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Editorial

Coconuts and Cocoa

The interplanting of coconuts with cocoa is one of the few examples of successful double cropping with tree crops. It is only successful where coconuts are planted on soils suitable for cocoa but is successful in such places because cocoa yields well under the degree of shade that coconuts, at normal spacing, provide. Such interplanting has been practised extensively in New Guinea during the past 25-30 years and also in the Philippines. More recently this practice has been adopted on the west coast of Malaya where there are some 50,000 acres of coconuts planted on coastal clay soils. Much of this acreage is held by plantation companies, one of which has announced its intention of planting 7,000 acres of cocoa. A considerable acreage is held by small-holders and they have started to interplant.

This extensive planting of cocoa will soon lead to cocoa becoming an appreciable addition to Malaya's exports. There is, however, a far more important aspect to this development and this lies in the knowledge gained from it. This cocoa is being established by planters who examine critically every aspect of the cultivation of a crop. This has already led to some interesting innovations and methods. Some of these are described in a paper, the first part of which is published in this issue. There is no doubt that more knowledge will be gained as the years go by and we hope to pass this on from time to time.

G. A. R. WOOD.

Review of Production and Consumption

January 1971

A. P. Williamson, Cadbury Schweppes Limited

Production

The West African mid crops were above average. In Brazil the Temperao crop was excellent and this, coupled with the good main crop, took Brazilian production back to the peak level reached in 1959/60. As a result world production in the 1969/70 crop year is now estimated at 1,416,000 tons, some 30,000 tons above the level forecast six months ago.

The current main crops in West Africa are expected to be similar to or rather better than last year, especially in Nigeria, where an increase of 20% is forecast. In Brazil observers are looking for production to be rather lower than last year's record level and this, coupled with smaller decreases elsewhere in South and Central America, means that total 1970/71 world production is forecast at 1,432,000 tons or only 16,000 tons more than in 1969/70.

Consumption

Final 1970 grinding figures are now available for the major consuming countries and it looks as though total world consumption will be much in line with earlier predictions. In Eastern Europe consumption is not now believed to have increased, but in Western Europe usage in 1970 has been rather higher than expected.

Despite the generally lower price levels, 1971 consumption is expected to be only slightly up reflecting the fact that manufacturers' other costs have been rising sharply in every sector.

Stocks

The nominal surplus in 1970 has now been increased to 95,000 tons which, allowing for the normal 1% loss in weight, is equivalent to a true surplus of about 70,000 tons. While this has resulted in a definite replenishment of the depleted stock levels existing at the end of 1969, the stock levels at the end of 1970 measured in terms of months' usage, are still historically low.

On the basis of the forecast of 1970/71 production and 1971 consumption, a similar surplus is predicted during the coming year. If this proves correct then this would go a long way towards overcoming the tight supply situation that has marked the cocoa market in recent years.

Prices

After trading for two months at around £260/ton prices started to rise sharply in the middle of July until they reached £350/ton early in September. It is now clear that this move was triggered off by enforced short covering by an international bank on the Continent and when the momentum of the move ran out, prices fell very sharply indeed and by the end of September they were back to £300/ton. There was another much smaller rally during October which took prices back up to £325/ton but since then prices have declined steadily and now stand at £270/ton. Month end prices for nearby Ghana shipment cocoa over the period under review:

June	£255·0/ton
July	£305·0/ton
August	£340·0/ton
September	£305·0/ton
October	£305·0/ton
November	£290·0/ton
December	£285·0/ton
January (mid)	£270·0/ton

WORLD COCOA PRODUCTION AND GRINDING DATA

Reproduced from Gill and Duffus Market Report dated December 1970

(Thousand long tons)

Production

	1968-69	1969-70	1970-71 (Forecast)
Africa	852	991	1,043
America	298	329	299
West Indies	37	60	47
Asia and Oceania	40	36	43
World Total	1,227	1,416	1,432
Principal Countries			
Ghana	334	403	415
Nigeria	188	220	265
Ivory Coast	142	178	170
Cameroon	102	107	105
Guinea (Spanish)	37	25	25
Brazil	163	197	160
Ecuador...	52	54	60
Dominican Republic	21	42	30
Venezuela	23	24	25
Colombia	18	19	21
Mexico	26	24	20
New Guinea	27	22	29

Grindings

	1969	1970	1971 (Forecast)
Western Europe	523	503	505
Eastern Europe and U.S.S.R. ...	179	177	182
North America	282	273	282
Australia and New Zealand ...	16	18	18
Central and South America ...	153	165	155
Asia	48	50	55
Africa	140	137	145
World Total	1,341	1,323	1,342
Principal Countries			
United States	265	260	265
Germany (Federal Republic) ...	122	125	127
Netherlands	109	114	112
United Kingdom	91	80	80
U.S.S.R.	97	100	105
France	42	38	37
NOMINAL BALANCE	—114	+93	+90

The Tropical Products Institute, London

G. R. Ames

The Tropical Products Institute provides for developing countries expert help on the post-harvest operations in agriculture, forestry and fisheries. TPI dates from 1894, when it was established as the Plant and Animal Products Laboratory of the Imperial Institute. It assumed its present title in 1958, when its terms of reference were widened to provide aid to countries outside the Commonwealth as well as to those within it.

Most of the Institute's work concerns the improvement of existing processing and handling, and with the establishment of processing in new areas. It covers such aspects as the initial processing of crops; storage; conversion; industrial utilisation; marketing and the economics of production.

Exchange of Information

Many of the problems confronting developing countries could be overcome if existing scientific and technical knowledge were available to the people concerned, and if they were able to use it effectively. The Institute receives many requests for information and advice on processing of particular crops. New producers may not know the procedures involved, or existing producers may be getting an inferior product, which they are unable to sell or for which the price is low. In the case of poor quality materials it may be very difficult for the producer to find out, unaided, what is going wrong.

Matters of this sort can often be resolved by correspondence, but in other cases it is necessary for the Institute's staff to visit the country concerned to help set up processing and to train the people concerned. One of TPI's engineers recently helped to install groundnut processing equipment in Madagascar, and he trained the local personnel who were to operate it. Other staff have worked in several parts of Africa on the control of insect pests in maize stores, both at large central depots and on the farms themselves; unless the proper control procedures are followed, losses of stored food can be very serious indeed.

Many of the requests received call for a laboratory analysis; new producers seeking an assessment of quality and existing producers wishing to find out why their product is of inferior quality. These problems can often be resolved by chemical investigations. For some materials, such as cocoa, the quality assessment is subjective, so it is necessary to seek the advice of commercial experts as well. Many firms, the majority in London, but some in Europe and North America, help TPI in this way. In this way the causes of inferior quality can often be identified and ways of improvement suggested. Furthermore, if the product is of acceptable quality then the producer can be put in direct touch with interested parties. In the field of essential oils, for example, buyers have been found for oils newly produced in Malawi, Gambia, Thailand, Burma, and the Solomon Islands.

The analysis of samples is also important in assessing whether a product has the necessary properties for commercial use. For instance, species of pine which give excellent paper pulp in some places, are quite unsuitable when grown elsewhere on a site with different soil and climate. Only by converting the wood into paper can its suitability be assessed. The commercial importance of thorough testing is considerable, as even a small paper mill can cost £10,000,000 and the forest to supply it another £10,000,000.

Another analytical service provided is the assessment of pesticide residues. For all edible crops it is important to ensure that when the product reaches the consumer it does not contain dangerous levels of pesticide residues which were applied to the crop before harvest or in storage or shipment. The analytical procedures are highly specialised as it is necessary to measure minute traces of the pesticide. Often a new method has to be developed for a pesticide in a particular commodity; as some of the natural substances present may interfere with the analysis giving a false result, great care has to be taken to remove all such substances. Many developing countries cannot afford to set up and maintain the laboratories required for this type of work, so the TPI service is especially valuable. Cocoa is one of many commodities on which the Institute has carried out pesticide residue analyses. It is important that countries know that their produce, whether exported or consumed internally, is safe – or, alternatively, be aware of the need to change the pest control procedures to ensure that their produce is safe.

Mention has already been made of the training of local personnel by TPI officers on overseas assignments. Where more intensive or varied training is required, the people concerned spend periods of from two weeks to a year working at the Institute. Their training programmes are arranged to meet the individual requirements, which could be for a thorough coverage of a single specialised subject such as pesticide residue analysis, or more general, such as the analysis and quality assessment of a range of different commodities.

A member of staff examining maize for weevil in a village store in Kenya.

