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Contents

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Editorial

Cocoa Marketing

The first article in this issue deals with cocoa marketing, and has been contributed by a leading broker on the London market. The selling of cocoa and the operation of this market are obviously subjects close to the interests of growers, but at the same time the various ways in which cocoa is marketed and the functioning of the terminal markets may not be completely understood. This article deals fully with this subject, and we hope it will clarify some of the intricacies of the cocoa market.

The main purposes of this terminal market have been made clear, and it might be added that while it is used largely by dealers and manufacturers it can equally well be used by some growers in order to fix the price at which they can sell their future production.

Like any commodity market, it is used by speculators whose interests are solely in financial gain. Their activities are not necessarily inimical to the interests of those more closely concerned with the cocoa industry, but they can lead to wider and more rapid changes in price. It must be made clear that such speculative movements are limited in scope and do not account for the extreme movements that have occurred. These are due to the supply and demand position. It is these wider fluctuations that a price stabilisation scheme, discussed at a United Nations Conference in 1966, will aim to reduce. An effective scheme will help to give confidence to the future of the crop, and it is for this reason that—to quote from Mr. Adrian Cadbury's annual statement—"We support the aims of the conference and hope it can be reconvened in 1967".

G. A. R. Wood.

Cocoa Marketing

C. H. Woodhouse, Woodhouse, Drake and Carey Ltd.

Pre 1918

Fifty years ago chocolate was still very largely a luxury. Raw cocoa came from hundreds of plantations all under different ownerships, chiefly in the Western Hemisphere. These plantations produced in general cocoa of high quality, with flavours varying from one country to another. Manufacturers blended these different cocoas to achieve precisely the flavour which characterised their chocolates.

The producers sent their cocoa to London and other consuming centres where it was sold by auction. Manufacturers received samples which they roasted and tested, and then bid for the parcels which suited their requirements. Auctions in their original form were known as "Sales by Candle", from the practice of having a lighted candle, with pins stuck at intervals down its side, set on the auctioneer's desk. The last bid before the pin fell out secured the cocoa.

Up to 1914, the bulk of world production was of these "flavour cocoas".

1918-1939

The greatly increased output from West Africa and Brazil which started in the 1920s brought about major changes in the cocoa trade.

In West Africa, cocoa became a small farmer's crop and prospered without official encouragement. There were no plantations, but thousands of small farms each produced a few bags of cocoa. Merchant firms and manufacturers set up buying agencies on the Coast, and their representatives went out into the bush and bought the beans from the farmers. The farmers, however, had no capital with which to buy the bags and other requirements, so these had to be provided in advance by the buyers, who also gave instructions as to how to prepare the cocoa for market.

The merchant firms brought the cocoa down to the ports, and their head offices in London and Paris sold the crop on the world markets.

The cocoa produced in West Africa was of a standard quality and flavour. No longer was it necessary for manufacturers to examine samples and test them before buying. The result was a revolutionary change in the industry, as the manufacturers in turn were greatly helped in their attempt at standardisation and their efforts to sell their chocolates at a reasonable price to the widest possible market.

The old and cumbersome methods of purchasing were no longer adequate to meet this ever-growing trade. Manufacturers were anxious to make contracts for their supplies many months ahead in order to ensure the steady flow of cocoa through the factories. This could even entail buying cocoa which had not yet been harvested.

The smallholders in Africa could not be expected to enter into contracts on this scale, and the merchant firms who bought the cocoa from them were not in a much better position, preferring, naturally, to sell only what they had in their warehouses.

Commodity dealers, especially those in London and New York, experienced in providing this sort of service in sugar, were prepared to provide a similar service in cocoa now that the conditions were ready for this expansion.

Terminal or futures markets, identical in form to those already existing in sugar and other commodities, were opened for cocoa trading in London and New York during the mid-twenties, which made it possible for dealers to carry out this function.

So far this article has been concerned mainly with West Africa as being the area of spectacular growth in cocoa production. The expansion was also considerable in several other areas, particularly Brazil. The development here, however, was on orthodox plantation systems, with landowners cultivating extensive cocoa farms, and the problem of marketing was simpler.

Flavour cocoas, as far as Europe was concerned, were mainly sold on the basis of examination of samples, and in London auctions were still held up to 1930. In the U.S.A. the tendency to buy flavour cocoas on description was far more prevalent.

Post 1939

The system described above was operative up to the outbreak of the war, Then, in order to ensure the livelihood of the Gold Coast and Nigerian farmers, the British Government agreed to buy the West African cocoa and other crops. For this purpose Produce Marketing Boards were set up in London by the Colonial Office. In 1947 the Cocoa Marketing Boards in the Gold Coast and Nigeria were established.

The Cocoa Marketing Boards used the organisation of the firms already established in West Africa to buy the cocoa from the farmers at prices fixed for the season by the local Governments, and to bring it to port, for which services they were paid their expenses plus a commission. On the selling side, those firms who were engaged pre-war in the trading of cocoa in London were used by the Marketing Boards to sell the cocoa for them. Similar arrangements were made in the French territories and the system carried on virtually unchanged until the Gold Coast and Nigeria became independent after which the selling organisation was transferred from London to Accra and Lagos.

A few years after independence in Ghana the trading firms were superseded by local co-operatives and a Government organisation. In Nigeria, many more accredited buying agents were permitted.

In the Ivory Coast and Cameroon, Caisses des Stabilization set up by the Governments have a similar object to the marketing boards. However, the purchasing and selling of the cocoa is left to the individual shippers to carry out within the framework of the scheme. The Caisses set a minimum price to be paid to the farmers for the whole season. The shippers (directly or through their agents up country) purchase cocoa from the farmer and sell to the world market at prices authorised by the Caisses. The differences between the purchase and the sale prices, less agreed expenses, are settled with the Caisses.

In Brazil, the remaining major producer of bulk cocoa, production is on plantations as well as on smallholdings. Selling arrangements are governed by the Foreign Trade Department in the Bank of Brazil, which is known by its Portuguese abbreviation "CACEX" and operates in a manner somewhat similar to the Caisses.

Cocoa proves no exception to the trend towards standardisation, and the demand for the top-quality flavour cocoa diminishes yearly. Occasionally a small manufacturer will pay high premiums for a parcel of some fine-flavoured cocoa, but in general the cocoa now produced in Venezuela, Ecuador, Trinidad and Grenada, whilst retaining its characteristic flavour, is sold entirely on description by local shippers and merchants.

Conditions of Sale

The marketing companies or shippers sell their cocoa to reputable trading firms throughout the world, and the terms and conditions of these sales are governed by standard contract forms issued by the Cocoa Association of London, the Cocoa Merchants Association in New York and the Association Francaise du Commerce des Cacaos in Paris. These bodies, consisting of all interests in the trade, were formed in order to regulate disputes and generally look after the interests of all the parties concerned.

In general, most countries prefer to sell their cocoa on a C.I.F. (Cost, Insurance, Freight) basis, although Brazil sells F.O.B. (Free on Board). Various recognised definitions throughout the world are used in the selling of basic cocoas to describe their quality. Over 80 per cent of all West African cocoas are sold on the description of Good Fermented, which permits of not more than 5 per cent mouldy and/or wormy beans and not more that 5 per cent slatey. The lower quality is described as Fair Fermented, where the tolerances are 10 per cent mouldy and/or wormy beans and 10 per cent slatey. Bahia cocoa is sold on the description of Superior, which permits of not more than 2 per cent wormy and/or mouldy beans. Fine grade cocoas have various descriptions. The top qualities of these may not contain any defects whatsoever. In order to ensure that the cocoa on arrival is of the quality described, samples are drawn by independent supervisors appointed by both the buyers and the sellers. If the cocoa is not of the quality described, then failing an amicable settlement, arbitrators are appointed by both parties. Weights are also checked on arrival.

Futures or Terminal Markets

It is not the intention here to explain in detail the many uses that can be made of terminal markets by all sections of the cocoa trade. By their opening, it became possible for cocoa traders to offer manufacturers cocoa for any deliveries, even a year ahead, which they might require, by making hedges on the market.

Hedging is such an important function in the trading of cocoa that a simple example is given to show how the risks of fluctuations can be minimised.

A dealer sells to a manufacturer a certain type of cocoa for delivery twelve months ahead at a premium of 10s. 0d. over the price quoted on the terminal for the same position. At the time of making his sale, he purchases the same quantity of terminal. The sale is now hedged and his position is then as follows:

Sale to manufacturer ..	200s. per cwt.
Purchase of terminal ..	190s. per cwt.

Having now a sale and purchase, he has no worries about whether the market goes up or down. His only interest now is to "undo his hedge", i.e. to purchase the actual cocoa he has to deliver to the manufacturer and sell his terminal at a profitable differential.

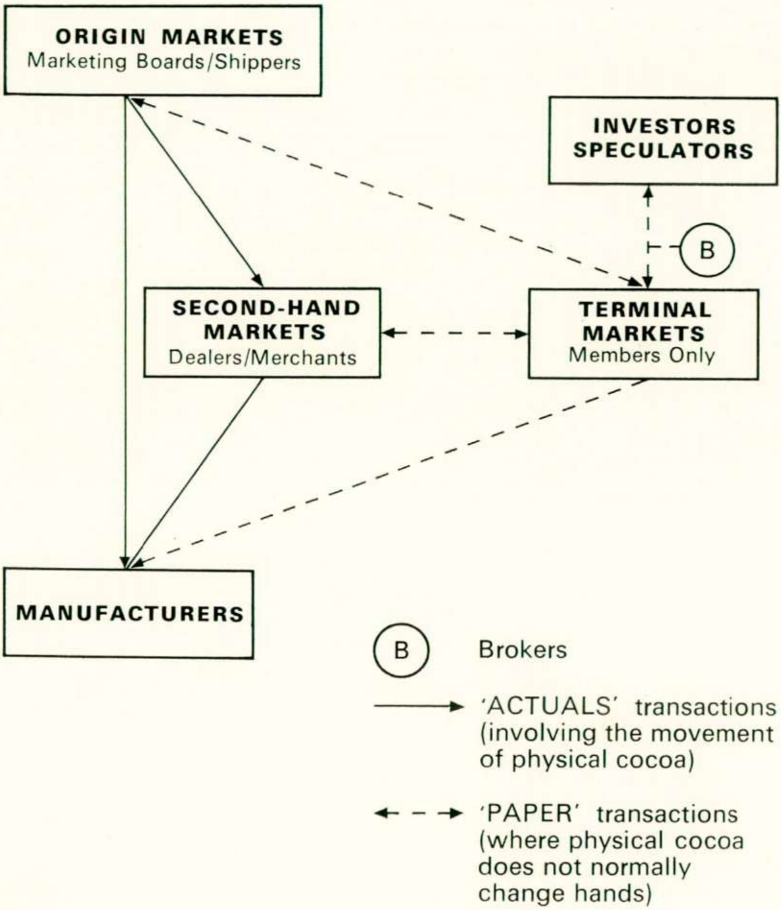
The market has in the meantime moved upwards and he eventually purchases the cocoa he needs to deliver to the manufacturer at 250s. per cwt., and at the same time he sells his terminal at 245s. per cwt.

Thus, his final result works out as follows:—

Sale to manufacturer ..	200s.	Purchase of Terminal ..	190s.
Purchase of cocoa to fulfil sale	250s.	Sale of Terminal	245s.
	Loss 50s.		Profit 55s.

Net profit .. 5s. per cwt.

THE PRINCIPAL MARKETING CHANNELS



NOTE:
Brokers are only shown as involved in investor and speculator dealings on the terminal market. They have to be employed in such cases but they may be involved in all the other types of transaction shown.

The process works identically where a dealer purchases first from the producer and eventually sells to a manufacturer.

