub-Committee.

XXXII.—INSPECTION AND CERTIFICATION OF EXPORT PRODUCE.

Minutes of meetings held at Head Office, Department of Agriculture, from 16th to 20th October, 1929.

The following members were present :—

Capt. J. M. Wingate, Gold Coast.

Mr. W. R. Hudson, Gold Coast (present at first sitting).

Mr. E. D. Hill, Gold Coast.

The following were absent :—

Delegate from Nigeria.

Delegate from Sierra Leone.

This Sub-Committee regrets that it was not possible for visitors to attend discussions on matters of common interest and express opinions on matters of outside interests on which their views were required.

I.—POSITION REGARDING DEPARTMENTAL INSPECTION OF EXPORT PRODUCE IN THE GOLD COAST.

Cacao and *Palm Kernels* are the only two exports examined at present.

Copra, *Cola* and *Palm Oil* will be examined in the near future.

Cacao Examination and Certification commenced January, 1926. Palm Kernel Inspection commenced in April, 1929. In 1928-29, 235,213 tons Cacao examined and 85,356 samples were taken. Number of Certificates issued to shippers was 2,623 for that period.

Since the inception of Palm Kernel Inspection 2,367 tons have been examined and 117 Certificates issued. Tables of figures showing defects since inception of examination of Cacao and Palm Kernels were given at the request of the Accra and Eastern Province Chamber of Commerce; these figures are not published, as they are regarded as confidential.

TYPES OF CERTIFICATES ISSUED.

Cacao.—I. Certificate of analysis of a specific shipment giving three classifications :—

Form I. General analysis of all defects (used chiefly for departmental use).

„ II. Figures for Liverpool standard.

„ III. Figures for American standard.

2. A "Separate" of any of the above forms.

3. A Report on Cacao in store—issued to owner for guidance as to purity of any particular bulk.

Palm Kernels.—A Certificate giving a general classification of defect.

PORTS OF INSPECTION AND TONNAGE OF CACAO EXAMINED FOR 1928-29.

Accra	...	...	...	...	...	103,289 tons.
Winneba	...	...	...	...	...	26,972 „
Saltpond	...	...	...	...	...	17,685 „
Cape Coast	}	...	...	...	...	9,194 „
Elmina		...	...	...	...
Takoradi	...	...	...	...	...	77,860 „
				Total	...	<u>235,000 tons.</u>

Tonnage examined for 1928-29 equalled tonnage shipped.

STAFF.

Head Office	Superintendent-in-Charge, Plants and Produce Inspectorate.
Accra (Port)	1 Inspector of Plants and Produce. 2 Assistant Inspectors of Plants and Produce. 4-12 Labourers.
Winneba	1 Inspector of Plants and Produce. 1 Assistant Inspector of Plants and Produce. 2-6 Labourers.
Saltpond Cape Coast Elmina	} 1 Inspector of Plants and Produce. 1 Assistant Inspector of Plants and Produce. 2-6 Labourers.
Takoradi	1 Inspector of Plants and Produce. 1 Assistant Inspector of Plants and Produce. 4-10 Labourers.

2.—VOLUNTARY AND COMPULSORY INSPECTION.

A voluntary system is practised in the Gold Coast. The expenditure entailed in examination and inspection is borne by Government.

At first any system of inspection by Government was opposed by merchants, but now that Certificates issued are recognised by insurance companies in England and by manufacturers in Europe and America it would appear that the compulsory system will in time be advocated by the merchants themselves.

Under a compulsory system a revenue would be received from the inspection and this revenue would be sufficient to cover expenditure of inspectorate.

The voluntary system was advisable at first to gain the confidence of merchants and growers.

Under compulsion bags and containers would be sealed, which would add value to Certificates.

The following resolution was made:—

This Committee has gone into the question of inspection both voluntary and compulsory, and is of opinion that to substantially improve the quality of West African exported produce the use of the compulsory system is essential.

In General Sessions, *the Chairman* proposed that this resolution should be submitted as a resolution of the Gold Coast Department of Agriculture, as the method of working had not yet been evolved. *Mr. Stockdale* asked whether the resolution would not be strengthened if it received the support of delegates from other Colonies where compulsory inspection was already in being. *Mr. Faulkner* said he agreed with the resolution, but considered that with compulsory inspection it was essential to establish an advisory committee including merchants' representatives and to extend the scheme from the ports.

The resolution was then amended and passed by the Conference as CONFERENCE FINDING No. 45.

3.—RELATION OF CERTIFICATION TO (a) MARKET STANDARDS; (b) INSURANCE, AND (c) ADVANCE CONTRACTS.

(a) *Market Standards.*

Present grading in Gold Coast conforms to—

- (1) Requirements under American Food and Drugs Act.
- (2) Liverpool Standard of Purity.

So far this standard bears no relation to ordinary market standards.

(b) *Insurance.*

It is understood that Departmental Certificates are being used for insurance purposes. Underwriters in United Kingdom are prepared to insure cacao against rejection into the United States of America on Gold Coast Certificates.

(c) *Advance Contracts.*

A recognised system of produce inspection would appear to be conducive to advance contracts, as certification ensures a standard of quality. Where no system of certification exists contracts made in advance are definitely of a speculative nature. When inspection is controlled by a Government Department it might be conducive to the making of forward contracts.

Forward contracts considerably reduce selling charges, such as storage, inspection, insurance on stored produce and freight.

Any system which would tend to increase the number of advanced contracts made would be advantageous to grower and manufacturer alike. It would be understood by merchants, however, that any Government scheme of inspection and certification has as its main object the improvement in quality of produce exported, but Government could be in no way concerned in matters of arbitration.

The Committee passed the following resolution for the consideration of the Conference:—

This Committee considers that examination and certification of produce for export has definite relationship to (a) market standards, (b) insurance, and (c) advance contracts, and that this relationship is conducive to the improvement in quality of the produce and tends to decrease market charges.

In General Sessions, *Mr. Faulkner* suggested that the words "or sealing" be inserted after the words "examination and certification." This was agreed to.

Mr. Stockdale questioned the suitability of the term "market charges." *The Chairman* quoted as an example of such charges the expenses incurred in reconditioning cacao at Rotterdam for the American market. *Captain Wingate* claimed that a system of certification would reduce market charges since forward contracts would be made, thus obviating charges for brokerage and storage. *Mr. Faulkner* suggested that the words "facilitate market operations" be substituted for the words "decrease market charges."

The resolution was then passed by the Conference, as amended, and recorded as CONFERENCE FINDING No. 46.

4.—F.A.Q. AND F.F.A. MARKET STANDARDS OF CACAO.

The demand for cacao products has increased considerably in the last ten years, but market standards for West African cacao F.A.Q. (fair average quality) and F.F.A. (fair fermented Accra) instituted years ago have not advanced with the times.

It is felt that such an antiquated system of market standards for cacao should be made to conform with the Raw Produce Import Regulations of the various consuming countries in the same way as tobacco, cotton, etc.

The Committee passed the following resolution for the consideration of the Conference :—

This Committee considers that the market standards for cacao F.A.Q. and F.F.A. are totally inadequate and strongly advocates that manufacturers and merchants be communicated with, with a view to having these standards revised and consequently improved.

In General Sessions, *Mr. Findlay* said that this question had arisen in Nigeria, and while on leave he had interviewed brokers and manufacturers with a view to establishing a uniform standard of grading. He discovered that the merchants experience the same difficulty as was found here with regard to classification of purple beans, but that classification depended on the state of the market. Although the standards of the manufacturers and brokers differed slightly they understood each other's requirements and desired no change, but this fact need not deter the Conference from passing the resolution.

Mr. Faulkner considered that according to Liverpool standards the term "Slaty" was loosely used. A purple bean with a good break was passed as well fermented. *The Chairman* quoted, as an example of the confusion obtaining at present, the case of French buyers in Togoland who prefer slathey beans for the manufacture of dark chocolate. *Mr. Fishlock* further illustrated the point by quoting the remarks of a prominent chocolate manufacturer in England that slathey beans were not regarded with such disfavour as weevilly or mouldy beans.

Mr. Findlay proposed that the resolution should be amended, and in this form it was passed by the Conference as CONFERENCE FINDING No. 47.

5.—BEGINNINGS OF PRODUCE (RAW) INSPECTION IN UNITED KINGDOM.

To estimate the amount of deterioration which raw produce must be subject to in the various stages of transport, i.e., from grower to manufacturer, it is necessary to be in possession of accurate data taken at the

various stages of such transport. To achieve this it is evident that a complete history of the produce must be known which would involve:—

- (a) Sampling up-country.
- (b) Sampling at port.
- (c) Sampling at destination.

Granted that a system of sampling is practised up-country and at the ports, there still remains the deterioration which accrues from such primitive methods of shipping such as at Accra, Saltpond, etc., and also to the unsatisfactory method of storage on board ship.

The following resolution was made:—

In order to complete the history of cacao consignments to the United Kingdom, this Committee recommends that an officer be posted to the port of Liverpool to supervise the examination of cacao on arrival at that port and to do the necessary investigational work there.

In General Sessions, *the Chairman* suggested that all West African Colonies could benefit. Under the auspices of the Imperial College of Science, work of this nature had already been commenced on shipments to London, but for the extension of this work to Liverpool shipments another officer would be needed there. An officer at Liverpool could also clear up complaints emanating from shippers and shipping companies.

Mr. Faulkner considered investigational work of this nature was not necessary for Nigerian produce, and that this problem should be left to the Gold Coast Department.

Mr. Stockdale agreed that this was a Gold Coast problem and considered that the work in London covered general requirements. He suggested that in time the Imperial College of Science might extend their scheme to Liverpool. *Mr. Pirie* said that the bulk of Gambia's exports were shipped to Marseilles so that an officer posted at Liverpool would be of little benefit to the Gambia.

The resolution therefore was not accepted by the Conference, as it was decided that the problem was of interest to the Gold Coast alone. The resolution was a finding of the Gold Coast Department and was not a Conference finding.

6.—POSSIBILITY OF ESTABLISHING UNIFORM QUALITY-GRADES IN THE COLONIES.

It would appear that where the four Colonies are producing the same produce and where that produce is marketed in the same countries, some system of unified grading is necessary. Such a system would considerably facilitate the marketing of cacao and in an indirect way assist in the general improvement of quality. It

is well known, however, that mixed parcels always command a price equal to the value of the lowest grade in that parcel, and in some cases the inclusion in an inferior parcel of produce of a higher grade does further reduce the value of that inferior parcel. The establishment of uniform grades would greatly assist in obtaining accurate figures, in this case, from West Africa, for statistical purposes.

In General Sessions, *the Chairman* said that on behalf of his own department he supported the Sub-Committee's resolution, and *Mr. Faulkner* welcomed the proposal.

This resolution was adopted by the Conference as CONFERENCE FINDING No. 48.

7.—COMPARISON OF SAMPLING METHODS EMPLOYED BY THE FOUR DEPARTMENTS.

The method employed in the Gold Coast is as follows :—

Cacao.—A number of samples are taken from every consignment equal to the square root of the total number of bags. Paper No. VI, page 57, of the 1927 Year-book of the Gold Coast Department gives an outline of the investigational work carried out to prove the efficacy of the system. From each sample 100 beans are cut and classified under the headings of Cacao Grading form No. 43. Class I of this form gives all defects, therefore making it possible for one bean to show more than one defect.

To eliminate personal error and speed up the process of cutting and examination, a squared table divided into 102 spaces is used and cut beans are placed in each sub-division. As it is practically impossible to distinguish germinated from ungerminated beans after cutting, the Grading Officer, to ensure accuracy and avoid confusion, places germinated beans on being cut from right to left at the bottom of the rectangle, and all other beans are placed from left to right from the top downwards. When all spaces are occupied with the exception of two it is known that 100 beans have been cut, and the percentage of defects are readily worked out.

Palm Kernels.—A similar number of samples are taken from every consignment (with a minimum of 20). From each sample 7 ozs. are weighed, and percentages of defects determined by weight.

8.—ATMOSPHERIC HUMIDITY IN RELATION TO STORAGE.

The storage question in West Africa, as in most countries, is a very important one. In the past, unfortunately, this question was one which affected merchants alone, but with increased competition in the cacao market the ruling factor must of necessity be quality, and not, as in the past, quantity. In this country, with the exception of Takoradi, where excellent transit sheds can be rented by the merchants, both the up-country and the port storage facilities leave much to be desired. Very little at present is known of the changes in quality which take place in produce under storage in West Africa, and this is especially so in the case of cacao, copra and cola, and to a certain extent in ground-nuts. However, it is thought that

serious deterioration in quality is due to unsatisfactory storage conditions, and with a view to obtaining accurate data the following investigational work has been commenced in the Gold Coast:—

1. Determination of moisture content of cacao—

- (a) On entry into transit shed.
- (b) At intervals during storage.
- (c) When the produce leaves the shed.

2. Determination of air humidity at various levels inside and outside the sheds on the landward and seaward sides.

Six hygrometers, six wet and dry bulb thermometers, and a Brown and Duval moisture tester are used in these investigations.

The Committee's resolution was sanctioned by the Conference as CONFERENCE FINDING No. 49.

9.—EVIDENCE ON DETERIORATION OF PRODUCE ON SHIPBOARD AND RAIL.

In the transport of produce from the producer to the port of destination there is room for much improvement, particularly in regard to road, rail, harbour and shipboard.

Road Transport (Lorry).—Recognised as the most convenient form of collection and delivery, it is operated on a major scale, and in the wet season leaves much to be desired in the protection of the produce from the weather. Beans so wetted in transit absorb a certain amount of moisture, are delivered at concentration centres, where large quantities are handled in limited spaces which do not permit of re-drying. Moulds form and deterioration sets in.

Rail.—Covered-in trucks provide ample protection for produce in transit; damage or deterioration can only arise from the state in which trucks are before loading. These trucks are used for the transport of cement, which might definitely affect cacao transported subsequently. Acetic acid, given off by over-fermented beans, coming into contact with lime dust (cement) causes a white deposit to form on the outside of the bag, which has recently been analysed as calcium acetate. It is not known if this is detrimental to the quality of the produce, but it serves to indicate that all trucks in which produce is to be railed should be thoroughly cleaned before loading.

Harbour. (Surf Boats).—Produce shipped from all ports in the Gold Coast other than Takoradi is subjected to wetting by spray and by the shipment of occasional waves. Subsequent storage in ships' holds not primarily intended for the storage of produce is extremely conducive to the formation of moulds, thereby increasing the humidity of the air and setting up condensation on the ships' bulkheads, with resultant deterioration.

The Committee's resolution was passed by the Conference as CONFERENCE FINDING No. 50.

10.—THE PROBLEM OF UP-COUNTRY CERTIFICATION.

(1) *Quality Prices.*—Small parcels of good quality cacao are usually too small to attract the attention of firms. It is necessary for farmers to co-operate and by bulking their produce in sufficient quantity to attract the attention of European firms and secure a premium for quality.

(2) *To Raise and Standardise Cacao Quality.*—Farmers encouraged to prepare produce in a standard manner would have to bring it to a central drying-ground and store. It is possible that the following improvements would result:—

(a) Better dried cacao less susceptible to mould.

(b) Better storage conditions, less susceptible to weevil attack and to effect of adverse atmospheric conditions.

(c) Produce can be certified by Government Inspectors to gain the confidence of merchants as regards quality and encourage premia on bulked lots.

(3) *To Reduce Unnecessary Expenditure on Cacao Marketing.*—Much time and money is spent by petty buyers collecting small parcels of cacao from widely-spread areas. If buyers could obtain their requirements from suitable centres, such as co-operative societies situated on every road, transport can be effected by motor and considerable time saved. Buyers would not have to lay out large sums to small brokers, but would deal direct with co-operative societies.

The following resolution was passed by the Committee:—

This Committee is of the opinion that in order—

(a) To improve the quality of Gold Coast cacao;

(b) To improve relations between farmers, merchants and Government,

(c) To encourage farmers to secure good value on quality,

(d) To maintain the confidence of merchants as regards to quality,

the establishment of co-operative methods for the preparation of marketing of high grade produce should be vigorously supported by Government.

This resolution was not passed by the Conference, as it was decided that the problem was of interest to the Gold Coast alone. It was allowed to stand as a finding of the Sub-Committee.

11.—LOCAL QUALITY PRICE SCALES.

One of the greatest difficulties of the Department of Agriculture of the Gold Coast, and presumably of the other West African Colonies, is the improvement of cacao quality. It is extremely difficult to persuade a native farmer to make efforts to improve his cacao if such efforts are not met with an increase in price. It would be unfair to expect the buyer to give premia on quality for small lots such as are produced by the average

West African farmer. It would appear that the only solution to this problem is the formation of societies or other bodies where cacao could be bulked in sufficiently large quantities to attract a merchant who is in a position to pay a premium.

The following resolution was made by the Committee :—

In order to stimulate the desire amongst farmers to improve the quality of their produce, this Committee is of the opinion that Departments of Agriculture in the various West African Colonies should co-operate with the merchants and *vice versa* with a view to securing premia for quality, or in other words establishing quality price scales.

This resolution was left by the Conference as a finding of the Sub-Committee.

12.—PROJECTED INSPECTION OF COPRA IN THE GOLD COAST.

The examination and certification of copra has not as yet commenced in the Gold Coast, but a system of sampling has been worked out by the Inspectorate Staff (*vide* Scott's Paper, XXV, page 190, in the 1928 Year-book). The defects taken into consideration are (1) Mould, (2) Insect Larvæ, (3) Immature Pieces, and (4) Extraneous Matter. It is understood that a system of copra examination and certification is practised in other West African Colonies, and it might be to the advantage of this Sub-Committee to discuss methods obtaining therein.

The following resolution was made by the Committee :—

This Committee feels that examination and certification of copra which is in its infancy in West Africa should conform as far as possible to the world's markets standards of the produce.

In General Sessions, *Mr. Sampson* said that the inspection and certification of copra was difficult owing to the fact that good copra, improperly stored, may rapidly deteriorate. *Mr. Fishlock* maintained that if copra is properly dried initially, i.e., to a content of moisture below 7 per cent., any moulds which may subsequently develop are regarded as innocuous by the crushers, who look with disfavour on the black and yellow types found on badly prepared copra.

After further discussion the resolution was re-cast in the following form and accepted as a Gold Coast finding :—

“ This Committee is of the opinion that the question of suitable drying of copra, an industry which is still in its infancy in the Gold Coast, merits further investigation locally and at the port of destination before a system of certification is adopted by the Department of Agriculture.”

13.—METHODS OF SAMPLING AND CERTIFICATION OF PALM PRODUCTS.

There are three groups of defects which cause the value of palm kernels to depreciate:—

- (1) Mouldy, soft and decomposed kernels.
- (2) Insect-attacked kernels.
- (3) Shell, fibre and extraneous matter.

The kernels themselves are fairly regular in shape. A slotted sampler on the lines of cacao samplers, but adapted to dealing with palm kernels, is used in a similar manner to that used in cacao sampling. The primitive method of removing shell by hand necessitates buyers deducting 5 per cent. of the weight of every bag. These pieces form a very heterogeneous collection, and vary so much in size and shape that a method of weighing must be adopted. Experiments used to determine defects are given in full in Paper XXVI of the 1928 Gold Coast Year-book, which go to show that a seven-ounce sample will give a fair indication of the quality.

The following resolution was made by the Committee:—

In the absence of a better system this Committee recommends that this form of sampling and analyses be continued, and in order to bring about a substantial improvement in the quality of palm kernels that examination and certification is made compulsory.

In General Sessions, *the Chairman* suggested that this resolution be accepted as a Gold Coast finding, but asked for the opinions of the delegates from Nigeria and Sierra Leone. *Mr. Faulkner* said that he had no objection to this system if it were used solely for examination, but pointed out that it differed from the system used in the produce inspection scheme in Nigeria. *Dr. Martin* suggested that the phrase "generally accepted system" be substituted for the words "better system."

The finding of the Sub-Committee was redrafted and passed by the Conference as CONFERENCE FINDING No. 51.

14.—MOISTURE PROBLEM OF COLA.

It is understood that a very serious loss occurs in cola from the time of harvesting to arrival in the consuming country, and may be dealt with under two headings.

- (1) Loss up-country in
 - (a) Harvesting mature and immature pods together.
 - (b) Harvesting over-ripe pods (nearly always attacked by weevils or borers).

Investigational work in this direction might produce a more satisfactory method of up-country storing.

- (2) Loss in transit.

The drying-up of the nuts is responsible for a large proportion of the loss in bulk, but the loss from mould must also be considered, as nuts after extraction from the pod are stored in bulk in shallow pits

in the ground and covered with light damp soil to keep them fresh. They are examined from time to time and sprinkled with water. If too much water is added there is a tendency for nuts to develop moulds and decompose. It is imperative that defects due to mouldiness or dryness be eliminated in produce.

The Committee's resolution was combined with that under the next item and passed by the Conference as CONFERENCE FINDING No. 52.

15.—PROPOSALS FOR GRADING AND CERTIFYING EXPORTED COLA.

No system of grading or examination has been worked out for the Gold Coast, but it would seem that grading would depend on the following defects:—

- (a) Nuts too dry.
- (b) Insect-attacked (usually in over-ripe nuts).
- (c) Mouldy or decomposed.
- (d) Immature nuts.

Size and colour of nuts are factors which control sale, and therefore would form a basis for grading. Grading, however, presents difficulties. The industry is entirely in the hands of Africans, principally illiterates, and little accurate information has been obtained on the organisation of the industry. The trade throughout West Africa is in fresh nuts, graded on the farms by the buyer, who pays attention to the following points:—

- (1) Size of nuts (only large nuts are in demand).
- (2) Freedom from mould or weevil.

To maintain freshness each nut is wrapped in a green leaf and packed in baskets in large quantities.

The Committee's finding was combined with that under the previous item and passed by the Conference as CONFERENCE FINDING No. 52.

16.—WORLD'S QUALITY-PRICE SCALES FOR COFFEE.

The supply of coffee is already greater than the demand and prices are controlled by the Brazilian producers to such an extent that coffee prices throughout the world are affected.

The following resolution was made by the Committee:—

In view of the encouragement given to farmers in the Gold Coast, it is recommended that the highest standard should be observed from the start and that measures should be taken to certify and grade accordingly.

In General Sessions, there was considerable discussion, during which *the Chairman* mentioned that at one time there was a subsidy of £5 per acre for established coffee in the Gold Coast. As a clear

definition of quality standards was lacking, the wording of the resolution was altered as follows, in which form it was accepted as a Gold Coast finding :—

In view of the encouragement given to farmers in the Gold Coast, it is recommended that a high standard should be secured from the start and that measures should be taken to carry on preliminary investigations into standards and methods of preparation.

17.—STANDARDISATION OF FRUIT IN PRIMITIVE PEASANT COUNTRIES.

The types of citrus fruits in West Africa are definitely of a high standard. Few would care to suggest that oranges and grape fruit in other tropical and sub-tropical countries can be compared. The West Indies have a definite position in the home fruit markets and are recognised as first-class producers of oranges, grape fruit, limes and mangoes. Produce from a new country is always at a disadvantage in the home markets until it becomes known. It is common knowledge that first impressions go a long way in any new industry. It is therefore sound policy to start such an industry as fruit export on sound grading lines and regulations to ensure that the standard set is strictly maintained. To achieve this end some sort of grading standards are necessary, and a system of marks for such grades must be worked out.

In America an export such as "Sun Kist" oranges is of a very constant high grade, and is understood and recognised as such in the United Kingdom and Europe. A large, trained grading staff is maintained by these firms, but the position occupied in the markets in the United Kingdom and elsewhere more than justifies the expenditure on this work.

The following resolution was made by the Committee :—

Having considered the possibilities of an export fruit trade in West African Colonies and the high quality of West African fruits, this Committee considers that a high standard of grading must exist from the commencement of such a trade and that steps should be taken to ensure that the quality of fruit exported from West African Colonies is maintained throughout.

In General Sessions, both *the Chairman* and *Mr. Stockdale* referred to the difficulties attending the establishment of an export fruit industry for West Africa. The latter stated that the quality of grape fruit would have to be improved before it could compete in the western markets, but suggested that West African oranges might capture the cheaper trade. He cited the banana industry of Jamaica as an example of a successful production of fruit by peasants, at the same time stressing the magnitude of the organisation required for marketing.

18.—EFFECT OF INEFFICIENT CULTIVATION-METHODS ON QUALITY OF PRODUCE.

Taking one or two instances:—

Cacao.—Defects in cacao beans might be materially reduced where their causes are definitely due to lack of cultural measures in the field. The primary causes of defective beans differentiate between those of faulty preparation and those of natural conditions. Better cultivation would produce a smaller percentage of physiological defects, such as under-developed beans, malformed seeds, etc. It is possible that trees bearing nothing but fully developed seed might be obtained by intensified cultivation.

Oil Palm.—Fruit gathered from palms growing in bush are generally small and of low quality. Thinning out, pruning and light tillage have resulted in raising the quality of the produce.

The Committee passed the following resolution:—

The Committee is of the opinion that inefficient cultivation is one of the causes militating against the production of produce of a high quality.

This resolution was recorded by the Conference as a finding of the Sub-Committee.

19.—CULTIVATION RULES AND PLANT PESTS ORDINANCES.

Cultivation Rules.

“Basic Rules for Cacao Farmers,” issued in leaflet form, crystallises the opinion of the Gold Coast Agricultural Department on what is considered the variety of conditions under which crops are grown, and is in such a simple and concise form that it cannot be misunderstood or misinterpreted.

The Committee passed the following resolution:—

This Committee suggests that copies be distributed to literates at every village and also displayed in prominent places about the country in both English and the vernacular of the districts in which it is to be posted.

Plants Pests Ordinances.

The Committee passed the following resolution:—

The Committee is of the opinion that the distribution of rules for cultivation and publications dealing with methods for improving the quality of produce lessens the necessity for an Ordinance.

This resolution was recorded by the Conference as a finding of the Sub-Committee.

XXXIII.—STATISTICS.

Members :

- W. H. Beckett, Gold Coast.
 Capt. J. R. Mackie, Nigeria.
 J. C. Muir, Gold Coast.
 C. L. Skidmore, Gold Coast.
 J. M. Ward, Gold Coast.

I.—AGRICULTURAL STATISTICS.

The following memorandum, referring to the Gold Coast, was submitted by Mr. Beckett :—

A.—SOURCES OF AGRICULTURAL STATISTICS IN THE GOLD COAST.

(a) RAILWAY RETURNS show the monthly tonnage of different agricultural products, on-loaded at each station. In most cases the produce travels coastwards, but there are important exceptions. Figures of total tonnage give a fair but not exact measure of the production of districts. A weekly return of cacao, off-loaded at Accra and Takoradi, serves as a check on the coastward-borne cacao, but the competition of road transport militates against the usefulness of the figures as a measure of seasonal production.

(b) CUSTOMS RETURNS give monthly tonnages and declared values of exported product for each port. With cacao the figures are a direct measure of production, as there is no internal consumption. The monthly figures refer to the tonnage covered by passed export bills of entry during that month, and there may be lag between export and passing of the export bill. In annual figures the frontier exports must be added.

(c) METEOROLOGICAL DATA are collected by the Department of Agriculture and river gauge readings by the Public Works Department.

(d) POPULATION figures are obtained at a decennial census.

(e) YIELD AND COST OF PRODUCTION data are available only from the department's stations.

(f) PRICES of local products are collected by Agricultural and Political Officers.

(g) DATA OF AREA UNDER CROPS do not exist. The new "Lands Department" will, however, in the future be able to produce data as the registration of holdings proceeds.

B.—OUTLINES OF SPECIAL METHODS USED IN THE GOLD COAST.

(a) GATE CHECKS.—Temporary officers are posted in the producing season at points, and keep records of the weights of produce passing (either head load or lorry borne).

(b) FERRY CHECKS.—At two ferries—Senchi, on the River Volta, and Prahso, on the River Prah—temporary officers are posted throughout the year. Returns are received for other ferries from the contractors working these ferries.

(c) THE MOVEMENT OF ANIMALS is recorded at the Veterinary Department quarantine ports.

(d) CROP DISTRIBUTION SURVEYS.—Compiled from observations of officers travelling in districts, and statistical returns. Examples are given by ¹Miles and ²Auchinleck and Chamney in the 1928 Year-book.

(e) AREA DEVELOPMENT SURVEYS.—A survey has been made of the ³Rice Area in the Western Province of the Colony; in the Western Province of ⁴Ashanti a survey of cacao and kola has been made; surveys of coconuts in the coastal strip of the Eastern Province, and a general survey in the Western Province for purposes of railway development are in progress.

The general method adopted has been for a staff of overseers to collect from each village the required statistics under the supervision of a European officer. A description is given in ⁵Muir's paper on "Crop Surveys, Gold Coast."

(f) SURVEY OF MINOR INDUSTRIES.—Two examples of these are given in the 1928 Year-book: a paper by ⁶Coull referring to the Northern Territories and a paper by ⁷Martinson on the "Local Edible Snails."

(g) THE PRICES OF LOCAL FOODSTUFFS and cost of living are obtained from public institutions such as prisons and Government schools.

CAPT. MACKIE gave an account of the methods used in Nigeria, where no special division exists for statistical work, as the department has a different organisation. The function is performed by the office of the Assistant Director. In Southern Nigeria the working of the produce-inspection scheme supplied statistics of distribution, total production, quality of produce, and was used for collection of other statistics. The collection of statistics was a purely secondary function entailing no extra expenditure, but producing statistics, which, in direct collection, would require expensive machinery. In the north the Cotton Market Scheme kept track of that industry.

The Sub-Committee felt that it was impossible to draw up resolutions common to the four West African Colonies, in virtue of the difference in the organisation of the separate departments, on the question of statistics of yield, prices, area, etc. It was wished, however, to record the following opinions:—

(a) CROP MOVEMENTS.

"A system of produce inspection at the points of production as in force in Nigeria is capable of providing many of the statistics required concerning crop movements."

(b) RIVER GAUGE READINGS.

"That a study should be made of the relation between river gauge readings, rainfall, and crop production where data are available."

1. Geographical Distribution of Principal Local Crops	Miles, 1928 Year-book.
2. Provisional Maps, Distribution of Cacao, 1927	Auchinleck and Chamney, 1928 Year-book.
3. Survey of Rice Areas in Western Province	Robb, 1928 Year-book.
4. Western Province of Ashanti Crop Survey	Muir (laid on the table).
5. Crop Surveys, Gold Coast	Muir, Conference Paper.
6. Minor Industries in the Northern Territories	Coull, 1928 Year-book.
7. The Edible Snail Industry	Martinson, 1928 Year-book.

(c) DECENNIAL CENSUS.

“ That steps should be taken to procure an amended classification in the decennial census, so as to show the actual numbers of farmers and other agricultural workers in the various centres.”

(d) YIELD AND COST OF PRODUCTION.

“ That the method used in Nigeria whereby an officer attached to an experiment station observes farms in the vicinity, meets the case. In the Gold Coast some special device is necessary.”

(e) LOCAL PRICES.

“ That collection of data is essential.”

(f) AREA.

“ That indirect methods only are generally possible but yield valuable information.”

(g) GATE AND FERRY CHECKS.

“ That such checks have given useful information and that useful information is produced by a complete produce inspection scheme at points of production.”

(h) SURVEYS.

“ That a complete survey may be justifiable for a definite purpose, but that for collecting information of total production and distribution a system of checks, together with an intelligent allocation of produce checked, is more rapid and less expensive.”

In General Sessions, *Mr. Beckett* explained that although the organisation employed for this purpose might differ in the various Colonies, it was highly desirable that the data should be in a readily available form.

The Committee's resolution was passed by the Conference as CONFERENCE FINDING No. 53 and the Committee's findings (a to h above) were allowed to stand as expressions of opinion by the members of the Committee.

2.—CROP FORECASTS.

Mr. Beckett submitted the following memorandum:—

NECESSITY FOR EXACT ANNUAL ISSUE OF FORECASTS OF CACAO CROP IN THE GOLD COAST.

(a) DIFFICULTY OF ANY CENSUS METHOD.—In the Gold Coast a very large percentage of the farmers are illiterate, and the application of any census method is impossible. At present we have only tentative estimates

of the area under cacao, the distribution of age-classes of trees throughout the area, the normal yield per acre under native farming conditions, or the relation between the produced, marketed and exported tonnages, and the lag between them.

(b) RAINFALL CROP CORRELATIONS have not been exhaustively explored. ¹Chamney has shown that a low April rainfall and high October rainfall are correlated with high yields. ²Maidment traced correlation between deviation of the April rainfall from 6 inches, and the earliness and duration of the crop at Kumasi and Aburi. ^{3, 4}Hewison suggests positive correlation between the heaviness of the September and October rainfall and the pod value (reciprocal of pods per lb. dry weight), and negative correlation between pod value and percentage loss from disease. ⁵Skidmore worked out the order of the correlation between the average monthly distributions of crop and rainfall, which correspond to a lag of five or six months.

(c) POD GROWTH CURVES.—⁶Hunter made photographic observations of the development of the cacao pod, and published with Waters an account of the time growth factor.

With this data a cacao crop precision using $\frac{1}{10}$ acre OBSERVATION PLOTS, and monthly pod counts in size classes, is being tried out this season by the ⁷Statistical Division of the Gold Coast Department. The radius of application of data (forecasts) from these plots requires investigation. A statistical analysis of the first complete season's record should produce a workable precision scheme, and also provide other useful data.

(d) TONNAGE INVESTIGATIONS.—⁸Miles gave a smooth curve using five years periods of Customs Export Returns showing the average annual increase due to planting up. Calendar years are used. ⁹The seasonal year (October-September) curve has been worked out, but not yet published. The curve of actual production cannot be produced, as no statistics of stocks held are obtainable from the merchants.

¹⁰Broatch worked out the average lag by taking production monthly percentage from agricultural stations and monthly Customs Returns, and ¹¹Waters summarised the available data and estimated the stocks held, using September as an arbitrary zero (excluding previous years' overlap).

¹²Auchinleck prepared standard monthly percentages distribution curves from the department's records on stations, and there is evidence of their applicability to the districts in parallelism with nearby railway station tonnage.

After a full discussion the following resolution was made by the Committee :—

That in view of the importance of the Gold Coast cacao crop, accurate information of crop prospects is desirable and the work should be further developed.

1.	Climatology of the Gold Coast. Plate VII...	...	...	Chamney, Bulletin 15, Gold Coast.
2.	Correlation between Rainfall and Cacao Yields ...	...	...	Maidment, 1927 Year-book.
3.	Fluctuation between Number of Pods and Weight of Cacao...	...	...	Hewison, 1928 Year-book.
4.	Variation in % Crop lost through Disease ...	...	...	Hewison, 1928 Year-book.
5.	Correlation between Rainfall and Number of Pods ...	...	...	Skidmore, 1928 Year-book.
6.	Rate of Development of Cacao Pods ...	...	...	Waters & Hunter, 1928 Year-book.
7.	Observation Plots ...	...	...	Division of Statistics (laid on table).
8.	Curve of Increase of Production ...	...	...	Miles & Muir, 1928 Year-book.
9.	Graph of Seasonal Exports ...	...	...	Waters (laid on table).
10.	Lag between Harvesting and Export ...	...	...	Broatch (laid on table).
11.	Forecasting Production and Export ...	...	...	Waters (Conference Paper).
12.	Standard Distribution Curves ...	...	...	Auchinleck (laid on table).

In General Sessions, *the Chairman* said that as this finding affected the Gold Coast only, it would be recorded as an opinion of the Gold Coast Department of Agriculture.

The Sub-Committee did not feel it incumbent to put up a scheme, as it is bound up in the internal organisation of a department. It felt, however, that unless a scheme was sufficiently complete to enable accurate forecasts to be got out, publication was unwise.

A further resolution was made by the Committee :—

That the whole question of cacao weather relation requires further detailed study and necessitates a cacao investigational station in the heart of the cacao belt in the Gold Coast.

The Conference agreed to this finding being recorded as an expression of the opinion of the Sub-Committee.

3.—AERIAL SURVEYS.

The usefulness of aerial surveys in defining crop areas was recognised, but in the case of the West African Colonies would be prohibitive in expense in the absence of suitable landing grounds.

The Committee passed the following resolution :—

Aerial surveys are at present impracticable locally, but the subject should be brought up at the Australian Conference in 1932, and the question of an imperial fund for financing the aerial surveys of the Colonial Empire be discussed.

In General Sessions this was fully discussed and several amendments suggested. The Conference finally adopted the form recorded as CONFERENCE FINDING No. 54.

4.—SAMPLING METHODS.

The following memorandum was submitted by Mr. Beckett :—

FORECASTS OF OTHER CROPS.

(a) SAMPLING METHODS FOR ANNUAL CROPS.—Several systems used in India have been described by ¹Hubback. For rent, payment in rice land, a system whereby the landlord cut a small area where the crop was heaviest, and the tenant where crop was thinnest, was used to produce a "fair"

1. Sampling for Rice Yields Hubback, Bulletin 166.

sample. The "average" here is the arithmetic mean of the extreme points of the range, and unreliable. Another system was for an officer to choose an "average" field, and about $\frac{1}{10}$ acre was cut from it. This depended on the ability of the observer to select the average yield. The system worked out by Hubback entailed samples of $\frac{1}{300}$ acre being taken, using an equilateral triangle of $67\frac{1}{4}$ inches sides. The triangle was defined by a block of wood with guides and wooden battens. Samples were taken from as many farms as possible in the day, and the observer worked from a centre and went out on four consecutive days to the four points of the compass respectively.

¹Bailey and Trought in Egypt investigated the usefulness of selected average plants and found that varieties could be arranged in order of yield with precision, but actual yield figures were not possible.

²Clapham, at Rothamsted, investigated the values of series of systematic and of random samples in estimating the plot yields in cereals, and found that the random arrangement was effective. The variance due to sampling errors could be kept a satisfactorily small fraction of the total variance of $\frac{1}{10}$ acre plots.

Engledow suggested collecting precision data, as in ³this census work with cereals, from different points in each district, by taking samples and taking statistics at certain stages in the development history of the plant.

For Discussion—Methods applicable to West Africa.

The items in the memorandum were discussed and the use of the seed supply as a means of forecasting the cotton crop in Nigeria described by *Capt. Mackie*.

This finding of the Committee was approved by the Conference as CONFERENCE FINDING No. 55.

5.—PUBLICATION OF CACAO STATISTICS.

In General Sessions, *Mr. Beckett* affirmed that there was not available in English a complete regular report on cacao production. *Mr. Faulkner* said that such information, when required, could be obtained from the merchants.

The wording of the original finding of the Committee was altered and passed by the Conference as CONFERENCE FINDING No. 56.

6.—OXFORD ECONOMIC SURVEYS.

The following memorandum was submitted by J. M. Ward :—

The idea of utilising Agricultural Surveys to collect dependable information for relevant studies on the economics of farming committees is comparatively new. Bailey's survey in New York State in 1906 may be taken as the first. In Great Britain the first survey was not made by the A.E.R.I. at Oxford until after 1913. Whether it is at all applicable to primitive peasant production in the Tropics is debatable, and remains to be proved.

1. Experiment Error in Field Trial with Cotton	...	...	Bailey & Trought, Bull. 63, Pusa, Egypt.
2. Estimation of Yield and Cereals	...	...	Clapham, J.A.S., XIX.2
3. A Census of an Acre of Corn (by sampling)	...	...	Engledow, J. A. S., XVI.

The principles underlying agricultural surveys may be stated briefly :

- (1) Individual farmers do know a good deal about their own businesses.
- (2) The survey method is a means of obtaining such information by personal visits, interrogation and observation.
- (3) There must be uniformity of method in gathering and classifying information.

(4) Reliance is placed upon the farmer's memory in the aggregate; and the average of a number of similar observations.

The accuracy of an average depends upon:—

- (a) The number of observations.
- (b) The accuracy of individual observations.
- (c) The absence of bias.

(5) Averages give a basis for comparison.

Details of results obtained by the survey method are given in the publications of the A.E.R.I., Oxford. It suffices here to say that after classification into various simple divisions, size of farm, type of farm, number of persons employed, production of farm, and appropriate translation many useful and illuminating relations emerge. In consequence it is suggested that until definite knowledge is acquired of the economic position of the peasant farmer of the West Coast, of the different apportionment of land, labour and capital in the varyingly successful farms of the one type, and in farms of different types, the Agricultural Departments are not utilising all the means at their disposal for fulfilling their obligations as advisory bodies.

In other countries agricultural surveys have proved themselves efficient machines for collecting such knowledge, and the method should be tried in West Africa.

Although it is the most rapid method of accumulating accurate and comparative information of the organisation of farms or agriculture in an area, nevertheless production of results must be slow. In our peasant-producer countries the size of farms is small, their numbers large, officers comparatively few, farmers round-about in their speech.

The accuracy of the method depends on numbers. Little can be shown for solid work till hundreds of farms have been examined. The interpretation of results—the object in view—is the last stage of a survey.

Lastly, there remains the most powerful impediment: For a system whose strength lies so much in the personal factor, and places such reliance on suitable interrogation, the impediments in the way of surveys in countries where the investigator and the farmer speak with different tongues, are obvious.

This difficulty and that of the restricted number of officers might be mitigated, to some extent, through the agency of such organisations as Co-operative Societies.

The Sub-Committee's opinion was passed by the Conference as CONFERENCE FINDING No. 57.

7.—WORLD AGRICULTURAL CENSUS, 1930.

Mr. A. C. Miles submitted the following memorandum:—

In connection with the above, which has been promoted by the International Institute of Agriculture, the Secretary of State for the Colonies has requested the Governments of British West Africa to make

every effort to supply the fullest information available. In addition, instructions were given for the census returns to be supplied simultaneously to the Empire Marketing Board, London.

The questionnaire prepared by the International Institute calls for more details of information than are available in any of the British West African Colonies. Since it is impossible to comply with the requirements of the Institute, it is suggested that we adopt a more or less uniform method of submitting such information as is available. In the past we have furnished the Institute with particulars of agricultural produce exported, merely giving the total tonnage as recorded in the official "Blue Book."

It is thought that we might add some further details for the purpose of the 1930 Census, and in this connection estimated acreage of crops might be quoted. While admitting estimates are not called for in the questionnaire, they would be of some value providing the Institute is advised that the areas are estimated. Such information would also be appreciated by the Empire Marketing Board.

If such information were prepared in connection with the more important exports, it would serve a useful purpose as being a basis for future calculation. Estimates could be corrected or adjusted from time to time, and when the next census becomes due much reliable information would have accumulated.

As the result of crop surveys in cacao areas we are able to estimate the acreage under that crop with a reasonable degree of accuracy. Based on the knowledge obtained from the surveys, we are able to estimate the approximate area under cacao cultivation throughout the Gold Coast.

It would be more difficult to estimate the area under oil palm in the Gold Coast. Owing to the neglect of this crop of late years for exportable products, the total exported would afford no indication of the probable acreage under palms. It is possible, however, to ascertain the approximate extent of distribution, and thus calculate the probable acreage.

The question of live stock and poultry is not discussed, as it is assumed those subjects will be undertaken by the Veterinary Departments.

The suggestions contained herein are open to numerous objections, and it is admitted that we have no apparent means of checking the accuracy of the estimated acreages. Since we are expected to make some effort to obtain additional data, the West African Conference affords a splendid opportunity for discussing the subject and arriving at a definite decision as to what shall be undertaken, and the form in which the information shall be submitted to the International Institute of Agriculture.

The Conference accepted the opinion of the Sub-Committee on this subject as recorded in CONFERENCE FINDING No. 58.

8.—FIELD EXPERIMENT.

The papers submitted to the Conference were discussed.

"Field Experiment in West Africa," by Faulkner and Mackie.

"Randomization in Field Experiment," by W. H. Beckett.

(See Papers III and IV, Bull. 20, Dep. Agr., Gold Coast.)

Captain Mackie observed that there seemed little difference between the general ideas expressed in the two papers. The argument was not that randomization was wrong, but that for certain

conditions, certain methods achieved the result. The Nigerian experiment had to provide economic data as well as scientific, large differences only were of importance at the present stage of development, and Faulkner's method was a successful one, used for purposes for which it was designed. The claimed advantage of greater reliability of estimates of error in random methods, though probably a real one, was not of sufficient order to merit a change in a complete system.

Mr. Beckett expressed his appreciation of the Nigerian system, which he had been able to study on the spot, but considered that it might be further improved by introducing randomization. The theory of randomization was being increasingly accepted by field experimenters, the chief retarding factor being misunderstanding of the application or randomization to their particular conditions. Randomized methods did not upset comparisons by eye, the working out of results could be done by trained African staff, only the same care in the field as in any other system was necessary, and the failure to take advantage of correlation between neighbouring plots was a direct gain, as often the correlation between adjacent plots was less than between plots further apart, and indeed sometimes negative correlations were found.

After a general discussion, the Sub-Committee did not feel competent to discuss the underlying mathematical theory nor to frame a general resolution. The subject had already been discussed in General Sessions (*see* Section IV).

9.—MR. STOCKDALE'S LETTER RE I. A. R. CONFERENCE IN AUSTRALIA, 1932.

As a Committee dealing with statistics, no resolution was put forward.

The Committee expressed the opinion that:—

“ Much time is lost in investigation along wrong lines through not knowing exactly what the merchant wants : that more information is required on the subject of quality from the merchant's point of view, and that some machinery should be set up to elicit this information and publish it.”

This finding was allowed to stand by the Conference as an expression of opinion on the part of the Sub-Committee.

PART D.

APPENDICES.

APPENDIX A.

LIST OF OVERSEAS DELEGATES TO THE SECOND WEST
AFRICAN AGRICULTURAL CONFERENCE, 1929.

UNITED KINGDOM.

- F. A. Stockdale, C.B.E., M.A., Agricultural Adviser to the Secretary
of State.
H. C. Sampson, C.I.E., B.Sc., Economic Botanist, Kew.

NIGERIA.

- O. T. Faulkner, C.M.G., B.A., Director of Agriculture.
A. J. Findlay, M.A., B.Sc., Assistant Director of Agriculture.
J. R. Mackie, B.Sc., Assistant Director of Agriculture.
C. J. Lewin, B.Sc., M.C., Senior Botanist.
W. B. Dowson, B.Sc., Superintendent of Agriculture.
H. G. Poynter, Superintendent of Agriculture.
K. T. Hartley, M.A., B.Sc., Chemist.

SIERRA LEONE.

- F. J. Martin, M.A., Ph.D., F.I.C., Acting Director of Agriculture.
E. Hargreaves, A.R.C.S., F.E.S., Entomologist.

GAMBIA.

- J. Pirie, Acting Director of Agriculture.

APPENDIX B.

LIST OF REPRESENTATIVES FROM THE GOLD COAST.

FORESTRY DEPARTMENT. Attended the Conference
at—

H. W. Moor, *Asst. Con- Accra.*
servator.

DEPARTMENT OF AGRICULTURE.

Headquarters Staff .. G. G. Auchinleck, M.Sc., Accra, Kumasi,
F.I.C., *Director.* Sekondi.
H. B. Waters, B.A., Accra, Kumasi,
Dep. Director. Sekondi.

APPENDIX B—*continued.*LIST OF REPRESENTATIVES FROM THE GOLD COAST—*continued.*

		Attended the Conference at—
Botanical Division ..	T. Lloyd Williams, B.A., A.I.C.T.A. A. S. Thomas, B.Sc., A.I.C.T.A.	Accra, Aburi, Sekondi. Accra, Aburi, Sekondi.
Chemical Division ..	R. Coull, B.Sc. ..	Kumasi.
Clerical & Finance Division.	J. M. Dunbar	Accra.
Entomological Division	G. S. Cotterell, A.R.C.S., D.I.C., F.E.S.	Accra, Aburi, Sekondi.
Experiment Stations—		
Tamale	J. E. Symond, A.I.C.T.A.	Kumasi, Sekondi.
Kpeve	H. K. Hewison, A.I.C.T.A., F.L.S.	Kpeve.
Asuansi	E. M. Cook, M.S.E.A.C.	Asuansi.
Atwabo	W. C. Fishlock	Sekondi.
Accra (Sisal) ..	H. E. Green	Accra.
Esiama	H. L. Hill C. L. Skidmore, B.Sc. .. J. T. H. Stein, B.Sc. .. J. M. Ward, N.D.A. ..	Esiama, Sekondi. Accra. Accra. Accra.
Extension Work ..	G. C. Coull, B.Sc. ..	Kumasi, Sunyani.
Horticulture	S. T. Phillips	Aburi, Accra.
Inspectorate	J. M. Wingate, A.I.C.T.A. W. R. Hudson L. J. Packham, A.R.C.S.I., N.D.A. E. W. A. B. Sam, B.Sc. E. D. Hill D. V. Parkes F. Pyatt	Accra, Sekondi. Accra, Kpeve, Sekondi. Sekondi. Accra. Kumasi, Ejura. Accra.
Publications & Meteorology.	N. P. Chamney, B.Sc. . .	Accra.
Rural Economics ..	A. W. Paterson, N.D.A., N.D.D. (Hons.).	Accra.
Statistics & Surveys ..	W. H. Beckett, M.A. .. J. C. Muir, B.Sc. .. J. D. Broatch, B.Sc. .. J. S. Martinson. . .	Accra, Sekondi, Axim. Accra. Sekondi. Asuansi.
Training Centre ..	H. Nicholas, B.A. .. W. T. O. Maidment, B.A. B. T. Steemson, B.A. ..	Kumasi. Kumasi. Sekondi.

APPENDIX C.

LIST OF PAPERS PRESENTED.

(Published in Bulletin No. 20, Dep. Agr., Gold Coast.)

Paper No.		
I.	The Colonial Advisory Council of Agriculture and Animal Health and the Imperial Agricultural Bureaux.	F. A. Stockdale (Colonial Office).
II.	Economic Botanical Work, Kew ..	H. C. Sampson (Royal Botanic Gardens, Kew).
III.	Field Experiments in West Africa ..	O. T. Faulkner and J. R. Mackie (Nigeria).
IV.	Randomization in Field Experiment and its application on Experiment Stations in the Tropics.	W. H. Beckett (Gold Coast).
V	Kpeve Investigational Station.. ..	H. K. Hewison (Gold Coast).
VI.	Need for further Research facilities in West Africa. Proposal for a Research Station for Oil Palms and Lateritic Soils.	F. J. Martin (Sierra Leone).
VII.	Notes on West African Soils	F. J. Martin and H. C. Doyne (Sierra Leone).
VIII.	Forestry in relation to Agriculture in the Gold Coast Colony and Ashanti.	J. R. P. Gent (Gold Coast, Forestry Dept.).
IX.	Deforestation in the Bissa Cacao Area ..	H. W. Moor (Gold Coast, Forestry Dept.).
X.	Inspection of Produce in Nigeria ..	A. J. Findlay (Nigeria).
XI.	Produce Inspection in Sierra Leone ..	F. J. Martin and G. Tuach (Sierra Leone).
XII.	*Inspection and Certification of Cacao on the Gold Coast.	A. B. Culham (Gold Coast).
XIII.	Forecasting the Production and Export of Cacao from the Gold Coast.	H. B. Waters (Gold Coast).
XIV.	The occurrence of <i>Sahlbergella</i> spp. and other Pests of Cacao in Fernando Póo, San Thomé and the Belgian Congo.	G. S. Cotterell (Gold Coast).

* By request of the Accra Chamber of Commerce, this paper has not been published.

APPENDIX C—*continued*.LIST OF PAPERS PRESENTED—*continued*.

Paper No.			
XV.	Crop Surveys, Gold Coast	.. ..	J. C. Muir (Gold Coast).
XVI.	The Oil Palm at Calabar	.. ..	E. H. G. Smith (Nigeria).
XVII.	Improvement of Small Press Process for Palm Oil Extraction.		D. Manlove and W. A. Watson (Nigeria).
XVIII.	A brief note on the Progress of Oil Palm Investigations in Sierra Leone.		D. W. Scotland and F. J. Martin (Sierra Leone).
XIX.	Statement on Oil Palm Investigational Work in the Gold Coast.		T. L. Williams (Gold Coast).
XX.	A Banana Industry for the Gold Coast	..	W. C. Fishlock (Gold Coast).
XXI.	The Prospects of a Fruit Export Industry in Sierra Leone.		D. W. Scotland and F. J. Martin (Sierra Leone).
XXII.	A Fruit Industry for the Gold Coast	..	G. H. Eady (Gold Coast).

APPENDIX D.

TIME TABLE AND ITINERARY.

16th October	<i>All Visiting Delegates arrived at ACCRA.</i>
17th October	Opening General Session. Meeting of Board of Agriculture.
18th October	Administrative Committee visited KPEVE, Entomological to Committee visited ASAMANKESE and ABURI, and
20th October.	remaining Delegates visited ABURI.
21st October	<i>Conference moved to KUMASI.</i>
22nd October	Second General Session.
23rd October	Administrative Committee visited EJURA, and remaining to Delegates visited SUNYANI.
24th October.	
25th October	Third General Session.
26th October	<i>Conference moved to SEKONDI.</i>
28th October	Administrative Committee visited AXIM, ESIAMA, and to BUTRE (palm oil mill).
29th October	All Delegates visited TAKORADI.

APPENDIX D—*continued.*TIME TABLE AND ITINERARY—*continued.*

- 29th October Fourth General Session.
 30th October Fifth General Session.
 Final General Session.
 31st October Delegates for Sierra Leone and Gambia sailed. The remaining Delegates left for ACCRA (staying at ASUANSI for one night, and visiting ABAKRAMPA—lime juice factory—en route) and sailed for Nigeria on 5th. November.

Only the principal items of the time table are given above. The times of meetings of Sub-committees are not included, nor are local visits. The following places of interest were visited :—

- From Accra .. Accra Sisal Plantation and Factory.
 Achimota College and Farm (by kind permission of the Principal).
 Kpeve Investigational Station.
 Asamankese Entomological Field Station.
 Aburi Botanic Gardens.
- From Kumasi .. Kumasi Training Centre—Cadbury Hall.
 Kumasi Investigational Station.
 Ejura.
 Sunyani.
- From Sekondi .. Axim.
 Esiama Rice Factory and Farm.
 Coconut Plantation of Kofie Ampoe II (Chief of Esiama).
 Butre Palm Oil Factory (by kind permission of Palm Oil Estates Managers, Ltd.).
 Takoradi—Examination of Produce.
 Railway Workshops, Sekondi (by kind permission of the General Manager, Gold Coast Railways).
- En route Sekondi to Accra. Asuansi Experiment Station.
 Asuansi Trade School (by kind permission of the Director of Education).
 Abakrampa Lime Juice Factory (by kind permission of the Manager, Messrs. Rose and Co., Ltd.).
-

INDEX.

	PAGE
Adco trials	62
Address of His Excellency the Governor	1
Adjournment	26
Administrative committee	25, 45
Aerial surveys	44, 93
Agricultural association	27, 45
" bureau. <i>See</i> Bureau.	
" census, World	44, 91, 95
" chemistry	34, 60
" conferences. <i>See</i> Conferences.	
" economics	35, 63
" " , cacao farming	9
" education	45
" entomology	36, 64
" industries, factors affecting	35
" meteorology. <i>See</i> Meteorology.	
" Service. <i>See</i> Colonial.	
" statistics	43, 89
Asexual propagation of perennial crops	31, 57
Association of agricultural workers	27, 45
Banana. <i>See</i> Fruit.	
Botanical Congress, World's	59
" effort, Co-ordination of	33, 60
Botany. <i>See</i> Economic Botany.	
Breeding cacao	30, 54
" cotton	57
Bureau, Imperial Agricultural, for agricultural economics	64
" " " " economic botany	30
" " " " meteorology	75
" " " " of soil science	30
Bureaux, Imperial Agricultural	2, Vol. II 11
" " " " , relations with	53
Cacao, Asexual propagation of	31
" Basic rules for farmers of	88
" botanical work	33
" breeding	12, 30, 54
" crop forecasting	13, 91, Vol. II 141
" crop surveys	Vol. II 172
" cultivation methods and quality	88
" " trials for <i>Sahlbergella</i> control	37, 66
" Deforestation in the Bissa area	Vol. II 125
" Forestry and	7, Vol. II 121, Vol. II 125
" inspection	76
" Intensity of light in plantations of	32, 57
" Kpeve investigational station	Vol. II 79
" manurial trials, for <i>Sahlbergella</i> control	37, 66
" Market standards of	42, 79
" Moth in stored	40, 66
" pests in Fernando Póo, San Thomé and Belgian Congo	Vol. II 162
" quality	83, 88
" red, Indicator properties of	62
" rejuvenation	12
" sampling methods	81
" statistics, Publication of	44, 94
" Weevil in stored	40, 66, 67
" Witchbroom disease on	29, 52
Cassavas, HCN content	61
Census, World Agricultural	44, 91, 95
Central research station	34, 47, 49, Vol. II 94
Certification of produce. <i>See</i> Produce inspection.	
Chemical control of milling	62
Chemistry	34, 60
Citrus fruit-piercing <i>I. epidoptera</i>	38, 66

	PAGE
Climate factors and principal crops	41, 69
" " " soil characteristics	74
" " " modification by artificial devices	74
Coffee alkaloid content	61
" propagation asexually	32
" quality	86
Cola marketing	43, 86
" moisture problem	85
" propagation asexually	32
" weevil and fly	38, 66
Colonial Advisory Council of Agriculture and Animal Health	2, 29, Vol. II 8
" Agricultural Service	2, 3, 49
Committees, Reports and findings of	25
Conference, First West African Agricultural	50, 60, 64
" Imperial Agricultural Research. <i>See under Imperial.</i>	
" Imperial Entomological	36, 65
" of Directors of Agriculture	29, 50
" of Empire Meteorologists	75
Congress, World's Botanical	59
Co-operative Societies	18, 21, 24, 35, 36, 83
Copra inspection	23, 84
Cotton stainer	31, 38, 57, 66
" trials in the Gold Coast	54
" " " Kpeve investigational station	Vol. II 86
Crop pests. <i>See Insect pests.</i>	
Cultivation methods and quality of produce	88
" rules	88
" trials for <i>Sahlbergella</i> control	37, 66
Drainage	61
Economic botany	30, 54
" " " Kew	4, Vol. II 13
Economics	9, 35, 63
Effective rainfall	71
Empire Marketing Board	30
Entomology, Agricultural	36, 64
<i>Euphorus</i>	37, 65
Experiment. <i>See Field experiment.</i>	
Extension work	30
Fertilisers ordinance	62
Field experiment	4, 96, Vol. II 18, Vol. II 25
Financing	36
" <i>See also</i> Co-operative societies.	
First West African Agricultural Conference	50, 60, 64
Food crops	11, 32, 58
" " " Kpeve investigational station	Vol. II 91
Forecasting the cacao crop	13, 91, Vol. II 141
Forestry	6, Vol. II 119, Vol. II 125
Fruit export	45, 87
" " " Bananas for the Gold Coast.	Vol. II 224
" " " from Sierra Leone	Vol. II 239
" " " industry for the Gold Coast	Vol. II 255
" piercing <i>Lepidoptera</i> on Citrus	38
General sessions	I
" " <i>See also</i> Discussions in 45-97.	
Grading of produce. <i>See Produce.</i>	
Grasses, Local	33, 59, 61
Handbook on local crop pests	36, 65
His Excellency the Governor, Sir Ransford Slater	I
Humidity in air and moisture in produce	70, 73, 81
Hygrosopicity of raw produce	73
Imperial Agricultural Bureaux	2, Vol. II 11
" " " <i>See also</i> Bureau.	

INDEX—continued.

105

	PAGE
Imperial Agricultural Research Conference, 1932	8, 27, 29, 30, 36, 44, 53, 64, 75, 97
" Entomological Conference	36, 65
Importation of fertilisers	62
" of plants, Regulations for controlling	59
Insect pests, Affinities of local crop	40, 68
" " , Artificial control of	40, 68
" " handbook	36, 65
Inspection and certification of produce	20, 42, 75
" " " " " " See also Produce inspection.	
Intensity of light	32, 57
Invitation to Sierra Leone for 1931	26
Irrigation	45
Kew, Bureau of Economic Botany	30, Vol. II 13
" " Royal Botanic Gardens	4, Vol. II 13
Kpeve Investigational station	Vol. II 75
Land tenure	36
Lateritic soil	35, 63, Vol. II 108
" " investigations in Sierra Leone	47, Vol. II 94
Light, Measurement of	57
Lime juice factory, Messrs. Rose's	18, 102
Limes, Chemical control of milling	62
Manurial trials for <i>Sahlbergella</i> control	37, 66
Marketing	36
Measurement of light	57
Meteorology	41, 68
" and distribution of plant diseases	72
" " forestry	7
" " , interchange of records	41, 69
Meteorological observations—measures for exactitude	73
" problems awaiting solution	74
" stations	41, 68
Milk, composition of	61
Moisture in produce and humidity in air	70, 73, 81
Mycology	45
Nut-cracking machinery	15
Oil palm at Calabar	16, Vol. II 181
" " botanical work	16, 34
" " fruit, Chemical control of milling	62
" " industry	15
" " , Intensity of light in plantations of	32, 57
" " investigations	27
" " " in Sierra Leone	47, Vol. II 94, Vol. II 213
" " " in Gold Coast	Vol. II 217
" " varietal plots	33
" " See also Palm kernels, Palm oil, Palm products, Palm sap.	
Ordinance, Fertilisers	62
" " , Plant pests	40, 68, 88
Oxford economic surveys	44, 94
Palm kernel inspection	76, 85
" " nut cracking machinery	15
" " sampling methods	43, 81
" oil extraction, Improvement in small press process for	Vol. II 209
" " factories	17
" " mill, Butre	18, 101, 102
" " milling, Chemical control of	62
" products, Inspection of	85
" sap, Composition of	62
Peasant farmer	9, 30, 35, 64
Pests. See Insect pests.	
Phenological relationships	41, 71, 72

	PAGE
Plant breeding	30, 54
" importation	59
" pests ordinances	40, 68, 88
" quarantine service	30
" selection work	30, 54
Produce deterioration on shipboard and rail	82
" grading	42, 80
" inspection	20, 42, 75
" " in Nigeria	Vol. II 129
" " in Sierra Leone	Vol. II 135
" " in the Gold Coast	76, Vol. II 140
" " in the United Kingdom	79
" " up-country	83
" insurance	42
" quality and cultivation methods	88
" " grades	42, 80
" " price scales	83
" sampling methods	81
Professional association of agricultural workers	27, 45
Quarantine services for plants	30
Rain-water analyses	61
Readjustment of salary scale	28, 50
Research station. <i>See</i> Central Research.	
Rice, Chemical control of milling	62
Rural economics. <i>See</i> Agricultural economics.	
<i>Sahlbergella</i>	37, 66
" in Fernando Póo, San Thomé and Belgian Congo	Vol. II 162
Salary scale, Readjustment of	28, 50
Sampling methods	44, 93
Second Imperial Agricultural Conference. <i>See under</i> Imperial.	
Selection grade for officers	28
Senior posts in Gold Coast, Sierra Leone and Gambia	29
Shea	32, 58, 62
Shelter belts for <i>Sahlbergella</i> control	37, 66
Sisal, Adco trials with waste	62
Soil, Adsorption of bases by	61
" characteristics due to effect of climatic factors	74
" investigations	34, 60
" " Lateritic. <i>See</i> Lateritic soil.	
" maps	35, 60
" mechanical analysis	34, 60
" sampling	60
" survey	30, 52
" " " Geological basis for	60
" work in Sierra Leone	35
Soils, Notes on West African	Vol. II 104
Statistics	43, 89
Storage investigations	43, 81
Surveys	90, 91, Vol. II 172
" <i>See also</i> Aerial, Oxford Economic, Soil.	
Unified Agricultural Service	2, 3, 49
Vegetative propagation	31, 57
Water table maps	61
Weather fluctuations	72
" forecasts for crops	70
" maps	71
Windbreaks	37, 66
Wind records, High altitude	71
Witchbroom disease on cacao	29, 52
World Agricultural Census	44, 91, 95
World's Botanical Congress	59

BULLETIN No. 20.

Department of Agriculture,
Gold Coast.

Second Conference
of
West African Agricultural Officers.

(Held in the Gold Coast, October, 1929.)

VOLUME II.

PAPERS.

1930.



Mr. F. A. STOCKDALE.

FOREWORD.

The Proceedings of the Conference and of the various Committees appointed to consider special questions will be found in Volume I. This present Volume contains Papers submitted by delegates to the Conference.

I have adopted the course of publishing these two Volumes as Bulletins of the Gold Coast Department of Agriculture, a procedure which perhaps is not strictly justified. Delegates from Sister Departments will, I hope, forgive the procedure, which has been adopted purely for questions of convenience.

G. AUCHINLECK,
Director of Agriculture, Gold Coast,
Chairman.

April, 1930.

VOLUME II.—CONFERENCE PAPERS.

LIST OF CONTENTS.

<i>Paper No.</i>	<i>Subject.</i>	<i>Writer.</i>	<i>Page</i>
I.	The Colonial Advisory Council of Agriculture and Animal Health and the Imperial Agricultural Bureaux.	F. A. Stockdale (Colonial Office).	7
II.	Economic Botanical Work, Kew.	H. C. Sampson (Royal Botanic Gardens, Kew).	13
III.	Field Experiments in West Africa.	O. T. Faulkner and J. R. Mackie (Nigeria).	18
IV.	Randomization in Field Experiment and its Application on Experiment Stations in the Tropics.	W. H. Beckett (Gold Coast).	25
V.	Kpeve Investigational Station..	H. K. Hewison (Gold Coast).	75
VI.	Need for further Research Facilities in West Africa. Proposal for a Research Station for Oil Palms and Lateritic Soils.	F. J. Martin (Sierra Leone).	94
VII.	Notes on West African Soils ..	F. J. Martin and H. C. Doyne (Sierra Leone).	104
VIII.	Forestry in relation to Agriculture in the Gold Coast Colony and Ashanti.	J. R. P. Gent (Gold Coast Forestry Dept.).	119
IX.	Deforestation in the Bissa Cacao Area.	H. W. Moor (Gold Coast Forestry Dept.).	125
X.	Inspection of Produce in Nigeria	A. J. Findlay (Nigeria).	129
XI.	Produce Inspection in Sierra Leone.	F. J. Martin and G. Tuach (Sierra Leone).	135
XII.*	Inspection and Certification of Cacao on the Gold Coast.	A. B. Culham (Gold Coast).	140
XIII.	Forecasting the Production and Export of Cacao from the Gold Coast.	H. B. Waters (Gold Coast).	141

*By request of the Accra Chamber of Commerce, this paper has not been published.

<i>Paper No.</i>	<i>Subject.</i>	<i>Writer</i>	<i>Page.</i>
XIV.	The Occurrence of <i>Sahlbergella</i> spp. and other Pests of Cacao in Fernando Póo, San Thomé and the Belgian Congo.	G. S. Cotterell (Gold Coast).	162
XV.	Crop Surveys, Gold Coast ..	J. C. Muir (Gold Coast).	172
XVI.	The Oil Palm at Calabar ..	E. H. G. Smith (Nigeria).	181
XVII.	Improvement of Small Press Process for Palm Oil Extraction.	D. Manlove and W. A. Watson (Nigeria).	209
XVIII.	A brief note on the Progress of Oil Palm Investigations in Sierra Leone.	D. W. Scotland and F. J. Martin (Sierra Leone).	213
XIX.	Statement on Oil Palm Investigational Work in the Gold Coast.	T. L. Williams (Gold Coast).	217
XX.	A Banana Industry for the Gold Coast.	W. C. Fishlock (Gold Coast).	224
XXI.	The Prospects of a Fruit Export Industry in Sierra Leone.	D. W. Scotland and F. J. Martin (Sierra Leone).	239
XXII.	A Fruit Industry for the Gold Coast.	G. H. Eady (Gold Coast).	255

PAPER No. I.

THE COLONIAL ADVISORY COUNCIL OF AGRICULTURE AND ANIMAL HEALTH AND THE IMPERIAL AGRICULTURAL BUREAUX.

By F. A. STOCKDALE.

I have been invited by the Chairman of your Conference to give a few details about the work of the Colonial Advisory Council of Agriculture and Animal Health and of the Imperial Agricultural Research Bureaux which have recently been formed.

As you all know, three Committees were appointed by the Secretary of State for the Colonies to consider the most desirable steps to be taken to ensure progressive agricultural expansion and development in the Colonial Empire, and one Committee to consider problems connected with animal health. The first Agricultural Committee was appointed to consider certain matters pertaining to Agricultural Research and Administration, and its report was divided into four sections, the first section dealing with proposals for the provision of Colonial Agricultural Scholarships for post-graduate training in agricultural sciences, the second and third making recommendations in regard to the collection and dissemination of agricultural information and to the organization of research, and the last section containing observations on the organization and conditions of service in Agricultural Departments. Action was immediately taken on the proposals for the provision of post-graduate scholarships tenable in the United Kingdom and at the Imperial College of Tropical Agriculture in Trinidad, whilst consideration of the recommendations made in the other sections was suspended pending their discussion at the Conference of Colonial Governors summoned in 1927 by the Secretary of State for the Colonies. This Conference suggested that a unified Service, financed by contributions to a common pool, should be created for each technical service, and a special Committee was appointed to frame and submit definite proposals. This Committee confined its recommendations to agriculture. The general principles and objects of the scheme submitted for agricultural research organization were approved by the Conference and detailed proposals were worked out by a further Committee under the Chairmanship of Lord Lovat.

The final recommendations were published in Cmd. 3049 of 1928, and may be summarized as follows:—

(1) That a Joint Council, to be called the "Colonial Advisory Council of Agriculture and Animal Health," should be established and that it should have two Committees—the Agricultural Committee and the Committee of Animal Health;

(2) That the Empire chain of Central Research Stations approved by the Imperial Conference of 1926, and subsequently endorsed by the Colonial Office Conference of 1927, be proceeded with; and

(3) That a Colonial Agricultural Service should be formed and that this Service should be divided into two wings—Specialist and Agricultural.

Detailed proposals were made in regard to the constitution, functions and staff for the Advisory Council; the methods of establishment, functions and staffing of Central Research Stations; and the methods which might be adopted for building up a unified Agricultural Service. It was recognized that this latter Service could not be brought into being in its entirety immediately and that its establishment would have to be given further close consideration by the Advisory Council after its constitution.

THE COLONIAL ADVISORY COUNCIL OF AGRICULTURE AND ANIMAL HEALTH.

The Secretary of State referred these proposals to the various Colonies and invited them to give first consideration to the proposal for the establishment of the Council and, upon receiving replies from the majority of Colonial Governments agreeing to participate, there was appointed in the beginning of this year the Colonial Advisory Council of Agriculture and Animal Health. It was thought that at the outset the number of members on this Council should not be too large, and the following gentlemen were asked to serve on it:—

The Parliamentary Under-Secretary of State for the Colonies,
Chairman.

The Assistant Agricultural Adviser to the Secretary of State for the Colonies, *Vice-Chairman.*

Lt.-Gen. Sir William Furse, K.C.B., D.S.O.,
Director of the Imperial Institute.

Dr. A. W. Hill, C.M.G., F.R.S.,
Director of the Royal Botanic Gardens, Kew.

Dr. G. K. Marshall, C.M.G., F.R.S.,
Director of the Imperial Bureau of Entomology

- Dr. E. J. Butler, C.I.E., F.R.S.,
Director of the Imperial Bureau of Mycology.
- Sir John Russell, D.Sc., F.R.S.,
Director of the Rothamsted Experimental Station.
- Professor T. B. Wood, C.B.E., F.R.S.,
Drapers Professor of Agriculture, University of Cambridge.
- Dr. J. B. Orr, D.S.O., M.C., D.Sc.,
Director of the Rowett Research Institute, Aberdeen.
- Dr. W. H. Andrews, M.R.C.V.S.,
Director of the Veterinary Laboratory, Ministry of Agriculture and Fisheries, Weybridge.
- Dr. A. T. Stanton, C.M.G.,
Chief Medical Adviser to the Secretary of State for the Colonies.
- Mr. R. V. Vernon, C.B.,
Assistant Secretary, Colonial Office,
- with Mr. G. H. Creasy, of the Colonial Office, as Secretary.