Investigational Work

Many of the problems on which TPI is asked to help cannot be solved by the application of existing knowledge; some problems need to be studied thoroughly to establish the causes of the difficulty. Such problems could be to assess the reason why West African palm oil is more difficult to bleach than the oil from South-East Asia, or why a fine-textured paper made from abaca tears too easily. The precise conditions under which a product is handled or stored can have a profound effect on its quality. Yams need to be kept in a cold store, but if it is too cold they are damaged, so a study is being carried out to establish the causes of the chilling injury. Bananas shipped to Britain from the West Indies are sometimes rotten because of attack by fungi, but a comparison of the effect of different fungicides has established that a particular pesticide applied at a specific time can overcome this. Fish could be a much more useful food in many tropical countries if it were kept in good condition, and the Institute is working on this problem.

In other cases, a crop may not be used, or is used less than it could be, because of difficulties in processing. Cracking cashew nuts by hand is difficult and laborious, so TPI has developed a machine for the operation; this has completed full-time trials in Kenya and is now available commercially. The drying of spices in the sun is not always easy in the humid tropics, so work is in progress on artificial drying; in this case it is necessary to find the precise conditions for drying so that the spice retains its familiar flavour and appearance.

Sometimes it may be possible to develop a new use for existing produce. Bread is a very popular food throughout the world, but it is made from wheat, which does not grow in the humid tropics. The Institute has shown that as much as half the wheat flour can be replaced by flour of starchy foods, such as cassava, without losing the characteristic structure of bread. This should enable many countries to reduce wheat imports, or to make more use of bread as a food.

Work of this type is, of course, speculative, as it may prove impossible to achieve the desired objective. Pectin is a substance used extensively in manufactured foodstuffs, which is obtained from citrus peel and other "waste" materials. TPI has examined the possibility of using cocoa pods as a source of pectin, for if this could be established as a commercial process cocoa growers would gain extra income. Unfortunately it was found that under normal conditions cocoa pods contained only a fairly low proportion of poor quality pectin.

Some agricultural waste products can be used to make building materials, for example, rice husks mixed with cement give strong building blocks. Groundnut shells can be used to make particle board, and it is hoped to set up pilot-scale manufacture of this board in India, following an assessment of several possible sites by the Institute's economists.

It is often necessary to develop new analytical methods for use both in the laboratory and in the field. An example of a new laboratory method is the case of aflatoxin, a substance poisonous to animals and, probably, man, produced by a mould which can grow on many types of foodstuffs. The method developed by TPI for detecting and measuring aflatoxin is now in use throughout the world. Many processing operations call for careful control and a knowledge of exactly how far the process has proceeded: long experience may make it possible to assess this by, say, the appearance of the material, but new producers would be helped if simple scientific test methods were available. A TPI project, to try to develop a colour test to measure the degree of fermentation of cocoa, is an example of this. Another case concerned pyrethrum, where attempts are being made to develop a strain of plants which give a higher yield of insecticide, and it was necessary to devise a quick yet accurate method of measuring the amount present in individual flowers.

Finally, an important part of the work of TPI is in the field of economics. Apart from helping with the organisation of production and marketing, the Institute studies the present state and future prospects of markets for produce exported from developing countries and carries out feasibility surveys to help to ensure that limited resources are not wasted on uneconomic enterprises.

This brief account should provide some idea of the range of services provided for developing countries by the Tropical Products Institute. These services are in most cases provided as part of the British Aid Programme and therefore no charge is made.

Canker: The Forgotten Disease of Cocoa

A. J. Vernon, Rothamsted Experimental Station

Until about 1925, no cocoa disease was more widely recognised, attracted more attention, or was considered more important than canker. The earliest reports (10) are too vague for the disease in question to be identified with certainty; but in 1892 it was said "Fortunately for the cultivator the serious diseases which attack the cacao are few; perhaps the most common is canker" (7). In another early textbook (14) nearly half the 18-page section on diseases is devoted to canker. For 20 years the causal agent was sought, until identified as *Phytophthora palmivora* independently by Rorer (9) in the West Indies, Petch (8) in Ceylon in 1910, and Demandt (3) in Samoa in 1914.

The decline in importance attached to canker since then is shown by the space given to it in general accounts of cocoa diseases. The proportion has fallen from half, as just mentioned, to successively lower fractions in the text-books of Van Hall, Nowell, Briton-Jones (1) and others, until, in the second edition of Urquhart, canker was relegated to three paragraphs out of 25 pages. In 1967, in his authoritative review of "black-pod diseases" of cocoa, Thorold (10) included a section on "complex diseases associated with Phytophthora"; but, in this, he cited mainly studies in which *Ceratocystis* and *Xyloborus* had seemed the primary causal agents of disease. The word canker he used only once, in inverted commas, in citing a failure to find the cause. This once best-known of all cocoa diseases had become a myth!

But meanwhile the disease was being rediscovered in West Africa. Until recently the only report from this region had been Dade's 1929 study of cushion-canker (2). Then in 1963, there was a single-sentence reference to its occurrence in a variety trial at Tafo, Ghana (5), followed in 1967 by the report of an outbreak in Nigeria involving 16 per cent of the trees in an area of Amazon cocoa at Araromi (6). However, the disease had been so forgotten that this outbreak was reported as "red bark canker" of "unknown etiology". Attempts to isolate the causal agent re-enacted the early unsuccessful studies of Carruthers and others. Dextrose agar was used, on which *Phytophthora palmivora* cannot compete with other fungi (water agar, or a more elaborate medium, is needed). Hence only *Calonectria* and *Fusarium* were isolated, which on re-infection do not cause cankers.

There can be no doubt that the Araromi outbreak was, in fact, *Phytophthora* canker. My recent examination (12) of Amazon cocoa at Gambari (Nigeria) and Tafo (Ghana) disclosed extensive cankering of a substantial proportion of the trees in all plots. The symptoms are typical of *Phytophthora* canker, and *Phytophthora palmivora* has been isolated from cankers at Tafo.

Many of the heavily cankered trees are in a decrepit condition, and presumably yield little or nothing. All the plots examined had many gaps; and presumably many of the deaths were caused by canker. Clearly it is time to revive our awareness of this disease.

Reason for Decline of Interest: the Varietal Situation

Almost every mention of canker in the literature includes a remark to the effect that Criollo cocoa is especially susceptible, and during the last 50 years this is usually accompanied by a comment that the disease has declined in general seriousness as Criollo cocoa has gone out of cultivation.

Provided that Criollo cocoa is defined by reference to a complex of characters, not solely to its white-bean character, these remarks are true: but they are not the whole truth. More comprehensively it may be said that the only cocoa genotypes known to be resistant to canker are those that derive from 18th and 19th century estate selections. These now account for almost all the world crop.

These resistant cultivars include in particular the Trinitario complex, other West Indian selections, the Amelonado cocoa of Brazil and Fernando Po and the Amelonado of West Africa. All accounts of the origin of Trinitario agree that its selection was inspired by the need to find something more "hardy" than the previously grown Criollo. The nature of the lack of "hardiness" of Criollo is vague in contemporary accounts; but from the extreme susceptibility of Criollo to canker in the West Indies described in the first scientific studies, it now seems certain that the selection of Trinitario must have been primarily for canker resistance. Less is known of the origin of cultivated Amelonado, but the genetic purity of the Fernando Po (hence West African) strain suggests a highly selective origin.

Thus canker resistance in the main cocoa types of traditional cultivation has probably come not by chance, but by selection, unconsciously directed to securing such resistance. Unfortunately this was overlooked in more recent attempts to derive cultivars from collections of wild cocoas, for instance, in the work on the Upper Amazon types. Certainly, in the West African studies no attention was paid to this point until 1963, when Glendinning realised that many of his Amazon-derived lines were susceptible. It may be that most wild cocoa is susceptible to an unsatisfactory degree. It is certainly essential to take this possibility into account in breeding from wild cocoa.

Description of Canker

Most pre-1935 text-books on cocoa and tropical plant pathology give good accounts of the disease and Nowell's is outstanding. The salient features of the disease may be summarised as follows.

Canker starts as a growing-back of the fungus from a black-pod, through the peduncle, into the cushion. From there it may spread into the bark. Newly-infected bark shows no external symptom, but incision reveals a cambial layer discoloured to some point in the range watery-grey→pink→claret→red, and with a slimy feel. The colour usually deepens after a few minutes exposure. (Plate 1).

At this stage *P.palmivora* can be readily isolated from the discoloured tissue, using standard mycological techniques, provided that a suitable culture medium is used (4). But *Calonectria sp.* and *Fusarium sp.* invariably accompany *P.palmivora*, and on an inappropriate medium their growth obscures its presence. Re-inoculation from cultures shows that their role is secondary: *P.palmivora* alone causes cankers, *Calonectria* and *Fusarium* do not.

Subsequent development depends on the susceptibility of the cocoa, a point not made clear in most accounts of the disease. In resistant cocoa the develop-

Plate 1. This illustrates the colour of a capsid as revealed by removing the outer layers of bark.

ment is usually as described for "cushion canker" by Dade (2). The spread of primary infection is halted, and host scar-tissue forms round the lesion. The secondary fungi take over completely, and the infected tissue turns brown. At this stage the outer bark is still intact, but *P.palmivora* can no longer be isolated. Insects then invade, the outer bark crumbles away, and all the diseased tissue is cleared out by insects, leaving a clean scar.