In London, trading is from 10 to 5 from Mondays to Fridays; the market is open continuously for business but trading may only take place on the market and between members. A London terminal contract stipulates a quantity (in multiples of five-ton lots) of a standard grade (e.g. Good Fermented Ghana) and also the month of delivery and the price. For convenience, the months of delivery, which may be up to 18 months ahead, are limited in number, the positions normally used being March, May, July, September and December. Whilst Good Fermented Ghana is specified in the contract, the seller may deliver other cocoas at a premium or discount, as laid down in the market rules. He also has the option to tender cocoa in main U.K. ports or in Amsterdam and Hamburg. Buyers and sellers must register their contracts with the London Produce Clearing House, an independent body, who on registration issue certificates guaranteeing the fulfilment of each contract. The certificates are returned to the Clearing House when the member liquidates his contract.

Because of the uncertainty about the type of cocoa that will be tendered, and since it is almost entirely used for hedging, the great majority of contracts are liquidated before the date on which delivery is due—a purchaser of one lot December cocoa will normally have sold it before the time for delivery. The two transactions cancel each other out (remembering that it is the Clearing House with whom he has the contract in each case and not two different members), and his position is then liquidated. Of course, a seller may tender cocoa if he wants, and a buyer may hold the contract and take delivery.

New York is the other major terminal market, and there are smaller ones in Amsterdam and Paris. All operate on similar basic principles.

Conclusion

It is not possible to deal with all the different aspects of marketing, but this article would not be complete without mentioning two other important methods which producing countries use at the present time:—

1. *Trade Agreements.* Considerable quantities of cocoa have been sold under trade agreements with the U.S.S.R. and Eastern Europe.
2. *Local Industries.* Over the past years, there has been a growing tendency for producing countries to start their own cocoa butter factories. Beans are sold to the factory and the resultant products are sold either by the marketing company or by the factory concerned. In most cases, in order to prove economical, some form of internal financial assistance is necessary.

Sellers should secure the maximum income for their products through good marketing, and the success or otherwise of their endeavour must be judged by this.

Opposite me as I write this article is a cartoon drawn in 1817 of a fat and extremely prosperous individual, and the inscription underneath him reads "Sell and Repent". His counterpart is an emaciated, white-faced individual and over the caption "Hold and grow fat".

The basic principles of marketing do not seem to have changed over the years.

Review of Production and Consumption

A. P. Williamson, Cadbury Brothers Limited

Production

When the F.A.O. Statistical Committee met at the end of March the main crop harvests in West Africa and Brazil were nearly complete, and it was able to make a realistic forecast of 1966/67 production. Its figure of 1,328,000 tons was nearly 100,000 tons above the 1965/66 production.

In comparison with the statistics issued in October the Ghana figure was reduced by 56,000 tons. Purchases of the main crop were the lowest for seven years but production did not fall to the same extent, as an appreciable tonnage was smuggled into the Ivory Coast. In Nigeria the figure was raised by 40,000 tons to 264,000 tons, but the Marketing Company has since announced that purchases reached 264,500 tons by the end of April, so it is clear that there will be a further upward adjustment. The final out-turn should not be far short of the record 1964/65 production. The Ivory Coast figure has been affected by the smuggling from Ghana, but even if a fairly generous allowance is made it is clear that production will be the second highest ever recorded. The estimate of last year's Cameroon production and also the forecast for this year have proved over optimistic and have been reduced. Outside Africa there has been a big increase in the Brazilian forecast, confirming last year's recovery.

Grindings

Most countries have now published their final figures for 1966, and the F.A.O. October estimate of the 1966 total world grind has been confirmed. The final figures for Western Europe were slightly lower than forecast, and the estimate of Russian usage has also been reduced, but these have been counteracted by rises in the estimated grindings in Eastern Europe and South America.

The forecast of 1967 grindings has been reduced by 29,000 tons. The figures for all the main blocks, with the exception of South America and Eastern Europe, have been lowered slightly. Since April, details of the first quarter's grindings in Western Europe have been released; these have proved disappointing and the next F.A.O. forecast in July will almost certainly be reduced.

World Stocks and Prices

It has now become apparent that the 1966 deficit was even larger than at first thought, and this has nullified any reduction in the estimated deficit for 1967. The present statistical position is, therefore, very much as six months ago. As more data becomes available the 1967 deficit is likely to be further reduced, but even so it is clear that over the three years 1965/67 there will be a net fall in world cocoa stocks.

After reaching a peak of £220/ton in July, cocoa prices fell during the autumn to £180/ton. By mid-February they had climbed to over £240/ton but by the end of May they had eased again to £220/ton.

WORLD COCOA PRODUCTION AND GRINDING DATA
issued by the F.A.O. in April 1967
(Thousand metric tons)

PRODUCTION

	1964/65	1965/66	1966/67 (forecast)
Africa ..	1,192·4	878·5	961·1
South America	211·5	249·8	251·3
North and Central America	85·7	78·4	82·1
Oceania	25·0	20·9	25·8
Asia ..	7·8	8·2	7·5
World Total	1,522	1,236	1,328
Principal Countries:			
Ghana ..	580·9	415·6	381·0
Nigeria	298·0	184·0	264·0
Ivory Coast	145·0	121·0	150·0
Cameroon	91·2	78·8	87·0
Fernando Po/Rio Muni	34·8	37·8	38·0
Brazil ..	118·5	170·0	163·0
Ecuador	48·2	36·0	43·0
Dominican Republic	33·0	30·0	31·0
Mexico..	22·7	22·5	23·0
New Guinea and Papua	21·0	18·0	22·0

GRINDINGS

	1965	1966	1967 (forecast)
Western Europe	595·4	600·8	602·1
North America	301·9	311·6	312·4
Eastern Europe and U.S.S.R.	150·4	162·7	175·7
Australia and New Zealand	17·5	17·9	19·3
Central and South America	148·5	151·3	145·8
Asia ..	51·0	56·9	50·0
Africa ..	78·7	89·0	108·1
World Total	1,343	1,390	1,413
Principal Countries:			
United States	285·0	293·8	293·8
West Germany	155·0	155·0	155·0
Netherlands ..	119·0	118·5	114·0
United Kingdom	102·2	107·7	107·7
U.S.S.R.	70·0	75·0	85·0
France ..	63·1	63·4	64·0
SURPLUS/DEFICIT			
Production > Grindings	179	—	—
Grindings > Production	—	154	85

Establishment and Maintenance of Cocoa on Borneo Abaca Limited's Estates

Part 1. Establishment

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Introduction

Cocoa has been grown by Borneo Abaca Limited since 1953. A viable cocoa estate has been established. There have been many ups and downs. In this paper we aim to set down what we would and would not do again if new plantings had to be established.

Background

Soil

Most of the cocoa on the BAL property has been planted on the slopes of Tiger Hill. The soil is a porous dark brown clay loam of good structure and is predominantly of the Table sub-series. No soil characteristic of the Jerangan sub-series described by Paton (2) has been planted to cocoa, though a small area has been planted on the Quoin sub-series. There have been small plots on other soil types. Four fields totalling 58 acres have been planted on Table Estate and the remaining 1,487 acres is on Tiger Estate.

The soils are less acid than those under cocoa in the Quoin Hill area. While there is considerable local variation, the pH over much of the estate averages 6·2 for 0 to 6″ soil samples, 5·7 for 12 to 18″ and 5·5 for 30 to 36″. In the more acid areas the average pHs are 5·5, 5·2 and 5·1 respectively. However, the foliar symptoms, diffuse light green to yellow mottling of the older leaves and the marginal and interveinal necrosis of oak-leaved pattern in young leaves, described by Wyrley-Birch as occurring in the Quoin Hill area (1), also occur at BAL. In addition there is a periodic general light chlorosis of the interveins of the hardening leaves.

Climate

The rainfall averages about 85″, evenly distributed throughout the year, though there have been marked variations from the monthly averages. Periods of ten days or so of water-stress occur. Sunshine over the past six years averaged 1,600 hours a year. Again, over the years, there appears to be little seasonal variation though marked differences within seasons. Temperatures range between 90° and 69°F. In spite of the rainfall and its distribution, it is unusual to have more than a few days without sun or with humidities over 90 per cent saturation.

Varieties

The cocoa is predominantly Amelonado, introduced into Sabah from Serdang, Malaya. Small plots of a wide variety of material were planted in 1956. Twenty acres of Trinitario were planted between 1956 and 1960. Six acres of Amazon seedlings originating from Serdang seed were planted, three in 1957 and three in 1963, thirteen acres if Amelonado x Amazon crosses in 1964, and two

Young cocoa under Leucaena glauca.

Cocoa planted in 1967 under Gliricidia.

acres of Amazon x Amazon crosses in 1965, both from the Cocoa Research Station, Quoin Hill.

Vegetation before planting
Most of the area was planted from secondary jungle following abandoned Abaca. About 240 acres were planted from logged primary jungle.

Ecological Objective
At the outset we should state that we consider that, for good economic yields, cocoa should be grown in as full sunlight as is consistent with absence of wind, reasonable humidity and the maintenance of a closed cocoa canopy. In other words, cocoa should have as much sunlight as possible, and the plantation should be established and maintained with this in mind.

Yields

The yields in lb. of dry beans per acre during the last three seasons have been:

	Crop Year (September–August)		
	1963–64	1964–65	1965–66
Cocoa over 8 years old in 1966 ..	910	640	950
9-acre field, shade removed August 1964	1,170	1,630	2,050
11-acre field, shade removed March 1965	680	340	1,760

Establishment

Soil
Basaltic or well drained alluvial soil would be chosen provided the pH of the surface soil was over five and there was an absence of manganese nodules. Soil derived from ash or on the raised coastal platform would be avoided.

Clearing and Shade
We would clear, fell and burn both secondary jungle and logged primary jungle and then establish shade before planting cocoa. Experience with thinned secondary jungle, where *Mallotus* or *Macaranga* were left, showed that early growth of cocoa planted as seedlings under this shade compared unfavourably with that of similar cocoa grown under *Leucaena* or *Gliricidia*—though both these types of shade have their problems. Growth under thinned logged primary jungle did not compare well with that planted under *Leucaena*. If logged primary jungle is left poisoned but standing, it does some damage when it ultimately falls and, if access is to be maintained, the fallen trees have to be sawn through. Workers are also disinclined to work under poisoned timber in a breeze.

All types of established shade would be sown or planted some six to nine months before sowing or planting the cocoa.

The following types of shade have been tried:—

Leucaena glauca (*leucocephala*) var. Hawaii. The seed was hot-water or acid-treated and sown in either the future cocoa rows, or in the interrows at about 10 lb./acre. (This high rate was used to force the plants to height and to prevent bushy growth with early seeding). One row every other cocoa interrow has

Cocoa planted in 1965 under vigorous hedgerows of Albizzia.

been tried. Inoculation with the specific *Rhizobium* made a marked difference only when normal growth was very poor. The rows must be clean-weeded for three months for successful development. We suspect poor growth to be related to more acid soil conditions.

The problem with this shade lies in getting rid of it when you want to, without killing the cocoa. It seeds profusely. When cut above or a little below ground it regenerates. While the planted rows are defoliated by 2, 4, 5–T, they recover. Treating the bark with sodium arsenite paste works but is time-consuming and costly.

Leucaena leucocephala var. Guatemala and El Salvador have been introduced but not yet grown as shade for cocoa.

Gliricidia sp. This can be established from cuttings but care must be taken not to bruise the bark. Rough handling and thrusting the five-foot piece into the ground results in a poor take. It has proved a successful shade planted at $10' \times 10'$ and subsequently lopped and/or thinned. Ring barking and sodium arsenite kills it. It can suffer from the aphid/ant/sooty mould combination resulting in defoliation and the sooty mould spreading to the cocoa, but band-painting the *Gliricidia* with dieldrin against ants may have reduced one outbreak. Some wind damage occasionally occurs, the whole tree being blown over. We would use this again in new plantings and it is well suited for supplying shade where the cocoa canopy has opened.