Subsequently Major Walter Elliot, M.C., M.P., and Dr. R. Forgan, M.P., have been added to the Council.

The functions of the Council were defined as being advisory to the Secretary of State for the Colonies and the participating Colonial Administrations on the following matters :—

- (a) The supply and training of specialist and agricultural officers for the Colonial Agricultural Services in conjunction with the recruiting authorities of the Colonial Office.
- (b) The establishment of Central Research Stations and general guidance of their work.
- (c) The efficiency and general well-being of the Unified Colonial Agricultural Service, including such advice upon the Agricultural Services as the Secretary of State or Colonial Governments may desire.
- (d) The collection, collation, and distribution of scientific and agricultural information in fields not covered by other agencies.
- (e) Main research policy in the Colonial Empire.
- (f) The representation and collaboration of the Colonial Empire as a unit in Imperial schemes of research and in Imperial Bureaux and corresponding centres.
- (g) The general progress of agriculture and food production in the Colonial Empire.

The Council has agreed, for the present, to meet quarterly and have, so far, held three meetings. At the opening meeting the general position was reviewed by the then Parliamentary Under-Secretary of State—the Right Honourable W. G. A. Ormsby-Gore, M.P.

Proposals in regard to Cacao Research and Sugar Research have been dealt with. A review on the Report of the Royal Commission on Agriculture in India has been prepared for circulation amongst Colonial Departments of Agriculture, a proposed circulation list for agricultural and veterinary publications has been drawn up and submitted to Departments of Agriculture, and the position in regard to Study Leave for Agricultural and Veterinary officers has been examined. Details in regard to the facilities which exist for Study Leave in the United Kingdom have been circulated to Colonial Governments. An examination of the proposals for a unified Colonial Agricultural Service has also been commenced. The replies from Colonial Governments to the proposals for the unified Agricultural Service have been carefully considered and a special Sub-Committee of the Council has been appointed to examine how the scheme can be brought into effect. There are certain difficulties in connexion with the inauguration of the scheme, but these are being closely investigated by the Sub-Committee. The replies received have been generally favourable to the scheme, but there are certain aspects of the proposals which require further examination. This is now being done.

Another matter which has been closely examined this year is the post-graduate teaching and research work at the Imperial College of Tropical Agriculture in Trinidad. Mr. Engledow, of the School of Agriculture, Cambridge, at the request of the Empire Marketing Board, visited Trinidad and reported upon the work of the College. He has also made a number of valuable suggestions for the future. These proposals have been examined in detail by the Governing Body of the College and will some time in December be considered by the Advisory Council of Agriculture and Animal Health.

The general supervision of the East African Agricultural Research Station at Amani has been handed over to the Council, and the first report on the work of that Station has recently been received. It has been an uphill task to do the spade work necessary for securing satisfactory provision for buildings and equipment, and the overhaul of the abandoned coffee estate, which has been handed over to the Station by the Tanganyika Government, has necessitated a very considerable amount of labour. The Station has now settled down on certain fundamental problems and one can look with confidence to its contributions to our knowledge in the near future. Provision of research for the Empire's coconut industry is also likely to be considered at an early date with a view to arranging for a closer co-ordination of the work which is now being carried on independently in Ceylon, Malaya, Zanzibar and Fiji. On the Animal side, the Committee appointed by the Secretary of State to advise on the Colonial Veterinary Services has submitted its report, and amongst its recommendations is one which proposed the inauguration of a Scholarship scheme for the Veterinary Services similar to that

which has been in force for the Agricultural Services. Certain Colonial Governments have been invited to participate in this scheme and they have agreed to do so. It is hoped that it will be possible to bring it into effect as from 1930. The future of the Royal Veterinary College is now before a special Committee, of which Sir C. J. Martin, Director of the Lister Institute, is Chairman, and the recommendation of the Imperial Agricultural Research Conference of 1927 that the South African Research Station at Onderstepoort should be extended to serve as a central research station for diseases of animals has been accepted by the Government of the Union of South Africa and negotiations are practically complete with regard to the additional work and the funds necessary for its extension. The proposal for a tropical central research station for animal diseases has not been lost sight of and will be examined as soon as further progress on the recommendations of the Committee on the Colonial Veterinary Services is possible. In the meantime, the work on animal nutrition which has been started by the Rowett Research Institute in Kenya has passed through its initial phase and has now begun on a further three years' programme, with the co-operation of the Government of Kenya. The supervision of this work, it is anticipated, will come under the Colonial Advisory Council of Agriculture and Animal Health at the end of that period.

IMPERIAL BUREAUX.

The Imperial Agricultural Research Conference recommended the establishment of a number of Imperial Bureaux and correspondence centres, in addition to the then existing Imperial Bureaux of Entomology and Mycology. The recommendations of the Conference were accepted in principle by the Governing Bodies of the Institutions to which it was recommended that the clearing houses of information should be attached, and the establishment of the following Bureaux has been decided upon:—

- Imperial Bureau of Soil Science, with headquarters at Rothamsted Experimental Station.
- Imperial Bureau of Animal Nutrition, with headquarters at the Rowett Research Institute, Aberdeen.
- Imperial Bureau of Animal Health, with headquarters at the Veterinary Research Laboratory, Weybridge.
- Imperial Bureau of Animal Genetics, with headquarters at the Animal Breeding Research Department, Edinburgh.
- Imperial Bureau of Agricultural Parasitology, with headquarters at the Institute of Agricultural Parasitology, near St. Albans.
- Imperial Bureau of Plant Genetics for crops other than herbage crops, with headquarters at the Plant Breeding Institute, Cambridge.

Imperial Bureau of Plant Genetics for herbage plants, with headquarters at the Welsh Plant Breeding Station, Aberystwyth.

Imperial Bureau of Fruit Production, with headquarters at the East Malling Research Station.

You have already received communications in regard to the work of these Bureaux. Their functions comprise the collection and distribution of information on their particular subjects and, in time, will provide for publications of reviews, etc., and for facilitating exchange of workers, study leave, supply of equipment, and for exchanging experimental material for research purposes. It is desired that as free an exchange as possible should take place between research workers in the same subject, but, at the same time, it is desired that all matters affecting administrative policy should be dealt with only through the recognized administrative channels. Communications have already been addressed to some of you by the Imperial Bureaux of Soil Science, Animal Nutrition, and Fruit Production, and it is hoped that as complete replies as possible will be furnished to the questionnaires which have been issued. The value of the work which has already been done by the Imperial Bureaux of Entomology and Mycology is recognized by all Colonial Agricultural Departments, and it can be anticipated that the newly constituted Bureaux will, in due course, render similar assistance in their special subjects.

CONCLUSION.

In conclusion, I would add that it is the desire of all to take the broadest view possible of the enormous variety of the Empire's agriculture in its tropical colonies, protectorates and mandated territories, and to organize the Colonial Departments of Agriculture and Agricultural Research Institutes in such a way that they may be in a position to render the fullest possible service to the producers, not only of the countries in which they are placed, but also to the producers of the tropics of the Empire as a whole. It is desirable that we should all continue to improve our service to all communities in the Colonial Empire, and it is hoped that the Advisory Council of Agriculture and Animal Health will earn their regard and appreciation.

I am here to-day to learn how the Council can be of assistance to the West African Colonies and to hear your general views in regard to its work. We have started on a great tour of adventure into the field of knowledge. It is our duty to wrest what we can from that store of yet unknown information and by our organized co-operation see that the information so gained is utilized to the fullest advantage. We must all be partners and colleagues in this quest, for we have not only duties to ourselves but also to the services to which we belong and, even more important, to those millions of primary producers we are appointed to serve.

PAPER No. II.

ECONOMIC BOTANICAL WORK, KEW.

By H. C. SAMPSON.

Kew has in the past played an important part in distributing plants of economic value to different parts of the Empire and in several instances such introductions have led to the establishment of major agricultural industries.

Most people will, however, agree that plant introduction work of this type has only a limited sphere of usefulness depending on the present or future demand for such economic products. It is, however, difficult always to foresee what is going to be useful. Nobody at the time realised that the distribution of trees of Para rubber to Ceylon and Singapore was going to revolutionise the planting industries of the East or that similar introduction of the oil palm to the East was likely to become a serious menace to one of West Africa's main industries.

There is another line of work, however, which has had attention at Kew for a considerable time and though this also relates to plant introduction it is concerned rather with the improvement of local agriculture by the introduction of varieties of staple crops, which may for one reason or another bring in a greater return than those at present grown; and in time where work further develops such introductions may be of extensive value for genetic studies.

Progress on these lines, however, means that Kew must be in close contact with the work of the Agricultural Departments of the Empire, and that it is very essential that the senior Officers of Kew should be able to travel and maintain this personal touch as well as to acquaint themselves with the local conditions of the principal countries of the Empire. It was with this end in view that the Empire Marketing Board has placed funds at the disposal of the Director which enable him to give effect to this and which has incidentally led to my appointment as Economic Botanist there.

Some of you may say that the work which I have briefly outlined above is not of much value, and that Botanic Gardens and acclimatisation stations are a thing of the past since most Colonies have now their own Agricultural Departments and their Agricultural Stations. The Royal Commission on Agriculture in India has in

its report emphasized the importance of developing the staple products of the country by improving these by selection rather than by introducing new products or new varieties of existing products from elsewhere. In the main this recommendation is quite sound, but even in India with its highly developed indigenous agriculture there are many examples of the introduction of exotics which have had a profound effect on the agriculture of the country. The history of many of the crops of that country is lost in antiquity, but some botanists hold that the cultivated *sorghums* of India are of African origin. Even in historical times there have been many introductions which are now widespread. The early Portuguese navigators were probably responsible for many of these, such as the cassava, the sweet potato, the groundnut, the cashew nut (this is still known on the West coast of India as the Portuguese mango) and possibly maize and tobacco. More recently, we have introductions made by the East India Company among which the American types of cotton are the most important. These are still grown in localities where soil and other conditions permit, as for example in the Dharwar district of Bombay where the Dharwar American crop is regularly marketed as such. Since the formation of the Indian Agricultural Service there have been some signal examples of useful introductions. The extension of the groundnut acreage in Madras which early in this century was only some 250,000 acres is now well over 1,500,000 acres. This extension has been made possible by the substitution of a more hardy African type of groundnut for the one which was formerly grown, which was a poor cropper and very liable to leaf disease. Throughout Bombay and the Central Provinces the groundnut has become a crop of major importance through the introduction of the small Spanish bunch variety. The introduction of an "hirsutum" type of cotton from Cambodia has revolutionised the agriculture of the Southern districts of Madras.

In the case of the planting districts these are mainly dependent on plant introductions such as coffee, tea, and rubber. There are only two indigenous planters' crops in India, namely, the Cardamon and the black pepper, and neither of these is of great importance.

Thus, although the recommendation of the Royal Commission is, in the main, sound, it is evident that there are striking instances where the introduction of new crops and new varieties of crops have been most beneficial to the economic progress of the country.

If this be true of India with its well-established indigenous agriculture, is it not true in probably greater measure in the British Dependencies of West Africa? The African, also, I imagine, is not tied down so much by custom as is the East Indian and the spread of exotic crops such as maize, sweet potatoes, cassava and groundnuts from one end of the continent of Africa to the other, often through tracts where the indigenous agriculture is very primitive, shows how readily he will take up new crops and methods. We

have more recent examples of introductions being readily taken up by native farmers, such as cacao in West Africa, cotton in Uganda and the Sudan, and tobacco in Nyasaland.

In the matter of improving existing crops, there is, as you know, an immense amount of work to be done. Kew has recently taken up work on the *sorghum* crop and, through the co-operation of the various Agricultural Departments in Africa, has now a fairly representative collection of the varieties grown. When this collection is more complete it is hoped that it will be possible to classify these not only botanically but also agriculturally. For example, there appears to be a close relation between the laxity of the head and the amount of rainfall in the tract where any type is grown. The botanical classification is now being worked out at the Herbarium at Kew, but dealing as we are with a cultivated crop of which the wild parent or parents are unknown, there is naturally a certain amount of confusion, it being difficult sometimes to place cultivated varieties. In order to clarify the position, Kew is now working in collaboration with the John Innes Horticultural Institution and Mr. Huskins of the staff there is working on the cytology of the *sorghums* to see whether this throws any light on the subject.

This line of work in the case of many other crops of economic value, whether local or otherwise, is capable of great expansion, and it is hoped that the Agricultural Departments will be as willing to co-operate in the future as they have in the past. I realise from my own experience that requests for material such as we may require is an extra tax on the work of the Agricultural staffs and I hope I am not asking too much when I ask for their continued co-operation. I am encouraged by the remarks of one Director to whom I wrote for specimens and information concerning *sorghums*, who replied that recently he had been inundated with questionnaires and that ours from Kew was the first one which he had received which offered promise of being of real value to his Department.

Another example on somewhat different lines is that connected with the banana breeding work which is now being done at the Imperial College of Tropical Agriculture at Trinidad. One of the chief aims of this work is to breed a banana which is immune to "Panama disease" and which at the same time will suit the banana trade both of America and Europe. The "Gros Michel" variety, which is at present almost universally grown in the Caribbean region for this trade, is very subject to this disease. There are immune varieties of bananas, but none of these is as good as the Gros Michel. The bananas for this trade are shipped "naked" and not in crates as is done from the Canaries. Thus it is essential that the fingers on the hands should not stand out. It is essential also that the hands should be fairly close together and uniformly spaced one from the other. This gives a bunch which will stand a considerable amount of handling without damaging or bruising the individual

fruit. The flavour of the fruit is also a matter which has to be considered, especially as the market has become accustomed to the flavour of one variety for so many years. Then again, the keeping and ripening qualities of the fruit have to be borne in mind. One peculiarity of the Gros Michel is that the fruits ripen before the stalk or "stem." In the Cavendish variety the reverse is the case and the fruit will frequently drop before it is ripe. A big risk is involved here, when it is considered that a banana boat will be carrying anything from 60,000 to 100,000 stems. It is clear, therefore, that the task of breeding a banana which will suit the trade is no easy matter. The assistance of Kew has been called in to help in securing banana varieties which may prove useful for breeding work and an Officer from Kew was sent last year to the East in search of banana material which was likely to prove of use in this work. He collected not only material of varieties of the "Gros Michel" type, but also much material of seeding forms of bananas from the area where it is thought likely that the "Gros Michel" type originated. He also collected bananas of other types which it was thought might prove of value. These were all sent to Kew where they were propagated in a greenhouse specially built for the purpose. The plants were periodically examined by the Bureau of Mycology for disease, and certified healthy suckers from these were when ready despatched to Trinidad, where after a further quarantine they were planted out and propagated for providing sufficient material for breeding work.

In addition to what I have already described, I may mention that the Director at Kew is also Botanical Adviser to the Secretary of State for the Dominions and Colonies. This work, in the past, has been largely connected with the work of the Colonial Agricultural Departments and though the appointment of an Assistant Agricultural Adviser to the Colonial Office relieves Kew of some of the work on which our help has been sought in the past there are still many agricultural questions, which have a botanical bearing, which Kew alone can answer. Further than this, the Empire Marketing Board, through the funds which they have made available at Kew, frequently refer to the Director technical questions, many of which are concerned with grants-in-aid for various lines of research. Such applications often require close scrutiny and consideration. It frequently happens that grants are asked for by one Colony which wishes to undertake work which could, it is thought, be better done in some other Colony, or which it can be pointed out has already engaged the attention of workers in more than one Colony. We have an example in this conference of the claims of different Colonies to undertake research work on the oil palm. Sometimes applications for such grants verge on the extravagant side and at others they are insufficient for the work proposed. A personal knowledge of the conditions of the different Colonies is, therefore, of the greatest advantage.

In many lines of work Kew has to depend on the co-operation of Officers of the Agricultural Service. Take the subject of grasses, for example. There is not much difficulty in naming these, but this is merely a beginning of the work. From an Agricultural point of view something more is required. One wants to know something of their habit, what conditions these grow under, whether they are perennial or annual, at what elevation they thrive and the class of soils on which they flourish. Then again it is necessary to know what variation in habit may be observed when these are grown on different soils ; whether they are suitable for cutting or for grazing and which are the species which are preferred by live stock.

Kew has been responsible for a publication on the pasture grasses of East Africa and at the present time, with the co-operation of Kew, one of the Agricultural Officers in Uganda is writing up the grass flora of that Protectorate.

PAPER No. III.

FIELD EXPERIMENTS IN WEST AFRICA.

By O. T. FAULKNER AND J. R. MACKIE (NIGERIA).

The object of this paper is to examine some of the various systems now in vogue for laying out field experiments and to discuss their applicability to West African conditions, rather than to criticise their mathematical or statistical soundness. A great change has come over Agricultural literature in recent years; a few years ago very few results were published at all, and these were rarely accompanied by full figures. The writers merely confined themselves to statements of facts, or supposed facts. In recent years there has been a tendency to go to the other extreme and agricultural scientists have tended to carry out their work almost as though their real purpose was the publishing of results that would convince the reader.

Our primary object, as members of Colonial Agricultural Departments, is to improve Agriculture, in particular native agriculture. The most important point is that the experimenter should himself reach a conclusion which represents the truth, the whole truth, and nothing but the truth. (One has even heard such statements as "I published it because it was a striking result; but the conditions of that year were entirely exceptional—it would never happen again; but that is a matter for the reader; everything I have said is true"). If the publication of the results becomes anything more than the secondary, very subsidiary consideration that it ought to be, then the whole significance of the work rests on a false basis. In our attempt to improve Agriculture we must keep the native farmer always in mind. If our experiments lead us to conclusions which are not practical or are uneconomic, then no matter by what statistical method the results have been obtained and prepared for publication, or how striking they are to the reader, these conclusions will never be adopted by the native and are therefore to all intents and purposes valueless.

It is generally accepted that the two essentials which govern all well planned field experiments are (1) that the experiment should yield a comparison of the different manures, treatments, or varieties, and (2) that it should yield a means of testing the significance of such differences as are observed. But there are two further essentials which for West African conditions are quite

as important, if not more so, than these, namely, that the experiment should be so arranged that it requires the minimum of expert European supervision, and also in such a way as to reduce to an absolute minimum of the risk of what Engledow calls the "damn-fool" mistake. European supervision is a luxury in West Africa, and a good deal of work which on a highly organised experimental station in England would be done by experts or post-graduate students, etc., devolves upon African assistants; and in examining the general applicability of any system of field experiments to West Africa this must be borne in mind.

RANDOMIZED BLOCKS.

The latest fashion of laying out experiments in a series of "randomized blocks" is justified by those who advocate it on the grounds that:

- (a) It is in a theoretical way sound statistically because the arrangement is random; for it is said that we cannot assume any test of significance to be valid if our plots have been chosen in any way according to a pre-arranged system.
- (b) It is the method which allows of the most satisfactory analysis of results.

With regard to (a), the first of these arguments, it is remarkable that, in actual practice, restrictions are usually imposed upon the random arrangement and the Latin Square or some other systematic arrangement is adopted; so that the statistical soundness of even the most modern method seems questionable, if the basis of soundness is "randomization." With say five varieties, there is one Latin Square, for example, to hundreds of thousands of truly random arrangements or "Barbarian Squares" as Mr. Jacob calls them. But, in any event, in Agricultural Experiments there are so many illogicalities that mathematical "purity" applied to them savours of pedantry. The whole application of statistical ideas to the comparatively small number of duplicates employed in field experiments is apparently fundamentally unsound to the pure mathematician; and the elaboration of methods for this purpose undoubtedly often leads to a feeling of confidence by the ordinary agriculturist which is unjustified. The structure is so imposing that the weakness of the foundations may easily be overlooked. Take, for example, the question of the significance of results obtained by these methods. If the odds against a result being due to chance are 30 : 1, we say that it is significant, but if they are only 10 : 1, it is not significant; but the 31st chance may turn up, and if it does the subsequent misleading of the public is just as serious economically as if the 11th chance turns up; and the

most complicated and accurate mathematics cannot alter this fact. The idea of fixing a limit to significance shows clearly what statistical analysis should be, namely, an aid to clarity of thought and not an end in itself. That it is often regarded as an end in itself has on many occasions been shown to be the case in this Department. The same experiment has been carried out during three or four successive seasons and the odds against the result being due to chance have each year been in the neighbourhood of 10 : 1—and yet the officer in charge has reported that the result has no significance, whereas, having been carried out under three or four entirely different sets of conditions, it is highly significant.

Again, it is agreed that “the soil of a field does not vary at random from point to point, but continuously in patches or streaks” and a definite correlation is known to exist between adjacent plots. Why should we therefore not take advantage of this correlation to reduce our unavoidable error? The argument seems to be that statistical methods should not be applied to non-randomized experiments. But we want the truth; and whether the statistical method is very perfect or not seems to us to matter very little. So long as it helps us to think clearly and does not actually lead to practical or false confidence, then it serves its purpose.

The real point lies in (b), the second argument: it is a useful method of conducting and analysing the particular type of experiment for which it was designed, *i.e.*, experiments with a large number of different manures in various combinations which need to be compared *each with the other*. One method is better than another for a particular experiment, and while all have their disadvantages, true wisdom lies in the choice of the right method for the particular experiment and the conditions under which it is carried out. For the particular type of experiment with which we are mainly concerned in Nigeria (namely testing the relative merits of one or two varieties or treatments, more from the economic point of view than the scientific), and in view of the conditions under which we have to work, we mostly make use of a method which may conveniently be called “Faulkner’s” method, but for certain types of investigation we find “Engledow’s” method more suitable.

FISHER’S “LATIN SQUARE” METHOD.

Fisher’s “Latin Square” method is too well known to need further description here, but it has certain disadvantages which we consider make it unsuitable for general adoption in Nigeria. These disadvantages may be enumerated as follows:—

- (1) Owing to the peculiar layout, comparisons by eye are rendered difficult, and such comparisons are often the most instructive.

- (2) The mathematics are too complicated. We understand that at Rothamsted the man who carries out the field work does not work out the results. The figures are taken to the laboratory where the calculations are made by experts. Such a system is obviously unsuited to Nigeria, where the officer in charge of the station has to work out and understand his own results.
- (3) The conduct of the experiment needs great care, much more than an African assistant could be relied upon to exercise, if "damn-fool" errors are to be avoided.
- (4) The advantage of the correlation between neighbouring plots of land is lost.

ENGLEDOW'S METHOD.

The method advocated by Engledow, which is fully described in a paper entitled "The Principles and Practice of Field Trials," published by the Empire Cotton Growing Corporation, has been specially devised for carrying out cereal yield trials with extreme accuracy on very small plots, and for this purpose is probably the best of its kind. To quote Engledow himself: "For the early stages of variety trials, when the amount of seed is small, the usual arrangement adopted is a chessboard of very small square plots, the utilized area of each of which is no more than one square yard. Usually it is desired to test more than two varieties at once. Suppose there are eight. Then the simplest arrangement is to sow them in order down the strip of plots thus:—

1	2	3	4	5	
6	7	8	1	2	
3	4	5	6	7	
8	1	2	3	4	and so on.

For field scale trials this is modified into an arrangement of long narrow strips and every variety under trial is separately compared with the standard variety, the arrangement being as follows:— s v v s s v v s s and so on, where each "s" and "v" represents one ridge or strip of half the width of an ordinary seed drill. For such field scale trials Engledow considers $\frac{1}{40}$ of an acre to be the optimum size of plot for most cereal crops. The statistical treatment of the results obtained from both these methods is the same and is based on the general principle of considering differences between adjacent plots and reducing the standard error by increasing the number of pairs of adjacent and comparable plots, the theory of which has been mainly developed by "Student." The main advantages of this system may be stated thus:—

1. It is particularly suitable for variety yield tests especially where it is desired to test several varieties simultaneously, and where the seed supply is very limited.

2. It takes advantage of the correlation between neighbouring plots and ridges; in fact, as Engledow says, the special applicability of "Student's" method (for standard error of varietal mean differences) turns on the existence of this correlation.
3. A particular experiment can easily be repeated for several years on the same plots.

From our point of view, however, for general experimental work it has the following disadvantages:—

1. It is not a practicable method for many purposes other than testing varieties, and, as Engledow admits, yield trials are only a minor part of the experimental work in new and developing countries.
2. It needs great care. Constant European supervision is almost essential.
3. It is not suitable for large plots and therefore permits little information to be gained as to the economics of the problem, apart from yield.
4. It is not very suitable for experiments with permanent crops.

FAULKNER'S METHOD.

This method, which is the one used for large scale field experiments at all our Nigerian Experimental stations, is not so well known as the two methods previously mentioned, and the following extract taken from an article contained in the Second Annual Bulletin of the Nigerian Agricultural Department, dated 1st July, 1923, explains the layout of the experiments and will not therefore be out of place:—

"In this method the plots are long and narrow, generally five times as long as wide, as these dimensions are believed to give the greatest accuracy consistent with general convenience. The plots of course adjoin by their long sides. Every alternate plot is a "control" plot and there is a control plot at the end of each series. Wherever possible there are at least eleven control plots and these receive exactly the same treatment, this treatment being generally the standard method of cultivation, or the standard variety which is used for the particular crop on the particular farm whenever there is no reason for doing otherwise. Each experimental plot lies between two control plots and if possible there are always four and never less than two such plots under each kind of treatment which is being tested."

"In the presentation of the results the yield per acre from each plot under the experimental treatments is compared

to the average yield per acre of the two adjacent control plots, the result being expressed as an increase or decrease as compared to that average."

The root-mean square difference between neighbouring pairs of control plots is then calculated and this is used as a measure of the uncertain errors in the observed differences between the yield of an experimental plot and the average of the yields of the two plots adjacent to it.

This system is, we consider, particularly suited to the type of experiment which is most common on West African Experimental stations and to the conditions under which they are carried out, and from these points of view it has the following advantages:—

1. Comparison by eye is greatly facilitated. The plots being side by side differences are easily seen and experimental plots can often be used as demonstrations for African farmers to whom the statistical aspect is of no interest.
2. The experiments are very easy to conduct, so much so that, although we usually try to arrange that a European shall supervise all important operations such as sowing, harvesting, etc., they can and have been successfully conducted by African overseers.
3. The mathematics are simple. Any intelligent African overseer can work out the result of any experiment, and on our farms they usually do so.
4. Advantage is taken of the correlation between neighbouring plots.
5. It is suited to the type of experiment with which we are mostly concerned, namely, testing one or two varieties, or manurial treatments, simple cultural experiments or testing the relative merits of one or two rotations; especially is it suitable for testing a new variety or practice against the old or native one, and ascertaining the nett financial value of the difference.
6. It is equally suitable for experiments with permanent crops as for experiments with annual crops.
7. It is a method which can be used on their own farms by native farmers provided the plots are laid out for them.
8. Within reason there is no limit to the size of the plots. This is an important point in tropical countries where sources of error are so numerous and expert supervision so limited. If the plots are large, quite a reliable result can be obtained even if any portion of a plot is so damaged by animals, birds, etc., or so spoilt by outcrops of rock, etc., as to be useless. One merely eliminates the damaged area and calculates the yield per acre from the remainder.

There is, in fact, a considerable measure of safety in large plots which is lacking where small ones are employed. Moreover they can be made to give information as to the relative economics of the crops or treatments which are being treated.

There are, however, one or two criticisms which might be levelled against our system :—

1. It is not well suited to manurial experiments or experiments in which a large number of varieties have to be treated, each against the other. In the few experiments of this kind which we have attempted, we have realised that the results would have been more valuable if Fisher's or some other of the more elaborate methods had been adopted. To get reliable results by this method the issue must be reduced to the simplest possible terms. The comparison of each of two new varieties with each other is obviously less reliable than the comparisons of each with the standard.
2. The statistical treatment of the results is open to criticism. As soon as the system of truly randomized plots is departed from, the laws of chance cannot *strictly* be applied, and the mathematics of all methods of statistical treatment are based on these. We do, however, know what assumptions have been made. They are generally admitted as permissible and leave an ample margin of safety.

In actual practice our conclusions have proved correct. We have found that treatments or varieties which our experiments have shewn to be sound are proved to be so by the readiness with which they are taken up by the native farmers, and after all this is the final test of all in West Africa. As examples of this, one can quote the introduction of exotic varieties of rice, and the way Ishan cotton has been taken up ; and there is evidence to show that our systems of mixed farming and green manuring are also likely to be adopted with increasing rapidity. *Vice versa*, when we have ever attempted to interest the natives in an innovation with which our experiments have given inconclusive or conflicting results, we have invariably failed.

CONCLUSION.

Our final conclusions are that :

- (1) The best method of laying out and conducting field experiments is the one which is best adapted to the type of experiment and to the conditions under which it has to be carried out, and
- (2) In West Africa the methods generally used on English Experimental Farms are unsuitable, except for very special purposes and in circumstances which are exceptional.

PAPER No. IV.

**RANDOMIZATION IN FIELD EXPERIMENT AND
ITS APPLICATION ON EXPERIMENT STATIONS
IN THE TROPICS.**

By

W. H. BECKETT (GOLD COAST).

CONTENTS.

	Page
1. Introduction	27
2. Necessity for Replication	28
3. Random Distribution	28
4. Size of Plot	29
5. Shape of Plot	30
6. Number of Replications	31
7. Objections to Randomization	31
8. Design	33
9. Compromise between Random and Systematic Arrangement	34
10. Summary of the Scheme	35

APPENDICES.

I. Fisher's Diagram	36
II. Soil Heterogeneity	37
1. Maize Uniformity Trial, showing plan of yield ..	38
2. Individual Yield Plan of Coconut Palms ..	facing 38
3. Uniformity Trial Diagram of Plots of 25 palms	facing 38
4. Table of S.D. of Plots of different sizes	39
III. Design	40
1. Restrictions on Randomization	40
2. The Latin Square	41
3. The Magic Square	42
4. Confounding	44
5. Re-arrangement of Plots	44
6. Examples of Modern Experimental Layouts..	47
IV. Analysis and Short Methods	51
1. The Standard Deviation	51
2. The Correlation Co-efficient	54
3. Standard Deviation of a sum or difference	56
4. Randomized Blocks	58
5. The Latin Square	61
6. Confounding and Seasonal Effect	64
V. References	74

INTRODUCTION.

The object of this paper is to put forward the case of randomization in field plot technique against systematic forms of arrangement. So much work has been done both on the practical and the theoretical side that it is impracticable to trace the development of the modern "confounded" layouts from the one plot idea of twenty years ago.

Several surveys of the subject have been made, and a short one written up to the present time is given in my paper on "Field Experiment" in the 1928 Year-Book of the Department of Agriculture. It is sufficient here to enumerate the generally accepted principles relative to the modern randomized layout, and the objections to, and criticisms of, those ideas when put into practice.

On the theoretical side, the work of the biometricians shows definitely that only by a randomized layout can we obtain a *valid* estimate of the error of the experiment, and, therefore, only by this arrangement arrive at a sound conclusion. The diagram of Fisher, published in the paper referred to above, shows this so clearly that no apology is needed for again making use of it. The diagram is shown in Appendix I. Fisher, who has probably done more than any other worker to develop modern technique, and disseminate modern ideas, has used the diagram to illustrate the principles to students in the statistical laboratory at Rothamsted, where I had the pleasure of spending six weeks as a temporary worker. Many of the ideas which are put forward here were the outcome of conversations with Dr. Fisher, Dr. Wishart and Mr. Clapham of the Rothamsted statistical department, Mr. Irwin of the Ministry of Agriculture, Mr. Hoblyn of East Malling Research Station, Mr. Engledow of Cambridge and Prof. Heigham of Armstrong College.

With a prior knowledge of the problems which present themselves in the Gold Coast, and a fortunate working acquaintance with the Nigerian system, gained on local leave at Samaru and Kano in the Northern Provinces in 1927, I was able to discuss the difficulties with the workers mentioned above, and I wish first to express my appreciation of the great help they gave me at every point.

In a field experiment we want the answer, with the minimum of time, expense and trouble, to a biological question. Furthermore, we want to know how reliable the answer is, and to estimate this we resort to certain biometrical formulæ for finding the error of the experimental result: and the significance of a difference in yield (or other physiological characteristic of the plant) between different

varieties, or between differently treated plots of the same variety, judged in the light of this "error." The reliability then, of the answer, depends on the "error," and all methods of field experiment are aimed at one of two things: the reduction of this error, and the validity of the estimate of it which our field technique and biometrical formula give us.

From the diagram we see that replication is the basis of both aims, that the random distribution of plots is concerned with getting a *valid* estimate of the error and field technique (local control) with its actual reduction.

I propose to deal with the subject in the same sections as appear on the diagram, allowing the argument to develop, rather than to outline the argument and proceed to justify it.

2. NECESSITY FOR REPLICATION.

The heterogeneity of a field is so apparent to the eye in a growing crop that figures from uniformity trials are almost unnecessary to demonstrate the need for replication of plots. One still sees here and there the single plot type of trial. A perusal, however, of the diagram in Appendix II, of a field of maize, shows clearly the large differences which exist in adjacent plots, differences greater than would be expected between different varieties or different treatments. It is apparent that to base an argument on difference in yield from the records of two plots would very often lead to quite a wrong result.

The second diagram shows the differences in yield of a field of coconut palms. Here individual yield is shown and the differences are large. The general trend of fertility is marked, but there are also differences between adjacent palms which must be mainly due to an intra-varietal heterogeneity. From the yield statistics from which the diagram was prepared, it is easy to find the number of replications of each unit in one plot which would give the minimum error, the point being that at which the sum of the soil heterogeneity and the intra-varietal heterogeneity is a minimum.

The third diagram is of square plots of 25 palms, and shows mainly the fertility differences over the field. The diagrams are sufficient in themselves to show the need of replication. Plot size will be discussed later.

3. RANDOM DISTRIBUTION.

The necessity for random distribution is due to the fact that our criterion, for judging the reliability of the answer to the biological question we asked of the field trial, is the "standard error," usually denoted by sigma (σ). This statistic is the second moment of an

infinite series, which conforms to a definite distribution, the "normal" curve. All we can do is to take a finite sample of this infinite population and obtain the second moment, which we will call the standard deviation (s). Although " s " is only an estimate of the true error, the relation of " s " to " σ " is known, and so " s " can be used with certainty as a criterion. The statistic " s ," however, depends on the sample being taken at random, and only in such a case is " s " a *valid* estimate of " σ ."

The development of random arrangements is quite clear if traced systematically, and the stages are given in diagrammatic form in Appendix III. Modern "confounded" experiments appear complicated at first, but once the arrangement is analysed, order appears out of the apparent chaos. The beauty of these confounded arrangements is that so much can be got out of one trial, and further promising lines of investigation are forthcoming, for which future trials can be designed. There is concentrated in one experiment several questions, for which reliable answers can be obtained, and which in separate experiments would multiply the field-work and area required enormously. Furthermore, the interaction of treatments and varieties can be observed, and a particularly useful form is one in which the varietal response to different treatments is required.

The method of designing these layouts will be discussed later.

4. SIZE OF PLOT.

From the theoretical standpoint, I have not seen any argument for a definite size of plot which would bear statistical investigation on a representative series of uniformity trials, either on different fields in the same year, or on the same field in different years.

I prefer to think of the heterogeneity of the soil in three stages: the *major* differences due to different soil formations and topography, the *minor* differences due to previous cultivations, ant hills, dung heaps, tree positions, etc., and the finer differences between adjacent foot lengths, say, in rows of barley. In conversation, Mr. Engledow elaborated a "streak hypothesis" covering this, and it is interesting to note that an investigation into the internal correlation between the small units (foot lengths), which make up an experimental plot, point to the fact that there is often a higher correlation between non-adjacent units than adjacent ones. The argument is engaging, and the investigation an interesting one, and should result in a much fuller knowledge of the nature of soil heterogeneity, but is rather outside the scope of this paper.

With our plots we are concerned with the *minor* differences. The area of the patches responsible for these differences is not a constant, and therefore the size of plot, giving minimum error, is not constant. A good example of this factor is given in 4 in

Appendix II, which gives the standard error associated with plots of different sizes built up of individually recorded coconut palms. In the one field the error diminishes as the size of plot increases, while in the other field the error remains almost constant. In the theoretically perfect field, with the units of different fertility levels distributed at random, we should find that the error diminishes as the square root of the size of plot. With small plots of a permanent crop the intra-varietal differences might have an effect comparable with the soil differences, but the case of plots so relatively small does not merit discussion here.

The question, then, of plot size, from a theoretical standpoint, is an open one. On the practical side, however, it is more definite. We must avoid the major differences; streaks do not affect us, except in fine records, as tiller counts in census work, and we need a plot, therefore, which is as small as possible to enable as many replications as possible, and large enough for the yield figures not to be seriously affected by small errors in the cultivations, sowing and recording. We must allow an area sufficient for edge to be cut off, if edge effect is considered large enough to affect the results.

By examination of the field of maize grown in one-fortieth acre plots, the standard deviation per plot is reasonably small. In practice the plot appears to be large enough for comparison of manurial treatments, spacing and time of sowings, though for cultivations using machinery it would probably be found to be rather small. It is possible only to give an opinion based on the experience of one's own observations and this size plot appears to me to be the best.

In permanent crops, of course, where the planting distance may be up to 25 feet square, $\frac{1}{4}$ of an acre appears to be a useful size.

5. SHAPE OF PLOT.

Plot shape can be treated in much the same way as plot size. Theoretically there is little to recommend it. Several rather ingenious analyses have been made showing the reduction of error by the use of long plots, but further investigation into the data reveals in most cases the purely local nature of this effect. The fertility gradient has a lot to do with it, and in many cases, where elongating one way reduces the error, elongating the other way increases it. The reduction of the error is more an indication of the nature of the heterogeneity of the particular field. Maskell suggests the method of using this factor, where the fertility trend is known, by elongating plots along the fertility gradient, and the blocks of plots across the gradient.

Against this we have the greater length of edge in long plots, and edge effect is a factor we want to reduce to a minimum.

On the practical side, long plots may be more convenient, particularly in special cases, such as Beaven's half drill strip method, where the sowing is simplified, and the reaping also, by using a very long narrow plot, corresponding to the width of the seed drill and length of the furrow. Where we are dealing with hand labour, a square plot is equally easy to use and has the advantage of less edge.

6. NUMBER OF REPLICATIONS.

This naturally depends on the precision required and the size of the differences which are being investigated. The size of standard error of the mean of the plots under one treatment, or variety, varies inversely as the square root of the number of replications, so that up to a point, the more replications the better. It would be useless, however, to obtain precision by replication of a finer degree than the field-work allowed, and a balance must be preserved. It depends entirely on the simplicity or otherwise of the question asked, and the size of the differences expected. In the straightforward comparison of varieties, spacings, time of sowings, etc., six replications appear sufficient. It is not, however, sufficient to make one experiment, as season has comparative effects on different treatments and varieties. A good working criterion is six replications over three seasons. Here it may be pointed out that a random arrangement used one year is not valid again unless arrived at by chance again. In a way it could be made an investigation into the change of heterogeneity of the soil, and as such, of course, valid, but for the purpose of repetition of the experiment in a different season it is not valid.

7. THE OBJECTIONS TO RANDOMIZATION.

From the biometrical point of view the objections raised are not to randomization itself but rather to its application, and the interpretation of results. Randomization in field work and the analysis of variance method of treatment of result, though not actually interdependent, are so very closely bound up in their development by Fisher, that they can be treated as one. The criticism of the method is that the analysis of variance test depends very greatly on the normality of the distribution, and that the extent to which tests become inexact as the distribution departs from normality is not fully understood. For our purpose, it is safe to assume that the "inexactness" is not comparable with the non-validity of the standard deviation obtained from a systematic arrangement. We are dealing with small samples, and a random selection is by far the most reliable. We can leave further investigation into this point to the mathematicians.

A criticism levelled against the design—Latin square, for example—is that a restriction is imposed. This is so, but the random

nature of the arrangement consists in the fact that the Latin Square chosen is one selected at random out of the total number of squares possible. In practice, in some cases, this is carried out, by writing out all the possible arrangements on cards, and choosing a card at random.

There are several criticisms, from the practical side. Engledow and Yule speak of the greater susceptibility of random arrangement to "error of the damn-fool order," such as mixing up seed packets. Personally, I consider such error as easy to make in either arrangement, but that if the plots are numbered consecutively and (in the case cited) the seed packets given plot numbers, the liability to error is negligible. In any experiment the design and working arrangement should be got out before going to the field.

Another criticism is that a random arrangement is bad for observation. In reply to this, several points suggest themselves. Firstly, if a difference is great enough to be marked, to the eye, in spite of the differences due to the soil heterogeneity, then an exact experiment is needed only to determine the size of the difference, and this cannot be determined by eye in any arrangement. Secondly, an experiment is not primarily a demonstration. Thirdly, a difference between adjacent plots may be fictitious and therefore misleading. Fourthly, a systematic arrangement, producing a bias in yield, would also produce a bias in the observed characteristic. Lastly, there is no reason at all why a side by side arrangement should not be used by putting the successive "rows" of a Latin square (or other arrangement) in a line. This point is explained further under "design." It might be said that the random arrangement does not lend itself to crop after crop studies in investigation of seasonal effect. Here it is only necessary to decide on what you set out to investigate, and design the experiment to that end.

Cultivation difficulties appear large at first, but the method of "line" arrangement referred to above gets over this. A diagram is given in Appendix III. In the Colony it concerns us little, as most of our cultivations are by hand. In Beaven's half-drill-strip method, randomization could be introduced simply by selecting the ABBA or BAAB arrangement of units at random, making a plan and driving the drill up the rows as required by the design. It would only result in a few, if any, extra journeys. In Faulkner's system, by a random arrangement, with several treatments, the number of "control" plots could be reduced without any alteration to the size and shape of plots.

The statistical work required in working out the results of randomized experiments is perhaps an objection to their use in certain cases. Going back a few years, the use of a straightforward standard deviation suffered from the same cause. Simplification and standardization removes much of the cause. Faulkner's

standard method of working out "R" appears to work smoothly and efficiently in practice with non-mathematical experimenters. I have attempted to reduce the working of randomized layout in a similar way, and give some examples in Appendix IV. In support of their usefulness, I might add that two Junior African Officers, on Asuansi Station were able in a few months to take a set of figures of a Latin square and work down to a "z" test.

This disposes of the "objections" which I have met so far. A somewhat deeper objection, however, has appeared recently in the Journal of the Ministry of Agriculture, in an article by R. N. Dixey of the Oxford Agric. Economics Research Institute. He draws attention to the "artificial" nature of the experiment on a station, and its divorcement from the conditions in the farm. This objection is to experimental work aimed at improving local farming methods. Fundamental research items are of course excluded from this criticism. He outlines the usefulness of surveys, for collecting information of times of sowing, planting distance, etc., and yield. Such figures, analysed in the laboratory, would yield most useful results. The idea is refreshing, and was in part anticipated at Asuansi Station this year. For correlation with maize experiments, $\frac{1}{40}$ th acre plots were marked out in outside farms, and, at harvest, counts of stands, ears, etc, and weights will be taken. This, I think, should form one main line of investigation in connection with our experiment station work.

8. DESIGN.

A random arrangement is one obtained by chance out of the total number of arrangements possible. In a comparison of two treatments, the AB or BA arrangement may be obtained by tossing a coin. In a randomized block experiment, the treatments may be given letters, and cards bearing the letters A, B, C, D, etc., placed in a box, shaken up and drawn out one at a time, for each block.

The usual method for a Latin square (for the lower denominations) is for all the possible squares to be written out on cards, the cards shuffled and one selected at random. The card should then be returned to the pack, the pack reshuffled, and a card selected. If the same card turned up, it is a random selection, but to repeat the first card for subsequent blocks without the reshuffling would not be random. For the higher denominations, the number of possible squares is so large that a complete set of cards is impracticable. Cards giving the "reduced" or type squares are made out and then rerandomizing is done on the type selected. For a 3×3 Latin Square there are 12 possibilities; for 4×4 , 576; for a 5×5 , 161,280.

A simple method is to use one set of cards bearing the treatment letters, do the first row and then gradually build up the square, always selecting at random each unit from the possible letters.

the 1st letter of the second row could not be the same as the 1st in the first row, and it could only be selected from the others. To complete the randomization, reshuffle complete rows, and then complete columns.

For a Græco-Latin Square, the first step is to produce a Latin Square and then superimpose the second set of treatments on the first row, and gradually build up the arrangement, always selecting at random from the available treatments. The randomization is complete by reshuffling complete rows or columns.

In the magic square, the technique is different. The arrangement is best built up in sections and the actual treatment letters randomized afterwards. The steps are best seen by reference to the diagram in Appendix III. Confounding by superimposition can be completed in sections as shown in the second series of diagrams. It will be noticed that a clock sequence of the units in a section is the basis of this design.

Once the design is complete on paper, its transference to the field need not be geographically exact. The actual shape of the "square" will depend on the shape of the unit plots.

9. COMPROMISE BETWEEN RANDOM AND SYSTEMATIC ARRANGEMENT.

In describing the following work I wish to make it clear that I have not had the opportunity of discussing the ideas outlined, with other workers, and merely put them forward as a possible line of future investigation. It has occurred to me that if a systematic arrangement could be carried out in the field, and the randomization done in the laboratory before the error was calculated, that some of the objections to random arrangement would be removed. If say, a number of treatments were repeated in a systematic check-board arrangement, randomized blocks could be made up in the laboratory, composed of complete sets of treatments, by separately shuffling cards representing the replications of each treatment, and taking out one from each until exhausted. The new series would be randomized blocks. This seems to be merely an extension of the idea of changing bodily the geographical position of complete rows of a Latin Square in the field.

The idea seems fruitful, in the case of permanent crops where the differences between plots are great in comparison with the expected differences due to treatments. By arranging the plots in order of yield, and then putting a Latin Square arrangement on it, the upsetting factor of large intrinsic differences is overcome. A test of this, on uniformity trial coconuts, was carried out, and plans are given in Appendix III, 5. The reduction of "z" by rearrangement and the increase in significance of an added % for treatment is suggestive of the usefulness of the method.

10. SUMMARY OF THE SCHEME.

Taking the various points discussed in the foregoing sections the proposed system is as follows :—

1. Rigidly mark the experimental areas, blocks and plots, and number consecutively on a plan.
2. Decide on the treatment of edge effect and allowance for upsetting factors, such as ant hills and whether yield is taken per crop unit or per unit area.
3. Use randomized arrangements, adapted to the available plots.
4. Work out the results by short and standard method.

Following these points, there would develop :—

5. Standard method of interpretation of results and odds required for significance.
6. Standardization of operations in all stations, and parallel trials.

All these points are embodied in Faulkner's scheme with the exception of No. 3, the case for which is the purport of this paper. With the embodiment of randomization the Nigerian scheme would be as near perfection as our knowledge and circumstances permit. This, with a rational development of surveys of native farming methods and yields, would most probably achieve the result most quickly—that is, of the general improvement of agricultural practice in West Africa.

APPENDIX I.

DIAGRAM.

(R. A. FISHER.)

I.

REPLICATION.

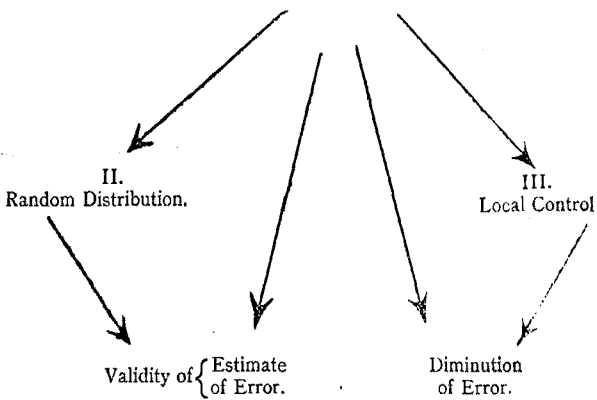


Diagram used in the Statistical Laboratory at Rothamsted.

APPENDIX II.

SOIL HETEROGENEITY.

1. Plan of Field of Maize, showing yield per plot.
2. Plan of Field of Coconuts, showing individual yields.
3. Plan of Field of Coconuts, showing yield per plot.
4. Table of S.D. for plots of different sizes.

APPENDIX II.

ASUANSI Investigational Station.

i. Plan of Field of Maize,
 $\frac{1}{40}$ th acre plots.
 Uniformity Trials, 1928.

									270	284	280	263	252	265	205	266	183	
									208	253	245	282	212	210	180	194	180	110
105	117	122	114	120	105	135	205	220	265	212	305	230	197	200	190	200	150	
110	162	207	130	155	197	184	255	205	234	230	244	243	190	190	170	213	122	
80	157	130	140	130	153	150	180	132	160	140	155	140	174	154	160	176		
				95	91	73	121	137		135	116	123	115	168	120			

Figures show number of ears harvested in each plot.

2.

E I

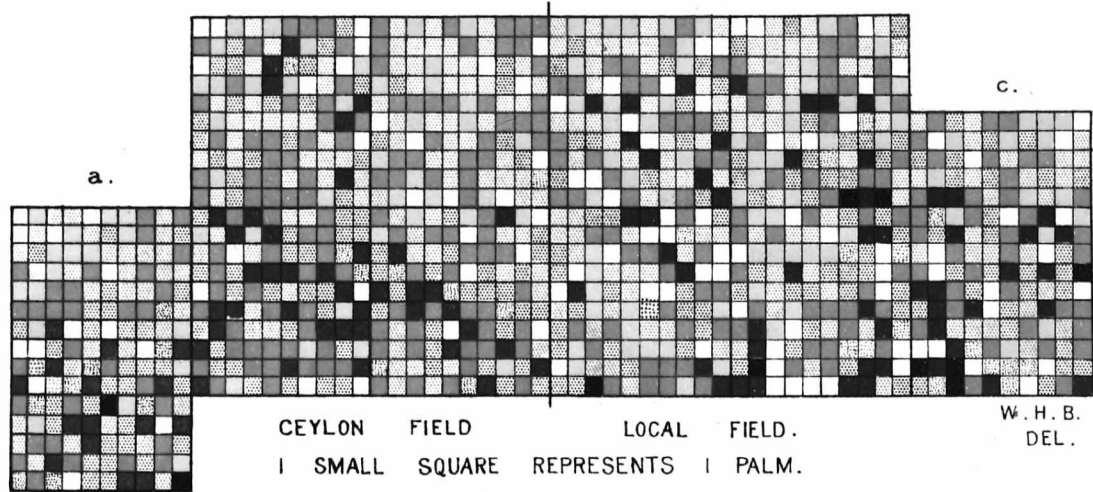
E II

b.

c.

a.

b.



	120	&	OVER	NUTS
	100	"	UNDER 120	"
	80	"	"	100
	60	"	"	80
	40	"	"	60
	30	"	"	40
			UNDER	20
			NOT	FRUITING.

YIELD PLAN OF COCONUTS - 1928
ASUANSI.

Survey H.Q. Accra, 1929.

APPENDIX II.

ASUANSI Investigational Station.

i. Plan of Field of Maize,
 $\frac{1}{40}$ th acre plots.
 Uniformity Trials, 1928.

									270	284	280	263	252	265	205	266	183		
									208	253	245	282	212	210	180	194	180	110	
105	117	122	114	120	105	135	205	220	265	212	305	230	197	200	190	200	150		
110	162	207	130	155	197	184	255	205	234	230	244	243	190	190	170	213	122		
80	157	130	140	130	153	150	180	132	160	140	155	140	174	154	160	176			
				95	91	73	121	137		135	116	123	115	168	120				

Figures show number of ears harvested in each plot.

2.

E I

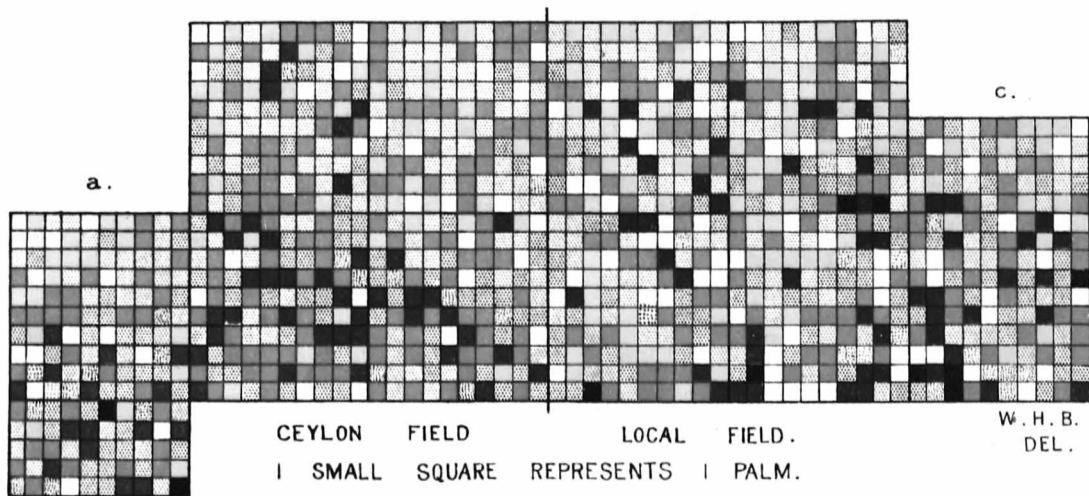
E II

b.

c.

a.

b.



CEYLON FIELD

LOCAL FIELD.

W. H. B.
DEL.

1 SMALL SQUARE REPRESENTS 1 PALM.

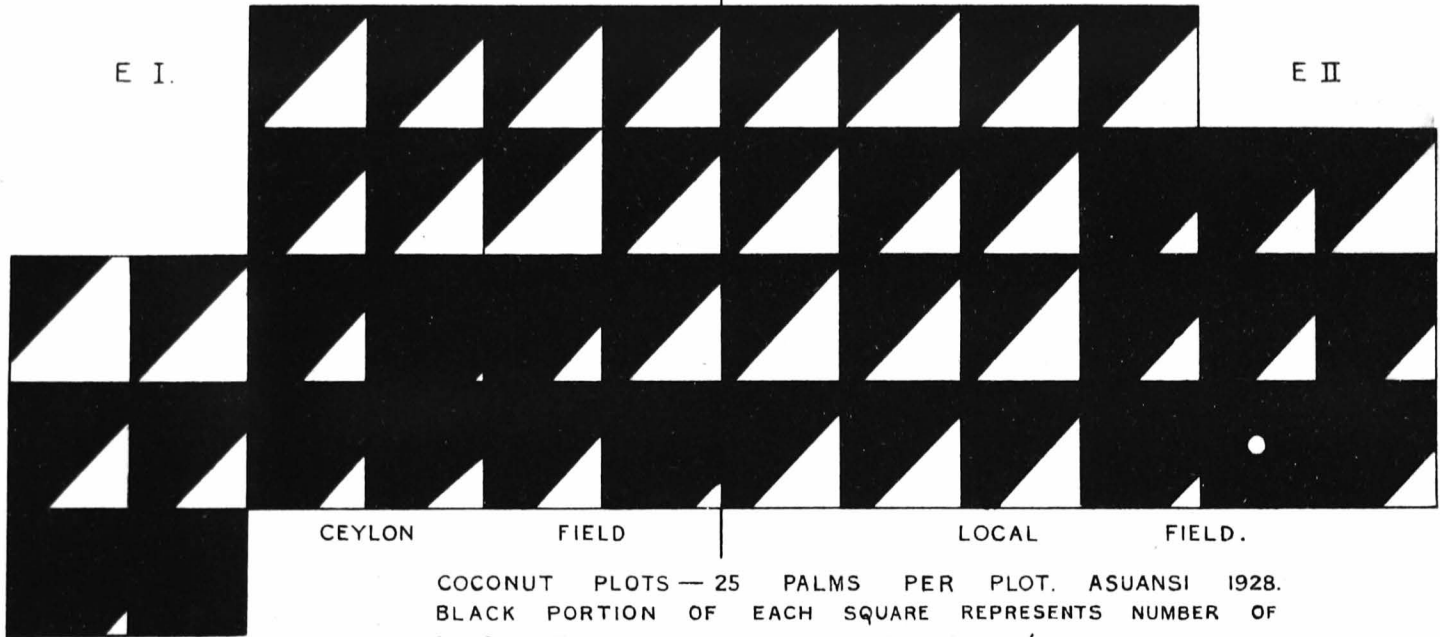
	120 & OVER	NUTS
	100 " UNDER	120 "
	80 " " "	100 "
	60 " " "	80 "
	40 " " "	60 "
	30 " " "	40 "
	UNDER	20 "
	NOT	FRUITING.

YIELD PLAN OF COCONUTS - 1928
ASUANSI.

Survey H.Q. Accra, 1929.

APPENDIX II.

3



DEL. W.H.B.

COCONUT PLOTS — 25 PALMS PER PLOT. ASUANSI 1928.
BLACK PORTION OF EACH SQUARE REPRESENTS NUMBER OF
NUTS, WITH A MAXIMUM OF 1600 NUTS. (ONE PLOT YIELDED
1715 AND IS SHOWN WITH A CLEAR CIRCLE IN CENTRE).

Survey H.Q. Accra, 1930.

4. Standard Deviation of Plots of Different Sizes.

No. of Trees per Plot.	CEYLON FIELD.			LOCAL FIELD.		
	Mean.	S.D.	$\frac{\text{S.D.} \times 100}{\text{Mean.}}$	Mean.	S.D.	$\frac{\text{S.D.} \times 100}{\text{Mean.}}$
			Per cent.			Per cent.
5	1,085	430	39.7	855	439	51.4
10	2,171	641	29.5	1,710	784	45.8
20	4,342	1,327	30.6	3,420	1,473	43.1
25	5,427	1,632	29.8	4,275	1,748	40.9
40	8,683	2,562	29.5	6,840	2,704	25.3
50	10,854	3,324	30.6	8,551	2,369	27.7
100	21,708	6,582	30.5	17,102	4,521	26.4

For plan see figure 2.

APPENDIX III.

DESIGN.

I. RANDOMIZATION.

Successive restrictions on the full random arrangement.

Example :—Number of plots = n^2 where $n = 4$

(a) *Complete Randomization.*

4	1	3	3
1	4	2	4
4	1	2	3
3	2	2	1

16 plots with 4 replications of 4 treatments.

(b) *Randomized Blocks.*

4	1	3	2
3	1	4	2
1	2	3	4
4	1	3	2

4 blocks of 4 plots, each containing 1, 2, 3 and 4 treatments.

(c) *The Latin Square.*

4	1	3	2
3	4	2	1
1	2	4	3
2	3	1	4

4 rows and 4 columns, each containing 1, 2, 3 and 4.

N.B.—The 4 rows or the 4 columns form 4 randomized blocks.

(d) *The Græco-Latin Square.*

2d	4a	1c	3b
4b	3c	2a	1d
3c	1b	4d	2a
1a	2d	3b	4c

4 rows and 4 columns, each containing, 1, 2, 3 and 4 and also *a, b, c, and d.*

Here four other treatments are superimposed on the first Latin square. The four treatments, 1, 2, 3 and 4, or the four *a, b, c, d*, each forms a Latin Square. Each row and each column contains the same *total* treatment, and each of the treatments 1, 2, 3 and 4, has superimposed on it the same total treatment $a + b + c + d$, and *vice-versa.*

(e) *The Magic Square.*

4	1	2	3
3	2	1	4
2	3	4	1
1	4	3	2

4 rows, 4 columns and 4 quarters, each containing the 4 treatments.

Here a further superimposition can be made by having different treatments in quarters, whether the original square is Latin or Græco-Latin, and still each row and each column contains the same *total* treatment.

2. THE LATIN SQUARE.

(a) *The Latin Square as produced in the Laboratory* :—Put all cards in the box and take out singly, producing the first row :—

B A E D C

and return cards to box.

The first letter of second row can only be selected from A, E, D, C, so take the 1st of these which turns up, say C.

B A E D C

C. and return cards to box.

The next letter may not be C or A, so take which turns up first of the available letters B, E, D. Repeat the process until the square is completed thus :—

1	2	3	4	5
B	A	E	D	C
C	E	B	A	D
A	D	C	B	E
E	B	D	C	A
D	C	A	E	B

Now reshuffle complete columns at random, say 2, 1, 4, 5, 3.

2	1	4	5	3	
A	B	D	C	E	1
E	C	A	D	B	2
D	A	B	E	C	3
B	E	C	A	D	4
C	D	E	B	A	5

and finally reshuffle the rows at random, say 5, 3, 1, 2, 4.

C	D	E	B	A	5
D	A	B	E	C	3
A	B	D	C	E	1
E	C	A	D	B	2
B	E	C	A	D	4

(b) *Line arrangement.*

If in the field the arrangement is in a line of long narrow plots, it would appear thus :—

C	D	E	B	A	D	A	B	E	C	A	B	D	C	E	E	C	A	D	B	B	E	C	A	D
1st row.					2nd row					3rd row.					4th row.					5th row.				

3. THE MAGIC SQUARE.

(a) *Definition :—*

Each row
Each column
Each section } contains all the treatments.

1st Stage of a 4×4 .

1	→	2
↑		↓
4	←	3

The 4 treatments can be arranged in $\underline{4}$ ways.

2nd Stage.

1 → 2 ↑ ↓ 4 ← 3	1 2 4 3	1 2 4 3	1 2 4 3	
2 ← 1 ↓ ↑ 3 → 4	3 4 2 1	2 4 3 1	3 1 2 4	

making a further 4 possibilities.

3rd Stage.

1	2	3	4
4	3	2	1
2	1		
3	4		

This stage can be completed in 4 ways similar to stage 2.

4th Stage.—When the 1st three stages are fixed, it will be seen that the fourth is fixed, thus giving $\underline{4} \times 4 \times 4 = 384$ possibilities.

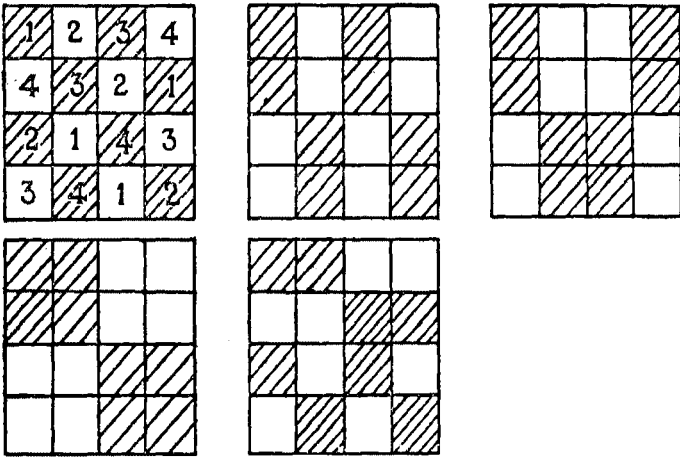
(b) A 6×6 Magic Square.

1 → 2 → 3	4 → 5 → 6
↑ ↓	
6 ← 5 ← 4	3 2 1
5 6 1	2 3 4
4 3 2	1 6 5
3 4 5	6 1 2
2 1 6	5 4 3

The construction is evident by following the arrows: after the two top sections, the middle two are made by moving the 1 along two places round the clock, and again for the bottom two. The six treatments can be randomized in the first section and then the 2nd section and so on. With a regular sequence of 1 to 6, type squares can be built up and then the treatments randomized in the complete square.

4. CONFOUNDING IN A 4×4 MAGIC SQUARE.

The shaded and unshaded positions represent superimposed treatments.



Types only are shown, and each can be reversed, or looked at from any side as base. The possibilities are numerous, but the exact number has not been calculated.

5. REARRANGEMENT OF PLOTS.

Rearrangement of plots according to yield, before putting a layout on them :—

(a) *Actual Plot figures, as on the field plan.*

847	790	893	917	3,447
854	1,125	891	1,451	4,321
976	999	852	1,319	4,146
1,093	1,076	1,053	1,494	4,716
3,770	3,990	3,689	5,181	16,630

The Latin Square put on to the plots :—

Treatment.				Plot numbers.			
D	C	B	A	1	2	3	4
A	B	D	C	5	6	7	8
C	D	A	B	9	10	11	12
B	A	C	D	13	14	15	16

The treatments are assumed. First the Latin Square was worked out on the uniformity trial and the value of "z" calculated. It was found to be .544.

(b) The original figures were adjusted as follows :—

Treatment	A =	— 6%
"	B =	— 2%
"	C =	+ 2%
"	D =	+ 6%

898	806	875	862	3,441
803	1,103	944	1,480	4,330
996	1,059	801	1,293	4,149
1,071	1,011	1,074	1,584	4,740
<hr/>				
3,768	3,979	3,694	5,219	16,660

and a "z" test made. The value of "z" = .852.

(c) The order of the plots was then rearranged in order of actual yield thus :—

Plot number.			
16	8	12	6
13	14	15	10
9	4	3	7
5	11	1	2

producing the rearranged Latin Square :—

1,494	1,451	1,319	1,125	5,389
1,093	1,076	1,053	999	4,221
976	917	893	891	3,677
854	852	847	790	3,343
<hr/>				
4,417	4,296	4,112	3,805	16,630

and the same Latin Square design put on these figures. On the field plan the treatments would appear thus :—

D	C	B	B
B	A	C	D
C	A	B	D
A	A	D	C

A "z" test produced a value .0659.

(d) These figures were then adjusted as in 2 above by adding -6, -2, +2, +6% respectively to treatments, A, B, C and D, producing the following square :—

1,584	1,460	1,293	1,058	5,395
1,027	1,054	1,116	1,019	4,216
996	972	8,839	873	3,680
837	801	864	837	3,339
4,444	4,287	4,112	3,787	16,630

and a "z" test produced a value .862.

(e) Table of "z" for the 4 squares :—

	Uniformity trial.	Adjusted treatments.
Original Layout	.544	.852
Rearranged Layout	.066	.862

$$\begin{array}{l} 1\% \text{ point of } z = 1.1401 \\ 5\% \text{ " " } z = .7798 \end{array} \left\{ \begin{array}{l} \text{for } n_1 = 3 \\ n_2 = 3 \end{array} \right.$$

We see that the value of "z," though considerably less in the rearranged layout for the uniformity trial, is actually increased when the adjustments for treatment were made. This is an indication of the usefulness of the method.

Here, of course, the same years' figures are used all the time, but in applying the method, past years' records would be used for making the rearrangement.

Probably by combining this method with the % increase method (used by Lord, in Ceylon, in rubber), very fine differences could be investigated, even in a field where the soil heterogeneity was large.

6. EXAMPLES OF MODERN EXPERIMENTAL LAYOUTS.

*a. Rothamsted Sugar Beet; 1928.*144 plots, each $\frac{3}{200}$ of an acre .. Total area = 2.16 acres.

S O O S S O O S S O S O

R	11	5	9	3	10	4	8	12	7	6	1	2
F	9	11	1	12	7	2	10	4	5	3	8	6
F	4	6	10	7	12	3	11	8	9	2	5	1
R	6	10	2	4	8	1	7	3	12	11	9	5
R	12	7	6	8	2	9	1	11	4	5	3	10
F	3	2	4	1	11	5	12	6	8	10	7	9
R	7	3	8	9	1	10	2	5	6	4	11	12
F	5	8	12	2	9	6	4	1	3	7	10	11
R	8	1	11	10	5	7	3	9	2	12	6	4
F	2	9	7	11	6	12	5	10	1	8	4	3
F	10	4	5	6	3	8	9	2	11	1	12	7
R	1	12	3	5	4	11	6	7	10	9	2	8

S=Subsoiled.

R=Ridged.

O=Not subsoiled.

F=Flat.

Basal Dressing—Sulphate of Ammonia, at 2 cwts. per acre.

Key to treatments:—c.p.a.=cwts per acre.

Treatment Number.	Superphosphate.	Potash.	Nitrochalk (top dressing).
1	 	Muriate 2 ct. per acre	
2	 	P. manure salts K = 2 c.p.a.	
3	2 c.p.a.	Muriate	
4	2 c.p.a.	P. manure salts	
5	 	Muriate	early 1 c.p.a.
6	 	P. manure salts	1 c.p.a.
7	2 c.p.a.	Muriate	1 c.p.a.
8	2 c.p.a.	P. manure salts	1 c.p.a.
9	 	Muriate	early and late each at 1 c.p.a.
10	 	P. manure salts	„ „
11	2 c.p.a.	Muriate	„ „
12	2 c.p.a.	P. manure salts	„ „

b. Potatoes. Rothamsted 1928, Great Harpenden.

81 plots, each divided into two, the shaded half receiving phosphate, quantity of N & K, and quantity of K.

a 1 b	a 2 b	a 3 b	a 1 b	a 2 b	a 3 b	a 1 b	a 2 b	a 3 b
A			B			C		
a 4 b	a 5 b	a 6 b	a 4 b	a 5 b	a 6 b	a 4 b	a 5 b	a 6 b
a 7 b	a 8 b	a 9 b	a 7 b	a 8 b	a 9 b	a 7 b	a 8 b	a 9 b
D			E			F		
G			H			I		

Treatment.	N	K
1	—	—
2	1½	—
3	3	—
4	—	1
5	1½	1
6	3	1
7	—	2
8	1½	2
9	3	2

3	P6	S9	S9	P6	H5	2	S9	P4
1	P7	2	M8	S4	1	M7	M8	S5
S4	M8	M5	P7	2	3	1	3	M6
2	S7	P8	P5	M9	S6	S7	2	S4
3	S6	P5	1	M4	P7	M5	P8	M9
M4	M9	1	2	3	S8	3	1	P6
P9	M6	S7	3	P9	S8	2	M6	1
2	M8	P4	M4	1	M7	3	S5	S8
1	3	S5	2	S6	P5	P4	P9	M7

P=Potash Manure salts

S=Sulphate of Potash,

M=Muriate of Potash,

Sulphate of Ammonia @ $1\frac{1}{2}$ & 3
cwt. p.a.

Super @ 3 cwt. p.a.(shaded half)

Muriate

P. manure salts } @ K equivalent.

Plots.	Treatments.				
	S. of Am.	Potash.			Super.
		S	M	P	
A4, B6, C7, D9, E4, F8, G7, H5, I3 ..	—	—	—	—	
A6, B8, C1, D1, E7, F2, G4, H7, I1..	$1\frac{1}{2}$	—	—	—	
A1, B9, C8, D4, E8, F7, G8, H1, I4..	3	—	—	—	
A7, B5, F3 ..	—	1	—	—	
C6, G9, I5..	$1\frac{1}{2}$	1	—	—	
D5, F3, H8 ..	3	1	—	—	
D2, F1, G3 ..	—	2	—	—	
E9, H3, I6 ..	$1\frac{1}{2}$	2	—	—	
A3, B1, C2 ..	3	2	—	—	
D7, E5, H4 ..	—	—	1	—	
A9, B3, F4 ..	$1\frac{1}{2}$	—	1	—	
C9, G2, I1 ..	3	—	1	—	
C4, H6, I9 ..	—	—	2	—	
A8, B4, G5 ..	$1\frac{1}{2}$	—	2	—	
D8, E2, F6 ..	3	—	2	—	
C3, G6, I7 ..	—	—	—	1	
D6, E1, H9 ..	$1\frac{1}{2}$	—	—	1	
A2, B2, F9 ..	3	—	—	1	
A5, B7, E6 ..	—	—	—	2	
C5, D3, F5 ..	$1\frac{1}{2}$	—	—	2	
G1, H2, I8 ..	3	—	—	2	

Designs "a" & "b" are taken from Rothamsted Statistical Department Records.

(c) *East Malling Fruit Research Station.*

Pyne's Royal Raspberry Experiment. 1927.

8 randomized blocks of 12 plots each. Each plot consists of three 20-yard lengths of row; separated by 18 in. in rows and 1 guard row between rows.

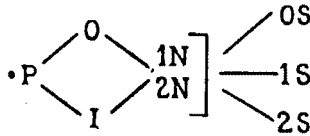
Treatments.

	N	P	S
A	1	-	-
B	2	-	-
C	1	1	-
D	2	1	-
E	1	-	1
F	2	-	1
G	1	1	1
H	2	1	1
J	1	-	2
K	2	-	2
L	1	1	2
M	2	1	2

S = Shoddy.