On susceptible cocoa, however, it seems that the active phase is usually more prolonged; instead of the secondary fungi taking over, the canker remains in the "red-slimy" state, from which *P.palmivora* can be isolated, and gradually becomes larger. It seems certain that a canker can remain in this state for several months and possibly even for a number of years. Often there is exudate, which is bright red when fresh, but drying to black. On resistant cocoa this exudate rarely appears and there is often no discernible discoloration of the bark.

A tree can remain alive for years with a main trunk riddled with, perhaps even girdled by, active cankers. Drought hastens death.

No thorough study of canker on Upper Amazon cocoa seems yet to have been made. In Fiji, on clonal Na32 and cocoa of Na32 female parentage, cankers are typically small but profuse: most show no external symptoms until the "Fusarium-stage" is reached (4). In the 35-acre "Amazon shade and manurial" trial (K2–01) at Tafo, Ghana, much of the cankering is also of this type. Many trees have lost one or more primary branches from the first jorquette, presumably killed by ring-girdling cankers. Further study is urgently needed.

The Seriousness of the Disease

It is difficult to assess, even approximately, the economic loss from canker. Much must depend on spacing and pruning. With wide spacing and strict pruning, traditional in some countries, canker is potentially much more serious than on close-spaced, unpruned cocoa. Indeed the former system is practicable only for canker-resistant varieties.

Even without loss of trees or main-branches and even with resistant cocoa, there must presumably be some eventual loss of yield from the cumulative effect of "cushion-cankers". Any branch loss will add to this. The consideration of decline of cocoa yield with age has been neglected in recent years. Van Hall says little about it, Urquhart less. But formerly this subject was much discussed in connection with canker. For example, Briton-Jones (1) attributed the general decline in yield in Trinidad after about the 25th year almost exclusively to canker. Presumably, on more susceptible varieties it will start sooner.

In Ghana and Nigeria the earliest sizeable plantings of Upper Amazon cocoa were attracting attention about ten years ago with yields of 1,500 to 2,000 lb/acre in the fourth to eighth year from planting. Since then, however, yields have generally declined, in some cases by as much as 25 to 50 per cent within a few years. It now seems that canker may be a major cause of this. If so, the much publicised short-term superiority of Amazon cocoa, and Amazon-based hybrids, over Amelonado, may have to be qualified by recognition of the long-term superiority of Amelonado in this respect.

Allowing one or more basal chupons to grow and develop a completely new trunk and branch structure, perhaps once every 15 to 30 years, depending on the susceptibility of the variety, might give an indefinite maintenance of yield. Again there has been a tendency to forget what was common knowledge to a previous generation. Briton-Jones (1) wrote, of old cocoa plantations in Trinidad, that "the majority of trees are under 50 years of age and many between 10 and 20 years. The reason is that a number of the original trees have in the course of time been killed by various agents and replaced by chupons, one of the main causes being canker. Some of the larger limbs of the original tree may be killed and in anticipation of the death of the whole tree the planters allow one or more of the basal chupons to grow so that later a selection of the best chupons can be made. In the course of a century such replacement by a young chupon may occur once, twice, or several times". (Extract slightly abbreviated). The cocoa of the K2–01 area at Tafo looks as though it would benefit greatly from such treatment.

Instead of replacing the whole trunk and branch structure by a basal chupon, the branch structure may be replaced by allowing a jorquette-chupon to develop an upper-storey of branches. The desirability, in relation to canker-disease, of allowing such higher growth, has been completely neglected in the controversy concerning height-restrictive pruning.

Even with resistant varieties, occasional trees may be killed by trunk-girdling canker so quickly that chupon regeneration is not possible (4). Whether the trees that so die are genetic "rogues" is not known.

The seriousness of such occasional death, depends largely on spacing. With very close spacings (e.g. 6 ft × 6 ft) an annual death rate of 3% can be sustained for over 30 years without any appreciable loss of yield from gaps. The tolerable annual death rate decreases with wider spacing (e.g. to about 1·5% at 8 ft × 8 ft) and at spacings wider than 11 ft × 11 ft any loss of trees means loss of yield (13).

When dead trees are replaced by seedlings the loss of yield is only temporary. An annual death rate of, say, 2% causes, at worst, an annual yield loss of only about 10% if dead trees are promptly replaced by seedlings coming into nearly full bearing in the fifth year. The cost of this, however, is likely to be equivalent to a further 10% loss of yield; and in practice many seedlings may fail to establish.

Cankers cause further loss in being sources of black-pod (2). Moreover, black-pod from this source cannot be controlled by spraying. This indirect susceptibility to black-pod is not revealed by the conventional varietal screening techniques based on pod studies. It does not affect black-pod incidence in the first few years of bearing of a new variety, before stem cankers have become established, but only in later years. Thus some Amazon types in Ghana are now suffering alarming black-pod losses (11) although in earlier years they had not appeared unduly susceptible.

Clearly what is needed is rigorous screening of new varieties for canker susceptibility by seedling stem inoculations.

Control

As was recognised many years ago, effective control can be secured by selecting resistant varieties. However, when a partially susceptible variety far outyeilds any available resistant variety, as the "Tafo hybrids" may do in Ghana, the possibility of other control measures must be considered.

Various writers, especially Briton-Jones (1) have suggested excising active cankers and painting the scars with fungicide. As recently as 1965 this has been recommended to control an epidemic in the Caroline Islands; but this is on Criollo cocoa, where any active canker is readily noticeable, and whose produce is especially valuable. This method would not be feasible, let alone economic, on any other type of cocoa.

As cankers begin by the growing-back of the fungus from black pods, strict black-pod control presumably diminishes canker incidence. No study ever seems to have been made of this point, but it could be a valuable side-effect of fungicidal spraying.

Cultural methods of controlling black-pod should also help to lessen canker; but one strongly advocated practice, i.e., "opening-up the canopy" by wide-spacing and strict pruning is in direct conflict with the mitigation of canker loss (not incidence) by close spacing and lax pruning as explained earlier. In my view the benefits of "opening-up" the canopy have been generally exaggerated, and the grave disadvantages of some "opening-up" practices have been overlooked.

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Resistance of Cocoa Capsids to Insecticides in use in Nigeria

Anthony Youdeowei, Department of Agricultural Biology, University of Ibadan, Nigeria

Introduction

In Nigeria, two species of cocoa capsids attack cocoa, *Theobroma cacao*. They are *Sahlbergella singularis*, the dominant and widespread species, and *Distantiella theobroma*, which has a restricted distribution. Their importance as pests of cocoa in West Africa was recognised as early as 1910 but it was in 1913 that they were first recorded in Nigeria (12). Attempts to control these pests in Nigeria started in 1951 by the Federal Department of Agricultural Research when lindance (gamma BHC) and DDT dusts were used. Lindane was dropped after the first year but trials with DDT dusts were continued and a limited measure of control was achieved. No further attempts to control these insects were made until 1956/57 when the use of lindane emulsifiable concentrate was studied by Donald (2). These trials led to the first firm recommendations by the Ministry of Agriculture and Natural Resources in Nigeria. Similarly, trials in Ghana in 1954-1956 by Hammond (11) led to recommendations in which lindane emulsifiable concentrate was used against the cocoa capsids. In Nigeria, 4 oz of toxicant in 10 gallons of water per acre were recommended to be applied with knapsack sprayers in August, September and October, followed by spot treatment. In Ghana, 4 oz of toxicant, followed by 2 oz each in five gallons of water per acre were applied with mist blowers in June and July, October and November.

It thus became the widespread practice in West Africa to control cocoa capsids with lindane. Following the success achieved with lindane, other chlorinated hydrocarbon insecticides such as aldrin and dieldrin became available and were tested for use against cocoa capsids.

The discovery and distribution of resistance in cocoa capsids

In August 1961 there was indication in the Pankese cocoa station, Ghana, that application of 1 oz of lindane in June and July failed to control *D. theobroma*. Further tests were conducted in which 4 oz of toxicant per acre were sprayed but this was without any effect on the capsids. Laboratory tests in 1962 (3) confirmed the presence of lindane resistant individuals in the Pankese capsids and suggested that this resistance also extended to aldrin. Following this discovery in Ghana, surveys were conducted in Nigeria in 1962, 1963 and 1964 in order to assess the presence and distribution of capsids resistant to lindane and the cyclodiene insecticides. It was found that resistance to lindane had developed in populations of *S. singularis* in an area about 60 sq. miles south of Olode along the Ife/Ondo road of Western Nigeria. Figure 1 shows the distribution of resistant *S. singularis* at the end of March 1964 and up till March 1968. This area lies in the heart of the best cocoa grown in Nigeria and it also coincides with the area where *D. theobroma* is common but no lindane resistance has been detected in this species which is the species that has developed resistance to lindane in Ghana. Further surveys made in 1967 and 1968 by Booker (1) showed that the limit of lindane resistance had spread especially in the northern and north-west directions from the original area (see Fig. 1). The area had increased from 60 sq. miles to 700 sq. miles (i.e. over 10 times) between 1962 and 1968. In this area, continued spraying with lindane has had no effect on *S. singularis*.