Papaya, *Carica papaya*, and old abaca, *Musa textilis* var. Tangongon have been tried as nurse crops on a small scale. Both appeared satisfactory but the abaca must be removed within 18 months.

Tree cassava, *Manihot sp.*, was tried and was not liked as being competitive, and it is difficult to control the level of shade due to rapid regrowth.

All these are low-shade trees. For general reduction of wind something taller is desirable.

Erythrina sp. has been found to be subject to a collar rot and to be particularly susceptible to arsenite damage.

Saman, *Enterolobium saman*, grows well but gives too heavy a shade, and is difficult to kill.

The relative merits of *Albizzia* and the small and large leaved *Parkia* (thought to be *Albizzia falcata*, *Parkia speciosa* and *Parkia javanica*) are variable and debatable. *Albizzia* gives a light shade but is subject to trunk snap and has bulky timber, so that when it falls or is thinned it causes damage. Both the *Parkia*, especially the small-leaved one, are less vigorous but more difficult to establish. They seem particularly subject, when planted singly, to caterpillar and bag-worm damage. However, the timber of the grown tree is less bulky and they are likely to be longer lived than the *Albizzia*, and better suited as a long-term high cocoa shade.

One possibility which is under trial is to sow seed between the rows of cocoa and thin subsequently. Alternate rows of *Albizzia* and *Parkia* might be tried, poisoning out the *Albizzia* and thinning the *Parkia*. All are easy to thin with arsenite. One possible difficulty is that high shade may tend to increase the level of rodent damage.

In conclusion, *Leucaena* would only be used on a limited scale, if at all. *Albizzia* and *Parkia* would be used, sown in rows up to the limit of the local seed supply, and *Gliricidia* used for the remainder of the area. A small area of *Papaya* might be tried. If abaca were to be replanted to cocoa, the cocoa would be planted in part of the area, direct into thinned abaca.

Spacing

The spacing chosen is always a matter of compromise between such factors as yield per acre, costs of planting, weeding and harvesting, speed in achieving a closed canopy and the necessity of supplying losses, the likelihood and frequency of spraying against pests such as capsids and diseases such as black pod, and the proportion of the crop borne on the trunk as opposed to the fan branches. Several spacings have been tried, ranging from $12' \times 12'$ to $5' \times 5'$. We would favour $10' \times 7'$ as about right for Amelonado. However, the new Amazon crosses will certainly require a different and wider spacing and, as the habits of growth of the new material in our conditions is not yet fully known, this will make the choice of spacing a problem.

Planting Material

Variety. It is unlikely that Trinitario would feature to any great extent in new plantings because of the specialised nature of the market and the need to secure attractive marketing arrangements. Further, the premium in price is unlikely to be worth the relative lack of vigour and lower yields.

Amelonado has served us well. However, the new Amelonado x Amazon and Amazon x Amazon material, supplied from the Cocoa Research Station, is more vigorous and there is no good indication that this vigour is not related to higher yields. While it is early days yet, AML x PA7 is outstandingly vigorous and precocious. The new material would have a strong claim for inclusion in any new planting, particularly in areas not well suited to Amelonado.

Seed and Seedlings. Seed at stake has been successful where cocoa thrives.

Three seeds were used per point, thinned to one. This is satisfactory for new plantings provided suitable cheap seed is readily available.

Seedlings have also grown well. These are used for supplies, for areas unsuited for seed at stake and if seed was expensive or not easily obtainable. They are grown under shade which is lightened with the approach of planting.

Wire baskets have been used for seedlings. They would not be used again, as planting from such baskets takes too much time and involves too much disturbance of the plant. Black polybags would be used with drainage perforations in the bottom half, size 7″ wide by 12″ deep when laid flat. This size is thought to give the best compromise in our conditions between the size of bag to be carried, cost, size of plant and time the plant can be left in the nursery. Fertiliser was only used in the nursery when the seedlings looked backward or off colour. As in the past, the seedlings would be planted out at three to five months from the sowing of the seed, and, at the time of planting, holes would be dug the size of the bag. Consolidation is important.

Wherever possible the nursery was sited near the clearing or area to be supplied. Such siting reduced road transport for which a light tractor and trailer were used. The seedlings were carried from the roadside to planting points in two containers slung from a shoulder stick. If there was a drought water was brought by tanker.

Summary

The soil, climate and yields of cocoa from the existing 1,500 acres of cocoa on Borneo Abaca Ltd.'s estates are described.

It is suggested that cocoa should be grown in as much sunlight as possible. Techniques should be geared to this objective.

Methods of establishment which, based on past experience, would be used in any new plantings, are described and discussed.

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2. Paton, T. R. (1963). "Soils of the Semporna Peninsula, North Borneo". London, H.M.S.O. pp. 28, 36 and 86.

This article is part of a paper presented at a Cocoa Seminar held at Tawau, Sabah, in October 1966 by the Sabah Planters' Association, to which we are grateful for permission to publish. The second part will be included in our next issue. The other papers presented at this seminar were:—

"Cocoa in Sabah",
R. Smith, Director of Agriculture, Jesselton.

"Cocoa Breeding in Sabah",
D. F. Edwards, Plant Breeder, Agricultural Research Centre, Tauran.

"A Note on Interplanting Oil-Palms with Cocoa",
G. A. R. Wood, Agricultural Adviser, Cadbury Brothers Limited, U.K.

"Establishment and Maintenance of Cocoa at Rumidi",
P. W. H. Wilson, Manager, Rumidi Estate, Cadbury Brothers Limited, Sandakan.

"Observations on Cocoa Planting in Sabah",
E. A. Wyrley-Birch, Agronomist, Cocoa Research Station, Quoin Hill, Tawau.

Monilia Pod Rot of Cocoa

C. Enrique Ampuero, Tropical Experiment Station, Pichilingue, Ecuador

Monilia pod rot is a very destructive fungus disease of cocoa in several South American countries. The disease, known as "watery pod rot", "Quevedo disease", and "ceniza", is caused by *Monilia roreri* Cif. and Par.

The disease was recorded for the first time in 1914 in Ecuador, but the pathogen was not properly identified until 1918 by Rorer (13). It is believed that the disease originated in Ecuador and spread south to Peru and north to Colombia, Venezuela and the southern part of the Panama Isthmus. Monilia has not been reported elsewhere in Latin America or in any other cocoa-producing country outside the Western hemisphere.

The pathogen attacks only the pods of cocoa and alternate hosts have not been found. In Ecuador and Colombia, where the disease is most serious, it causes the destruction of 15 to 80 per cent of the pods. The magnitude of the loss is directly correlated with climatic conditions.

Ecuador was once one of the major cocoa-producing countries of the world, exporting 47,000 tons in 1914. The incidence of Monilia pod rot and witches' broom caused a dramatic crop reduction in 1922, and exports reached their lowest level of 10,580 tons in 1933 (11). It is difficult to separate the losses attributed to Monilia pod rot and witches' broom because both diseases occur during the rainy season; however, when the attack of Monilia is very severe, it is the major limiting factor in cocoa production.

Symptoms

The pods are infected when they are young and the infection develops internally as the pod grows. The first indication of the disease is the appearance of spots of mature coloration on the surface of immature pods without any other external symptoms. The coloured spots, which are surrounded by yellowish halos, turn brown and later increase rapidly in size, sometimes covering the entire surface of the pods. Under favourable weather conditions the spots are covered with a layer of white mycelium in which abundant cream or tan-coloured spores are produced. This stage of the disease is the most characteristic symptom in the field. The spores are easily detached from the pods. Some pods may be infected without any external symptoms. When the pods are opened abundant liquid is present as a result of tissue maceration. The beans may be partially or completely destroyed, depending on the stage of ripening when infection occurs. Hardening of the exterior surface resembles that of pods from trees infected with witches' broom disease. They can be differentiated because Monilia-infected pods are heavier than healthy pods of equal size (14) and there is also some watery rot. Pods become less susceptible to infection as they mature.

Disease cycle

The fungus remains in the conidial stage in infected pods between the wet and dry seasons. Spores are disseminated by wind, insects and rain (12). The role of each of these disseminating agents has not been satisfactorily resolved. It is believed that wind is the most important means of dissemination in Ecuador,

Diseased pod showing white mycelium.

Cocoa pod attacked by monilia.

although several investigators in Colombia (9, 12, 16) have reported that Monilia infection increased when pods were injured by insects.

The conditions favourable for spore germination and penetration have not been fully studied. However, Lopez (10) indicated that spores germinated better at 22°C. than at 35°C. at 80·5 per cent relative humidity.

Desrosiers *et al.* (5) found a close relationship between the amount of rainfall occurring during the early stages of pod formation and the incidence of Monilia subsequently found on the pods as they approached maturity. Based on this information, he suggested that Monilia infection takes place either during the flowering period or very early in the development of the pod. Bejarano (2) agreed with this theory because he found fruit-set to be reduced when flowers were inoculated six hours after pollination.

The sexual stage of the pathogen has not been found in the field or produced *in vitro*. Thus, the conidial stage is the only known infectious stage in the life-cycle of the organism. Desrosiers (15) and Naundorf (12) have suggested that the fungus might survive on the soil surface, but there is insufficient evidence to be conclusive.

Control

Favourable conditions for Monilia infection occur throughout the rainy season. During this period there is considerable flowering and fruit-set. Therefore, it is important to protect young fruits with fungicides during this critical period. It is not necessary to spray mature pods because they are much less susceptible or they may be infected internally already.

Several attempts to control Monilia pod rot with fungicides have been conducted in Ecuador. Zineb, maneb, Brestan 60, cuprous oxide and sulphur have given control when sprayed on a 10-14-day cycle during the rainy season, using high or low volume applications (1, 2, 4, 6, 7). The number of cycles can be reduced by applying fungicides only during the peaks of flowering and fruit-set in the rainy season, when conditions are more favourable for infection. Spraying is not necessary during the dry season.

Because of the great variability within the species *Theobroma cacao*, the possibility of finding plants with resistance to *M. roreri* has been considered. With this purpose in view, studies are being conducted at Pichilingue Experiment Station to assess the germ plasm available. Several clones have shown low incidence of Monilia pod rot under natural conditions (3) or field inoculation using a technique developed by Bejarano (2). There is no evidence that pod colour exerts any influence on the incidence of the disease (8). Until resistant varieties can be developed, harvesting at frequent intervals and destruction of infected pods should help to reduce the amount of primary inoculum and the subsequent loss from this disease.

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The Development of Pesticides

A Chemical Manufacturer's Viewpoint

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Despite the success of lindane, DDT and aldrin in controlling *Distantiella theobroma* and *Sahlbergella singularis*, the major insect pests of cocoa in West Africa, new compounds have continually been sought and tested by industry with the co-operation of the official cocoa research workers in West Africa. Fresh impetus has been given to this work with the discovery of resistance, albeit localised, by *D. theobroma* in Ghana (1) and *S. singularis* in Nigeria (2) to BHC and cyclodienes.

In this paper I shall outline the complex of chemical, entomological and medical tests essential to the discovery of any new pesticide, and then describe in more detail the test methods used against cocoa mirids, pointing out some of the difficulties, both technical and commercial, involved in finding a new cocoa mirid insecticide.

Finding a new insecticide

Up to now all the new compounds generally known to have been field-tested against cocoa mirids have been effective against many other pests as well, and were selected by industry for their general potential in world agriculture or public health. In seeking these new compounds industry has to synthesise a large number of novel compounds and screen them in the laboratory against insects representative of the major pests of the world. Approximately one in 2,000 of these new compounds may be sufficiently toxic to insects to warrant further tests, but very few will ever satisfy all the requirements for commercial development.