N = Sulphate of Ammonia or equivalent.

P = Sulphate of Potash or equivalent.

*Comparisons.*

1 N v. 2 N
 P v. No P
 2 S v. 1 S v. O S

Differential Effects.

N and P
 Excess N and P
 N and S
 S and P
 N, S, P

(Designed by the Statistician of East Malling Fruit Research Station.)

APPENDIX IV.

ANALYSIS AND SHORT METHODS.

In agricultural experiment it is frequently necessary to calculate a statistic such as a standard deviation or correlation coefficient without mechanical aid, and in so doing the arithmetical work can be considerably reduced by taking advantage of several short methods. These methods are, unfortunately, not commonly known, due no doubt to their absence from the text books. Examples of such methods are given below for the Standard Deviation, correlation coefficient, and two types of field experiment.

Throughout the paper the following notation will be used :—

- x is any one reading.
- \bar{x} is the mean.
- S is the total.
- n is the number of readings.
- σ is the standard deviation of x .
- σ_m is the standard deviation of the mean \bar{x} .
- V is the variance.

1. THE STANDARD DEVIATION.

For simplicity, a series of 10 values has been chosen. In actual fact, in such a simple case there would be little difference between the direct and short methods, but in case of values having several figures, or a mean which runs into several places of decimals, the saving in labour is considerable.

Below is given the direct calculation of the Standard Deviation :—

<u>x</u>	<u>$(x-\bar{x})$</u>	<u>$(x-\bar{x})^2$</u>
14	3.4	11.56
12	1.4	1.96
9	- 1.6	2.56
12	1.4	1.96
15	4.4	19.36
8	- 2.6	6.76
14	3.4	11.56
7	- 3.6	12.96
5	- 5.6	31.36
10	- 0.6	.36
<hr/> $S=106$	<hr/> 14.0	<hr/> 100.4
$\bar{x}=10.6$	-14.0	
$\Sigma (x-\bar{x})^2$	=	100.4

$$\sigma = \sqrt{\frac{\Sigma (x-\bar{x})^2}{n-1}} = \sqrt{\frac{100.4}{9}} = 3.34$$

$$\sigma_m = \sqrt{\frac{\sigma^2}{n}} = \sqrt{\frac{100.4}{9 \times 10}} = 1.07$$

A common method in use is to take differences from an arbitrary mean, and then to correct the figure obtained for total sum squares by subtracting n times the square of the difference between the arbitrary mean, \bar{x}' , and the true mean \bar{x} . In this case let us use 10 as the arbitrary mean and take differences from that value. The figure obtained for total sum square is 104. The difference between the arbitrary and true mean is $(10-10.6) = -0.6$ and n times the square of this value is $10 \times (-0.6)^2 = 3.6$. By subtracting this from 104 we get the true total sum squares figure which is 100.4.

$$\text{i.e., } \Sigma (x-\bar{x})^2 = \Sigma (x-\bar{x}')^2 - nd^2 \quad \dots\dots\dots(i)$$

where \bar{x} is true mean,

\bar{x}' is the arbitrary mean.

$$\text{and } d = -(\bar{x}-\bar{x}') = -0.6.$$

<u>x</u>	<u>(x-\bar{x}')</u>	<u>(x-\bar{x}')²</u>
14	4	16
12	2	4
9	- 1	1
12	2	4
15	5	25
8	- 2	4
14	4	16
7	- 3	9
5	- 5	25
10	0	0
<hr/>	<hr/>	<hr/>
106	17	104
	-11	$nd^2 = 3.6$
		<hr/>
		100.4

Proof of identity:

$$\Sigma (x-\bar{x})^2 = \Sigma (x-\bar{x}')^2 - nd^2$$

Let $(x-\bar{x}) = a = \text{one difference}$

then $(x-\bar{x}') = a-d$

The statistic required is :

$$\Sigma (x-\bar{x})^2 = \Sigma a^2$$

Now $a = a - d + d$

$$\begin{aligned} \therefore a^2 &= (a - d + d)^2 \\ &= (a - d)^2 + 2d(a - d) + d^2 \\ &= (a - d)^2 + 2ad - 2d^2 + d^2 \\ &= (a - d)^2 + 2ad - d^2 \\ \Sigma a^2 &= \Sigma (a - d)^2 + \Sigma 2ad - \Sigma d^2 \end{aligned}$$

Now $\Sigma a = 0$ (i.e., deviations from the mean).

$$\therefore \Sigma 2ad = 0$$

and $\Sigma d^2 = nd^2$ (d being constant).

$$\therefore \Sigma a^2 = \Sigma (a-d)^2 - nd^2$$

$$\text{i.e., } \Sigma (x-\bar{x})^2 = \Sigma (x-\bar{x}')^2 - nd^2 \dots\dots\dots(i).$$

A further adaptation of the idea is the basis of the short method. Instead of taking 10 as the arbitrary mean, take 0, and use the identity :

$$\Sigma (x-\bar{x})^2 = \Sigma x^2 - n\bar{x}^2.$$

x	x^2	
14	196	
12	144	
9	81	
12	144	$d = \bar{x} = 10.6$
15	225	
8	64	$d^2 = 112.36$
14	196	
7	49	$nd^2 = 1123.6$
5	25	
10	100	
	1224	
	$nd^2 = 1123.6$	
	100.4	

Proof of identity :

$$\begin{aligned} (x-\bar{x})^2 &= x^2 - 2x \cdot \bar{x} + \bar{x}^2 \\ &= x^2 - 2x \cdot \bar{x} + 2\bar{x}^2 - \bar{x}^2 \\ &= x^2 - 2\bar{x}(x-\bar{x}) - \bar{x}^2 \end{aligned}$$

$$\therefore \Sigma (x-\bar{x})^2 = \Sigma x^2 - \Sigma 2\bar{x} (x-\bar{x}) - \Sigma \bar{x}^2$$

but $\Sigma (x-\bar{x}) = 0$

and $\Sigma \bar{x}^2 = n\bar{x}^2$

$$\Sigma (x-\bar{x})^2 = \Sigma x^2 - n\bar{x}^2 \dots\dots\dots(ii)$$

i.e. to find the total sum square difference, square the readings, add them together, and subtract n times the square of the mean.

In certain cases it is useful to employ a slightly different form of the identity (ii), viz. :—

$$\left. \begin{aligned} \Sigma (x-\bar{x})^2 &= \Sigma x^2 - n\bar{x}^2 \\ &= \Sigma x^2 - \frac{S^2}{n} \\ &= \Sigma x^2 - S \cdot \bar{x} \end{aligned} \right\} \dots\dots\dots(ii)$$

2. THE CORRELATION COEFFICIENT.

If $x_1 \ x_2 \ x_3 \ \dots \ x_n$ and $y_1 \ y_2 \ y_3 \ \dots \ y_n$ are the corresponding observations, the following statistics may be calculated.

Means $\bar{x} = \frac{\Sigma x}{n}$; $\bar{y} = \frac{\Sigma y}{n}$

Variance $\sigma_x^2 = \frac{\Sigma (x-\bar{x})^2}{n-1}$; $\sigma_y^2 = \frac{\Sigma (y-\bar{y})^2}{n-1}$

S.E. of Mean $\frac{\sigma_x}{\sqrt{n}}$; $\frac{\sigma_y}{\sqrt{n}}$

Product Moment $\frac{\Sigma (x-\bar{x})(y-\bar{y})}{n-1}$

Correlation Coefficient, $r = \frac{\text{Product Moment}}{\sigma_x \sigma_y}$

If the analysis has entailed the calculation of the standard deviation, we now require to find the Product Moment. The short method uses the identity:—

$\Sigma (x-\bar{x})(y-\bar{y}) = \Sigma xy - n\bar{x}\bar{y}$ (iii)

which, combined with the identities under (ii) above, gives the following of short method for r .

$$r = \frac{\text{Product Moment}}{\sigma_x \sigma_y} = \frac{\Sigma (x-\bar{x})(y-\bar{y})}{n-1} = \frac{\Sigma xy - n\bar{x}\bar{y}}{(\Sigma x^2 - n\bar{x}^2)(\Sigma y^2 - n\bar{y}^2)} \dots\dots\dots(iv)$$

or
$$\left[\frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\left(\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right) \left(\Sigma y^2 - \frac{(\Sigma y)^2}{n}\right)} \right]$$

Proof of identity :

$$\begin{aligned} (x-\bar{x})(y-\bar{y}) &= xy + \bar{x}\bar{y} - \bar{x}y - x\bar{y} \\ &= xy - \bar{x}\bar{y} - \bar{x}(y-\bar{y}) - y(x-\bar{x}) \\ \therefore \Sigma (x-\bar{x})(y-\bar{y}) &= \Sigma xy - \Sigma \bar{x}\bar{y} - \Sigma \bar{x}(y-\bar{y}) - \Sigma y(x-\bar{x}) \\ \text{but } \Sigma (y-\bar{y}) &= 0 \\ \Sigma (x-\bar{x}) &= 0 \\ \Sigma \bar{x}\bar{y} &= n\bar{x}\bar{y} \\ \therefore \Sigma (x-\bar{x})(y-\bar{y}) &= \Sigma xy - n\bar{x}\bar{y} \\ &\text{or } \Sigma xy - \frac{S_x S_y}{n} \dots\dots\dots(iii) \end{aligned}$$

For example, a perfect correlation has been chosen, of the two series of numbers, 1, 2, 3, 4, 5 and 2, 4, 6, 8, 10. In the direct calculation the figures would be set out as follows:—

	x	y	$x-\bar{x}$	$y-\bar{y}$	$(x-\bar{x})^2$	$(y-\bar{y})^2$	$(x-\bar{x})(y-\bar{y})$
	1	2	-2	-4	4	16	8
	2	4	-1	-2	1	4	2
	3	6	0	0	0	0	0
	4	8	1	2	1	4	2
	5	10	2	4	4	16	8
Sum	15	30	—	—	10	40	20
Mean	3	6	—	—	—	—	—

$$\begin{aligned} \text{then } r &= \frac{\text{Product Moment}}{\sigma_x \sigma_y} \\ &= \frac{20}{4} \\ &= \frac{\sqrt{10}}{\sqrt{4}} \cdot \frac{\sqrt{40}}{\sqrt{4}} \\ &= \frac{20}{\sqrt{400}} = 1 \end{aligned}$$

Using the short method, the figures would be set out thus:—

	x	y	x^2	y^2	xy
	1	2	1	4	2
	2	4	4	16	8
	3	6	9	36	18
	4	8	16	64	32
	5	10	25	100	50
Sum	15	30	55	220	110
Mean	3	6	—	—	—

$$\begin{aligned} r &= \frac{\Sigma xy - n\bar{x}\bar{y}}{\sqrt{(\Sigma x^2 - n\bar{x}^2)(\Sigma y^2 - n\bar{y}^2)}} \dots\dots\dots (iv) \\ &= \frac{110 - (5 \times 3 \times 6)}{\sqrt{(55 - 5 \times 3^2)(220 - 5 \times 6^2)}} \\ &= \frac{110 - 90}{\sqrt{(55 - 45)(220 - 180)}} \\ &= \frac{20}{\sqrt{10 \times 40}} \\ &= 1 \end{aligned}$$

3. STANDARD DEVIATION OF A SUM OR DIFFERENCE.

In several forms of field experiment, the standard deviation of mean difference between series of observations is the basis of the estimate of error used in testing the significance of the observed mean differences.

If $x_1, x_2, x_3 \dots x_n$ and $y_1, y_2, y_3 \dots y_n$ are the two sets of observations, x being one variety, say, and y the other variety, and $(x_1, y_1), (x_2, y_2)$ the pairs of corresponding observations of yield, the standard deviation of the mean difference, between the x 's and the y 's is defined by

$\sigma_{xy}^2 = \sigma_x^2 + \sigma_y^2$ where there is no correlation between the two series, and by

$\sigma_{xy}^2 = \sigma_x^2 + \sigma_y^2 - 2r \sigma_x \sigma_y \dots \dots \dots$ (v)
 where there is a correlation, and 'r' is the calculated correlation coefficient. The calculation of σ_{xy} is obviously lengthy, and a short method, described by Student, and now commonly known as Student's Method, consists in finding the standard deviation of a new series, $(x_1 - y_1), (x_2 - y_2), (x_3 - y_3)$, etc., obtained by taking the differences between the paired observations.

An explanation of the theory underlying this method is given below :—

$$\sigma_x = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}; \quad \sigma_y = \sqrt{\frac{\Sigma(y - \bar{y})^2}{n - 1}}$$

$$\text{and } r = \frac{\text{Product Moment}}{\sigma_x \sigma_y}$$

$$\begin{aligned} \text{Now } 2r \sigma_x \sigma_y &= 2 \cdot \frac{\text{Product Moment}}{\sigma_x \sigma_y} \cdot \sigma_x \sigma_y \\ &= 2 \cdot \text{Product Moment} \\ &= \frac{2 \Sigma(x - \bar{x})(y - \bar{y})}{n - 1} \end{aligned}$$

$$\begin{aligned} \text{Now } \sigma_{xy}^2 &= \sigma_x^2 + \sigma_y^2 - 2r \sigma_x \sigma_y \\ &= \frac{\Sigma(x - \bar{x})^2}{n - 1} + \frac{\Sigma(y - \bar{y})^2}{n - 1} - \frac{2 \Sigma(x - \bar{x})(y - \bar{y})}{n - 1} \\ &= \frac{\Sigma \left\{ (x - \bar{x}) - (y - \bar{y}) \right\}^2}{n - 1} \\ &= \frac{\Sigma \left\{ (x - y) - (\bar{x} - \bar{y}) \right\}^2}{n - 1} \dots \dots \dots \text{(vi)} \end{aligned}$$

which is Student's method, as $(x - y)$ is the difference between one pair of observations and $(\bar{x} - \bar{y})$ is the mean of these differences.

A simple arithmetical example is given to illustrate the use of the identity.

x	y	$x-y$	Difference.	Squares.
1	2	-1	-1 - (-3) = 2	4
2	4	-2	1	1
3	6	-3	0	0
4	8	-4	1	1
5	10	-5	2	4
				10
		-15		
		-3		

$$\sigma_{xy} = \sqrt{\frac{10}{4}}$$

For the direct calculation of

$$\sigma_{xy} = \sqrt{\sigma_x^2 + \sigma_y^2 = 2r\sigma_x\sigma_y}$$

From the previous section we have

$$\sigma_x = \sqrt{\frac{10}{4}}$$

$$\sigma_y = \sqrt{\frac{40}{4}}$$

$$r = 1$$

$$\begin{aligned} \therefore \sigma_{xy} &= \sqrt{\frac{10}{4} + \frac{40}{4} - 2 \times 1 \times \sqrt{\frac{10}{4}} \sqrt{\frac{40}{4}}} \\ &= \sqrt{\frac{10}{4} + \frac{40}{4} - 2 \sqrt{\frac{400}{16}}} \\ &= \sqrt{\frac{10 + 40 - 40}{4}} \\ &= \sqrt{\frac{10}{4}} \end{aligned}$$

The saving of arithmetical work is obvious, even in the simple example taken. In practice the short method described in Section I would be used for obtaining the Standard Deviation of the series -1, -2, -3, -4, -5.

The direct method is used here to avoid confusion between that short method and the basis of Student's Method, with which we are dealing.

4. RANDOMIZED BLOCKS.

In working out a randomized block experiment, a table should first be made giving the treatments in columns, and the whole working carried out in totals. For the total sum squares we use the method already described under "Standard Deviation" observing that 'n' is here equal to (Number of rows) times (Number of columns).

- If R = Number of Rows or Blocks.
 C = Number of Columns or Treatments.
 x = One reading.
 S = Grand total = $\Sigma S_r = \Sigma S_c$.
 \bar{x} = General mean = $\frac{S}{R \cdot C}$
 S_r = Sum of rows.
 S_c = Sum of columns.
 \bar{x}_r = Mean of row = $\frac{S_r}{C}$
 \bar{x}_c = Mean of column = $\frac{S_c}{R}$

$$\text{Total Sum Square} = \Sigma x^2 - R \cdot C \bar{x}^2 = \Sigma x^2 - \frac{S^2}{R \cdot C}$$

$$\begin{aligned} \text{Row Sum Square} &= C \cdot \sum_1^r (\bar{x}_r - \bar{x})^2 \\ &= C \left\{ \sum_1^r (\bar{x}_r)^2 - R \bar{x}^2 \right\} \\ &= C \left\{ \sum_1^r \frac{S_r^2}{C^2} - R \left(\frac{S}{R \cdot C} \right)^2 \right\} \\ &= \sum_1^r \frac{S_r^2}{C} - \frac{S^2}{R \cdot C} \\ &= \frac{\sum_1^r S_r^2}{C} - \frac{S^2}{R} \dots\dots\dots \text{(vii)} \end{aligned}$$

$$\text{Similarly. Column S.S} = \frac{\sum_1^c S_c^2}{R} - \frac{S^2}{C} \dots\dots\dots \text{(viii)}$$

A worked out example is given below :—

Readings.

	A	B	C	D	E	F	G	H	Block Totals
	103	72	62	63	60	63	64	53	540
	23	32	28	13	22	30	44	19	211
	82	81	75	95	111	99	122	102	767
	52	52	22	32	62	26	73	57	376
Treat- ment Totals	260	237	187	203	255	218	303	231	1896
	General Mean								59

Squares.

A	B	C	D	E	F	G	H	Block Totals
10609	5184	3844	3969	3600	3969	4096	2809	38080
529	1024	784	169	484	900	1936	361	6187
6724	6561	5625	9025	12321	9801	14884	10404	75345
2704	2704	484	1024	3844	676	5329	3249	20014
20566	15473	10737	14187	20249	15346	26245	16823	139626 112338
Total Sum Squares =								27288

$$\begin{aligned}
 S^2 &= 1896 = 3594816 \\
 S^2/R &= S^2/4 = 898704 \\
 S^2/C &= S^2/8 = 449352 \\
 S^2/RC &= S^2/32 = 112338
 \end{aligned}$$

Rows.

$$\begin{aligned}
 540^2 &= 291600 \\
 211^2 &= 44521 \\
 767^2 &= 588289 \\
 376^2 &= 141376
 \end{aligned}$$

$$\begin{aligned}
 S^2/R &= \frac{1065786}{898704}
 \end{aligned}$$

$$\frac{8167082}{8}$$

$$20885 = \text{Row Sum Squares.}$$

Columns.

260 ²	=	67600
237 ²	=	56169
187 ²	=	34969
203 ²	=	41209
255 ²	=	65025
218 ²	=	47524
303 ²	=	91809
231 ²	=	53361
		457666
		449352
		48314

2079 = Column Sum Squares.

ANALYSIS OF VARIANCE.

	Sum Squares.	Degree of Freedom.	Variance.	Log. V.
Treatments ..	2079	7	297	2.4728
Blocks	20885	3		
Error	4324	21	206	2.3139
	27288	31		

“z” is defined as half the difference between the *Natural* logarithms of the two variances, and the general significance of the experiment is governed by the value of “z” for the appropriate degrees of freedom. Fisher (*Statistical Methods for Research Workers*) gives tables of the 5% and 1% points.

As $\log_e x = 2.30258 \log_{10} x$, it is simpler to look up the common logs of the variances and multiply by $2.30258 \div 2$.

$$\begin{aligned}
 \text{e.g. } \log_{10} 297 &= 2.4728 \\
 \log_{10} 206 &= 2.3139 \\
 \text{difference} &= .1589 \\
 \text{“z”} &= .1589 \times 1.15 = .17
 \end{aligned}$$

In the table of “z,” we look up the value for n_1 = number of degrees of freedom attached to the larger variance, in this case 7, and $n_2 = 21$.

For the 5% point, a value of “z” between .4725 and .4420 is required. Our calculated value is .17, and the experiment as a whole is therefore not significant.

5. THE LATIN SQUARE.

Asuansi Coconuts EI (b) and EI (c).

Arranged as a 4×4 Latin Square.

C	932	B	1090	D	861	A	866	3749
B	1152	C	1060	A	676	D	966	3854
A	1336	D	1535	B	1437	C	1030	5388
D	1462	A	1379	C	1289	B	1537	5667
4882		5114		4263		4399		18658
1166·125								
S = Grand Total = 18658								
S/n = \bar{x} = General Mean = 1166·125								

The total sum square difference

$$= \sum (x - \bar{x})^2 \\ = \sum (932 - 1166)^2 + (1152 - 1166)^2 + \text{etc.}$$

A short method uses the identity:—

$$\sum (x - \bar{x})^2 = \sum x^2 - \frac{S^2}{n} \\ = 932^2 + 1152^2 + 1336^2 + \text{etc.} - \frac{18658^2}{16}$$

Proof of Identity:

$$\sum (x - \bar{x})^2 = \sum (x^2 - 2x\bar{x} + \bar{x}^2) \\ = \sum (x^2 - 2x\bar{x} + 2\bar{x}^2 - \bar{x}^2) \\ = \sum x^2 - \sum 2\bar{x}(x - \bar{x}) - \sum \bar{x}^2.$$

but $\sum (x - \bar{x}) = 0$, and $\sum \bar{x}^2 = n\bar{x}^2$.

$$\therefore \sum (x - \bar{x})^2 = \left. \begin{aligned} & \sum x^2 - n\bar{x}^2 \\ & = \sum x^2 - \bar{x}S \\ & = \sum x^2 - \frac{S^2}{n} \end{aligned} \right\} \dots\dots\dots(ii)$$

Squares of readings:

868624	1188100	741321	749956	3548001
1327104	1123600	456976	933156	3840836
1784896	2512225	2064960	1060900	7422990
2137444	1901641	1661521	2362369	8062975
<hr/>				
6118068	6725566	4924787	5106381	22874802 = $\sum x^2$
				-21757560 = S^2/n

Total sum squares diff: = 1117242 = $\sum (x - \bar{x})^2$

$$\begin{aligned} S^2 &= 348120964 \\ S^2/\sqrt{n} &= 87030241 \\ S^2/n &= 21757560\cdot25 \end{aligned}$$

If \bar{x}_r = mean of a row, and S_r = row total sum sq., diff. for rows

$$\begin{aligned}
 &= \sqrt{n} \Sigma(\bar{x}_r - \bar{x})^2 \\
 &= \sqrt{n} \left\{ \Sigma(\bar{x}_r)^2 - \sqrt{n}(\bar{x})^2 \right\} \\
 &= \sqrt{n} \left\{ \Sigma \left(\frac{S_r}{\sqrt{n}} \right)^2 - \sqrt{n} \left(\frac{S}{n} \right)^2 \right\} \\
 &= \frac{\Sigma S_r^2 - \frac{S^2}{\sqrt{n}}}{\sqrt{n}} \dots\dots\dots(ix)
 \end{aligned}$$

The form of the final identity is chosen for a particular purpose, which will be seen later.

Similarly S.S.Q.D. columns = $\frac{\Sigma S_c^2 - \frac{S^2}{\sqrt{n}}}{\sqrt{n}} \dots\dots\dots(x)$

and for treatments = $\frac{\Sigma S_r^2 - \frac{S^2}{\sqrt{n}}}{\sqrt{n}} \dots\dots\dots(xi)$

Rows.

S_r	$(S_r)^2$	
3749	14055001	
3854	14853316	
5388	29030544	
5667	32114889	
	90053750	= ΣS_r^2
	87030241	= S^2/\sqrt{n}
	4) 3023509	= $\Sigma S_r^2 - \frac{S^2}{\sqrt{n}}$
	755877	\sqrt{n}

Sum Squares Difference for Rows = 755877.

Columns.

S_c	$(S_c)^2$
4882	23833924
5114	26152996
4263	18173169
4399	19351201
	87511290
	87030241
	4) 481049
	120262

Sum Squares Difference for Columns = 120262.

Treatments.

A	B	C	D	
866	1090	932	861	
676	1152	1060	966	
1336	1437	1030	1585	
1379	1537	1289	1462	
<hr/>	<hr/>	<hr/>	<hr/>	
4257	5216	4311	4874	18658

S_r		S_r^2
4257	—	18122049
5216	—	27206656
4311	—	18584721
4874	—	23755876
		<hr/>
		87669302
		87030241
		4) 639061
		<hr/>
		159765

Sum Squares Difference for Treatments = 159765

	Degrees of Freedom.	Sum Sq. Diff.	Variance.
Total	15	1117242	74483
Rows	3	755877	251959
Columns	3	120262	40087
Treatments	3	159765	53255
Remainder	6	81338	13556

In a "z" test,

$$z = \frac{1}{2} \log_e \text{ difference.}$$

$$= \frac{1.1512925 \times \log_{10} \text{ difference.}}{}$$

Treatments ..	log 53255	= 4.7264
Error	log 13556	= 4.1322
		<hr/>
	Difference	= <u>.5942</u>

n_1 = number of degrees of freedom corresponding to the larger variance = 3

$$n_2 = 6$$

$$z = .5942 \times 1.1512925$$

$$= .6910$$

\therefore not significant.

6. CONFOUNDING AND SEASONAL EFFECT.

The effect of different manurial treatments has been investigated over four successive crops of maize grown on the same plots at Kumasi. Superimposed on these manurial trials was a trial of Green Manuring and of Deep and Light Cultivations, arranged in complete blocks, each containing the six different manurial treatments in the block. For the purpose of analysing the effect of green Manuring and of Cultivation, these blocks are taken as the units. Eight of these units were chosen in two groups of four. The four units received (in addition to the same *total* amount of manurial treatment) (1) deep cultivation; (2) deep cultivation with green manuring; (3) light cultivation and (4) light cultivation with green manuring, respectively.

Treatments. D = Deep Cultivation.
L = Light Cultivation.
G = Green Manuring.

and the units are therefore:—

1.	D	3.	L
2.	D.G	4.	L.G

We thus have material for investigating the effect of Deep versus Light Cultivation by comparing (1 + 2) with (3 + 4), both having one G, which does not upset the comparison. Similarly by comparing (1 + 3) with (2 + 4) we have the effect of Green Manuring, as both these groups receive the same *total* cultivation, one L and one D. The complete figures of the yields are given in the following table:—

TABLE SHOWING COUNTS OF STANDS AND EARS AT HARVEST AND WEIGHTS OF SHELLED CORN IN GRAMMES.

		" A. "				" B. "			
		1 Deep 38 & 39	2 Deep Green 36 & 37	3 Light 34 & 35	4 Light Green 32 & 33	3 Light 26 & 27	4 Light Green 24 & 25	2 Deep Green 20 & 21	1 Deep 22 & 23
Jan. 1927	Stands	135	175	148	136	190	182	161	126
	Ears	206	252	261	213	266	365	348	245
	Weight	22,770	33,410	33,095	25,900	47,870	48,383	36,570	30,360
Jan. 1928	Stands	285	255	163	310	228	174	245	137
	Ears	409	327	229	441	279	307	342	151
	Weight	41,669	36,000	28,982	49,075	33,795	37,182	36,000	16,770
July 1928	Stands	287	244	186	206	266	266	267	340
	Ears	514	426	316	347	536	355	577	629
	Weight	71,090	55,125	43,090	43,465	53,305	50,735	55,285	77,925
Jan. 1929	Stands	276	231	138	247	173	164	242	218
	Ears	390	305	196	387	272	261	351	315
	Weight	37,208	32,835	21,320	38,759	30,573	28,411	36,265	30,043
Mean	Stands	246	226	159	225	214	194	229	205
	Ears	380	328	251	347	363	322	405	335
	Weight	43,184	39,443	31,624	39,300	41,386	41,178	41,030	38,775

A.—ACTUAL YIELDS.

The first stage in the analysis consists in preparing the various Tables I. to IV., which are self explanatory.

TABLE I.—ACTUAL YIELDS IN 100 GRAMMES PER PLOT.

Seasons.	Blocks.	Treatments.				Totals.
		1	2	3	4	
Jan. 1927	A	227	334	331	259	1,151
	B	304	366	479	484	1,633
		531	700	810	743	2,784
Jan. 1928	A	417	360	290	491	1,558
	B	168	360	338	372	1,238
		585	720	628	863	2,796
July 1928	A	711	551	431	435	2,128
	B	779	553	533	507	2,372
		1,490	1,104	964	942	4,500
Jan. 1929	A	372	328	213	388	1,301
	B	300	363	306	284	1,253
		672	691	519	672	2,554
Total	A	1,727	1,573	1,265	1,573	6,138
Total	B	1,551	1,642	1,656	1,647	6,496
Grand Total		3,278	3,215	2,921	3,220	12,634

TABLE II.—BLOCKS.

—	A	B	—
Seasons :—			
Jan. 1927 ..	1,151	1,633	2,784
Jan. 1928	1,558	1,238	2,796
July, 1928	2,128	2,372	4,500
Jan. 1929	1,301	1,253	2,554
	6,138	6,496	12,634

TABLE III.—TREATMENTS.

Seasons :—						
Jan. 1927 ..	531	700	810	734	—	
Jan. 1928 ..	585	720	628	863	—	
July 1928 ..	1,490	1,104	964	942	—	
Jan. 1929 ..	672	691	519	672	—	
	3,278	3,215	2,921	3,220		12,634

TABLE IV.—TOTAL YIELDS OF PLOTS.

	1	2	3	4	—	—
A	1,727	1,573	1,265	1,573	6,138	—
B	1,551	1,642	1,656	1,647	6,496	—
	3,278	3,215	2,921	3,220	12,634	—
						394·8

In calculating the total sum square difference for the 32 readings, the work is reduced by using the identity :—

$$\sum_1^{32} (x - \bar{x})^2 = \sum_1^{32} x^2 - \frac{S^2}{32} \dots\dots\dots(i)$$

where x is any reading

\bar{x} is the mean

S is the sum of all readings.

The total variance is due to various causes—season, treatment, difference in fertility of the blocks, and the interaction of the season with these three components, together with the residual variance which is that contributed from all other sources, and which provides us with our estimate of the standard error of the experiment.

From Table I calculate the total sum square difference :—

$$\begin{aligned} \Sigma x^2 - S^2/n &= (227^2 + 334^2 + \dots) - \frac{12634^2}{32} \\ &= 556695 \text{ with } 31 \text{ degrees of freedom.} \end{aligned}$$

In calculating the variance due to component readings which are in themselves sums of several readings, such as treatment totals, we could first divide through by the number of replications of each treatment and find the treatment means. The sum square difference of these four numbers could be found, and then this would have to be multiplied by the number of replications to give the total contribution of the treatments to the Total sum square difference.

If t_1, t_2, t_3, t_4 , are the treatment means, and T_1, T_2, T_3, T_4 , the treatment totals, and the number of replications is 8, giving in all 32 readings,

$$t_1 = \frac{T_1}{8}; t_2 = \frac{T_2}{8}, \text{ etc.}$$

The sum square difference would be:—

$\Sigma (t - \bar{x}) \times 8$, as each t is the mean of eight x 's. Now, using the method of equation (i) above, we have,

$$\Sigma (t - \bar{x})^2 = \Sigma t^2 - 4\bar{x}^2,$$

but $t = T/8$, and $\bar{x} = S/32$,

$$\begin{aligned} \therefore 8 \left[\Sigma_1^4 t^2 - 4\bar{x}^2 \right] &= 8 \left[\Sigma_1^4 \left(\frac{T}{8} \right)^2 - 4 \left(\frac{S}{32} \right)^2 \right] \\ &= \Sigma T^2/8 - S^2/32. \end{aligned}$$

i.e., sum the squares of the totals, divide this by the number of readings each total represents, and then subtract the square of the Grand Total divided by the total number of readings.

This operation has been carried out in each case, and will be found under "Details of the Arithmetic."

From Table IV calculate the Sum Square Difference of the Plots irrespective of Seasonal Effect.

As each value is the sum of 4 yields,

$$\begin{aligned} \text{Sum Square} &= \frac{1727^2 + 1575^2 + \dots}{4} - \frac{12634^2}{32} \\ &= 33970, \text{ with 7 degrees of freedom.} \end{aligned}$$

For Treatment, the sum square difference

$$= \frac{3278^2 + 3215^2 + 2921^2 + 3220^2}{8} - \frac{12634^2}{32}$$

since each value is the mean of 8 yields,

$$= 9708 \text{ with 3 degrees of freedom.}$$

For Blocks, the sum square difference

$$= \frac{6138^2 + 6496^2}{16} - \frac{12634^2}{32} \text{ since each value is the mean of 16 yields,}$$

$$= 4005 \text{ with 1 degree of freedom.}$$

The residual variance is got by difference

$$33970 - (9708 + 4005) = 20257 \text{ with 7 degrees of freedom.}$$

We now have the seasonal effect to consider.

SEASONS \times BLOCKS. From Table II.

$$\begin{aligned} \text{Sum Squares diff.} &: = \frac{1151^2 + 1558^2 + \dots}{4} - \frac{12634^2}{32} = 354158 \\ \text{Blocks} &= (\text{already calculated}) = 4005 \\ \text{Seasons} &= \frac{2784^2 + 2796^2 + 4500^2 + 2534^2}{8} - \frac{12634^2}{32} = 304587 \\ \text{Season} \times \text{Blocks} &= 354158 - (4005 + 304587) = 45566 \end{aligned}$$

SEASONS \times TREATMENTS. From Table III.

$$\begin{aligned} \text{Sum Squares diff.} &: = \frac{531^2 + 700^2 + \dots}{2} - \frac{12634^2}{32} = 454676 \\ \text{Treatment} &= (\text{already calculated}) = 9708 \\ \text{Seasons} &= (\text{already calculated}) = 304587 \\ \text{Season} \times \text{Treatment} &= 454676 - (304587 + 9708) = 140381 \end{aligned}$$

$$\begin{aligned} \text{SEASON} \times \text{RESIDUAL} &= 556695 - (9708 + 4005 + \\ &20257 + 30458 + 45566 + \\ &140381) \end{aligned}$$

$$= 556695 - 524504 = 32191$$

We have now calculated the Sum Square difference for the different components, and from these we calculate the variances by dividing each by the appropriate number of Degrees of Freedom. The following table gives the Variance.

TABLE V. ANALYSIS OF VARIANCE.

	Sum of Squares.	Degrees of Freedom.	Variance.
Seasons.. .. .	304,587	3	101,529
Blocks	4,005	1	4,005
Treatments	9,708	3	3,236
Residual	20,257	3	6,752
Seasons × Blocks	45,566	3	15,189
Seasons × Treatments	140,381	9	15,598
Seasons × Residual	32,191	9	3,577
Total	556,695	31	—

The variance due to treatment may be further partitioned into that due to (1) Green Manuring *v.* No. Green Manure; (2) Deep versus Light cultivation and (3) the interaction of these two components.

We have the Treatment Totals :—

Deep C. 1	Deep C. 2 Green M.	Light C. 3	Light C. 4 Green M.
3278	3215	2921	3220

and from this we get

Deep C.	6493	Green M.	6199	Interaction	6136
Light C.	6141	No. G.M.	6435	„	6498

The Sum Square Differences are calculated in the same way as before, and are as given below. In each case the Number of Degrees of Freedom is 1.

Deep Cultivation <i>v.</i> Light Cultivation	= 3,872
Green Manure <i>v.</i> No. Green Manure	= 1,741
Interaction	= 4,095
Total Treatments	= <u>9,708</u>

The calculations are given at the end of this section.

DETAILS OF ARITHMETIC.

TABLE I. Squares.

51,529	111,556	109,561	67,081	
92,416	133,956	229,441	234,256	
173,889	129,600	84,100	241,081	
28,224	129,600	114,244	138,384	
505,521	303,601	185,761	189,225	
606,841	305,809	284,089	257,049	
138,384	107,584	45,369	150,544	
90,000	131,769	93,636	80,656	
<hr/>				
1,686,804	1,353,475	1,146,201	1,358,276	5,544,756
				<u>-4,988,061</u>
				<hr/>
				Total sum square difference: = 556,695
				<hr/>
				$S^2 = 12634^2 = 159,617,956$
				$S^2/n = 12634^2/32 = 4,988,061$
				<hr/>

TABLE IV. Squares.

Plots.	Treatments.
$1727^2 = 2,982,529$	
$1573^2 = 2,474,329$	
$1265^2 = 1,600,225$	
$1573^2 = 2,474,329$	
$1551^2 = 2,405,601$	$3278^2 = 10,745,284$
$1642^2 = 2,696,164$	$3215^2 = 10,336,225$
$1656^2 = 2,742,336$	$2921^2 = 8,532,241$
$1647^2 = 2,712,609$	$3220^2 = 10,368,400$
<u>4)20,088,122</u>	<u>8)399,821,150</u>
5,022,031	4,997,769
- 4,988,061	-4,988,061
<hr/>	<hr/>
33,970	9,708
<hr/>	<hr/>

Blocks.

$6138^2 = 37,675,044$
$6496^2 = 42,198,016$
<u>16)79,873,060</u>
4,992,066
- 4,988,061
<hr/>
4,005
<hr/>

Residual.

9,708
4,005
<hr/>
13,713
33,970
<hr/>
20,257
<hr/>

TABLE II. Squares.

$$\begin{array}{r}
 1151^2 = 1,324,801 \\
 1558^2 = 2,427,364 \\
 2128^2 = 4,528,384 \\
 1301^2 = 1,692,601 \\
 1633^2 = 2,666,689 \\
 1238^2 = 1,532,644 \\
 2372^2 = 5,626,384 \\
 1253^2 = 1,570,009 \\
 \hline
 4)21,368,876 \\
 \quad 5,342,219 \\
 \quad - 4,988,061 \\
 \hline
 \quad \quad 354,158 \\
 \quad \quad 308,592 \\
 \hline
 \quad \quad \underline{45,566}
 \end{array}$$

Seasons.

$$\begin{array}{r}
 2784^2 = 7,750,656 \\
 2796^2 = 7,817,616 \\
 4500^2 = 20,250,000 \\
 2554^2 = 6,522,916 \\
 \hline
 8)42,341,188 \\
 \quad 5,292,648 \\
 \quad - 4,988,061 \\
 \hline
 \quad \quad 304,587 \\
 \quad \quad 4,005 \\
 \hline
 \quad \quad \underline{308,592}
 \end{array}$$

TABLE III. Squares.

281,961	490,000	656,100	552,049
342,225	518,400	394,384	744,769
2,220,100	1,218,816	929,296	887,364
451,584	477,481	269,361	451,584
<hr/>	<hr/>	<hr/>	<hr/>
3,295,870	2,704,697	2,249,141	2,635,766
			2)10,885,474
			5,442,737
			4,988,061
			<hr/>
	304,587		454,676
	9,708		314,295
	<hr/>		<hr/>
	314,295		140,381
	<hr/>		<hr/>

Further analysis of the confounded treatments:

6493 ² = 42159049	6199 ² = 38427601	6136 ² = 37650496
6141 ² = 37711881	6435 ² = 41409225	6498 ² = 42224004
<hr/>	<hr/>	<hr/>
4 79870920	4 79836826	4 79874500
4 19967730	4 19959206	4 19968625
<hr/>	<hr/>	<hr/>
4991933	4989802	4992156
- 4988061	- 4988061	- 4988061
<hr/>	<hr/>	<hr/>
3872	1741	4095
1741		
4095		
<hr/>		
9708		
<hr/>		

B—YIELD PER STAND IN GRAMMES.

Table I.

Seasons.	Blocks.	Treatments.				Totals.
		1	2	3	4	
Jan. 1927	A	169	191	224	190	774
	B	240	227	252	266	985
		409	418	476	456	1759
Jan. 1928	A	146	141	178	158	623
	B	122	147	148	214	631
		268	288	326	372	1254
July 1928	A	248	226	232	211	917
	B	229	207	200	198	834
		477	433	432	409	1751
Jan. 1929	A	135	142	155	157	589
	B	138	150	177	173	638
		273	292	332	330	1227
Total	A	698	700	789	716	2903
Total	B	729	731	777	851	3088
Grand Total		1427	1431	1566	1567	5991

Table II.

ANALYSIS OF VARIANCE.

	Degrees of Freedom.	Sum Squares.	Variance.	Log ₁₀ V.
Seasons	3	33138	11046	—
Blocks	1	1069	1069	—
Treatments	3	2364	788	2.8965
Residual	3	1467	489	2.6893
Seasons × Treatments..	9	4762	529	—
Seasons × Blocks .. .	3	5665	1888	—
Residual	9	1936	215	2.3324
Total	31	50401	—	—
Deep <i>v.</i> Light Cultiva- tion	1	2,363	2363	3.3735
Green Manuring <i>v.</i> No Green Manure ..	1	0	0	—

C—YIELDS IN GRAMMES PER EAR.

Table I.

Seasons.	Blocks.	Treatments.				Totals.
		1	2	3	4	
Jan. 1927	A	110	133	127	122	492
	B	124	105	131	133	493
		234	238	258	255	985
Jan. 1928	A	101	110	127	111	449
	B	111	105	121	121	458
		212	215	248	232	907
July 1928	A	138	129	136	125	528
	B	124	96	99	143	462
		262	225	235	268	990
Jan. 1929	A	95	108	108	100	411
	B	95	103	112	109	419
		190	211	220	209	830
Total	A	444	480	498	458	1,880
Total	B	454	409	463	506	1,832
Grand Total		898	889	961	964	3,712

ANALYSIS OF VARIANCE.

Table II.

	Degree of Freedom.	Sum Square.	Variance.
Seasons	3	2,142	714
Blocks	1	72	72
Treatments	3	601	200
Residual	3	1,012	337
Seasons × Blocks	3	491	164
Seasons × Treatments	9	918	102
Seasons × Residual	9	664	74
Total	31	5,900	—
Deep v. Light Cultivation	1	595	595
Green Manuring v. No Green Manure	1	1	1

APPENDIX V.

REFERENCES.

- SECTION I. "Field Experiment," W. H. Beckett. *Gold Coast Department of Agriculture Year Book*, 1928.
- „ 5. "Unavoidable Error of Field Experiment," O. T. Faulkner. *Agricultural Journal, India*, Vol. 18, Part 3.
- „ 5. "Experimental Error," E. J. Maskell. *Tropical Agriculture*, Vols. 12 and 13.
- „ 7. "Trials of New Varieties of Cereals," E. S. Beaven. *Journal Ministry of Agriculture*, Vol. 29, Nos. 4 and 5.
- „ 7. "The Principles and Practice of Yield Trials. F. L. Engledow and G. U. Yule. *Empire Cotton Growing Corporation*, III, 2 and 3.
- „ 7. "A Note on the Interpretation of Field Trials," O. T. Faulkner. *Nigeria Agricultural Bulletin*, July 1923.
- „ 7. "The Method of Field Experiment," R. N. Dixey. *Journal of Ministry of Agriculture*, XXXVI, 4 July 1929.
- „ 8. "Statistical Methods for Research Workers," R. A. Fisher. *Olliver and Boyod*.

- APPENDIX II. "Field Experimentation with Rubber," L. Lord and L. Abeyesundera. *Bulletin No. 82*, Ceylon.

PAPER No. V.

KPEVE INVESTIGATIONAL STATION.

BY H. K. HEWISON (GOLD COAST).

The Administrative Committee of the Second Conference of West African Agricultural Officers visited Kpeve Investigational Station from the 18th to 20th October. The following notes were prepared in order to outline the work being done and to facilitate discussion, particularly during the tour of the Station by the delegates.

Distance from sea	.. ..	62 miles.
Elevation above sea level	.. ..	500 feet.
Rainfall .. .. .	.. ..	52 inches (Average for 2 years 1927-28).

The 400 acres comprising the area of this Station lie to the North of the 6° 40' parallel in what was German Togoland, and were originally acquired privately for plantation purposes.

During the years 1913-14 some thirty acres were planted up with Amelonado cacao, but with the advent of hostilities development ceased and the place ultimately came under the Administrator of Enemy Property in whose control it remained until 1921. In that year the freehold was purchased by the Department of Agriculture and Kpeve became the centre of agricultural activity in the Trans-Volta District. The policy of the period, however, did not embrace extensive development of the Station itself, and, until 1928, work mainly centred on bringing the existing but neglected cacao into condition, and on extensive nursery work. In 1927 an area was put under cotton, the intention being to supply seed to localities growing kidney cotton and other unsatisfactory types.

During the year 1928 plans were made to develop Kpeve as an Investigational Station, and the preparatory work of opening up the area, road-making and draining, commenced in September of that year.

PROGRAMME OF WORK, 1929.

PERENNIAL AGRICULTURAL CROPS.

CACAO.

- Daily records and measurements of flowering, flower shedding, fruit setting, and fruit development.
- Effect of climatic factors (particularly rain) on pollination, flower shedding, fruit setting, and fruit shedding.
- Local pollination agents: frequency, efficiency, amount and quality of pollen carried.
- Water relationship of the cacao plant.
- Selfing and hybridization on selected trees for material for progeny plots.
- Individual tree yield records over one acre.
- Short interval pickings with special fermentation for greater detail of crop production.
- Seasonal variations in yield of trees in terms of pod number, and value as dry cacao.
- Relationship between yield and climatic factors.
- Relationship between losses and climatic factors and/or physiological factors.
- Fork mulch trials on area of randomized plots—key tree records and special fermentation
- Standard manurial trial.
- Manurial trials on area of randomized plots—key tree records and special fermentation.
- Fermentation studies (temperatures, etc.).

OIL PALM.

- Establishment of area of Deli type.

MISCELLANEOUS.

- Establishment of *Hydnocarpus anthelmintica*.

ANNUAL AGRICULTURAL CROPS

GENERAL.

- Five course rotation.

COTTON.

- Data for plant diagrams showing squaring, flowering, flower shedding, fruit setting, and boll shedding.
- Growth rate measurements.
- Drain effects on growth, flowering, etc.

- Progeny rows of F_2 and F_1 of selfed selections.
 Selection and selfing of desirable individuals from among various stands.
 Areas of American Upland, "Webber," Sakel and other importations.
 Variety trials—randomized plots—Ishan and Sonko varieties.
 Spacing—randomized plots—Ishan and Sonko varieties.
 Ridging—randomized plots—Ishan and Sonko varieties.
 Planting date—randomized plots—Ishan and Sonko varieties.

GREEN DRESSINGS.

- Frequency trials.

MAIZE.

- Breeding and selection.

MISCELLANEOUS.

- Foodcrop variety, time and spacing trials—randomized plots.
 Volume of water carried from given areas by drains.

PROGRAMME OF WORK, 1930 AND ONWARD.

CACAO.

- (a) Establishment of plots of budded, selfed and hybrid cacao from known Kpeve individuals.
- (b) Establishment of plots of types similar to those of (a) from known individuals at Asuansi and Aburi.
- (c) Provision of information regarding the advantages of various methods of care and treatment of cacao from the time of putting out in to the field. Treatments to include : forking, mulching, manuring, various types of shade, no shade, lateral protection and no lateral protection, and varieties of cover crops. Treatments to be carried out singly and in combination.
- (d) Complete range of investigation of growth, flowering, fruiting and yielding capacities of trees of (a) and (b).
- (e) Elaboration of enquiries already instituted regarding : flowering, flower-shedding, fruit setting, fruit-shedding, maturation of fruit, seasonal variations in yield, seasonal losses from diseases, water and climatic relationships.

- (f) Actual relationship between the productivity of various portions of the tree with a view to deciding advantages of trees forking near the ground (as budded types) as opposed to normal types having a series of short main stems and tiers of branches.
- (g) Losses of applied manures and plant food material from areas due to wash, etc.
- (h) Effect upon (i) the parent tree and (ii) the yield of the parent tree of permitting the development for an indefinite period of years of a " sucker " arising at ground level.
- (i) Effect upon the crop period of overhead shade plus lateral protection as opposed to lateral protection without overhead shade.

COTTON.

- (a) Selection and breeding work on all available cottons for the production of a type best suited to Togoland conditions.
- (b) Acclimatization of and selection from introduced cottons.
- (c) Effects of various cultural treatments involving spacing, time, preparation of land, green manuring and stand trials.
- (d) Determining a satisfactory rotation embodying cotton.
- (e) Minimum period of green manuring necessary for the maintenance of fertility for satisfactory crop production.
- (f) Elaboration of enquiries re flowering, bolling and shedding, water requirements and responses to environmental factors.

GENERAL.

- (a) The establishment for the purpose of investigating (i) growth, (ii) response to cultural treatments, (iii) varietal productivity and (iv) breeding of :—

Cinchona.

Citrus and fruit generally.

Coffee.

Foodstuffs (Cassava, Yams, Sorghum, S. Potatoes, etc.)

Rice (involving irrigation).

Oil Palms.

Papaya.

Sugar Cane.

- (b) Arising from investigations previously carried out, an attempt to define " effective rainfall " for various crops on the various soils of Kpeve.

RAINFALL FIGURES.

Month.	1927.		1928.		1929.	
	Wet Days.	Inches.	Wet Days.	Inches.	Wet Days.	Inches.
January	No record.		2	1.85	2	0.32
February	No record.		2	3.04	7	2.44
March	No record.	4.31	11	4.38	15	7.71
April	10	4.44	15	3.69	13	3.91
May	17	5.33	11	2.23	17	6.01
June	16	5.91	16	10.19	18	6.66
July	10	5.10	12	3.31	13	4.47
August	6	0.52	11	5.62	14	12.90
September	18	9.99	17	9.96	22	2.40
October	20	9.56	21	6.72	11	1.55*
November	7	2.11	3	0.34	7	4.58*
December	6	2.53	5	2.32	1	0.20*
TOTALS	(110)	(49.80)	126	53.65	140	53.15*

* Added subsequently.

CACAO (a) GENERAL.

Planted .. .. .	.. .. .	.. .. .	1913-14.
Area .. .. .	.. .. .	.. .. .	20 acres.
Fruiting Trees (1929) .. .. .	.. .. .	.. .. .	4,032.

Yields on record, expressed as lbs. Dry Cacao per acre, are as under:—

Year.	Jan.—Dec.	April—March.	Sept.—August.	Season.
1922	354	456	437	1922-23
1923	439	375	341	1923-24
1924	251	365	309	1924-25
1925	580	556	651	1925-26
1926	897	832	801	1926-27
1927	264	567	818	1927-28
1928	1,091	1,063	881	1928-29
1929	1,397*	1,060*	924*	1929-30
	(12 months)	(April-Dec.)	(Sept.—Dec.)	

* Figures for 1929 added subsequently.

CACAO (b) STANDARD MANURIAL TRIAL.

OBJECT :—A trial laid down on the four Departmental Stations to ascertain the effect of applying artificial manures and mulch to fruiting trees.

SCHEME :—Eight quarter-acre plots (A to H) : A, B, C, and D, each comprising four rows of sixteen trees, form one block ; E, F, G and H, each comprising two rows of thirty-two trees, form a second block.

TREATMENT.

Plot.	No. of Trees.	Treatment.	Amounts.	Date of Application.			
				1st. 1926-27.	2nd. 1927-28.	3rd. 1928-29.	4th. 1929-30.
A	50	No treatment ...	—	—	—	—	—
B	51	Dried Blood Sulphate of Potash ...	1 cwt. ... ½ cwt.	4-6/8/1926	21-24/12/1927	6-7/11/1928	
C	56	Basic Slag Sulphate of Potash ...	2 cwt. ... ½ cwt.	4-6/8/1926	21-24/12/1927	6-7/11/1928	
D	63	Dried Blood Basic Slag Sulphate of Potash ...	1 cwt. ... 2 cwt. ... ½ cwt.	4-6/8/1926	21-24/12/1927	6-7/11/1928	
E	53	Mulching ...	6-7 tons	2/11/1926	13/1/1928	2-6/3/1929	
F	55	Dried Blood Sulphate of Potash Mulching ...	1 cwt. ... ½ cwt. ... 6-7 tons	4-6/8/1926 2/11/1926	21-24/12/1927 13/1/1928	6-7/11/1928 2-6/3/1929	
G	54	Basic Slag Sulphate of Potash Mulching ...	2 cwt. ... ½ cwt. ... 6-7 tons	4-6/8/1926 2/11/1926	21-24/12/1927 13/1/1928	6-7/11/1928 2-6/3/1929	
H	49	Dried Blood Basic Slag Sulphate of Potash Mulching ...	1 cwt. ... 2 cwt. ... ½ cwt. ... 6-7 tons	4-6/8/1926 2/11/1926	21-24/12/1927 13/1/1928	6-7/11/1928 2-6/3/1929	

6 tons of Mulch applied to each plot in 1927-28 and 7 tons in 1928-29.

YIELDS.

Plot.	No. of Trees.	Yield per Plot in lbs. Dry Cacao.			Yield per Tree in lbs. Dry Cacao.		
		Crop Year Sept.-August.			Crop Year Sept.-August.		
		1926-27.	1927-28.	1928-29.	1926-27.	1927-28.	1928-29.
A	50	362 (2)	347 (1)	299 (4)	7.2 (2)	6.9 (1)	6.0 (2)
B	51	370 (1)	325 (3)	354 (2)	7.3 (1)	6.4 (2)	6.9 (1)
C	56	286 (4)	266 (4)	299 (3)	5.1 (3)	4.8 (4)	5.3 (4)
D	63	315 (3)	342 (2)	361 (1)	5.0 (4)	5.4 (3)	5.7 (3)
E	53	231 (7)	191 (8)	160 (8)	4.4 (7)	3.6 (8)	3.0 (8)
F	55	260 (5)	211 (7)	272 (5)	4.7 (5)	3.8 (7)	4.9 (6)
G	54	252 (6)	217 (6)	243 (7)	4.7 (5)	4.0 (6)	4.5 (7)
H	49	186 (8)	222 (5)	245 (6)	3.8 (8)	4.5 (5)	5.0 (5)

Figures in brackets show order of yield.

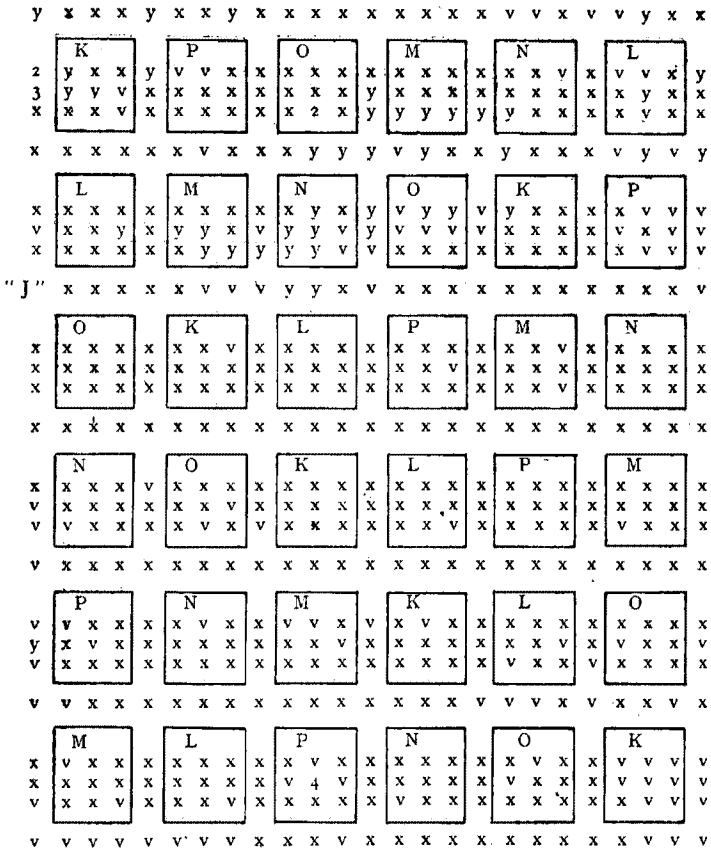
CACAO (c) MANURE AND MULCH TRIALS.

OBJECT :—To ascertain the effect of artificial manures and mulching upon fruiting cacao.

ARRANGEMENT :—Restricted randomisation with a non-effective zone of a line of trees between any two plots.

SITUATION :—The thirty-six plots involved in these trials will be found to the East of the N.-S. line of trees containing "J" of the flower-count and pod-growth recording. Each plot is clearing demarcated by pegs.

PLAN OF PLOTS.



x Fruiting trees.
 y, 2, etc. Immature trees.
 v Vacancies.

TREATMENT:—

" K " .. No treatment.
 " L " .. Forked and Mulched.
 " M " .. Dried Blood 16 lbs. per plot.
 " N " .. Sulphate of Potash .. 4 lbs. " "
 " O " .. Basic Slag 32 lbs. " "
 " P " .. Sulphate of Potash and Basic Slag. 4 lbs. and 32 lbs. per plot.

For simplicity, each plot of nine trees is taken to be one-twenty-eighth of an acre.

On this reckoning, the manures are applied at the following rates:—

Dried Blood	.. .. .	4 cwt. per acre.
Sulphate of Potash	.. .. .	1 cwt. per acre.
Basic Slag	.. .. .	8 cwt. per acre.

TIME OF APPLICATION.

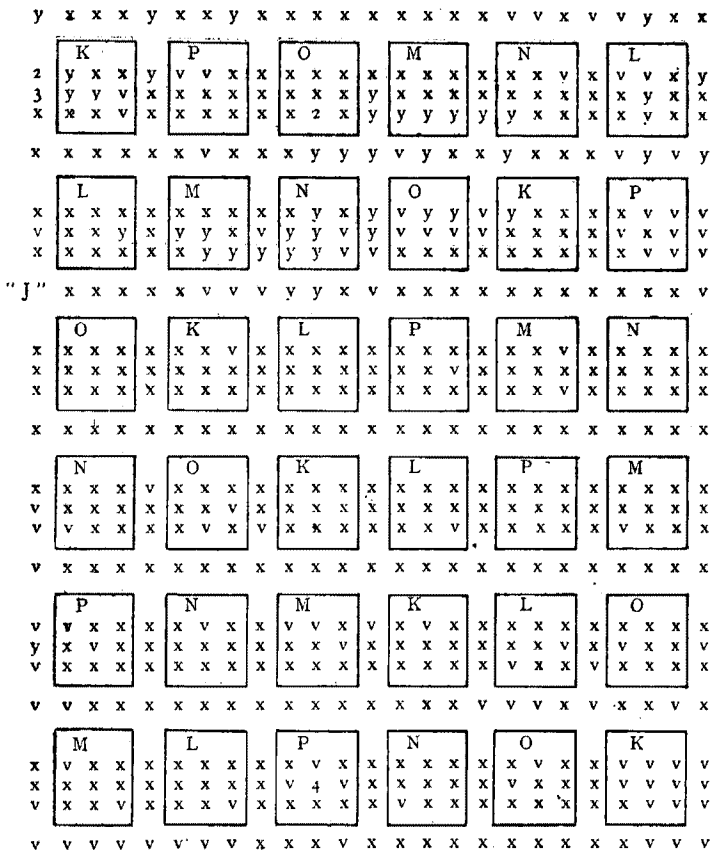
New Manurial Trials.	No. of Trees	Treatment.	Treatment.					
			1st.	2nd.	3rd.	4th.	5th.	6th.
6 plots	245	No treatment	—					
"		Forking	20/11/1928					
"		Mulching	4/4/1929					
"		Dried Blood 16 lbs. per plot	16/1/1929					
"		Sulphate of Potash 4 lbs. per plot	16/1/1929					
"		Basic Slag, 32 lbs. per plot	16/1/1929					
"		Sulphate of Potash 4 lbs. per plot	16/1/1929					
"		Basic Slag 32 lbs. per plot						

YIELDS:—To be recorded individually for each central or "key" tree and collectively for the nine trees comprising the plot.

The data collected are:—

- Number of pods picked.
- Weight of pods picked.
- Wet weight of beans extracted from the pods.
- Dry weight of cacao produced.

PLAN OF PLOTS.



x Fruiting trees.
 y, 2, etc. Immature trees.
 v Vacancies.

TREATMENT:—

"K" .. No treatment.
 "L" .. Forked and Mulched.
 "M" .. Dried Blood 16 lbs. per plot.
 "N" .. Sulphate of Potash .. 4 lbs. " "
 "O" .. Basic Slag 32 lbs. " "
 "P" .. Sulphate of Potash and Basic Slag. 4 lbs. and 32 lbs. per plot.

For simplicity, each plot of nine trees is taken to be one-twenty-eighth of an acre.

On this reckoning, the manures are applied at the following rates:—

Dried Blood	.. ..	4 cwts. per acre.
Sulphate of Potash	.. ..	1 cwt. per acre.
Basic Slag	.. ..	8 cwts. per acre.

TIME OF APPLICATION.

New Manurial Trials.	No. of Trees	Treatment.	Treatment.					
			1st.	2nd.	3rd.	4th.	5th.	6th.
X 6 plots	245	No treatment	—					
..		Forking	20/11/1928					
..		Mulching	4/4/1929					
M ..		Dried Blood 16 lbs. per plot	16/1/1929					
N ..		Sulphate of Potash 4 lbs. per plot	16/1/1929					
O ..		Basic Slag, 32 lbs. per plot	16/1/1929					
P ..		Sulphate of Potash 4 lbs. per plot	16/1/1929					
		Basic Slag 32 lbs. per plot						

YIELDS:—To be recorded individually for each central or “key” tree and collectively for the nine trees comprising the plot.

The data collected are:—

- Number of pods picked.
- Weight of pods picked.
- Wet weight of beans extracted from the pods.
- Dry weight of cacao produced.

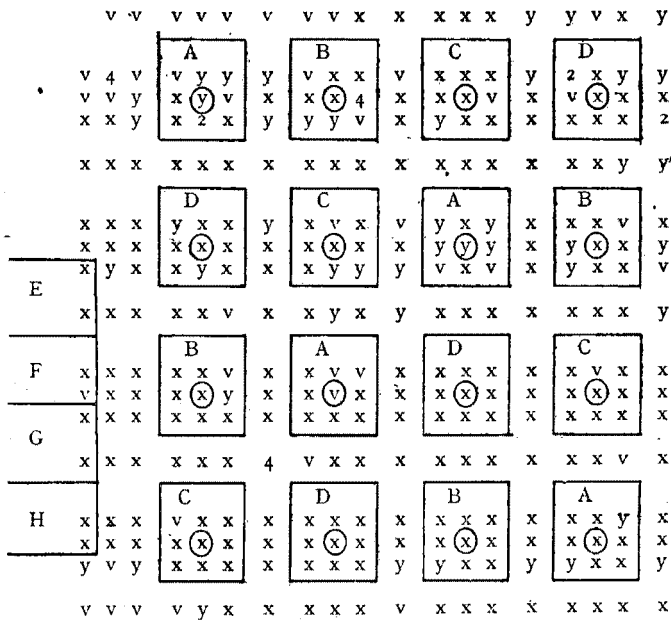
CACAO (d) FORK-MULCH TRIALS.

OBJECT OF TRIAL :—To ascertain the effect of mulching and deep forking on fruiting cacao.

SITUATION :—The plot given over to the above will be found at the eastern end of the Manurial Trial Plots "E," "F," "G" and "H." On reference to the survey plan of Block "A" Cacao it will be found to be one of the few areas of any stand remaining from other manurial trials.

PLAN OF PLOTS.

The following is a plan of the plot and the immediate surround of trees :—



ARRANGEMENT :—Restricted randomisation was adopted in laying out the area, and it will be observed that there is a non-effective zone of a line of trees between any two plots.

TREATMENT :—Plots marked "A" .. No treatment.
 " " "B" .. Mulched.
 " " "C" .. Forked.
 " " "D" .. Forked and Mulched.

TIME OF TREATMENT.

Fork and Mulch Area.	No. of Trees.	Treatment.	Treatment.			
			1st.	2nd.	3rd.	4th.
16 Plots.						
A	103	Nil				
B		Mulching	3/11/1928			
C		Forking	21/8/1928	1-9/8/1929		
D		Forking and Mulching	21/8/1928 3/11/1928	1-9/8/1929		

YIELDS:—Yields will be recorded individually for each of the central or "key" trees (marked with circle in the plan) and collectively for the nine trees comprising a plot. The data collected are:—

- (1) Number of pods.
- (2) Weight of pods.
- (3) Wet weight of extracted beans.
- (4) Dry weight of resultant cacao.

CACAO (e) FLOWER AND POD DATA.

On ten fruiting trees, selected at random over the area, daily records are made, over a definite region of each tree, of the incidence of flowering and fruit development.

The object of making such records is to obtain, primarily, definite information of the number of flowers opening and of the proportion setting fruit or shedding and of the rate of fruit development. In addition to obtaining this much needed information regarding fruit production in cacao, it is proposed to utilise such records in an investigation of the influence of the environmental conditions on fruiting, particularly with regard to moisture relationships, pollination and pod losses.

The region of each tree involved in the present work is limited, and observations are confined to that area which the observer can reach from ground level. Up to the present, any attempt at working from an elevated position has resulted in damage that negatives any records taken.

Pins inserted in the nearby bark are used to mark the opening of flowers, and when fruit sets the pins are replaced by a copper tack carrying the date and a serial number. When flowers are shed, the pins are collected and the loss recorded.

Data relating to the work since its inception in May, 1928, are accessible to any interested member of the Committee.

CACAO (*f*) FERTILISATION.

On ten trees whose yield record is known, artificial pollination is carried out with a view to establishing plots of progeny cacao—such plants to be grown against clone material from the same source and cacao from other stations.

CACAO (*g*) FERMENTATION.

(*a*) Beans from the key trees of the Fork-Mulch and New Manurial trials are fermented in separate bags immersed in a bulk mass formed by the beans of the surround trees of these plots and of the Guano and Standard Manurial area. The contents of the bags are dried apart from the other cacao and weighed separately. The object of this is not only to ensure the greatest possible accuracy during the trial concerned but also to ascertain whether there is justification for the practice of apportioning dry weight cacao to the wet weight of the beans prior to fermentation.

(*b*) Fermentation trials are carried out at periods through the year using mature ripe and fully developed but green fruits. The object is to ascertain the rates of fermentation and the condition at various stages of fermentation of the respective material used, and the differences between the ultimate products.

CACAO (*h*) INDIVIDUAL TREE YIELDS.

Records are kept of the pod yield of each tree over an acre block of cacao—the object being ultimately to use the material whose history is known for trials of various kinds.

COTTON TRIALS 1929-30.

To compare the yields of Sonko and Ishan Cottons and to test the efficacy or otherwise of

(*a*) The following spacings:—

4' × 1'
4' × 2'
4' × 3'

(b) the following times:—

28th and 29th May	} 12 day interval.
11th and 12th June	
25th and 26th June	

(c) the following treatments:—

ridged land.
flat land.

ARRANGEMENT :—

There are thus 10 factors giving 36 combinations. Each combination is grown on one 1/10th acre plot, resulting in 3.6 acres composed of 36 randomised plots.

The complete trial consists of 6 replications of this arranged in 3 Sections of 2 Blocks each.

Surrounding each Section is a 9 feet edge effect strip, which will be harvested separately.

The plots in each block are numbered 1-36. Replicated-like treatments have the same plot numbers but different block numbers. Plots demarcated by bush rope.

Total area of trial including edge strips and excluding paths = 23.12 acres.

HISTORY :—

Weather conditions at sowing were favourable and vacancies were rare on all plots. All three time plantings got away well, especially the first and second. In mid-August, however, partial chlorosis and subsequent browning of the leaves was noticed in Block I Plot 6. Affected plants took on a stunted appearance and the symptoms were soon apparent on practically every plot.

CAUSE :—

The prevalence of the disease on both ridged and flat, old and fresh cleared land, on native Sonko, Ishan and recently imported varieties, and all three spacings and time plantings, together with the absence of any apparent evidence of association with any insect or fungus, leads one to attribute the disease to some functional derangement of the plant consequent on meteorological conditions.

RAINFALL DATA.

Month.	Rainfall in Inches.	Number of Wet Days.
May	6.01	17
June	6.66	18
July	4.47	13
August	12.90	14
September	2.40	22

IMPORTATIONS, SELECTIONS, ETC. :—

Special plots of the following are maintained, and selfing carried out each day from 6-8 a.m. and 3-5 p.m.

Allen Cotton—seed obtained from Northern Territories, planted 4th July, 1929.

Sakallarides—proved failure; seven plants alone surviving; planted 6th July, 1929.

Webber and American—unselfed—planted 28th June, 1929.

Webber and American—selfed F₁—planted 4th July, 1929.

Station Selections—selfed F₁—planted 12th July, 1929.

Botanist's Selection—selfed F₂—planted 4th July, 1929.

OTHER DATA.

Plant Diagrams—data for these are collected on 8 plants in Block III, Plot 34.

Growth Rate Measurements—are made daily on 20 plants in Block III, Plot 18.

Flowering—and other data—counts and dates of (1) flowers opening, (2) bud shedding, (3) bolls shedding, and (4) bolls harvested, are recorded on a row of plants selected from the Rotation Cotton—Plot A.

PLAN OF PLOTS (Blocks I and II, Section 1).

28/5/29 Sonko 4 × 3 Ridged	25/6/29 Sonko 4 × 2 Flat	25/6/29 Ishan 4 × 3 Flat	25/6/29 Ishan 4 × 2 Ridged	28/5/29 Ishan 4 × 2 Flat	28/5/29 Sonko 4 × 1 Flat
11/6/29 Sonko 4 × 3 Ridged	25/6/29 Ishan 4 × 2 Flat	28/5/29 Ishan 4 × 3 Ridged	25/6/29 Sonko 4 × 3 Ridged	25/6/29 Sonko 4 × 3 Flat	28/5/29 Ishan 4 × 2 Ridged
25/6/29 Sonko 4 × 2 Ridged	11/6/29 Ishan 4 × 1 Flat	28/5/29 Ishan 4 × 1 Ridged	11/6/29 Ishan 4 × 2 Ridged	28/5/29 Ishan 4 × 3 Flat	11/6/29 Sonko 4 × 2 Flat
11/6/29 Ishan 4 × 3 Flat	28/5/29 Sonko 4 × 1 Ridged	28/5/29 Sonko 4 × 2 Ridged	11/6/29 Sonko 4 × 2 Ridged	25/6/29 Ishan 4 × 3 Ridged	11/6/29 Ishan 4 × 2 Flat
11/6/29 Ishan 4 × 2 Ridged	11/6/29 Ishan 4 × 3 Ridged	25/6/29 Sonko 4 × 1 Ridged	28/5/29 Sonko 4 × 3 Flat	25/6/29 Ishan 4 × 1 Ridged	11/6/29 Sonko 4 × 1 Flat
11/6/29 Sonko 4 × 1 Ridged	25/6/29 Sonko 4 × 1 Flat	28/5/29 Ishan 4 × 1 Flat	28/5/29 Sonko 4 × 2 Flat	11/6/29 Sonko 4 × 3 Flat	25/6/29 Ishan 4 × 1 Flat
28/5/29 Sonko 4 × 3 Ridged	25/6/29 Sonko 4 × 2 Flat	25/6/29 Ishan 4 × 3 Flat	25/6/29 Ishan 4 × 2 Ridged	28/5/29 Ishan 4 × 2 Flat	28/5/29 Sonko 4 × 1 Flat
11/6/29 Sonko 4 × 3 Ridged	25/6/29 Ishan 4 × 2 Flat	28/5/29 Ishan 4 × 3 Ridged	25/6/29 Sonko 4 × 3 Ridged	25/6/29 Sonko 4 × 3 Flat	28/5/29 Ishan 4 × 2 Ridged
25/6/29 Sonko 4 × 2 Ridged	11/6/29 Ishan 4 × 1 Flat	28/5/29 Ishan 4 × 1 Ridged	11/6/29 Ishan 4 × 1 Ridged	28/5/29 Ishan 4 × 3 Flat	11/6/29 Sonko 4 × 2 Flat
11/6/29 Ishan 4 × 3 Flat	28/5/29 Sonko 4 × 1 Ridged	28/5/29 Sonko 4 × 2 Ridged	11/6/29 Sonko 4 × 2 Ridged	25/6/29 Ishan 4 × 3 Ridged	11/6/29 Ishan 4 × 2 Flat
11/6/29 Ishan 4 × 2 Ridged	11/6/29 Ishan 4 × 3 Ridged	25/6/29 Sonko 4 × 1 Ridged	28/5/29 Sonko 4 × 3 Flat	25/6/29 Ishan 4 × 1 Ridged	11/6/29 Sonko 4 × 1 Flat
11/6/29 Sonko 4 × 1 Ridged	25/6/29 Sonko 4 × 1 Flat	28/5/29 Ishan 4 × 1 Flat	28/5/29 Sonko 4 × 2 Flat	11/6/29 Sonko 4 × 3 Flat	25/6/29 Ishan 4 × 1 Flat

RESULTS.—As published in News Letter No. 14 of June, 1929:—

20 acres were laid down to cotton field trials in 1928, and comprised 4 blocks of land measuring 5 chains by 10 chains. A block contained twenty adjacent strips or plots of $\frac{1}{4}$ acre; each plot was 5 chains by $\frac{1}{2}$ chain. The average yield was 190 lbs. of seed-cotton per acre and the crop was exceptionally free from stain (94 % "clean"). The results have not been worked out fully, but the general conclusions are given below.