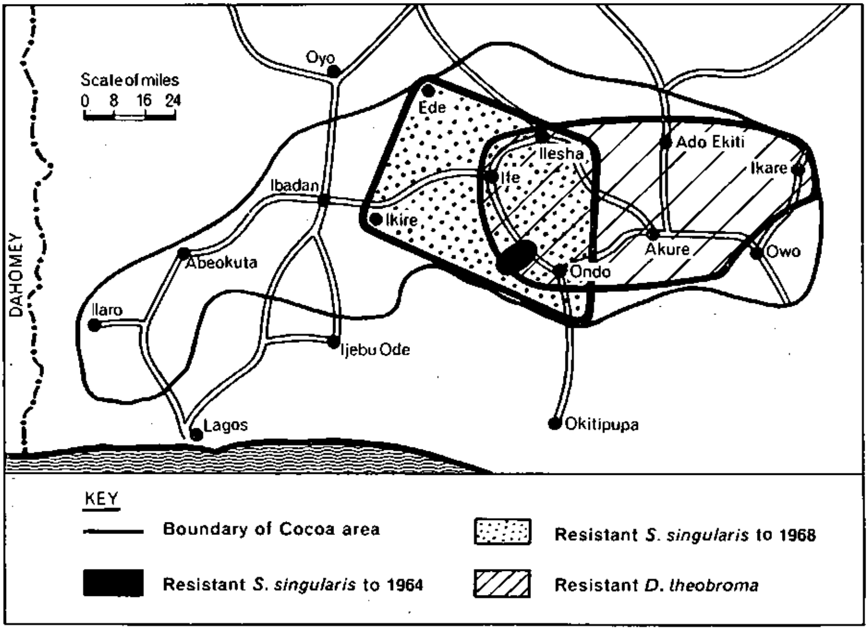

Figure 1. Map showing the distribution of *S. singularis*, resistant to lindane in Nigeria (as at March 1968) in relation to the main cocoa area.

Methods used for detecting resistant capsid species in Nigeria

Only two methods, which are suitable for laboratory and field use, have been adopted in Nigeria for detecting populations of capsids which have developed resistance to chlorinated hydrocarbon insecticides. A team of four men including a graduate research officer, or a suitable supervisor, collect capsids from as many sites as possible in the cocoa growing areas. Usually, the capsids are collected on one day and tested the following day in the laboratory. For this survey, the country is divided into the west (including the mid-west), east and north zones. During the 1962/63 season capsids were tested from 82 sites in the west, 17 sites in the east and no site was sampled in the north. In the 1963/64 season, 83 sites were sampled in the west, 11 in the east and 14 in the north zone.

I Petri Dish Method

Circular filter papers (Watmans No. 1) were dipped in a 0·05% emulsion of lindane and air dried for about one hour. They were then used to line the floor of 9 cm. petri dishes into which "healthy" capsids were confined. The capsids were thus continuously exposed to the insecticide. Control experiments were set up at the same time using papers treated with distilled water. Records of the number of individuals knocked down were taken every 15 minutes until complete knock-down was achieved in the test insects. The capsids were usually not fed during these tests. The percentage knockdown corrected by Abbots formula, which takes into account control knockdown, is calculated and plotted against time.

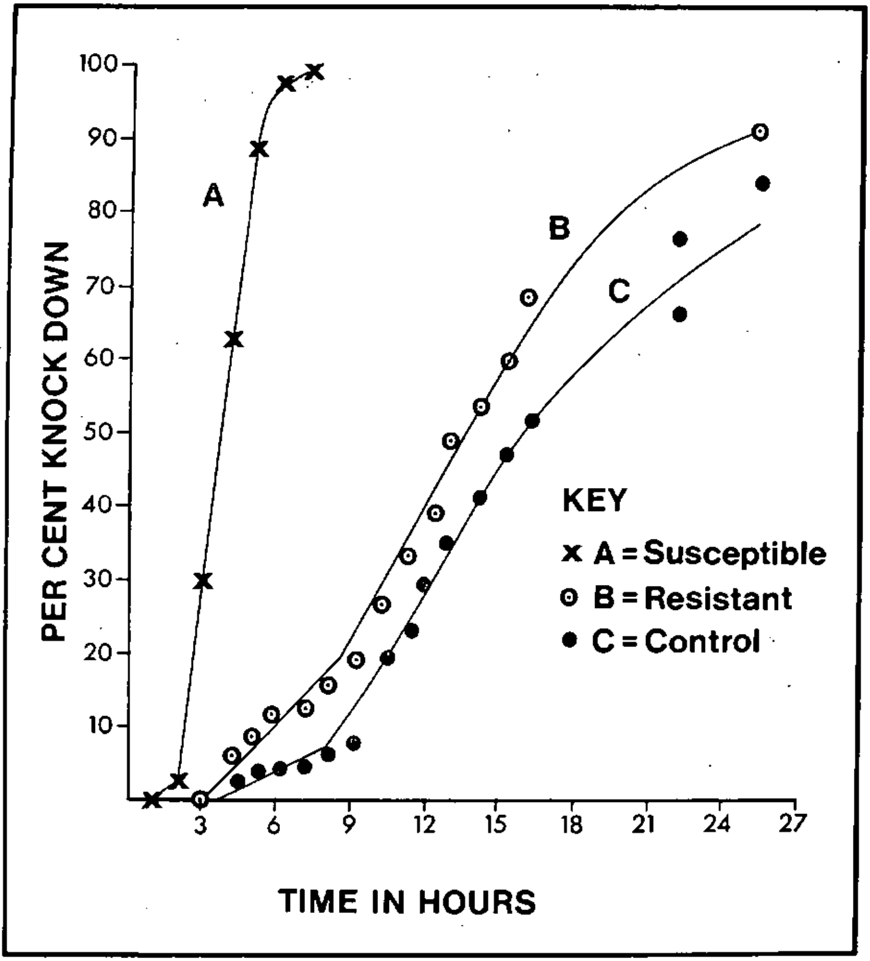

Figure 2. The rates of knockdown of 4th and 5th instar nymphs of *S. singularis* exposed to 4·0% dieldrin impregnated WHO papers. Comparison of susceptible, resistant and control insects. (From Entwistle 1964).

II WHO Field Kit Method

This is the standard method developed by Telford (13) for similar tests in Ghana. Plastic tubes, 4 cm × 12 cm, used by the World Health Organisation for insecticide work on mosquitoes were used. One end of the tube was screened while the other end was screwed to a plastic sliding partition. Specially prepared 4·0% Dieldrin impregnated papers were obtained from the World Health Organisation and these were used to line the inside of the plastic tubes. Capsids were introduced into the tube and thus were continuously exposed to the insecticide impregnated papers. Control experiments were made using filter papers to line the tubes. This is a slight modification of the method used for testing mosquitoes. Records and calculations were made as described under the first method.

The behaviour of 4th and 5th instar nymphs of *S. singularis* when continuously exposed to 4·0% dieldrin impregnated papers is shown in Fig. 2. Similar curves were obtained with the Petri dish method. The susceptible and resistant individuals were distinguished by a survival time of about 10 hours. Any capsid which survived for over 10 hours when exposed continuously to the insecticide-impregnated papers was regarded as having developed resistance. The behaviour of resistant and control capsids were usually atypical and similar.

Categories of Resistance

Entwistle (4, 5) did not distinguish between levels of resistance in *S. singularis.* Booker (1) however observed that in all his tests, there were three clearly defined rates of mortality and these have been designated as follows:

(a) *Resistant* – where the rate of mortality was similar to that of the controls. In this class, mortality of less than 60% was recorded after 12 hours continuous exposure to 4% Dieldrin impregnated papers.

(b) *Partly resistant* – where the mortality rate after 12 hours was in the range of 65% to 80%.

(c) *Susceptible* – where mortality of 100% was achieved within 12 hours.

The Search for Alternative Insecticides for Resistant Capsids

In 1963 trials were started by the Cocoa Research Institute of Nigeria in order to find an alternative insecticide suitable for controlling resistant capsids. Entwistle, Youdeowei and Eguagie (6) tested Sumithion and Sevin against *S. singularis*, comparing their efficiency with that of lindane. These workers concluded that "in order to obtain a satisfactory level of control with Sumithion and Sevin, i.e., of the order of 95%, it may be necessary to increase the dosage rate to 2 oz and 4 oz per 100 cocoa trees respectively". The dosage rates were expressed in terms of 100 trees rather than acres owing to the extremely wide variation in tree numbers that were encountered. No firm recommendations were made after the trials.