Much of this screening work is empirical since too little is known of the physiology of insects to enable chemists to predict the structure of a new insecticide. Nevertheless, with experience it is sometimes possible to guess how the structure of a newly-discovered chemical should be modified to increase its efficiency or reduce its toxicity to man. The examination of new compounds in the laboratory therefore covers not only their toxicity to insects, but also other important properties which affect their efficiency, such as fumigant action, translocation in the plant, persistence on the leaves or in the soil, phytotoxicity and mammalian toxicity. The results give some idea of the types of insect complex, crop and application for which the compound is best suited. In addition, the properties of new chemicals are compared with those of established products, particularly in respect of those characteristics known to contribute significantly to their success.

Finally, new compounds are examined for properties not possessed by the standard insecticide, but which it is considered, from a detailed knowledge of the pest and crop, could be of advantage in achieving more efficient control.

Lindane as a standard for new cocoa mirid insecticides

When looking for a new cocoa mirid insecticide, lindane is obviously the best comparative standard to use. The success of lindane has been attributed to:—

1. Rapid kill of the mirids
2. A fumigant effect (4, 8)
3. Absence of taint or residues harmful to the consumer in the harvested crop (4)
4. No phytotoxicity with young or old plants (4)
5. No adverse effects on spraymen (4)
6. Chemical stability when formulated as a spray concentrate
7. A high cost/efficiency ratio so that farmers get a good return for the cost of the spray (7, 9)
8. No build-up of secondary pests (4, 5)

The rapid kill of mirids by lindane has often been overlooked as a factor responsible for its success in cocoa. Farmers will, however, be encouraged to repeat their initial spray application by the excitement of seeing a pest die soon after treatment. The uneven cover likely when spraying is carried out by unskilled operators will be offset by the fumigant effect of lindane well described by Raw (8).

A low toxicity by ingestion or absorption through the skin is clearly important in cocoa since farmer spraymen, normally with scanty clothing, become drenched in the fall-out from mistblowers. Dermal and nasal irritation by the spray mist can also prevent the development of a potential cocoa insecticide, and the solvents and wetters in the spray must be as free from these disadvantages as the insecticide itself.

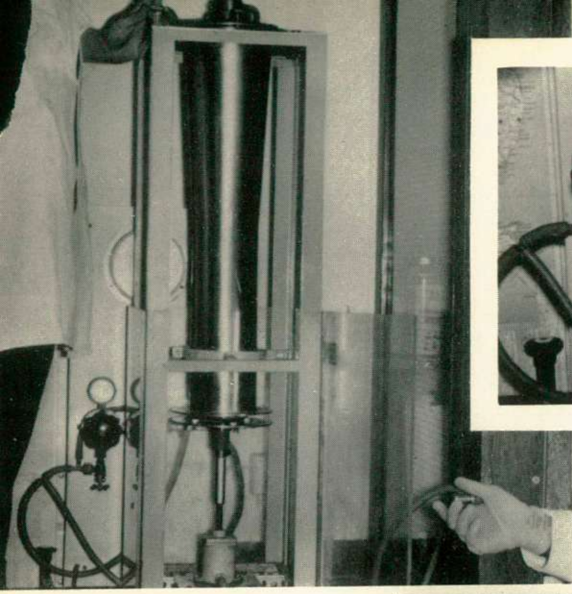
The build-up of secondary pests in the farmer's cocoa has not occurred where lindane has been used, although the reasons why are not known. Entwistle *et. al.* (5) showed that heavy applications could upset the biological balance by killing predators and parasites of the pests. From this one concludes that the average farmer application rate must be low enough to avoid such an undesirable action. This is perhaps a reasonable assumption since only four applications are made each year, and, as lindane has only a short persistence on plants, the insect population of the farmer's cocoa would be exposed to the insecticide for a few days only. During the rest of the year the treated crop could be recolonised by predators and parasites from nearby untreated areas, while cocoa mirids which are local in habit would be less likely to reinvade very rapidly.

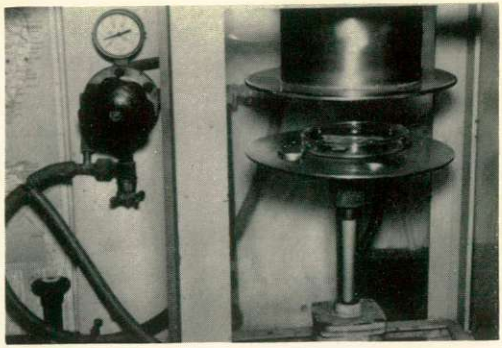
Laboratory tests for a mirid insecticide

The laboratory methods for detecting the properties required in new cocoa mirid insecticides are fairly simple, but the work is complicated by the fact that, because industrial laboratories are sited away from cocoa-growing areas, neither *D. theobroma* nor *S. singularis* can be reared in sufficient numbers for their tests. The closely-related cotton stainer *Dysdercus fasciatus* is commonly used instead, but I have found that this insect can differ markedly from *Distantiella* in its susceptibility to pesticides, so that repeat tests on the pest itself in West Africa are essential.

To determine the toxic level of any new compound to cocoa mirids, two laboratory methods are commonly used:—

1. A single, measured drop of insecticide, usually in acetone solution, is placed onto the back of each insect from a micro-syringe, or





The Potter tower down which spray can be delivered to give an even deposit on the platform (inset).

Plastic rings lined with PTFE attached to cocoa pods with plasticine so that mirid nymphs can be trapped on the cocoa pod.

Young cocoa plants minus leaves on which mirid nymphs are trapped by lining the plastic funnels with PTFE.

2. Insects are sprayed in a spray-tower (Fig. 1) with a water emulsion of the insecticide similar to that normally used in the field. The tower method is better where possible field dosage rates must be predicted, while the micro-drop technique will show up finer differences between compounds. With either method the insecticide acts by penetrating the insect's cuticle (contact action) and/or by inhalation (fumigant action). The extent to which either method of entry predominates is important, because an insecticide with a strong fumigant action can be sprayed in smaller volumes than one with contact action alone. To measure the fumigant action, insects are held on fine gauze, close to, but not touching, a treated surface.

The persistence of the insecticide on the plant can also help to compensate for poor spray-cover in the field, since an insect not hit directly may die subsequently when it walks over a lethal deposit. The appropriate persistence measurements must be done on cocoa since pesticides have different lives on different plants and even on different parts of the same plant. Thus, with cocoa, persistence must be checked on the pods, green shoots and bark, all of which are commonly inhabited by the mirids (3). Figs. 2 and 3 show persistence tests on pods and shoots. The insects are trapped on the treated surface within plastic rings and funnels lined with poly-tetra-fluoro-ethylene, which produces a virtually frictionless surface over which the insects cannot walk.

While this entomological work is progressing mammalian toxicity and metabolic studies will have continued. The possible hazard to spray operators is initially deduced from experiments with rats and later other animals, and before a product is used, commercially long-term feeding tests determine the hazard to the consumer from continued ingestion of any residues found in the crop. The determination of residue levels cannot begin until a method of analysis has been found which is sufficiently sensitive to detect a low concentration of the chemical. Usually this method of analysis has to be modified for different crops, and the high fat content of cocoa is frequently a problem.

The importance of the constituents of a spray concentrate other than the pesticide is often not realised. These must be carefully investigated since they can determine whether or not a spray will corrode the sprayers, remain stable when diluted long enough for an even rate to be applied, damage the plants or cause taint, or perhaps increase the toxicity of a pesticide to the spraymen.

Field trial for a mirid insecticide

Field trials initially involve a few acres of cocoa and build up to large development projects if a chemical is successful. Unfortunately, no method exists for the accurate comparison of compounds in the field, and in the past tests have frequently been repeated with inconclusive results, except to increase the total development cost.

Field trial assessments have commonly depended on the counting of mirids before and after several acres of cocoa have been sprayed. Such counts can never be carried out with a high degree of accuracy since it is only possible easily to reach mirids up to 10 feet from the ground, and these may not be an adequate sample of the whole population. Furthermore, the very small, dark brown to black mirids hiding in crevices are not readily seen, in the dim light beneath the cocoa canopy, and to count all of them would require long and diligent searches not possible in trials. Their numbers are also very small, not more than two to three per tree on average. With such opportunities for error only very big differences between compounds can be detected with confidence, and only the rare, outstandingly good compound is going to be obvious.

In searching for alternatives to lindane to control resistant mirids, research workers may therefore have to choose between compounds with apparently similar insecticidal efficiencies, if they are not to wait for an outstanding compound which might never appear. Their choice may then depend on other factors such as safety to the operator, the effect on predators, and in particular the absence of taint in the crop. Chemical structures provide no clue as to whether a compound will taint cocoa, and even if they did, a test on the spray formulation used in the field would still be essential. The taint test is at present too large, complex and expensive to be initiated before the insecticidal efficiency of a compound in the field has been established. The procedure will be described in a later paper in the *Cocoa Growers' Bulletin*; it is essentially empirical and must be carried out on the finished chocolate, so that a considerable area of the crop must be treated. A small-scale method to be used early in the development of a compound could assist in reducing the cost of developing new chemicals substantially by eliminating those which taint, before expensive field trials are done.

Commercial considerations

It will be clear that the cost of developing an insecticide is borne by the chemical manufacturer, the cocoa research institutes and the chocolate manufacturers. Galley and Stevens (6) estimate the cost to the manufacturer of developing a new agricultural pesticide to be from £½ million to more than £1 million. This figure includes costs of manufacturing, for example those arising from plant design and construction, not discussed in this paper.

In the writer's view insecticides which are highly selective for cocoa pests will not easily be found or developed in spite of the strong desire in many quarters for such compounds. It will be appreciated that a chemical killing specifically *Distantiella* and *Sahlbergella* would only be of use in cocoa in West Africa, and the risks involved in developing a product for such a restricted outlet will be obvious, especially while resistance to lindane and aldrin remains localised.

However, it need not be too readily assumed that new general insecticides will necessarily upset the biological balance in cocoa. Lindane is a good example of a chemical killing a wide range of species that causes no build-up of secondary pests, perhaps because of its short persistence and the way it is applied. Selectivity may also be achieved with systemic insecticides which kill the mirids as they suck the sap. These could be successful in young cocoa, but in mature trees there could be considerable problems in ensuring that the whole tree became toxic to the mirids while preventing excessive residues building up in the pods, which are their favoured habitats. Fairly general insecticides with properties enabling them to be applied selectively are therefore the most likely chemicals to be developed, when they are required, for the future control of cocoa mirids.

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Leaf Analysis Applied to Cocoa

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"It would seem unlikely that with any other crop have results with fertilisers been so unsatisfactory or so unpredictable as with cocoa", (12). The problem remains—how best to determine the fertiliser requirements for optimum yield.

It will be appreciated that only a fraction of the world's cocoa crop of nearly one-and-a-half million tons* receives any fertiliser whatsoever. It has been estimated (2) that every ton of beans has removed from the soil on which the trees are growing some 48 lb. of nitrogen, 12 lb. of phosphorus and 40 lb. of potassium. This means that the world crop is removing annually from the soil some 37,000 tons of nitrogen, 9,000 tons of phosphorus and 31,000 tons of potassium. And of course, as fertiliser, these figures would be increased according to the proportion of the element present. That is to say, the requirement of nitrogen as ammonium sulphate is in the region of 185,000 tons. And this takes no account of the content of the pod shells which may or may not be left in the field. These have a particularly high content of potassium.

Cocoa is usually established in new land taken out of forest, and it benefits from the years of accumulated organic matter and leaf litter. On some young, immature soils breakdown of the parent rock will also release new sources of nutrients. However, in the course of time the constant loss of nutrients must be made good, and this applies more particularly to land where cocoa is being replanted. Problems arise when it is necessary to know what fertiliser to apply and how much.