Three planting dates at intervals of a fortnight—beginning, middle and end of July—were tried, and the earliest planted gave the highest yield; the yields of comparable plots were approximately 220 lbs. per annum for July 1st planting, 150 for July 15th, and 170 for July 31st. Consequently, still earlier planting dates are being tried during the next season.

Ishan gave better yields than Sonko in 14 out of 18 pairs of adjacent plots and yielded at the rate of 186 lbs. per acre as against 150 lbs. for Sonko. The superior yielding qualities of Ishan were less apparent in the earlier planting. The highest yielding for any plot was 422 lbs. per acre for Sonko and 388 for Ishan. In evaluating the relative merits of these two varieties the ginning percentage and lint value have to be taken into consideration. Sonko yielded 34 lbs. of lint from 100 lbs. of seed-cotton and Ishan only 30 lbs. The varieties are being baled separately so that valuations can be requested from the British Cotton Growing Association and the bales sold separately.

Ridged plots yielded at the rate of 203 lbs. per acre as against 208 planted on the flat, and therefore these methods of cultivating appear to be equally effective. The land on which these trials were conducted is practically flat, so that ridging is not essential to prevent soil erosion and to conserve rainfall. The local farmers make heaps from 4 ft. to 6 ft. apart.

The cotton was grown at a spacing distance of 4 ft. between rows and normally 2 ft. between stands of plants (thinned to 2 plants to a stand). With 1 ft. between stands the average yield was 200 lbs. per acre, 214 for 2 ft. between stands, and 200 for 3 ft. between stands. Varying the spacing from 4 square ft. to 12 square ft. per stand therefore made very little difference to the yield.

These tests are being repeated this year—with slight modifications based on last year's experience—in six randomised blocks each containing 36 square plots of one-tenth of an acre.

ROTATION TRIAL.

OBJECT.

Using the following 5 crops—yams, groundnuts, guinea corn, maize and cotton to find :—

- (1) their most satisfactory sequence ;
- (2) their most satisfactory sequence for cotton ;
- (3) the effect of the preceding crop or crops on cotton ;
- (4) the effect of the cotton crop on the ensuing crops ;
- (5) any inter-relationship of the crops concerned.

LAY-OUT.

Restricted randomisation involving 25 one-tenth acre plots. (5 five-course rotations.) Columns A, B, C, D, and E show the five rotations.

PROCEDURE.

In each column each year, the crops rotate by "moving up" one square—*e.g.*, in Column A, groundnuts follow yams, and yams follow maize.

PLAN OF PLOTS.

A	B	C	D	E
Maize	Cotton	Ground Nuts	Yams	Guinea Corn
Yams	Guinea Corn	Cotton	Ground Nuts	Maize
Ground Nuts	Maize	Guinea Corn	Cotton	Yams
Guinea Corn	Ground Nuts	Yams	Maize	Cotton
Cotton	Yams	Maize	Guinea Corn	Ground Nuts

PLANTING AND HARVESTING DATES.

Crop.	Date Sown.	Date Harvested.
Maize	23rd April	5th September.
Groundnuts	24th April	6th—11th September
Guinea Corn	28th April	—
Yams	22nd & 23rd April	21st—25th September
Cotton	14th June	—

N.B.—61 % of number of yam mounds harvested only, to provide seed for next year.

YIELDS AND COSTS.

Maize.

Total yield of shelled grain per acre	= 1 ton 9 cwts. 22 lbs.
Actual number of plants on the $\frac{1}{2}$ -acre	= 4,258
<i>Pro rata</i> number per acre ..	= 8,516
Production cost per lb. of maize	= .506d.
No. of ears per 3d.	= 15

Yams.

No. of mounds treated (61 %)	No. of tubers	Weight of tubers in lbs.
370	438	2,696

Groundnuts.

Total net weight of unshelled dried nuts	= 337.2 lbs.
Yields per acre	= 674.4 lbs.
	= 6 cwts. 2.4 lbs.
Cost of producing 1 lb. unshelled nuts	= 3.02d.

REMARKS.

The full experiment was to have consisted of 7 replications of the above trial. These replications were to have embodied different green manures, different spacings, different varieties and various time of sowing. Unfortunately, however, the land could not be cleared in time.

ZEA, SORGHUM AND PANICUM SELECTION TRIALS.

OUTLINE.

The best hundred cobs from the August-September planting to be recorded, shelled, counted, weighed and packeted. (Corn will be found (a) in the *Hydnocarpus* area, (b) in the plot of *Citrus* brought from Trinidad, and (c) on the bungalow hill.)

Half the contents of each of the 100 packets to be sown in order to ascertain the best *yielders* and the *best types* of these selected.

The reference number of the best fifty of these plots to be taken, and the corn remaining in their respective packets to be sown as progeny blocks. (It is necessary for the purpose of the work to sow in blocks and not in rows.)

In each of the fifty progeny blocks the ten most central plants are to be marked; five are to be de-tasselled (A) and five left (B).

The best cobs from each of the (A's) and (B's) to be collected, recorded, shelled, counted, weighed and selected—the best fifty being sown in progeny blocks as before and the ten most central plants subjected to the same treatment.

Grain selections from this F.2. should provide material with which to work and upon which to base some hypothesis.

The grain from the fifty best cobs should again be sown—this time half the grain of each cob in progeny blocks and half in progeny rows.

In the plots the procedure should be as before; in the rows, alternate halves should be de-tasselled.

The final sections from each of these should, if weights and other features warrant so doing, be sown and bulked for seed purposes.

Whilst the foregoing particularizes maize, the form of work can be applied to similar selection with both guinea corn and millet.

PAPER No. VI.

**NEED FOR FURTHER RESEARCH FACILITIES IN
WEST AFRICA. PROPOSAL FOR A RESEARCH
STATION FOR OIL-PALMS AND LATERITIC
SOILS.**

BY F. J. MARTIN (SIERRA LEONE).

At the First West African Agricultural Conference held at Ibadan, Nigeria, in March, 1927, the following resolutions were passed:—

Resolution No. 9.

This Conference recognises the necessity for the provision of facilities for fundamental scientific research in the West African Colonies

Resolution No. 12.

It is further recommended that the study of the varieties of the oil-palms and their yields, and the breeding of new strains should be prosecuted.

Resolution No. 10.

(a) The Chemical Committee consider that a soil survey of British West Africa is desirable and should be undertaken by the Agricultural Chemists in and for each Colony.

(b) * * * *

(c) The Committee wish to emphasise that a great deal of work is entailed in a soil survey, and that the rate of progress will depend entirely on the staff, accommodation and equipment, placed at the disposal of the respective chemical departments.

There was a general feeling at the Conference that research facilities should be extended, and that two of the important problems needing attention were oil-palms and soil problems.

Type of Research Station required.—At the Ibadan Conference it was suggested that an Agricultural College for West Africa should be established in Nigeria and the facilities for research should be provided at that institution. It was not suggested that the proposed Agricultural College should be a Central Research Station, and although nothing was definitely formulated with regard to research

the idea prevailing was that the staff of the College should have time and facilities for dealing with agricultural problems such as could easily be investigated in the neighbourhood of the College.

At the Imperial Research Conference (London 1927) opinion was somewhat divided as to whether Central Research Stations should also be teaching institutions. Mr. P. H. Lamb (Nigeria) made out a very good case for the inclusion of teaching in West Africa on the grounds that the native staff was very badly trained, and the progress of the different departments is much hampered by the fact that their native assistants are so extremely inefficient. Sir John Farmer, however, issued a warning to the fact that it would be a fatal mistake to put teaching first and research second.

The following paragraph is taken from the report of the Imperial Research Conference on the question of instructional work at research stations.

"Instructional Work by Station.—The Conference do not consider that a research station, as such, should be expected to undertake any teaching work, except in so far as the advanced instruction of a limited number of post-graduate students can be undertaken with advantage to the research work in progress. In making this recommendation they do not overlook the need, in certain parts of the Empire, and notably in West Africa, for the provision of additional teaching facilities, designed primarily to enable native students to become qualified assistants in research work, whether at a Central Research Station or in an Agricultural Department, but they consider such provision to fall within the sphere of other Government services."

With regard to West Africa, Mr. Lamb pointed out that a single Research Station could not serve the whole of West Africa owing to differences in climate. In Nigeria alone the rainfall varies from 15 ins. yearly in the neighbourhood of Lake Chad to 300 ins. in some parts of the mandated territory of the Cameroons. Sir John Farmer, in considering the possibility of a single station suiting different kinds of work, suggested that if any crop were grown in a particular region to such an extent that it formed an industry in that region then nothing was simpler than to have sub-stations to deal with specific problems. In view of the wide range of climates in West Africa it would appear that the problems that could be tackled at one Research Station could not cover the ground for the whole of West Africa. We are, therefore, driven to the alternative suggestion foreshadowed by Sir John Farmer that problems pertaining to certain regions should be tackled in sub-stations or small scale research stations.

This does not necessarily mean that the provision of a sub-station for each climatic zone in West Africa is indicated. As Mr. Lamb very pertinently pointed out, there are certain problems

in the drier parts of Northern Nigeria, connected with the growing and irrigation of cotton, which are somewhat similar to those existing in the Sudan. These problems can perfectly well be solved elsewhere, and Mr. Lamb indicated that he would like research officers in the Sudan to supply him with the necessary advice. He also indicated that a station suitably situated in West Africa might be able to solve certain problems probably better than elsewhere in the Empire.

All this points to the conclusion that as far as West Africa is concerned it would appear that the needs of research will be better served by the provision of sub-stations to deal with specific problems, as and when they occur, rather than by a Central Research Station to cater for the whole of a large area with such a diversified climate.

Reverting to Resolution No. 12 of the Ibadan Conference, there was a demand for further research work on oil-palms. This demand for further knowledge of *Elaeis guineensis* dates from about 1900, and in 1919, a committee composed of Dr. A. W. Hill of Kew and the Directors of Agriculture from the various West African Colonies made definite proposals for the study of the oil-palm in West Africa. The lines of investigation advocated by that committee are given in Appendix A, and as will be seen they open up a wide field of research.

The question next arises as to whether such research lies within the province of the local Agricultural Departments or whether it could more suitably be undertaken by a special sub-station such as those foreshadowed at the Imperial Conference in 1927. In general it would appear that fundamental or long range Research, *i.e.*, that type of problem which must of necessity extend through a long term of years, can most usefully be carried out either in Central Research Stations or sub-stations for research on specific problems. At the first meeting of the Colonial Advisory Council of Agriculture and Animal Health, Mr. Stockdale, the Assistant Agricultural Adviser, dealing with cacao research, stated that it was for local Agricultural Departments to carry out research in such matters as density of shade, spacing between trees, cultural methods and manuring, and the selection of local high yielding strains, but that it was for the long range research station to undertake research into such things as the basic principles underlying the multiplication of high yielding strains and physiological questions in general. The lines of investigation suggested by Dr. Hill's committee ten years ago include investigations that would come under Mr. Stockdale's definition of long range research, and a perusal of Mr. Deighton's report on oil-palm investigations in Sierra Leone (submitted to the sub-committee dealing with Economic Botanical problems) suggests several important problems which certainly cannot be undertaken by our Sierra Leone Departmental staff or I think by other Departmental staffs in West Africa. Such problems include the causes of the seasonal variations in the weight and proportion of fruit in the heads throughout the year, the breeding true to type of oil-palms of high yield and good quality, the effect of rainfall and sunshine on

yield, etc. It might seem at first sight that the breeding of a good type of oil palms might come within Mr. Stockdale's "selection of local high yielding strains" but the work envisaged is rather more specialised than that, and would require a knowledge of genetics not usually found in local departments. Also, as Mr. Lewin (Botanist, Nigeria) pointed out at the Ibadan Conference, it might possibly take 30 years to fix a good type of oil-palm, owing to the mixed parentage of our present stock, and if this estimate is anything like correct, it puts the problem at once into the region of long range research.

It is, therefore, suggested that in view of the repeated demands in the past for further research on oil-palms, the recommendations of Dr. Hill's committee in 1919 and the resolution of the Ibadan Conference in 1927, there is an immediate need for the initiation of further research work on this problem, and that from a consideration of the fundamental type of many of the problems involved and the duration of the breeding experiments, such work could best be carried on in a research station, one of the main functions of which would be the investigation of oil palm problems.

The establishment of such a station in the West Coast was foreseen at the Imperial Conference in 1927, and attention was drawn to the probable need of such an institution by Major Walter Elliott, D.Sc., M.P., who also pointed out the enormous value of the trade in oil-palm products from the West Coast; this is over £10,000,000 per annum.

Although the lines of research suggested by Dr. Hill's committee are mainly botanical, it does not follow that a sub-station founded to deal with oil-palms must necessarily restrict itself to the botanical aspects of the problem. It will probably be found that it will have of necessity to study certain aspects of soil science in relation to biological problems. Thus we find that arising out of cotton work in the Sudan, fundamental questions affecting soils under irrigation are always cropping up. In his report on Sumatra, Mr. Ormsby-Gore draws special attention to the combined work of the plant geneticist and soil scientist in producing the enormous yields and tremendous profits obtained from the sugar industry. In West Africa we have the problem of lateritic soils ever with us, and as the oil-palm flourishes best in regions of a heavy rainfall it will generally be found associated with soils of a lateritic nature.

Very little is known of the properties of lateritic soils, yet these are widely distributed, not only in West Africa, but throughout the tropics, and probably the bulk of the agricultural produce of the West African Colonies is derived from this type of soil. So little indeed is known of lateritic soils that until recently there was no suitable definition of a lateritic soil. In the past, any red tropical soil was generally called lateritic on account of its colour, when, as is now known, lateritic soils are not necessarily red nor are red soils

necessarily lateritic. In view of the fact that lateritic soils are so widely spread in all tropical colonies where the rainfall is high, it is curious that so little is known about them, and the vast number of soil analyses which have been carried out in the past have to some extent fallen into disrepute owing to the impossibility of interpreting the results. We now know that the constitution of the clay substance in the soil is probably very different in lateritic soils from that found in non-lateritic soils, and that such clays have very different properties. We do not know the significance of these properties and various others connected with lateritic soils, but it is very obvious to anyone interested in soil work that much work of a fundamental nature must be carried out before we can hope to understand the properties of these soils. This work cannot be undertaken by the normal staff of the ordinary Agricultural Departments for reasons of which the following are probably the most important—firstly, the departmental chemists are far too busily engaged on routine and advisory work to embark on fundamental research, and, secondly, if they had the time, they are not necessarily fitted by inclination, training and experience to undertake that particular form of investigation, nor are their library facilities or laboratory accommodation generally sufficient. In making this remark I am in no wise belittling the qualifications possessed, or the work carried out, by the ordinary agricultural chemist, such chemists are not usually appointed for their capacity or wish to undertake fundamental research, nor do they acquire the necessary training, experience and inclination by merely being transported to the tropics. They do extremely valuable work in various ways, such as local soil surveys, initiating, supervising and providing the chemical control for fertiliser experiments, the examination of various agricultural products, the *ad hoc* problems of the ordinary Agricultural Department, and even in some cases, teaching. These duties, in an active Department, do not leave time or provide a suitable atmosphere for fundamental research, and if the problems connected with lateritic soils are to be seriously tackled, then the work will have to be carried out in a research station where suitable facilities are available.

It is, therefore, suggested that this Conference considers the proposal of recommending to the various Governments concerned, the establishment in West Africa of a small scale research station having for its chief objects (1) the investigation of oil-palm problems and (2) the investigation of the properties and problems pertaining to lateritic soils, since these two problems can both be investigated in the same locality.

It would of course be quite improper for the Conference to make such recommendations without giving some idea of the cost and locality for such a station. With regard to locality, a consideration of climatic conditions suggests at once that the locality for such a station should be either in Southern Nigeria or Sierra Leone. The

oil-palm grows best in regions where the rainfall is heavy and it is probable that the amount of rainfall would not be considered entirely suitable unless it exceeded 80 inches a year.

Estimated annual cost of sub-station.—It is estimated that the annual cost of running the station would be from £6,000 to £8,000 a year, and the method by which the figure is arrived at is shown in Appendix B.

Initial Cost.—It is very difficult to estimate a figure for the initial cost of buildings, etc., but it is obvious that a commodious laboratory will be required and that suitable houses must be provided for four European officers. The cost of these buildings is not likely to be less than £15,000.

It is possible, however, that use might be made of existing facilities, either in Nigeria or in Sierra Leone, which would materially diminish the initial cost of the proposed sub-station. I have not visited any existing research station in Nigeria, except Ibadan (which would be unsuitable on account of its low rainfall, 50 inches annually) and can consequently deal only with any existing stations in Sierra Leone which might be utilised. It must, however, be realised that, however desirable it may be to diminish the initial cost of a research station, it would be most unsound to consider any proposition in any locality unsuited for the purpose of the proposed research station.

At N'jala, near Mano, Sierra Leone, we have a thoroughly well built and commodious set of laboratories* which at the time of writing this paper has never been used. These laboratories, which are similar in design to the ground floor of the Imperial College of Trinidad, were originally intended for a scheme of agricultural education which it is now found impossible to carry out in its original form. This building, constructed with thick concrete walls, with the floor well raised above the level of the ground, is situated on the top of sloping ground and provides as pleasant a laboratory for research work as could normally be expected. It is adjacent to the Departmental agricultural station, where there are already in existence several plantations of oil-palms, including varieties from Nigeria, Sierra and Sumatra. The Nigerian oil-palms are now some eight years old, individual records of trees have been kept, and as will be seen from Mr. Deighton's report, which has been submitted to the appropriate sub-committee of this Conference, information of great value is now being obtained. The Sierra Leone varieties are much younger but are now coming into bearing, while the Sumatran palms, pedigree stock, have only just been planted out into the field.

This set of circumstances makes N'jala a most desirable place for the establishment of a station for investigating oil-palm problems, and moreover, provided that satisfactory arrangements could be

* These laboratories cost approximately £18,000 to erect.

made with the Sierra Leone Government, work could start at once. I have not the authority of the Sierra Leone Government to offer the facilities which exist at N'jala for the purposes of a research station, but His Excellency, the Governor of Sierra Leone, welcomes a general discussion on the question of research stations, and has given permission for representatives from Sierra Leone to express their personal views provided that it is clearly understood that such expressions are personal and are not necessarily the considered opinion of the Government they represent. My view is that in considering the locality for the establishment of a research institution for oil-palms and lateritic soils, the possibilities of N'jala should not be overlooked. It may be possible for arrangements to be made with the Sierra Leone Government to enable some of the existing buildings and plantations at N'jala to be taken over for the purpose of research work on oil-palms, and if this is so, a great amount of time would be saved in starting this work.

Whether this can be done or whether it is decided that some other locality is more suitable, the main point at issue is that immediate steps should be taken to push forward vigorously with oil-palm investigations. For the past 29 years the attitude of Mr. Micawber has been adopted, mainly through the difficulty of organising concerted action, but now that this difficulty has been in part removed by periodical meetings of this Conference, it is time for a definite move to be initiated. The annual cost of a research station such as that outlined is not prohibitive, and if the Empire Marketing Board will assist (and from the Report of the Imperial Agricultural Research Conference, page 10, this appears probable), the remainder of the cost, shared in agreed upon proportions between the four West African Colonies, should not put any undue financial strain on any of them. Compared with the value of the produce at stake (over £10,000,000 worth of oil-palm products exported annually) the provision required for the research station is only a minute fraction of one per cent.

I cannot close this paper without a reference to the increasing competition from the East Indies. At the Ibadan Conference Messrs. Auchinleck and Waters drew attention to the gravity of the Eastern menace to the West African export trade. Since that time Mr. Ormsby-Gore has visited the East Indies and has described the thorough and systematic manner in which the Dutch are developing agriculture (including the cultivation of oil-palms) in their colonies. In a recent series of articles in *The Times*, Major W. Elliott describes how the production of sugar in Java has beggared the West Indies, and, on top of this, the newly-bred sugar cane P.O.J. No. 2878 has revolutionised sugar production even in the East Indies. Pasoeroean has conquered Pitt; it is our duty to see that neither Medan nor T.G. 115 shall bring penury and pauperism to our West African Colonies.

APPENDIX 'A.'

Appendix "A" of the report of a committee consisting of Dr. A. W. Hill (then Assistant) Director of the Royal Botanical Gardens, Kew, and the Directors of Agriculture of the various West African Colonies, 1919.

 LINES OF INVESTIGATION.

1. A general survey of the existing types of palms comprising :
 - (a) The collection and preparation of specimens.
 - (b) Obtaining particulars of the habit, habitat and yield of fruits of the different kinds of oil-palm.
 - (c) Collation of observations for group survey.
 - (d) Investigation of the chemical nature of the oils from the pericarp and kernels, and of the proportion of pericarp to kernel, in different kinds.

2. A comparison of the types (in both mature and seedling stages) met with in the different Colonies to be made by the different investigators through the interchange of material and information regarding the types.

For the proper carrying out of these investigations, it is particularly essential that the investigators should confer together in the first year of the enquiry and thereafter, at convenient intervals, members of the mercantile community who are interested in the industry should be invited to attend conferences when this may usefully be done.

3. A careful study of the methods of pollination of the oil-palm to be made. This study should be accompanied by experiments in hand-pollination, in order to test whether pollen from the same tree is more or less efficaceous than that from a different tree.

4. Extension of the present investigations of the effects on yield of different kinds of cultivation, including :—
 - (a) Observations on the effects of different treatments of the soil.
 - (b) Observations on the effects of different treatments of the plant.
 - (c) Observations in relation to the effects of soil altitude and rainfall.
 - (d) Preventive and remedial measures against enemies.

5. Investigation of the best methods of propagation including :
 - (a) Nursery work : devising methods to secure a high percentage of germination and of survival of seedlings.
 - (b) Determination of the best methods of making plantations, with reference to times for planting out and age of seedlings used.

6. To form plantations of the different types of selected palms from the several Colonies for the purpose of testing (in correlation with the results obtained from a study of the naturally-sown oil palms) the effects of altitude, rainfall, soils, etc., on the growth and yields of the palms.

7. Special breeding work in plantations of selected types (*see* 1 and 2), which will obviously include :—
 - (a) Determination of percentage “ breeding true.”
 - (b) Investigation of types arising from cross-pollination (botanical characters, yield, nature of oils).
 - (c) Investigation of the possibility of using fixed characters for breeding for improvement.

8. The investigation of different methods of preparing oil and of mechanical nut cracking, including the following collateral lines of work :—
 - (a) Chemical investigation by the local chemist and by the Imperial Institute.
 - (b) Devising means of extending proper methods of preparation among natives.
 - (c) To carry out investigations in co-operation with local manufacturers, and to afford such manufacturers scientific assistance in connection with problems of the preparation of the oil.
 - (d) To determine the changes that take place in the oil and kernels on keeping: (1) on the West Coast (2) during transit and storage in England.

APPENDIX 'B.'

ESTIMATED ANNUAL COST OF PROPOSED RESEARCH STATION.

	<i>Cost of first year.</i>
One Director (Botanist or Chemist). Class IV: *	
£1,200—£1,350	£1,200
One Senior Officer (Chemist or Botanist). Class V: *	
£1,000—£1,200	1,000
Two Junior Officers (1 Chemist, 1 Botanist). £600—£920 (or Class VI)	1,200
Four African Laboratory Assistants. £60—£200	240
Two African Clerks. £50—£100	100
Four Laboratory Boys at £30 a year	120
Other charges, including apparatus, library, electric light and gas, passages, transport and labour ..	2,140
	<hr/> £6,000 <hr/>

The staff shown above is similar to that indicated by Dr. Hill's committee in 1919, and the increased cost as compared with Appendix "B" of the Committee's report is due to the higher salary scales now in existence on the West Coast.

* Class and salaries taken from the Proposed Salary Scales for the Unified Agricultural Service. Cmd. 3049, 1928, Table P, page 26.

PAPER No. VII.

NOTES ON WEST AFRICAN SOILS.

BY F. J. MARTIN AND H. C. DOYNE (SIERRA LEONE).

During the process of investigations in this laboratory during the past two or three years, it was considered desirable to obtain samples of soil from other West African Colonies for comparison with those of Sierra Leone. We were enabled to do this partly through the courtesy of the Directors of Agriculture in the other Colonies, partly through Mr. D. G. Thomas, Assistant Conservator of Forests, Sierra Leone, and partly through Mr. F. Montague Dyke (Niger Company). To these gentlemen who so kindly assisted us, we tender our sincere thanks.

The soils received are too small in number to be taken as representative of any other than a minute proportion of the large area from which they were drawn, yet since there are, so far, no published reports of analyses of West African soils, we think that the results obtained may be of interest to those engaged in research work on agricultural problems on the West Coast.

In submitting our requests for soils we asked only for first foot samples. We did this for two reasons: the time we have to spare for such analyses is limited, and we hesitated to ask even the most kindly of the people who assisted us to undertake the laborious task of digging and sampling down to four feet—our usual practice in Sierra Leone. We asked that the soil samples submitted should be as characteristic as possible of the area from which they were taken, but the difficulties of obtaining samples representative of a large area are too well known to need any further mention. The samples from Sierra Leone however, may be taken as characteristic of their types.

The details of the analyses are given in Appendix "A" and only certain aspects of these samples will be considered in the body of this paper.

Mechanical composition.—There was, as is common all the world over, a great variation in the mechanical composition of samples examined. The soils varied from the lightest of sandy soils to heavy clays and the state of division of the soil particles appeared to bear no relation to the climate or locality from which the soils were taken.

Chemical composition of clay fraction.—The clay fraction of the soil was found to be by far the most interesting of the various soil fractions. It is the quantity and quality of this fraction which frequently determines the nature and possibilities of the soils, and in view of the importance of the colloidal constituents as a vital factor in the composition of soil, a detailed chemical analysis of the clay was made in each case.

According to Glinka, climate plays a large part in determining the characteristics of soil. In West Africa the most important aspect of climate is the way in which it can be correlated with the constitution of the clay fraction. Clay in temperate climates may be considered to consist of hydrated silicates of alumina, and the ratio of the silica to the alumina is high, varying from 3 to 5. In West Africa the ratio is found to be considerably lower than this, and varies with the climate. The following table gives the figures for the samples examined together with the rainfall zone in which they occur. For comparison, figures are given for the Anglo-Egyptian Sudan*, a drier area than any of those examined in West Africa.

TABLE 1.

Zone.	Annual Rainfall in inches.	Silica/alumina ratio of clay (average).
Light Rainfall. Sudan (5)†	less than 25	3.65
Medium Rainfall. Gold Coast (4)	} 25—50	2.39
Gambia (4)		
Nigeria (5)		
Fairly Heavy Rainfall. Gold Coast (1)	} 50—80	2.07
Congo Belge (2)		
Nigeria (1)		
Heavy Rainfall. Sierra Leone (9)	} over 80	1.55
French Guinea (1)		
Cameroons (1)		

† The numbers in brackets indicate the numbers of clay fractions analysed.

There is a distinct relation between the rainfall and the nature of the clay so far as this is indicated by the silica/alumina ratio. This is a point of some importance since there is a marked difference

* Joseph, A. F., *Jour. Agric. Sc.*, 1924, vol. 14, p. 490.

between the properties of clays having a high silica/alumina ratio and those having a low ratio. Clays having a low silica/alumina ratio are not so easily dispersed, not so plastic, do not so easily absorb certain dyes and ammonia, and have little capacity for base exchange, when compared with clays of a higher silica content. This set of clay properties, characteristic of lateritic soils, introduces an entirely different set of problems to those encountered in temperate climates or hot dry countries. So far, very little work has been carried out on the significance of these properties in the treatment of lateritic soils, and we are of the opinion that these and other problems of a like and equally important nature, will have to be very carefully studied before we can arrive at any proper conception of the nature and properties of lateritic soils.

In view of the fact that, up to the present, we have had no definite returns from phosphatic manures, it is interesting to note the avidity with which phosphorus is removed from solution when placed in contact with lateritic soils. As an instance of this the following is quoted. Twenty grammes of soil were shaken with a solution of acid calcium phosphate containing 0.04 per cent. of P_2O_5 and left for five days. The suspension was filtered, the phosphate from the filtrate estimated, and from that the percentage of phosphorus removed by the soil was calculated.

TABLE 2.

Soil.	Percentage of P_2O_5 removed from Solution.	Silica/alumina ratio.
2,387	99.3	1.36
1,105	98.2	1.66
2,514	96.5	1.75
2,505	97.7	1.89
2,340	72.1	2.11

The results show that the soils are capable of removing large quantities of phosphorus from solution, while a comparison of the proportion removed with the silica/alumina ratio, suggests that the greater the proportion of alumina present the greater the proportion of phosphorus removed. This might reasonably be expected.

A comparison between the plant nutrients present and the rainfall from the area in which the soils were taken, suggests that

there are probably definite relationships between climatic conditions and the plant nutrients found in soils. The climates of the regions from which samples have been taken have been split up into zones in accordance with the rainfall and all soils taken from any Colony within that zone have been averaged. The results so obtained are shown in Table No. 3. An average has also been made of the soils within each climatic zone irrespective of Colony. These averages have not been weighted and the average of three soils from one Colony has been treated as of equal significance of the average of ten soils from another Colony. While it must always be borne in mind that the number of soils examined is small, yet the indications in West Africa have some support from analyses in other parts of the tropics. In general it is probable that as far as organic matter and nitrogen is concerned, the higher the rainfall the greater the amounts of these substances present, whereas as regards the available* mineral constituents, these decrease with increasing rainfall.

* By available is meant the amount soluble in 1 per cent. Citric acid.

TABLE 3.

PLANT NUTRIENTS IN SOILS FROM WEST AFRICAN COLONIES.

AVERAGE FIGURES FROM SAMPLES ANALYSED.

Climatic Zone.	Rainfall (inches).	Total.		HCL Soluble.		Citric Sol.	
		Org. matter.	N.	P ₂ O ₅	K ₂ O	P ₂ O ₅	K ₂ O
Heavy Rainfall Zone.	Over 80	%	%	%	%	%	%
Nigeria (18)	"	1.50	.029	.034	.061	.0002	.0064
Sierra Leone (4) ..	"	3.63	.158	.086	.119	.0008	.0081
		2.57	.094	.060	.090	.0005	.0073
Very Heavy Rainfall.	50—80						
Congo Belge (2) ..	"	1.95	.020	.031	.083	.0008	.0158
Gold Coast (1) ..	"	2.10	.098	.066	.282	.0070	.0090
Nigeria (2)	"	1.20	.061	.040	.157	—	—
		1.75	.060	.046	.174	.0039	.0128
Medium Rainfall.	25—40						
Nigeria (4)	"	1.14	.045	.028	.100	.0009	.0105
Gold Coast (2) ..	"	2.15	.107	.047	.156	.0058	.0199
Gambia (11)	"	1.74	.064	.020	.165	.0046	.0124
		1.68	.072	.032	.140	.0038	.0143

between the properties of clays having a high silica/alumina ratio and those having a low ratio. Clays having a low silica/alumina ratio are not so easily dispersed, not so plastic, do not so easily absorb certain dyes and ammonia, and have little capacity for base exchange, when compared with clays of a higher silica content. This set of clay properties, characteristic of lateritic soils, introduces an entirely different set of problems to those encountered in temperate climates or hot dry countries. So far, very little work has been carried out on the significance of these properties in the treatment of lateritic soils, and we are of the opinion that these and other problems of a like and equally important nature, will have to be very carefully studied before we can arrive at any proper conception of the nature and properties of lateritic soils.

In view of the fact that, up to the present, we have had no definite returns from phosphatic manures, it is interesting to note the avidity with which phosphorus is removed from solution when placed in contact with lateritic soils. As an instance of this the following is quoted. Twenty grammes of soil were shaken with a solution of acid calcium phosphate containing 0.04 per cent. of P_2O_5 and left for five days. The suspension was filtered, the phosphate from the filtrate estimated, and from that the percentage of phosphorus removed by the soil was calculated.

TABLE 2.

Soil.	Percentage of P_2O_5 removed from Solution.	Silica/alumina ratio.
2,387	99.3	1.36
1,105	98.2	1.66
2,514	96.5	1.75
2,505	97.7	1.89
2,340	72.1	2.11

The results show that the soils are capable of removing large quantities of phosphorus from solution, while a comparison of the proportion removed with the silica/alumina ratio, suggests that the greater the proportion of alumina present the greater the proportion of phosphorus removed. This might reasonably be expected.

A comparison between the plant nutrients present and the rainfall from the area in which the soils were taken, suggests that

there are probably definite relationships between climatic conditions and the plant nutrients found in soils. The climates of the regions from which samples have been taken have been split up into zones in accordance with the rainfall and all soils taken from any Colony within that zone have been averaged. The results so obtained are shown in Table No. 3. An average has also been made of the soils within each climatic zone irrespective of Colony. These averages have not been weighted and the average of three soils from one Colony has been treated as of equal significance of the average of ten soils from another Colony. While it must always be borne in mind that the number of soils examined is small, yet the indications in West Africa have some support from analyses in other parts of the tropics. In general it is probable that as far as organic matter and nitrogen is concerned, the higher the rainfall the greater the amounts of these substances present, whereas as regards the available* mineral constituents, these decrease with increasing rainfall.

* By available is meant the amount soluble in 1 per cent. Citric acid.

TABLE 3.
PLANT NUTRIENTS IN SOILS FROM WEST AFRICAN COLONIES.
AVERAGE FIGURES FROM SAMPLES ANALYSED.

Climatic Zone.	Rainfall (inches).	Total.		HCL Soluble.		Citric Sol.	
		Org. matter.	N.	P ₂ O ₅	K ₂ O	P ₂ O ₅	K ₂ O
Heavy Rainfall Zone.	Over 80	%	%	%	%	%	%
Nigeria (18)	"	1.50	.029	.034	.061	.0002	.0064
Sierra Leone (4) ..	"	3.63	.158	.086	.119	.0008	.0081
		2.57	.094	.060	.090	.0005	.0073
Moderately Heavy Rainfall.	50—80						
Congo Belge (2) ..	"	1.95	.020	.031	.083	.0008	.0158
Gold Coast (1) ..	"	2.10	.098	.066	.282	.0070	.0090
Nigeria (2)	"	1.20	.061	.040	.157	—	—
		1.75	.060	.046	.174	.0039	.0128
Light Rainfall.	25—40						
Nigeria (4)	"	1.14	.045	.028	.100	.0009	.0105
Gold Coast (2) ..	"	2.15	.107	.047	.156	.0058	.0199
Gambia (11)	"	1.74	.064	.020	.165	.0046	.0124
		1.68	.072	.032	.140	.0038	.0143

The relationship between the climate and the nature of the soil is of great interest both to the chemist and the agriculturist, since it will be obvious that the methods of cultivation, and the preservation of fertility in soil, depend to a great extent upon a proper appreciation of the principles underlying these relationships. Much further research, however, is required before we can pretend to any great understanding in these matters.

WHAT IS LATERITE ?

So far in this paper we have carefully avoided using the terms "laterite" and "lateritic" as descriptive of any particular soil. Until recently any red tropical soil was called laterite, but it is now known that all red soils are not necessarily lateritic, nor are all lateritic soils red in colour. In a recent paper (*Jour. of Agric. Sc.*, 1927, vol. 17, p. 530) we defined the terms "laterite" and "lateritic" as applied to soils. We suggested that since the clay fraction is generally the most important fraction in determining the reaction of the soil, the classification of soils of a supposed lateritic nature should be based on an analysis of the clay. Where the silica/alumina ratio of the clay falls below 1.33 the soil is called laterite, where the ratio lies between 1.33 and 2.0 the soil is called lateritic, where the ratio exceeds 2.0 it was not suggested that the soil should be described by any term which suggests the presence of a high proportion of alumina.

We regard clay as mainly a heterogeneous mixture of hydrated silicates of aluminium of the form $m.SiO_2, n.Al_2O_3, x.H_2O$, these hydrated silicates constituting the clay base or clay substance. Clay is formed from the weathering of the minerals contained in rocks, such as the feldspars in granite rocks. Under certain conditions of weathering in temperate climates soil clays are formed having SiO_2/Al_2O_3 ratios of 3 to 5 (e.g., England, Holland), under dry conditions in tropical countries the SiO_2/Al_2O_3 ratio is still high (e.g., Sudan), but in moist or wet tropical countries weathering has been carried on to such an extent that the SiO_2/Al_2O_3 ratio may have been reduced to from 1 to 2 (e.g., Sierra Leone, parts of Gold Coast, Nigeria and Belgian Congo). We think that when the decomposition of the clay has reached such a point that there is not sufficient silica left to combine with all the alumina, then the soil merits a particular description, for which we use the term "lateritic." For hydrated silicates of alumina this point is reached when the SiO_2/Al_2O_3 ratio falls below 2.

It is of course possible to take the ratio $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$ or $\frac{SiO_2}{R_2O_3}$, but in following up the process of weathering of norite rocks in Sierra Leone we have found that the final products of such weathering always contain a high proportion of alumina, whereas

the amount of iron is in some cases low and in others high. The iron appears to be a somewhat fugitive element usually, but not necessarily, associated with the formation of lateritic soils, and we have therefore come to the conclusion that the safest course is to base our definition on the proportions of silica and alumina present. This confirms the conclusion arrived at by Bauer in the Seychelles.* He found that the iron oxide is a variable compound and is best considered as an unessential constituent, while aluminium is the essential constituent.

It has been pointed out that some soils (not necessarily tropical) containing much iron have a low $\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3}$ ratio and a comparatively high $\text{SiO}_2/\text{Al}_2\text{O}_3$ ratio (over 2), and that such soils may have properties similar to those of lateritic soils. While this is recognised as possible it is preferable not to class them as lateritic, since there is no evidence of the presence of the extremely advanced stage of weathering (including the presence of free alumina) of which laterite is the outcome. We prefer to call such soils pseudo-lateritic soils.

It is recognised further that in some cases free alumina may be present in the clay fraction but that the ratio of silica to alumina in the rest of the clay fraction may be sufficiently high to bring up the silica/alumina ratio of the whole fraction to over 2.0. This is a stage which must frequently be found in soils which are gradually becoming laterised. It would appear from analytical figures and general appearance of some of the soils examined, that soils of this type are probably frequently found in West Africa, particularly where the rainfall falls below 60 inches a year. These soils might well be called semi-lateritic. We have not sufficient information to fix a definite upper limit to the silica/alumina ratio but think that 2.2 or 2.3 might perhaps be regarded provisionally as a suitable figure.

NEED FOR FURTHER RESEARCH ON LATERITE.

It is hardly necessary to dilate on the sketchiness of our knowledge of lateritic soils. We have no fundamental knowledge of these soils such as exists with regard to soils of temperate climates. Multitudinous analyses of plant constituents and mechanical composition have been made of tropical soils, but the frequent failures to interpret the analyses correctly have led to such examinations falling into disrepute. We have very little actual knowledge of the constitution of lateritic soils, their behaviour towards mineral and organic compounds, the influence of a high proportion of sesquioxides in the clay in place of the more normal alumina-silicates

* M. Bauer: *Beiträge zur Geology der Seychellen, Neues Jahrbuch für Min., Geol., und Pal.* 1893, vol. 2, pp. 163—219.

of temperate climates, and the effect of the high degree of unsaturation of the clay complex and the consequent high hydrogen-ion concentration. Many soils exceptionally low in phosphorus do not appear to give any increased yield when this substance is added. If we determine the percentage of the normal plant nutrients in our tropical soils we are frequently unable to say which constituent is deficient and how much, because we have not sufficient data to form a basis of comparison. We do not know the effect of the original rock on the final lateritised product, yet it is conceivable that differences in the nature of the original rock may survive through a considerable period of lateritisation. Thus in Sierra Leone lateritised recent sedimentary deposits are different in colour and texture from the lateritised norite formation giving rise to the hills of the Colony.

Many other points might be enumerated but sufficient has been said to show that there is much of the fundamental nature of lateritic soils of which we are ignorant. Some small attempt to attack the problem of lateritic soils has been made in Sierra Leone but we have never had sufficient time to concentrate continuously on this problem, and it is concentrated and continuous work that is needed. We also think that the limited chemical staffs of most Agricultural Departments are so fully occupied that there seems little likelihood of this problem being seriously tackled by them. Further facilities for research are therefore necessary and it is suggested that such facilities could be provided by attaching one or two chemists to an existing laboratory with the definite object of investigating this problem, or, what is probably more suitable, by the incorporation of this form of research in any agricultural research institution, which may be set up in a suitable locality (climatically) on the West Coast.

APPENDIX "A" (I).

Colony — Gambia.*

Origin of Soil	Cape St. Mary.	Sukutu Farm.	Kerewan Farm.	Kansala Farm.
Description	Reddish brown.	Brown.	Reddish brown.	Brown.
MECHANICAL ANALYSIS.				
Gravel, over 2.0 mm.	0.7	0.4	0.3	1.2
Coarse sand, „ 0.2 mm.	69.5	46.5	44.8	24.2
Fine sand, „ 0.02 mm.	23.6	37.7	45.3	56.7
Silt and clay, less than 0.02 mm.	6.7	15.5	9.8	17.5
CHEMICAL ANALYSIS.				
HCL sol. K ₂ O	0.035	0.020	0.020	0.022
„ „ P ₂ O ₅	0.024	0.007	0.008	0.012
Citric sol. K ₂ O	0.003	0.003	0.002	0.003
„ „ P ₂ O ₅	0.013	0.001	Trace	0.001
Total N	0.026	0.039	0.028	0.044
Org. matter	0.56	0.77	0.54	0.94
Exchangeable CaO	0.029	0.033	0.009	0.044
pH	5.6	5.7	5.9	5.6
ANALYSIS OF CLAY.				
SiO ₂	37.1	41.3	37.6	38.1
Al ₂ O ₃	29.7	31.5	28.9	31.7
Fe ₂ O ₃	9.2	5.9	10.1	7.5
CaO	0.88	0.12	0.14	0.14
Loss on ignition	20.3	18.4	20.6	19.9
SiO ₂ /Al ₂ O ₃ ratio	2.12	2.22	2.20	2.03

* From report by Imperial Institute.

APPENDIX "A" (II).

Colony — Sierra Leone.

Origin of Soil	Mabang Swamp.	King Tom.	Regent Road.	Lumley Road.
Description	Black.	Brown.	Grey Yellowish brown.	Red.
MECHANICAL ANALYSIS.				
Stones and gravel, over 2.0 mm.	1.1	Nil.	56.64	48.5
Coarse sand, ,, 0.2 mm.	16.0	29.0	20.8	20.8
Fine sand, ,, 0.02 mm.	29.6	52.2	8.5	27.6
Silt and clay, less than 0.02 mm.	54.4	18.8	70.7	—
CHEMICAL ANALYSIS.				
HCL sol. K ₂ O	0.124	0.043	0.058	0.037
,, ,, P ₂ O ₅	0.192	0.054	0.081	0.115
Citric sol. K ₂ O	0.021	0.016	0.0028	0.0086
,, ,, P ₂ O ₅	0.015	0.0011	0.0016	0.0016
Total N	0.33	0.27	0.25	0.24
Org. matter	6.99	3.3	4.05	5.44
pH	—	4.2	4.5	4.6
Exchangeable CaO	—	0.09	0.08	0.025
Lime requirements	0.46	0.39	—	0.38
ANALYSIS OF CLAY.				
SiO ₂	35.7	31.7	26.0	21.99
Al ₂ O ₃	32.0	31.0	32.3	33.00
Fe ₂ O ₃	7.9	10.8	12.8	21.6
CaO	0.2	Trace.	0.9	Nil.
Loss on ignition	24.1	24.1	27.69	21.26
SiO ₂ /Al ₂ O ₃ ratio	1.89	1.73	1.36	1.13

APPENDIX "A" (III).

Colony — Sierra Leone.

Origin of Soil	Skarcies Swamp.	N'jala.	Konno Grit.	Newton.
Description	Black.	Grey.	Black.	Brown.
MECHANICAL ANALYSIS.				
Stones and gravel, over 2.0 mm.	0.2	Nil.	20.8	Nil.
Coarse sand, ,, 0.2 mm.	5.2	34.8	26.4	50.4
Fine sand, ,, 0.02 mm.	34.6	38.6	16.6	24.2
Silt and clay, less than 0.02 mm.	60.2	26.6	57.0	25.4
CHEMICAL ANALYSIS.				
HCL sol. K ₂ O	0.15	0.009	0.369	0.056
,, ,, P ₂ O ₅	0.003	0.016	0.189	0.025
Citric sol. K ₂ O	0.0101	0.007	—	—
,, ,, P ₂ O ₅	0.0009	0.0003	—	—
Total N.. .. .	0.22	0.07	0.144	0.065
Org. matter	10.54	2.54	3.81	1.67
pH	4.7	4.5	5.1	5.3
Exchangeable CaO	0.084	—	—	—
Lime requirements	0.34	0.18	0.24	0.25
ANALYSIS OF CLAY.				
SiO ₂	35.3	36.6	27.4	36.2
Al ₂ O ₃	34.1	29.3	28.0	33.9
Fe ₂ O ₃	8.5	4.8	11.8	8.2
CaO	Trace.	Nil.	0.3	Trace.
Loss on ignition	19.4	25.9	41.1	19.8
SiO ₂ :Al ₂ O ₃ ratio	1.76	2.11	1.66	1.81

APPENDIX "A" (IV).

Colony—Gold Coast.

Origin of Soil	Accra.	Aburi.	Kuraban	Koforidua.	Abetifi.
Description	Reddish brown.	Greyish brown.	Reddish brown.	Greyish brown.	Greyish pink.
MECHANICAL ANALYSIS.					
Gravel,* over 2.0 mm.	—	—	—	—	—
Coarse sand, over 0.2 mm.	35.8	37.0	43.4	50.2	29.6
Fine sand, over 0.02 mm.	22.6	18.0	17.8	17.6	44.2
Silt and clay, less than 0.02 mm.	41.6	45.0	38.8	32.2	26.2
CHEMICAL ANALYSIS.					
HCL sol. K ₂ O ..	0.154	0.170	0.087	0.282	0.213
„ „ P ₂ O ₅ ..	0.059	0.043	0.041	0.066	0.043
Citric sol. K ₂ O ..	—	0.033	—	0.0091	0.0069
„ „ P ₂ O ₅ ..	—	0.011	0.0004	0.0070	0.0008
Total N	—	0.150	0.046	0.098	0.080
Org. matter	1.7	4.1	1.1	2.1	1.6
pH	6.8	6.5	6.6	6.8	6.6
Exchangeable CaO ..	0.092	0.42	0.134	—	0.045
Lime requirement ..	0.12	0.02	0.09	0.16	—
ANALYSIS OF CLAY.					
SiO ₂ *	37.4	37.6	46.3	36.2	40.3
Al ₂ O ₃	30.4	27.4	28.3	33.9	28.7
Fe ₂ O ₃	13.5	14.0	9.6	5.1	11.6
CaO	—	—	—	—	—
Loss on ignition ..	15.2	17.2	14.4	22.9	18.7
SiO ₂ /Al ₂ O ₃ ratio ..	2.1	2.3	2.8	1.8	2.4

* All gravel removed before samples were submitted for examination.

APPENDIX "A" (v).

Colony—Nigeria.

Origin of Soil	Ilorin.	Minna.	Samaru.	Kano.
Description	Brown.	Light grey.	Greyish yellow.	Pinkish grey.
MECHANICAL ANALYSIS.				
Gravel, over 2.0 mm.	2.3	0.5	Nil.	0.5
Coarse sand, „ 0.2 mm.	45.6	56.8	21.8	19.2
Fine sand, „ 0.02 mm.	21.4	32.0	69.6	68.0
Silt and clay, less than 0.02 mm.	33.0	11.2	8.6	12.8
CHEMICAL ANALYSIS.				
HCL sol. K ₂ O	0.247	0.073	0.080	0.110
„ „ P ₂ O ₅	0.04	0.012	0.014	0.030
Citric sol. K ₂ O	—	0.0158	0.0063	—
„ „ P ₂ O ₅	—	0.0012	0.0004	—
Total N	0.043	0.038	0.036	0.032
Org. matter	1.17	0.78	0.62	0.59
pH	6.2	6.6	6.6	6.7
Exchangeable CaO	0.070	0.051	0.042	0.056
Lime requirement	0.1	0.02	0.06	0.04
ANALYSIS OF CLAY.				
SiO ₂	37.0	40.4	44.1	44.5
Al ₂ O ₃	30.8	25.4	26.5	27.2
Fe ₂ O ₃	15.0	8.8	7.2	7.6
CaO	—	—	—	—
Loss on ignition	15.1	20.7	17.4	17.3
SiO ₂ /Al ₂ O ₃ ratio	2.06	2.70	2.82	2.77

APPENDIX "A" (VI).

Colony—Nigeria and Cameroons.

Origin of Soil	Agege.	Ibadan.	Aba.	Ndian.
Description	Grey brown.	Light brown.	Greyish brown.	Yellowish grey.
MECHANICAL ANALYSIS.				
Gravel, over 2.0 mm.	Nil.	18.7	Nil.	21.5
Coarse sand, ,, 0.2 mm.	78.8	51.6	88.4	68.8
Fine sand, ,, 0.02 mm.	13.8	32.4	2.8	20.8
Silt and clay, less than 0.02 mm.	7.4	16.0	9.6	10.4
CHEMICAL ANALYSIS.				
HCL sol. K ₂ O	0.066	0.136	0.042	0.094
,, ,, P ₂ O ₅	0.400	0.055	0.048	0.008
Citric sol. K ₂ O	—	0.0193	0.007	0.009
,, ,, P ₂ O ₃	—	0.0018	0.0001	Trace.
Total N	0.080	0.074	0.031	0.027
Org. matter	1.20	2.56	1.18	1.20
pH	6.7	6.5	5.6	6.3
Exchangeable CaO	0.121	0.129	0.106	0.09
Lime requirement	0.04	0.06	0.12	0.06
ANALYSIS OF CLAY.				
SiO ₂	41.4	38.9	36.4	23.8
Al ₂ O ₃	28.7	24.8	26.9	30.4
Fe ₂ O ₃	6.4	15.0	9.2	9.2
CaO	—	—	0.56	1.0
Loss on ignition	20.9	18.6	24.5	32.6
SiO ₂ /Al ₂ O ₃ ratio	2.44	2.66	2.3	1.33

APPENDIX "A" (VII).

Colony — Belgian Congo.

Origin of Soil	Leverville.	Leverville.
Description.. .. .	Chocolate brown.	Chocolate brown.
MECHANICAL ANALYSIS.		
Gravel over 2.0 mm.	0.2	Nil.
Coarse sand „ 0.2 mm.	26.4	20.2
Fine sand „ 0.02 mm.	63.0	63.2
Silt and clay less than 0.02 mm.	10.6	16.6
CHEMICAL ANALYSIS.		
HCL sol. K ₂ O	0.078	0.087
„ „ P ₂ O ₅	0.025	0.037
Citric sol. K ₂ O	0.0175	0.014
„ „ P ₂ O ₅	0.0013	0.0002
Total N	0.01	0.03
Org. matter	0.50	0.64
pH	6.0	5.0
Exchangeable CaO	—	—
Lime requirement	0.06	0.16
ANALYSIS OF CLAY.		
SiO ₂	34.8	38.1
Al ₂ O ₃	31.6	29.8
Fe ₂ O ₃	16.7	14.7
CaO	—	Trace.
Loss on ignition	17.3	17.8
SiO ₂ /Al ₂ O ₃ ratio	1.87	2.17

APPENDIX " A " (VIII).

Colony — French Guinea.

Origin of Soil	.. .. .	Kindia.
Description	.. .. .	Grey brown
MECHANICAL ANALYSIS.		
Stones and gravel,	.. .. . over 2.0 mm.	5.3
Coarse sand	.. .. . „ 0.2 mm.	54.0
Fine sand	.. .. . „ 0.02 mm.	40.0
Silt and clay	.. .. . less than 0.02 mm.	6.0
CHEMICAL ANALYSIS.		
HCL sol. K ₂ O	.. .. .	0.093
„ „ P ₂ O ₅	.. .. .	0.002
Citric sol. K ₂ O	.. .. .	—
„ „ P ₂ O ₅	.. .. .	—
Total N	.. .. .	—
Org. matter	.. .. .	0.66
pH	.. .. .	6.3
Exchangeable CaO	.. .. .	—
Lime requirement	.. .. .	0.08
ANALYSIS OF CLAY.		
SiO ₂	.. .. .	32.67
Al ₂ O ₃	.. .. .	36.35
Fe ₂ O ₃	.. .. .	4.00
CaO	.. .. .	Trace
Loss on ignition	.. .. .	26.39
SiO ₂ /Al ₂ O ₃ ratio	.. .. .	1.52

PAPER No. VIII.

FORESTRY IN RELATION TO AGRICULTURE IN THE GOLD COAST COLONY AND ASHANTI.

BY J. R. P. GENT (GOLD COAST, FORESTRY DEPARTMENT).

Agriculture and Forestry have always been in very close contact and in many countries have grown up together, influencing each other's development and giving mutual assistance.

This is the case in temperate as well as tropical countries, and before coming to the particular point of this paper I should like to remind you of one of two very striking instances of this interdependence.

One, most striking because it is so modern that people still living have seen a great part of the process, is the development of the rich Canterbury Plains of New Zealand from a barren desert, uninhabited by man or beast, covered only by a vegetation of wiry tussock grass and perpetually swept by a bitter wind blowing down and across them from the Southern Alps to the sea. This country was made habitable by systematic planting of broad belts of trees at frequent intervals, which broke up the wind and, in the shelter afforded, a diligent agriculture has made one of the finest mixed farming countries in the world.

In Europe, as in India, West Africa and the tropics generally, forests existed before agriculture, and the forest has provided not only the land for the expanding agriculture, but has been, particularly in the early days, indispensable as a source of fodder for the live stock. The growing and storing of hay and root crops, the feeding of cake and so on, belong to a highly developed agriculture, but the prevalence of large oak and beech forests on the continent of Europe bears witness to the ancient importance, still surviving in places, of such forests in providing pannage for the farmer's pigs.

In India, at the present day, a complete fodder famine is almost annually averted only by the availability of a reserve store of grass in certain savannah forests, which at the critical time is cut and baled and distributed to the affected districts.

It is a perpetual lamentation of the forester that the average farmer does not appreciate what the forest means to him, but continues to over-exploit it mercilessly while he has it and only too late finds out that he has killed the goose that was the supplier of golden eggs.

It is in the new expanding countries that this phase is most prominent. While the old world is expensively replacing forests which in its younger days it thoughtlessly destroyed, the new countries are light-heartedly committing just the same mistake and will in the end have to pay for it. The trouble is that people in general will not realize that forests as such, apart from their obvious value as a source of supply of timber, fodder and so on, play a part in the general economy of the world for which there is no substitute.

As a preventative of floods, silting and erosion, for the conservation of water supplies, there is nothing as effective as the natural forest, which costs nothing ; when it has gone there are only expensive palliatives which may or may not be effective ; the Mississippi dams and draining works were expensive, but not effective, and the farmers suffered more than anyone from a disaster ultimately due to the deforestation of the head waters of this river and its tributaries.

The immense effect which forest has on climate, more particularly in the tropics, is a subject on which the average man outside the ranks of technically trained foresters and agriculturists is completely ignorant.

Yet it is on these qualities of the natural forest that the work of the Forest Department of this Colony is based. It is perhaps unique among Forest Departments in that it has been told, if not quite officially at any rate quite seriously, that it should not even think the word " timber," and in the main part of its work it does not do so.

To make clear what is the forest policy of the Gold Coast Government and how it is being carried into effect, which is what I have been asked to do in this paper, it is necessary to go over the primary facts which led to the formulation of the policy.

The climate of the Gold Coast (including Ashanti and the Northern Territories) is similar to that of Nigeria and is mainly influenced by the same two major factors, the south-west wind which brings the rain and the Harmattan which comes from the north-east and is dry.

These two factors combine to dictate the character of the natural vegetation in any particular part of the country and produce three main types of forest. In the south-west, with rainfall from 65 to 80 inches and a weak Harmattan, is the evergreen forest ; in the north and east, with a rainfall of 40 to 55 inches and a very strong Harmattan, is grass savannah with a less or greater number of drought and fire-resisting trees which may reach a fair size but do not form closed forest.

Between these extremes is the so-called deciduous forest, which leads over gradually from one to the other. This deciduous forest varies in composition a good deal, the variation of rainfall within it is comparatively small, and the incidence of the Harmattan is the determining factor, whether at any particular place it contains a greater or less proportion of trees of the evergreen forest or of those characteristic of drought conditions. In this intermediate zone one can fairly say, "Show me your forest and I will tell you what crops you can grow." There is a general opinion that the climate of equatorial Africa is very gradually becoming drier and that the desert conditions of the Sahara are encroaching on the Sudanese or savannah type of vegetation, and this in turn on the forest proper.

Whether or not this change, due to wide natural causes quite beyond control, is actually occurring, it is quite clear that the same result is being produced, and at a much faster rate than Nature unaided would work, by the activity of man with his fire and shifting cultivation. The Forest Department in Nigeria is continually repeating its warning in this matter, and with particular reference to the savannah zone, where effects are so much more rapid.

In the Gold Coast we are mainly occupied with the invasion of the deciduous forest country by the savannah and of the evergreen by the deciduous.

The reason for our anxiety in this, as in so many other things, is that we are a one-crop country, and that crop Cacao.

At the present day only the southern half of Ashanti and the centre and west of the Colony, an area of some 28,000 square miles, possesses climate which will maintain a vegetation of the forest type, and this area is surrounded by savannah on the north, east and south.

On these three sides the forest edge is being continually nibbled away by uncontrolled farming and its concomitant fire. Further, within the forest area is a great network of roads, each of which, along its whole length, forms an excellent front of attack by the cultivator in search of new land, mainly for cacao, on a good line of communication. Thus, apart from the shrinkage of the forest area all round its periphery, it is internally divided into blocks of various sizes, each one of which is similarly attacked on all four sides, and in these circumstances it is clear that almost complete extermination of the forest is a matter of measurable time.

The sanitarian will probably say, "Very well, why not exterminate it and have done with it. It is a fuggy, damp, unhealthy place and the sooner it is cleared to let the sun and air in the better"; and the farmer's one idea is to clear as much forest as he can and put cacao in place of it.

The sanitarian would probably not regard the tropical house at Kew as an ideal place to live in but cacao does, and is unhealthy without that type of damp heat ; while the farmer, though he invariably goes to the forest for his new cacao land, fails to realize that by destroying the forest he is destroying the conditions which here make for a healthy cacao farm.

The great effect of forest on the climate of a continental country, and still more of a tropical continental country, is in its effect on atmospheric humidity ; every square inch of the enormous leaf surface of every tree in the forest is continually, by transpiration, transferring water from the subsoil to the air. It is no mere matter of evaporation, but a mechanical pumping out of water vapour by the vital processes of the tree, and the amount of water vapour thus passed into the air is in the aggregate enormous.

The Harmattan arrives at Tamale with a humidity of 35 per cent. or under. In passing over the deciduous forest of north Central Ashanti it receives moisture and reaches Kumasi with a humidity of nearly 80, increasing to 82 at Tarkwa and to 88 at Axim in the heart of the evergreen forest.

The three main crops on which the agricultural wealth of the Gold Coast depends are cacao, oil palm and kola ; of these, cacao predominates, and they are all confined to the forest zone.

There is no doubt that it is the necessity for a certain constant humidity that prevents their cultivation outside. This humidity may be said to be between 80 and 89, that is the range of humidity in the forest zone. When the humidity has a much greater range than 9 points and a minimum below about 75 these crops do not thrive.

The critical season from this point of view is, of course, the Harmattan period, and that is when the whole burden of maintaining or rather creating a high atmospheric humidity, in the face of the invading bone-dry air currents, rests upon the forests of the country.

The three types of forest are effective to different degrees ; most effective is the evergreen forest, in which the trees maintain almost their full load area throughout this period and so keep their stream of water vapour turned on at full blast ; the deciduous forest, which lives nearer to the source of the trouble and receives the full brunt of the attack, has had to protect itself to some extent, but a proportion of the trees shirk it by becoming leafless. A number, however, and most of the underwood, hold on so that this forest as a whole is working at about half power during this season. The savannah simply succumbs, the grass dying back and practically all the trees becoming leafless, so that from this class of forest there is no appreciable help.

Government's Forest Policy, therefore, is to retain the natural deciduous and evergreen forest over such a proportion of the cacao

producing zone, and so distributed through that zone, as to be sufficient to maintain a high degree of atmospheric humidity throughout the year.

In carrying this policy into effect we are considerably helped by the physical features of the country. There is first a fairly natural boundary along the north-east and north of the cacao zone, consisting of well-marked chains of hills on which the south-west winds deposit a good rainfall of 60 inches or so, which is sufficient to maintain a good type of deciduous forest, tending in places towards the evergreen. Against this forest the savannah, which lies just outside it, cannot prevail if Nature is left to itself, but, with large-scale clearance for farming, the Harmattan and fire are let in and conditions changed to such a degree that the cleared forest is unable to regenerate itself in its original form and is replaced by a much more xerophytic type and not infrequently by savannah trees and grass direct.

The first point, then, is to hold as much as possible of these hills under permanent forest as a first line of defence and the backbone of the whole system of Reserves. A similar first line is also wanted along the south to check the spread inland of the wedge of coastal savannah. This is an expansion of dry conditions which is quite visibly taking place and we are unfortunately having the greatest difficulty in obtaining forest reserves along this line; in fact, the line as we are establishing it is a good deal farther back than it should be and amounts to abandoning a good deal of territory that it should have been possible to hold.

The root of the trouble here is not so much the Harmattan, the forest to the north reducing this to reasonable proportions, but low rainfall. The rainfall was sufficient when falling on well-forested country to maintain a perennial flow in many streams which are now, thanks only to the deforestation of their catchment areas, dry for a great part of the year.

On this line there are no marked hill ranges and the aim is to hold under forest as much as possible of the higher land and water partings in order to reduce the flood run-off and conserve as much as possible of the rainfall for the maintenance of water supplies and soil moisture; at the same time, of course, the atmospheric humidity is automatically affected by the presence of the forest, which in this respect takes its place in the general scheme.

With these two outer lines provided for, it is necessary to find within the zone itself a sufficient area of forest to maintain, throughout the zone, a degree of sustained humidity such as cacao requires.

To quote from the Department of Agriculture Bulletin, No. 15: "Cacao is successfully grown on the Gold Coast, with a rainfall much less than is usually considered necessary, simply by reason of the humid atmosphere." The ideal at which we aim is to secure

that 20 per cent of the land area in the cacao zone shall be kept under permanent forest well distributed throughout the whole zone, so that everywhere there shall be forest continually renewing the humidity that sun and wind are continually removing.

For this purpose we are again helped by a series of hill ranges running north-east to south-west and parallel to each other across the country. These give an excellent framework for the interior Reserves and are in themselves ideal for the purpose, since condensation is naturally greatest among the hills, and these forests are again of the greatest importance in maintaining the flow of streams which water wide areas.

Between these main hill ranges which are, as it were, the ribs of the system, we have to find further blocks of forest scattered through the definitely agricultural valleys, where they will contribute to the general humidity and have no small additional value as windbreaks and catchment areas.

Towards the ideal 20 per cent. we have in the course of the last five years succeeded in getting some 8 per cent. of the area protected, and of this the greater part is situated in the most vital area, the north-east and north barrier, which is almost complete, and we are now principally concentrating on the internal hill ranges which I called the ribs.

There is no doubt that the success, for it is a success, so far attained in putting the policy into effective operation has been that Government has worked as far as possible with and through the Native Administrations.

It is true there is a Forests Ordinance, by which Government can require essential areas to be maintained as Forest Reserves, but it is not part of the policy to use these compulsory powers unless absolutely necessary. The Ordinance was not brought into being until a number of Native Administrations had constituted their own Reserves in the places where they were asked and had generally shown that, though they might not always understand what it was all about, they did believe that in this matter Government knew more than they did and was acting in their interests.

This, however, will lead me beyond my subject.

I hope that I have been able to make clear the basis on which our forest policy rests and the way in which it is being carried out.

As an effort towards climatic control in the interests of a specialized agriculture, it is not without general interest, and it is of further interest as an example of an attempt to accomplish by co-operation of all states and parties an end which is essential to the welfare of the whole community, but could not be brought about by any individual action.

PAPER No. IX.

DEFORESTATION IN THE BISSA CACAO AREA.

BY H. W. MOOR (GOLD COAST, FORESTRY DEPARTMENT).

The area referred to is the valley of the Pawmpawm Su, a river rising East of Begoro and flowing in a south easterly direction for part of its course and then turning north eastwards to the Afram River. The name of the town has been used, as Bissa is the most important centre for the greater part of the cacao grown in this locality.

This area extends on the west up the slopes of the mountain mass, referred to as the Scarp Range, and is limited on the east by the range continued from the Akwapim Hills along the right bank of the Volta River. These ranges converge to a point near Koforidua and this topographical feature, in conjunction with the orientation of the valley, is of importance to the cacao grown here. The formation is the section of a funnel with its axis in a north-easterly—south-westerly direction and the larger end opening on to the Afram Plain in the north-east.

The basin in which this cacao grows is about 350 square miles in area, produces about 10,000 tons or 10 per cent. of all the cacao grown in the Eastern Province of the Colony and supports a population of some 70,000 souls, nearly all of whom are engaged in this industry. The future of the cacao here is also of some interest to a considerable number of others engaged in handling this product.

There is little forest left in the locality but from the evidence of the odd trees and patches remaining it is obvious that up to very recent times this part of the country was covered with deciduous type of forest of good average height and density and with only a narrow transition belt between itself and the grass savannah.

The present condition is somewhat different. A belt of oil palms, now neglected, created some 50 years ago has replaced the forest east of the Pawmpawm Su, the greater part of the transition belt has been absorbed by the savannah which has now also thrust a wedge up the valley of the river and the rest is a mixture of good and bad cacao farms, areas of oil palms and sporadic patches of savannah and secondary growth, with here and there the remains of the original forest. It may be noted here that most of the grass patches lie more or less along the axis of the funnel, culminating in a final patch at the top of the Scarp Range at the very

source of the Pawmpawm Su. From the ages of the dry zone species now established in these patches it is clear that they are of quite recent formation. This savannah intrusion is quite definitely the direct result of excessive deforestation.

This is a comparatively old cacao-producing area, the species having been introduced in about 1908. The greater part of the deforestation was accomplished by about 1920 but it was not until the dry season of 1925-26 that it was first noticed that the trees in whole farms had shed all their leaves together. Here was a phenomenon new to the local industry. Cacao is essentially an evergreen species and the fact that it had acquired a deciduous habit shows, if nothing else, a remarkable power of adaptability. That it had acquired this habit is a point that needs stressing. It has been observed and appears to be the experience of farmers that young cacao will not establish itself in conditions in which the surrounding matured trees have to resort to deciduousness. It may be inferred, therefore, that conditions were more suitable when cacao was first introduced and have since progressively deteriorated. As further evidence of a desiccatory process the fire during the dry season of 1927-28 may be quoted. It was the first known fire on any appreciable scale in this locality and burnt out a semicircular belt a mile wide on a four mile radius destroying several hundred acres of cacao and severely damaging many thousands of oil palm trees.

The first available agricultural report on the area is dated May 1928, and includes the result of an inspection of the cacao farms of 21 villages not in the fire zone. In nine of these villages the report states ". . . the cacao is in a pathetic state of die back . . . The Harmattan has had a very serious effect on these villages and the impression one gets is that the farmers have given up their cacao in despair." At three of these nine villages the cacao is said to have been grown under unsuitable conditions. As the first farm here was established in 1908 these have matured, produced crops and died off all within twenty years and the statement may be ventured that the culmination of the deforestation saw the beginning of the decay of these farms. They are now potential patches of savannah.

Could the annual output of individual localities be determined and related to the areas in bearing, some more definite conclusions might be drawn. However, it is the general opinion of merchants dealing in this product from this vicinity that in spite of the annually increasing area from which cacao is brought to the centres the volume of the product handled from year to year is stationary or, in the opinion of some, decreasing.

Cacao, as is well known, is an evergreen tree and essentially a crop of the tropical rain forest belt. Its requirements, as may be expected from its habitat, are a deep, moist but well-drained soil with a good supply of organic matter, an ample and well-distributed

rainfall providing a high degree of humidity of atmosphere and soil and protection from wind and sun. A combination of these factors provides suitable growing conditions. The soil and the actual volume of the precipitation may be considered variable factors in that, deficiencies in the one may be, within limits, neutralised by the other. Protection from the sun is also a variable as the lack of this may, in certain circumstances, be offset by a high atmospheric moisture content. The constants, however, are humidity, whether of soil or atmosphere (and these are usually closely related) and protection from drying winds. A wind, and particularly as dry a one as the Harmattan, is a stronger desiccating agent than the sun and without protection from such wind it appears difficult to maintain the moisture factor to the extent required by cacao. That a forest mass definitely mitigates the effect of the Harmattan is established by a comparison of the humidity figures from Sekondi and Accra. They are both coastal towns but the one is to the lee of a forest mass and the other is not ; the difference in the average humidity figures favours Sekondi and while the relative humidity in Accra drops as low as 18 per cent. the Harmattan is said to be scarcely noticeable in Sekondi. A point that, apparently, has never been investigated is the proportionate depth of forest belt necessary to protect efficiently, in given circumstances, a given area of cacao. Also, though figures have been put forward from time to time, no authoritative statement yet appears to have been made as to the average minimum moisture conditions, in terms of relative humidity, required for the continued cultivation of cacao ; nor are any figures available referring to the absolute minimum, for definite periods, which this crop can stand without being permanently injured.

The question now is to what extent did this area in the recent past and to what extent does it now fulfil the necessary requirements of growth of cacao ? This country was, up to twenty years ago, under forest. There are no rainfall figures for Bissa itself but judging by the known rainfall of surrounding stations it is assumed to be an average of 50" to 55" per year, a low figure for the production of this crop. Actual rainfall depending more on air currents and on the topography of the land than on vegetation it can be assumed that the volume of the precipitation is now much the same as it has ever been. The soil, apart from pockets, appears to be shallow and poor and at the best of times could not have contained a superabundance of organic matter. The Harmattan is, and always has been, an annual event. On the whole, therefore, as this crop did establish itself, it may be said that this area was originally just within the limits of cacao production and it is quite possible that small farms scattered about in the original forest might have continued in bearing for a considerable period.

But this was not to be. An area with delicately balanced soil and climatic conditions was subjected to wholesale deforestation, the soil exposed to the sun and the eroding and leaching effect of

heavy rain and all lateral protection from the desiccating Harmattan winds removed. This, moreover, in a funnel-shaped valley opening on to the direct path of this wind, the strength of which must necessarily be concentrated as it progresses up the valley. It is not surprising, therefore, that the cacao which just managed to establish itself is dying back long before it has attained its allotted span.

Remedial measures are possible but hardly practicable. As the greater part of this cacao is growing on exposed north-eastern and adjoining aspects, a windbelt reserve will have to be of considerable depth to be of any use. There is little or no forest left to reserve and as reforestation is an unduly costly and prolonged process it is too late now to help the remaining farms which must be left to struggle on as best they can.