In 1964 dichlorvos (DDVP) at 0·5% and carbaryl (Sevin) at 0·5% were tested against *S. singularis* but the levels of control achieved in small scale trials were less than 85% (7). Further small and large scale trials were conducted between then and 1968 when several organochlorines, organophosphates and carbamate insecticides were tested (8, 9, 10). Table 1 gives the results of the 1968 trials and the most promising insecticides are marked with an asterisk. Further trials are being carried out but up till 1970, no alternative insecticide has been approved for control of lindane resistant capsids.

Discussion

The surveys described in this paper have shown that since 1964, the area where capsids have developed lindane resistance has increased by over ten times in four years. This lies in the heart of the best cocoa where the farmers have continued to spray with lindane. It is therefore important that the survey should be continued every year in order to be able to follow the direction and rate of spread of the resistant population. It is significant to note that even though this area coincides with the area where *D. theobroma* is common in Nigeria, this species has remained susceptible to lindane.

Booker's classification of capsids into resistant and partly resistant is an important contribution to the study of resistance in cocoa capsids. With this classification it will be possible to study the progress of development of resistance in capsid populations.

No studies have been made on the mechanism of resistance in *S. singularis* in Nigeria. This is because no satisfactory laboratory technique has been developed for mass rearing this species.* Several efforts by different entomologists have failed and until this problem of breeding is overcome and some genetical studies made, it will be difficult to understand the mechanism of lindane resistance in cocoa capsids.

Table 1. The reduction in S. singularis nymphs on ten selected cocoa trees two days after spraying insecticides at a rate of approximately thirty trees per gallon.

Treatment	No. of replicates	Reduction		Results compared with 0·7% fenitrothion on the same day		
		Mean	S.E.	Better	Equal	Worse
Unsprayed	10	10%	8·9	0	0	0
Organophosphates						
*0·7% fenitrothion ...	6	96·5%	0·7	—	—	—
0·6% fenitrothion ...	4	97·4%	2·0	1	1	1
0·5% Abate	2	90·5%	6·3	—	—	—
*0·5% Amidithion ...	4	90·0%	9·3	1	0	1
*0·5% Cyanox	4	99·2%	0·5	3	0	1
0·5% dimethoate ...	2	86·2%	6·0	—	—	—
*0·5% Dursban	2	100%	—	2	0	0
*0·5% fenthion	2	97·5%	2·1	1	0	0
0·5% formothion ...	2	87·0%	7·1	—	—	—
0·5% malathion ...	2	90·0%	1·4	0	0	2
0·6% NPD	4	91·6%	4·4	0	2	0
Organochlorines						
*1% DDT	3	97·8%	0·9	1	2	0
0·25% lindane	2	72·5%	6·3	0	0	2
Carbamates						
0·75% carbaryl... ...	1	90%	—	—	—	—
*0·5% propoxur... ...	2	100%	—	2	0	0

(From Gerard 1969.)

* A satisfactory method for rearing the other species, *D. theobroma*, has been developed in Ghana.—Ed.

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Underplanting Coconuts with Cocoa in West Malaysia

PART 1 - PLANTING

J. R. Leach, R. Shepherd and P. D. Turner, Harcros Advisory Services, Kuala Lumpur, Malaysia

This article is adapted from a paper presented at the Third International Cocoa Conference held in Accra, November 1969, the proceedings of which are in the press. The paper is published here in two parts by permission of the authors and the organisers of the Conference.

Introduction

Shortly after the Second World War, an attempt was made in Malaya to establish cocoa as a component of the country's agriculture. This attempt, however, was unsuccessful, mainly because of the severe problems of dieback, experienced because planting material was restricted almost entirely to the Amelonado variety. West Malaysia has only two estates on the East Coast where cocoa is grown as a monocrop; development in these areas has not been without serious problems, but the use of different planting material offers more encouraging prospects.

Small-scale trials under coconuts in the Lower Perak district on the west coast were more successful; growth and early yields were much better than those experienced on the east coast inland plantings and by 1965 large-scale commercial plantings had commenced. The rapid rise in price in recent years gave stimulus to underplanting, and 1968 and 1969 have seen considerable expansion in acreage of cocoa under coconuts.

Climatically, the area being used for underplanting at present is monsoonal, although there are normally no prolonged periods of drought with less than two inches of rain. A six-year average gives an annual precipitation of 75 in. falling over 120 days, as shown in Table 1. The two wettest periods are October and November and, to a lesser degree, March and April. It is noticeable that peak cropping periods are March-April and September-October, virtually coinciding with the high rainfall. The soils of the area are coastal alluvia, predominantly marine clays, which are amongst the richest soil types in Malaya. They are acid, with pH values of 4·5-5·0, and normally contain medium to high levels of nitrogen, phosphorus and exchangeable potassium, high levels of exchangeable magnesium, and moderate levels of exchangeable calcium. Base saturation values are generally moderate to high (8).

The concept of underplanting coconuts with cocoa is not new, since such mixed plantings have been established in the Philippines (1) and Papua and New Guinea (15). It has been found that not only was there little evidence of a depressing effect of the cocoa on the coconuts, but that yield of the latter could increase (6). Clearly, there exist a number of situations where the soil is sufficiently fertile to support both crops, especially with provision of adequate fertilisers. There is a considerable area of land on the West Coast of Malaya where coconuts alone are grown on good soils, and much of this could be underplanted with cocoa.

Planting Material

Most of the cocoa planted commercially at present is either legitimate or illegitimate Upper Amazon material or crosses between Upper Amazon and Amelonado; though some hybrids of Upper Amazon × Trinitario can also be found. In 1966 Sabah hybrid material became available. Based on the results of breeding trials in both Malaya (5, 9) and Sabah (4), a number of parental combinations have been selected from which yields are expected to be much greater than that of earlier material. Considerable prominence has been given to the clone Nanay 33 since trial results have shown this to be outstanding. Parinari selections are also included in crosses and a fuller account of the material used can be found elsewhere (10).

NURSERY TECHNIQUE

Seed Germination

Much of the planting material in Malaya is currently derived from hand pollinations carried out by the Department of Agriculture in Sabah, but with the establishment of seed gardens in Malaya, this dependence on imported materials should diminish. Every effort is made to germinate the seeds with the minimum of delay on account of their limited viability, even when packed in charcoal. Faster and more consistent germination has been achieved if the seed mucilage, which contains a germination inhibitor, is removed. This is done by rubbing the seeds with dry sand or sawdust after bulking them in wicker baskets for a day, during which time the mucilage becomes softer.

Nursery Practice

After germination, the seeds are planted in polythene bags of 250 gauge arranged in beds about 3 ft wide and any convenient length. Paths 1½ ft wide are left between the beds. The size of bag used depends upon the length of time which it is intended to retain the seedlings in the nursery. Thus, where the nursery stage does not exceed 2½ months a layflat size of 7 × 9 in. or 7 × 10 in. is sufficient, but where this period is extended up to 4½ months, the larger 8 × 12 in. size is preferred. All bags are perforated and, as the nurseries provide heavy shade, clear polythene can be used without the splitting which takes place with direct exposure to the sun. Bags are filled with good friable clay topsoil mixed with coarse river sand in a ratio of 2 : 1, except in the top inch of the bag, where the ratio of 1 : 1 is used to improve aeration and drainage. Various organic supplements, e.g., up to 15% well-rotted cow dung, are sometimes added to the soil mixture.

Nurseries are shaded both above and at the side, the latter being made necessary by the strong winds which occur near the coast. A peripheral fence of wire mesh netting keeps out rats. The initial shade intensity is about 80%, and as palm fronds are used this gives a dappled shade. After the first whorl of leaves has hardened, the shade is progressively reduced until by the sixth week from germination the light intensity is similar to field conditions (2).

Nursery Maintenance

When seedlings are grown in good conditions it has been found that the nursery maintenance required is minimal. The seedlings are watered during the early morning and late evening, taking care not to saturate the rooting medium. In coastal areas problems have arisen through brackish water leading to serious leaf damage, so piped water is preferred. The correct schedule for chemically-defined fertilisers, if one is required, has yet to be determined for Malaysian nurseries. The most usual nutrient deficiency symptom is the pale foliage coloration associated with a low level of nitrogen. This is readily corrected by weekly application of ½ oz urea in 1 gal. water per 200 seedlings. Considerable importance is attached to discarding any seedlings which are abnormal or poorly developed, though with Upper Amazon hybrids it is usually found that about 90% of the seedlings are suitable for field planting.