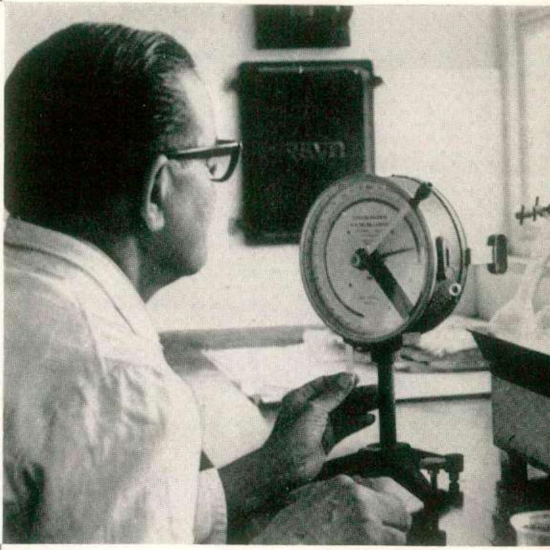
In an article on "How useful is soil chemical analysis?" published in a previous issue of the *Bulletin*, A. J. Smyth (13) has dealt with the problems of interpreting soil analysis data in relation to cocoa nutrition. As he points out, soil analysis can give only partial answers to the fertiliser needs of the crop, and he mentions the need for other techniques and in particular the analysis of the plant itself. This may consist of samples of either leaves, bark or roots, but, in general, efforts are concentrated on analysis of the leaves.

Although soil analysis can measure the nutrient content, it often cannot estimate availability of these nutrients nor can it tell just what nutrients the plant will absorb. An example lies with iron nutrition. Even though there may be no shortage of iron in a particular soil, if the pH is above 7, i.e. the soil is alkaline, cocoa will show the striking symptom of iron chlorosis because the iron is not available to the plant. The basic idea behind the use of leaf analysis is to use the plant itself as a guide to what it is getting from the soil.

A considerable range of literature exists on techniques for leaf analysis for a wide range of crops. Different systems of interpretation of results have been worked out but in its simplest form the results of the analyses of the nutrients in the leaf are compared with standards. Thus, if it has been established experimentally that the standard level of nitrogen in a leaf for optimum growth is 2 per cent of the dry matter content, analyses showing levels lower than this

* Tons referred to in this paragraph are short tons (2,000 lb.).

Taking leaf samples.



Using a torsion balance.

Leaf analysis in the laboratory.

would indicate the need for fertilising with nitrogen. In practice things are not so simple.

Before dealing with the establishment of standards, an outline of the technique will be given and then the problems involved in using the technique.

Technique of leaf analysis

Leaves are selected from the tree and oven dried at 100°C. for 24 hours. The dry leaf material is then ground to a powder in a hammer mill and is ready for chemical analysis.

In general, micro-methods of analysis are employed to save on the amount of leaf material required. Details of the methods used can be readily found in the literature. In a large laboratory handling hundreds of samples the procedures are routine, and most techniques employ colorimetric determinations for speed of final assessment. Leaves are usually analysed for ash, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg), all expressed as a percentage of the dry weight of leaf powder. In particular instances the analysis may be carried a stage further to cover the minor elements. Because of the small quantities of these nutrients in the leaf, copper, for example, in a cocoa leaf is only found at a level of ten parts in a million, the methods are difficult and usually involve spectroscopy. In general, therefore, in speaking of leaf analysis only the major elements are considered.

Practical application

It is obviously important in taking leaf samples that they should be comparable, i.e. be of the same age, come from the same part of the tree, etc. This is easy in monocots like the banana or sugar cane, where the third open leaf is specific for each plant. In a tree crop, matters are more difficult.

Referring to Fig. 1, the reason for precision in regard to age of leaf is shown diagrammatically. In a young cocoa leaf the levels of N, P, and K are high and diminish with increasing age. On the other hand, levels of Ca and Mg increase with age. This is a physiological fact and means that even on the same branch one leaf may show a low level of K as compared with another leaf merely because it is older and not because it is deficient in K.

The habit of growth of cocoa by flushes does not help with the problem but does serve as some guide in relation to time of sampling. Leaf samples may be specified as coming from the second and third leaves of flushes which have just hardened. A more precise method is to date the flushes as they expand and sample five or six weeks later, but this increases the time and labour required.

Only passing mention will be made of the effect of season and position on the tree, some of the most recent work being that of Acquaye (1). These problems are common to most tree crops.

There is one problem, however, that is associated with crops such as cocoa, coffee and perhaps tea, grown under shade. Light intensity affects the levels of nutrients in the leaf, particularly that of potassium. As shown diagrammatically in Fig. 2, samples of leaves from trees grown under identical soil conditions will show higher levels of nutrients when the trees are shaded as compared with when they are unshaded. This has led the writer to suggest that shade and nutrients are in some ways interchangeable, that is to say, low levels in the leaf may be corrected either by applying fertiliser or by increasing shade. Light intensity of course has important effects on yield as well.

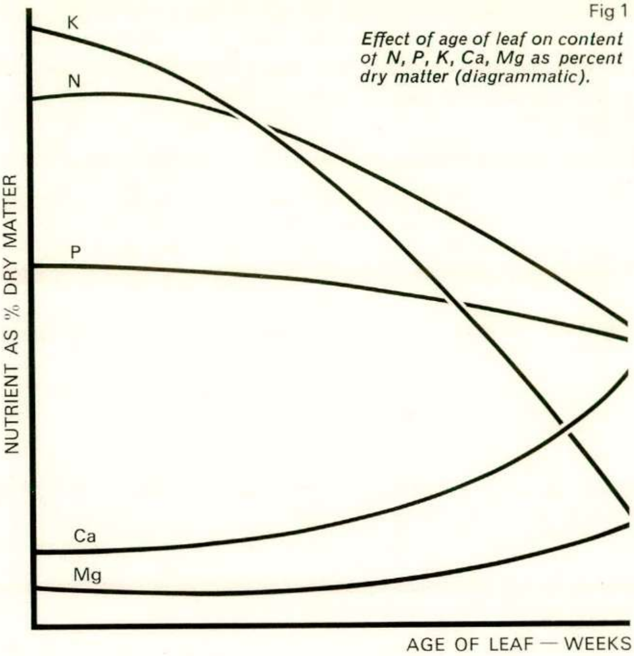


Fig 1

Effect of age of leaf on content of N, P, K, Ca, Mg as percent dry matter (diagrammatic).

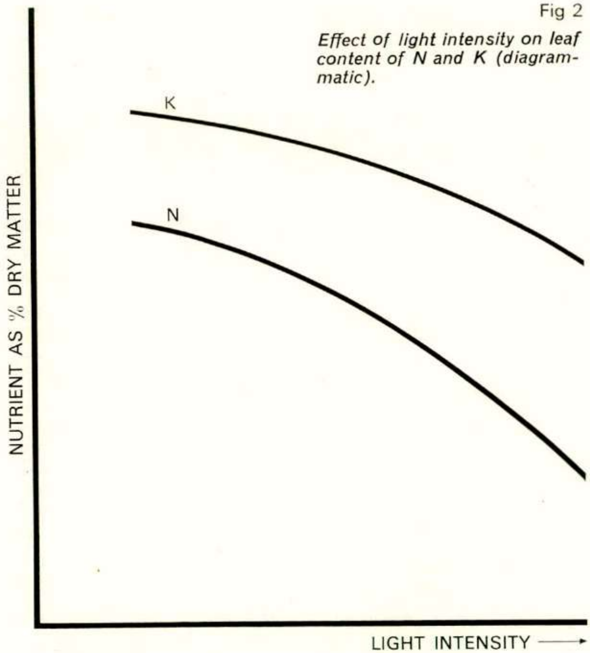


Fig 2

Effect of light intensity on leaf content of N and K (diagrammatic).

Leaf analysis for cocoa

Hardy *et. al.* (6) sampled leaves from terminal shoots which had just hardened and were turning green in a fertiliser experiment at River Estate, Trinidad. Using the values found for the different fertiliser plots, they stated that a close relationship existed between leaf composition and yield, high yield being associated with a high K content relative to N and P and a low P content relative to N and K. Instead of using the individual levels of N, P and K they expressed their results as ratios and gave as optimum ratios (1) $N/P_20_5=4.66$: (2) $N/K_20=0.89$ and (3) $K_20/P_20_5=5.21$. They indicated that in this particular trial high yields were associated with these values of the ratios and that departures from them resulted in lower yields. This would imply that corrections of the adverse ratios by the use of fertilisers would increase yield.

Later Murray (11), while showing the effect of shade on levels of leaf nutrients, found that Hardy's "ideal" values for the ratios did not apply on other sites. And at much the same time Fennah (5) showed that a difference of 0.1 in the N/K_20 ratio, which Hardy had indicated as distinguishing a high-yielding from a low-yielding tree, could occur through an age difference in the leaf of only a week or two.

Jones *et. al.* (7), as a result of the successful application of crop logging, which included leaf analysis, to sugar cane undertook a similar programme in another fertiliser trial at River Estate. Dealing with the results, Maliphant (9) demonstrated the difference due to season and shade and found correlations between yield and N/P_20_5 ratios. These latter, however, varied with season and were of little practical value.

Machicado and Havord (10) applied the technique in Costa Rica but ran into similar problems of sample and seasonal variation. In Ghana, Burridge *et. al.* (3), sampling every four weeks, have shown the changes in nutrients with season and drawn attention to the fall in N and P in the leaves when the crop was developing. In addition to the major elements they also did analyses for the minor elements. Loué (8) has done leaf analysis in the Ivory Coast and shown widespread deficiencies of P and K in the field.

Despite the work that has been done, the technique remains of only limited value in planning fertiliser usage. If a marked deficiency exists, the low levels in the leaf will override problems of sampling and indicate the type of fertiliser required to correct the deficiency. In the more normal range, however, the technique lacks precision. It has been suggested that using leaf analysis is like trying to show the difference between a cart-horse and a race-horse by taking blood samples! Accepting the various limitations of the technique, Murray (12) has given the following table for normal levels in the leaf, low levels where growth is affected but visual symptoms do not appear, and deficient where visual symptoms will be seen.

Nutrient	Deficient	Low	Normal
N	1·80	1·80–2·00	2·00
P	0·13	0·13–0·20	0·20
K	1·20	1·20–2·00	2·00
Ca	0·30	0·30–0·40	0·40
Mg	0·20	0·20–0·45	0·45

Conclusions

Clearly, as with soil analysis, leaf analysis is not the final answer to determining the nutrient requirements of cocoa. As Smyth has said, there is no satisfactory substitute for field experimentation to establish the fertiliser requirements of cocoa. Even this, however, presents difficulties. For a field experiment to give reliable results it needs careful planning, a large acreage of uniform cocoa, trained staff and a considerable expenditure of time, money and effort. And the results only apply to the particular area, so that considerable caution must be exercised in attempting to apply the results elsewhere.

What, then, is the answer to the nutritional problems of cocoa? In a new area, soil analysis will give general indications of marked deficiencies and should include the minor elements. Leaf analysis will give confirmation, and considerable value should be placed on visual symptoms. Thus, in Ecuador, Tollenaar (14) found visual symptoms of boron deficiency in cocoa in new areas of land before any analyses were done. Symptoms of iron deficiency are so obvious that no other confirmation is necessary.

Leaf analysis will distinguish between visual symptoms which are rather similar, i.e. potassium deficiency and chloride toxicity. This may be done by the simpler technique of tissue testing. Normal chemical leaf analysis is expensive and time-consuming. In tissue testing the leaf tissue is chopped into fine pieces and extracted with Morgan's reagent. Very simple colorimetric tests are done on the extract, and while lacking the precision of proper analysis can give preliminary indications of not only deficiencies but toxicities in the crop.