It is suggested, however, that the opportunity now presents itself of studying the whole subject of die-back due to exposure to the Harmattan. Results, even the negative ones of knowing how and where not to plant cacao, must be of use to the future of an industry which is still expanding in a more or less uncontrolled and haphazard manner. With this object lesson before the farmers it is possible that they will realise before it is too late that it is not in their best interests to clear all forest in order to substitute a crop requiring forest protection.

PAPER No. X.

INSPECTION OF PRODUCE IN NIGERIA.

BY

A. J. FINDLAY (NIGERIA).

It has often been argued that inspection of produce should be unnecessary as the merchants who buy the produce should be in a position to refuse to purchase any produce not up to the standard of quality which is desired. In theory this should hold good, but in practice it does not do so, and the application of this axiom is not confined to West African produce.

If a merchant is asked why he cannot confine his purchase to high grade produce, he will reply that if he did so he would lose his trade so long as there are other merchants who are prepared to buy inferior produce. Again it may be argued that high grade produce will always fetch a higher price on the home markets so that the merchants should be able to pay a higher price to the producers in order to attract them. Unfortunately this is not the case, for in all cases where inferior produce can find a market there is a decided tendency for the general quality of produce to become inferior and the price of that produce is based on the lower quality which is in greatest quantity. That is to say the produce of any country obtains a reputation, good or bad, on the home markets and the comparative value of that produce is determined by its reputation.

Nigerian cacao was a typical example of this. At one time all Nigerian cacao was bought as Lagos F.A.Q., the lowest quality in the cacao market, and the price paid was naturally based on the reputation of the bulk of this low grade cacao. The few producers who took the trouble to prepare a higher grade cacao could not obtain a higher price so that they had no incentive to prepare better produce and reverted to the production of the ordinary low grade quality. Such conditions would continue indefinitely if no steps were taken to provide the necessary incentive for the production of better quality produce, and the only incentive from the producer's point of view is a higher price sufficient to compensate him for the extra trouble taken in better preparation.

But this can only be attained if steps are taken to improve the general quality of a country's produce and so enhance its reputation on the home markets. The inspection and grading of produce is one of the methods which has been adopted to improve the quality of Nigerian produce, and this was done because it was found that the merchants themselves were not in a position to adopt methods which would ensure general improvement.

It was essential to prohibit the export of inferior produce and in order to do this it was necessary to place all export merchants on the same footing and prohibit them from buying inferior produce. This eliminated the old complaint that if one merchant refused inferior produce it would be taken and disposed of to his next door neighbour who had no objection to buying inferior produce. Such conditions could not voluntarily be imposed so Produce Export Regulations had to be framed and made legally binding to all connected with the preparation of, and trade in, produce.

Government regulations connected with trade are often regarded with suspicion and as interfering with the general policy of free trade, but when such regulations are framed on sound principles and efficiently and equitably enforced, such suspicion is soon allayed as the benefits derived from the improvement of the quality of produce soon become apparent.

It has sometimes been maintained that it was quite unnecessary to place restrictions on the producer by regulating the quality of the produce that he should prepare for sale for export, as in a country like Nigeria the producer had been quite content to prepare produce in his own way and, good or bad, obtain a monetary return which satisfied his requirements; not only that, but production had been going on increasing and the effects of produce regulations might be to restrict and diminish production. Granted that production was increasing and the native producer was, for the most part, satisfied, yet it must not be forgotten that increased production might lead to a reduction in price and probably a consequent deterioration in quality, finally resulting in that particular produce becoming unprofitable, because it could not compete with similar produce from other sources. The rubber industry in West Africa may be taken as an example of an industry which has been killed through being unable to compete with superior produce from other sources. When a "slump" in trade comes, the lowest grade produce is the first to go out of the market. Thus inspection of produce safeguards the quality so that there may be no deterioration from the average quality when there is a decided drop in value. It is characteristic of the native producer that he will become careless in the preparation of his produce if the price he can obtain is not to his liking. He must go on producing if he is to satisfy the desires to which he has become accustomed through having at his disposal money derived from the sale of export produce, but it is essential that he must in his own interests be forced to maintain the quality of his produce. It has been found by experience that the only practicable way which will be applicable to the mass of producers is to make regulations which set a standard of quality.

Serious objection may be taken to regulations which introduce the element of force, but this objection cannot be maintained when it is realised that such regulations react in favour of the producer.

It is no hardship for the producer to exercise care in the preparation of his produce if he is compensated for this care by an improved price for his produce. The case of palm kernels in Nigeria is significant in this respect; when the quality of Nigerian palm kernels was improved and standardized as the result of inspection, the exporter was enabled to pay an increased price all over because he was protected from losses due to shipment of inferior kernels. In order to provide against such losses, the exporter must necessarily allow a margin in the price paid to the producer. That margin is no longer necessary, and now goes to the producer in the form of an additional value of 10s. to 15s. per ton of kernels.

The effect of inspection in the case of Nigerian cacao has been even more marked. The standard of quality has been raised so much that even Lagos F.A.Q. cacao often closely approaches the market value of fine cacao, and the producer is the one who is reaping the benefit of the enhanced price. Even the cacao manufacturer benefits substantially; formerly Lagos F.A.Q. was a very doubtful commodity, now the quality is so uniformly good that it has a definite role in the manufacturer's business and is in good demand.

Another gratifying effect of the improvement and standardization in quality of Nigerian produce consequent upon inspection is the stabilization of prices, subject of course to market fluctuation. Uniformity in quality must lead to uniformity in price. Nigerian producers have not been slow to realize this and to-day they have a far greater knowledge of the true value of their produce than ever before; consequently the majority are not the victims of unscrupulous buyers.

The export merchants in Nigeria pay for the inspection of their produce and therefore expect to get something for their money. Besides among other things, the monetary advantage which accrues from produce of an improved quality, the merchant benefits greatly in being able to conduct his produce-buying business with almost the minimum of trouble on the score of quality, because a standard of quality is virtually guaranteed to him through Government inspection before purchase. The fact that the export merchants gladly pay the prescribed inspection fees and openly express their satisfaction with the resulting advantages is in itself ample proof of the success of the inspection scheme in Nigeria. Even the cunning and wily middlemen who used to reap rich harvests off inferior and adulterated produce have been known to express their appreciation. The benefits to the producers have already been dealt with. There are many in the latter class who still consider the restrictions irksome, but that is because they are either too lazy to exercise even ordinary care in the preparation of their produce or have fraudulent intentions in that they desire to dispose of inferior or adulterated produce. That class of producers should certainly be discouraged.

The unscrupulous middleman is now sadly restricted in the practice of his wiles for the Produce Export Regulations have been framed so as to allow him no loopholes and so safeguard the producers from whom he buys and the exporters to whom he sells. There is now even no chance for unscrupulous exporters.

From the point of view of shipping companies, it would appear at first glance that produce inspection has been the means of depriving them of a certain amount of freight. Take the case of Nigerian palm kernels; the average percentage of shell and dirt in kernels has been reduced approximately from 6 per cent. to 3 per cent.; in an annual export of 250,000 tons it would appear that this reduction means that 7,500 tons less of shell and dirt are exported. Exactly so, but actually these 7,500 tons of shell and dirt have been replaced by good kernels, so that there is no actual loss to the shipping companies, who benefit by the improvement in the quality of the produce because cargoes do not deteriorate during the voyage and because of the increased production consequent upon improved prices.

Mention of shipping recalls other advantages which accrue from produce inspection. Under the Export Regulations, all cacao must be thoroughly dry before export with the result that not only is deterioration, through growth of moulds, etc., avoided but also loss in weight due to evaporation of excess moisture is prevented. Loss in weight in shipping kernels used to be a matter of grave import to shippers but this has now been reduced to almost a minimum and present day loss of weight is probably due to causes other than the evaporation of excess moisture.

The Produce Export Regulations for Nigeria are made under the Agriculture Ordinance and provide primarily for the maintenance of a certain standard of quality in the produce which is inspected under those Regulations. For example, no palm kernels can be exported which contain more than 4 per cent. of shell and dirt; that is, the standard of quality is what we generally call "4 per cent. of kernels." Similarly with palm oil; there must not be an excess of 2 per cent. of water and dirt; the standard is "2 per cent. oil." In the case of cacao it is different, for any cacao which is thoroughly dry can be exported, but provision has been made for the grading of cacao.

The first regulations provided for three grades of cacao:—

- (1) "Special Grade" in which the limits were 1 per cent. defective and 1 per cent. slaty, a grade introduced to encourage the preparation of a high grade cacao similar to that being prepared under the Department's Co-operative Fermentary Scheme.
- (2) Grade I, in which the limit was 10 per cent. defective and
- (3) Grade II, which included all other cacao which was thoroughly dry.

Leaving out of consideration the "Special Grade," the original grading was designed to deal with cacao irrespective of whether it was fermented or not. Any further grading was left to the buyers and exporters. The insistence on thorough drying had an almost immediate effect in that nearly all cacao was bought as Grade I and there was a very definite desire on the part of both buyers and sellers to bring inferior cacao up to that standard by careful picking. The final result was that in the 1926-27 main crop, that is the first season after the introduction of the regulations, 95 per cent. was Grade I and 4.2 per cent. Grade II; the other 0.8 per cent. consisted of "Special Grade." There was a further improvement in the following season, for the 1927-28 main crop showed 98.6 per cent. Grade I, 0.6 per cent. Grade II and 0.8 per cent. "Special Grade."

The result of our initial experience in grading was so gratifying that we decided in 1928 to introduce grading according to fermentation and amended our regulations to include four grades as follows:— Special Grade with limits of 1 per cent. defective and 1 per cent. slaty; Grade I with limits of 8 per cent. defective and 8 per cent. slaty; Grade II with a limit of 8 per cent. defective but no limit to slaty; and Grade III all other cacao which is thoroughly dry. That is to say we provided for a "fair fermented" grade while still including the "Special Grade" which is better than "Good Fermented" and the two original grades of F.A.Q.

Unfortunately I have not available the figures for the 1928-29 season grading, but the introduction of the "fair fermented" grade proved so successful that we now contemplate the introduction of further grades based on the quality as indicated by fermentation. We have gone so far as to suggest that a new and universal system of grading should be adopted which would definitely differentiate between slaty, purple, and chocolate brown beans; that is to say we wished to come to a decision on the question as to when a purple bean can be classed as fermented and when it should be classed as definitely under-fermented and equivalent to slaty; our proposed grades were therefore to take cognisance of purple beans and fix the proportions which would be admissible among the non-slaty beans of each of the grades. Our proposed new grades have not found favour with the merchants, brokers and manufacturers at home, and further consideration or proposals to alter the Liverpool brokers system of grading must meantime be deferred, although it is a subject which will come up for discussion at this Conference.

The Nigerian Department has meantime been advised to continue the good work in the improvement of cacao and bring its grading system into line with that of Liverpool.

The question of introducing grades for palm kernels will never arise, but it is likely that a system of grading for palm oil according to its quality as judged by the F.F.A. content will eventually be suggested. Whether or not it will be introduced is another question; the objection under existing conditions would be that it must be

impracticable in operation because it would involve chemical tests for innumerable samples of oil ; a modified system might be introduced whereby only bulk samples would be chemically tested for grading purposes. The rapid increase in bulk shipment of palm oil must react on the method of handling before shipment and lead to general bulking methods. Also bulk shipping at the port according to grades is already being carried out and this will tend to a demand for the delivery at the port of graded bulk oil.

Another consideration on the grading of palm oil is that there is a tendency to depart from the old system of selling oil by description, *e.g.*, Lagos soft ; Lagos Medium ; Niger hard ; Saltpond ; and so on, and to introduce the system of selling on the basis of F.F.A. content, that is of quality as determined by the percentage of F.F.A. present in the various grades. This would constitute a most desirable change which would benefit all concerned in the palm-oil industry.

The principle of grading agricultural produce is now widespread in its application because of its obvious advantages to the producers. In the case of cacao, a parcel of "good fermented" will always fetch more than one of "F.A.Q." and it is the producer who gets the benefit of the enhanced price to compensate him for the increased care he has taken in production. This enhanced price will always serve as an incentive to the preparation of better quality produce and with cacao it is the enhanced price alone which counts. In applying improved methods to other produce, it may be possible to achieve improved quality along with increased quality at a decreased expenditure of labour. Here a premium for improved quality is extremely desirable but not essential as the increased quantity at a smaller cost will provide an incentive to the adoption of improved methods. Graded produce is a boon to the merchant and if he can buy produce which has already been graded, it is all the more desirable. Grading has always the effect of improving the average quality of produce, to the benefit of producers, merchants, manufacturers and even consumers.

It must be remembered that the prime object of an Agricultural Department in West Africa is to improve native agriculture, so that in framing Produce Export Regulations every consideration must be given to the producers as well as exporters. In designing the regulations for Nigeria every effort has been made to treat all concerned with equal fairness. The large exporter may be penalized as well as the small native producer, but in each case it is the person who has committed the offence against the regulations that becomes liable for the penalty. No one will admit sooner than the merchants themselves that the application of the Produce Export Regulations in Nigeria has proved the fallacy of the contention that Government interference in trade is to be wholly deprecated.

PAPER No. XI.

PRODUCE INSPECTION IN SIERRA LEONE.

BY F. J. MARTIN AND G. TUACH (SIERRA LEONE).

Although the desirability of the inspection of produce had been mooted by the mercantile community of Sierra Leone before the war it was not until 1917 that the first Produce Ordinance came into being. Owing to the war and the consequent shortage of staff, it was some five years later (1922) before the first produce inspector was appointed.

In the first Ordinance, Rules were made only with respect to palm kernels, and these allowed the inclusion of 5% of shell, dirt and other adulterants in palm kernels intended for export. Subsequently further ordinances, amendments, rules, etc., were passed to tighten up the regulations with respect to palm kernels, and other items, such as palm oil, ginger and piassava were brought under the Ordinance.

It is not the object of this paper to trace step by step the development of the law relating to the inspection of export produce but to state briefly the present position.

In June, 1928, "An Ordinance to amend and consolidate the Law relating to Native Produce" was passed. This Ordinance included all the provisions made in the somewhat numerous previous Ordinances and amendments to Ordinances; and Rules made under the new Ordinance included or supplanted all the Rules made under the previous Ordinance.

The 1928 Ordinance dealt with—

- (a) Licences.
- (b) Standardization and Grading of Produce.
- (c) Standard of Produce offered for sale and Protection of Produce in store or transit.
- (d) Adulterated Produce.
- (e) Water transport of Produce.

The rules made under the Ordinance are confined to palm kernels, palm oil, piassava and ginger. Standards to which these products should conform are laid down and the methods by which produce must be sampled and examined are described. Provision is also made for the compulsory protection of water borne produce when such is intended for export, or for sale for export.

The following standards for produce intended for export are cited :—

Palm Kernels.—The palm kernels shall be thoroughly dry, hard and sound, and the total shell, fibre, mouldy or decayed kernels, fluff, sand, and other extraneous matter mixed with such palm kernels, shall not exceed four per cent. of the total weight thereof.

Palm Oil.—The palm oil shall not contain more than two per cent. of water and other extraneous liquids and substances.

Piassava.—The piassava shall be thoroughly clean, dry and pliable, and shall not contain more than five per cent. by weight of weak and strawlike fibres and extraneous matter.

Ginger.—The ginger shall be thoroughly dry, and sufficiently free from weevils to ensure its commercial soundness, and entirely free from maggots, mildew, sand and other extraneous matter.

The following provisions were made for the carriage of water borne produce :—

Where any boat or canoe is used in the carriage of any produce which is intended for export or for sale for export—

- (a) the proprietor of such boat or canoe and the person in charge thereof shall see that the bottom thereof is fitted with flooring boards or other materials sufficient and suitable for preventing the produce from coming into contact with water in the boat or canoe and that sufficient and suitable matting or tarpaulin is available in the boat or canoe for protecting the produce from the weather, and
- (b) the person in charge of the boat or canoe shall see that all the aforesaid equipment is used for the purpose for which it is intended.

The methods by which produce is examined are given in the Ordinance, a copy of which is attached* as Appendix I and attention is directed to the standards and methods of examination in vogue in Sierra Leone. We think, especially in any cases where new regulations are being introduced, that it would be advantageous if methods of examination and standards used were as similar as possible throughout the British West African Colonies. With regard to methods of examination there appears to be no reason why these should differ appreciably from Colony to Colony and the collected experience of this committee should enable it to recommend suitable methods of examination. In Sierra Leone inspection of produce is confined to the four items mentioned above, but we are also interested in the inspection and grading of other produce, such as cacao and raphia which is now being exported in small quantities from Sierra Leone. In dealing with these products, especially cacao, we hope to benefit from the wide experience of the Gold Coast and Nigeria.

* Not printed herein.—Ed.

Standardization of Produce.—It will be seen from the foregoing paragraphs that at present we attempt no grading of produce in Sierra Leone. Our main object is to get our produce clean and dry and certain standards are set to which all produce must conform. In addition, Regulations are imposed on the transport of water-borne produce in order to eliminate soaking in transit, since this soaking is invariably accompanied by a depreciation in the quality of the produce. At some future date it may be desirable to introduce grading of produce such as ginger, piassava, or cacao, and in so doing we should like to introduce grades which conform to existing grades of similar products on the West Coast.

Administration of Produce Inspection.—The staff of the Division of Inspection consists of two European Inspectors and ten African Sub-Inspectors. There are two ports for Sierra Leone and except for some of the piassava all produce is shipped through Freetown or Bonthe. For inspection purposes therefore the country is divided into two areas (*a*) the Northern and Central Provinces with headquarters at Freetown and (*b*) the Southern Province with headquarters at Bonthe, as it is through these ports that the provinces mentioned export the bulk of their produce. The Inspector of Produce is stationed at Freetown, the largest port, and the Assistant Inspector at Bonthe.

These areas are subdivided into smaller areas, each of which is in charge of an African sub-inspector. The headquarters of these small areas are in the principal trading stations into which produce is brought from outlying stations and sold to large firms for export. Each sub-inspector in his small area visits periodically all the buying centres in his area and examines the produce on hand. Where produce is found below the standard a prosecution is instituted.

At river stations, during the dry season when the river is no longer navigable and produce is stored until the rains, a special form of inspection is instituted. By arrangement with the merchants concerned no produce is put into a firm's main store until it has been passed by a sub-inspector. The produce is again inspected before shipment and if not up to standard is picked over and the mouldy and decayed portion rejected. No prosecutions are instituted against the owners of produce which has deteriorated during storing and all we do is to ensure that it is thoroughly picked over and only produce which is up to standard exported.

In addition to up-country inspection, all produce is subject to inspection at the port of shipment before it is exported, and that the up-country inspection is working successfully is shown by the fact that the number of prosecutions in Freetown is small compared with those up-country. As will be seen by the Ordinance, the native producer is exempt from prosecution but all the middlemen from the smallest buyer to the largest exporter are liable to prosecution if they attempt to deal in produce which is not up to the required standard.

Efficacy and value of Inspection work.—It is very difficult to place an actual value on much of the inspection work but there has been a marked improvement in much of the Sierra Leone produce and this is most marked in the case of kernels, many of which are water borne. The efficacy of the inspection work is shown by the fact that after five years of inspection the kernels offered for export at the ports of shipment now generally conform to the standard required while a few years ago this was much less general. Through the courtesy of a well known firm in Freetown we have given details of their shipments in 1922, before inspection was instituted, and in 1928 after inspection had been in force for five years. These figures are summarised below and show the greatly improved quality of the kernels exported.

Month.	No. of tons shipped.		Average oil content %	
	1922.	1928.	1922.	1928.
June	519	741	48·42	49·55
July	448	1,015	47·61	49·60
August	881	1,083	47·76	49·50
September	1,254	784	47·48	49·19
July—September ..	3,102	3,623	47·59	49·46

There is a marked increase in the oil content of the kernels due to the extra care now taken to protect kernels from soaking, mould and decay. It is interesting to note that a big increase in quality came in the first year and in 1923, about a year after inspection started, one of the principal exporting firms (not the one quoted above) wrote to the Department as follows:—"Our head office states that the oil contents of our kernels have been increased from 47 to 48 per cent."

Kernels are purchased in England on a basis of an oil content of 49 per cent.; for each unit under this amount 1·5 per cent. of the price is discounted and for each unit over this amount 1·5 per cent. is added. It will therefore be seen that the increase in value in Sierra Leone kernels due to the work of the inspection department is rather over 10s. a ton, or over £32,500 a year, recent annual exports being about 65,000 tons.

We have no direct evidence of improvement in the quality of palm oil, with the exception that the adulteration of palm oil with emulsion of vegetable matter and water, which was common a few years ago, is now very uncommon. The free fatty acid content is of course quite unaffected by inspection.

With regard to piassava the regulations have been in force for such a short time (only since July, 1928) that there is no information of real value forthcoming as a result of inspection. The rigid imposition of the actual standards cited under the Ordinance is being preceded by propaganda and instruction among the native workers, and it is hoped that as a result of instruction and inspection the quality will gradually improve.

Our Department is a little bewildered sometimes by the contradictory reports about the type of piassava required. Some firms say that only the best piassava is required and that poor piassava is not wanted. Other firms say that they can dispose of any kind of piassava and they are prepared to, and do, buy and ship badly-prepared fibre. There is little doubt however that since this badly-prepared fibre has eventually to be picked over and cleaned, it is much better that it should be done in the colony where labour is comparatively cheap. Moreover, if we can maintain a high standard of cleanliness and quality the colony should reap its reward in a much higher price being paid for this product, and this we hope will reach the pockets of the native instead of the middleman in Germany, where most of the piassava now goes for cleaning prior to reshipment to England.

A few years ago an attempt was made to inspect and grade ginger. Two grades, A and B were described, the former "peeled" ginger and the latter "scraped" ginger. In spite of propaganda by the Government and support by the firms, most of whom were initially all in favour of grading the ginger, the financial inducements offered to the natives were not sufficient to persuade them to peel their ginger, and only a small proportion of ginger was peeled. Finally the firms went back on their original request for peeled ginger and reported that there was no demand for peeled West African ginger. We now content ourselves with ensuring that the ginger is thoroughly dry and sound and do not bother whether the "hands" have been peeled or only scraped.

There is little doubt that the attempt to compel producers to peel ginger was premature. The Sierra Leone ginger, apart from its very valuable quality (*e.g.*, high gingerine content), is unfortunately not of a very large size and consequently the peeled "hands" look small and meagre compared with, say, Jamaican ginger. The reason for the small size of Sierra Leone ginger appears to be largely in the method of cultivation, the "seed" merely being dibbled into the uncultivated ground, much too closely spaced, and left without cultivation or any manuring till ready to harvest. It is very probable that given proper cultivation and manuring, bigger hands would be produced, these are in fact obtained on our experimental farm, but until the native has improved his methods of cultivation of ginger, there would appear to be little prospect of any further improvement in value by any meticulous cleaning and grading. Our inspection is therefore confined to seeing that the ginger is dry and free from weevils and mould.

PAPER No. XII.

**INSPECTION AND CERTIFICATION OF CACAO
ON THE GOLD COAST.**

By

A. B. CULHAM (GOLD COAST).

This paper was circulated amongst delegates as a Confidential document and by request of the Accra and Eastern Provinces Chamber of Commerce has not been published. The paper gave an account of the system of examination and certification of cacao at the main ports of the Colony which had been in operation since January, 1927. The method of sampling consignments of cacao was described in detail and an account was given of the various cacao bean defects recorded and of the standards by which these defects were defined. A month to month analysis of the incidence of total defects was given ; this analysis was supported by actual figures and by three graphs (for Accra, Central Province ports and Sekondi-Takoradi). Each graph was a rectangular diagram showing monthly total defects in quality classes vertically and the tonnage of cacao exported each month horizontally ; this device of utilising two dimensions showed clearly not only the variation in quality but also the quantity of cacao in each quality class. The paper concluded by discussing methods for securing an improvement in the quality of raw cacao in the Gold Coast.

PAPER No. XIII.

**FORECASTING THE PRODUCTION AND EXPORT
OF CACAO FROM THE GOLD COAST.**

BY H. B. WATERS (GOLD COAST).

INTRODUCTORY.

“Cacao crop forecasts” are prepared by the Division of Statistics and Surveys and issued by the Department of Agriculture, once a fortnight during the main season, and once a month for the rest of the year; circulated first to merchants, they are later published in the *Gazette*. The methods of forecasting at present applied by this Division are summarized in this memorandum. This analysis shows to what extent reliance can be placed in the results obtained, in what particulars the methods are deficient, and how the bases of estimation could be improved. The methods are intricate, laborious and in some cases inadequate, but the general lines of investigation are known to be sound, and time alone is necessary for the perfection of the system devised for the preparation of accurate forecasts.

The cacao crop of the Gold Coast is mainly produced in two well-defined periods each year, called the main season and the mid-season. The production of the main crop takes place, on an average throughout the country, during the period of six months from September to February. The production of the mid-crop usually occurs within the months of April to June. In this memorandum the main crop is referred to as the *major crop*, any crop produced during the remaining six months of March to August is called the *minor crop*, and the name “mid-crop” is confined to the flush of production within the minor season that occurs about Easter time. The term “production” refers to the time when freshly prepared cacao is in a marketable condition, which, on an average, is two weeks later than the time of harvesting the cacao pods. During these two weeks the wet raw beans are extracted from the pods, fermented, cured and dried.

ESTIMATION OF PRODUCTION.

Two main points have to be considered in the estimation of cacao crop production and for an appreciation of the causes of annual variations in the cacao crop: first, the effect of variations in the area and, secondly, the effect of variations in yield per unit area of bearing

trees. Other points of minor importance include abnormal conditions that occasionally occur with other crops (such as failure to harvest, due to low prices, or failure to market, due to lack of transport facilities) and abnormal happenings that occasionally occur with other produce (such as destruction by fire or by rain or by bad storage); these have been so rare in the case of Gold Coast cacao in the past that they need not be considered here. From the merchants' point of view there is one additional item that might be included, and that is the amount of stocks held over by the farmer from the previous crop; this will be referred to later. The various methods of forecasting will accordingly be dealt with under the two main heads of "area" and "yield per unit area." While in theory the division between the two is clear cut, in practice overlapping occurs, due to the complexity of a subject in which the final result is the outcome of many and diverse interdependent factors. Each method will be discussed under the heading to which it is the more applicable.

Relative effect of variations in area and yield.

During the years 1916 to 1922 the average increase in crop production due to an increased area under cacao, was about 16,000 tons annually, and since then the increase has become smaller each year, until for 1929 it is estimated at 2,000 tons. The average annual variation in crop production, due to variation in yield, has been between + 6 per cent. and - 6 per cent., equivalent to 9,000 tons for 1916, 20,000 tons for 1922, and 27,000 tons for 1928. In 1916, therefore, the increase due to acreage was more important than variations in yield, being 16,000 tons increase for the former as against 9,000 tons for the latter; by 1922 the latter had become slightly the more important. For 1929 the expected yield, due to an increase in producing area, is estimated at 2,000 tons, and the difference in production, due to yield variation, is liable to be in the neighbourhood of 30,000 tons; the increase due to acreage therefore is likely to be considerably less than any variation from the normal in yield per acre.

Increasing importance of yield per unit area.

Estimating the yield per acre is likely to be of increasing importance in the future, and the situation will be reversed only in the event of a sudden era of planting activity on the part of the farmer or of annihilation of existing farms through the sudden visitation of some pest or disease. While the forecaster must still gather full information in regard to the establishment of new farms and the abandonment of old farms, it is evident that he must pay increasing attention to the estimation of the yield per acre.

VARIATIONS IN AREA.

The annual increase due to an increase in bearing area has been explained in a paper by Miles (Paper No. V in Year-Book, 1928*). The graph (see Appendix II) which forms part of this paper shows the annual export of cacao from 1906 to 1928, and a line of "best fit" has been drawn to show the general trend of variations in export. As the exports have been constantly increasing the curve steadily rises and is called the curve of annual increase.

This curve shows the increase in *exports*, but at the same time it represents the *area* of cacao in bearing, and consequently its slope shows the rate of increase in bearing area. Three factors are involved: (i) new areas coming into bearing, (ii) established areas going out of bearing, and (iii) any underlying trend of increase or decrease in yield per unit area over a sequence of years. The cacao trees which are ceasing to bear in old-established areas are not going out of cultivation on account of old age, but because in the early days of the industry some farms were planted in situations or localities that are not entirely suited to cacao growing. In some cases the trees in these farms have already died and there is always the possibility that the remaining areas may succumb in a particularly severe season, but on the whole it is anticipated that these farms will continue to go out of cultivation gradually, thus tending merely to offset a portion of the newly planted areas. An underlying trend of decrease in yield per acre is discussed in a later paragraph under the heading of "Decline in fertility in early years"; its effect is known to be gradual and consequently at present it is convenient, and legitimate, to consider it to be a factor which results in a decreased acreage tending to offset new areas. The effect of these three factors is to show, on balance, an increasing area in bearing, hereinafter referred to as "new areas."

The average yield throughout the years 1906 to 1928 has been estimated at 5 cwt. per acre, or 4 acres to the ton of cacao, and consequently, if the vertical scale for the curve of annual increase in exports be multiplied by 4, the curve then represents the acreage (see Appendix II). Examination of this acreage curve shows that from 1921 to 1924 the "new areas" of cacao coming into full bearing amounted to 60,000 to 70,000 acres each year, but that since then the "new areas" have declined

*References are to Year-Books and Bulletins of the Gold Coast Department of Agriculture.

each year, and amounted to 44,000 acres in 1925, 28,000 acres in 1926, probably 20,000 acres in 1927, and possibly 12,000 acres in 1928. In the light of this knowledge alone, therefore, the acreage of bearing cacao in the Gold Coast in 1929 is estimated at 924,000 acres, or 8,000 acres more than in 1928, and the total crop is estimated at 231,000 tons, or 2,000 tons more than in 1928. This crop figure is not, of course, the official estimate for 1929, but it is given to illustrate the method employed. The forecaster finds that it is possible and advisable to calculate an estimated figure by every possible method of estimation; the mean of a number of such estimations can then be expected to give a fairly reliable figure. This particular method is one that can be applied locally to figures for port shipments, rail shipments, and other data which enable the location of producing areas to be fixed.

Annual
deviations
from curve
of increase.

Annual variations from the curve of increase require further explanation. For every year there is an export figure that can be read off from the curve of increase (Appendix II); in 1924 it is 204,000 tons. There is also the actual export figure for the year; in 1924 it is 222,000 tons. The difference between these two figures, 18,000 tons in 1924, is the deviation of the observed export from the mean of increase. This deviation may be due to each, or a combination, of three main causes: first, the yield per acre may have been above average; secondly, a larger acreage than in the previous or subsequent years may have come into bearing, for in calculating the curve of increase it is assumed this increase in "new areas" is gradual and not intermittent, at any rate over a limited period of years; and thirdly, a larger quantity of stocks than usual may have been held over from 1923 or a smaller quantity than usual may have been carried over into 1925. (I have purposely omitted the effect of early and late crops on calendar year figures, as this is dealt with later under the heading of "Calendar Year.")

Port
shipments.

Advance figures for exports from all maritime ports are obtained each month by courtesy of the Comptroller of Customs. In the first place, these figures give a general indication as to the expansion, stagnation or decline of the export from each port; at present Saltpond shows a tendency to increase and Winneba to remain stationary; secondly, the monthly figures enable comparisons to be made with previous years. The usual method is to use graph paper and record the export curve to the end of each month, starting with October as the initial month.

Advance figures showing the quantity of cacao ^{Rail}railed from each railway station are obtained each ^{shipments.} month by courtesy of the Manager of the Gold Coast Railways. As with port shipments, the rail shipments show the tendency of each station to rail more or less cacao, and these data indicate those areas in which cacao production is expanding, where it is falling-off, and where it is stationary. The figures must be interpreted intelligently, for the opening of new roads may divert traffic, a reduction in freight rate increase it, and so on. The increasing competition of lorry-borne traffic must also be borne in mind.

A new venture, started in 1928, has been the estab- ^{Gates,}lishment of gate checks at various points on main roads. ^{lorry}Such stations have been established at Bechem and ^{shipments.}Teppa in Ashanti and at Senchi Ferry on the road to Togoland. The origin and destination of agricultural produce passing through these checks have been recorded daily and the figures so obtained for cacao have supplied further data for the estimation of the location of cacao producing areas in the Gold Coast. In future years it will be possible to use these figures for comparison to indicate the trend of increase or decrease.

Another means of estimating the variation in area ^{Surveys.} is by local surveys. Muir conducted a survey in Ashanti during the major crop season 1928-29. He found that in the Sunyani and Ahafo districts, which produced approximately 8,000 tons of cacao during the season, the proportion of non-fruited to fruited cacao was approximately three to one. The cacao tree takes four years to come into bearing and reaches full bearing two years later. With this knowledge it can be assumed that the production from these districts will be fourfold in five years' time and that the increase each year will be in proportion. An independent check on the accuracy of the survey was available from the figures for the gate checks through which all cacao exported from these districts must have passed. 8,088 tons of cacao passed through gate checks at Bechem and Teppa during the major season 1928-29, and the total production estimated by means of the survey was 8,500 tons. The discrepancy therefore was 412 tons, or 5 per cent., which is a very close agreement and demonstrates that both survey methods and gate checks are equally satisfactory for the collection of accurate data.

By utilizing all available figures of port shipments, ^{Distribution} rail shipments, check gates and surveys it has been found ^{map.} possible to prepare a spot map showing the distribution

of cacao producing areas in the Gold Coast (Paper No. VI in Year-Book, 1928). Various devices were used in the preparation of this map and full use was made of available knowledge of local weather conditions, position of roads relative to the railway, and the reports of officers who have toured and made observations in various districts. In the map for 1927 each area producing 100 tons of cacao is marked by a dot, which also represents 400 acres. The preparation of such a map for each year or season will assist still further in defining the location of cacao farms and in providing further bases for the estimation of the cacao crop.

Use of
distribution
map.

Various methods of subdividing or partitioning suggest themselves, but the method which comes to mind the most readily is obviously subdivision according to rainfall. By transferring the isohyets from a rainfall map to the cacao spot map, it will be found that a certain proportion of the farms receive a rainfall of between 45 and 50 inches, others receive 50 to 55 inches, and so on. The farms receiving a low rainfall would be expected to yield less heavily than those receiving adequate rainfall. Due allowance can thereby be made for this variation in yield and a refined estimate made for comparison with those obtained by other methods. Whichever way the area is partitioned, the final estimate for the whole Colony is obtained from the sum of the estimates for each subdivision.

VARIATIONS IN YIELD PER ACRE.

The average yield per acre of cacao from Gold Coast farms has varied comparatively little in the past from year to year. There have been no seasons in which the yield has been surpassingly high, nor any in which it has been exceedingly low. Individual fields have undoubtedly been subject to fairly large seasonal variations, especially those located in unsuitable situations. But on the whole the level of seasonal output has been remarkably constant.

Statistics.

Statistical analyses have already been undertaken in many of the lines of work involved. It is not enough to know for example that the seasonal yield per acre has on the average been comparatively unchanging. It is essential to discover exactly what variations have occurred in the past, so that the extent to which variations are likely to occur in the future can be accurately gauged. With such information in his possession the forecaster can set limits to the final estimate and can say, for example, that the odds are 10 to 1 against the crop

being less than 230,000 tons or more than 240,000 tons in the next year. The results of various statistical studies will be frequently referred to throughout this paper and others will be suggested.

The average seasonal yield from cacao plots on seven experiment stations from 1922 to 1927 has been 567 lbs. per acre, with the highest yield in one year of 613 lbs., or 9.0 per cent. more than the average, and a lowest yield of 509 lbs. or 9.6 per cent. less than the average. The average deviation was 5.5 per cent.

The deviations in seasonal export from the mean of increases given by Miles (Paper No. V., in Year-Book, 1928) for the 13 years from 1916 to 1928 exceeded 23,000 tons or 15 per cent. in one year, 1921, and averaged 6 per cent., which is equivalent to 13,800 tons with a total annual crop of 230,000 tons. More refined methods of analysis are being applied and will probably show that the variation in export due to variation in yield per acre is even less than this.

On any individual farm the seasonal variation in yield may be due to any one of five main factors: these are the physiology of the tree, the fertility or nature of the soil, varying environmental conditions, sporadic outbreaks of pests or diseases, and the climatic conditions for the season. Usually the variation is due to a combination of these factors, each of which has a definite effect on the others. By far the most important factor is the weather, and the controlling agency in weather is the rainfall.

The physiology or nature of the tree invariably plays a part in determining crop yields. Some crops are known to be risky, such as cotton, in that the yield may be very low or very high; some trees have certain peculiarities, such as the cherry, in that unfavourable conditions at the time of flowering and setting cause a very great reduction in yield. The cacao tree has two characteristics in the Gold Coast: the first, which is fairly definite, is its tendency to produce a greater proportion of its annual yield during the mid-season in the early years of its life, and the second, which is surmise, is its habit of producing superior and inferior crops in alternate seasons.

The tendency of the mid-crop to disappear with the increasing age of the tree was first pointed out by Auchinleck and Knowles (BULLETIN No. 4, page 11). The point is not of very great importance, except that as less cacao is believed to be planted each year the size of

the minor crop relative to the major crop is likely to decrease. Sufficient data are available for a statistical analysis of this point, and this will be done shortly. The annual variation of the minor crop is relatively much greater than that of the major crop, but the actual amounts are much smaller. The minor crop has usually been about one-seventh of the main crop in recent years.

Alternate
year
cropping.

The tendency of the cacao tree, like the apple, to produce good crops in alternate years was noted by Auchinleck and Knowles (BULLETIN No. 4, page 13). The important point to know is whether this habit is inherent in each tree so that on the average half the trees produce a good crop in one year and the other half in the next, or whether it is seasonal, so that the majority of the trees produce well one year, and the minority in the next. An examination of export figures leads to the conclusion that this characteristic is seasonal. The 1928-29 season was a fruitful year, and the 1929-30 season is likely to be a lean year. A thorough test on statistical lines might show that the tendency to alternate year cropping is entirely fortuitous or has been due to an alternation of favourable years as regards weather conditions. Sufficient data are available for such an analysis.

Individual
tree records.

There is a mass of information already available for the study of problems such as those in the preceding two paragraphs. For these the reader is referred to BULLETIN No. 4, "Yields of Cacao on Experiment Stations," by Auchinleck and Knowles, and Papers IX, X and XI, in the 1927 Year Book, giving the yields at Asuansi, Aburi and other Stations. Further material is collected each year and, in particular, individual tree records are being kept at Kpeve, Asuansi and Kumasi. Statistical studies of these figures may be expected to yield results of definite value to the forecaster.

Fertility or
nature of
the soil.

Three aspects of variation in yield due to soil conditions will be considered. These are (i) the decline in fertility during the early years of the life of a cacao farm, (ii) the effect of cultivation, and (iii) the time of production from hillside and riverside farms.

Decline in
fertility in
early years.

The production of very heavy crops in the early years of the life of a farm, was first mentioned by Auchinleck and Knowles (BULLETIN No. 4, page 13), who noted a gradual falling off from year to year to a somewhat constant level. This phenomenon appears to have a rational explanation. The soil fertility stored up during forest conditions is gradually utilised, and ultimately the annual yield reaches a level at which the crop

exhausts from the soil each year an amount of available fertility equivalent to that added to the soil each year by the normal processes of nature under cacao farm conditions. Two processes are involved, first the adjustment of the soil from forest to cacao farm conditions, and secondly the adjustment of the crop to the productivity of the soil. Admitting this as a fact, the next step is to assess the probable yield of a tree of a certain age under average conditions. This study has not been completed. But assuming for the moment that the yields per acre to be expected from 10-year old trees were 600 lbs., for 11-year old trees 575 lbs. and for 12-year old trees 560 lbs., then, knowing from the study of acreage (Appendix II), the proportion of the trees in each age-class, the forecaster could make an improved estimate of the total crop and also an improved curve of acreage (Appendix II), from which the effect of underlying decreases in yield had been eliminated. The final result of such an analysis would be to state that the decline in yield due to the loss of fertility in young farms is estimated at so many tons as compared with the crop of the previous season.

The Gold Coast farmer does not cultivate his cacao Cultivation. farm, so that at present this factor can be left out of consideration. Should there start a movement for better cultivation, the forecaster would have to allow for the higher average yields that might be expected to follow. This applies to better farming methods generally, such as mulching with green material or the application of fertilisers or manures.

The early production in the season of cacao on river- Time of Production. side farms was first mentioned by Dade (BULLETIN No. 6, page 17). The valley farms at Anyinam ripen their crop seven weeks before the ordinary farms on the higher ground. The knowledge of such a fact is useful in local estimates of the crop in various localities. The main point to note about information of this description is that every scrap of definite knowledge is of value in assisting to formulate a forecast, and no line of study, however trivial, can legitimately be disregarded.

Although not of urgent importance the effect of Environ- mental conditions. changes in environmental conditions should receive some attention. First, the felling of forest close to cacao farms would be expected to lead to lower yields, soil desiccation and less suitable conditions for growth and health, and on the other hand the reservation of a new forest area close to areas suitable for, or actually planted in, cacao would lead to more ameliorating conditions

and consequently increased yields. Secondly, any concerted effort on the part of farmers to improved farming by adjustments of overhead shade and lateral protection would show results in higher yields. Thirdly, water-logging or drowning might occur in riverside farms in years of excessive floods. These are minor points, but not therefore to be overlooked.

Pests and diseases.

Auchinleck and Knowles (BULLETIN No. 4, page 6) stated that the losses in yield due to the losses of mature pods through disease or unfavourable climatic conditions varied from 3 to 20 per cent. at various Experiment Stations over a period of 14 years. Dade (BULLETIN No. 6, page 20), found that the total average incidence of pod disease in farms at Anyinam in 1926 amounted to 55.4 per cent. of the total crop, but on the other hand he discovered that when 70 per cent. of the crop reaped was diseased, the loss to the farmer was only 4 per cent. Cotterell has given accounts of Sahlbergella (BULLETIN No. 3), Thrips (Year-Book, 1927, No. 16), Minor Pests (Year-Book, 1927, Paper No. 17). Bunting and Dade have published a book (*Gold Coast Plant Diseases*), containing accounts of pod, root, stem and leaf diseases.

Incidence of pests and diseases.

The general impression to be gained is that the incidence of pests and diseases have not affected the variation of the total crop from year to year to any great extent in the past. Sporadic outbreaks have occurred in different localities, but in the sum they appear to have balanced fairly well. Conditions which favour the pests of Sahlbergella or of Thrips are inimicable to the fungoid diseases of collar crack, stem canker, white thread and pod canker. The Entomologist and the Mycologist send in reports throughout the season stating whether pests or diseases are above or below normal and these points are mentioned in the forecast and due allowance made for abnormal incidence. The possibility of the sudden attack of some new or introduced disease is one that cannot be ignored, nor the possibility of seasonal conditions so suiting one of our known pests that it should get out of control. The chances happily are remote, due to the scattering of the cacao farms in the bush, but precedents are numerous. The forecaster has ever to be on the alert for such an eventuality.

Climatic conditions.

The collection of rainfall, temperature and other meteorological data is done by the Division of Publications and Meteorology. The problem of assessing the effect of climatic conditions on the cacao crop was first defined by Auchinleck and Knowles (BULLETIN No. 4, page 11), in 1926. They pointed out the difficulty of

establishing a correlation between rainfall and crop, due to the existence of variable factors, including the amount and distribution of rainfall, temperature of the air, the force of the wind, and the amount of sunshine. Since then a great deal of work on these lines has been done, although the subject has by no means been fully explored nor a full solution reached. In parenthesis, it might be added that every investigation of this nature undertaken by members of the staff of the Department has added further to our knowledge of the cacao tree and has thus put us in a position to guard established farms with ever increasing confidence.

In 1924, Smellie (*Gold Coast Agricultural and Commercial Society Journal*, Vol. iii, No. 2) maintained that a high rainfall in one year was followed by a heavy crop in the next. In 1927, Maidment (*Year Book*, 1927, page 83) made a study of Kumasi and Aburi cacao yields and rainfall records and showed that a low rainfall of less than six inches in the month of April, when most of the flowers for the main crop were forming and the fruit setting, resulted in an early and prolonged crop, and that a high rainfall of over six inches led to a late crop of short duration. In 1928, Chamney (*BULLETIN* No. 13, page 35), took into consideration both the April rainfall and the previous October rainfall, which affect the main season and the mid-season respectively, and found that a distinct indication was thereby given as to whether the crop would be above or below average. In the 1928 *Year Book*, which is in the press, are published two papers on the subject, one by Skidmore (*Paper No 12*) indicating the existence of correlation between rainfall and the number of pods harvested on cacao at Kpeve, and the other by Hewison (*Paper No. 14*), discussing fluctuations in ratio between number of pods and resultant weight of cacao.

Progress has therefore been made and the extremely complicated nature of the task made still more apparent. In addition to the amount of rainfall it is necessary to know its distribution (especially the number of days of rain), any periods of drought, and the duration of the rainy season. Attempts have been made to estimate what is known as effective rainfall (*BULLETIN* No. 13, page 23), by which is meant that amount of rain which becomes entirely available to the crop. During a storm, for example, one inch may fall in half an hour and nine-tenths might run off immediately leaving only one-tenth for the crop. With a slight drizzle throughout the day and the same amount of rainfall, three-tenths might be

Effect of
Rainfall.

Effective
Rainfall.

lost by evaporation from the surface of the leaves and seven-tenths absorbed by the soil and made available for the crop.

Relative
Humidity.

The relative humidity must also play an important part in crop production. A considerable acreage of Gold Coast cacao is produced in areas of rainfall less than 60 inches, which is considered to be the minimum rainfall for cacao in other countries; this deficiency in rainfall is counterbalanced by high relative humidity. It is possible that the average relative humidity in cacao farms varies seasonally and this variation should be taken into consideration when assessing the effectiveness of the rainfall. In this and similar problems there is ample scope for the investigator for original work.

Experiment
Stations.

Cacao plots are maintained on the Investigational Stations of Asuansi, Kpeve and Kumasi, and at Aburi Botanic Gardens. The average seasonal yields from 1922 to 1928 have been calculated by Broatch (Paper for 1929 Year Book) and compared with the estimated yields per acre for the whole of the Gold Coast crop as calculated from the figures for exports. The results show that the yields of these plots are a fair but by no means certain guide to the average yield over all the cacao farms in the country. Several factors militate against a better correlation. First, in the calculation of the general yield per acre from export figures, the assumption is made that the area of new cacao coming into bearing is gradual and not intermittent, and secondly, it is assumed that exports from October to May do in fact represent the production of the major crop whereas, in the absence of knowledge of the stocks held over, the error may be considerable. Thirdly, a small number of plots, in this case, four, are unlikely to be representative of the whole cacao area of the Gold Coast.

Variation
versus
Actual
Yields.

In this connection there are two points I should like to stress. First, to expect any relation whatever between the yields of only four farms and the whole Gold Coast crop might appear to be rather optimistic. But we are not so much concerned with the actual yields per acre but with the variations from year to year. If the crop on these four stations gives promise of yielding a better crop than in the previous year, then it appears reasonable to assume that the odds are against the yield per acre being in general below that of the previous year.

Value of
negative
results.

The second point I wish to mention is the value of negative results in statistical work of this nature. Suppose no connection whatever were found between

the yields from these four stations and the total crop, it does not follow that there is no result or that the time spent has been wasted. The result is the very definite one that no connection whatever has been found between the two, and the statistician can immediately discard that line of work.

As the plots on existing stations are too few for our purpose, the next step is obviously to have more plots spread throughout the cacao area. In 1929, therefore, an attempt will be made to arrange with farmers in various districts for the Department to record pod data and yields in their farms. The size and number of plots are still under consideration. As a basis for discussion, it has been suggested that the cacao area should be divided into twelve areas of approximately equal production, and that five farms representing conditions should be chosen in each division. Areas on one-tenth of an acre could be demarcated in each and records taken on these sixty plots.

The records of yields over a period of years would show whether or not these plots were representative of the cacao farms as a whole, and if so the behaviour of these plots could be used as a reasonable basis for the estimation of the total crop. Cacao plots on Investigational Stations of the Department, except perhaps at Kpeve, are not typical of native farms: they are planted at a wider distance, they have occasionally been cultivated, and they normally receive more attention. Consequently the small sample plots to be demarcated in native farms are more likely to serve our purpose than any plots that have been, or might be, planted by the Department.

In conjunction with these sample plots an attempt will be made to forecast the yield per acre by pod counts. A cacao pod is growing on a tree from four to five and a half months before it is ripe enough to pick (Paper No. 13 in Year Book, 1928); hence it would appear that it ought to be possible to estimate the crop per acre by this method with a fair degree of accuracy in July and August, or three months before the main harvesting months. This would not, of course, be possible in the first year of recording or in the second, and in all probability it would take five years or more to perfect the method. The difficulties are that the average size of mature pod varies from year to year and during the season for reasons that have only partly been explained; a small pod may not mature, and pod diseases and tree setbacks may introduce factors incapable of estimation. The method

is however sufficiently promising to warrant trial. In addition to the estimation of the total yield, counts of pods in size classes on sample plots will give definite information as to the earliness or lateness of the season and as to the probable duration of the crop.

Local
application
of methods.

The forecasting methods discussed above have been concerned mainly with the estimation of the average yield per acre for the whole of the Gold Coast, and most of these methods are capable of local application, in the same way that the estimates of area could be made both for the whole of the Gold Coast and also for each area separately. Correlation of rainfall with crop for example, can be applied generally by saying that the rainfall precipitation throughout the cacao area in April has been lighter than average and therefore a crop above average is indicated, or it can be applied locally by saying that the rainfall at Kumasi has been, say, above average and therefore a lighter yield per acre than usual is indicated for cacao in the Kumasi area. The cacao producing area can be partitioned off in this way by various methods, a separate estimate made for each area, and the sum of these estimates gives the total estimate for the Colony. For the most part the application of these methods locally has not been thoroughly worked out. At present the most we can do is to argue somewhat in this manner:—"The production of cacao in the vicinity of Kumasi is increasing each year, according to the figures for rail shipments by 10 per cent. and according to conducted surveys by 14 per cent., hence an increase of 12 per cent. through 'new areas' coming into bearing can be assumed. With a normal yield per acre the total export from certain railway stations will therefore be tons. April rains were heavy, indicating a yield per acre below average, no decline in mid-crop due to ageing trees is expected as many trees are still coming into bearing, alternate year cropping indicates a low yield per acre, pests are normal, pod diseases less than usual, the cacao plots in Kumasi Investigational Station will probably produce a normal crop, and observation indicates a crop slightly below the average. The Kumasi crop is therefore estimated at tons, provided rainfall during the season is normal." An analysis similar to this given for each district forms a fair basis for estimation.

Observation. Frequent reports are sent in by the officers of the Department from Kumasi, Koforidua, Aburi, Asuansi, Oda and other cacao producing centres. Information is given under the heads of type of crop, average as

compared to the same period last year, weather conditions, diseases, latest yields, prices, and officer's personal opinion. These reports are in themselves a good guide to the crop and assist greatly in the preparation of the issued forecasts.

In a paper of this description it is difficult to get the various points in proportion, for some important items are self-explanatory and some unimportant items require a long explanation. In recapitulation I wish to emphasise therefore the main lines along which we are attacking the problem. First, the variation in the acreage of bearing areas is estimated generally by the curve of increase in exports, and locally by surveys, observation, port shipments, rail shipments and gate checks. Secondly, the variation in yield per acre is estimated mainly by climatic conditions, especially correlation of rainfall with crop, by yield data on Experimental Stations and, in future, on sample plots, and by general observation. Points which are borne in mind and are usually of minor importance are the decline in mid-crop with increasing age, alternate year cropping, decline in fertility in early years of production, and the incidence of pests and diseases. A correct appreciation of every line of estimation requires the application of the latest methods of statistical analysis, which will receive special attention in 1929.

ESTIMATION OF EXPORTS.

The final subject for consideration is concerned with the various estimates that could be prepared. Mention has already been made of three crops, the major crop, the minor crop and the mid-crop (which is produced within the minor crop). Estimates could be made of the production and of the export of all three crops, making six estimations in all. In addition, there are three annual periods for which estimates might be required, viz., the calendar year, the financial year and the seasonal year.

The monthly percentage distribution of crop production for experiment stations between 1922 and 1925 has been given by Auchinleck and Knowles (BULLETIN No. 4, page 10). They recorded that in the case of Amelonado, which is the variety commonly grown in the Gold Coast, the average major crop amounted to 86 per cent. of the annual crop, the minor crop to 14 per cent., and the mid-crop to 10 per cent. The major crop is produced, on an average throughout the country, during the period of six months from September to February.

Export of
cacao.

As far as can be ascertained the major crop is exported on the average during the eight months October to May. The monthly percentage distribution for the years 1922 to 1928 is given by Broatch (Paper for 1929 Year Book), who shows that exports reach minima about the end of May and the beginning of October. From 1922 to 1928 the average exports for the four months June to September amounted to 13.5 per cent. of the annual exports, showing a good agreement with 14 per cent. for minor crop production (*see* Appendices II and III).

Relation
between
production
and
export.

Produced from September to February the crop is exported from October to May. The export period given is an estimation, calculated in the absence of data of the amount of stocks held over from one season to another, and is therefore liable to correction. The difficulty is that there can be no guarantee that the major crop will be exported entirely and exclusively during the eight months October to May; actually the exports for this period are bound to include cacao held over from the previous minor crop and cacao produced during the earlier part of the following minor season. The subject has been studied by Broatch (Paper for 1929 Year Book) who in addition has estimated the average period from the time a parcel of cacao is produced to the time it is exported. He found that this period from production to export was 9 weeks for the years 1922 to 1928.

Calendar
Year.

Major and minor crop production is of prime interest for the Department, but the world at large is more interested in the annual export for the calendar year. On an average the calendar year export consists of 65 per cent. of the major crop produced in the previous year, the whole of the minor crop, and 35 per cent. of the major crop produced mainly in the current year. The latter figure has varied from 29 per cent. to 48 per cent. in the years 1922 to 1928. Sometimes a late major crop is succeeded by an early major crop, in which case the export figure for that year is erroneously high and likely to give an exaggerated impression of production: this has probably occurred in the case of the Nigerian cacao crop for 1929. Calendar year export figures are given in the Blue Books and are normally quoted in published articles on the production of cacao from the Gold Coast. They should be interpreted with caution.

Financial
Year.

The Government financial year is from April to March. Annual export figures for this period contain, on an average, 15 per cent. of the major crop produced mainly

in the previous year, the whole of the minor crop, and 85 per cent. of the major crop produced in the current year. The latter figure has varied from 80 per cent. to 92 per cent. in the years 1922 to 1928 and tends to increase. The figure for any financial year therefore usually bears a closer relation to the second major crop in the period than does the export figure for the calendar year.

The problem remains of deciding the best basis for the estimation of the "annual" cacao crop from year to year, so that a definite figure can be decided upon for the estimated production of each seasonal year. The trend of increase in production cannot be legitimately gauged from calendar year or from financial year figures. There appear to be three alternatives for the calculation of seasonal year exports from port export figures. These are, first, the exports for the twelve months from June to May, secondly, from October to September, and thirdly, the exports for the eight months from October to May, plus one-half of the exports for the preceding four months, June to September, and one-half of the exports for the following four months, June to September. The first approximates to a major crop and the preceding minor crop and is the least satisfactory. The second approximates to a major crop and the following minor crop and is better, as the monthly exports fall to a lower minimum in September to October than in May. The third approximates to a major crop and one-half of the preceding and following minor crops, and, although artificial, gives the nearest approximation to the export for a seasonal year. Inspection of figures for the seasonal year calculated according to the third method (Appendix I), shows that the record season was 1926-27, and the second best season was 1927-28 and not 1924-25, as calendar year figures would lead one to suppose.

The best of these alternatives cannot be entirely satisfactory. The fact remains that, in the absence of reliable data of the cacao held by farmers and merchants at the close of the major season and at the close of the minor season, it is impossible to calculate true figures for the actual production and export of each major and minor crop. As a corollary there is no way of testing the accuracy of the Department's estimate of production, except in the case of blatant inaccuracy. The subsequent comparison of export figures with estimates of production cannot be relied on with any degree of certainty.

Seasonal
Year.

Absence of
data for
"carry
over."

Issued forecasts refer to production.

The accurate estimation of exports therefore entails a knowledge of the amount of stocks held in the Colony. At present reliable information as to the stocks in hand is not available to the Department of Agriculture and consequently any estimates of exports can only be extremely tentative. The crop forecasts issued by the Department are confined to an estimation of crop production, and refer particularly to the production of the major crop and to the production of the mid-crop.

Estimation of stocks.

The only method the Department can employ at present to estimate stocks is to compare production with exports. Assume that by the end of March 140,000 tons of the previous major crop, known to have ceased production at the end of February, have been exported and that the total major crop production estimated by methods described in this memorandum were 200,000 tons, then it is clear that stocks of major crop in the Colony on April 1st were 60,000 tons, or 30 per cent of the total major crop. To say how much of this were in the hands of the farmers, how much with brokers and how much with export merchants would be difficult, and any estimation could be based only on the results of enquiry.

Stocks at end of each month.

An examination of stocks held on an average during the years 1922-1928 (Broatch's figures) is given graphically as an Appendix (No. IV). The assumptions are made that the surplus from the previous minor crop is completely exported during September and that none of the current major crop is exported until October. These assumptions may or may not be legitimate, or the overlaps either way may balance, in which case the final result comes to the same thing. But it is believed that the graph diagram gives a very fair idea of the stocks held in the country at the end of each month during a normal year. Starting from above 8 per cent. at the end of September, stocks steadily accumulate until by the end of December they reach very nearly 40 per cent. of the total annual crop. With lessening production stocks gradually decline and the major crop is practically out of the country by the end of May. Minor crop stocks begin to accumulate in March, reach their maximum in May or June and then decline until, by the end of September, they too have left the country.

Minimum stocks.

If the total annual crop were 230,000 tons, then the greatest quantity of stocks held in the country at any one time, viz., at the end of December, would be about 90,000 tons ($230,000 \times 38.9$). The smallest quantity, viz., at

the end of August would be 5,000 tons. No great accuracy is claimed for these figures. They are recorded mainly to show the method by which they can be obtained and are made in the absence of stock returns. It would be interesting to know the proportion of the 90,000 tons of stocks at the end of December in the hands of farmer, broker and merchant respectively.

The time necessary for marketing and transport to port normally accounts for the amount of stocks held in the country. 60 per cent. of the total annual crop is produced in the three months October and December and consequently storage accommodation and transport facilities have a severe strain to bear in these and the following months. Undue delay between production and export may be due to several factors. The farmer may hoard cacao as tangible wealth available for a rainy day despite its deterioration during storage, for although it deteriorates in quality it may not lose value, as buyers may not, and frequently do not, discriminate in price between good and bad cacao. A general hold up may be due to lack of transport facilities, motors, railways or shipping, which may be inadequate to cope with traffic at the time. Individuals holding mid-crop cacao may defer sale for the better prices ruling for major crop produce. But by far the most usual reason for undue delay in marketing is holding for a rise in price.

The local price in cacao growing areas was approximately 20s. a cwt. in January 1923, 55s. a cwt. in January 1927, and 27s. in January 1929. Such large fluctuations in price are bound to have an effect on the minds of growers, who are liable to speculate by holding their cacao when they consider that the price is too low. (Inspection of figures showing the fluctuations in price during the past six major seasons leads to the conclusion that the farmer who has consistently held his cacao for one month before selling has received practically the same average price as the farmer who has sold his cacao immediately after production). Any tendency therefore to hold excessive stocks on the part of the farmer, broker or merchant has to be allowed for in the preparation of forecasts of exports.

There is very little doubt that merchants could supply the information in regard to stocks in hand that is lacking for the preparation of a full forecast. Statements of stocks, giving amounts of major crop and

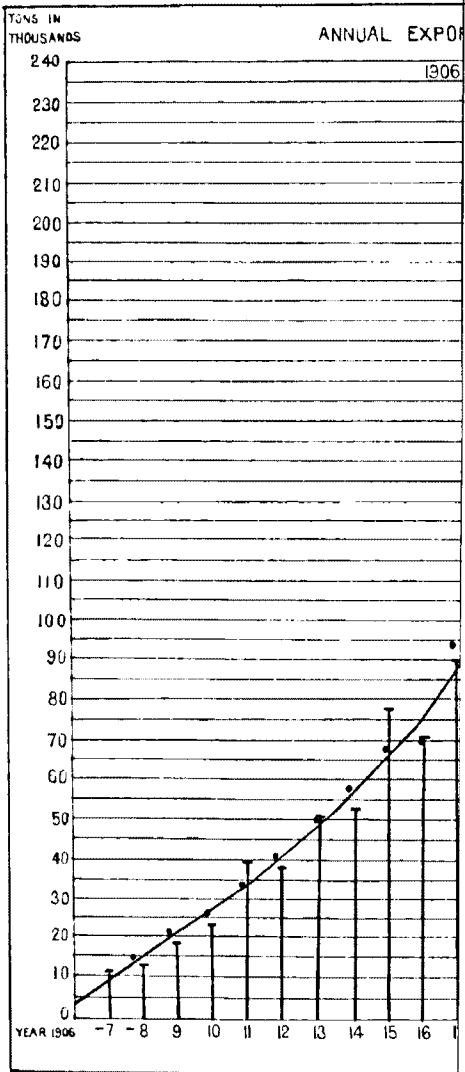
mid-crop held, would be useful at each of the following times :—

- | | | |
|---------------|----|---|
| 1st January | .. | To assist in preparation of distribution map for calendar year. |
| 1st March | .. | Approximate end of major crop production. |
| 1st June .. | .. | Approximate beginning of minor crop export. |
| 1st September | .. | Approximate beginning of major crop production. |
| 1st October | .. | Approximate beginning of major crop export. |

Of these, statements of stocks on 1st January and on 1st September would be the most useful. The assistance of merchants by furnishing figures of stocks (confidentially if desired) would greatly stimulate the work of perfecting the existing machinery already designed by the Department of Agriculture for the preparation of reliable estimates of production

Appendix I. See page 161.

FROM PAPER NO. V
BY A.C.



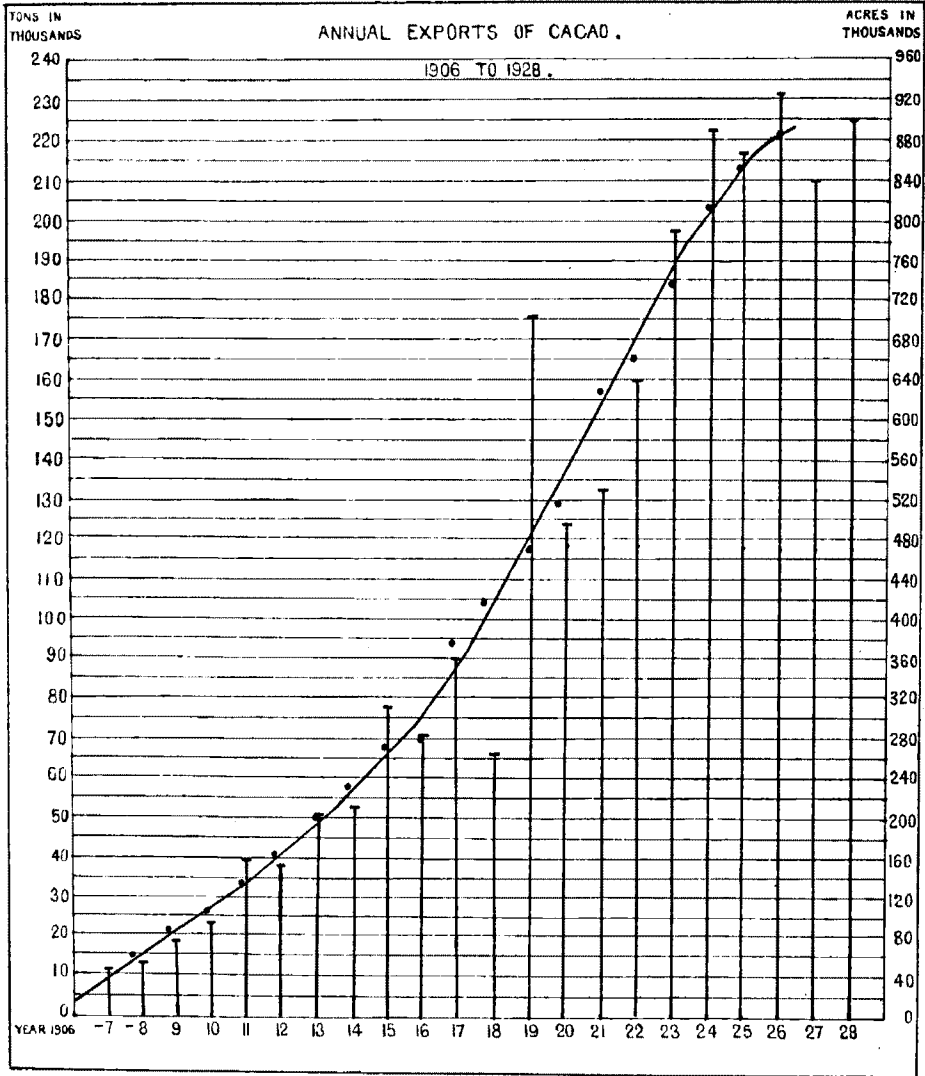
VERTICAL LINES REPRESENT ERROR
BLACK DOTS SHOW MEANS OF 5
BLACK CURVE SHOWS GENERAL TRENDS

mid-crop held, would be useful at each of the following times :—

- | | | |
|---------------|----|---|
| 1st January | .. | To assist in preparation of distribution map for calendar year. |
| 1st March | .. | Approximate end of major crop production. |
| 1st June .. | .. | Approximate beginning of minor crop export. |
| 1st September | .. | Approximate beginning of major crop production. |
| 1st October | .. | Approximate beginning of major crop export. |

Of these, statements of stocks on 1st January and on 1st September would be the most useful. The assistance of merchants by furnishing figures of stocks (confidentially if desired) would greatly stimulate the work of perfecting the existing machinery already designed by the Department of Agriculture for the preparation of reliable estimates of production

Appendix I. See page 161.



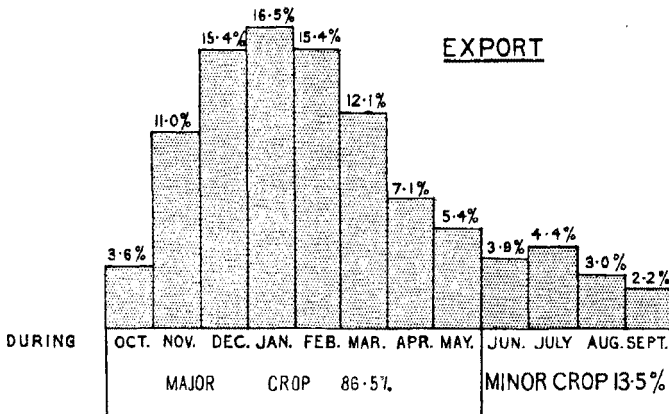
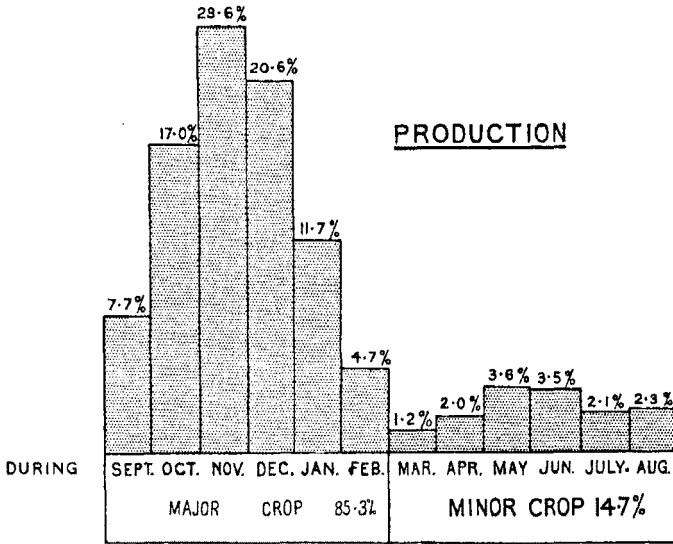
VERTICAL LINES REPRESENT EXPORTS OF INDIVIDUAL YEARS.
 BLACK DOTS SHOW MEANS OF 5 YEARS PERIODS WITH OVERLAP OF 4 YEARS.
 BLACK CURVE SHOWS GENERAL TREND OF INCREASE.

GOLD COAST CACAO

AVERAGE FOR SIX SEASONS—1922-1928

(FROM PAPER FOR 1929 YEAR BOOK

BY BROATCH)

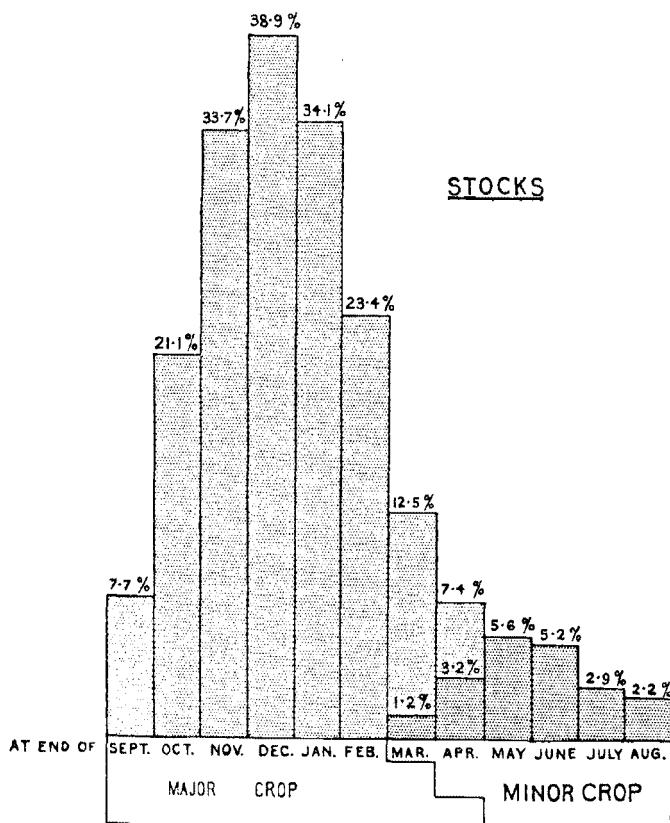


GOLD COAST CACAO

Appendix IV.

AVERAGE FOR SIX SEASONS—1922-1928.

	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JULY	AUG.	SEPT.
PRODUCTION	7.7	17.0	23.6	20.6	11.7	4.7	1.2	2.0	3.6	3.5	2.1	2.3	
EXPORT		3.6	11.0	15.4	16.5	15.4	12.1	7.1	5.4	3.9	4.4	3.0	2.2
EXCESS PRODUCTION OVER EXPORT	7.7	13.4	12.6	5.2									
EXCESS EXPORT OVER PRODUCTION					4.8	10.7	10.9	5.1	1.8	0.4	2.3	0.7	2.2
ACCUMULATED STOCK	7.7	21.1	33.7	38.9	34.1	23.4	12.5	7.4	5.6	5.2	2.9	2.2	0.0



APPENDIX I.
EXPORTS OF CACAO FROM GOLD COAST.

(Togoland omitted.)

		CALENDAR.	FINANCIAL.	SEASONAL.	
1922	..	156,271	176,243	182,934	1922—23
1923	..	194,082	193,837	200,377	1923—24
1924	..	218,727	214,856	206,821	1924—25
1925	..	213,238	209,778	202,745	1925—26
1926	..	225,921	236,669	231,545	1926—27
1927	..	205,068	201,534	207,582	1927—28
1928	..	219,823	234,950	—	1928—29

PAPER No. XIV.