FIELD PLANTING

Seed at Stake

Some growers prefer to eliminate the nursery stage by planting seeds directly into the field, and usually, three seeds will be sown at each point, with later selection and retention of the most vigorous, though sometimes rodent attack can be so severe that five seeds per point are required. This seed-at-stake method has been used with success on numerous occasions, but requires a greater supply of planting material and is often accompanied by pest problems. In general, a nursery is preferred, mainly due to the greater attention it is possible to give to the seedlings and the higher costs involved in field upkeep when the nursery stage is omitted. It remains to be seen whether the two different practices result in any variation in subsequent time to maturity and yield, and trials have been established to determine this.

Soil Cultivation and Planting

Before planting either seed at stake or seedlings in the field, the soil is frequently strip-rotovated. However, where the soils are of favourable structure, it is sufficient to eradicate the vegetation along the planting rows, using herbicides. Whilst a few resistant noxious growths require removal by hand, a herbicide mixture of Ansar, Amine-80 and sodium chlorate in a 3 : 1 : 5 ratio has been found suitable for most weed situations. This is applied as a "cocktail" comprising 3 pints Ansar, 1 pint amine and 5 lbs. sodium chlorate in 40 galls water to cover up to 7 acres as described in Part 2 of this paper.

As seedlings are very prone to transplanting shock, care is taken during transport from the nursery to the field to avoid this as far as possible. Greatest shock occurs when seedlings have been retained in the nursery for longer than two months, by which time the tap root will have forced its way through the bottom of the bag. If emergent roots are pruned about one week prior to field planting, this appears to reduce the level of shock attributable to tap root disturbance.

Actual planting technique depends on soil structure. If the structure is poor then holing is carried out in advance of planting, but in good quality soils a small hole of sufficient size for the plant can be dug at the time of planting. The seedlings are planted at the same depth as they were in the nursery. The bags are removed with the minimum of disturbance and soil filled and packed carefully around the soil core, a few inches at a time until the hole is filled.

Planting System and Density

Outside Malaysia, coconut harvesting involves collecting the nuts after they have fallen and this method is usually considered satisfactory. In Malaysia, however, germination of unshed nuts has been noticed on some palms and this, together with the great danger of theft of fallen nuts, has led to the normal practice for harvesting, by cutting the nuts from the palms, using a knife attached to a long pole. This has affected the layout of cocoa plantings since it is sometimes preferred to plant cocoa in alternate coconut rows only, thus leaving one row with freedom of access for the harvester and his cumbersome pole. At present, however, there is no great shortage of coconut land for cocoa planting, which does not encourage planting every coconut row. It is possible to plant every row, if a small premium is paid for coconut harvesting under the more difficult conditions. This premium is covered many times by the additional income from cocoa.

Coconuts are normally planted in avenues 26 ft or 30 ft apart; cocoa is planted in two rows 10 ft apart and equidistant from the palms. Within the rows the cocoa is spaced either 6¾ ft or 6⅓ ft, giving a stand per acre of 447 and 458 respectively. Triple rows have also been tried, but planting at this density becomes too dense. Field drainage sometimes presents a problem and a distance of 5 ft from the drain edge is maintained to avoid trees falling over. The high planting density allows selective thinning based on vigour and yield. Initial thinning is carried out at the end of the second year in the field, reducing the stand to a density of 400-420 trees per acre. There is no subsequent thinning until yields of 800 lb per acre are being obtained, at which time consistently low-yielding trees are removed. Removal at this stage should not result in over-large gaps in the canopy.

Shade

A certain amount of shade for the young seedlings on transplanting from the nursery is provided by the coconut stand; this is greater where the coconuts are of the Dwarf variety, which is planted at double the density normal for Tall variety palms. However, this shade is initially insufficient and additional shade is provided by 3-ft-lengths of fallen palm fronds, which are firmly set upright in the ground about 9 in. from the cocoa seedlings. These are later removed when the plants have become well established. Where there is insufficient overhead shade, three to five seeds of rapidly-growing shade plants are sown about 2 ft from the seedlings and at right angles to the cocoa row to provide low shade for a longer period. Suitable shade for this purpose can be provided by *Sesbania aculeata* or *Cajanus cajan*. This type of shade is desirable and has an additional attraction in that it helps to raise the height at which jorquetting occurs.

Where vacant patches occur in the coconut stand due to lightning strike, a common feature on these estates, overhead shade is provided by larger trees. Wherever possible, these gaps are filled well in advance of the cocoa planting. The larger trees are planted about 4 ft from the outside of cocoa rows and intermediate between the cocoa seedlings. Useful trees for this purpose are *Gliricidia* sp., *Sesbania grandiflora* and *Leucaena leucocephala*, with Gliricidia being very useful in that it is readily propagated by cuttings. Since *Sesbania grandiflora* is a smaller tree, it is planted at twice the density of the others.

Cocoa under Coconuts in Lower Perak, West Malaysia.

Table 1. SITIAWAN, PERAK, WEST MALAYSIA. (4° 13′ N. 100° 42′ E.)

	RAINFALL (40 yrs.) (a)	SUNSHINE (hrs. per day) (b)
January ...	7·9	6·7
February ...	5·5	7·4
March ...	6·1	7·2
April... ...	6·4	7·2
May	4·8	6·7
June... ...	3·3	7·1
July	3·4	7·0
August ...	3·9	6·7
September ...	6·1	5·8
October ...	8·8	5·7
November ...	10·3	5·6
December ...	8·7	6·0
Total for year	75·2 inches	2,392 hours

Sources of data:

(a) Rainfall Probability Tables for Malaysia.
Wycherley P.R., 1967. R.R.I.M. Planting Manual No. 20.

(b) Dale, W. L. (1964) "Sunshine in Malaya".
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Notes on Contributors

G. R. Ames, B.Sc., Ph.D., F.R.I.C.

Joined the Tropical Products Institute in 1957 and worked on problems related to vegetable oils, sugar and essential oils and spices. In 1968 he became Technical Assistant to the Director, and in 1970 the Institute's Scientific Secretary.

Anthony Youdeowei, B.Sc., Ph.D. (Lond.), F.R.E.S.

Born at Abari, Nigeria, in 1937 and educated at Government College, Ughelli, and University of Ibadan, graduating with honours in Zoology, specialising in Entomology. Studied at Rothamsted Experimental Station for Ph.D., completing a thesis on "Aggregation in *Dysdercus intermedius*". Returned to the Cocoa Research Institute of Nigeria where he continued his work on the biology, behaviour and control of cocoa capsids in close collaboration with the International Capsid Research Team in Ghana and Nigeria. In 1970 he was appointed lecturer in applied entomology at the University of Ibadan and is continuing his research into cocoa capsids.

Cocoa Abstracts

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

June 1970

Scheiber, E. Enfermedad del cacao "Mal de Machete" provocada por Ceratocystis fimbriata en la República Dominicana. (Cocoa canker caused by *Ceratocystis fimbriata* in the Dominican Rep.). Turrialba, Rev. Interam. Ciencias Agr. 19, 3, pp. 340-4 (1969).
Canker in cocoa caused by the fungus *Ceratocystis fimbriata* was first observed in the Dominican Rep. in 1966. The symptoms, occurrence, distribution and control of the disease are discussed. Infection mainly occurs in adult trees by pruning. Intensity of attack depends on the type of cocoa. Diseased coffee trees in mixed *arabica* coffee-cocoa stands easily transmit the disease to cocoa. *Xyleborus* attack seems not to be involved in the infection. Suggestions presented for control of the disease include among others: eradication of entirely diseased trees in zones of severe attack, removal of partially diseased branches in zones of moderate attack and reduction of pruning. English summary. Photos. Map. 12 refs.

July 1970

Biagni, M. Cocoa: a commodity on the rise. Ceres; FAO Rev. 2, 5, pp. 18-9 (1969).
After the supply and price crisis of 1964/65 when cocoa prices fell to US $0·22/kg, prices have increased to $1/kg in Dec. 1968. The author expresses the opinion that prices will be remunerative for many years. In 1968, world consumption rose by 2%, and in Asia and Africa consumption increased even by 33%. However, world production increased only by 1%, while world exports decreased by 3%, causing a substantial decline of cocoa stocks. Despite the demand, African producers are very cautious and rather reluctant to extend their production, due to unhappy experiences in former years with large crops. Tables.

Rohan, T. A. The flavour of chocolate, its precursors and a study of their reaction. Gordian 10, p. 500-1; 11, p. 542-4 (1969).
The 2nd and 3rd parts of a study on the chemical nature of chocolate flavour deal with: (1) the identification of the three principal component groups of flavour precursors, viz. the carbohydrate, flavenoid, and the amino acid fractions; (2) the changes occurring during fermentation, drying, and roasting with respect to the potential flavour precursors; (3) the significance of free amino acids present in cocoa beans during the development of chocolate flavour; and (4) the degradation of amino acids in cocoa beans and in model systems including the effect of heat and moisture. Tables. To be continued.