In conclusion, it must be stressed that mineral nutrition is only part of the plant's requirement for optimum growth and yield. It is not always sufficiently appreciated that the most important soil nutrient is water and that when water stress occurs this will override fertiliser applications. Knowledge is slowly being gained of the physiology of the tree, and leaf analysis, though not yet satisfactory as a single practical tool, is one of many approaches to the problems of how best to achieve high yields.

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Cocoa Abstracts

These abstracts are reprinted from "Tropical Abstracts", published by The Royal Tropical Institute, Amsterdam.

November, 1966

Laryea, A. A. Extension and training. Ghana Farmer 9, 3, p. 104–8, 115 (1965).

The rapid expansion of the cocoa industry in Ghana is largely due to a sound research programme supported by an effective extension service undertaking training of farmers as well as the provision of services and activities that promote the adoption of new practices. A detailed account is presented of the organisation of the extension service in Ghana. Three main points discussed are the provision of extendable knowledge, suitable personnel to carry out field commitments satisfactorily, and the advisory service. The methods of extension followed include personal contact as well as group contact by means of village meetings, farm tours, agricultural shows and exhibits, extension campaigns carried on jointly with other agencies, and the use of leaflets and the press. Sometimes agricultural legislation is used as an indirect extension measure. Photos.

Migvar, L. Growing cocoa in the Caroline Islands. Agr. Ext. Bull., Trust Territ. Pac. Isl. 3, p. 1–40 (1965).

This publication is a guide to cocoa growing in the Caroline Islands, where this crop fits well into existing agricultural systems especially if combined with coconut production. Cocoa production, only 12 tons in 1963, is expected to rise steeply to a maximum of 1,000 tons. At present a mixture of types is grown, but in future only Trinitario × Forastero seedlings will be planted. Good soils are found on all high islands though sometimes in limited areas only. The main pests are rats, the giant African snail, termites, the *Rhyparida* beetle, a bug (*Trigonops* sp.), and the cocoa moth. Black pod is not a serious disease but much damage is caused by *Phytophthora* canker. The control of these pests and diseases is discussed. Processing will be centralised; fermentation will be carried out in wooden boxes with hinged lids, arranged like the steps of a stair. Graphs. Figs. Photos.

Soria, V. J. Obtención de clones de cacao por el método de índices de selección. (Obtaining cocoa clones by the selection index method). Turrialba. Rev. Interam. Ciencias Agr. 16, 2, p. 119–24 (1966).

Selection of the cocoa clones at the Inter-American Institute of Agricultural Sciences at Turrialba, Costa Rica, since 1961 has been based on selection indices. Indices of pod number, total bean yield per tree, pod index and dry bean weight are based on the differences between trial or progeny means and individual tree records divided by their standard error; indices of tree vigour and resistance to diseases are given according to arbitrary scales. The total selection index of a tree is obtained by adding the indices for the 6 separate features, those for pod number and bean yield being weighted by a factor 2. English summary. Tables. 3 refs.

Sajoso. Pengamatan pengaruh naungan pada beberapa perkawinan tjoklat asal Keravat (Observations on the effect of shade on some cocoa crosses from Keravat). Circ. Agr. Res. Stat. Manokwari, Agr. Ser. 10, p. 1-16 (1965).

This study of the shade effect on cocoa, conducted in W. New Guinea (Indonesia), showed that non-shaded trees had bigger but shorter trunks, less main branches, and smaller leaves than shaded trees. Moreover, the trees without shade came into bearing earlier and in the 2nd and 3rd year of harvest yielded about twice as much as the shaded cocoa. It was observed that the microclimatic conditions in both treatments differed clearly, which is considered the main cause of the differences in growth and development of the cocoa trees. Indonesian text. English summary. Tables. 10 refs.

Saunders, J. L. El complejo Xyleborus-Ceratocystis de cacao. (The *Xyleborus-Ceratocystis* complex of cocoa). Cacao; Inst. Interam. Ciencias Agrícolas 10, 2, p. 8–14 (1965).

The author reviews the literature on the distribution in the Americas, alternative host plants, symptoms, and epidemiology of the cocoa disease caused by the fungus *Ceratocystis fimbriata*, on its transmission by borer beetles of the genus *Xyleborus*, and on the control of the disease-vector complex. 44 refs.

Manço, G. R. Phytophthora palmivora in flower cushions, old infected pods and leaves of cacao plants. Turrialba, Rev. Interam. Ciencias Agr. 16, 2, p. 148–55 (1966).

Observations made in the humid lowlands of eastern Costa Rica, supplemented by laboratory studies, demonstrated that flower cushions of cocoa trees may become infected with *Phytophthora palmivora* growing from the pods or through the cut pod stalk. The fungus may survive in the cushions for at least 8 months and frequently destroys them. Pods may be infected both by mycelium from the cushions and by spores from diseased leaves. The fungus can survive in old pods left on the trees for at least 7 months, chlamydospores being found in the pod tissue. Formation of sporangia was observed to occur during the night on leaves in the laboratory as well as in the field; the optimum temperature is 22°C. and the optimum relative humidity is 100 per cent, but some were found even at temperatures of 15 and 30°C. and at a relative humidity of 90 per cent. Abundant inoculum was found to be present all over the canopy of the trees. Spanish summary. Tables. Graphs. Figs. 13 refs.

December, 1966

O casqueiro — foco da podridão parda. (The pod shell, source of black pod disease). Cacau Atualidades 3, 3, p. 6–7 (1966).

A trial conducted in the State of Bahia (Brazil) showed that, in a heap of cocoa pod shells, those infected with *Phytophthora* formed large quantities of spores when they were at the surface of the mound, whereas sporulation decreased to zero with the distance from the surface. Suppression of sporulation is probably due to CO_2 accumulation. When burying the shells is too expensive, planters are advised not to spread them over the field but to collect them in large heaps, which may be treated with a disinfectant. Fig.

Moreno Galvis, R. Algunos aspectos de la fertilización en cacao (Theobroma cacao L.) con observaciones preliminares sobre su respuesta a la aplicación de tres elementos mayores al suelo. (Some aspects of cocoa manuring with preliminary observations on its response to the application of three major elements to the soil). Acta Agron., Colombia 15, 1–4, p. 69–107 (1965).

The main part of this paper consists of a review of literature on the manuring of cocoa. In addition, preliminary results are presented of a fertiliser trial conducted in Colombia at an altitude of 1,000 m, in a shaded monoclonal field receiving supplementary irrigation. Yield data over 9 months were inconclusive but indicated that the best yields were obtained by applying N, P and K fertiliser, whereas bean weight was appreciably increased by N only. English summary. Tables. Graphs. Fig. 53 refs.

Maravalhas, N. The effect of "dancing" on the quality of fermented cocoa. Trop. Agr., Trinidad 43, 4, p. 351–3 (1966).

In Trinidad, tests on the effect of dancing on the quality of fermented cocoa showed that dancing significantly improved the internal colour of the beans without having any significant effect on the development of internal mould or insect attack after 3 months of storage. The slight tendency to increased internal mouldiness was more than compensated for by the better internal colour and external appearance. From author's summary. Tables. 2 refs.

January, 1967

Asomaning, E. J. A., and Lockard, R. G. Analysis of the growth of cocoa in sand culture: studies up to the jorquette stage. Rep. Cocoa Res. Inst. (Ghana Acad. Sci.) 1962–63, p. 84–6 (1964; received 1966).

Observations of the growth of Amelonado cocoa seedlings in sand culture, conducted in Ghana, indicated that primary branching is not directly connected with the age or size of the plant. However, the number of weeks to branching was inversely related to the N concentration in the nutrient solution, and was higher in 30–1 pots than in 5–1 pots. Correlations with relative growth rate, net assimilation rate and leaf area ratio were not clear, but plants that formed primary branches had an initially high leaf area ratio which declined rapidly after the onset of branching. This suggests that primary branching is associated with an increase in the efficiency of dryweight accumulation per unit of leaf area. Tables.

Nichols, R. Studies of fruit development of cacao (Theobroma cacao) in relation to cherelle wilt. I. Development of the pericarp. II. Auxins and development of the seeds. III. Effects of fruit-thinning. Repr. from Annals of Botany, New Ser. 28, 112, p. 619–35 (1964); 29, 114, p. 181–96, 197–203 (1965).

These three papers present results of investigations on cherelle wilt of cocoa conducted in Trinidad. The first paper is concerned with the anatomy and physiology of pod development, and in particular with the changes induced by ovule growth which determine the end of susceptibility to fruit shedding. The second paper discusses the role of auxins in the development of the seeds. The third paper contains the results of fruit thinning trials showing the effect of fruit thinning on the incidence of wilting of young pods. Tables. Graphs. Fig. Photos. 24, 30, 9 refs.

Glendinning, D. R., and Martinson, V. A. Plant breeding and selection. Rep. Cocoa Res. Inst. (Ghana Acad. Sci.) 1962–63, p. 37–50 (1964); 1963–65, p. 52–75 (1966).

Observations of varietal trials with cocoa in Ghana were continued; data of several trials are presented. It was discovered that some of the Amazon and ICS clones received from Trinidad via Kew in 1951–56 had been mixed up; this may invalidate some experimental results. Sorting-out is in progress but has not yet been completely successful. Three Series II Amazon × local Trinitario and four Amazon × Amelonado hybrids were released in 1964; since seed gardens to provide these varieties were planted in 1959, sufficient seed will soon become available. New plantings in 1963 included trials with hybrid series IV, V and VI, selected for tolerance of their parents to virus, black pod, and drought, respectively. Intervarietal competition in variety trials proved to be more important than was expected; a publication is announced.

Soria V., J. Principales variedades de cacao cultivadas en América tropical. (Principal varieties of cocoa cultivated in tropical America). Turrialba, Rev. Interam. Ciencias Agr. 16, 3, p. 261–6 (1966).

The classification of cocoa cultivars into Criollo, Forastero and Trinitario types is outlined, and a brief description is presented of the main varieties (exclusive of artificial hybrids) grown in American countries. Types or varieties listed are: Criollos, pentagona cocoa, Ceylon cocoa, "Criollo types", Nicaragua Criollo and Matina of Mexico and Central America; Colombian Criollo, Pajarito, and Amanavén of Colombia; Venezuelan Criollo, Trinitarios, Porcelano, Forastero de Barlovento, and Camacita of Venezuela; Cacao nacional and Trinitarios of Ecuador; two varieties of Peru; Pará, Maranhão, Comum and Catongo of Brazil; Calabacillo types of the Dominican Rep.; and Trinitarios of the W. Indian islands. 17 refs.

Freeman, G. H. Methods of raising cocoa seedlings in the nursery and their effect on subsequent growth in the field. Repr. from J. Hort. Sci. 40, 4, p. 341–9 (1965). B.

Trials conducted in W. Nigeria showed that cocoa seedlings grew well in the nursery in polythene pots under a shade of from 8 to 10 palm fronds per 3 m length and with light watering. Late sowing and early transplanting were satisfactory, so seedlings need only remain in the nursery for 5–6 months. In the Ibadan area this was achieved by sowing in December and transplanting in late May or early June. Younger plants also grow well in the field, but there are risks in sowing seed in January, when cold, dry harmattan winds may be expected. Provided a plant is big enough to transplant, its original size has no bearing on its subsequent growth in the field as measured by trunk girth at three-monthly intervals. Sowing seed at permanent sites is risky, as beans may be eaten by rodents. From author's summary. Tables. 11 refs.

Rochelle, L. A., et al. Sôbre enraizamento de estacas de cacaueiro. (On rooting of cocoa cuttings). Anais Escola Super. Agr. "Luiz de Queiroz", Univ. São Paulo 22, p. 199–202 (1965).

In a trial conducted at Campinas, Brazil, dipping of cocoa cuttings in a 100 p.p.m. solution of indolebutyric acid for 24 hours gave 73 per cent rooting; the same treatment with 100 p.p.m. naphthalene acetic acid gave 44 per cent rooting, whereas untreated cuttings showed 35 per cent rooting. English summary. Table. 3 refs.