**THE OCCURRENCE OF SAHLBERGELLA SPP.
AND OTHER PESTS OF CACAO IN FERNANDO
PÓO, SAN THOMÉ AND THE BELGIAN CONGO.**

BY G. S. COTTERELL (GOLD COAST).

As a result of a resolution at the First West African Agricultural Conference the writer made a tour, in the latter half of 1928, of the cacao growing areas of Fernando Póo, San Thomé and the Belgian Congo.

OBJECT OF TOUR.

The object of this tour was to obtain information on the occurrence of *Sahlbergella* spp. in these three countries and also to ascertain if there were parasites of *Sahlbergella* spp. other than the one occurring in this country. Previously the writer had been unable to obtain any information of the occurrence of *Sahlbergella* spp. in Fernando Póo. Previous workers had also stated that *Sahlbergella* had not been found attacking cacao in San Thomé. It was known to be a serious pest in the Belgian Congo and it was not expected that any new natural enemy would be found in the latter country.

Some doubt had been felt by the writer as to whether *Sahlbergella* spp. had been imported along with cacao when this crop was first introduced to the Colony, a large number of pods having been imported to this country from Fernando Póo by the Basél Mission Factory Company. This doubt has now been cleared up proving conclusively that *Sahlbergella* spp. is indigenous to the mainland. It is of interest to note, however, the *Sahlbergella theobroma* has not yet been recorded as occurring outside the Gold Coast.* No case of damage by this species was seen during the writer's extensive tour.

The tour was estimated to take approximately three months but owing to lack of transport facilities from country to country and difficulties of transport in the Congo five months were taken, inclusive of one month at sea and three weeks on the Congo River.

DESCRIPTION OF COUNTRIES VISITED.

Fernando Póo and San Thomé.

Fernando Póo is a Spanish owned island 25 miles from the mainland, Victoria in the Cameroons being the nearest point. San Thomé, under Portuguese administration, is approximately 200 miles

* Since this paper was written, Mr. Hargreaves, Entomologist, Sierra Leone, has informed the writer that he has obtained one example of *S. theobroma* in that country.

further south and on the equator. San Thomé is considerably smaller than Fernando Poó, the former occupying an area of 358 square miles and the latter 760 square miles.

Both Islands are mountainous, Fernando Póo rising to a single peak 12,000 feet high, whereas San Thomé rises to a number of peaks over 3,000 feet, the highest being the Pico de San Thomé, approximately 6,000 feet in height. San Thomé is characterised by the steepness of its slopes and deeply cut ravines.

Soil.

Both islands are volcanic in origin but San Thomé appears to be a considerably older formation. The parent rock is basalt. The soil of Fernando Póo is of exceedingly heavy texture and of considerable depth. Places occur where the depth is over 60 feet. Gravelly and stoney soils are absent except in river beds and on the coast. Owing to the texture of the soil, roads are impassable during the wet season and it is also almost impossible to walk on account of the slippery nature of the soil. In San Thomé, on the other hand, gravelly and shallow soils are common. The best soils are found in the ravines.

Climate.

Climatic conditions in each island are very different. Fernando Póo has an annual rainfall of approximately 100 inches. The seasons are similar to those of this country but there is no small dry season. Rains commence in March or April, reaching a maximum in August and September, after which they gradually tail off until December when the dry season commences.

Although the island of San Thomé is only 30 miles long, climatic conditions are extraordinarily different in the north and south. In the north the mean annual rainfall is 30 inches, whereas in the south 300 inches is the average. In the north there is a four to five months dry season lasting from June to October, during which time the sky is usually overcast and humidity is high. In the south, rain falls in every month but the months of June and July are somewhat dryer. Humidity is always high and except near the coast sunshine is comparatively uncommon.

Cacao Production.

Approximately one-sixth of Fernando Póo is under cacao. Excellent crops are obtained, yields being as much as from 1,500 to 2,000 lbs. per acre. Cultivation is confined to the slopes and ravines under 1,800 feet. A high quality bean is produced fetching as much as £100 per ton on the Spanish market, where it is given a preferential tariff. On the open market as much as £80 per ton has been obtained.

In San Thomé cacao is grown almost everywhere where a suitable soil exists. Cultivation is confined to sheltered slopes and ravines under 1,800 feet. Owing to attacks of Thrips, yields have fallen off considerably during the last ten years.

Belgian Congo.

Conditions in the Belgian Congo vary immensely. Cacao production is a very minor industry, exports being approximately 600 tons. The majority of this is grown in the Bas-Congo in latitude 5° S. This district is hilly and in parts covered with dense forest. Soil is good in parts but cacao is chiefly confined to the alluvial soils alongside the many perennial streams.

Climate.

Climatic conditions are similar to those that occur in the north of San Thomé. Mean annual rainfall is 55 inches. There is a five months dry season when practically no rain falls and when the sky is overcast and humidity high. Mean annual rainfall was considerably higher 20 years ago but has fallen off owing to the heavy destruction of forest that has taken place in developing oil-palm areas. The remainder of the cacao is grown in scattered plantations in the equatorial region of the Congo in altitudes under 1,800 feet. All these plantations are alongside the Congo River or its tributaries. Soil in this area is poor, of lateritic origin, and similar to the poorer soils of the Gold Coast. Secondary forest prevails, the occurrence of primary forest being rare. Seasons and rainfall are similar to those of the Gold Coast but there is no Harmattan. Here again oil-palm cultivation is the major industry, cacao being subsidiary. Yields are poor and cultivation is dying out.

OCCURRENCE OF SAHLBERGELLA SPP. AND OTHER PESTS.

In discussing the occurrence of *Sahlbergella* spp. and other pests in all three countries the writer intends to take each country separately.

Fernando Póo.

The writer arrived at Santa Isabel, the capital of Fernando Póo, at the end of August, 1928, and spent a little over three weeks in this island. Owing to the lack of roads and uncertainty of transport around the island by sea it was impossible to visit all cacao producing areas.

Sahlbergella spp.

It was soon discovered that *Sahlbergella singularis* is a common pest of cacao. The crop was commencing to mature and nymphs were found congregating under the ripening pods. Nymphs and adults were found on most cacao farms but were not causing much damage.

Owing to the better soil and more regular humidity the power of recovery of the tree is considerably better than that of the average tree in the Gold Coast. The severest attack is generally found on trees growing in the poorer soils. A marked feature was the large

proportion of nymphs in the first three instars compared with those in the latter two, indicating that an efficient natural control was present. Nymphs of all stages were bred up and the nymphal parasite, *Euphorus sahlbergellae*, Wilk., already recorded from the Gold Coast, was found to be far more abundant. Parasitism was found to be as high as 12 per cent. in September. In the Gold Coast parasitism ranges from 1 to 5 per cent., depending on the mean humidity, periods of high humidity being favourable to the development of the parasite. The hyperparasite *Mesochorus melanothorax*, Wilk., was not bred out and is probably not present in the island. Hyperparasitism in the Gold Coast is as high as from 40 per cent. to 50 per cent. The absence of the hyperparasite coupled with the higher degree of humidity accounts for the higher percentage parasitism by *Euphorus*.

In the course of breeding up nymphs of *S. singularis* a closely allied species was obtained.* No difference had been noticed in the nymphal stages. It was at first thought that this was a different species of *Sahlbergella*. The adult closely resembles *Sahlbergella singularis* but is considerably smaller.

S. theobroma was not observed, neither was any damage that might have been caused by this species. If this species is present in the island it is natural to expect that it would be found on large stands of young cacao. One plantation consisting of over 1,000 acres of cacao under four years of age, and, therefore, in the critical stage for attack, was systematically searched. No sign of damage was observed and it was therefore concluded that the species was not present. Neighbouring older trees were being attacked by *S. singularis*.

Other Pests.

Other pests of cacao that occur in the Island are *Characoma stictograpta*, Hmp., the Pod Borer, and *Helopeltis* sp. The former was found to be more common than in the Gold Coast on account of the greater degree of humidity. In practically all cases "black pod" disease, *Phytophthora*, was found associated with attack.

Helopeltis is of little importance as a pest in the island. The common species in Fernando Póo has been identified as *H. bergevini*, Popp.

The scales *Stictococcus* spp. were found to be particularly abundant but doing little damage. It is possible that their presence is, if anything, beneficial on account of the predaceous ants which cultivate them and which keep away pests such as *Sahlbergella* and Thrips. These scales were commonly found on leaf petioles, a situation in which they are rarely found in the Gold Coast.

Heliothrips rubrocinctus, Giard, was not common. A small black ant, *Rhoptromyrmex* (*Acidomyrmex*) sp.n. is exceedingly

* This has since been identified by the Imperial Bureau of Entomology as *Bryocaropsis* sp.

abundant. Small nests constructed of dirt, excrement and regurgitated material, etc., are constructed between two contiguous leaves. Thrips are rarely, if ever, found on trees, or adjacent trees, infested with nests of this ant. This ant was not observed in San Thomé but is common in the Congo.

Two species of weevil, *Ischnotrachelus theobromae*, sp.n. and *Mylocerus* sp. were found to be common on the leaves of young unshaded cacao and causing a considerable amount of defoliation. Only the adults cause damage. Nothing is known of the habits of the larvae.

One of the most important pests of cacao is the Melolonthid, *Camenia obesus*, Burm., the larvae and adults of which feed on the tap root and lateral roots a few inches below the surface of the soil. Damage is most severe on young cacao, when it frequently results in death. Older trees recover owing to their more robust root system. At the time of the writer's visit more than 30 larvae and adults were collected from around the tap root of one young tree within six inches of the surface of the soil. A German proprietary insecticide is used as a fumigant with apparently successful results. The constituents of this fumigant are not known. Manuring with compound manures is stated by a number of planters to prevent attack.

"Black Pod," *Phytophthora*, is much the worst pest in the island, accounting for as many as 90 per cent. of the pods on a number of farms where spraying is not resorted to. Beans from diseased pods are carefully separated and placed in a grade by themselves or mixed with a very low grade. Most farmers spray with Bordeaux Mixture, resulting in almost complete immunity. Spraying is carried out three times in the year, first when the flowers are setting, again about three months after, and again when the fruits are commencing to mature. Frequently Paris Green is mixed with the Bordeaux Mixture as a stomach poison against the Pod Borer, *Characoma stictographa*.

No remedial methods are applied for *Sahlbergella*. A contact spray of Nicotine Sulphate has been tried with successful results but is uneconomic, being too expensive in proportion to the amount of damage done.

San Thomé.

The writer arrived at San Thomé early in November. Thanks to the facilities granted by the San Thomé Government and by Plantation Administrators, the writer was able to visit practically every cacao plantation in the island.

Sahlbergella spp.

Sahlbergella spp. have not been recorded as attacking cacao in San Thomé. Navel* goes so far as to list *Sahlbergella* under the

* Navel, H. C.—Les Principaux Ennemis du Cacaoyer aux Iles de San Thomé et de Principe. Paris, Emile Larosse, 1921. Rev. of Appld. Entom. Vol. x, Ser. A pt. 6, June 1922, p. 323.

head of insect pests of cacao found on the mainland but not in San Thomé. After a most thorough search, no sign of damage was seen. It therefore appears to be conclusive that these pests do not occur in the island. Conditions are ideal for *S. singularis* owing to the frequent flushes of new growth following the attack by Thrips. San Thomé obviously owes its immunity to its isolation from the mainland and the San Thomé Government should take all steps possible to prevent importation.

Other Pests.

The Pod Borer, *Characoma stictographa*, Hmp. has also not been recorded and was not observed by the writer. *Helopeltis* spp. were observed, but doing very little damage. *H. sanguineus* Popp., has been determined as the commonest species.

Borers are comparatively common but attack was found to be localised. The commonest is a moth borer, probably *Eulophonotus myrmleon*, Feld.

Mallodon downesii is also common but is only found attacking aged or moribund trees.

The most serious pest of the island is *Heliothrips rubrocinctus*, Giard., the Red Banded Thrips of cacao. So much has been written about the damage caused by this insect in San Thomé, that it is unnecessary to go into detail here. All that is necessary to state is that in the south of the island, where a high degree of humidity pertains throughout the year, damage by this pest is as great, if not greater, than in the north. During the dry season trees are completely defoliated and even at the time of the writer's visit, when the rainy season had commenced, the foliage on most plantations was completely brown as a result of recent attack, almost the entire under surface of the leaves being covered with Thrips colonies.

H. rubrocinctus was first recorded as a pest in 1916, since which time it is stated to have accounted for a drop of 50 per cent. in the export of the cacao. Cacao has been established in the country on plantation lines since 1855, the first cacao being introduced in 1822.

A number of writers have stated that the recent severe infestation is the result of excessive deforestation. About 1910 a large number of the original forest trees that had been left for shade, were cut out with the object of obtaining an increase in yield. This resulted in more sun entering the plantation and therefore a decrease in humidity. It also resulted in opening up trees growing on slopes facing the sea to the warm sea breezes. In the north of the island, where there is an extensive dry season, this would bring about conditions favourable to the increase of Thrips, but the same cannot be said of the south where Thrips is if anything more abundant.

It is possible that a number of climatic and other factors are partly responsible for Thrips recently having become a pest of such

importance. There being, in the north (1) deforestation, (2) absence of wind-breaks, and in the south, (1) impoverishment of soil due to soil erosion, (2) excessive humidity, and in both the north and south, (1) excessive age of cacao and (2) soil exhaustion following too long production of cacao on the same land resulting in severe attack on re-established cacao. Most of these reasons are discounted for, however, by the facts that (1) attack is frequently as serious on cacao at the bottom of sheltered ravines where the best soil occurs, (2) attack on alternative food plants such as *Terminalia* spp. and *Persea gratissima* is just as severe as on cacao and (3) attack is as severe in the south as it is in the north although climatic conditions are entirely different.

In the writer's opinion, although it has been stated that *H. rubrocinctus* was present previous to 1916, the present attack has resulted from a recent importation of the pest, for the following reasons :—

- (i) Sudden commencement of attack ; damage by Thrips was negligible prior to 1916.
- (ii) Severity of attack on alternative breeding plants such as *Terminalia* sp., *Persea gratissima* and *Artocarpus* spp., which are not affected by absence of shade, etc.
- (iii) Absence of natural enemies. There are a number of casual predators but apparently no specialised checks. The larva of an unidentified Chrysopid is stated to be a natural enemy, but is not abundant, and was not observed by the writer.

A number of ornamental plants has been imported in recent years and it is possible that *Heliothrips* was imported on one of these.

In the Gold Coast, Thrips is effectively controlled by an internal nymphal parasite, *Dasyscapus parvipennis*, Gahan., parasitism reaching as high as 80 per cent. during heavy infestations. This parasite was not observed in San Thomé. Again, in Fernando Póo the small black ant *Rhoptromyrmex (Acidomyrmex)* sp. already referred to, is an important check on this pest. Thrips are rarely, if ever, seen on infested trees. This ant was not observed in San Thomé.

The writer suggested that the San Thomé Government should send someone to the Gold Coast to collect the parasite and attempt to import same to San Thomé as a control. Importation should not be difficult providing a certain amount of experimental work is carried out first to ascertain the best stage for transit.

As a result of the amount of dead and moribund wood left following Thrips attack, Termites are of considerable more importance than they are here. In the Gold Coast only one case has been observed of attack on healthy wood. In San Thomé living wood is

frequently attacked but only when in proximity to dead or living wood. The commonest species of termite are *Neotermes gestroi* and *Schedorhinotermes putorius* recorded by De Seabre.*

Belgian Congo.

The writer arrived in the Belgian Congo in mid-November and remained until the end of January. Owing to the distances to be covered and difficulties of transport, one month's stay as originally estimated was insufficient.

Sahlbergella spp.

Sahlbergella singularis is common in the Congo wherever cacao is grown. Owing to the distances between the few existent plantations in the equatorial district absolute proof is given that this species is indigenous to the mainland as it could hardly have spread over these distances in the short time that cacao has been established.

In the Mayumbe district of the Bas-Congo where cacao was first established, *Sahlbergella* is doing considerable damage particularly to cacao growing on alluvial soil. A number of plantations have ceased to cultivate cacao owing to the ravages of this pest. The attack commenced to become important following two consecutive years of drought, namely 1918 and 1919. A feature of this part of the country is that with cacao growing on the heavier texture soils, *i.e.*, the soil derived from mica-schists and limonite, attack has not been so severe, whereas with cacao growing on alluvial soil large areas have been completely destroyed.

Attack is said to be thrown off by manuring. One plantation in the Mayumbe district, which had previously suffered considerably from *Sahlbergella* attack, had become completely free since manuring with superphosphate was resorted to two years before.

Sahlbergella theobroma was not observed and has not been recorded from the Belgian Congo. The writer had the opportunity of reading a report on a visit by Dr. Staineur, State Mycologist, to one plantation, in which he stated that he had observed a species of *Sahlbergella* attacking *Eriodendron* seedlings. In the Gold Coast *S. singularis* does not, except on rare occasions, attack *Eriodendron* seedlings but *S. theobroma* does. It is possible that this species was *S. theobroma*. Unfortunately the writer was unable to meet either the Mycologist or the Entomologist whilst in the Congo, the former being on tour and the latter in Europe.

Other Pests.

Heliothrips rubrocinctus is not a serious pest in the Congo. A certain amount of cacao is grown on the banks of the Congo River, where it is open to warm winds blowing up the river. "Die-back" is common but Thrips attack is negligible.

* De Seabre, A. F.—Etudes sur les Maladies et les Parasites du Cacaoyer et d'autres plantes cultivées à San Thomé, xv. Rev. Appld. Entomology, Vol. x, Ser. A, pt. 6, p. 299.

A number of insects which are purely minor pests in this country are important in the Mayumbe district of the Congo as a result of the large amount of cacao grown without shade. In the Mayumbe district borers are exceedingly common. The commonest species are the branch and stem borers, *Eulophonotus myrmeleon*, Feld. (fam. Megalopygidae: Lepidoptera), *Tragocephala anselli*, Bates, and *T. maynei*, Gahan. (fam. Cerambycidae). A common form of damage is caused by the adult of probably a species of *Tragocephala* on herbaceous shoots. The bark is eaten in the form of a number of longitudinal slits to form an incomplete ring around the shoot a few inches below the growing point. An egg is then inserted just above, the resulting larvae boring downwards. A similar type of damage is done by both *T. gorilla*, Thoms., and *T. chloris*, Chev., to herbaceous shoots and young cacao in this country, but a complete ring is eaten out before oviposition, the idea of the ring presumably being to stop further growth and subsequent distortion of the egg previous to hatching. In the Congo a number of shoots are girdled without an egg being laid.

Helopeltis sp. is not so common as in the Gold Coast and causes little damage.

Other important minor pests are the Lymantriid, *Euproctis mediasquamosa*, Baker; the Acridiid, *Zonocerus variegatus*, L., the latter abundant on young cacao grown without shade; the Curculionids, *Systates* spp. all attacking foliage; the Eumolpid, *Menius parvulus*, Jac., the Pentatomid, *Atelocera serrata*, Westw., and the Noctuid, *Characoma stictographa*, Hmp., attacking pods.

In both San Thomé and the Belgian Congo, difficulty is encountered in establishing new cacao on land that is or has already been occupied by cacao. A number of writers in the Congo have stated that this is the result of attack by the Nematode, *Heterodera radicola*, on the smaller lateral rootlets. A large number of young moribund plants were examined by the present writer and nematode nodules were found but not in sufficient quantity to cause much damage. There was, however, a certain deficiency in the amount of rootlets present in relation to the size of the plant. In the writer's opinion this slow growth is due to soil exhaustion following prolonged production of cacao. The same condition occurs in this country, except on the better soils, without Nematodes being present.

"Morte Subite."

An unusual phenomenon occurs with cacao in San Thomé and the Mayumbe district of the Congo. A tree in apparent perfect health will suddenly commence to wilt and die within eight days. The leaves are not abscised but remain on the tree as in the case of root disease. Attack is not necessarily localised and almost always goes for the most robust trees. This condition is known amongst the natives as "Sun-stroke." A number of workers have studied

this problem but have been unable to find a pathological cause. The writer had a good opportunity of studying the phenomenon when in the Belgian Congo as he was there when attack was prevalent. The entire root system of a number of trees was dug out and carefully examined. No diseased or insect-attacked areas could be found but in all cases the lateral rootlets were found to be dying inwards from their extremities, the distance depending on the extent of wilt. A previous observer had marked off a number of trees during the period of attack and examined their roots. Some of these had their radicles dead and within a few days these trees all developed "Morte Subite." Attack in the Congo always occurs at the same time of year, namely January, at the beginning of the rains following the main dry season. Being unable to find any pathological factor, the writer suspected it to be purely physiological, particularly as it does not appear to be contagious. Frequently two trees have been allowed to grow from one planting hole from cacao planted at stake. Numerous cases were observed of attack occurring on one tree and not on the other. The writer was informed that if a tree is cut back within a foot or so of the ground immediately wilt is observed, a large percentage of the trees put out new shoots and recover. On one plantation, proving conclusively that it is a physiological condition, the writer found that native boys are employed, when attack is prevalent, to spot the first sign of wilt, when all the leaves are cut off, resulting in recovery.

It appears that some balance in the water or food supply of the tree breaks down subsequent to some unknown correlation of climatic conditions occurring at a particular time of the year.

Attack, if not immediately controlled, is serious as up to 2 per cent. of the trees may be lost annually.

PAPER No. XV.

CROP SURVEYS, GOLD COAST.

BY

J. C. MUIR (GOLD COAST).

INTRODUCTORY.

In conducting crop surveys the aim may be simply to demarcate broadly the areas of a country in which the principal crops are grown, or to obtain accurate information on one or all of the Agricultural Industries of an area, with data on total production—yield—acreage—distribution and conditions determining distribution, together with figures relating to the proportion of the total population engaged in the cultivation of each crop.

The former class of survey is of general interest and may serve to indicate where more detail is required, while the second class fulfils several definite functions.

In the first place it provides Departmental information on the average production of native owned farms, and gives figures on which to base estimates of the probable expansion of the industry which is being examined. A detailed knowledge of production and distribution may serve to indicate where transport facilities in the form of roads or railways require to be provided in order to assist in the development of potentially rich areas which remain in a backward state on account of the absence of adequate means of transport. In rapidly developing districts where export crops are grown, information on the quantity of produce available immediately and the possibility of future development of various centres is in request by merchants who intend to erect durable and consequently expensive storage sheds and wish to place these to the best advantage.

GENERAL EXPORT CROP SURVEY.

A map showing the Distribution of the Principal Export Crops of the Gold Coast which is typical of the class of Surveys first mentioned, based on information supplied by officers who had travelled the districts in which each crop was grown, was published by Miles* in the 1928 Year Book. The map gives an indication of the quantity of any crop available for sale.

* Miles, A. C.—“Geographical Distribution of Principal Local Crops,” Plate No. II, “Distribution of Principal Commercial Crops, 1928.”—1928 Year Book, Department of Agriculture, Gold Coast.

SPECIFIC CROP SURVEYS.

In 1927* Auchinleck and Chamney prepared a map showing the distribution and quantity of cacao produced in each part of the cacao belt. Information relating to the tonnage of cacao available in each district was obtained from Railway Traffic Statements and from information supplied by Officers of the Department. Each 100 ton lot of cacao is represented on the map by a dot, the area covered by the dot conforming to the acreage necessary to produce 100 tons of cacao, 5 cwts. per acre being taken as a fair average yield for the cacao belt as a whole. (Paper No. VI, Department Year Book, 1928.)

SURVEY OF CACAO AREAS, WESTERN PROVINCE, ASHANTI.

Following upon the paper and map produced by Auchinleck and Chamney, a survey of the cacao areas of the Western Province, Ashanti, was carried out to obtain a more exact knowledge of the distribution and total production of cacao in this Province, and in the second place to provide information on the proportion of the population engaged in cacao cultivation in typical cacao country, and on the average production or size of native owned cacao farms.

METHOD OF OBTAINING INFORMATION.

In each cacao producing village in the Province a house to house visit was made and records obtained as to number of residents, number with Fruiting Cacao, number with Non-Fruiting Cacao and Average Production of Cacao per annum in loads of 60 lbs. In some villages it was found impossible to obtain direct from the head of each household a statement of the number of loads of cacao produced by his family, and in such cases an Elder nominated by the chief of the Village would obtain the information relating to production of cacao from each family, and when the survey party had obtained all details of population and proportion of cacao farmers, this Elder would supply the figure for the total output of cacao from the village.

The information relating to population and production of cacao for the four districts of the Western Province, viz., Sunyani, Ahafo-Goaso, Wenkyi and Kintampo is summarised in Table 1 in the Appendix.

CHECK ON ACCURACY OF INFORMATION RELATING TO PRODUCTION OF CACAO OBTAINED BY CENSUS.

It was realised that the figures for production of cacao obtained direct from farmers would not invariably be accurate in view of the

* Cacao Production—Export 1927. Department of Agriculture, Gold Coast (Distributed with memorandum).

fact that farmers were sometimes unwilling to give information which they feared might be used as a basis for taxation, and also, because of a general tendency to state production of cacao in round numbers. It was a comparatively easy matter to find points at which to check cacao leaving the census area, as there are only four motor roads leading from the Western Province of Ashanti to railhead at Kumasi. Temporary clerks were stationed at the exits from three of the Districts Bechem (for Sunyani), Teppa (for Ahafo-Goaso) and Tansu (for Wenkyi), and recorded at their checking stations the quantity in pounds and origin of each lot of cacao being forwarded to Kumasi for railing.

During the height of the cacao season a night shift was found necessary and it appears probable that a certain proportion of the cacao carried by night was not recorded. No check was made on cacao leaving Kintampo District.

ACCURACY OF CENSUS RETURNS OF PRODUCTION AS COMPARED WITH GATE CHECKED TOTALS.

The net amount of cacao alleged to pass the checking stations in Sunyani, Ahafo-Goaso and Wenkyi Districts according to the census of production aggregated to 9,570 tons, while the actual amount recorded at these stations was 9,058 tons (Table 1 in Appendix) a deficit of 512 tons or — 5·4 per cent. of the census figure.

A minor amount of this discrepancy is probably due to failure of temporary officers to record all of the night traffic and to the fact that several of the firms used 150 lb. bags instead of the usual 140 lb. bag. When this was discovered it was impossible to make any adjustment as the produce from the various firms was not recorded separately.

In each of the three sections of Sunyani District, and in Ahafo and Wenkyi taken individually, seasonal variation in yield would probably account for the major part of the difference between census and check totals, which amounts to — 27·3 per cent., — 3·8 per cent., + 13·6 per cent., + 33·5 per cent. and — 7·8 per cent. of the census figures for Sunyani (Sections 1-3), Ahafo and Wenkyi respectively (see Table 1 in Appendix). Taking the Province as a whole, such fluctuation in yield might not greatly affect the final total, yields above average in one part of the Province possibly being counterbalanced by yields under average in other parts. In this connection it is of interest to note that those sections in which the checked totals are lower than the census totals are situated in the more exposed parts of the Province and suffered from an exceptionally severe Harmattan during the previous dry season, which would affect the ensuing cacao crop.

YIELDS PER ACRE AND TOTAL AREA UNDER CACAO.

It was found impossible to obtain direct from farmers a satisfactory figure for average yield of cacao. This would be a matter of some difficulty given every opportunity to measure farms, but farmers were definitely averse to having their farms measured and it was deemed inadvisable to urge this point in case the census would be prolonged unduly or brought to a complete stop through misunderstanding of our motives.

Of the four districts with which the survey is concerned, the cacao in Wenkyi, Kintampo and the north of Sunyani District, is grown at the extreme north of the cacao belt and is exposed to the full effects of a severe dry season, so that a minor season crop of cacao is never produced and cropping capacity is diminished.

Comparing the apparent productivity of cacao trees in these regions with the Amelonado to be seen at Kumasi Experiment Station, they appeared to fall short of the latter, which averaged 511 lbs. per acre over the 5-year period 1920-5.

On the other hand the apparent productivity of cacao in the south of Sunyani and the whole of Ahafo-Goaso is greater than that at Kumasi, so in the absence of more reliable information the Kumasi yield of approximately $4\frac{1}{2}$ cwts. per acre has been taken as an average for the Province.

Taking an average yield of $4\frac{1}{2}$ cwts. per acre the area under fruiting cacao in the Western Province of Ashanti would be in the neighbourhood of 44,712 acres, made, up as follows:—

	Acreage.
(1) Tons of cacao checked leaving Sunyani— Wenkyi and Ahafo-Goaso .. 9,058 tons	40,258
(2) Tons of cacao ex Sunyani leaving by routes on which no check was made .. 609 tons	2,707
(3) Census tonnage, Kintampo District, unchecked 393 tons	1,747
Total Acreage	44,712

ANTICIPATED INCREASE IN PRODUCTION.

Proportion of Farmers with Fruiting to Farmers with Non-Fruiting Farms.

Considering Table I, it will be seen that the total farmers with fruiting cacao farms amount to 10,143 and that the total farmers with non-fruiting cacao farms amount to 9,698. The latter class contains farmers with non-fruiting farms only, while the former in

all cases possessed non-fruiting in addition to fruiting cacao farms, it having become customary to plant cacao in all clearings made for food crops.

The total number of farmers with non-fruiting cacao farms is therefore 19,831, which is approximately twice the number with fruiting farms.

This does not, however, give us an accurate idea of the ratio of increase in production to be expected within a short period, as the size of the farm unit has increased since cacao cultivation became more profitable with the opening up of the province by motor roads. The proportion of non-fruiting to fruiting cacao was estimated by the survey party at 3 to 1, so that the area of non-fruiting would be in the neighbourhood of 134,136 acres and the total area under cacao in the province about 178,848 acres.

MAP SHOWING TONNAGE OF CACAO IN WESTERN PROVINCE.

From the data obtained in the course of the Survey the attached map has been prepared showing the distribution and production of cacao in Sunyani, Ahafo and Wenkyi Districts, and the distribution only in the case of Kintampo District.

The distribution of the crop is shown in brown, while each 100 tons of cacao is represented by a red dot, the quantity shown on the map being the tonnage actually recorded at the checking stations.

MEAN PRODUCTION AND MEAN AREA OF FARMS.

The average size of peasant owned cacao farms in this Colony is a matter over which there has been some difference of opinion, hence the mean production per farmer with fruiting cacao in each section of the Western Province of Ashanti, although this is probably not as high as in most parts of the cacao belt, the Western Province being still in the developing stage.

Section ..	Sunyani.			Ahafo.	Wenkyi.	Kintampo.
	I.	II.	III.	IV.	V.	VI.
Mean production in loads of 60 lbs. per farmer with Fruiting Cacao ..	29.95	53.57	52.12	36.97	23.91	25.60
Acreage at $4\frac{1}{2}$ cwts. per acre	3.57	6.38	6.21	4.40	2.85	3.05

PROPORTION OF POPULATION ENGAGED IN CACAO GROWING.

In the four districts the proportion of the population engaged in the cacao industry is set forth along with the population per 1000 in possession of fruiting farms.

	Sunyani.	Ahafo.	Wenkyi.	Kintampo.
Total farmers per 1,000 population	251.4	256.5	192.8	197.7
Farmers with fruiting farms per 1,000 population ..	145.5	138.7	91.4	64.4

It will be seen that total cacao farmers are approximately double the number of farmers with fruiting cacao.

At present the proportion of non-fruiting to fruiting cacao is estimated at 3 to 1, so that within a short period the production of the province will have quadrupled while the number of farmers with fruiting cacao will only be approximately twice the present number. In other words the mean production of cacao per farmer will be twice the present figure.

FREQUENCY DISTRIBUTION OF FARMERS ACCORDING TO THE AMOUNT OF CACAO PRODUCED.

Taking the production of cacao per villages in each section of the Province and dividing by the number of farmers with fruiting farms we are enabled to make frequency distribution tables of the farmers according to the amount of cacao they produce. The Frequency Table No. 2 (in Appendix) would have been more clear if the production of each farm had been obtained separately in the course of the census, and their significance may be doubted in view of the considerable discrepancy between census and check totals in some of the sections, nevertheless they bring out in the various sections those features which are known to exist. In Sections I, II and III of Sunyani there is a considerable proportion of the larger farms producing over 60 loads, but in Section I the model farm is small as it is in Sections IV, V and VI.

The cacao industry in the Province started in Sections I—III of Sunyani along the old trade route from Kumasi to Berekum, which was in existence before the advent of motor roads. After the industry had obtained a firm hold on those parts it spread slowly into the more remote places. The N.W. of Sunyani District is distant from the trade route and soil and rainfall conditions are not altogether favourable for cacao so that these factors explain why this area contains the bulk of the small producing units in Section I.

In Section IV, Ahafo-Goaso, the best favoured district of the Province as regards soil and rainfall conditions, sparseness of population and lack of communications are jointly responsible for the small size of the cacao farms, while in Wenkyi V and Kintampo VI the modal unit is also small and is likely to remain so, due to adverse agricultural conditions, of which the absence of extensive tracts of heavy forest and the severity of the dry season are the most important.

LIMITATIONS OF CENSUS OF PRODUCTION METHOD.

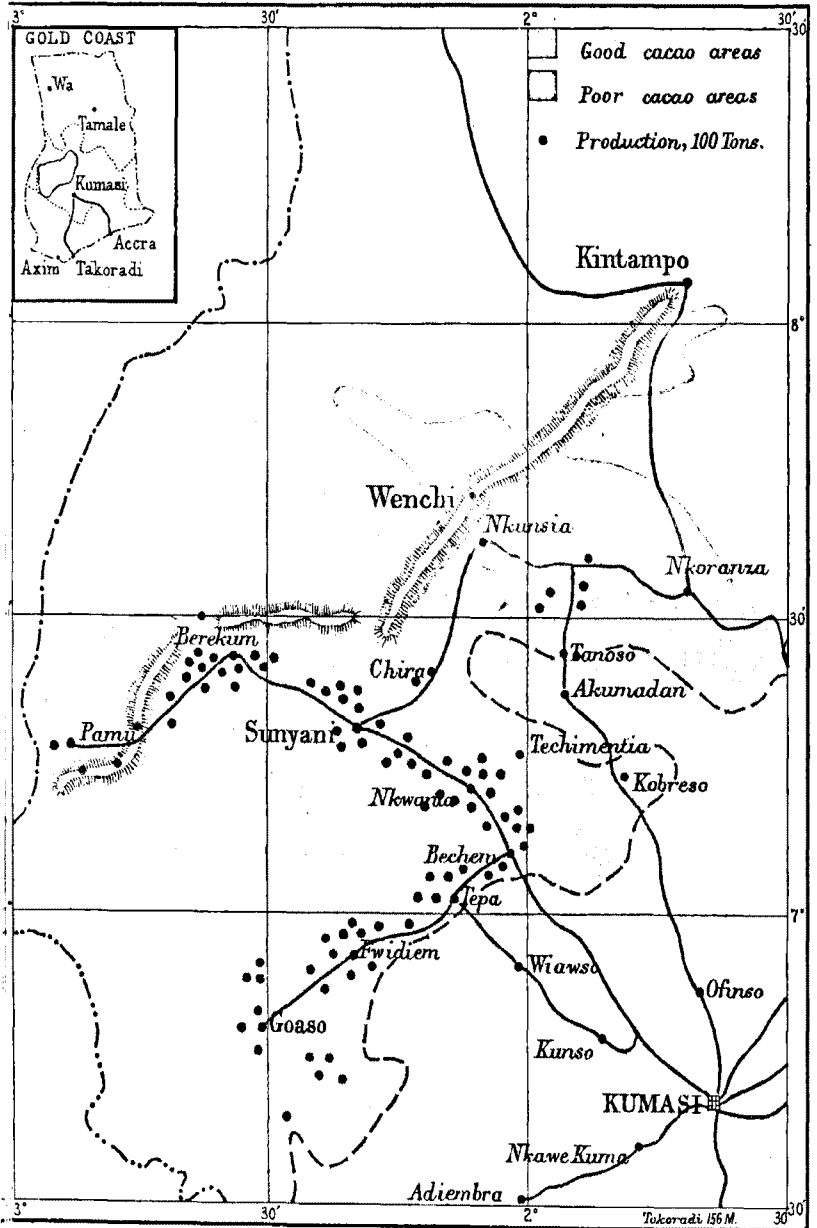
While the method has given satisfactory results in the Western Province as a whole, it must be admitted that the discrepancy between census and check totals, taking each district by itself, was in some cases so great that it can hardly be suggested that a census of production in the absence of checks would be entirely satisfactory over a small area.

The approximation used in arriving at an estimate of the acreage leaves much to be desired, but if a ground survey of the farms could be carried out in conjunction with a census of population and a check on produce leaving the census area, an exact knowledge of the industry under examination could be arrived at.

The Census of Production Method however limits itself to the export crops sold in standard quantities, African peasant farmers being incapable even of estimating roughly the quantity of food crops which they produce, so that a survey of a food crop area would require to be conducted by taking a census of the population engaged in the industry, making a ground survey of the farms to obtain acreage, and using trial plots of the various foods within the survey area to arrive at yields per acre.

MAP OF WESTERN ASHANTI

Showing
CACAO DISTRIBUTION & TONNAGE



Takoradi 156 M.
Survey H Q Accra 1930.

APPENDIX.

TABLE I.

SUMMARY OF CENSUS AND GATE CHECK FIGURES.

	Sunyani.				Ahafo-Goaso.	Wenkyi.	Kin-tampo.
	Section I.	Section II.	Section III.	Total.			
Number of Compounds..	3,646	956	768	5,370	1,384	2,182	1,088
Population.							
Adults ..	15,402	4,428	3,267	23,097	8,382	9,761	4,804
Children ..	13,209	3,845	2,997	20,051	4,911	8,158	4,080
Total ..	28,611	8,273	6,264	43,148	13,303	17,919	8,898
Cacao Farmers.							
Male ..	5,354	1,224	1,187	7,765	2,129	3,184	1,702
Female ..	2,041	678	582	3,301	1,215	478	57
Total ..	7,395	1,902	1,769	11,066	3,344	3,662	1,759
Cacao Farmers with Fruiting Farms.							
Male ..	3,069	865	874	4,808	1,454	1,485	562
Female ..	577	315	287	1,179	482	162	11
Total ..	3,646	1,180	1,161	5,987	1,936	1,641	573
C. E. Amount of Cacao said to be produced, loads of 60 lbs. ..	152,793	64,069	57,640	274,502	66,297	39,233	14,669
N. Amount not passing checks ..	—	7,000	15,742	22,742	—	—	—
S. U. Amount said to pass checks ..	152,793	57,069	41,898	—	—	—	—
S. A. Net amount in tons ..	4,093	1,529	1,122	6,744	1,775	1,051	—
B. According to check on Cacao Exported	2,976	1,472	1,276	5,724	2,365	969	—
A - B —% A	-27.3%	-3.8%	+13.6%	—	+33.5%	-7.8%	—

TABLE II.

DISTRIBUTION OF FRUITING FARMS PRODUCING SO MANY LOADS PER FARM.
CACAO CROP SURVEY WESTERN PROVINCE, ASHANTI, 1928.

No.	Sections.	Number of Loads.							Mean.	Standard Deviation.	Coefficient of Variation.
		0-20	20-40	40-60	60-80	80-100	Over 100	Total.			
1.	Section I. ..	867	1,716	412	225	122	303	3,645	29.95	21.47	71.70
2.	„ II. ..	89	257	290	424	105	15	1,180	53.57	24.29	45.34
3.	„ III. ..	2	483	255	232	189	—	1,161	52.12	21.72	41.67
4.	„ IV. ..	178	1,040	650	1	67	—	1,936	36.97	14.65	30.62
5.	„ V. ..	771	556	304	10	—	—	1,641	23.91	14.50	60.64
6.	„ VI. ..	292	147	126	8	—	—	—	25.60	14.9	58.20

1 load = 60 lbs.

PAPER No. XVI.

THE OIL PALM AT CALABAR.

BY E. H. G. SMITH (NIGERIA).

Calabar, an important commercial centre and port, is situated on the Cross River in the south east corner of Nigeria, close to the mandated Cameroons. The climatic conditions are well suited to the Oil Palm, the rainfall being well distributed and averaging 112 inches per annum. Oil Palm plots were established at Calabar by the Nigerian Department of Agriculture in 1912, 1913 and 1915, and their value is enhanced by individual tree records which have been maintained since 1922. In the present paper the Calabar records are analysed and an account is given of the selection work which has been commenced. It may conveniently be divided into three parts.

PART A.—A classification of the types found, and a description of the plots.

PART B.—An analysis of yield records.

PART C.—An account of the initial stages of Oil Palm selection.

PART A.

THE TYPES AND THE PLOTS.

It is not surprising that a cross fertilised species growing almost exclusively under natural conditions should exhibit a vast range of variation in all its characters. Nevertheless, in the wild oil palm certain fairly well defined types exist, and four of these, viz., the thick shelled, thin shelled, green fruited and mantled types were used in establishing the Calabar plots. As the systematy of the species is somewhat confused, the normal bunch and fruit characters of these types will be described.

1. Thick-Shelled Type.

This is the common type of wild oil palm which has been described by Farquhar (1, 2, 3 and 4). At Kew (5) it has been classified as *Elaeis Guineensis* var. *angulosa*, Becc., but it is probably identical with the local form called "Akponojub" which has been

classified at Kew as *var. communis*, Chev. Becc. The average of this type is probably intermediate between Yampolsky's *var. macrocarpa* and *var. dura* (6).

Bunches.—Large.

Fruits.—Large, apical and external ones especially large. Pointed and angular. Internal fruits compressed and irregular, heart-shaped or rectangular and often flattened.

Colour glossy black after fertilisation, but, when ripe, glossy dark red in upper region and light red basally. Internal fruits dark red at apex only, light red elsewhere.

Mesocarp.—Thin and exceeded by shell in thickness. Colour dark to light red or almost white. Devoid of prominent coarse fibres.

Shell.—Thick and hard.

Kernel.—Large. One (usually) to four (rarely) per nut.

The following forms have also been found at Calabar :—

- (a) Shell and mesocarp of equal thickness. Kernel large. (This is similar to the Deli type but the fruits are usually smaller).
- (b) Large, brownish, eggshaped fruits with shell, mesocarp and kernel proportions similar to (a).
- (c) Mesocarp of medium thickness, very thick shell, small kernel.

2. Thin-Shelled Type.

This is classified at Kew (5) as *var. ceredia*, Chev., but it appears to be identical with the local form called "Asogejub," which has been classified at Kew as *var. communis forma tenera*. The typical shell percentage is rather higher than that of Yampolsky's *var. tenera*. (6).

Bunches.—Small.

Fruits.—Small, elongated and rounded. Larger fruits rectangular.

Mesocarp.—Three or four times as thick as the shell.

Contains a well marked ring of coarse fibres situated rather nearer to the shell than to the epicarp. (This fibre ring is invariably present in the fruits of palms possessing the normal thin-shelled characters and its presence or absence has been taken as the criterion in the classification of palms otherwise apparently intermediate in type).

Shell.—Thin and spherical. The nut is set toward the apex of the fruit.

Kernel.—Small. One or two per nut.

3. Green-Fruited Type.

This has been confused in some literature (2, 3 and 4), with the King Palm (*var. idolatrica*, Chev.) but it is quite distinct from the latter for the leaflets are not fused but free. At Kew (5 and 7) it is suggested that the green fruited type may be classified as *var. communis, forma leucocarpa*. The green fruited type contains both thick and thin shelled forms similar in this respect to the two types which have been described. In addition, Bücher and Fickendey (8) have described a mantled form, but no example of this has been found at Calabar.

Bunches.—Large.

Fruits.—Large. Rounded or eggshaped.

Colour pale green immediately after fertilization, deepening as growth proceeds. On ripening, green colour gives place to light brick red, the latter colour spreading upwards from the base.

- (a) Thick shelled form—fruits slightly angular.
- (b) Thin shelled form—fruits plump. Possess characteristic fibre ring.

4. Mantled Type.

This is readily distinguished by the mantle of sterile carpels, usually six in number, which surrounds the fruit. It has been classified both as *var. Poissonii*, Chev. (5) and as *var. diwakkawakka*, Bücher and Fickendey (8). Both thick and thin shelled forms have been recognised by Bücher and Fickendey and by Yampolsky (6).

Bunches.—Small and contain few fruits.

Fruits.—Each surrounded by mantle. Extent of mantle development varies even with fruits on the same bunch.

- (a) Thick shelled form. Shell extremely thick. Kernel smaller than in ordinary thick shelled type.
- (b) Thin shelled form. Possesses characteristic "fibre ring." Kernel smaller than in ordinary thin shelled type.

* * * *

A brief description of the plots the records of which are to be analysed subsequently is now necessary. In establishing nurseries, seed was taken (with one exception) from only one wild parent tree of each type. It is believed that seed of the original parent trees was used for supplying until 1921. After this very few supplies were required. Supplying was particularly heavy in plots 11 and 12; many of the palms in the latter plot were established in 1920. The particulars of each plot follow, together with a census of the palms existing in 1928.

Plot 4.

Planted August, 1912, with nursery seedlings obtained from two *thin shelled* palms, a triangular spacing of 20 feet by 20 feet was adopted. Fruiting commenced early in 1916.

CENSUS 1928.

Thick shelled type	..	..	186
Thin shelled type	..	..	66
Young, non fruiting or dead	..	..	16
			<hr/>
			268 palms.

Plot 6.

Planted August, 1912, with nursery seedlings obtained, it is believed, from a *thick shelled* parent. Spaced 30 feet square.

CENSUS 1928.

Thick shelled type	..	..	125
Thin shelled type	..	..	8
Young or Blank	..	..	2
			<hr/>
			135 palms.

Plot 10.

Planted November, 1913, with seedlings from a *thick shelled* parent, probably the same palm from which Plot 6 was established. Fruiting commenced during 1916. Spaced 25 feet square.

CENSUS 1928.

Thick shelled type	..	..	221
Thin shelled type	..	..	17
Young or Blank	..	..	5
			<hr/>
			243 palms.

Plot 11.

Planted September, 1915, from nursery seedlings obtained from a *mantled* parent. The shell thickness of the parent was not recorded but there is reason to believe (q.v.) that it was probably thin shelled. Yield records date only from 1920. Spaced 25 feet square.

CENSUS 1928.

Mantled type, thick shelled form			24
Mantled type, thin shelled form	..	..	6
Ordinary thick shelled type	..	..	35
Ordinary thin shelled type	..	..	10
Young, Undetermined or Blank	..	..	9
			<hr/>
			84 palms.

Plot 12.

Planted September, 1915, with nursery seedlings obtained from a *green fruited* parent. As with Plot 11, no record was kept of the shell thickness of the parent, but it was probably thin shelled. Yield records date from 1920. Spaced 25 feet square.

CENSUS 1928.

Green fruited type, thick shelled form	19
Green fruited type, thin shelled form	12
Ordinary thick shelled type ..	30
Ordinary thin shelled type ..	10
Young or Undetermined ..	7
	78
	—

AN ANALYSIS OF THE 1928 CENSUS.

The ratio of different types of progeny derived from various parents are of considerable interest for, at the present time, they afford the sole data bearing on the genetics of the oil palm. In the following table the results of the 1928 census are summarised:—

Plot.	Parent Tree.	Progeny produced.	Actual numbers.	Expectation based on ratio in last column.	Ratio.
4	Thin shell	Thick shell ..	186	189	} 3 : 1
		Thin shell ..	66	63	
6	Thick shell?	Thick shell ..	125	124.7	} 15 : 1
		Thin shell ..	8	8.3	
10	Thick shell	Thick shell ..	221	223.1	} 15 : 1
		Thin shell ..	17	14.9	
11	Mantled and	Mantled	30	37.5	} 1 : 1
		Non-mantled ..	45	37.5	
	Thin shell?	Thick shell ..	59	56.25	} 3 : 1
		Thin shell ..	16	18.75	
12	Green fruited and	Green fruited ..	31	35.5	} 1 : 1
		Non-green fruited	40	35.5	
	Thin shell?	Thick shell ..	49	53.25	} 3 : 1
Thin shell ..	22	17.75			

It should be stated that in no case is the difference between the actual number and the expected number statistically significant. It is probable that in the case of palms in bearing in 1928 all individuals in each plot were derived from a single parent, with the

exception of plot 4, in which two similar parents were used. Moreover, since the parents were wild palms, it is highly probable that fertilisation was effected by pollen from the predominant bush type, *i.e.*, thick shelled. It would be idle, in view of the lack of definite information as to the male and female parentage of these palms, to make categorical statements as to the mode of inheritance of fruit characters based on these records. It is a remarkable fact, however, that in each of the seven instances under review the results obtained are statistically similar to well recognised Mendelian ratios. It is therefore tentatively suggested that shell thickness is governed by at least two factors and that the green-fruited and mantled forms are governed each by one. Further, "thick shell" is dominant to "thin shell." Deighton (9) has reported a much higher proportion of thin shelled progeny (raised from Nigerian thin shelled seed) than that obtained at Calabar, where, in Plot 4, the ratio of thick to thin was 3 : 1. However, the palms in the former case may have been derived from thin shelled parents surrounded by an unusually high proportion of trees of the thin shelled type, whereas, in the latter case, it may be assumed with tolerable certainty that cross fertilisation by the predominant thick shelled type occurred.

PART B.

AN ANALYSIS OF THE YIELD RECORDS.

In order to avoid confusion, summaries of the actual data will be confined to Appendices I and II and a discussion of the results will be given here. The yields from Plot 4, which, due to close spacing (triangular 20 feet) are abnormally low, have been omitted from the tables. In addition, all young palms are disregarded.

The following table shows the number, type and distribution of the palms included in the analysis of yield records :—

Type.	Number of each Type in Plot.				Total number of Tree Records analysed.
	6	10	11	12	
Thick shelled	125	220	21	10	376
Thin shelled	8	17	7	4	36
Green fruited thick shelled	—	—	—	6	6
Green fruited thin shelled	—	—	—	7	7
Mantled thick shelled ..	—	—	20	—	20
Mantled thin shelled ..	—	—	4	—	4

It will be seen that, with the exception of the thick shelled type, the number of palms available is small, thus, even though the records of each extend over a period of six years, conclusions drawn from such data can be but tentative.

Thick-Shelled Type, Plots 6 and 10.

While annual fluctuations occur, there is no marked increase in the total weight of bunches or of fruit produced per annum since 1922 when the records commenced. As the palms age, the mean bunch weight increases but this is offset by a decrease in the number of bunches produced. Thus, at Calabar, two groups of thick shelled palms, growing at different spacings, have reached their maximum yield by their ninth or tenth year after planting out, and have maintained that yield during the next six years, for the annual fluctuations which have occurred may be regarded as normal. The maximum yield on two Sumatra plantations was reached in approximately the same time (Waters (10)) but according to Annet (quoted by Rutgers (8)) maximum production does not occur until the twelfth year.

A comparison of Plots 6 and 10 can be made as regards their thick shelled populations. It must first be noted, however, that Plot 6 (planted out 1912) is fifteen months older than Plot 10 and that the soil of the latter is probably better than that of the former. Plot 6 is spaced at 30 feet square (48.4 trees per acre) and Plot 10 at 25 feet square (69.7 trees per acre). The difference in spacing has had no great effect on the mean bunch weight nor on the mean weight of fruit per bunch. The average annual yield of fruit per tree is 73 lbs. in Plot 6 and 59 lbs. in Plot 10, but the higher tree yield in the former case does not compensate for the wider spacing, for a mean yield of approximately 85 lbs. per tree would be required to bring the yield per acre up to that of Plot 10. This undoubtedly suggests that a spacing of 30 feet by 30 feet is too wide for this locality, and this is supported by the fact that, after sixteen years, the leaves have not yet met to form a complete canopy. On the other hand, there is some indication that 25 feet by 25 feet is too close a spacing, for Plot 10 contains a number of stunted palms and a large proportion of low yielding ones. It is suggested that the optimum spacing for Calabar would be 27 or 28 feet square, giving 59.8 or 55.6 trees per acre respectively. A greater number of trees per acre could, of course, be obtained by adopting a triangular spacing. Mass (8) advocates a spacing of 9 metres (approximately 29.5 feet) square or triangular in Sumatra.

Thin-Shelled Type, Plots 6 and 10.

Conclusions drawn from the yields of thin-shelled palms in these plots are less reliable owing to the small number of individuals. The mean bunch weights are slightly lower, and the mean weight

of fruit per bunch considerably lower, than in the case of the thick-shelled type from the same plots. A low percentage of fruit weight to bunch weight is a characteristic of all thin shelled types, and this reduces the effect of the higher oil content when yields per acre are compared with those of the thick shelled types. Nevertheless, in both plots, the thin shelled palms gave a higher yield of mesocarp oil per acre than the thick shelled, but kernel yield is lower. On Plot 10 results obtained by the Cooker Press show that the thin shelled type yields 15 per cent. more mesocarp oil and 56 per cent. less kernels than the thick shelled type.

Mantled Type, Plot 11.

This plot was planted out in 1915 with seedlings, spaced 25 feet square, obtained from a mantled parent. The diversity of types obtained has already been described. Both this plot and Plot 12 contain a large number of young palms, and probably the yield of older trees growing in competition with these has been favourably affected. Yields of Plots 11 and 12 are not comparable with those of 6 and 10, as the former pair were established two or three years later. A comparison between both forms of the mantled type and the ordinary thick and thin shelled types in Plot 11 shows that the former yield a larger number of bunches per tree, but that the mean bunch weight and percentage of fruit weight to bunch weight is lower than in the latter two types. Within the mantled type the thin shelled form gives a lower average yield of mesocarp oil per acre than the thick shelled form, this being due to the exceptionally low percentage of fruit weight to bunch weight in the former. The thick shelled mantled palms give a lower yield of kernels than any other thick shelled type.

Green-Fruited Type, Plot 12.

This plot is similar in every way to Plot 11 except that it was planted out with seedlings obtained from a green fruited parent. In this plot the ordinary thick and thin shelled individuals have given higher yields than elsewhere in Calabar plantations. The green fruited palms have yielded well and a noticeable feature is the high percentage of fruit weight to bunch weight recorded for the thin shelled form of this type. The thin shelled green fruited palm appears to be the most promising of all types at Calabar.

A COMPARISON WITH SUMATRA YIELDS.

For palms in full bearing, estimates of yield of oil and kernels per acre in Sumatra are as follows:—

Estimate due to	Mesocarp Oil (lbs.)	Kernels (lbs.)	Extraction efficiency from which oil yield has been calculated.
Rutgers (8)	1,854	605	80 %
Yves, Henry	(a) ordinary soil 1,070	—	90 % (?)
Quoted by Waters (10)	(b) good soil 1,516	—	90 % (?)
Waters (10)	(average) 1,400	—	90 % (?)

It is difficult to compare the Calabar records, based, as they are, on a small number of trees and on the Cooker Press extraction process. This process has an extraction efficiency of from 60 to 65 per cent. in the case of thick shelled fruit, but with the other types its efficiency is not known.

The Calabar records may be summarised as follows:—

Plot.	Type.	Yield of Mesocarp Oil per acre by Cooker Press (lbs.).	Estimated yield of oil at extraction efficiency of 90 % (lbs.).	Yield of kernels per acre (lbs.).
6	Thick shelled .. .	587	810	333
10	" "	734	1,020	445
11	" "	544	750	316
12	" "	991	1,370	575
6	Thin shelled	549	Unknown but probably at least 25% more than by Cooker Press.	144
10	" "	845		195
11	" "	991		236
12	" "	1,206		283
11	Thick shelled, mantled.	919	Do.	333
11	Thin shelled, mantled.	729	Do.	153
12	Thick shelled, green fruited.	1,343	Do.	575
12	Thin shelled, green fruited.	1,627	Do.	354

There is thus some indication that the attainment of yields equal to those of Sumatra is by no means an impossibility in the Eastern Provinces of Nigeria. Indeed, with factory extraction from plantations of selected palms $\frac{3}{4}$ -ton of oil per acre seems quite feasible.

FREQUENCY DISTRIBUTIONS OF INDIVIDUAL TREE YIELDS.

In Tables I and II of Appendix I the frequency distributions of the yields, in lbs. of bunches per annum, are given for the thick shelled trees of Plots 6 and 10. These tables show that the average yields per acre for both these plots have been reduced by the large number of trees whose annual yields fall into the lowest classes and weight the distributions. The high proportion of low yielding trees is most marked in Plot 10, which is the most closely spaced. Variation in yield is to be expected from a large population of unselected palms, and low yielding individual trees will always occur. Plantations established with palms of unknown parentage are likely to contain large numbers of low yielding trees, as well as a high proportion of trees with fruit of poor quality. The extent to which these can be eliminated by breeding must be a matter of conjecture for some years.

PART C.

THE INITIAL STAGES OF OIL PALM SELECTION AT CALABAR.

The main object of oil-palm work recently commenced at Calabar was the self fertilization of the best trees so that the possibility of producing superior pure lines might be explored. Work of this nature, owing to the length of the period between successive generations, will take many years to complete. It should be mentioned that once the scheme has been initiated it was, of necessity, left in charge of an African assistant, European supervision being confined to flying visits.

THE FLOWERING OF THE OIL PALM.

Self fertilisation is rendered difficult by the irregular nature of flowering. On some trees the male and female inflorescences follow each other in short cycles; or even, at times, alternate male and female inflorescences are produced. On others, the cycles are more prolonged and occur at greater intervals. A resting period of varying duration is noted in many instances; but this does not occur at the same time on all trees. This resting period occasionally lasts almost for a whole year, for it is observed that several of the palms that have given high average yields over the period for which data are available have produced only one or two bunches during a single year. Certain individuals show a

tendency to produce bisexual inflorescences. Natural self-fertilisation by this means does not seem possible, as the male flowers shed their pollen several days before the stigmas of the female flowers are receptive. Flowering of the oil palm requires further investigation; Mason and Lewin (12) found that flowering at Ibadan was affected by rainfall distribution and suggest, further, that the relative length of night and day is of importance. They also point out that the sex ratios of individual trees vary greatly.

THE SELECTION OF PARENT TREES.

In the absence of information as to the behaviour of the various types of oil palm on self-fertilisation, it was decided to include at least one sample of each type in the first series of selections. Inflorescences of these trees have been self fertilised and the seed produced is now under propagation at Ibadan. The first selection was based mainly on the gross yield of bunches producing during the period 1922-27, after making an allowance for the age of the individual and after excluding outside trees wherever possible. Later, on the results of a rough method of field analysis of the fruit, several of the original selections were discarded. Details of this and of the selected trees are given in Appendix III.

METHOD OF POLLINATION.

The method of pollination devised by Hill and Mason (13) has been followed with certain modifications. Once the parent trees have been selected, it is necessary to accumulate a stock of pollen for each tree before selfing can be commenced. The assistant visits each tree in turn and records the degree of development and sex of all the young inflorescences found. A chart is kept, showing the stages of development of all the inflorescences for each tree, and affords information as to which trees should be visited on any given day. Once a supply of pollen is available, female inflorescences are bagged as they appear, and are self fertilised when the majority of the stigmas are receptive. No female inflorescences are bagged unless pollen is available, and where a succession of developing male inflorescences is observed, the earlier ones can be ignored. Each female inflorescence is labelled on the day of pollination and its particulars are recorded in a note book. It is considered advisable to bag male inflorescences before anthesis, to prevent possible contamination of the pollen. This is done on what is judged to be the second day previous to anthesis; the spathe and any awkward leaves are removed, and the inflorescence is sprayed with a 5 per cent. solution of commercial formalin. This will kill any viable pollen, and assists in the removal of weevils and other insects that are always present. Normally, anthesis of the male inflorescence is completed during a period of a few hours, but when the inflorescence is enclosed in a bag, anthesis is more gradual

and pollen cannot be collected from the whole. When the majority of the flowers are mature, the inflorescence is cut off, the pollen is shaken on to clean papers and dried in the sun for a short time. It is possible to increase the yield of pollen by leaving the entire inflorescence in the sun for a short while prior to this. The pollen is then sifted from the empty anthers which are mixed with it. Sufficient pollen for a single female inflorescence is placed in an envelope, which is then sealed. A large male inflorescence should yield pollen sufficient to fertilize from two to four female inflorescences. The envelopes containing pollen are then kept in calcium chloride desiccators until required. The formalin spray is constantly in use during all operations involving the handling of pollen to prevent contamination which otherwise would be likely to occur.

The pollen germinates well up to a month from collection, after which viability decreases. Pollen three or four months old was successfully used; but it was the practice to replace pollen in the desiccators as fresh inflorescences were obtained and no attempt was made to determine how long it could be kept. The freshest pollen available was always used for pollination.

In the preparation of female inflorescences, the spathe and leaves are removed and the spines of the main branches and bracteoles are cut off to facilitate handling and bagging. The opening of the flowers is irregular, but they usually open over a period of three days, as described by Heusser (6). In some instances one or two flowers have been observed to open abnormally early and these present a difficulty, for they are by no means easy to discover without damaging the inflorescence. For example, an immature inflorescence was observed with a single withered flower bagged on the same day, the rest of the flowers did not open until eleven days later. Bagging appears to retard the opening of the flowers slightly, and this is particularly the case with the mantled form, which is the most difficult to bag successfully for this reason. The inflorescences are bagged about a week before the opening of the flowers, this being somewhat earlier than the practice described by Hill and Mason (13). A window in the bag facilitates observations on the opening of the flowers. When the majority are receptive the bag is lifted and pollen from an envelope is dusted over the inflorescence. When the operation is completed the bag is replaced as rapidly as possible and is left in position until all the stigmas have withered, a period of one to three weeks. It is considered unsafe to attempt to remove immature flowers, as if this is done, there is a risk of the worker failing to discover them all. It was not found practicable to pollinate through the window according to the method of Hill and Mason; for, in addition to the difficulty of covering the inflorescence with pollen, the windows are difficult to replace satisfactorily while the bag is in use.

THE RELIABILITY OF THE METHOD.

As a control, one or two female inflorescences on non-selected trees were bagged each week but not pollinated. The results available at the time of writing are :—

No fruits set	..	..	41	inflorescences
A single fruit set	..	..	2	„
A few fruits set	..	..	2	„
			—	
Total number of controls			45	„
			—	

The four failures may undoubtedly be ascribed to carelessness on the part of the African assistant. The inflorescences were either bagged too late or, in the case of single fruits setting, one early opening flower passed undetected. There is reason to believe, however, that such mistakes would be less likely to occur with selected trees for which a detailed record of inflorescence production is maintained. The results are regarded as being as satisfactory as can be expected without constant European supervision. As a safeguard against mistakes, the progeny of each selfed inflorescence is segregated to facilitate detection at a later date.

LITERATURE CITED.

- (1) Farquhar, J. H. J.—The Oil Palm and its Varieties—1913.
- (2) Bulletin of the Imperial Institute, Vol. VII. No. 4—1909.
- (3) Bulletin of the Imperial Institute, Vol. XVIII. No. 2—1920.
- (4) Kew Bulletin of Miscellaneous Information. No. 2—1909.
- (5) Useful Plants of Nigeria, Part IV—Kew Bulletin of Miscellaneous Information—1922.
- (6) Rutgers, A. A. L., Heusser, C., Maas, J. G. J. A. and Yampolsky, C., Investigation on Oil Palms—Medan—1922.
- (7) Kew Bulletin of Miscellaneous Information, No. 8—1914.
- (8) Bücher, H. und Fickendey, E.—Die Ölpalme—Berlin—1919.
- (9) Report of the Mycologist—Annual Report—Lands and Forest Department, Sierra Leone—1927.
- (10) Waters, H. B.—Notes on a visit to Sumatra and Malaya—Sixth Annual Bulletin of the Agricultural Department, Nigeria—1927.
- (11) Barnes, A. C.—An Improved Process for the Extraction of Palm Oil by Natives—Fifth Annual Bulletin of the Agricultural Department, Nigeria—1926.
- (12) Mason, T. G. and Lewin, C. J.—Growth and Correlation in the Oil Palm—Annals of Applied Biology—Vol. XII—1925.
- (13) Hill, A. G. G. and Mason, T. G.—Pollination of the Oil Palm (*Elaeis Guineensis*)—Fourth Annual Bulletin of the Agricultural Department, Nigeria—1925.

APPENDIX I.

PLOT RECORDS.

Two tables, A and B, are given for each plot. Annual yields are included for the thick shelled type in Plots 6 and 10 but in all other cases, owing to the small number of trees available, average yields over the period 1922-28 are given. All palms coming into bearing since 1922 have been excluded. Calculations of yields per acre have been made from the number and spacing of trees available. The acreages are as follows:—

Plot 6—(30 feet by 30 feet):

125 Thick Shelled Palms	..	..	..	2.583
8 Thin Shelled Palms	..	..	..	0.165

Plot 10—(25 feet by 25 feet):

220 Thick Shelled Palms	..	..	..	3.156
17 Thin Shelled Palms	..	..	..	0.244

Plot 11—(25 feet by 25 feet):

20 Thick Shelled Mantled Palms	..	..	..	0.287
4 Thin Shelled Mantled Palms	..	..	..	0.057
21 Thick Shelled Palms	..	..	..	0.301
7 Thin Shelled Palms	..	..	..	0.100

Plot 12—(25 feet by 25 feet):

6 Thick Shelled Green-Fruited Palms	..	..	..	0.086
7 Thin Shelled Green-Fruited Palms	..	..	..	0.100
10 Thick Shelled Palms	..	..	..	0.143
4 Thin Shelled Palms	..	..	..	0.057

The yield per acre of mesocarp oil and kernels is calculated from the results given by the Cocker Press process of extraction during the two years that this process has been in operation at Calabar.

PLOT 6—TABLE A.

(Planted 30 Feet Square.)

TABLE A.

125 THICK-SHELLED PALMS.

1	2	3	4	5	6	7	8	9	10
Year.	Number of Bunches.	Weight of Bunches in lbs.	Average Weight per Bunch in lbs.	Weight of Fruit in lbs.	Average Weight of Fruit per Bunch in lbs.	Percentage Fruit Weight to Bunch Weight.	Average Number of Bunches per Tree.	Average Weight of Bunches per Tree in lbs.	Average Weight of Fruit per Tree in lbs.
1922 ..	928	11,928	12.9	—	—	—	7.4	95.5	—
1923 ..	746	11,645	15.6	—	—	—	6.0	93	—
1924 ..	855	14,338	16.8	9,170	10.7	64	6.8	115	73.5
1925 ..	808	16,142	19.9	10,449	12.9	64.5	6.5	129	84.5
1926 ..	641	13,673	21.3	8,785	13.7	64	5.1	109.5	70.5
1927 ..	480	11,488	23.9	7,273	15.1	63.5	3.8	92	58
1928 ..	732	14,807	20.2	10,021	13.7	67.5	5.8	119	80
Average 1922-28	741	13,432	18.1	9,140	13.0	65	5.9	107.5	73

EIGHT THIN-SHELLED PALMS.

Average 1922-28	40	643	16.1	352	8.8	56	5.0	80	44
-----------------	----	-----	------	-----	-----	----	-----	----	----

PLOT 6—TABLE B.
(Planted 30 Feet Square.)

TABLE B.

THICK-SHELLED TYPE. AREA = 2.583 ACRES.

1	2	3	4	5	6	7
Year.	Number of Years since Plot Planted Out.	Number of Bunches per Acre.	Weight of Bunches per Acre in lbs.	Weight of Fruit per Acre in lbs.	Weight of Mesocarp Oil per Acre in lbs.	Weight of Kernels per Acre in lbs.
1922	10	343	4,617	—	522	294
1923	11	289	4,507	—	509	288
1924	12	331	5,550	3,550	625	355
1925	13	313	6,248	4,045	712	404
1926	14	248	5,292	3,402	599	340
1927	15	186	4,447	2,816	496	282
1928	16	283	5,732	3,879	682	388
Average 1922-28	10-16	287	5,199	3,538	587	333

THIN-SHELLED TYPE. AREA = 0.165 ACRES.

Average 1922-28	10-16	242	3,897	2,133	549	144
-----------------	-------	-----	-------	-------	-----	-----

PLOT 10—TABLE A.

(Planted 25 Feet Square.)

TABLE A.

220 THICK-SHELLED PALMS.

1	2	3	4	5	6	7	8	9	10
Year.	Number of Bunches.	Weight of Bunches in lbs.	Average Weight per Bunch in lbs.	Weight of Fruit in lbs.	Average Weight of Fruit per Bunch in lbs.	Percentage Fruit Weight to Bunch Weight.	Average Number of Bunches per Tree.	Average Weight of Bunches per Tree in lbs.	Average Weight of Fruit per Tree in lbs.
1922 ..	1,354	19,986	14.8	—	—	—	6.2	91	—
1923 ..	1,157	19,403	16.8	—	—	—	5.3	88	—
1924 ..	1,389	23,999	17.1	15,556	11.2	65	6.3	109	70.5
1925 ..	1,110	22,354	20.1	—	—	—	5.0	101.5	—
1926 ..	807	17,701	21.9	11,414	14.1	64.5	3.7	80.5	52
1927 ..	770	17,292	22.5	11,115	14.4	64	3.5	78.5	50.5
1928 ..	947	21,568	22.7	13,816	14.5	64	4.3	98	63
Average 1922-28	1,076	20,329	18.9	12,975	13.3	64.5	4.9	92.5	59

17 THIN-SHELLED PALMS.

Average 1922-28	81	1,443	17.8	796	11.1	54.9	4.8	85	47
-----------------	----	-------	------	-----	------	------	-----	----	----

PLOT 10—TABLE B.

(Planted 25 Feet Square.)

TABLE B.

THICK-SHELLED TYPE. AREA = 3.156 ACRES.

1	2	3	4	5	6	7
Year.	Number of Years since Plot Planted Out.	Number of Bunches per Acre.	Weight of Bunches per Acre in lbs.	Weight of Fruit per Acre in lbs.	Weight of Mesocarp Oil per Acre in lbs.	Weight of Kernels per Acre in lbs.
1922	9	429	6,333	—	722	437
1923	10	367	6,147	—	701	424
1924	11	440	7,603	4,928	877	532
1925	12	352	7,082	—	807	489
1926	13	256	5,608	3,616	644	391
1927	14	244	5,478	3,521	627	380
1928	15	300	6,832	4,377	779	473
Average 1922-28	9-15	341	6,441	4,111	734	445

THIN-SHELLED TYPE. AREA = 0.244 ACRES.

Average 1922-28	9-15	332	5,913	3,262	845	195
-----------------	------	-----	-------	-------	-----	-----

TABLE NO. I.

PLOT 6—THICK-SHELLED PALMS.

Frequency distributions of yields in lbs. of bunches for individual trees over the period 1922-28. Yields of 125 trees included for each year.

Bunch Yields in lbs. per Annum. Class Interval 15 lbs.	Number of Trees in each year whose yield in lbs. of bunches falls within limits of each class.							Total Frequency Distribution, 1922-28.
	1922	1923	1924	1925	1926	1927	1928	
361	—	—	1	—	1	—	—	2
346	—	—	—	—	—	1	1	2
331	—	—	—	2	—	—	1	3
316	—	—	—	1	1	—	—	2
301	—	—	—	1	1	1	1	4
286	—	—	1	2	1	—	—	4
271	—	—	2	—	3	—	—	5
256	—	—	—	1	1	1	4	7
241	—	1	—	2	—	1	3	7
226	1	—	4	2	2	1	4	14
211	2	3	3	6	—	—	1	15
196	4	1	2	6	3	—	3	19
181	9	1	4	11	7	4	8	44
166	2	2	7	7	5	7	7	37
151	8	4	8	8	9	6	9	52
136	8	11	10	6	12	4	12	63
121	6	10	12	11	7	11	13	70
106	9	15	8	4	9	6	5	56
91	12	11	8	11	5	17	9	73
76	10	15	19	9	8	11	8	80
61	10	18	15	10	8	12	9	82
46	16	15	9	7	15	7	9	78
31	13	9	4	8	8	14	11	67
16	5	6	2	4	10	9	5	41
0	10	3	6	6	9	12	2	48

TABLE NO. II.

PLOT 10—THICK-SHELLED PALMS.

Frequency distribution of yields in lbs. of bunches per annum for individual trees over the period 1922-28. Yields of 220 trees included for each year.