Shaw, D. E., and Velsen, R. J. van. Lightning strike of cacao and Leucaena in New Britain. Papua and New Guinea Agr. J. 20, 3-4, pp. 75-82 (1968).
A description is given of a condition, attributed to damage by lightning strike, involving 31 cocoa and about 200 interplanted *Leucaena leucocephala* trees at

two sites on a plantation in New Britain. Symptoms consisted of sudden partial or full defoliation and death of bark, followed by discoloration of wood inwards and downwards, resulting in death of branches and some trees. Recovery occurred in all but six cocoa and several *Leucaena* trees left after sampling of partially damaged specimens. Author's summary. Fig. Photos. Four refs. See also ibid. pp. 83-4: Hicks, P. G. Lightning strike of cocoa in New Britain. Fig.

August 1970

Muller, C. Le marché du cacao dans les pays de la Communauté Européenne. (The cocoa market in the countries of the E.E.C.). Ann. Géogr. 78, 430, pp. 680-95 (1969).
The cocoa imports, consumption, marketing, industry, trade circuits within the E.E.C. countries, and the significance of the Common Market regulations are discussed. Imports from African producing countries are steadily increasing; E.E.C.-associated producing countries benefit from the preferential tariffs and from the recent creation of a forward market in Paris. Specialisation in the processing industries leads to large-scale trading in non-finished products within the Community. English summary. Tables. Graph. Figs. Maps.

Are, L., and Afonja, B. Correlation studies on some chupon-main stem characters of virus infected mature cocoa trees. Nigerian Agr. J. 3, 2, pp. 56-60 (1966; received 1969).
In Nigeria, field trials with swollen shoot infected, mature amelonado cocoa showed that mean yields almost doubled to a maximum of 28 pods/tree after the number of chupons increased from zero to four. Better canopy condition was significantly correlated with higher crop yield and with more chupons. Utilisation of canopy score as an additional calibrating variate in covariance analysis is suggested. Assessment of results of rehabilitation work may be aided by including the number of chupons as a calibration variate. Tables. 11 refs.

Opeke, L. K., and Toxopeus, H. Preliminary studies on the yield and establishment of WACRI series I and II cacao varieties in Western Nigeria. Nigerian Agr. J. 4, 1, pp. 22-7 (1967; received 1969).
Performance studies of 30 progenies of cocoa (*Theobroma cacao*) showed that the progeny S II:H may yield up to 1,160 kg dry beans per ha at an age of nine years. Production was some 25-250% higher than that of the common, commercially planted variety F_3 Amazon. Progenies S II:F and S II:K were superior to the F_3 Amazon in respect of establishment, while yields were also better. For areas with severe dry seasons S II:K is suggested for planting; under well-distributed rainfall S II:H is recommended. Tables, Fig. Seven refs.

García Reyes, F. Estudio preliminar sobre el comportamiento de hibridos de cacao para la zona cafetera Colombiana. (Preliminary study on the performance of cocoa hybrids in the coffee region in Colombia). Cenicafé 19, 4, pp. 127-34 (1968).
A field trial was conducted in a zone marginal for coffee in Colombia to study yield characteristics of three different cocoa hybrid seedling populations, and

two local Amelonado selections. The preliminary results indicated, among others, that the progenies of P-7×UF-2 and P-7×ICS-39 generally produced better and earlier than the progenies of SCA-6×ICS-1 and the local selections. It was calculated that the P-7×UF-2 and P-7×ICS-39 progenies planted at a density of 1,100 trees/ha may produce 538 and 600 kg/ha/year, respectively, against 325-388 kg and 250 kg/ha/year produced by the progenies of SCA-6× ICS-1 and the local selections, respectively. Tables. Three refs.

Toxopeus, H., and Okoloko, G. E. Cacao marcotting in Nigeria. I: Use, technique and monthly rooting success. Nigerian Agr. J. 4, 2, pp. 45-50 (1967: received 1969).
Trials over two years with cocoa showed that marcots could be successfully obtained from 30-year-old non-vigorous amelonado trees. A routine technique is described in detail. Percentage establishment was 61% under the experimental conditions, but it may be as low as 29% under adverse environmental conditions. Tables. Photos. Nine refs.

Die-back and death of cocoa trees caused by a new species of parasitic tree. Nature 219, 5161, pp. 1386-7 (1968).
A new "die-back" disease of cocoa has been identified in Bahia, Brazil. Field observations indicated that the symptoms usually occurred in cocoa trees growing near to a local tree called "mata cacau" (cocoa killer) identified as *Acanthosyris paulo-alvimii* (*Santalaceae*); most of the species of this family are partial or total parasites feeding on the roots of their hosts by means of haustoria. This was confirmed in a pot experiment; parasitic outgrowth from the cocoa killer tree penetrating the cocoa roots could be identified under the microscope. Uprooting and burning of the parasitizing tree are the only means of control. Table. Photos. Two refs.

Couraud, A. La culture du cacaoyer au Sambirano. Manuel du planteur. (The cultivation of cocoa in Sambirano. Planter's guide.) Bull. Madagascar 19, 280-281, pp. 786-810 (1969).
General aspects of cocoa cultivation and practical recommendations for the establishment and maintenance of cocoa plantings are presented. Discussed are, among others, tree, fruit and bean characteristics, ecology, propagation methods, provision of shade, processing of the beans, and pests and diseases. Tables. Photos. Map.

September 1970

Jacob, V. J. Studies on the germination of Amelonado and F_3 Amazon seeds. Ann. Rep. Cocoa Res. Inst. Nigeria 1967-68, p.63 (1969).
In studies conducted in Nigeria, 50 peeled and 50 unpeeled beans of both Amelonado and F_3 Amazon cocoa were sown weekly in topsoil and in sawdust. Percentages of germination and number of days required for maximum germination were recorded. Peeled beans scored higher percentages of germination than the unpeeled ones. Sowing in sawdust gave a higher percentage of germination than sowing in topsoil; this pattern, however, was reversed during the dry season. Table.

Wessel, M. Effect of soil cover and soil moisture content. Ann. Rep. Cocoa Res. Inst. Nigeria 1967-68, pp. 38-8 (1969).
Farmers in Nigeria believe that when weeds are regularly cutlassed in newly plated cocoa areas, soils dry out more quickly and severely during the dry season. An experiment, however, showed that: (1) soil moisture content during the dry season was highest under mulch and lowest under grass and weed re-growth; (2) the moisture content of the bare soil plots (monthly cutlassed) was significantly higher than that of the re-growth plots except for the top 15 cm; and (3) the mulch treatment increased the amount of water held at field capacity. Table.

Toxopeus, H. Commercial assessment of WACRI Series I and II varieties. Ann. Rep. Cocoa Res. Inst. Nigeria 1967-68, pp. 40-2 (1969).
The mean cured bean weight, shell percentage and butterfat content of cured cocoa beans from open-pollinated pods of 8 W.A.C.R.I. (Nigeria) series II var., 19 series I var., and of F_3 Amazon progenies, as well as the results of flavour tests on samples of the 8 series II var. are summarised. Var. SIIK [Amelonado × (Parinari 35 × Nanay 32)] appears to be a most promising commercial variety; its establishment ability and production potential are excellent, the beans are heavy and have a low shell percentage and a high butterfat content. Tables.

Toxopeus, H. Management of polyclonal seed orchards. Ann. Rep. Cocoa Res. Inst. Nigeria 1967-68, pp. 51-2 (1969).
Recommendations are presented for the management of polyclonal cocoa seed orchards. Seed orchards should be decentralised, and two to four ha in size. For bi- or poly-clonal seed orchards; parent clones are to be planted in alternate rows; all seeds are to be produced by hand-pollination; and all open-pollinated fruits are to be removed throughout the year. Consequently, seed orchards need not be completely isolated from other cocoa. Seed pods of all varieties harvested at a time should be issued to farmers as a mixture only. The size of a seed orchard should be based on the area to be planted annually.

Couprie, F. Traitement du cacao après fermentation. Essais de séchage et de stockage en Ouganda. (Treatment of cocoa after fermentation. Trials on drying and storage in Uganda). Café Cacao Thé 14, 1, pp. 39-46 (1970).
This second and last of a series of articles on cocoa processing in Uganda deals with the effects of four different drying treatments on beans fermented during five, six, seven, eight or nine days, and the effects of storage on acidity and other bean quality characteristics. Drying in the sun (treatment 1) and soaking for eight hrs. followed by artificial drying (treatment 2) gave similar results, which were superior to results obtained by drying in the sun for two days followed by artificial drying (treatment 3) and direct artificial drying (treatment 4). Soaking resulted in loss of weight of approx. 5%, but this practice is necessary to obtain excellent cocoa after six months of storage; the aroma is developed during the first three months, and the acidity during the following three months. German, English and Spanish summaries. Tables. Five refs.