(Cacao shade trials in Ghana). Rep. Cocoa Res. Inst. (Ghana Acad. Sci.) 1962–63, p. 90–1, 113–8 (1964); 1963–65, p. 94–6, 96–8 (1966).

In the Amelonado cocoa trial K_1 at Tafo, Ghana, irrigation in the wet year 1962–63 increased yields only in the shade + fertiliser treatment. The yield pattern remained the same; the dry-cocoa yields in 1964–65 were: shade without fertiliser 1,325; shade with fertiliser 1,837; no shade and no fertiliser 2,530; no shade with fertiliser 3,668 kg/ha. Leaf analyses showed, inter alia, that shade had little effect on minor element levels except on B which was reduced by 16 per cent. In trial field K_2O_1, planted with Amazon cocoa in 1958, treatments since 1962 are: no shade, light shade (*Terminalia ivorensis* at 12×12 m), and heavy shade (*T. ivorensis* at 6×6 m). The 1962–63 yields were highest under light shade, lowest under heavy shade; 1963–64 and 1964–65 yields decreased with increasing shade. Flowering and fruit setting showed a similar pattern. Tables. Graph.

March, 1967

Lent, R. The origin of the cauliflorous inflorescence of Theobroma cacao. Turrialba, Rev. Interam. Ciencias Agr. 16, 4, p. 352–8 (1966).

The origin of the cocoa inflorescence was investigated by following the vascular traces of inflorescences to their origin and by studying the arrangement and development of axillary buds. All leaves have at least two buds in their axil: the principal axillary bud which can form a vegetative branch, and the subordinate bud. The latter, a lateral of the principal axillary bud, may lie dormant in the bark for various periods of time but finally forms an inflorescence. Inflorescences on mature trunks and branches usually originate at axils of leaves of the main axils or at axillary sites on old branch bases buried in the wood of the main axils. Axillary pits containing other subordinate meristems can be found at the axils of leaves on sucker shoots and young trunks. The subordinate buds of the cotyledonary nodes are also described. From Author's summary. Spanish summary. Figs. Photos. 13 refs.

Hardy, F. Cacao soils and ecology of Bahia, north-east Brazil. Cacao; Inter-Am. Inst. Agr. Sci. 9, 4, p. 1–12 (1964; received 1966).

The climate, geology and geomorphology of the cocoa-growing region of the State of Bahia (Brazil) are outlined. A soil survey showed that latosols, red-yellow podzolic soils, alluvial soils, and hydromorphic soils predominate; only certain types of the first two groups are suitable for cocoa. The Bahia soils are compared with those of W. Africa and the W. Indies; results of W. African research nutrient requirements of cocoa are applied to Bahia soils. The condition of cocoa plantings in Bahia is briefly described and possible causes of the recent decline in yields are indicated. A programme of replanting is advocated on the basis of experience gained in Trinidad. Tables. Map. 10 refs.

Ruinard, J. Notes on the importance of proper husbandry in some tropical crops. Neth. J. Agr. Sci. 14, 4, p. 263–79 (1966).

Weeding × fertiliser trials with cocoa seedlings, groundnuts, and maize, conducted in Ghana, demonstrated that growth and yields of these crops were improved much more by increasing the frequency of weeding than by application of fertilisers. Moreover, the weeds showed a much greater response to fertiliser applications than did the crops themselves. The results suggest that improvement of peasant farming in the tropics should be attempted in the first place by persuading farmers to give more care to crops cultivated in the traditional way, rather than by the introduction of modern farming methods involving capital outlay. Tables. Photos. 1 ref.

Knoke, J. K., and Saunders, J. L. Induced fruit set of Theobroma cacao by mistblower applications of insecticides. J. Econ. Entomol. 59, 6, p. 1427–30 (1966).

In Costa Rica, trunks and branches of trees pertaining to a self-compatible cocoa clone were sprayed by means of a mistblower with 0·1 per cent carbaryl, malathion, dieldrin or dimethoate, or with water, at intervals of 2, 4, 8 or 16 days. Flower abscission was retarded by carbaryl; other insecticides were toxic. Pod setting was reduced by all insecticides, least by carbaryl. The number of pods per m_2 of bark after 110 days was increased by carbaryl except when applied at a two-day interval, reduced by the other insecticides when applied at two- or four-day intervals; it increased with the frequency of water spraying, indicating that mistblowing induces pollination. Spanish summary. Tables. 13 refs.

Díaz, F., and Newhall, A. G. A comparison of ways of evaluating fungicides for the control of Phytophthora leaf blight of cocoa seedlings. Cacao; Inter-Am. Inst. Agr. Sci. 11, 1, p. 8–10 (1966).

In Costa Rica, young cocoa seedlings were artificially inoculated with the fungus *Phytophthora palmivora*, the cause of leaf blight, and subsequently sprayed with four fungicides. One field method and three laboratory methods of assessing the fungicidal effects were compared, viz. (1) visual scoring of each plot for disease incidence on a scale from 1 to 10, (2) scoring of disease incidence in random samples of leaves, (3) counting all functional leaves of 10 plants per plot, (4) determining the dry weight of all leaves from 10 plants per plot. The rapid visual field method (1) showed the considerable differences in the effectivity of the fungicides as accurately as the best laboratory method (2). Table. 7 refs.

Newhall, A. G. When does it pay to spray cacao? Cacao; Inter-Am. Inst. Agr. Sci. 11, 1, p. 10–2 (1966).

Spraying cocoa with copper fungicides against black pod disease in the humid climate of Costa Rica usually results in a considerable yield increase. Tables show when spraying becomes profitable at various cocoa prices, yield levels, and proportional yield increases. It should be taken into account that the effect of spraying is cumulative and that spraying controls cherelle wilt and epiphytes. Freshly made Bordeaux mixture is still the best copper fungicide. However, cuprous oxide is almost as persistent in a rainy climate and has the advantage that it can be applied by low-volume spraying so that a short dry spell is sufficient to fix the deposit on the pods. The spraying schedule should be adapted to the rainfall distribution. Tables. 19 refs.

Maia Rocha, H., and Jiménez Sáenz, E. Importancia de la sustancias polifenólicas en el mecanismo fisiológico de la resistencia de cacao (Theobroma cacao L.) a Phytophthora palmivora (Butl) Butl. (Importance of polyphenolic substances for the physiological mechanism of the resistance of cocoa to *Phytophthora palmivora*). Turrialba, Rev. Inter-Am. Ciencias Agr. 16, 4, p. 319–29 (1966).

Investigations conducted in Costa Rica demonstrated that the degree of resistance of cocoa trees to black pod disease caused by the fungus *Phytophthora palmivora* depends on the presence of certain polyphenolic compounds in the epicarp. The problem is rather complicated because the degree of resistance depends on the nature of the polyphenols present as well as on their concentrations; considerable differences between trees exist with respect to both factors. Moreover, the composition of the polyphenolic mixture changes in different ways as the pods grow older. In general, resistance decreases as the fruits develop. English summary. Tables. Graph. Figs. Photos. 19 refs.

Soria V., J., and Saunders, J. L. Observations of resistance to insects by some cocoa varieties. Cacao; Inter-Am. Inst. Agr. Sci. 11, 1, p. 1–3 (1966).

An outbreak of mirids (*Monalonion* sp.) occurred in Costa Rica cocoa fields in 1965. Observations in three progeny trials showed that progenies with Upper Amazon parents (in particular SCA 12) suffered much less from defoliation and die-back than did Trinitario progenies; progenies of the local clone CC 9 occupied an intermediate position. In Ecuador, adults of the shot-hole borer *Xyleborus ferrugineus* were caged on the bark of trees of three clones and one seedling progeny. Clone SCA 12 was heavily attacked but this resulted in a high insect mortality. Clone ICS 95, another field-resistant clone, showed few attacks and the beetles tried to escape from the trees. Borers caged on clone ICS 1 and on the SCA 6 × ICS 1 progeny were little active. The results suggest that the bark of some cocoa trees contains a chemical compound conferring tolerance of or resistance to insect attack upon them. Tables. 5 refs.

April, 1967

Toxopeus, H. Cacao research in the Americas and Ivory Coast with particular attention to populations and breeding work and the exchange of viable material with Nigeria (based on a journey to the U.K., U.S.A., Trinidad, Costa Rica and Ivory Coast by Dr. L. K. Opeke and Mr. H. Toxopeus of Cocoa Research Institute of Nigeria). Mem. Cocoa Res. Inst. Nigeria 11, p. 1–28 (1966).

The journey on which this report is based was made in 1964 to explore the possibilities of a cocoa planting material introduction programme in Nigeria. The report discusses: (1) quarantine measures to be adopted when such a programme is put into execution; (2) cocoa populations in America; and (3) cocoa collections and breeding programmes in Trinidad and Costa Rica. The appendices include data on methods of cocoa-growing in Trinidad and on cocoa research at Beltsville (U.S.A.), in Trinidad, in Costa Rica, and in the Ivory Coast. Maps. 15 refs.

Asomaning, E. J. A., and Lockard, R. G. Mineral nutrition. Rep. Cacao Res. Inst. (Ghana Acad. Sci.) 1962–63, p. 59–83 (1964); 1963–65, p. 86–90 (1966).

Some results of studies on the mineral nutrition of cocoa seedlings, conducted in Ghana, are: (1) urea is a better source of N than nitrate; (2) nitrate or nitrite may cause leaf-edge scorch masking symptoms of deficiency in other nutrients; (3) Mo is more likely to affect growth and leaf composition when the plants receive nitrate than when they receive urea; (4) S deficiency depresses leaf N and Cu, increases leaf Ca, Mg, Mn, B and particularly Mo; (5) Amelonado seedlings were less affected by nutrient deficiencies than Amazon seedlings; (6) seedlings grown in demineralised water die 8–12 days after germination, with cotyledons still attached; addition of Ca to the water gives normal development; (7) formation of seedless, distorted pods with a hard core is probably due to B deficiency. Tables. Graphs.

(Investigations into black pod disease and stem pitting of cacao in Ghana). Rep. Cocoa Res. Inst. (Ghana Acad. Sci.) 1963–65, p. 29-32 (1966).

In Ghana the bacterium *Pseudomonas aeruginosa*, isolated from the mealy-bug *Planococcoides njalensis*, was found to inhibit the growth of *Phytophthora* mycelium on artificial media as well as on inoculated pods. Spraying the pods with a bacterial suspension may give preventive biological control of black pod disease. The bacterium also inhibited the growth of the fungus *Trachysphaera fructigena*, the cause of mealy pod disease. A new stem-pitting disease of unknown origin was observed in some localities. External symptoms are a swelling of the stem mostly occurring at a height of 25-45 cm from the ground; in a few cases swelling of branches was observed. Bark and wood of the swollen parts are distended, and the outer surface of the wood is deeply pitted or grooved. The swellings had little effect on the vigour of the canopy or on the growth of the trees. Table.

Virus research. Rep. Cocoa Res. Inst. (Ghana Acad. Sci.) 1962–63, p. 21–2 (1964); 1963–65, p. 22–9 (1966).

In Ghana, killing of cocoa trees with arboricides was found to require relatively high concentrations to overcome the effect of shade. The chemicals did not kill mealybugs or inactivate swollen shoot virus. Mechanical inoculation of seed confirmed that seedlings with an Amelonado parent are more easily infected with swollen shoot virus than are crosses of Upper Amazon and/or Trinitario parents. Higher susceptibility of Amelonado to swollen shoot and mottle-leaf viruses was also observed in field trials E1 and E3 in which part of the trees had been inoculated. The first of these trials showed that shade enhances the differences in canopy density and yield between healthy and diseased trees although shaded trees were generally better than unshaded trees. Trial E3 demonstrated that growth was retarded more by the New Juaben virus than by two other strains of swollen shoot virus or by mottle-leaf virus (see also ibid. 1962–63, p. 88–9; 1963–65, p. 90–4). Tables.