Bunch Yields in lbs. per Annum. Class Interval 15 lbs.	Number of Trees in each year whose yield in lbs. of bunches falls within limits of each class.							Total Frequency Distribution, 1922-1928.
	1922	1923	1924	1925	1926	1927	1928	
391	1	—	—	—	—	—	1	2
376	—	—	—	—	—	—	—	—
361	—	—	—	—	—	—	—	—
346	—	—	1	2	—	—	—	3
331	1	—	—	—	—	—	1	2
316	—	1	1	—	—	—	—	2
301	—	—	—	1	1	2	—	4
286	1	—	—	2	1	1	1	6
271	—	2	1	2	2	—	—	7
256	2	1	1	3	—	1	4	12
241	3	1	1	4	—	1	2	12
226	5	2	4	1	3	2	1	18
211	1	3	7	4	2	2	5	24
196	4	3	11	4	2	1	2	27
181	7	3	11	11	9	5	5	51
166	7	5	4	7	4	6	8	41
151	7	12	15	12	7	5	13	71
136	13	14	14	10	10	10	12	83
121	10	17	17	15	13	13	19	104
106	23	24	20	15	9	13	18	122
91	14	14	13	10	15	11	15	92
76	20	15	27	21	18	25	21	147
61	11	14	17	15	17	21	19	114
46	19	26	18	21	32	19	19	154
31	20	16	14	23	25	32	19	149
16	19	15	8	20	22	16	16	116
0	32	32	15	17	28	34	19	177

PLOT 11—TABLES A and B.

(Planted 25 Feet Square.)

TABLE A.

TWENTY THICK-SHELLED MANTLED PALMS.

1	2	3	4	5	6	7	8	9	10
Year.	No. of Bunches.	Weight of Bunches in lbs.	Average Weight per Bunch in lbs.	Weight of Fruit in lbs.	Average Weight of Fruit per Bunch in lbs.	Percentage Fruit Weight to Bunch Weight.	Average No. of Bunches per Tree.	Average Weight of Bunches per Tree in lbs.	Average Weight of Fruit per Tree in lbs.
Average per annum 1922-28 ..	188	2,129	11.3	1,298	6.7	52.5	9.4	106.4	64.9

FOUR THIN-SHELLED MANTLED PALMS.

Average per annum 1922-28 ..	39	378	9.7	128	4.3	39.5	9.7	94.5	32
------------------------------	----	-----	-----	-----	-----	------	-----	------	----

TWENTY-ONE THICK-SHELLED PALMS.

Average per annum 1922-28 ..	146	1,638	11.2	1,164	8.3	64	6.9	78	55.5
------------------------------	-----	-------	------	-------	-----	----	-----	----	------

SEVEN THIN-SHELLED PALMS.

Average per annum 1922-28 ..	60	693	11.5	412	7.3	54.5	8.6	99	—
------------------------------	----	-----	------	-----	-----	------	-----	----	---

TABLE B.

THICK-SHELLED MANTLED TYPE.

1	2	3	4	5	6	7	8
Year.	No. of Years since Plot Planted Out.	No. of Trees for which yields are included.	No. of Bunches per Acre.	Weight of Bunches per Acre in lbs.	Weight of Fruit per Acre in lbs.	Weight of Mesocarp Oil per Acre in lbs.	Weight of Kernels per Acre in lbs.
Average per annum 1922-28	7-13	20	654	7,408	4,517	919	333

THIN-SHELLED MANTLED TYPE.

Average per annum 1922-28	7-13	4	684	6,631	2,245	729	153
---------------------------	------	---	-----	-------	-------	-----	-----

THICK-SHELLED TYPE.

Average per annum 1922-28	7-13	21	485	5,438	3,865	544	316
---------------------------	------	----	-----	-------	-------	-----	-----

THIN-SHELLED TYPE.

Average per annum 1922-28	7-13	7	600	6,930	4,120	991	236
---------------------------	------	---	-----	-------	-------	-----	-----

PLOT 12—TABLES A and B.
(Planted 25 Feet Square.)

TABLE A.

SIX THICK-SHELLED GREEN-FRUITED PALMS.

1	2	3	4	5	6	7	8	9	10
Year.	No. of Bunches.	Weight of Bunches in lbs.	Average Weight per Bunch in lbs.	Weight of Fruit in lbs.	Average Weight of Fruit per Bunch in lbs.	Percentage Fruit Weight to Bunch Weight.	Average No. of Bunches per Tree.	Average Weight of Bunches per Tree in lbs.	Average Weight of Fruit per Tree in lbs.
Average per annum 1922-28 ..	40	1,031	26.0	707	19.5	62.5	6.7	171.8	117.8

SEVEN THIN-SHELLED GREEN-FRUITED PALMS.

Average per annum 1922-28 ..	49	884	18.2	615	12.3	57.5	7.0	126.3	87.9
------------------------------	----	-----	------	-----	------	------	-----	-------	------

TEN THICK-SHELLED PALMS.

Average per annum 1922-28 ..	58	1,266	21.9	946	15.8	62.5	5.8	126.6	94.6
------------------------------	----	-------	------	-----	------	------	-----	-------	------

FOUR THIN-SHELLED PALMS.

Average per annum 1922-28 ..	24	474	20.1	282	11.9	53.5	5.9	118.5	70.5
------------------------------	----	-----	------	-----	------	------	-----	-------	------

TABLE B.

THICK-SHELLED GREEN-FRUITED TYPE.

1	2	3	4	5	6	7	8
Year.	No. of Years since Planted Out.	No. of Trees for which yields are included.	No. of Bunches per Acre.	Weight of Bunches per Acre in lbs.	Weight of Fruit per Acre in lbs.	Weight of Mesocarp Oil per Acre in lbs.	Weight of Kernels per Acre in lbs.
Average per annum 1922-28	7-13	6	465	11,989	8,222	1,343	575

THIN-SHELLED GREEN-FRUITED TYPE.

Average per annum 1922-28	7-13	7	490	8,840	6,150	1,627	354
---------------------------	------	---	-----	-------	-------	-------	-----

THICK-SHELLED TYPE.

Average per annum 1922-28	7-13	10	406	8,849	6,614	991	575
---------------------------	------	----	-----	-------	-------	-----	-----

THIN-SHELLED TYPE.

Average per annum 1922-28	7-13	4	421	8,314	4,946	1,206	283
---------------------------	------	---	-----	-------	-------	-------	-----

APPENDIX II.

EXTRACTION PROCESSES.

Two extraction processes have been employed at Calabar. From 1923 until mid 1926 a modified washing process was in operation. This is described by Mr. Roebuck as follows :—

- (i) The fruits were placed in an iron pot, with a small quantity of water to prevent burning, and cooked until soft enough to be depericarped.
- (ii) The cooked fruits, after being beaten with pestles, were placed on an iron tray and the oil was washed out first with hot and then with cold water.
- (iii) The oil was allowed to rise to the surface of the receptacle containing the washings and was then skimmed off. These skimmings were placed on an iron pot and boiled and the oil skimmed off and weighed.
- (iv) The washings were sometimes allowed to stand overnight and the oil skimmed off again.

From mid 1926 till mid 1928 the Cooker-Press process (Barnes' II) was used. A mean extraction efficiency of 63·5 per cent. from Ibadan thick-shelled fruit is claimed for this process. The results given by the two methods are summarised in the attached table. Owing to the circumstances under which the extractions were made, a margin of error must be allowed, especially where only small quantities of fruit were treated. The percentages of mesocarp to fruit obtained by the washing process are probably more accurate than the corresponding figures for Cooker-Press extraction. In comparing the efficiency of the two processes on different types of fruit it will be seen that, while the increased yield of mesocarp oil due to the Cooker Press is over 50 per cent. in the case of the ordinary thick-shelled and green-fruited thick-shelled, the increase is about 100 per cent. for mantled thick-shelled and for all thin-shelled types.

TABLE NO. I.
RESULTS OF TWO EXTRACTION PROCESSES
PROCESS I.
DURING FIRST PERIOD—1923 TO MID 1926—BY MODIFIED NATIVE
WASHING PROCESS.

I	2	3	4	5	6	7	8
Type of Oil Palm Fruit extracted.	Plot.	Total Number of Extractions.	Average Weight of Fruit in lbs. treated per extraction.	Percentage of Weight of Mesocarp to Fruit by Difference.	Percentage Weight of Mesocarp Oil to Fruits.	Percentage Weight of Kernels to Fruits.	Percentage Weight of Dry Shell to Fruits.
Thick-shell ..	4	40	367	42.0	10.4	10.8	42.2
	6	47	573	44.0	11.2	10.8	41.2
	10	46	859	43.0	11.1	10.7	42.3
Thin-shell ..	4	45	76	62.7	14.5	6.5	22.4
	6	26	29	61.9	14.1	6.9	18.0
	10	37	45	63.7	13.8	7.6	17.9
Green-fruited, thick-shell ..	12	30	68	43.0	11.0	9.7	34.3
Green-fruited, thin-shell ..	12	30	45	62.0	16.1	7.1	21.0
Mantled, thick-shell ..	11	36	98	50.0	11.9	9.1	32.4
Mantled, thin-shell ..	11	33	13	50.5	13.5	6.3	18.6

PROCESS II.
DURING SECOND PERIOD—MID 1926 TO MID 1928—BY COOKER-PRESS
PROCESS.

Thick-shell ..	4	26	424	38.5	17.0	10.3	43.7
	6	27	679	38.0	17.6	10.0	43.0
	10	27	925	37.5	17.8	10.8	45.2
Thin-shell ..	4	26	106	57.5	27.7	5.6	21.7
	6	22	30	64.5	27.4	7.3	14.3
	10	25	51	62.0	27.8	6.8	15.7
Green-fruited, thick-shell ..	12	26	82	44.0	19.3	8.2	30.5
Green-fruited, thin-shell ..	12	25	49	65.3	32.0	7.1	13.9
Mantled, thick-shell ..	11	26	98	46.0	24.4	8.8	35.6
Mantled, thin-shell ..	11	25	18	56.8	30.2	6.1	15.7

APPENDIX III.

ANALYTICAL METHODS, AND CHARACTERS OF THE SELECTED PALMS.

Owing to the distance of Calabar from the laboratory at Ibadan, it was necessary to devise a rough method of field analysis to distinguish which of the trees selected on yield alone would be acceptable on relative percentages of mesocarp, shell and kernel. No great virtue or accuracy is claimed for the method itself, or for the sampling employed; but, in the hands of an unsupervised African assistant, it appears to have served its purpose. The method is as follows :—

1. Once the fruit has been separated from the bunch, it is placed in a box and, while being mixed by hand, about 5 lbs. of fruit are taken out. All unfertile fruits are disregarded. From the first sample 4 lbs. of fruit are then weighed out carefully on druggists' scales. All weighings during analysis are made to the nearest $\frac{1}{4}$ oz.
2. The 4-lb. sample is then cooked and washed to separate the mesocarp from the nuts. The nuts, which are wet from the washing, are then placed for a short time in the sun and are weighed when dry. The mesocarp is cooked and washed to separate the coarse fibre, the latter is also dried and weighed. The weight of mesocarp (plus exocarp) is obtained by difference, the weights of nuts and coarse fibre being added together and subtracted from 4 lbs. and the difference entered as weight of mesocarp.
3. As it is impossible to separate kernels from shell if the nuts are cracked at once, the nuts are now dried for about two days and then weighed again. The difference between the two nut weighings can only be recorded as a percentage loss and this slightly reduces the percentages for kernels and shells. Immediately after the second weighing the nuts are cracked and the kernels weighed. The shell weight is obtained by difference.

In Table I the results of some of these analyses are given. Characters of palms selected on yield and analysis are given in Table II.

TABLE No. I.

PERCENTAGES OF MESOCARP, COARSE FIBRE, SHELL AND KERNEL OBTAINED BY THE ROUGH METHOD OF FIELD ANALYSIS DESCRIBED FOR CERTAIN INDIVIDUAL TREES.

Type.	Tree No.	No. of 4-lb. Samples taken.	Percent. Mesocarp.	Percent. Coarse Fibre.	Percent. Shell.	Percent. Kernel.	Percent. Loss.	Remarks.
Okporo. Ordinary thick-shell type.	68	4	31.4	3.1	46.9	14.8	3.6	Discarded.
	97	3	40.3	4.1	36.9	15.5	3.2	Discarded.
	41	3	45.2	3.5	30.7	16.9	3.6	—
	120	3	36.3	4.3	41.2	15.0	3.1	Discarded.
	222	3	47.5	5.7	32.6	10.7	3.5	—
	224	3	46.8	2.3	35.7	11.7	3.5	Discarded.
	233	5	47.1	4.8	33.6	11.6	2.9	—
	234	2*	40.9	4.4	36.6	14.5	3.5	Discarded.
	256	2	52.2	4.3	31.2	10.3	1.9	—
	703	3	45.8	3.4	33.0	14.1	3.6	—
	765	2	32.6	3.1	49.6	10.0	4.7	Discarded.
Osok. Ordinary thin-shell type.	244	3	62.1	6.0	20.6	8.2	3.2	—
	339	2	62.5	7.6	16.0	9.2	4.7	—
	340	2	61.1	4.3	21.9	9.7	3.0	—
	387	5*	66.6	3.3	13.8	13.2	3.0	—
	416	3	76.4	6.1	7.8	8.8	0.9	—
Afia-Oku. Green-fruited, thick-shell type.	341	2	53.3	3.9	28.8	10.8	3.1	—
	371	4	36.3	2.9	46.0	11.2	3.5	Discarded.
	375	2	50.2	3.1	31.2	12.1	3.2	—
Afia-Oku. Green fruited, thin-shell type.	366	2	65.8	4.7	16.4	7.6	5.5	—
	373	4*	57.9	3.3	22.4	12.2	4.2	—
	384	2	58.3	2.9	24.6	11.1	3.0	—
Ayara Mbana. Mantled, thick-shell type.	261	3	57.0	7.6	22.5	10.2	2.5	—
	262	4	54.3	6.3	27.1	8.7	3.5	—
	268	3*	53.1	7.0	27.4	9.0	3.5	Discarded.

Note.—An asterisk in the third column denotes that one of the samples was less than 4 lbs. in weight.

TABLE 4.—PLOT A.—CULTIVATED.

Year.	No. of Bunches.	Weight of Bunches lbs. per acre.
1924 (6 months)	25	374
1925	109	1,434
1926	147	2,041
1927	176	2,806
1928	167	2,630
1929 (9 months)	212	3,344

TABLE 5.—PLOT D.—UNCULTIVATED.

Year.	No. of Bunches.	Weight of Bunches lbs. per acre.
1924 (6 months)	8	114
1925	69	795
1926	39	399
1927	42	480
1928	17	213
1929 (9 months)	—	—

Thus it will be seen that while clearing and cultivation do not appear to have increased the yield at Odumase materially, at Anaji the yield has been greatly increased over the whole period.

TABLE NO. II.

YIELDS AND PARTICULARS OF THE SELECTED TREES.

Type.	No. of Tree.	Height in feet.	Yield in Bunches— period 1922-28 inclusive.				Average Weight produced in lbs. of Fruit per annum.	Percentage Fruit Weight to Bunch Weight.
			Total No. of Bunches.	Total Weight in lbs.	Average Weight per Bunch in lbs.	Average Weight produced in lbs. of Bunches per annum.		
Okporo. Ordinary thick-shell.	141	10.0	44	778	17.7	111	97	65.0
	222	16.0	47	1,417	33.7	202	134	67.5
	224	17.5	58	1,300	22.4	186	139	66.5
	233	16.0	56	1,675	29.9	239	136	61.5
	256	14.5	99	1,533	15.5	219	159	63.5
	703	14.0	61	1,983	32.5	283	218	69.5
	706	13.0	47	1,277	27.2	182	105	63.5
Osok. Ordinary thin-shell.	200	14.0	35	1,139	32.6	163	72	52.0
	244	12.0	73	1,245	17.1	178	99	53.5
	339	10.0	55	1,262	22.8	180	97	49.0
	340	13.0	33	1,046	31.7	149	80	57.0
	387	2.0	45	527	11.7	176	103	54.5
	416	19.5	30	557	18.6	80	52	55.5
	770	9.5	44	633	14.4	90	55	60.0
Afia-Oku. Green-fruited, thick-shell.	341	10.0	47	1,275	27.1	182	128	69.5
	375	15.0	52	2,105	40.5	301	157	59.5
Afia-Oku. Green-fruited, thin-shell.	366	14.0	51	962	18.9	137	85	60.0
	373	10.0	48	1,269	26.4	181	108	58.5
	384	7.0	63	1,042	16.5	149	103	59.5
Ayara Mbana. Mantled type, thick-shell.	261	13.5	105	1,197	11.4	171	126	61.5
	262	17.0	69	1,117	16.2	160	85	48.5
Ayara Mbana. Mantled type, thin-shell.	292	12.5	104	1,125	10.8	161	77	39.5

Note.—1. Tree 387 is a young tree which commenced to bear in 1926.

2. The figures given in the last two columns for average fruit weight and percentage fruit weight to bunch weight are calculated on—

Two years' results—1926-27 for tree 387

Three " " 1924 and 1926-27 for trees 141, 200, 222, 224 and 233.

Four " " 1924-27 for the rest of the trees.

The yield of fruit in 1928 has been excluded, due to the interference caused by Selang.

PAPER No. XVII.

**IMPROVEMENT OF SMALL PRESS PROCESS FOR
PALM OIL EXTRACTION.**

BY D. MANLOVE AND W. A. WATSON (NIGERIA).

The main objects in the work of evolving a small scale process for the native were to provide a means, other than central mills, of producing edible oil of the highest quality and to extract a larger proportion of the oil in the fruit than the native can do by his "soft" oil method. It was essential that the process should not be more laborious than the native process, and for real success it needed to be less laborious. Thus we wanted better oil than the native hard process yields; more oil than the native soft oil process yields; less labour than at least the soft oil process takes; and a minimum of expensive apparatus.

Barnes seems to have come to the conclusion that there was no scope for hand operated machinery in dealing with the problem. Thus he says in his "Mechanical Processes for the Extraction of Palm Oil," Second Bulletin, Agricultural Department, Nigeria (page 58), "The advantages of hand operated machinery for the extraction of palm oil over the crude native methods are not sufficiently obvious even to the educated native to encourage the adoption of small scale mechanical processes. Experimental work indicates that the yields of oil to be obtained by hand plant are little if any higher than are obtainable by a method which can be worked by the native with no apparatus apart from that made by himself, unless very special care be taken."

The "Cooker Press" at the stage Barnes left it was far from perfect. True it yielded the better oil that is desired, but had the following weaknesses:—

- (1) While it gave a fairly satisfactory high extraction from fruit with thick pericarp, when the fruit was poor it gave no more than the soft oil process.
- (2) It was too laborious because, firstly, the process of picking the nuts from the mashed but unpressed fruit was most tedious and secondly there was the double labour of transferring the fruit from a pot to a mortar, where it cooled and had to be reheated in the pot. Incidentally this was a very wasteful method.
- (3) The Cooker itself was too elaborate and expensive. It was also designed to provide for heating the fruit without the addition of much moisture. Such an addition was found to be essential for efficiency.

We have for some months been trying to overcome these objections to Barnes' process and to satisfy ourselves whether or not it was possible to improve the existing methods to a notable degree.

The first objection to Barnes' method, namely the inability of the process to cope with poor fruit, was met by the addition of water during the mashing of the fruit. The idea of doing this occurred after some experimenting in altering the fibre to nut ratio in the mashed fruit before supplying it to the press. By picking out only a certain proportion of nuts it was thought a ratio of fibre to nut might be reached more akin to the best fruit, which would make possible a satisfactory pressing. This, however, proved impracticable; it was impossible to avoid a heavy loss from oil adhering to the nuts and from the oily fibre adhering to them. In no case did the result make us feel any confidence in advocating the use of such a method by the native.

It seemed to us essential to supply the mashed fruit to the press in such a condition that the presence of the nuts did not prevent the bulk of the oil being obtained by the first pressing. The addition of water as such had apparently been regarded with little favour. Still, if properly introduced, it might be capable of rendering the oil more "free." The mashed fruit was therefore steamed in the cooker till, on withdrawing, it appeared to be thoroughly moist. Employing fruit so treated, the pressing results showed a marked improvement on any previous trials. The oil flowed freely from the press on applying the lightest pressure. Along with it came, as was to be expected, a certain amount of free water from which the oil could be readily separated by settling and skimming. The nuts in the remaining cake were so well "washed" by the water as to be almost oil free. The bulk of the oil is obtained in the first pressing but it is worth while to give a second pressing of the nut-free fibre. The fibre can be readily separated from the nuts if the mixture be spread out for a time to dry.

Regarding the addition of water, it is interesting to note that in factory treatment of fruit the prevention of the addition of water was long believed to be essential to good working. This idea was embodied in the "dry" process. More recently the factories, like ourselves, seem to have come to the conclusion that addition of water is necessary for efficiency.

The second objection to Barnes' working—that it was too laborious—has to a large extent been obviated by the method described. There is, however, still room for improvement as it is felt that the labour in picking the nuts from the pressed fibre, though admittedly less than before, is still too great; especially when one considers the comparatively small proportion of oil that is yielded by the second pressing (of nut-free fibre). The waste of effort in transferring the fruit to the mortar and thus letting it

cool was solved by mashing the fruit in the pot it is boiled in. If the fruit has been well boiled the mashing need not be vigorous to separate the pulp from the nut.

The last objection to the "Cooker-press" process was the elaborate cooker designed to steam the fruit. This is a luxury for the native in its present form. The steaming of the fruits would have to be done by him in pots. As the mashing is most conveniently done in the vessel in which the fruit is being steamed, the native earthenware pot is not satisfactory for this purpose. At present cast iron pots are being used but it may be that small steel drums will prove more suitable.

In practice it is found that thorough mashing of the fruit is necessary if a high yield of oil is to result. The greater quantity of the water used in boiling the fruit is left in the pot during the mashing. The mashed fruit can absorb considerably greater quantities of water than the unmashed; more hot water may be added as the mashing proceeds. The optimum proportion of water to use in steaming the pulp is uncertain, but in practice it seems that there should be enough to ensure that when the mass is added to the press cage a flow of oil commences before applying any pressure.

By the use of this method an increase over the native yield of oil of 35-40 % has been regularly obtained, and this figure has frequently been exceeded.

TYPICAL RESULTS IN COMPARING OUR METHOD WITH THE
NATIVE METHOD.

Place.	Weight of Fruit.	Our Yield of Oil.	Native's Yield.	Per cent. increase over Native Results.
Loburo	385 lbs.	59.3 lbs.	41.5 lbs.	43 %
"	412 "	66 "	49 "	35 %
Papalanto.. ..	337 "	51.5 "	35 "	47 %
Arigbajo	375 "	54.8 "	37 "	49 %

In these trials the "native extraction" was carried out by villagers themselves by the soft oil method.

The process as it stands is believed to give a better oil than the soft oil process. It is also less laborious and, as we have seen, yields much more oil. As compared with the hard oil process it is, however, less obviously an improvement. In districts such as

the South of Ondo Province, where quantity rather than quality is the first consideration, the extra labour of our process as against the hard oil method is a serious handicap against its adoption by the professional oil-makers.

In our efforts to introduce the new process we are therefore at the moment confining our attention to soft oil districts, though not necessarily to districts where the fruit is poor. The method has been tentatively tried in the Eastern Provinces where "richer" fruit is found and there it appears to be entirely satisfactory. At the same time, we have not given up hope of introducing the method into hard oil districts, even if we are not able notably to improve it. It may be that its adoption may be brought about by making the production of soft oil more economically attractive. The payment of a substantial premium on press-made oil might have this effect.

In our efforts to popularise the method in the soft-oil districts some progress has already resulted, and with the approach of a new season further efforts will be made to see if by this means a real contribution can be made to meet what has come to be regarded as the "Eastern Menace."

PAPER No. XVIII.

A BRIEF NOTE ON THE PROGRESS OF OIL-PALM INVESTIGATIONS IN SIERRA LEONE.

BY D. W. SCOTLAND AND F. J. MARTIN (SIERRA LEONE).

In 1919 a Conference was held in London to consider some common, or co-ordinated, scheme of investigations regarding the oil-palm and its products, which should be carried out by and on behalf of the West African Colonies. The members of the Committee included the Directors of the various Agricultural Departments, and the Chairman was Dr. A. W. Hill (then Assistant), Director of the Royal Botanic Gardens, Kew. Unfortunately, the scheme recommended by this Committee never came into existence, but fortunately certain "lines of investigation" were suggested, and it has been possible to carry on slowly with some of this work.

At N'jala, Sierra Leone, plantations of different kinds of selected palms from the various Colonies have been made. These were not all laid down at once, but from year to year as time and money allowed. These plantations are described in detail below.

NIGERIAN OIL-PALM PLANTATION.—The area of this plantation is 4.4 acres. It was planted in 1920-1921, the trees being spaced 24 feet by 24 feet on the quincunx or alternate planting system. The seed was obtained from the Director of Agriculture, Southern Provinces, Nigeria, from trees which were reputed to be of the thin shelled type, which is called by the natives *Osoh-Eyop*. The seed did not breed true to type, but gave thick and thin shelled types, intermediate types, fruits with no shell and mantled fruits. The numbers of each type are as follow:—

Thick shelled	153
Thin shelled	139
Medium shelled.. ..	15
Shell-less	5
Mantled	2
Undetermined	21

The yields from the plantation compare favourably with the figures given by M. Ives Henry for plantation yields in Sumatra. The average figures for the whole plantation are :—

Year.	Age of Plantation (years).	Yield per acre, thin shelled type. Lbs.			Yield per acre, thick shelled type. Lbs.		
		Fruit.	Oil.	Kernels.	Fruit.	Oil.	Kernels.
1926	6	1,514	550	129	1,767	440	212
1927	7	2,492	905	212	2,995	745	359
1928	8	2,719	987	231	3,656	914	440

This being the oldest plantation at N'jala, more work has been carried out on it than on any of the others. A complete record of this work is given in a paper by Mr. F. C. Deighton (Mycologist, Sierra Leone),* from which it will be seen that the yields from the individual trees vary greatly and that those with high yields are the most promising trees to breed from. It will also be seen that the ratio of fruit to stalk varies and this appears to be due to the degree of fertilization, which, among other things, is affected by the length of spines on the fruit heads. Blind heads occur regularly; this may possibly be due to imperfect fertilization and may be associated with the climatic conditions prevailing at certain seasons of the year. There is little doubt that we must be fully informed as to the conditions affecting the extent of natural fertilization and be prepared to supplement this if and when necessary. There is a definite periodicity in the yields obtained from this plantation, the maximum yields being in March-May, while there is a small increase in August-October. The factors governing this are as yet unknown.

KAWEI OIL-PALM PLANTATION.—This is a Sierra Leone variety with a thick shell. The plantation, which is two acres in extent, was laid out in 1924, the palms being spaced 24 feet by 24 feet. The first small fruit-heads appeared in November, 1927, and a few more palms fruited in 1928. They are now coming more generally into bearing, although the yields are still small.

HENOI OIL-PALM PLANTATION.—This is a thin shelled Sierra Leone type. The area is $1\frac{1}{2}$ acres and the plantation was laid down in 1924. Like the Kawei, this plantation started to bear in 1927, but the yields are still small.

* Bulletin No. 7, Agriculture Department, Sierra Leone.

KPOLEI OIL-PALM PLANTATION.—This is another thin shelled type found in Sierra Leone. The area of the plantation in this case is one acre and the plantation was laid out in 1925. The palms started to bear in January, 1929, but only a few trees and those had very small heads.

ANGOLA OIL-PALMS.—Only six of these palms have been obtained, but these have been set out separately from the others. They were planted out in August, 1926, and the fruit palms started to bear in November, 1928.

SUMATRAN OIL-PALM PLANTATION.—A plantation containing two different strains of Sumatran oil-palms was established during the present year at N'jala. In this case the seeds were obtained from known parent stock. One lot of seeds was from T.G. 113 and is a very good type, while the other, T.G. 115,* is said to be an exceptionally fine and heavy yielding palm. It is hoped that with trees of this parentage a very fine strain of palms will be obtained. It is realized, however, that this strain may not do as well in West Africa as it does in the East.

TUGBOI OIL-PALM PLANTATIONS.—Tugboi is the "*pisifera*" or so-called seedless type. Actually the seed is very tiny and the shell reduced to a soft, fibrous mass. There is a variation in this type from the seed with a microscopic kernel and very little fibre to the seed, as big as a pea with a soft shell. Some difficulty was experienced with germination, but eventually enough seeds were germinated to plant up about seven acres at Gorahum and one acre at N'jala. Tugboi seedlings have been transferred to N'jala and will be planted out early in 1930. Some of the Gorahum palms were planted out in 1927.

DIWAKKA-WAKKA OIL-PALMS.—Owing to the good reports of the performance of this type of palm in the Cameroons a quantity of seed has been obtained and arrangements have been made for establishing a plantation of this variety. This is the well-known "mantled" type, the calyx as well as the fruit being fleshy and oil bearing.

This completes the roll of the oil-palm plantations at N'jala. The object of them is to test certain points, including comparative yields, percentages breeding true to type, quality of fruit and variation of yield with the seasons. An opportunity is also provided for the selection of high yielding palms for future breeding experiments should the staff at any future date be augmented sufficiently to allow of this.

* The yields of clean fruit from this palm were as follows :—

1923-1924	..	347	lbs. of fruit with 72 per cent. of pericarp.
1924-1925	..	119	" " 70 " "
1925-1926	..	341	" " 71 " "
1926-1927	..	419	" " 69 " "

PLANTATION ON COMMERCIAL SCALE.—In view of the importance* of the oil-palm in the economic life of this Colony it has been decided to demonstrate the possibilities of the exploitation of the oil-palm along plantation lines. An area of some 2,200 acres has been obtained for this purpose, and is now being planted up with local and imported varieties of palms. The varieties include Hanoi, thin and thick shelled Nigerian types, Sumatran types and Diwakka-wakka. Some 500 acres have already been planted and nursery arrangements have been made for planting to continue at the rate of at least 500 acres a year. In carrying out this demonstration the opportunity has been taken to find out the most suitable spacing distances for the various types, and distances varying from 25 to 30 feet are being tried.

CULTIVATION OF WILD STANDS.—In order to demonstrate the value of cultivating the wild palm stands, small demonstration plots, each of about five acres in extent, have been established in different parts of the Protectorate. These plots are situated as near as possible to important towns, so that they may be more readily seen by native visitors to trading and other centres. The palms are thinned out to about 70 to the acre and vacant spaces are planted up with young palms. It is hoped that this will interest the native in cleaning and tending his own palms and also provide the Department with useful information.

CONCLUSION.—It will be seen that much work is being carried out on this problem. Young plantations of different varieties are now coming into bearing, a plantation of commercial proportions has been started, and small blocks of wild palms are being cultivated for demonstration purposes. Unfortunately we have not got the scientific staff to deal effectually with the material which is available, and while it will be possible to record the yields of the various plantations, there is no botanical staff to deal with the various and pressing botanical problems. So far as this Colony is concerned, there appears to be no possibility of a suitable botanical staff being employed for this purpose, and a great part of the value of these plantations, will be lost. In Sierra Leone we should be prepared to accept the results of investigations in other West African Colonies, but so far as can be ascertained from the records forwarded to this Colony there is apparently no Colony where fundamental research on oil-palms is being carried out. There is an urgent need for such work and we suggest that this Committee should explore the situation with a view to forwarding a resolution for the consideration of the General Sessions of the Conference.

* Oil-palm products often exceed 75 per cent. of the total domestic exports.

PAPER No. XIX.

STATEMENT ON OIL PALM INVESTIGATIONAL
WORK IN THE GOLD COAST.

By T. L. WILLIAMS (GOLD COAST).

This Memorandum is intended to give (i) a short sketch of the work in hand on oil palms at the present time (ii) a brief summary of the results to date. The investigational work on oil palms in the Gold Coast is now carried on at two centres, Odumase, in the Krobo Oil Palm area of the Eastern Province, and Anaji, near Sekondi. The work is in the charge of the Division of Botany.

GENERAL PLAN OF THE STATIONS.

In both cases wild stands of palms were taken and part of the area cleared of the surrounding bush. The palms are being thinned out to between 60 and 70 per acre and young palms planted in the gaps. The remaining area at each station is divided into two parts, one being untouched, and the fruit from the other being harvested with as little disturbance to the plot as possible. The areas at the two stations are as follows:—

<i>Odumase</i> —Plot A	Cultivated	..	10	acres.
„ B	Uncultivated	..	5	„
„ C	Not harvested	..	5	„
<i>Anaji</i> —Plot A	Cultivated	..	50	„
	Plots B			
	and D	Uncultivated	..	40 „ (each 20 acres.)
	Plot C	Not harvested	..	20 „

GENERAL DESCRIPTION OF THE INVESTIGATIONAL
WORK.

A.—The following yields are recorded:—

- (i) Bulk yields of all varieties for each plot—at Odumase these are subdivided into different varieties.
- (ii) At Odumase the yields from all the trees of different height classes (0–6 ft., 6–12 ft., 12–18 ft. and above 18 ft.) are taken separately. At Anaji this record is taken on 50 trees in each class.
- (iii) Individual yields of 60 marked trees of different varieties have been taken at Odumase since 1924 and of 20 trees at Anaji. The number of trees that are being individually recorded was increased considerably in 1928.

- B.—Experiments to find a quick and reliable method of germination.
- C.—Breeding and Selection work.
- D.—Approximately 40 trees at each station have their rate of leaf formation measured at quarterly intervals in order to determine the rate of growth at different ages, etc.

VARIETIES IN THE GOLD COAST.

The varieties commonly grown in this Country are described by F. N. Howes (2) and G. G. Auchinleck (1). The two common types Abepa and Abetuntum are very similar in every way and many examples of intermediate types are known. Abedam is also very similar except as regards colour which is green until ripening when the colour changes to a light brick red. The thin shelled palms, Abobobe or Adibe are of similar type to the thick shelled varieties, except as regards thickness of shell which itself varies greatly.

Diwakkawakka or Klode (Ewe)—the mantled form—is rare in the Colony.

Abehene or King Palm is probably only a teratological form and no palm of this type with mantled fruit has been seen or definitely reported.

A certain number (about 50 in all) of Deli palms from Sumatra are planted out on various experiment stations and will shortly be coming into bearing.

Comparing these types with the types described by Smith (3) and also by Deighton (4) it would appear that, as is to be expected, there is great similarity between the types found in the various Colonies.

RESULTS.

In the following paragraphs a brief summary is given of the results obtained so far. The full analyses of the yields, etc., will be given in a paper to be published in the 1929 Year Book of the Department of Agriculture.

I. BULK YIELDS.

(a) *Odumase*.—The bulk yields for plots A and B are given in Table 1, expressed as weight of bunches per acre and also the weight of fruit per acre. This latter figure is in most cases obtained by calculation, the average percentage of fruit per bunch having been found to be 58.2 per cent. The number of plots is also given.

TABLE 1.—PLOT A.—ODUMASE.

Year.	No. of Bunches per acre.	Weight of Bunches lbs. per acre.	Weight of Fruit lbs. per acre.
1924	261	2,192	1,359
1925	1,086	14,956	8,147
1926	834	16,528	9,619
1927	303	5,479	3,188
1928	168	3,061	1,781
1929 (8 months) ..	183	3,410	1,984

TABLE 2.—PLOT B.—ODUMASE.

Year.	No. of Bunches per acre.	Weight of Bunches lbs. per acre.	Weight of Fruit lbs. per acre.
1924	354	2,509	1,460
1925	1,801	17,536	10,204
1926	595	7,556	4,397
1927	351	3,439	2,001
1928 (8 months) ..	234	3,489	2,030

It will be noted that the yields of fruit per acre in 1925 and 1926 are at an almost incredible level. The station was in charge of an African Overseer and immediately these yields went up every step was taken to check up the recording, and two other Overseers were placed in charge at different periods. No errors were found, and it will be seen that comparable increases are shown for plots A and B, and also for the varieties classified separately as well as for the height class yields.—See Table 3 below. These figures are very much higher than any other yield figures published even for palms planted out in plantations in Sumatra and also the fluctuations from year to year are very great—it will be noted that for 1929 the yield is in the up grade again. These figures are shown in Graph 1.

It is probable that the yields are not correct in spite of the fact that no errors have been detected and the figures are put up merely for discussion.

TABLE 3.—HEIGHT YIELD RECORDS.—ODUMASE.

Year.	No. of Bunches per acre.	Weight of Bunches lbs. per acre..
Trees up to 6 ft. high.		
1924	85	757
1925	354	4,178
1926	258	4,424
1927	116	1,513
1928	69	916
1929 (8 months)	73	1,239
Trees 6-12 ft. high.		
1924	75	651
1925	354	4,421
1926	315	6,268
1927	80	1,669
1928	56	1,042
1929 (8 months)	50	1,056
Trees 12-18 ft. high.		
1924	54	426
1925	239	3,843
1926	181	4,643
1927	55	1,326
1928	27	628
1929 (8 months)	37	894
Trees above 18 ft. high.		
1924	30	242
1925	160	2,523
1926	85	1,894
1927	45	1,094
1928	29	742
1929 (8 months)	29	561

Unfortunately no record was taken each year of the number of trees in each height class (a count is at present being undertaken), and these figures are given in order to show that their fluctuation is similar in each height class each year.

(b) *Anaji*.—The figures from this station are quite different to those from Odumase and are of a very much more normal type.

Yields of Cultivated Oil Palm Plots.

(Pounds of Bunches per acre)

ODUMASE (PLOT A) ———

ANAJI (PLOT A) - - - -

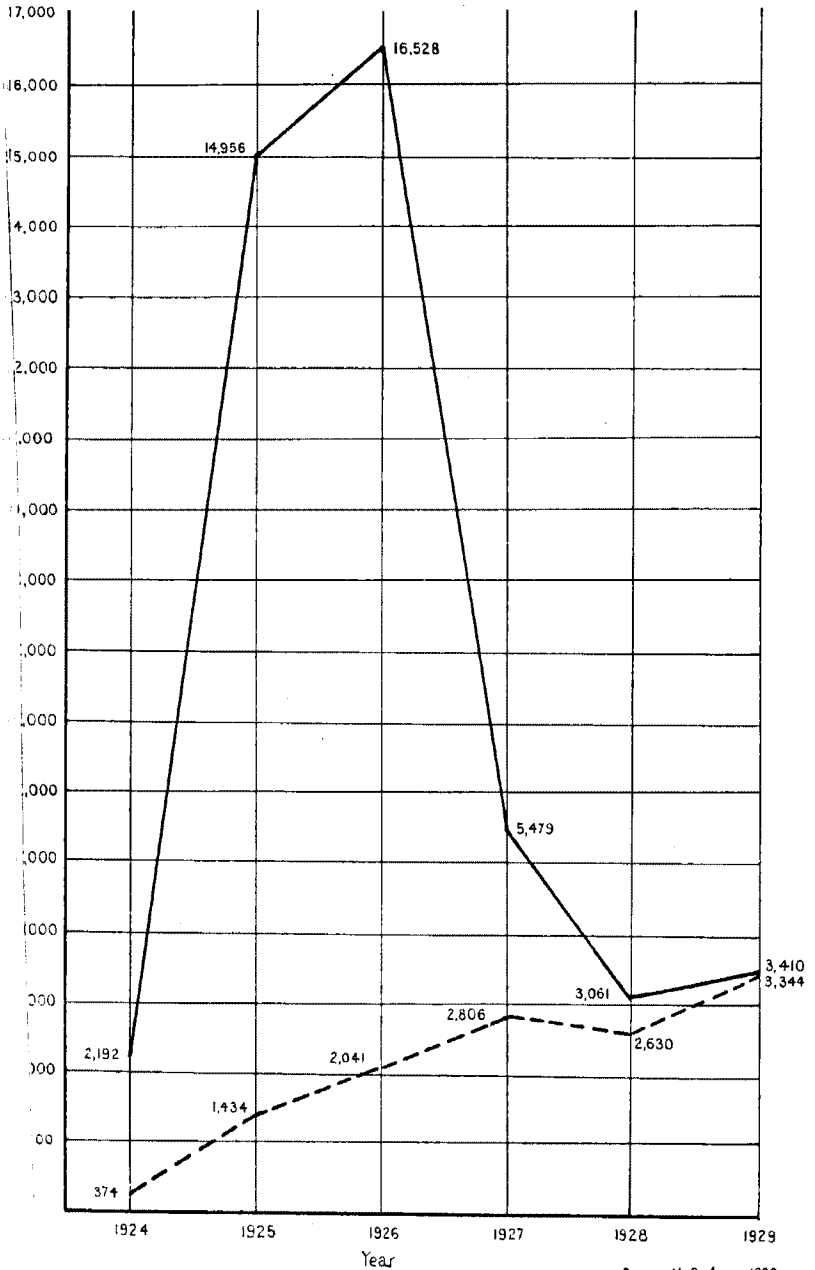


TABLE 4.—PLOT A.—CULTIVATED.

Year.	No. of Bunches.	Weight of Bunches lbs. per acre.
1924 (6 months)	25	374
1925	109	1,434
1926	147	2,041
1927	176	2,806
1928	167	2,630
1929 (9 months)	212	3,344

TABLE 5.—PLOT D.—UNCULTIVATED.

Year.	No. of Bunches.	Weight of Bunches lbs. per acre.
1924 (6 months)	8	114
1925	69	795
1926	39	399
1927	42	480
1928	17	213
1929 (9 months)	—	—

Thus it will be seen that while clearing and cultivation do not appear to have increased the yield at Odumase materially, at Anaji the yield has been greatly increased over the whole period.

2. INDIVIDUAL YIELDS.

Particulars of the yields of the best individually recorded trees over a period of $4\frac{1}{2}$ years are given below in order to have a basis of comparison with the Nigerian yields as given by E. H. G. Smith.

These trees were selected entirely at random and there is little doubt that these yields will be exceeded by some of the trees on which recording was commenced in 1928.

Variety.	Total Yield in Bunches. Lbs.	Average Yield per Year.	Total No. of Bunches.	Average No. per Year.	Weight per Bunch Lbs.	Fruit as per cent. of Bunch.
ODUMASE.						
Abepa No. 1	937 $\frac{1}{2}$	197 $\frac{1}{2}$	37	7.7	25.3	61.2
Abetuntum No. 14	883 $\frac{1}{2}$	186	38	8.0	23.3	59.1
Abetuntum No. 20	812 $\frac{1}{2}$	171.1	45	9.5	18.1	48.5
Abedam No. 8	812 $\frac{1}{2}$	171.1	35	7.4	23.2	45.1
Abodam No. 7	728 $\frac{1}{2}$	152.2	34	7.2	21.4	48.8
ANAJI.						
Abetuntum No. 5	576	128.0	40	9.9	14.4	—
Abepa No. 2	433	96.2	19	4.2	24.1	—
Abepa No. 3	419	93.1	18	4.0	23.1	—
Abedam No. 12	412	91.6	25	5.5	16.5	—
Abetuntum No. 4	404	89.8	26	5.8	15.5	—

It will be noted that these yields whilst fairly good are not as high as those mentioned in E. H. G. Smith's report on the oil palm at Calabar.

BREEDING AND SELECTION.

This work has not reached a very advanced stage as yet. The object is to produce a high yielding type of palm with a high percentage of pericarp oil, both by means of cross and self fertilisation. Crosses have been made between high yielding thin shelled types and the higher yielding thick shelled types and both these types are also being self fertilised. Selection of parent trees to date has been based mainly on the gross yield of bunches from 1924-1928, the percentage of fruit to bunch also being taken into

consideration. The technique of pollination used has been that of Hill and Mason (5) with minor modifications (7). A certain number of trees have been bagged but not pollinated to act as a control and the results show that the method is satisfactory.

GERMINATION EXPERIMENTS.

Various methods of planting and heat treatments have been tried. Whilst the experiments are not yet concluded, certain facts are already apparent :—

- (a) Treating by heat as recommended by Rutgers (6) has resulted in almost total failure.
- (b) Soaking in cold water for a fortnight hastens germination.
- (c) Both trenches with the nuts heaped up in them and planting out in beds have been tried and so far there does not appear to be very much difference as long as both are kept well watered.
- (d) Depth of planting is very important as regards time taken for germination. Deep planting, as would be expected, delays the development of the seedling.
- (e) Planting the whole bunch intact appears to give a satisfactory germination percentage within a reasonable time.

RATE OF LEAF FORMATION EXPERIMENT.

This experiment has not proceeded long enough for any accurate results to be obtained but the average number of leaves formed by trees of medium age appears to be about 28 per annum.

REFERENCES.

- (1) Auchinleck, G. G., "Notes on Structure and Classification of Oil Palm Fruit." Year Book, 1926.
- (2) Howes, F. N., "Extracts from Report on Oil Palms at Odumase." Year Book, 1926.
- (3) Smith, E. H. G., "The Oil Palm at Calabar." Second West African Agricultural Conference. Paper No. XVI herein.
- (4) Deighton, F. C., "Report on the Nigerian Oil Palm Plantation at Njala." Sierra Leone. Bulletin No. 7.
- (5) Hill, A. G. G., and Mason, T. G., "Pollination of the Oil Palm." Fourth Annual Bulletin of Agricultural Department, Nigeria.
- (6) Rutgers, A. A. L., "Investigations on Oil Palms." Medan. 1922.
- (7) Williams, T. L., "Programme of Economic Botanical Work." Year Book, 1928.

PAPER No. XX.

A BANANA INDUSTRY FOR THE GOLD COAST.

BY W. C. FISHLOCK (GOLD COAST).

The idea of establishing an export industry in bananas for the Gold Coast Colony is not a new one. It was put forward by the writer of the present paper in a pamphlet (1) read at a meeting of business men in Winchester House, London, in October, 1924. The writer also advocated the establishment of an industry in bananas in a short article (2) which was published in the Journal of the Gold Coast Agricultural and Commercial Society. The establishment of such an industry in West Africa has also been referred to elsewhere, for example, in the Report of the Imperial Economic Committee (3), Third Report—Fruit, and in the Tropical Agriculturist (4).

II. BRIEF REVIEW OF THE BANANA INDUSTRY.

Fawcett (5) records that late in the '60's. of the last century planters in Jamaica "Woke up to the fact that bananas could be most profitably grown there." The enterprise of the Boston sailor, Captain L. D. Baker, was, however, the chief factor in the astonishing growth of the banana trade. In "The Story of the Banana" (6), it is recorded that in 1870 a few bunches of bananas were brought into Boston from Jamaica by schooner, this shipment was probably made by the Captain Baker referred to by Fawcett.

From these small beginnings the industry has developed into a vast and very highly organized one. The extent of it is shown by the fact that, in 1928, 12,967,000 bunches were imported into the United Kingdom, and no less than 64,300,000 bunches were imported into the United States of America in the same year. The larger steamers engaged in the trade carry about 70,000 bunches as a full load; the import figures quoted therefore show that over 185 full steamer loads were imported into the United Kingdom in 1928, and over 918 full steamer loads into the United States of America during the same year. The imports of bananas into the United Kingdom for the period 1924-1928 are shown in a tabular form (Appendix I).

It is worthy of note that, from the numbers of bunches quoted and values, the average value of Jamaica bananas was, in round figures, 6s. 6d. per bunch, while the average value of Canary bananas, again in round figures, was 14s. 6d. per bunch. This is significant, and will be referred to later in the paper.

The imports into the United States of America in 1928 were nearly five times the quantity imported into the United Kingdom, or about twice the quantity per head of population. The imports into the United Kingdom were at the rate of one bunch per 3.39 head of population, while imports into the United States of America were at the rate of one bunch per 1.71 head of population. Of the 62,547,000 bunches imported into the United Kingdom during the five years 1924-1928, 80% were of foreign origin and 20% from British Possessions.

The importation of bananas into the United Kingdom was formerly chiefly in the hands of one firm, and it has been suggested that the market in the United Kingdom was "rationed," *vide*, Report of the Imperial Economic Committee (3) already referred to.

During recent years some of the leading planters and business men in Jamaica have formed a Co-operative organization, known as "The Jamaica Producers' Marketing Company, Ltd." This organization runs a line of steamers carrying bananas to the United Kingdom. The writer is informed that the venture has been "enormously successful," and that it is probable the Company will have to seek supplementary sources of supply, which they would prefer to be within the Empire. They are of opinion that the Gros Michel variety would be the best for the purpose.

The third Report of the Imperial Economic Committee (3) states that there is an increasing demand for bananas on the Continent of Europe. The increased demand appears to be for Canary bananas, and the Committee express the view that this increased demand for Canary bananas may reduce the supplies from this source for the United Kingdom.

III.—JAMAICA AND THE BANANA INDUSTRY.

It has already been noted that the export of bananas from Jamaica commenced about 1870, in a very small way. From this Island, with an area of 4,200 square miles and a population of 863,000, 22,000,000 bunches, valued at £2,365,464 were exported in 1927, a considerable proportion being produced by peasant growers of African descent.

The approximate average price paid per bunch near points of production was 3s.

Of the 22,000,000 bunches exported from Jamaica in 1927, 1,971,000, or a little under 9% went to the United Kingdom.

IV.—YIELDS AND MONEY RETURNS IN JAMAICA.

Fawcett, in his work already referred to, states that "the yield ought to be 225 to 230 payable bunches per acre, and, taking the contract price all the year round at £8 15s. od. per 100, the receipts would average £20 per acre."

H. Q. Levey (7) quotes as follows:—

“Gross receipts from 3 acres, £97, or at the rate of £32 6s. 8d. per acre, with a profit of £18 13s. 4d. per acre.”

And

“Gross receipts from 10 acres.—2 crops, £349 10s. 7d. or at the rate of £17 9s. 6d. per acre per crop. Profit from the two crops £223 3s. 0d., or £15 11s. 9d. per acre.”

And

“Gross returns per acre £27 8s. 0d., profit per acre £15 11s. 9d.”

V.—PROBABLE YIELDS IN THE GOLD COAST COLONY.

It is, of course, largely a matter of conjecture to forecast probable yields of a crop in a country where it has not yet been grown to any considerable extent, or under careful observation. But there is no reason to doubt that yields favourably comparable with those obtained in Jamaica could be obtained from large areas of land in the Gold Coast.

Planted at 12 ft. by 12 ft. there are 302 plants to the acre. It is not likely that all would fruit, but probably at least 80% would do so. This would give, in round numbers, 240 bunches to the acre. Not all of these would be “payables.” Usually about 80% of the total yield of bunches are payable; this percentage gives 192 payable bunches to the acre, as compared with Fawcett’s estimate of 225 to 230 bunches per acre in Jamaica.

In Jamaica, bananas are sometimes planted at 14 ft. by 14 ft., and two seed suckers planted in each hole; this gives 444 plants to the acre. Levey gives the following yields from an area thus planted:—1,200 stems from three acres, or 400 stems per acre. And 440 stems giving 70% payables equal 308 per acre.

It is probable that by planting two suckers in each hole the size of the bunch is reduced, and, therefore, while a larger gross number of bunches is obtained, the return of payable bunches is less, on account of the larger number of bunches of less than nine hands—the payables. (See para. XIV.—Methods of Grading.)

VI.—COMPARATIVE MONEY RETURNS FROM BANANAS IN JAMAICA AND FROM CACAO IN THE GOLD COAST.

The average of Fawcett’s and Levey’s gross money returns per acre for Jamaica, already quoted, is £24 6s. 0d. Their figures are not recent, and are now probably low, on account of change in prices. On the assumption that the probable yield of bananas in the Gold Coast would be 192 bunches per acre, and that the price paid per bunch would be the same as in Jamaica, viz., 3s., the gross money return would be £28 16s. 0d. per acre.

It is estimated that the average crop of cacao in the Gold Coast is 5 cwt. per acre, or nine and one-third loads of 60 lbs. each. The average price paid for cacao at Koforidua in 1927 was about £2 2s. od. per cwt. At this figure the gross money return per acre to the farmer from cacao is £10 10s. od. In this connection it must, however, be borne in mind that cacao is a permanent crop, while bananas require to be replanted every two or three years. More labour is therefore required to produce bananas than cacao. As in the case of cacao production in the Gold Coast, cost, so far as production by African farmers is concerned, need hardly be taken into account; and what is visualised in this paper is an industry which would be, in the main, an African one.

VII.—PLANTINGS ALREADY MADE IN THE GOLD COAST.

The writer has no information as to the date of introduction of what may be termed "the bananas of commerce," viz., the Gros Michel and the Canary varieties, into the Gold Coast. It is, however, certain that both varieties have been grown on the various Agricultural Stations of the Department of Agriculture for many years. Plots exist at the present time on the Agricultural Stations at Kumasi, Asuansi, Kpeve, and at the Botanic Gardens, Aburi. A considerable number of plants, probably over a thousand in all, of the Canary variety were still existing at the end of May on the now abandoned Agricultural Station at Tarkwa, and the writer saw a fine ten-hand bunch on a plant there at the time mentioned.

Small plantings of the Canary variety were made at Ateiku by Mr. W. G. Greirson, Manager of the West African Mahogany Company, Limited, in 1925. Mr. Greirson informed the writer that he had obtained excellent results from the plants there.

At Tarkwa Agricultural Station very good returns were obtained from plants of the Canary variety growing on a plot of land not ideal for banana cultivation. On the other hand, plants of the same variety planted in wet, badly drained, and very poor soil there, were complete failures. The plot at Tarkwa first mentioned was situated at the foot of a hill, the soil was a heavy loam, tending to clay, and the plot was not replanted for several years. In spite of these unfavourable conditions, most of the plants in it continued to thrive and yield fair bunches.

VIII.—FACTORS AFFECTING THE ESTABLISHMENT OF SUCH AN INDUSTRY AND THEIR CONSIDERATION.

In contemplating the establishment of a new agricultural industry in any country certain factors have to be considered. Among them are:—

- (a) Is there a satisfactory and profitable market available for the produce of such an industry?

- (b) Is the proposed new industry suited to the habits of the people?
- (c) Are soil conditions suitable?
- (d) Is the climate suitable?
- (e) Do suitable means of transport for the produce of the industry exist?
- (f) Are there suitable shipping facilities?
- (g) Are the growers likely to find a ready cash sale for their produce near points of production?
- (h) How is the new industry to be financed and guided in the early stages of its growth?

These various questions may be considered and discussed.

As regards (a), there is no doubt as to the existence of a large, growing, and profitable market for bananas. It is highly probable that, when the industry is started, bananas from the Gold Coast will at first go to England. Shipments to the United States of America may follow. It has already been mentioned that an important firm in England dealing in bananas from Jamaica are of opinion that they will have to seek supplementary sources of supply, which they prefer to be within the Empire. The Report of The Imperial Economic Committee, already quoted, also draws attention to the need of complementary sources of supply, and to the dependence of the United Kingdom market on bananas of foreign growth.

As regards (b), the answer "Yes" can be given with confidence. The cultivation of bananas is not an exacting one, and it is a cultivation easily carried on by peasant growers. The product is not one which requires elaborate local preparation before shipment, such as, for example, rubber. In the suggested new industry the peasant farmer would plant and cultivate the bananas during the growing period and, when the bunches were mature, cut and convey them to a buying centre for sale. The whole thing is very simple, and appears to be well adapted to the habits of the Gold Coast peasant farmer. The writer feels confident in saying that what has been so well done by peasant farmers of African descent in Jamaica in this industry can be equally well done by peasant farmers in the Gold Coast.

The next question, (c), is not quite so easy to answer. But there are, undoubtedly, large areas of land in the Colony, and those not remote from suitable means of transport, which are well suited for the cultivation of bananas. The writer made an extensive survey of country with a view to the selection of suitable sites for banana cultivation early in 1925. The areas considered suitable will be discussed under the heading "Areas in the Colony suitable for the crop."

The answer to the next question (*d*) is "Yes." We may rest assured that a climate suitable for the growth of cacao is also suitable for the growth of bananas. In Barbados, with a rainfall of 55 to 60 inches per annum, and a dry atmosphere, the Canary banana has been very successfully grown.

As regards means of transport, question (*e*), so far as the areas suggested in this paper are concerned, there are adequate and suitable means of transport already in existence. Of course, there are still large areas of land in the Colony remote from means of transport, but it is not suggested that bananas for export be grown in such localities. The areas east of Mansu, and around Ateiku are especially well situated for transport as they have direct railway communication with Takoradi.

In regard to (*f*), Takoradi Harbour is eminently suitable as a shipping point. At present some of Messrs. Elder Dempster and Company's ships have limited cool storage accommodation available on the homeward voyage, and there is no doubt that an enterprising firm would soon provide adequate and suitable cool storage accommodation were an industry in bananas established. Further, there is no doubt that, were sufficient supplies of bananas forthcoming, large firms interested in the business would run ships for the purpose of carrying bananas direct from the Gold Coast to the United Kingdom.

The question (*g*) is one of organization and finance. As will be explained later, it is suggested that, for a commencement, an area of 500 to 1,000 acres, either in one block or closely adjacent blocks making up the area suggested, be established. In that case there would be little difficulty about the provision of a ready cash market at a buying centre near the point of production. Suitable financial arrangements would have to be made in advance, but, once the plants were well established, no great difficulty in that regard need be anticipated.

The first part of the next question (*h*), is closely bound up with the question of means whereby the industry could be started, and will be dealt with under that head. Guidance and advice would obviously be in the hands of Officers of the Department of Agriculture.

IX.—MEANS WHEREBY THE INDUSTRY COULD BE STARTED.

Having drawn attention to some of the factors affecting the establishment of such an industry, we now have to consider the means whereby it could be started. It is the writer's opinion that, in such an undertaking, the first steps must be taken by Government. There appear to be two ways of taking these steps, they are (1) by means of a bonus system, and (2) by Government itself establishing an area in bananas.

Under a bonus system farmers in a selected area would be paid a bonus of, say, £5 per acre for every acre of bananas they planted and brought to the fruiting stage. The payment of this bonus would, of course, be spread over the period of planting and cultivation, in other words, it would be paid in instalments as planting and cultivation progressed.

Alternatively, (2), Government might rent or acquire a suitable area of land and establish the first plantation of bananas as a Government venture. In this case the question of cost arises, and it is well known that the cost of such ventures under Government control is usually greater than would be the case with private enterprise. Levey, already quoted, gives the cost of planting, cultivating, and harvesting bananas in Jamaica as £11 16s. 3d. per acre (his own experience). At the time Levey wrote, the standard rate of pay for an able bodied field labourer in Jamaica was 1s. per day. The standard rate of pay in the Gold Coast being 1s. 6d. per day, we have to add 50% at least to Levey's figure, bringing it to close on £18 per acre. Probably £20 per acre would be a safer estimate. Of course, costs for the second and third years would be less.

The bonus system would appear to be the best method to adopt. Under it, Government commitments could be strictly limited, and, in the unfortunate event of failure, its losses would be equally limited. It has the further advantage that, from the very start, the industry would be in the hands of private enterprise, Government giving the bonus to stimulate interest in the industry in its infancy, and also to ensure that the growers, in the unfortunate event of failure, suffered little, if any, monetary loss. At the worst, assuming that Government paid a bonus of £5 per acre on an area of 1,000 acres, and the industry failed, the total loss would be only £5,000, and that would be money spent in the country.

The question of finance arises in connection with means of establishing the industry. It has already been stated that what is visualised in this paper is an industry carried on in the main by African farmers, and it would appear that the bonus system suggested would go far towards the solution of the question of finance in the planting and cultivation stage. Apart from the bonus scheme, it is probable that, once a start was made, individuals and firms with capital would soon become interested and give the industry financial assistance.

Ready cash would of course have to be available for the prompt purchase of the bunches as they matured, but there is little doubt that this would be forthcoming when it was seen that a fair supply of fruit was coming to maturity. Banks will of course make advances against shipping documents.

X.—AREAS IN THE COLONY SUITABLE FOR THE CROP.

It is the writer's considered opinion that there are extensive areas of land in the Colony, and these close to convenient means of transport, suitable for the cultivation of bananas. As a result of observations made in a fairly extensive tour of country, made in 1925, and already referred to, the following localities are suggested, in order of general merit, as suitable sites for a commencement. Factors taken into consideration in regard to these localities were, nearness to suitable means of communication with Takoradi, soil conditions, and climate, that is, rainfall.

The localities suggested are :—

(a) The country East and North-east of Mansu, towards the river Prah. (Mansu is on the Gold Coast Railway, and is roughly 20 miles from Takoradi). From villages around Mansu large quantities of plantains are railed to Sekondi. We may rest assured that where plantains can be successfully grown, there also will bananas thrive. The banana is not so exacting in its requirements as the plantain. Rainfall is good, and the soil appears to be good. A great advantage is its nearness to Takoradi.

(b) The area next suggested is the country around Impahor. Impahor is on a lorry road, and is roughly 15 miles North-west of Takoradi. The country tends to be more hilly than that East and North-east of Mansu, and the soil is rather heavier, the latter is by no means a disadvantage however. Rainfall is good.

(c) Another promising area is the country around Ateiku, on the Central Province Branch of the Gold Coast Railway, and roughly 70 miles from Takoradi, with direct railway communication with that port. There are considerable areas of what appears to be very suitable land for the cultivation of bananas, North and South of the railway, around Ateiku. Plantains and bananas both thrive well in the locality. The West African Mahogany Company have a large concession there, with Ateiku as headquarters. The concession has a nine miles frontage on the railway.

The areas mentioned by no means exhaust possible areas in the Colony, but they are suggested as being well situated as localities in which the industry may be started in favourable circumstances as regards rainfall, soil, and means of transport to Takoradi. They have all been gone over by the writer.

XI.—GUIDANCE AND ADVICE IN THE EARLY STAGES OF THE INDUSTRY.

This, perhaps, is the vital point in connection with the establishment of such an industry. In all probability success or failure would depend on its handling during the first two years of its existence. It is, in the writer's opinion, of the greatest importance that it should be under the close supervision of the Department

of Agriculture. Officers of the Department should be in close touch with the working of every detail of the young industry, from the clearing of the land to the shipment of the fruit. The Department should be in a position to certify every shipment of fruit.

XII.—VARIETIES TO GROW, AND WHY.

Though details of cultivation are outside the scope of this paper, it is necessary to briefly consider the question of varieties to grow. There are two varieties, or, to be correct, species, of bananas grown commercially. They are the tall growing Gros Michel, or Jamaica, banana (*Musa sapientum*) and the dwarf, or Canary banana (*Musa Cavendishii*). Each has its particular merits.

A large proportion of the bananas imported into the United Kingdom is of the Gros Michel variety, while practically all the bananas going into the United States of America are that variety. The Gros Michel banana has the very valuable property of possessing a thick skin, by virtue of which it travels well without crating. On the other hand, the Canary banana, while it is a much better fruit, bruises easily, and requires to be crated for shipment.

It is the opinion of an English firm, doing a large business in bananas, that there is room in the United Kingdom market for further large supplies of the Gros Michel banana, but not for the Canary variety. They say that the latter, as imported from Brazil, is liable to "stem rot," and when attacked by this disease, the fruits drop off before the bunch ripens for sale. On the other hand, The Imperial Economic Committee, in their Report, express the view that there is a growing demand for Canary bananas on the Continent of Europe, and that supplies from the Canary Islands for the United Kingdom may decrease accordingly.

There are certain points in connection with the Canary banana which are worth consideration. As already mentioned, it fetches a higher price than the Gros Michel, the relative prices in Covent Garden Market being, according to a recent quotation, Canary bananas, 14s. to 15s. per bunch, Gros Michel, 9s. to 10s. per bunch. There seems to be ample margin between these prices to cover extra cost caused by crating and extra room occupied on ship, and yet allow a higher price to be paid to the grower.

The Canary banana is also immune to the dreaded Panama disease. It is also less liable to damage by wind. Further, there are larger supplies of planting material available in the Colony. Planting material could only be imported under very stringent precautions, and even then with some risk. But it is not suggested that only the Canary variety be grown; both kinds should be grown for the sake of comparison.

XIII.—SUPPLIES OF PLANTING MATERIAL.

Reference has been made to supplies of planting material. This is, of course, an important matter. So far as can be ascertained, there are about 300 plants of the Gros Michel and about 850 plants of the Canary bananas growing on the various Stations at present maintained by the Department of Agriculture in the Colony and Ashanti. To these may be added about 1,000 plants of the Canary variety still growing on the now abandoned Agricultural Station at Tarkwa. A good supply of planting material could soon be raised from these plants. Steps should be taken in the propagation of planting material as soon as possible.

XIV.—METHODS OF GRADING.

Grading is done with a two-fold object in view, for size of bunch and for maturity. For size of bunch bananas are graded into "payables." A "payable" bunch is one with not less than nine hands. The term "straight" is also used for a bunch with nine hands and over. Bunches of less than nine hands are graded as follows:—

Bunches of eight hands count $\frac{3}{4}$, *i.e.*, 100 bunches with eight hands per bunch count as 75 payables.

Bunches with seven hands count $\frac{1}{2}$, *i.e.*, 100 bunches with seven hands per bunch count as 50 payables.

Bunches with six hands count $\frac{1}{4}$, *i.e.*, 100 bunches with six hands per bunch count as 25 payables. Bunches with less than six hands are usually rejected.

Grading for maturity is done by observation of the degree of angularity of the ribs on the individual fruits or fingers, and the top, or largest hands, furnish the chief guide to maturity. Usually bananas are graded into one of three degrees of maturity, they are:—Round full fruit, that is, when all the fingers of the top hand, and down to the one before the last at the bottom, present a round smooth surface. Full three-quarter, the fingers on the top hand are nearly round, but still show slightly defined ribs. On the other hands the ribs are still well defined, but not sharp. Three-quarter, the fingers on all the hands, although plump, have four or five sharp ribs, and the tips of the fruits still retain the remaining portion of the flower, which the round full and full three-quarter have shed in the process of maturing. (Adapted from Levey's work, reference 7).

XV.—PACKING.

The Gros Michel banana is shipped without crating. The Canary variety is always crated. For the making of crates there is an abundant supply of suitable wood in the Colony. It is furnished by the "Waw Waw" tree, which is common all through the forest region of the Colony. This wood could easily and cheaply

be converted into suitable material for making crates. Canary bananas are usually packed one bunch in a crate, but sometimes two smaller bunches are placed in a crate. The interstices are tightly packed with dry banana leaves, to prevent movement and consequent bruising of the fruit.

XVI.—SHIPMENT.

Messrs. Elder Dempster and Co., Ltd., report that they have a limited amount of cool storage accommodation available on their fortnightly express boats from Takoradi. They think the charge for this would be about 60s. per ton of 40 cubic feet. Their present rate of freight on bananas from West Africa to Liverpool (not in cool storage) is 5s. per double, and 3s. per single crate.

XVII.—MARKETING IN THE UNITED KINGDOM.

This is the part of the industry that would probably give least trouble of all. The writer has been assured that there are numerous firms in the United Kingdom who would be keenly interested in such a matter. Of course, everything would depend on regular supplies of sound fruit coming forward.

SUMMARY OF PAPER.

I.—The idea of establishing a Banana Industry in the Gold Coast Colony has been brought forward before. It has also been referred to in Reports and Publications.

II.—The banana industry is a vast and highly organized one. Close on 13,000,000 bunches are imported into the United Kingdom annually, and over 64,000,000 per annum into the United States of America. 80% of the bananas imported into the United Kingdom are of foreign growth.

III.—Jamaica, the largest of the British West India Islands, with an area of 4,200 square miles and a population of 863,000, exports about 22,000,000 bunches per annum, of which the great bulk goes to the United States of America, only about 9% going to the United Kingdom. The average price paid to growers in Jamaica, at buying centres near points of production, is 3s. per bunch.

IV.—The yield per acre in Jamaica is estimated at 225 to 230 "payable" bunches per annum. The gross average money return per acre is about £24 to £25 per annum. The figures quoted are for several years ago, and are now probably low. Average profits stated by Levey (of Jamaica) are about £16 to £17 per acre.

V.—Probable yields in the Gold Coast are largely a matter of conjecture, but it may be safely assumed that yields favourably comparable with those of Jamaica could be obtained from large areas of land in the Colony.

VI.—As compared with cacao in the Gold Coast, bananas in Jamaica give a larger monetary return. The banana crop is, however, not a permanent one, and the fields require replanting every two or three years.

VII.—Small plantings have been made at various times in the Gold Coast, and returns from them appear to indicate that the crop could be profitably cultivated on a larger scale.

VIII.—Various factors affect the establishment of such an industry, but it may be safely assumed that there are no inimical factors in the Gold Coast, and the crop appears to be well suited to the habits of the people.

IX.—It is suggested that Government take the first steps in starting the industry. It is also suggested that a bonus system be adopted for the purpose of stimulating the industry. Under a bonus system Government would be committed to a definite and limited liability only. Ready cash would have to be available for the purchase of the fruit when mature. Once considerable areas of bananas were coming to maturity; there would probably be no difficulty in this regard.

X.—Three areas of country are suggested as likely to provide suitable sites for a start in the industry. They are, roughly in order of merit, East of Mansu, around Impahor, and around Ateiku.

XI.—Guidance and advice in the early stages of the industry would be in the hands of the Department of Agriculture.

XII.—Two species of banana are grown commercially, Gros Michel and Canary. The first named stands a lot of handling without serious bruising, and is shipped without crating. It is, however, a coarser fruit than the Canary banana. The latter has to be crated for shipment. The Canary banana fetches a higher price than the Gros Michel, the relative prices being, Canary, 14s. to 15s. per bunch, Gros Michel, 9s. to 10s. per bunch.

XIII.—A certain amount of planting material is available in the Colony. It could be quickly and considerably increased by propagation. This should be taken in hand soon. It is not advisable to import planting material.

XIV.—Bananas are graded with two objects in view :—size of bunch, and maturity. A bunch with nine hands is the standard, or “payable” size. Bunches with eight hands count $\frac{3}{4}$, bunches with seven hands count $\frac{1}{2}$, and bunches with six hands count $\frac{1}{4}$. Maturity is judged by the rounding of the ribs on the individual fruits, or fingers.

XV.—Canary bananas are packed in crates, one large bunch or two smaller ones per crate. The interstices are carefully filled with dry banana leaves, to prevent bruising. There is an abundant supply of wood suitable for the purpose of making crates in the Colony. The Gros Michel is not crated.

XVI.—A limited amount of cool storage accommodation is available on Messrs. Elder Dempster and Company’s express boats from Takoradi fortnightly.

XVII.—There would be no difficulty in disposing of the fruit in the United Kingdom.

REFERENCES.

- (1) “The Establishment of Industries in Fresh Fruit in the Gold Coast Colony.” By W. C. Fishlock. Printed by Andrew Churchman, 16, King Street, Hammersmith, W.6. 1924.
- (2) “A Note on Bananas.” By W. C. Fishlock. Journal of the Gold Coast Agricultural and Commercial Society, Vol. IV, No. 2, pp. 29 & 30.
- (3) “Report of The Imperial Economic Committee on Marketing and Preparing for Market Foodstuffs Prepared in the Overseas Parts of the Empire, Third Report—Fruit.” pp. 240–274. Cmd., 4s. 6d. 1926.
- (4) “The Tropical Agriculturist (Ceylon).” Vol. LXXII. No. 2. February, 1929.
- (5) “The Banana, Its Cultivation, Distribution and Commercial Uses.” By W. Fawcett. Duckworth & Co., London. 1913.
- (6) “The Story of the Banana.” United Fruit Company, Boston, Mass., U.S.A., 1921.
- (7) “The Cultivation of Bananas in Jamaica (*Musa sapientum*).” By H. Q. Levey. Jamaica Agricultural Society, Kingston, Jamaica, 1912.

THANKS.

The writer tenders sincere thanks to:—

LIEUT.-COLONEL LEVEY, D.S.O., O.B.E., Director, Gold Coast Commercial Intelligence Bureau, London.

THE SECRETARY, Jamaica Agricultural Society, Kingston, Jamaica.

Messrs. T. J. POUPART, LIMITED, Covent Garden Market, London (per W. Ravenhill, Esq.).