(Pests of cacao in Ghana). Rep. Cocoa Res. Inst. (Ghana Acad. Sci.) 1963–65, p. 29, 32–46 (1966).

Investigations in Ghana into biological control of cocoa mealybugs showed that spraying infected trees with a mycelial suspension of *Cephalosporium* sp., isolated from *Planococcus citri*, gave considerable mortality. The ant *Oecophylla longinoda* was found to attack *Ferrisiana virgata*, the mirid *Distantiella theobroma*, and hairless caterpillars, but not thrips; other ants behaved similarly but did not attack the mirid. Investigations into the distribution and control of lindane-resistant mirids were continued. Two bugs that have developed into cocoa pests are *Bathycoelia thalassina* and *Pseudotheraptus* sp. Damage caused by this coreid is similar to mirid damage but lesions on the pods are larger and pods become deformed. The bug is less sensitive to carbaryl than are mirids; its recent spread may be a side-effect of insecticidal control of other pests. Tables. Graph. Map.

Schreurs, J. Investigations on the biology and control of Glenea lefebueri, a noxious longicorn beetle of cocoa in West New Guinea. Papua and New Guinea Agr. J. 17, 4, p. 129–35 (1965).

The cerambycid beetle *Glenea lefebueri* was observed to cause serious damage to cocoa plantings in the Vogelkop area of W. New Guinea; it also occurs in the eastern part of the island. Only living trees at least two years old were attacked; varietal differences in susceptibility were indicated. Larvae were mostly found tunnelling in the main stem, relatively seldom in branches. Adults damaged the young shoots. The life-history of the species is described. Natural enemies did not effectively control the pest. Control by periodical excision of the larvae is possible but not recommended. Good curative as well as preventive control was obtained by spraying with 0·2 per cent (active) dieldrin. Tables. Figs. Photo. 4 refs.

February, 1967

Ascenso, J. C. Selecção e melhoramento do cacaueiro em S. Tomé e Príncipe. (Cocoa selection and breeding in São Tomé and Príncipe). Garcia de Orta 13, 2, p. 305–16 (1965; received 1966).

A survey of the cocoa population in São Tomé and Príncipe showed that the majority of the trees are of the yellow Amelonado type originally introduced; some plantations have a red Amelonado type, some have a Calabacillo type, whereas only few Criollo and Trinitario trees were found. A breeding and selection programme is outlined. So far, 134 clones have been made from mother trees in the existing population, and these are being tested; some hybrid seed has been introduced from Trinidad. The main selection criterion is yield; vigour of growth and precociousness are secondary criteria; resistance to *Phytophthora* will only be considered at a later stage. English and French summaries. Graph. Figs. Photos. 24 refs.

Soria V., J. Notes on the cacaos collected by the Brazilian-international expedition to some areas of the Brazilian Amazon basin. Cacao; Inter-Am. Inst. Agr. Sci. 10, 4, p. 10–3 (1965).

A list is presented of the 43 successfully established cocoa selections made by an expedition into the Brazilian part of the Amazon basin in June–July 1965. Most wild and cultivated trees encountered had fruits of the Amelonado type, but in some areas there was a considerable proportion of trees with Angoleta and Cundeamor pods though no influence of Criollo cocoa could be detected. Witchbroom is prevalent everywhere; several other diseases and pests were observed, but no *Ceratocystis* was seen and there is evidence of resistance against this fungus. Some remarks are made on the occurrence of other *Theobroma* spp. in the area. Table. See also ibid. p. 14–6; Soria V., J. Notes on the native cocoas in the vicinity of Iquitos (Peru) and of Alto Beni (Bolivia).

Zevallos, A. C., and Alvim, P. de T. Influência da eritrina no aumento de produção do cacau. (Effect of *Erythrina* on the yield increase of cocoa). Cacau Atualidades 3, 4, p. 2–3 (1966).

At Uruçuca, Brazil, individual yields of 140 cocoa trees in a field evenly shaded by *Erythrina glauca* were found to be inversely related to their distance from a shade tree. Mean yields of wet beans over the period 1948–57 of cocoa trees 2–2½, 6·3, and 8·4 m from the nearest shade tree were 4·11, 3·78 and 3·08 kg, respectively. Moisture content, porosity, and mineral element content of the topsoil (0–30 cm) were highest near the shade trees, whereas soil moisture at a depth of 60–90 cm increased with the distance from the *Erythrina* trunks. The effect is ascribed to the structure of the *Erythrina* root system which has superficial lateral roots and but a few feeder roots near the trunk, to humus accumulation near the shade tree trunks, and to mechanical loosening of the soil by the *Erythrina* roots. Table.

Murray, D. B. Cocoa — prospects for the future. J. Agr. Soc. Trinidad Tobago 66, 2, p. 163–70 (1966).

The cocoa industry of Trinidad is at a critical stage between expansion and extinction, a loss of its position as a supplier of flavour cocoa being possible. The rehabilitation scheme resulted in an increase of annual production from 3,630 tons in 1945 to an average 8,000 tons in 1951–60, but a series of six years (1959–64) with subnormal rainfall in the dry season caused a drop to 5,000 tons in 1965. If the industry is to survive, management practices have to be improved, but the small size of most farms and the high cost of clear-felling and replanting militate against this. Also cocoa-growing should be restricted to the 32,000 ha of soils capable of sustaining yields of over 600 kg/ha. An adverse factor is the increasing incidence of *Ceratocystis*; on the other hand, witchbroom is no longer a serious problem now that resistant planting material is available, and the disease of *Erythrina poeppigiana* shade has been beneficial by reducing shade density. Graphs.

Burgos, J. J., and Reyes, E. H. Tipos agroclimáticos mundiales del cacaotero (Theobroma cacao L.). (World agroclimatic types for cocoa). Agron. Trop., Venezuela 15, 1–4, p. 169–91 (1965; received 1967).

The authors discuss the environmental requirements of the cocoa tree in terms of daylength, temperature, total rainfall and rainfall periodicity, and evapotranspiration. Climates suitable and unsuitable for cocoa cultivation are defined on the basis of these data; climatic data of many cocoa-growing regions of the world are presented and the climate of each region is characterised by a formula. English summary. Tables. Map. 24 refs. This paper is 1 of 9 contributions presented to a symposium on the agroclimatology of Venezuela held at Maracay in September 1960 and collected in this issue of Agron. Trop. (p. 9–242). Other papers are concerned with the climatology of Venezuela and the effect of regional climates on crops and farm animals. Tables. Graphs. Maps. Refs.

Wessel, M. Cocoa on basaltic soils near Ikom. Mem. Cocoa Res. Inst. Nigeria 12, p. 1–10 (1966).

The 300-km_2 Ikom region, where cocoa has been successfully grown by farmers for 30 years, is becoming the most important cocoa-growing area of E. Nigeria; the Eastern Nigeria Development Corporation established 3,200 ha of cocoa between 1954 and 1965. Good growth of the cocoa is mainly due to the favourable physical properties and great depth of the soils, which are derived from basaltic rocks. However, the soils are strongly leached and generally poorer in minerals than cocoa soils in W. Nigeria. Annual rainfall in the Ikom region is about 3,000 mm, with a marked dry season, against 1,125–1,575 mm in W. Nigeria. A mixture of W. African Amelonado and of Trinitario types brought in from Cameroon is grown under thinned forest shade. Average yields of peasants' fields are estimated at 450 kg dry beans per ha against 400 kg/ha in W. Nigeria. Tables. Graph. Map. 5 refs.

Capriles de Reyes, L., and Gonzalo Armas, E. Tipos de potes mas convenientes para propagación de cacao. (Types of pots most convenient for the propagation of cocoa). Cocoa, Bol. Inform. 2, 1–2, p. 3–8 (1965; received 1967).

A trial conducted at Caucagua, Venezuela, compared the growth of seedlings and rooted cuttings of the same cocoa clone in polyethylene bags of 9·5 (diameter) × 14 (height) cm, 9·5 × 22 and 15 × 25 cm containing, respectively, 1·5, 2·7 and 6 kg of a soil-sand-sawdust mixture. After seven months the size of the nursery plants was found to increase with the volume of the containers, the differences being more pronounced in the seedlings than in the cuttings. In view of the relative costs, 9·5 × 22 cm bags are recommended. Tables. 2 refs. See also ibid. p. 9–14: Reyes E., H., and Pérez Zamora, A. Transporte de plantas de cacao. (Transport of cacao plants). Tables.

(Recommendations to cocoa farmers in Venezuela). Dia de Campo 3, p. 1–51 (1965; received 1967).

This bulletin, issued on the occasion of the third field day held at the Caucagua cocoa research station in Venezuela, contains practical recommendations to small-scale cocoa farmers in northern Venezuela. The three longest contributions are concerned with the construction of nurseries and of simple drying floors using locally available materials, and with the construction and use of the equally simple "Caucagua" small solar fermentation unit. Other subjects discussed are the rejuvenation of cocoa fields, insecticidal control of the beetle *Steirastoma breve*, and the use of herbicides for weed control. The most important weeds of cocoa in the area are listed and illustrated at the end of the publication. Tables. Figs.

Soderholm, P. K., and Shaw, E. W. A modified side graft technique for use in a cacao virus indexing program. Proc. Caribbean Region Amer. Soc. Horticult. Sci. 9, p. 25–9 (1966).

The grafting of a susceptible Amelonado cocoa type indicator on clonal material is required as a virus indexing procedure for the introduction of new accessions in the collection of cocoa cultivars maintained at Miami, Florida (U.S.A.). A modified sidegraft technique is described, which was found superior to the customary patch-budding method in that a rapid growth of the scion buds was obtained without the necessity of cutting back the clonal stock above the graft. The quarantine period for new accessions was reduced by two to five months through the use of this new technique. Spanish summary. Fig. 4 refs.

Bonaparte, E. E. N. A. Interspecific competition in a cocoa shade and fertiliser experiment. Trop. Agr., Trinidad 44, 1, p. 13–9 (1967).

The "light shade" treatment of the Amazon cocoa shade × fertiliser trial (K_2, O_1) at Tafo, Ghana, has *Terminalia ivorensis* shade trees spaced at 12·2 × 12·2 m and cocoa planted at 3 × 3 m; consequently, distances between cocoa and shade trees are 2·15, 4·82 or 6·46 m. Mean yields over two successive years of cocoa trees at these distances from the shade trees were 37·0, 43·6 and 51·3 pods per year, respectively. The differences are ascribed to the effect of mean light intensity, which was found to increase from 38 to 62 per cent of full daylight with the distance from the shade tree. Competition for moisture is an unlikely factor as the dry season was very mild in both years and *T. ivorensis* is devoid of leaves from December to February.

Lavabre, E. M., et al. Étude préliminaire de la transmission de viroses nucléaires et de bactérioses aux chenilles de cacaoyers. (Preliminary investigations into the transmission of nuclear viroses and bacterioses to caterpillars attacking cocoa). Café, Cacao, Thé 10, 4, p. 336–41 (1966).

Trials on the biological control of cocoa pests, conducted in the Ivory Coast, showed that early instars of *Anomis leona* succumbed after ingestion of a fluid obtained from another noctuid caterpillar (*Argyroploce* sp.) liquefied as a result of virus infection; however, the cause of their death was not certain as they dried out instead of becoming limp. Later instars were not susceptible. Strains of a pathogenic bacterium isolated from *Heliothis* caterpillars killed all stages of *A. leona* larvae but only the younger instar larvae of *Earias* sp. Promising results were also obtained with the artificial transmission of a disease of *Anomis* larvae caused by microsporidia. English, German and Spanish summaries. Table. 3 refs.

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