Messrs. ELDER DEMPSTER AND COMPANY, LTD., Liverpool.

W. G. GREIRSON, Esq., Manager, West African Mahogany Company, Ltd., Ateiku, Gold Coast.

And the OFFICERS-IN-CHARGE, Agricultural Stations, Kumasi, Asuansi, Kpeve, the Botanic Gardens, Aburi, and the OFFICER-IN-CHARGE, Division of Statistics, Department of Agriculture.

For useful information most kindly given.

APPENDIX I.

IMPORTS OF BANANAS INTO THE UNITED KINGDOM—1924—1928.

Country of Origin.	1924.		1925.		1926.		1927.		1928.	
	Thousand Bunches.	£000	Thousand Bunches.	£000	Thousand Bunches.	£000	Thousand Bunches.	£000	Thousand Bunches.	£000
British West Indies ..	1,706	570	2,403	919	3,581	1,203	1,971	640	2,741	
Canary Islands	2,649	1,902	2,222	1,648	2,591	1,847	1,809	1,308	1,599	
Honduras	1,639	724	2,713	1,150	1,400	561	2,645	1,145	1,829	Not available.
Costa Rica	2,157	993	1,923	950	2,175	964	2,044	932	2,410	
Colombia	3,079	1,276	2,762	1,187	3,710	1,440	3,771	1,542	3,590	
Brazil	—	—	—	—	—	—	455	182	790	
Other Countries	78	36	7	6	89	32	1	1	8	
Total	11,308	5,501	12,030	5,860	13,546	6,047	12,696	5,750	12,967	5,609

PAPER No. XXI.

**THE PROSPECTS OF A FRUIT EXPORT
INDUSTRY IN SIERRA LEONE.**

BY D. W. SCOTLAND AND F. J. MARTIN (SIERRA LEONE).

“The 22 of the same month (July 1579) we came to Sierra Leone and stopped two days watering in the mouth of Tagrine and then put to sea again; here also we had oysters and plenty of lemons which gave us good refreshing.”

This quotation, from Master Francis Fletcher's account of Sir Francis Drake's visit to Sierra Leone in the sixteenth century, establishes the fact that citrus has long been grown in this Colony, and although the presence of limes and oranges and the almost entire absence of lemons lead us to suppose that Sir Francis was not such a good botanist as sailor, yet there is little doubt that his two days "watering in the mouth" was due partly to the abundant supply of good river water and partly to the supplies of fresh fruit and meat.

Bananas and citrus fruit grow well in Sierra Leone. Citrus fruits, as will be seen above, are known to have been long in the Colony, and although the records of the presence of bananas are not so ancient, these fruits are widely spread throughout the whole of the Colony and Protectorate, and can be found in every little village. In addition to citrus and bananas, the avocado pear grows extremely well, and in view of the attempts to popularize this extremely palatable fruit in America, it may well be that in the future a demand will be created for it. At present this demand is lacking, and there seems little immediate prospects of an avocado pear industry, so that beyond looking into the possibilities of this fruit on a very small experimental scale, nothing is being done towards its exploitation.

The position with regard to bananas and citrus fruit is different. There is a well-established market for these fruits and since certain types of bananas and citrus grow well in this country efforts are being made to encourage their cultivation.

By what circuitous route the citrus was brought to Sierra Leone from the neighbourhood of Cochin-China, which is believed to be the native home of the citrus plant, is yet unknown. It is sufficient to record that limes, sour and sweet oranges, and shadocks are now to be found in the Colony, and, judging from the report of Sir Francis Drake's visit, must have been here for a considerable time.

Very little attention has been paid to the cultivation of either oranges or lime. These trees grow where they list and their immediate parentage is not a matter of moment or even fleeting curiosity on the part of their native owners. Yet in spite of this the orange and the lime flourish in Sierra Leone, the lime doing especially well.

LIMES.

The hardy features and good yields of the indigenous limes were one of the first things to impress the senior author on his arrival in Sierra Leone in 1912, and in order that the possibilities of lime cultivation in Sierra Leone might be fully explored a visit was made to Dominica in 1913, especially to study the lime industry. Subsequently experimental plots were laid down on the department farm at N'jala. These plots are now some 15 years old and the yields of limes, both of the indigenous variety and those imported from Dominica, demonstrate how sound was the original view of the possibilities of this crop.

TABLE I.
YIELDS OF DOMINICA AND SIERRA LEONE LIMES.

Variety.	Dominica.	Sierra Leone.
Soil.	Lateritic Gravel.	Sandy Alluvium.
Planted.	1916.	1913.
	Barrels per acre. commenced fruiting	Barrels per acre. commenced fruiting
4th year	70	no records
5th year	271	heavy crop
6th year	223	46
7th year	118	92
8th year	45	276
9th year	106	420
10th year	233	112
11th year	223	117
12th year	—	149
13th year	—	223
14th year	—	*106
15th year	—	
Average	162	172

* Many fallen limes carried off by abnormal floods.

The spacing of the Dominican limes was originally 15 by 15 ft. on the quincunx or alternate planting system. The grass and weeds were periodically cutlashed and the cut material used for mulching the trees. The trees were lightly pruned and all suckers removed. In 1925 the trees began to suffer from overcrowding and early in 1926 they were drastically and thoroughly pruned. It is interesting to note that following this there was an

increase in yield from 45 barrels per acre in 1925 to 106 barrels in 1926. In early 1928 the trees on half this plot were thinned out by removing alternate rows, so that one-half of the plot is now 15 by 30 ft. and the other 15 by 15 ft. The spacing in the Sierra Leone limes plot was originally 20 by 10 ft. on the square system. The cultivation and after-treatment of this plot has been similar to that described above for the Dominican limes. In 1928 half of this plot was thinned out by removing alternate trees, so that the spacing is now 20 by 20 ft. Early in 1926 this plot was carefully pruned and it is of interest to note that the yield increased from 117 barrels per acre in 1925 to 149 barrels in 1926 and to 223 barrels in 1927. There was a decrease in the harvest collected in 1928, due in no small measure to the abnormal flooding of this area at the time of optimum production, fallen limes being carried away by the flood water. The Dominican lime plot was not inundated by these floods.

It will be seen that over a period of 8-9 years the average yield of limes has been from 160 to 170 barrels per acre. This is a very good average yield and compares favourably with yields obtained in other lime-producing countries.

The quality of the fruit has also proved to be suitable. Samples of the juice obtained from the local and imported varieties were sent to the Imperial Institute for examination and the following figures were obtained:—

	Sierra Leone Variety.	Dominica Variety.	Figures Recorded for Commercial Raw Lime Juice.
Specific gravity at 15/15° C. ..	1.0385	1.0384	1.035-1.040
Total solids—oz. per gal. ..	13.6	14.0	—
Citric acidity—oz. per gal. ..	12.9	13.5	10.6-13.5
Total organic acids—oz. per gal. ..	13.2	13.8	—
Combined organic acids—other than citric — calculated as citric acid $C_6H_8O_7 \cdot H_2O$ —oz. per gal:	0.3	0.3	0.4 0.7

The samples of lime juice were further described as “of normal composition and equal in acidity to commercial lime juice of high quality.” These analyses can be accepted as satisfactory, and it is therefore demonstrated that good crops of limes can be grown in Sierra Leone and that the limes so produced yield juice of good average quality.

The main products obtained from limes are:—

- (1) Concentrated lime juice.
- (2) Hand-pressed oil.
- (3) Distilled oil.

Limes are sometimes sold fresh, but there is a very poor European market for these; sometimes they are pickled in sea water and sometimes citrate of lime is made from the concentrated juice. The big trade, however, so far as the home market is concerned, is with lime oils and lime juice.

The economic side of the question merits consideration, and after careful calculation from the known costs of labour, clearing, etc., it is estimated that the cost of bringing an acre of limes into bearing in Sierra Leone is roughly from £15 to £20 an acre and the subsequent annual cost of maintenance about £8 per acre, including manuring and harvesting. If we assume an average yield, as from our records seems reasonable, of 100 barrels an acre, each acre may be expected to yield products to the following value:—

125 gallons of concentrated juice testing 64 oz. per gallon at, say, 3s. 4d. a gallon*	.. ..	£20	15	0
200 oz. (2 oz. per barrel) of hand-pressed oil at 1s. an oz.*	.. ..	10	0	0
250 oz. (2½ oz. per barrel) of distilled oil at 6d. an oz.*	.. ..	6	5	0
		<hr/>		
Value of annual products per acre	.. ..	£37	0	0
		<hr/>		

From this must be deducted the cost of extracting the oil, and this depends upon the size of the plant. It is estimated that the cost of extracting the juice and the oil would be about 1s. 3d. per barrel of fresh limes. This figure, however, is much affected by the cost of fuel.

At the present time, beyond publishing the information obtained from experiments in Sierra Leone, nothing has been done to extend the cultivation of this crop. Presumably it could be done in two ways, by large firms on plantation lines and by peasant cultivators on small farms. Both methods can be seen in the West Indies, and there is little doubt that where the population is sufficiently keen on agriculture, peasant proprietors lead to fewer native problems. The most obvious problem is that of the paid labourer. There comes a time when he is too old to work and he is then liable to be turned off the plantation with no visible means of support and subsistence for his old age. In the case of peasant proprietors, the man who owns the lime trees still continues to do so after he is too old to work, and his sons or other relations collect the fruit for him and in return look after him. In the case of a large number of small native farmers, the extraction of the various products has to be undertaken by a central factory which can either be run co-operatively or by outside capital.

* Present prices (June, 1929), which are somewhat inflated, are concentrated lime juice, 5s. 2d. per gal.; hand-pressed oil, 4s. an oz.; distilled oil, 1s. 9d. an oz.

Professor Clark Powell in commenting on lime growing in Sierra Leone, said: "Limes also produce well and I see no factor that would prevent the establishment of a lime industry, subject to favourable market conditions."

GRAPE FRUIT.

The question of the cultivation of grape fruit in Sierra Leone has recently been mooted. There are in the Colony a number of grape-fruit trees in a flourishing condition. The type of fruit of most of these is of poor quality, but in some cases there are trees of a good variety. While there seems little reason to doubt that grape fruit could be successfully grown in Sierra Leone, too little is known at present of cultural conditions and the effect of climate to warrant any immediate commercial development of the industry, and one of the objects of the Government experimental farm at Newton is to obtain the necessary data.

Through the generosity of the Empire Marketing Board this Colony was recently visited by Professor Clark Powell and he made certain suggestions as to the most suitable lines of investigation to follow. In accordance with his recommendations these features have been embodied in the programme for the Experimental Fruit Farm at Newton. Briefly, the programme includes the following trials:—

- (a) *Root Stock Trials.*—The following root stocks are being tried—Seville orange, Cleo, Shaddock, Rough Lemon and Tangerine, and a certain number of each of these root stocks will be budded to Marsh, Royal and Duncan. (See Diagram No. 1.)
- (b) *Variety Trials.*—Six varieties will be tried, namely Marsh, Walters, Duncan, Thompson, Royal and Foster. Half the root stocks used for each variety will be Seville and the other half Shaddock. (See Diagram No. 1.)
- (c) *Fertiliser Trials.*—These trials follow along similar lines to those which appear so successful at Riverside, California, that is, each fertilised row of trees is completely shielded from the effect of nearby fertilised rows by a complete ring of guard trees. From the results of experiments elsewhere it would appear that nitrogen is essential as a fertiliser for citrus fruits. The trials devised, therefore, are to test the efficacy of various forms of nitrogen, and to try phosphorus and potash in combination with nitrogen. The different treatments will be given, each treatment will be repeated six times, and each experimental unit will consist of eight trees. The method of arrangement is that

of randomized blocks and the actual layout is shown in Diagram No. 2. The following fertilisers, or combinations of fertilisers will be used:—

- (1) Control.
- (2) Nitrogen as Ammonium Sulphate.
- (3) " Urea.
- (4) " Calcium Cyanamide.
- (5) " Dried Blood.
- (6) Ammonium Sulphate, Super, Potash.
- (7) " " Super.
- (8) " " Potash.
- (9) Fish Manure, Potash.
- (10) Nitrophoska.*

The total area of fertilised plots, including guard rows, is about 30 acres. The guard trees will be lemon on sour orange, so that they may be readily distinguished from grape fruit.

(d) *Irrigation Trials*.—The effect of the irrigation during the dry season will be tried and five acres of irrigated land will be compared with five acres of non-irrigated land. The trees for this test will be Marsh on Seville.

Until the results of these trials are known it is impossible to give any clear idea of the prospects of grape fruit in Sierra Leone. At present only the nursery work is in progress, and this has been designed to cover the requirements of the present programme and still leave a comfortable margin for any further work considered necessary. All the plants in the nursery appear to be doing well.

LEMONS.

There are one or two lemon trees in the Colony and the few trees at the N'jala Experimental Farm produce freely. The fruit, however, is not appreciated by the natives and they are consequently not propagated. On his recent visit to Sierra Leone Professor Clark Powell reported as follows:—

"Practically no lemons are produced within the Empire. Conditions in Sierra Leone seem very favourable to lemon culture and I would suggest that five acres of lemons be planted at Newton, one-third to be budded on rough lemon. This planting would serve to demonstrate the feasibility or otherwise of commercial lemon production in Sierra Leone. Data as to fertiliser practice, and other points, will be derived from the grape fruit plantings. It is quite possible that some of the companies in England dealing with citrate of lime will be interested in Sierra Leone and I would suggest your advising them that conditions for lemons in Sierra Leone (Colony) are very promising."

* Nitrophoska I.G.2 contains 15 per cent. N, 11 per cent. of water sol. P_2O_5 and 26.5 per cent. Potash.

The experiments suggested by Professor Clark Powell have been incorporated in the programme for the Newton Fruit Farm and the nursery work already started. The young seedlings are doing well.

In view of the possibilities of citrus cultivation a special survey of citrus diseases existing in Sierra Leone was made by the Mycologist (Mr. F. C. Deighton). He reported that at present Sierra Leone is free from serious diseases such as "wither-tip" and citrus canker.

BANANAS.

During the dry season of 1924-25, Dr. Dunlap and Mr. Sanderson, representatives of Messrs. Elders and Fyffes, visited Sierra Leone and made a careful survey of the Colony and Protectorate with a view to investigating the possibilities of growing Gros Michel banana for export purposes. During his visit, Dr. Dunlap found, identified and described a number of different varieties of bananas and plantains, and we have to thank him for the following information with which he has so kindly supplied us. Seven kinds of bananas and three of plantains were found and these are described below.

BANANA VARIETIES.

1. *Musa Cavendishii*.—This variety, commonly known as the Canary Banana, possesses a small low plant with curved fruits. Originally this variety came from China. It is shipped only from the Canaries and is packed in crates.

The Mende name for the Canary banana is "Serequti" and the Temne name is "A polot."

2. *Musa Sapientum*.—Six varieties are included under this head.

(a) *Guineo Negro* (in Cuba, Guineo Prieto).—The plant is only moderately tall and the fruit is short and thick, standing out more or less horizontally on the bunch.

This is the common variety in Sierra Leone especially in the Mende country. The flavour is not considered good but it is appreciated by some people. In texture the fruit is mealy. This variety is very resistant to disease. The local names for this variety are: Mende, "Tendei," "Maguti"; Temne, "A pof."

(b) *The "Green red" or "Silver" banana* (in Spanish, Colorado Blanco).—The plant is a very tall one and the fruit, although similar in shape to Guineo Negro, is larger. It is a colour variation of "red" (or Claret) banana.

This banana is shipped to a certain extent, although it has a peculiar flavour not liked much by anyone. This flavour is similar to that of the red banana.

(c) "*Gros Michel*," "*Jamaican*" or "*West Indian*" banana.

This is one of the tallest of the banana plants and there is always a lot of red colour on the leaf stem. This banana is the principal banana of commerce from the West Indies and Central America. It is well shaped for packing and stands transport well, and therefore is not crated as Canary bananas are. Unfortunately it is one of the varieties susceptible to Panama disease. The Mende name of this variety is "Jininga," and the Temne name "A yininka."

(d) "*Kongo*" or "*Man o War*" (*West Indies*) banana.

The plant of this variety resembles that of the "*Gros Michel*" but is not so tall. It has a longer fruit than *Guineo Negro* and the fruit has a very fine flavour which is highly appreciated by the inhabitants of Sierra Leone. In Temne country this is the variety generally presented to Chiefs and big men who would not feel at all complimented by the presentation of, say, "A pof." The Mende name is "Manawa" and the Temne "A manawa."

(e) "*Colorado*," "*Morado*" (*Spanish America*), "*Common red*" or *Claret* banana.

The plant of this variety is very tall and the stem is red. The fruit is like "*Guineo Negro*" but stouter, larger and longer. It has a red skin and almost pink flesh. In Central America and the West Indies it is used for shade purposes and it gives a good shade. The fruit, however, has a rather peculiar flavour but it is exported from these places as it is often used for table decoration. The Mende name is "Seremia" (?) and the Temne name is "A pof a yim."

(f) "*Apple*" banana or "*Manzano*" (*Spanish*).

This is a very tall plant with a fruit something like that of "*Guineo Negro*," but has a tip or neck giving it a bottle shaped appearance. It is planted to some extent in the Canaries but unfortunately does not ship well. It has a sub-acid flavour hence its name of apple banana. The Mende name is "Momongi" or "Momonga." This variety is said to exist in the Temne country but was not encountered and the Temne name is unknown.

3. *Musa Paradisaca*.

(a) *Maiden Plantain*.—In this variety of plantain the fruit is closely packed as with most bananas. The plantain fruit has however a long tapering neck and is very straight with little or no curve towards the point. As a rule it is only eaten when cooked, and is generally roasted. The Mende name is "*Kundibi*" and the Temne name is "A kuntibi."

(b) *Horse Plantain*.—The fruit hangs rather horizontally on the bunch stem and each fruit is separated by some distance from the others. In this it differs from the *Maiden Plantain*. There is a limited export of this fruit from Central America and the West

Indies to New Orleans where it is eaten cooked as a vegetable. The Mende name of the Horse Plantain is "Manawawai" (?) and the Temne name is "A bana A temne" also "A plantain."

(c) *Unknown species*.—Dr. Dunlap is of the opinion that the species in question is at present unclassified but akin to *Musa Ensete*, an Abyssinian seed-bearing species. The seeds of "A polo" (the Temne name of this species) and also the plant are much smaller than those of *Musa Ensete*. The fruit are very small and short, two or three inches only, and are packed closely on the bunch rather like the fruit of the "Guineo Negro" banana. The plant does not grow higher than 6 ft. This variety is reproduced by seed only and the lifetime of a plant is from two to three years. It dries up and withers during the dry season but shoots up again with each wet season during the two or three years of its life. It produces its fruit in the second or third year and dies immediately afterwards. The seeds are black and about the size of a large pea. The Temne name for these seeds is "Mapolo", and they are bored and strung and used as waist girdles by women and girls often indeed forming the entire garb of the latter. The seeds are also used as praying rosaries by Mohammedans. The Mende name for this variety is "Yendegbabi" and the Temne name is "A polo."

PANAMA DISEASE.

Unfortunately Dr. Dunlap also discovered the presence of Panama Disease on bananas in various parts of the Colony and Protectorate. This is the well known "wilting disease" of bananas and was found more or less generally where bananas were growing between Freetown and Mano. The ravages of Panama Disease in the West Indies and adjacent countries are too well known to need recapitulation here, and in view of the serious nature of this disease the services of Mr. G. H. Jones, (Mycologist, Nigeria) were secured for the purpose of investigating the distribution of the disease in Sierra Leone. He found evidence of the disease in all parts of the Colony he visited and further found that some plants were susceptible while others were not.

The susceptible kinds are Gros Michel, Guineo Negro, the Red Banana and Silver Banana.

Kinds not susceptible are—Canary Banana and Congo Banana.

In view of the prevalence of Panama Disease it is obvious that the only varieties which could safely be grown are Canary or Congo bananas, and of these the Canary banana is one of the well known bananas of commerce. It possesses one drawback and that is it needs careful packing; in general it needs crating, whereas Gros Michel, the banana universally grown in the West Indies, does not need crating.

BANANA EXPERIMENTS.

Bananas, however, are such a valuable crop that they can stand the cost of crating and shipment, especially where the country is so easily accessible from Europe as Sierra Leone, and consequently bananas form an important part in the programme of our experimental farm at Newton.

The object of the banana experiments is to determine the following points :—

- I. The probable yields which may be expected.
- II. The most economical methods of cultivation and distances for planting.
- III. The response to fertilisers.

The distances of planting trials include a series of six different distances varying from 9 by 11 to 12 by 12 ft. Each sub-plot is half an acre in extent and is repeated three times. In laying out the trials the main plot was divided into three sections, each containing one of the six spacings; the positions of the sub-plots in each section being determined by randomisation. (*See Diagram No. 3.*)

The fertiliser trials were designed to elucidate the following points :—

- I. The effect of each of the manures, nitrogen, phosphorus and potash.
- II. The effect of the different kinds of nitrogen in the presence of phosphate and potash.
- III. The effect of the lime and mulch.

For the first set of experiments all three constituents are used in some sub-plot and in others either nitrogen, phosphorus or potash is omitted. Each treatment is being repeated 5 times on $\frac{1}{4}$ th acre sub-plots of bananas planted 9 by 11 ft. (sub-plots 55 by 99 ft.) and the type of layout is that of randomized blocks (Diagram No. 4, Plot 5, shows the arrangement of the sub-plots). All sub-plots received an original dressing of lime at the rate of 1 ton per acre and all will receive an equal amount of grass mulch. The actual fertilisers in use are as follows :—

- (a) Sulphate of Ammonia
- (b) Superphosphate
- (c) Sulphate of Potash

and the rates of application are

Nitrogen	.. ..	60 lbs. per acre
Phosphorus	.. ..	80 „ P ₂ O ₅ per acre
Potassium	.. ..	160 „ K ₂ O „ „

The second set of the experiments are designed to discover the most economical forms of nitrogen and the following forms are being tried :—

Ammonium sulphate
Urea
Calcium cyanamide
Nitrophoska
Fish Guano
Dried Blood.

With the exception of nitrophoska, when the manures do not contain sufficient phosphorus and potash a basal dressing of these will be given to bring the content of phosphorus and potash to a standard rate of 160 lbs. K_2O and 80 lbs. P_2O_5 . The "no nitrogen" sub-plots will also receive the dressing of phosphorus and potash. The size, shape and method of spacing in the sub-plots is the same as that in the other experiment. Each treatment is repeated 5 times and the method of layout is that of randomised blocks (See Diagram No. 4, Plot 6).

The third set of experiments is designed to discover the value of mulching and liming. Some sub-plots receive a light mulch, some a heavy mulch and some nothing ; a proportion of each of these is limed. The general layout of the sub-plots is shown in Diagram No. 4, Plot 7.

It will of course be some years before the results of these experiments can be considered, the present position is that the programme is laid out and the bananas are already planted and have received their first dose of fertilisers.

The staff of the Fruit Farm includes two qualified and experienced Europeans and the expense of the farm is being jointly borne by the Sierra Leone Government and the Empire Marketing Board.

SUMMARY.

I. Limes can be grown successfully in Sierra Leone. They yield well and give a good average quality of juice. The costs of establishing and running a plantation are moderate compared with the annual value of the products it is possible to obtain. There appears no factor which would prevent the establishment of a lime industry given satisfactory market conditions.

II. Isolated grape fruit and lemon trees have been grown successfully and satisfactory yields have been obtained in Sierra Leone but they have never been grown on plantation lines. Experiments are in progress to determine the yields, the most suitable root stocks, varieties, fertilisers and the need, if any, of irrigation during the short dry season.

III. Bananas are grown all over the colony but nowhere on commercial lines. Experiments are being made to determine yields, best methods of cultivation, distances of planting, fertilisers, etc.

IV. There appears to be no serious citrus disease such as "wither-tip" or "canker" in Sierra Leone.

V. Panama Disease of bananas exists in the colony but a variety (the "Canary" banana) which is immune to the disease is being grown.

VI. Land is available in the Eastern part of the Colony within easy distance of railway transport and shipments.

VII. Sierra Leone is the nearest tropical Colony to England and can be reached by the Elder Dempster mail boats in 9 days. This is an important factor in the shipment of cargoes of fruit.

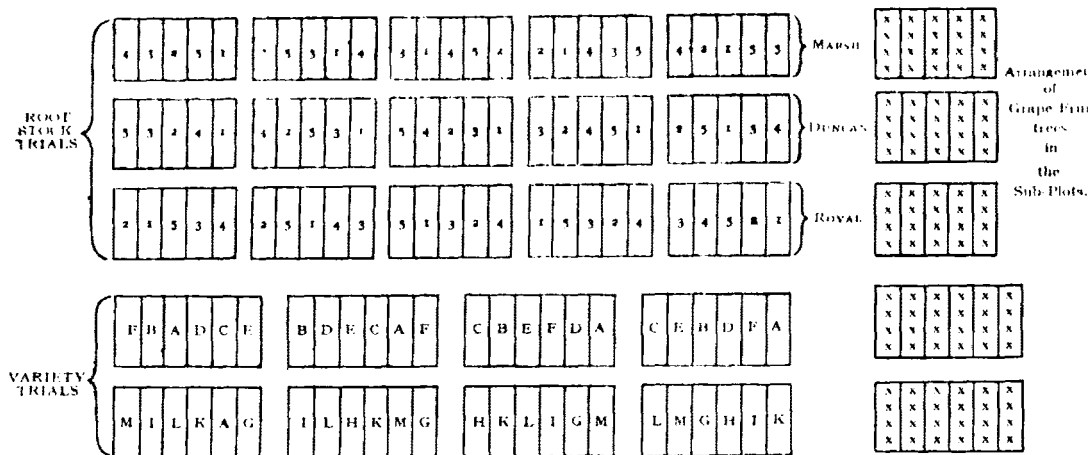
In conclusion the writers would like to express their thanks to Mr. J. Eaden, Assistant Manager, Experimental Fruit Farm, Newton, who so kindly supplied the data from which the costs of production and extraction of lime products were calculated.

PAPER No. XXI.
DIAGRAM No. 1.

KEY TO NUMBERS
AND LETTERS.

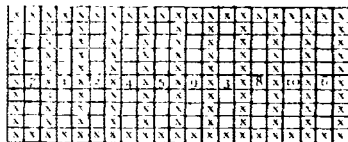
- | | | |
|----|-----------|-------------|
| 1. | Rootstock | Seville |
| 2. | " | Cleo |
| 3. | " | Shaddock |
| 4. | " | Rough Lemon |
| 5. | " | Tangerine |
-
- | | | |
|----|----------|-------------|
| A. | Marsh | on Seville |
| B. | Duncan | " |
| C. | Walters | " |
| D. | Thompson | " |
| E. | Foster | " |
| F. | Royal | " |
| G. | Marsh | on Shaddock |
| H. | Duncan | " |
| I. | Walters | " |
| K. | Thompson | " |
| L. | Foster | " |
| M. | Royal | " |

PLOT 17.

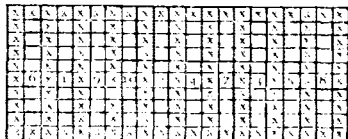
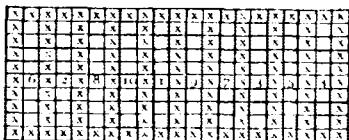
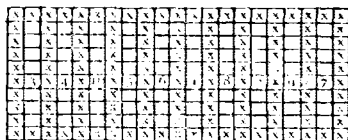
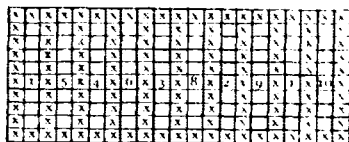


GRAPE FRUIT - ROOT STOCK AND VARIETY TRIALS.

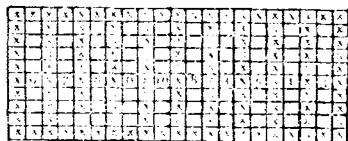
PLOT 15.



PLOT 16.



PLOT 21.



PLOT 23.



PAPER No. XXI.

DIAGRAM No. 2.

Each "X" indicates a Guard Tree.
 Each space between Guard Trees accommodates a row of 8 Fertilised Trees.
 Each blank square contains a Fertilised Tree.

The following is a guide to the Numbers used to indicate Fertilisers:—

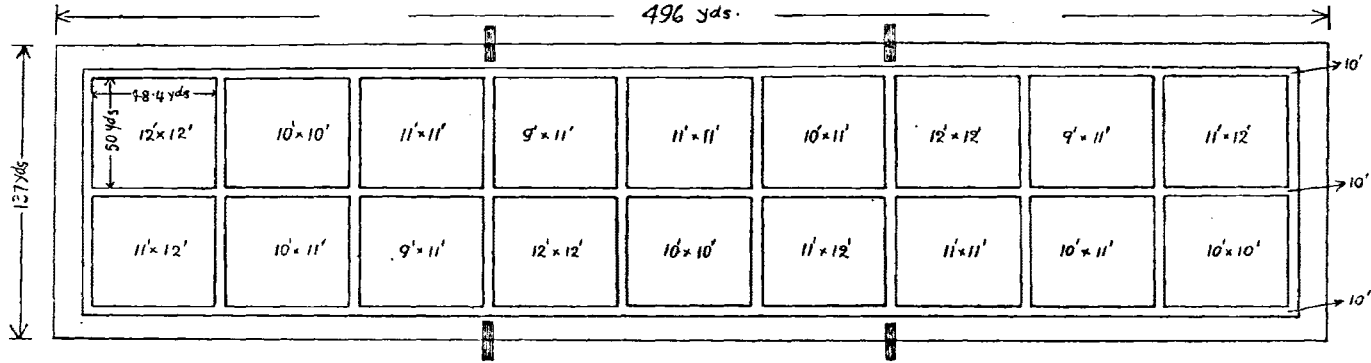
1. Control—No Manure.
2. Ammonium Sulphate.
3. Urea.
4. Calcium Cyanamide.
5. Dried Blood.
6. Am. Sulphate and Super + Potash.
7. Am. Sulphate + Super.
8. Am. Sulphate + Potash.
9. Fish Guano + Potash.
10. Nitrophoska.

SCHEME OF FERTILISER TRIALS ON GRAPE FRUIT.

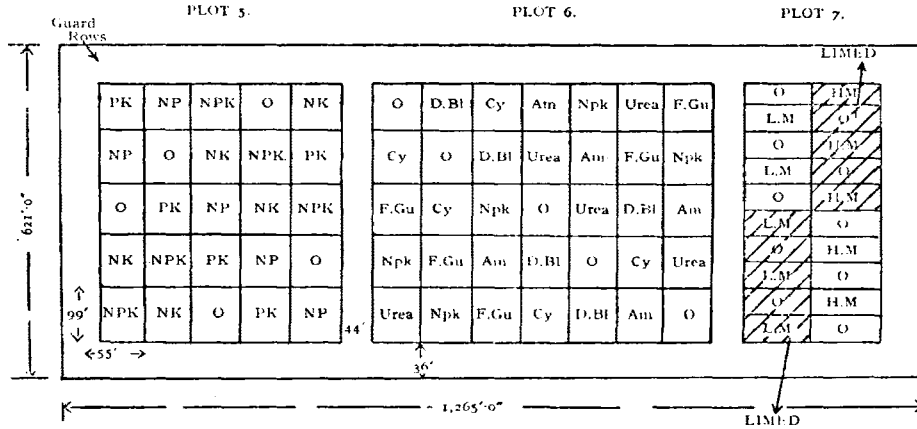
PAPER No. XXI.
DIAGRAM No. 3.

PLOT 12.

496 yds.



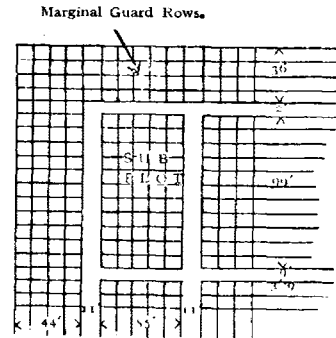
BANANA — DISTANCE OF PLANTING TRIALS



—BANANA FERTILISER TRIALS—

—FRUIT FARM NEWTON—

- N. = Ammonium Sulphate.
- P. = Super Phosphate.
- K. = Potassium Sulphate.
- D.Bl. = Dried Blood.
- Cy. = Calcium Cyanamide.
- Am. = Ammonium Sulphate.
- Npk. = Nitrophoska.
- F.Gu. = Fish Guano.
- L.M. = Light Mulch.
- H.M. = Heavy Mulch.
- O. = Control.



Showing layout of Bananas.
 Each sub-plot is $\frac{1}{4}$ Acre.
 Each square is 9 ft. by 11 ft. and
 contains one Banana Plant.

PAPER No. XXII.

A FRUIT INDUSTRY FOR THE GOLD COAST.

BY G. H. EADY (GOLD COAST).

THE GOLD COAST CLIMATE.

The Gold Coast is situated wholly within the torrid zone and has a mean annual rainfall between 24 ins. in the coastal savannah and 88 ins. in the rain forest. There is a marked double rainy season.

The mean annual shade minimum temperature in the coastal savannah lies between 71 and 75 degrees, the mean annual shade maximum for the same type of country being 83°—87°. In the rain forest mean shade minimum falls between 67° and 71° with a mean maximum of 83°—89°. The mean temperature range in the inland savannah is generally greater reaching 26° in some districts.

The mean annual relative humidity lies between 71 and 88 per cent. with a very marked drop to as low as 20 per cent. in the Harmattan season, during December and February.

FRUITS AT PRESENT CULTIVATED.

The sweet orange (*Citrus aurantium*) is to be found in many cacao farms and in and around practically all towns and villages in the country. Large quantities are grown in the Krobo District of the Eastern Province, around Dixcove in the Western Province, and smaller quantities on all Agricultural Stations.

The grape fruit (*Citrus grandis*) is not commonly cultivated but thrives and fruits well on all Experimental Stations.

The lime tree is grown in every town and village throughout the Colony. Shaddocks, lemons, sour oranges, rough skinned lemon, citrons and tangerines are cultivated at Aburi and on other Stations in the Colony, and produce heavy crops annually.

Pineapples (*Ananas sativus*) may be purchased in most markets in the Colony, and are grown practically everywhere, including Agricultural Stations.

The Mango (*Mangifera indica*) is a very common fruit, but the trees do not fruit well in humid districts. The fruit is generally of poor quality, fibrous and of an indifferent flavour. A large number of trees are to be found scattered throughout the less humid districts and generally bear heavy crops.

Bananas (*Musa Cavendishii* and *M. Sapientum*) together with other varieties thrive well throughout the wet districts and produce good crops. All varieties are cultivated on the Departmental Agricultural Stations.

Avocado pears (*Persea gratissima*) are as common as mangoes and oranges in the various markets. Large quantities are produced on the Akwapim ridge in the Eastern Province and elsewhere in the Colony. The trees thrive well under practically all conditions and invariably produce heavy crops. Other tropical fruits grown on Agricultural Stations include Pomegranate (*Punica granatum*), Monstera (*Monstera deliciosa*), Durian (*Durian Zebethinus*), Soursop (*Anona muricata*), Guava (*Psidium Cattleianum* and *P. guyava*) and other lesser known smaller fruits.

The fruits mentioned include practically all the well known tropical and sub-tropical species. They all grow well, produce good or moderate crops if given suitable conditions of soil and climate, and could be cultivated on a large scale if required.

POSSIBILITIES OF AN INDUSTRY IN ANY ONE OF THE FRUITS MENTIONED.

Oranges.

These could be undoubtedly grown on plantation lines and made to yield large crops with suitable cultivation and treatment. The objection to the Gold Coast orange is its bad colour, which would prevent ready sales being effected since the public look for a good colour in all citrus fruit. A further objection appears to be green ripening due to a humid atmosphere which is scheduled for investigation by the Department.

Oranges grown in the Gold Coast were exhibited at the Imperial fruit show held in 1926, and received favourable comment. The fruit in this case was apparently clean and of good colour which indicates that Gold Coast oranges can be produced to satisfy public taste providing they are allowed to ripen sufficiently before reaping.

Many crates of from 100—200 fruits properly picked, cleaned, and packed, taken to England when proceeding on leave, over a period of 17 years, have invariably arrived in excellent condition with a very small percentage of decayed fruit. Moreover the fruit was of excellent colour, appearance and flavour equal to that purchased in local shops, with which comparisons were made.

Before an industry in this fruit could be recommended it would be necessary to (a) Investigate the cause of bad colour and appearance undoubtedly present in fruits from some districts. (b) Determine the cause of green ripening. (c) Import new varieties. (d) Conduct tests as to suitability of all varieties and selection of a type suitable to local conditions and for export. (e) Propagate selected types by budding, using sour orange or shaddock stock.

(f) Arrange fertiliser trials, and (g) Cultivation trials. (h) Produce trees immune from gummosis of the stem and collar which at present attacks a large percentage of all oranges grown on their own roots.

Grape Fruit.

The Gold Coast Grape Fruit exhibit at the Imperial Fruit Show in 1926, received very favourable comment and considerably impressed fruit merchants whose opinion was sought. The following excerpt is taken from a letter from the Director, Gold Coast Commercial Intelligence Bureau, London, to the Director of Agriculture, Gold Coast, dated November 2nd, 1926.

“The opinion of many fruit merchants was if we had put up our grape fruit in competition we should have secured a very good prize.”

“It may interest you to know that one large wholesale fruit merchant was ready to place orders for grape fruit and and limes for a very considerable amount for next year.”

From the above it is evident that Grape fruit from this country is regarded as equal to, or at least comparable with, that produced anywhere in the world and that large quantities would find a ready sale.

Although the importation of new varieties such as Marsh's seedling, Duncan and other well known varieties, is advisable, a large number of trees could be produced by budding from varieties and types already in cultivation having suitable characteristics desired by the trade.

An industry in this fruit appears to be a practical proposition inasmuch as disposal of the fruit in the United Kingdom is concerned. Other factors favourable and unfavourable are dealt with in detail in subsequent paragraphs.

Limes.

Of all the Citrus family, both spined and spineless limes are the heaviest yielders. A yield of 163 barrels of fresh fruit per acre has been obtained on the Asuansi Agricultural Station in the Central Province wherein Messrs. Rose's Lime Juice factory is situated. As an export industry the cultivation of limes is not recommended, but according to the firm already mentioned lime plantations return a gross receipt of £25 per acre, less transport charges on the fruit from plantation to factory or collection area. An acre of average cacao does not yield a nett profit of more than £10 per acre under the most favourable seasonal and market conditions. It must be realized, however, that large areas under limes would yield a substantial profit only when situated within reasonable distance of a factory, otherwise transport charges would considerably reduce the value of the plantation from a money making point of view.

Another factor in favour of limes is that the tree thrives well and produces large crops under condition of soil and climate inimical to cacao.

Shaddock or Pomelo.

These large pyriform thick skinned fruits, sometimes with pink flesh, are little known outside the areas wherein they are cultivated. Commercially the fruit is of little value but seedlings are valuable as stock for oranges and grape fruit, being immune to collar and stem diseases.

Lemons.

The true lemon (*Citrus limonum*) is only to be found on Agricultural Stations and only a few trees are cultivated. The demand in the United Kingdom exceeds the supply and during 1928 it was no uncommon occurrence to have to pay as much as 6d. each for these fruits. Frequently they were unobtainable at any price.

No lemons are produced within the Empire, the chief imports into the United Kingdom being from Spain, Sicily, Greece, France and the United States. The Empire Marketing Board, The Director, Gold Coast Commercial and Intelligence Bureau, London, and prominent fruit salesmen in the United Kingdom are of the opinion that a lemon industry in the Gold Coast would pay handsome profits and that the United Kingdom alone could absorb the whole of the fruit produced.

A possible industry in this fruit will be dealt with later.

Sour or Seville Orange.

A limited market only exists for these fruits which are imported into the United Kingdom, chiefly from Seville, Spain. Cultivation in the Gold Coast for export purposes is not recommended.

Citrons.

Both the round and fingered varieties are represented at Aburi by a few small trees. Exports into the United Kingdom are chiefly from Southern Europe and the Mediterranean region. The United States have a small acreage under this crop. The demand being limited, the extension of this crop in the Gold Coast is not advisable.

Mandarin or Tangerine Oranges.

Varieties of these are cultivated at Aburi, Asuansi, Kumasi Agricultural Stations. On the Wioso Agricultural Station in the Western Province, one line of 26 trees produced an average of 600 fruits per tree in 1921. The trees were so heavily laden that it was necessary to support the branches with forked sticks. The fruits were delicious, attractive in appearance and easy to handle on account of the loose skin and easily separable segments.

Countries producing large quantities of these fruits include America, Spain, Italy, Palestine, South Africa, France, China, Brazil, Argentine, Paraguay, Malta and The Cook Islands.

Although fruit of the finest quality could be produced in the Gold Coast without a great deal of trouble, it is the opinion of the Empire Marketing Board and prominent fruit salesmen in England that difficulty would be experienced in marketing same, and, for this reason it would be unwise to cultivate the tree with the object of ultimately exporting the fruit.

Pineapples.

This country does not produce sufficient fruit to meet internal consumption at the present time but the plants grow and fruit well throughout the Colony. On the Agricultural Stations Smooth Cayenne and Queen varieties are cultivated on a small scale.

The market can usually absorb considerably greater quantities than are now received, but experimental shipments of fruit from the Gold Coast have not, so far, been successful. Pineapples were shipped to England in 1926 with the intention of exhibiting the fruit at the Imperial Fruit Show. The fruit either arrived in a green condition, was of a bad colour, or decayed. During 1927 The Gold Coast Intelligence Bureau, London, handled a shipment of pineapples on behalf of Mrs. Grant, of Sekondi. The fruit was shipped to arrive in a greenish condition but were not marketable until, after careful handling, they were allowed to become a brownish russet colour which the public look for when purchasing pineapples. By the time they reached this colour the insides were so soft that they were not eatable.

Several small consignments of the fruit taken to England by an Officer of the Agricultural Department were no more successful, the fruit generally being decayed on arrival. The conditions mentioned could be remedied by proper packing, and storage on the steamer, correct temperature during the sea voyage, growing suitable varieties and reaping the fruit at the proper stage of ripening.

Until such time as fruit can be shipped so as to arrive in good condition an export industry is not practicable.

Mangoes.

A great deal could be done to improve the types and varieties already in existence by the importation of new and better varieties and increasing them by asexual propagation, but an industry other than a purely local one is inadvisable.

Bananas.

A separate paper has been submitted by an Officer of the Agricultural Department.

Avocado or Alligator Pears.

All previous experimental consignments of fruit have arrived in England in a decaying condition. The fruit is very delicate, requires very careful reaping, packing, handling, and storage, and is not suitable as an industry in this country.

Other Fruits.

Pomegranates are in small demand on the London market and are not as a rule handled by the best class trade. A limited market exists for *Monstera* which is represented at Aburi but does not ripen its fruits. Durian fruits very shyly in this country, the species being represented by only a few trees on the Agricultural Stations. Sour Sop is cultivated on the Agricultural Stations and by the villagers of this country, the same remarks applying to Guavas which produce very heavy crops. None of the fruits mentioned above is considered suitable for cultivation on a large scale, except possibly to supply local requirements.

A FRUIT INDUSTRY FOR THE GOLD COAST.

An industry in the fruit mentioned is limited at the present time to *Lemons* and *Grape Fruit*, these crops being easily cultivated and handled. The most important factor however is that the fruit would be easily marketable in the United Kingdom as compared to other fruits, which would have to meet severe competition from other countries.

COMMENCING THE INDUSTRY.

The industry being a specialized one, where care is required in cultivation, selection of varieties, weeding, mulching, pruning, reaping, handling, grading, packing and shipment, it is obvious it would be useless to attempt the cultivation of either Lemons or Grape Fruit in the same manner as Cacao is cultivated by the majority of the farmers at the present time. A number of individually owned plantations with a central packing house, or plantations commenced on a bonus system, as has been done with Coffee in this Colony, even with Co-operative management, would be doomed to failure from the commencement.

The trees have to be grown on plantation principles and receive care and attention throughout the whole period from seedlings to old age, and the fruit "picked." No fruit of any description is picked in this country and even on Agricultural Stations, unless supervised by a European, the method of collecting is by beating or shaking the branches and allowing the fruit to fall to the ground.

Having regard to the primitive methods of Agriculture in force at present and to the temperament of the African, the industry would have to be commenced and managed by Government, unless a European firm or company with a knowledge of, or interest in, the fruit industry, could be induced to obtain a concession for the purpose.

RAINFALL, SITUATION, SOIL.

(A) **GRAPE FRUIT.**—In the United States the trees are grown in many districts on every sandy soil with very low rainfall which requires irrigation. Large and good crops are produced under these conditions but insect pests cause a considerable amount of damage and production costs are relatively high.

At Aburi with a rainfall of 48 ins. good crops are produced but in general a rainfall of under 50 ins. is undesirable. In the West Indies Grape Fruit cultivation is successful in a high rainfall area of 250 ins. per annum. A district with a rainfall of over 50 ins. should be chosen and this should be fairly evenly distributed.

A site near a motor road or railway is an obvious advantage, other conditions being suitable, and should be chosen with due regard to the soil and rainfall conditions necessary. Flat land is suitable providing it is well drained but land with a moderate slope is preferable.

The best soils are deep loams, fertile, and well drained. Shallow, heavy poorly drained soils are unsuitable and clay soil should be avoided. Trees on good fertile soil will produce heavy crops without the use of irrigation or artificial manures and production costs will be at a minimum. Many suitable situations exist in the Gold Coast.

(B) **LEMONS.**—At Aburi, elevation 1,500 ft., rainfall 48 ins. the trees grow well and produce fairly good crops on very poor soil. The tree requires practically similar conditions of rainfall, situation and soil, as the orange. The tree luxuriates in the tropics, grows well in the sub-tropics and will endure the mild frosts of the South of France. A rainfall above 50 ins. is advisable, although in well watered districts the trees would probably fruit well on less than this. A very humid atmosphere is detrimental to the production of good fruit, whilst a short resting period, such as is encountered during the Harmattan season, would be distinctly beneficial.

Conditions as to suitable situations are the same as required for Grape fruit. The higher elevations up to 4,000 ft. are preferable but unobtainable in this country. Strong winds are a disadvantage and strong sea breezes definitely harmful.

The type of soil in which lemons luxuriate is of a light rich nature on a marly or limestone formation, but the tree does well on any good rich soil such as may be found in many places in the Western Province of the Colony in well watered areas.

SUPPLY OF PLANTS AND PLANTING MATERIAL.

(A) **GRAPE FRUIT.**—The most desirable characteristics are, thinness of skin, fine texture, yet strong enough to stand up to the handling and travelling necessary, smoothness, good and even colour without roughness or corrugations, and fruit of good shape. A

minimum of seeds, pith and rag, is desirable, but sweetness is of little importance, providing the fruit possesses high juice content with a brisk and distinct flavour and is free from bitterness and too much acidity.

Certain trees at Aburi and on other Agricultural Stations possess these characteristics and large numbers of seedlings could be raised by budding on to sour orange stocks. "March's Seedling," "Duncan," "Excelsior," "Hall," "McCarty" and "Triumph," varieties are being imported by the Department and budded plants could be raised from these.

(B) LEMONS.—The chief characteristics desirable are good colour, smooth, even, thin yet tough skin and a brisk and distinct flavour. Fruit approximating to these desiderata exist at Aburi and on other Stations. Large numbers of budded seedlings could be raised on sour orange stocks or from seed if necessary. The Department is importing the following varieties from all of which budwood would be available within a few years:—"Eureka," "Lisbon," "Villafranca," "Genoa," "Spanish."

NURSERY AND SEEDLINGS.

(A) GRAPE FRUIT } Numbers of Grape Fruit and sweet orange
(B) LEMONS } trees in this country are destroyed by
gummosis of the collar and stem for which reason a resistant stock is essential. The sour or Seville orange is resistant or nearly so; and possesses certain other desirable characteristics of value. The first, or one of the first, operations after acquiring the land chosen for the plantation would be the selection of a site suitable for a nursery. The seed-bed need not be raised from the ground unless local conditions require such practice and seed from healthy vigorous well grown trees obtained, preferably from only one tree. When the seedlings are about 8 ins. high they should be transplanted into the nursery, 15 ins. apart and 3 ft. between the rows, taking care to discard all small, weak and diseased plants and those with deformed roots.

Budding may be undertaken whenever the seedlings are large enough and preferably about 10—12 ins. from the ground, otherwise the stem may develop gummosis or collar rot. Small and backward seedlings should be destroyed. The usual practice should be followed in this operation which presents no real difficulties in this country. Bud-wood should only be cut from trees known to produce the right type of fruit in abundance and only from such trees as show the least tendency to single limb mutation.

Budwood may be kept for some time under suitable conditions and transported to the nursery by the most direct route, or alternatively, seedling stocks could be raised and budded in the vicinity of the parent trees and the budded plants transported to the plantation.

PLANTING.

(A) **GRAPE FRUIT.**—All natural growth should be removed from the selected area and holes dug 25 ft. by 25 ft. apart each way. When removing plants from the nursery to the plantation all weak trees should be discarded as they are inferior to the well grown ones and will always remain so. Young plants should each be provided with a stake to which they must be tied to encourage straight stems.

The actual planting operation would naturally follow the standard practice and needs no description here.

(B) **LEMONS.**—A planting distance of 20 ft. by 20 ft. is recommended which gives 109 plants to an acre. A greater or lesser distance may be necessary according to the type of soil otherwise the procedure would be the same as given under Grape Fruit.

CARE OF THE YOUNG PLANTATION.

(A) **GRAPE FRUIT AND (B) LEMONS.**—Until such time as the trees come into good bearing the young trees require continual attention. Vacancies should be filled as soon as they occur in order to obtain trees of uniform growth.

Clean weeding is not recommended except for an area extending for three feet either side of each tree. Weeds and bush may be cutlashed when necessary and the trees mulched with the weeds cut from the centre of the rows. Pruning should be confined to removing branches and suckers that arise from undesirable positions and crossed branches, the object being to produce well balanced trees with fairly open centres.

Whilst the grape fruit and orange require only a minimum amount of pruning the lemon tree demands almost constant attention. The tree should be regularly pinched back and built up wholly of short stocky branches strong enough to bear a heavy load. The tree should not be allowed to grow more than 8 ft. to 10 ft. high and all suckers and vigorous shoots removed as occasion demands.

CULTIVATION.

With a medium rainfall, clean weeding of young Grape Fruit or Lemon plantations is not recommended since the valuable surface soil would be lost by erosion and the humus content quickly destroyed, apart from the damage to the feeding roots which lie close to the surface.

Cover crops should be encouraged whenever possible.

The addition of fertilizers will probably be necessary when the trees commence to bear but, providing good crops are produced, may not be required.

PROBABLE YIELD.

(A) GRAPE FRUIT.—Trees in full bearing are capable of yielding 500 fruits per tree.

A yield of 20,000 fruits per acre is within the limits of a healthy plantation.

Records of the individual yields of trees both at Tarkwa and Aburi, where the soil is very poor, average 300 fruits per tree over a period of several years. In this country there is a double fruiting season extending from March to June and September to December. The greatest proportion of the fruit being produced during the earlier season.

(B) LEMONS.—The fruiting season is much more irregular than with other citrus fruit, being produced in this country throughout the greater portion of the year. Pruning is an important operation in relation to production but if properly carried out good trees will yield 400—500 fruits per tree or 40,000 per acre per annum.

PICKING.

(A) GRAPE FRUIT.—This operation is as important as the actual production of the fruit and should receive very great care. Fruit must not be dropped or bruised or suffer mechanical damage whatsoever; otherwise a large percentage will be decayed before reaching distant markets.

Pickers, in addition to being taught that extreme care is necessary in handling the fruit, should wear gloves to avoid finger nail marks. Other points requiring attention are (a) The use of a type of clipper that will not injure the fruit. (b) Containers must be free from roughness, sand, splinters, or any material likely to damage the fruit. (c) The stem must be cut flush with the button and no portion allowed to project beyond the fruit otherwise punctures will occur. (d) Fruit must not be piled over 12 ins. deep. (e) Fruit must not be picked when wet or during wet weather. (f) Fruit must not suffer from prolonged exposure to the sun. (g) Fruit should be fully mature before being picked and of a degree of ripeness that by the time they reach the consumer they are fully ripe and of a pale lemon yellow colour.

(B) LEMONS.—The same care in handling, prevention of damage and mechanical injury is required as with Grape Fruit but the fruit should be picked in a green or semi-ripe condition and artificially coloured. At Aburi the fruits do not ripen uniformly and attain a good colour if left on the trees and it is safe to assume that they would not do so when grown on a large scale in other parts of the Colony. Artificial ripening also allows fruits to be picked when of uniform size, stored for several months and placed on the market when prices are most favourable.

GRADING AND PACKING.

(A) **GRAPE FRUIT.**—Cases recommended are of the same type as those used in South Africa, the inside measurement being, length 23 ins., breadth 11½ ins., depth 11½ ins. with a central division across the breadth. These could be manufactured locally providing suitable timber was available or shipped out in shooks made of Swedish white wood. The use of standard cases is essential.

Fruit must be entirely free from surface markings of any description and each fruit must be wrapped in tissue paper. Cases should be packed to counts of 64, 70, 80 and 96 fruits and stencilled accordingly. The fruits should be firmly packed but not so tight as to cause the wood of the case to cut into the fruit.

(B) **LEMONS.**—Standard cases should be used, each fruit separately wrapped in tissue paper and packed to a count of 300 per crate, the same general care being required as for Grape Fruit.

Artificial colouring may be effected by exposing the green fruit to Carbon Dioxide and Carbon Monoxide gas in a humid atmosphere of 90°. The process occupies about six days.

The following method in use in New South Wales is taken from a description of the process adopted by the Department of Agriculture in that country.

The actual operation was conducted thus:—

The fruit just picked into "lug" boxes was stacked on pieces of wood battens resting on an earth floor. The head of boxes was then covered with a heavy canvas cover, thus enclosing the stack of fruit in practically an air tight condition. An oil engine of 2 H.P. attached to a motor spray machine was used from which the exhaust gases were conducted by a pipe sufficiently long to prevent the temperature of the fruit rising above 75° Fah. (piping 12 ft. long was necessary).

The engine was run intermittently for five days. The actual engine running time was 61 hours, but probably the colouring could be accomplished with less engine running. The cost of oil and benzine for each experiment was 15s. 8d., and up to 97 bushels of fruit were treated at one time. It is believed that the exhaust gases were ample for treating at least three times that quantity of fruit.

In addition to keeping the temperature around 75° it is important to maintain a humidity of not less than 80%. This was accomplished by spraying water on to the ground beneath the boxes when humidity showed a declining tendency.

SHIPMENT.

The Gold Coast is in direct shipping communication with England, the voyage taking 13 days.

With careful handling and packing, it is not essential that Grape Fruit and Lemons for the English market should be refrigerated in transit. Messrs. Elder Dempster's Steamers have cool room stowage available which it would be necessary to use if other stowage was not available. With a progressive firm like Messrs. Elder Dempster & Co., however, it is fairly safe to assume that shipping difficulties, should they arise, would be solved even to the extent of running special steamers if and when the industry should warrant such provision.

MARKETING.

The Geographical position of the Gold Coast is such as to make it compare favourably with other Colonies interested in Citrus culture, since its only competitor of any importance at present would be South Africa, whose fruit takes practically a week longer to reach the market than would fruit from the Gold Coast. It must however, be remembered, that Sierra Leone are very seriously considering the citrus fruit market and in the case of this trade developing they will be able to get their fruit over in three or four days less time.

Detailed arrangements as to marketing the fruit would have to be made beforehand with wholesale fruit Salesmen such as Messrs. Broome and Green, Messrs. J. and H. Goodwin & Co., or other prominent firms. It would be advisable to mark on each crate, before shipment, the nature of the contents and numbers of fruits per case.

COSTS.

(A) FROM SEEDLING TO BEARING TREES.—Assuming 20 acres of land is planted to commence with, the cost of bringing the plantation into bearing would approximate to the following:—

	£	s.	d.
Cost of trees	35	0	0
Clearing	150	0	0*
Planting	3	0	0
Pruning, etc.	5	0	0
Treating diseases	5	0	0
Cutlassing, wedding	250	0	0
Mulching, etc.	50	0	0
	<hr/>		
	£498	0	0

The cost of bringing an acre of Grape Fruit to the bearing stage should not cost more than £25 per acre in this country. In the case of Lemons the cost would be slightly greater on account of the extra number of trees required and a greater expenditure on pruning. This should not, however, exceed £30 per acre.

* This amount will vary with the type of vegetation and may be higher or lower.

(B) MAINTENANCE COSTS AFTER MATURITY PER ACRE PER ANNUM.

	Grape Fruit.			Lemons.		
	£	s.	d.	£	s.	d.
Pruning	1	0	0	2	0	0
Cultivation	3	0	0	3	0	0
Treating, diseases, etc. ..	1	10	0	1	10	0
Fertilisers	6	0	0	6	0	0
Per acre per annum ..	<u>£11 10 0</u>			<u>£12 10 0</u>		

(C) ESTIMATED COST OF LANDING FRUIT IN ENGLAND PER CASE.

	Grape Fruit. (per box of 60.)			Lemons. (per box of 300)		
	£	s.	d.	£	s.	d.
Cost of production	0	0	6	0	0	9
Picking	0	0	2	0	1	0
Packing and material	0	0	3	0	0	5
Cases	0	0	6	0	0	6
Transport	0	0	6	0	0	6
Freight to England	0	3	0	0	3	0
Commission, United Kingdom charges, etc.	0	2	0	0	2	0
	<u>£0 6 11</u>			<u>£0 8 2</u>		

A yield of 363 boxes of Grape Fruit, containing an average of 77 fruits should be obtained per acre and 133 boxes containing 300 fruits in the case of Lemons.

WHOLESALE PRICES IN THE UNITED KINGDOM.

(A) GRAPE FRUIT.—An examination of the wholesale prices of Grape Fruit in the United Kingdom reveals very considerable fluctuations not only from one part of the year to the other, but even in any one month. There are naturally also the ordinary variations in prices on any one date due to differences in quality and picking.

As an illustration, Jamaican Grape Fruit may be taken. At Liverpool during the past 12 months, according to the market report of a well known firm of fruit merchants, the price of this fruit has fluctuated between 10s. 9d. and 17s. in November and 31s. 6d. and 46s. in September.

Another striking case is that of Florida Grape Fruit where quotations have varied between 12s. to 19s. 3d. and 26s. to 40s. which was obtained in May.

The highest prices were, however, obtained by Porto Rican Grape Fruit, the best qualities of which reached 47s. to 48s. and 44s. to 49s. in September

South African Grape Fruit were available in July and August, but did not attain very high prices, ranging between 9s. 6d. and 18s. 9d. with one solitary quotation—the last of the season—of 25s.

Similar fluctuations were noted in the wholesale prices of Grape Fruit in London as given by a large firm of wholesale fruit merchants.

Isle of Pine Grape Fruit varied in price between 17s. to 25s., Florida between 19s. to 30s. 6d. and Jamaican between 12s. and 23s.

(B) LEMONS.—No wholesale prices are available but as the retail price for good fruit is never less than 2d. and frequently much more this may be taken as varying between 20s. and 30s. per box.

ESTIMATED NET REVENUE PER ACRE.

(A) GRAPE FRUIT.—With a wholesale price as low as 10s. per case, a nett profit per acre of £55 would be obtained. Even assuming the yield was only 200 fruits per tree and the wholesale price 10s. per case a nett profit of £27 would be received. The greatest possible nett profit from an acre of cacao could not exceed £10 per acre, so it is evident Grape Fruit culture in this country would be a highly remunerative undertaking.

(B) LEMONS.—The nett profit per acre from Lemon trees grown on good soil and in full bearing exceed the figures quoted above and even with a yield less than half that estimated, and double the production costs, a very handsome profit would be available.

INCREASED DEMAND IN GREAT BRITAIN FOR GRAPE FRUIT.

The steady increase in the demand for Grape Fruit has provided the trade with one of its most interesting features of recent years, and there is every indication that the time is not far distant when grape fruit will rank with the apple, orange, banana and grape as being among the most popular fruits handled by our industry. This consistent and increasing demand will undoubtedly be helped by the fact that the Grape Fruit furnishes yet another instance of a fruit that is available to the trade from one year's end to another, since no sooner is the crop at one source of supply exhausted than the sequence of supply is taken up by some other grape fruit producing area. American Grape Fruit provides the British market with the bulk of its requirements at present, and it is interesting to note that imports of American grape fruit into the United Kingdom during 1926 amounted to the record figure of 25,939 cases.

The other principal sources of supply are South Africa and British West Indies, and in each of these cases the trade has grown rapidly in the past six years, but the increase in the proportion supplied by the United States has been by far the greatest. Statistics indicate that three-fourths of the grape fruit imports now are supplied by the United States. Some of these imports, however, consist of fruit from the Isle of Pines shipped via New York. Grape Fruit first appeared as a separate item in the United Kingdom Trade Statistics in 1920, when 21,974 boxes of 70 pounds each were imported. The United States that year supplied 58.3% of the total. British imports in 1927, the last year for which detailed statistics are available, amounted to 606,468 boxes of which 74.6% was accredited to the United States.

While the bulk of the American exports is shipped during the six months February to July, exports are maintained on a substantial level throughout the year. South African and West Indian supplies in the British market are, in a sense, complimentary to each other. Thus South African Grape Fruit is available principally from June to September and West Indian supplies largely from December to April.

Although the consumption of grape fruit in Great Britain has grown very rapidly in recent years, the quantities consumed per head of the population are still very small, as indicated by the fact that during the past five years the per capita consumption of grape fruit has been only .2 of a pound.

IMPORTS OF GRAPE FRUIT INTO THE UNITED KINGDOM.

Year.	South Africa.	British West Indies.	Other British Countries.	U.S.A.	Other Foreign Countries.	Total.
1921 ..	2,440	8,770	254	17,923	4,931	34,318
1922 ..	10,216	8,854	—	30,689	800	50,559
1923 ..	12,509	16,877	1,170	45,105	4,418	80,238
1924 ..	15,768	15,787	925	93,689	4,018	130,186
1925 ..	21,837	28,171	787	200,071	17,353	268,186
1926 ..	20,997	43,486	2,688	239,847	25,939	332,956
1927 ..	23,907	47,493	8,926	501,314	24,829	606,468

FACTORS AFFECTING THE GRAPE FRUIT INDUSTRY.

During the past eight years the world's production of Grape Fruit has increased rapidly and a further large increase may be expected. Taking the import figures into consideration it appears to be inadvisable to carry out further expansion. The production and delivered costs must however, be taken into consideration. The West Indies cannot land and sell Grape Fruit in the United Kingdom

at less than 13s. 6d. per box, California and Texas 18s. per box, Florida, the Isle of Pines and Porto Rican 16s. per box. Landed costs of Gold Coast Fruits should be considerably below any of these figures which places the Gold Coast produce in a distinctly advantageous position. Should the supply at any time exceed the demand the country which can produce good quality fruit at a lower price than any of its competitors is justified in continuing its existing industry or commencing one.

The factor of lower production and landing costs loses its importance unless fruit of good quality and uniformity can be produced since the public will always pay more for a high grade product irrespective of its origin.

There appears to be no reason why the Gold Coast cannot produce fruit equal to that of anywhere in the world. If it can do so, and at the same time keep production and landing costs below that of other countries, it is in a distinctly advantageous position.

LEMONS IMPORTED INTO THE UNITED KINGDOM.

Statistics relating to imports of Lemon into the United Kingdom are unfortunately not available. No Lemons are produced within the Empire. Competent authorities are unanimous in the opinion that Gold Coast fruit would find a ready sale, and that the demand exceeds the supply.

INSECT PESTS.

The following notes have been obtained from Mr. G. S. Cotterell (Entomologist).

The following pests occurring in this country are listed in tabular form:—

Name of Insect	Family.	Nat. Order.	Species attacked.	Remarks.
<i>Zonocerus variegatus</i> L.	Acridiidae ..	Orthoptera	<i>C. aurantium</i> <i>Tangerine nobilis</i> .	Foliage of young plants. Damage caused by (nymphs) hoppers and adults. March and April.
<i>Papilio demodocus</i> . Esp.	Papilionidae	Lepidoptera	<i>C. aurantium</i> <i>C. grandis</i> . <i>C. acida</i> .	Larvae eat foliage. Eggs laid singly on under surface of leaves.
<i>Othreis (Ophideres) fullonica</i> L.	Noctuidae	Lepidoptera	<i>C. aurantium</i> <i>C. grandis</i> .	Maturing fruits. Adults only. At night. March and April. Also attacks bananas.
<i>Achaea (Ophiusa) lievardi</i> Boisd.	Noctuidae ..	Lepidoptera	<i>C. aurantium</i> <i>C. grandis</i> .	Maturing fruits. Adult only. At night. March and April. Also attacks bananas.

INSECT PESTS—continued.

Name of Insect	Family.	Nat. Order.	Species attacked.	Remarks.
<i>Leptoglossus membrana-ceous</i> F.	Coreidae ..	Rhyncota ..	<i>Citrus nobilis</i> ..	Fruits. Adults only.
<i>Lepidosaphes pinnaeformis</i> Be.	Coccidae ..	Rhyncota ..	<i>C. aurantium</i>	Under surface of foliage.
<i>Cercyonia citri</i> , sp.n.	Halticidae ..	Coleoptera ..	<i>C. acida</i> . <i>C. aurantium</i>	Young plants. Boring in terminal shoots. Can be serious on <i>C. acida</i> .
<i>Tragocephala gorilla</i> , Thoms.	Cerambycidae	Coleoptera ..	<i>C. aurantium</i> <i>C. grandis</i> .	Larvae boring in branches.
<i>Ceratitis capitata</i> , Wied.	Trypetidae ..	Diptera ..	<i>C. aurantium</i>	Fruits. Larvae only. "Mediterranean Fruit Fly."
<i>Ceratitis punctata</i> , Wied.	Trypetidae ..	Diptera ..	<i>C. limonum</i>	Fruits. Larvae only. Also attacks bananas.

The two fruit-piercing moths, *Othreis* and *Achæa*, are exceedingly important in this country and therefore the following additional notes are given. Damage is caused by the adults only.

Othreis (*Ophideres*) *fullonica*. L.—This is a large yellow-underwing moth. Its proboscis is considerably stronger than that of *Achæa lienardi*, the other fruit moth, and a fewer number of punctures cause the fruit to fall. Only maturing fruits are sucked. Fruits lying on the ground are not generally touched. The moths suck the fruits after dark sheltering amongst the foliage of the trees during the day.

Nothing is known of the habits or food-plants of the larvæ in this country. *O. fullonica* occurs in Fiji where it is reported as feeding on *Erythrina indica*; in Queensland on various species of Menispermaceæ, the chief being *Pericampylus incanus* and *Stephania* spp.; in India on *Cocculus hirsutus*, Menispermaceæ; and in South Africa on *Exocaria reticulata*, Euphorbiaceæ. Hutchinson records 16 species of Menispermaceæ from West Africa including one species of *Cocculus*, namely *C. pendulus*, and three species of *Stephania*, namely *S. latifcata*, *S. abyssinica* and *S. Dinklagei*. It is probable that the larvæ will be found feeding on one of these species in the Gold Coast.

There is probably only one generation per year as only the March-April Citrus crop is attacked. The moths are not known to be migratory in habit.

Achæa lienardi. Boisd.—This moth, which is light brown in colour with two characteristic white spots on each hindwing, is if anything, more harmful than *Othreis* sp. on account of the large number present during attack. They are attracted to a number of fruits, the most important being Mango and Guava. The former

is particularly attractive. Attack is limited to the March-April crop and damage is done at night. In the Akwapim district the moth migrates from an easterly direction and has its origination on the Accra-Akuse plains. Nothing is known in this country of the habits and food-plants of the larvæ. *A. lienardi* is well known as a pest of Citrus in South Africa and Rhodesia, where the larvæ are stated to feed on *Royena pobescens*, (Monkey Apple Tree), Fam. Ebenaceæ; *Acacia* sp. (Wattle), Fam. Leguminosæ; *Eugenia smithi*, Fam. Myrtaceæ; *Eucalyptus* spp. Fam. Myrtaceæ, and occasionally cabbage.

Another moth similar to *Achæa* also occasionally attacks fruits but has not yet been identified. *Achæa obvia* and *A. catella* have previously been reported as attacking citrus fruits in this country.

Neither *Achæa* nor *Othreis* are attracted to the sour orange.

It is significant that fruit moths have never been recorded as causing damage in the present chief Citrus growing area, namely, between Dixcove and Sekondi. The actual period when damage is done is very limited, not amounting to more than one to two weeks at the outside. It is possible that the April-March crop in this area is either sometimes later or earlier than that obtained elsewhere. It is also possible that the food-plants of the larva of *Othreis*, which does not migrate, are absent.

In the case of *Achæa*, which migrates, the sea-breezes on the Coast may have an effect on migration.

Possibility of Control.

It is possible that all these moths would be controlled if an early or late fruiting variety could be grown. There are also certain varieties of oranges that are less liable to attack than others. In the event of the food-plants of the larvæ being found, it is unlikely that it would be economic to eradicate them or to spray.

It may be possible to obtain natural enemies from other countries that do not occur here.

Successful control of *Achæa* has been obtained in South Africa by the use of poison baits. The most attractive bait consists of the following (75% of the moths are stated to be attracted by this bait):—

- 2 ozs. Lead Arsenate.
- 3 lbs. Sugar.
- 4 fluid ozs. Grape Vinegar.
- 4 gallons of water.

Mixed and put out in large shallow tins on the ground. Tins require shaking every morning and renewal once a week. Dead moths must be removed at frequent intervals.

This bait is made more attractive if halved oranges which have been dipped in the poison for fully a minute are placed pulp side uppermost in the tins.

Achæa is also attracted to baits consisting of Sodium Arsenite, Sugar and water flavoured with pineapple juice and vinegar

Another recommended bait is :—

- 1½ ozs. Lead Arsenate.
- or ½ oz. Sodium Arsenite.
- 53 ozs. Treacle.
- or 2½ lbs. low grade Sugar.
- 4 galls. water.

The addition of cut fruits, as stated above, make this bait more attractive.

It is stated that these traps are more attractive to *Achæa* if placed on the ground. This is in accordance with the habits of *Achæa* in this country. *Othreis*, however, does not generally feed on fallen fruits in this country and therefore baits of this nature would probably be more effective if slung in the trees. Large shallow tins are more attractive than deep ones.

DISEASES.

Gummosis.—Lemons, tangerines, grape fruit, and orange trees grown from seed are attacked in this country; lime, sour orange, shaddocks and rough skinned lemons appear to be immune since the condition has not been recorded. *Gummosis* should not become a serious disease providing all citrus are grown on sour orange or other resistant stock.

Fomes Lamaënsis. (Muel).—This fungus causes the occasional loss of lemon and grape fruit trees, but is unlikely to cause serious damage providing trees are treated or removed as soon as attacked.

Fruit rot and Die back.—Lemons are sometimes found withered to a mummified condition and covered with a black pycnidia of a *Diplodia*.

The disease occurs with a die back on trees growing in exposed situations on uncultivated or poor soil. With good soil and conditions little trouble may be expected.

REFERENCES.

- “Grape Fruit Culture in the British West Indies and British Honduras.”
(Professor Clark Powell.)
- “Oranges (World Production and Trade).” (Empire Marketing Board.)
- “Tropical Planting and Gardening.” (Macmillan.)
- “Climatology of the Gold Coast.” (Chamney.)
- “The Standard Cyclopædia of Horticulture.” (Bailey.)
- “The California Citrograph.”
- “The B. and G. Fortnightly Review.” (Broome and Green.)
- “The Tropical Agriculturist.”
- “Tropical Agriculture.”
- “Gold Coast Plant Diseases.” (Bunting and Dade.)

THANKS.

The writer cordially thanks the following for information supplied:—

Mr. G. S. Cotterell (Entomologist).

The Director, Gold Coast Commercial and Intelligence
Bureau.

The Empire Marketing Board.