Wessel, M. Potting for cacao seedlings. Ann. Rep. Cocoa Inst. Nigeria 1967-68, pp. 38-9 (1969).
Experiments conducted in Nigeria showed that washed sand enriched with superphosphate, crushed hoof and horn flakes, and bone meal, is a suitable potting medium for many tree species and a promising substitute for "forest topsoil". Tables.

Bénac, R., and Dejardin J. Essais d'engrais sur cacaoyers au Cameroun (region de Yaoundé). (Fertilizer trials with cocoa in Cameroon, Yaoundé region). Café Cacao Thé 14, 1, pp. 13-27 (1970).
In Cameroon, fertilizer trials conducted in cocoa plantings of smallholders started in 1958. After it became apparent that the total production of the different plots did not differ, trees were classified on the basis of productivity, and the data were analysed following the method of multiple regression by stages. It appeared that if the production level of the trees is poor, N, P and Ca + Mg should be applied together without K. If the production level is high, P and K should be used together. The initial state of the trees, explains 25 to 28% of the variability out of 27 to 29% explained on the whole. Further studies are needed on the main causes of yield variability. English, German and Spanish summaries. Tables. Graph. 17 refs.

Tarjot, M. Etude de la résistance des cacaoyers à la pourriture des cabosses due au Phytophthora palmivora (Butl.) Butl. en Côte d'Ivoire. Troisième partie. Inoculations expérimentales sur le terrain. (A study of the resistance of cocoa trees to pod rot caused by *Phytophthora palmivora* in the Ivory Coast. Third part. Experimental inoculations in the field). Café Cacao Thé 13, 4, pp. 297-309 (1969).
Using a special inoculation technique, which is described, Upper Amazon, Trinitario, Amelonado, and hybrid cocoa trees were tested in the field in the Ivory Coast for their resistance to black pod disease. The trials indicated, among others, that some varieties, including Amelonado, showed a cyclic susceptibility. Many of the Upper Amazon type had a high susceptibility to pod rot irrespective of the time of the year, while others showed periods of maximum susceptibility and hence a relative low susceptibility index. English, German and Spanish summaries. Tables. Graphs. Fig. Eight refs.

Okaisabor, E. K. Epidemiology of Phytophthora pod rot. The persistence of Phytophthora palmivora (Butl.) Butl. in diseased flower cushions. The survival of P. palmivora in diseased pods, leaves and chupons. Laboratory assessment of the longevity of P. palmivora in the soil. Ann. Rep. Cocoa Res. Inst. Nigeria 1967-68, pp. 81-4 (1969).
Results are presented of investigations in Nigeria on the degree of viability and longevity of spores of *Phytophthora palmivora* (pod rot) in diseased flower cushions, pods, leaves and chupons of cocoa and in the soil. Tables.

Okaisabor, E. K. A hyper-parasite of P. palmivora. Ann. Rep. Cocoa Res. Inst. Nigeria 1967-68, p. 84 (1969).
A fungus isolated from black pod rot disease lesions on cocoa pods was found to be actively parasitic on *Phytophthora palmivora.* The fungus tentatively identified as *Botryodiplodia theobromae* attacks spores of *P. palmivora* by the formation of parasitic coils (Nigeria).

Abreu J. M. de Ensaio de acaricidas no contrôle ao ácaro Tetranychus mexicanus (McGregor, 1950) Pritchard e Baker, 1955, nocivo ao cacaueiro na Bahia. (A trial with acaricides for the control of *Tetranychus mexicanus*, a pest of cocoa in Bahia). Comun. Técn., CEPLAC 31, pp. 1-6 (1969).
Cocoa seedlings kept under nursery conditions in the State of Bahia, Brazil, have been attacked by mites, mainly by the species *Tetranychus mexicanus*. A trial was conducted to test the effectiveness of the following acaricides: phosphamidon 0·05%, chlorophenamidine 0·05%, Phosalone 0·10%, vamidothion 0·10%, malathion 0·10%, metasystox 0·10%, gusathion 0·20%, and ethion 0·10%. The results showed that all the acaricides gave good control up to the last evaluation, 21 days after spraying. Table. Five refs.

Piart, J. Etude de quelques caractéristiques biologique du miride du cacaoyer Distantiella theobromae Dist. au moyen d'un élevage au laboratoire. (Study of some biological characteristics of the mirid of the cacao tree, *Distantiella Theobromae*, by rearing in the laboratory). Café Cacao Thé 14, 1, pp. 28-38 (1970).
After studies on rearing of the cacao mirid (*Distantiella theobromae*) in the Ivory Coast showed that kapok (*Ceiba pentandra*) is preferred to cocoa plants as food plant, a method of rearing by using branches of kapok was developed. This method is described in detail and the results obtained are presented. It appeared that rearing can be satisfactorily maintained during five generations after which the yield gradually decreases. German, English and Spanish summaries. Tables. Photos. Seven refs.

Gerard, B. M. Cacao mirid control trials. Small scale trials. Ann. Rep. Cocoa Res. Inst. Nigeria 1967-68, pp. 19-20 (1969).
In Nigeria, small-scale field testing of the short-term effects of insecticide treatments on mirid (*Sahlbergella singularis*) populations in cocoa trees showed that of the newer organophosphorous compounds, 0·5% Dursban, Cyanox, fenthion and amidithion sprayed at a rate of approx. 5 l/40 trees were most promising. The method of testing applied is described. Tables.

Gerard, B. M. Cacao mirid control trials. Ultra-low volume trials. Ann. Rep. Cocoa Res. Inst. Nigeria 1967-68, p. 21 (1969).
In Nigeria, ultra-low volume spraying tests were conducted with malathion LV 96% concentrate against mirids (*Sahlbergella singularis*) in cocoa using a knapsack mistblower. Malathion, applied in 6 sec. at 1·9 ml/tree killed approx. 84% of the mirids. Surviving mirids were in parts of the tree not covered by the spray. With smaller restrictors spraying could be done more thoroughly, giving a higher percentage of kill. Malathion concentrate is recognised as a very safe insecticide, and low volume sprays can be cheap and effective. However, mistblowers are too expensive for small cocoa planters. They are useful on large plantations, and most effective with fumigant insecticides.

Ventocilla, J. A. Efeito do BHC sôbre as mosquinhas ceratopogonideas polinizadoras do cacaueiro. (Effect of BHC on the ceratopogonid midges which are pollinators of cocoa). Rev. Ceres 16, 89, pp. 205-13 (1969).
In Minas Gerais, Brazil, BHC caused slight decrease of midge population. English summary. Graph. 15 refs.

Report to the government of Tanzania on cocoa production; based on the work of J. O. Torto. U.N. Development Progr., FAO, TA 2496, pp. I-III, 1-25 (1968; received 1970).
This report describes progress of smallholders cocoa production in Mbeya, Tanga and Morogoro regions, and production by two cocoa estates in Tanzania. The effects of rainfall on the production, the prospects for an expansion of the production, and recommendations aiming at further development are discussed. The appendix contains reports on demonstration plots and special trials, processing, and on different related matters such as producer's price, co-operative fermentaries, and quality of commercial cocoa. Appendix. Tables. Map. One ref.

October 1970

Alvim, P. de T. Cacau na Amazônia. (Cocoa in the Amazon region). Cacau Atualidades 6, 4, pp. 54-61 (1969).
The Brazilian Amazon region produces around 3,000 to 4,000 tons of cocoa per year, or 1·5 to 2% of the national production. There are no plantations and the product is collected from spontaneous growing trees, mostly found on the higher river banks. Problems of the climate, the soils and the cultivation techniques are discussed. A great part of the region has a climate with a period of water deficit, contrary to the climate of the State of Bahia, where rains are better distributed. The main disease that has been prohibitive for commercial cocoa growing was witches broom, but nowadays resistant varieties are available. The greater part of the non-inundated soils is acid and poor. The use of lime and fertilizers will be uneconomic, for the time being, as transport will make them too expensive. Fig. Photos. Map.

Alencar, M. H. Estrutura fundiária da região de maior concentração cacaueria da América Latina. (Landownership structure of the largest cocoa growing region in Latin America). Cacau Atualidades 6, 4, pp. 77-80 (1969).
From an analysis of the data available on the cocoa region of the southern part of the State of Bahia and the northern part of the State of Espirito Santo in Brazil, it can be concluded that the greatest part of the cocoa production comes from a small number of municipalities. Within these municipalities the main production comes from the middle-size farms. Any attempt to increase the cocoa production should be through technical assistance to this group to obtain the greatest result within the shortest time. A division of the number of farms according to size and cocoa production is presented. Locally, farms are classified according to the total volume of cocoa produced and not according to their size. Tables.

Vello, F. Renovação de lavouras sob cacauais velhos. (Replanting cocoa under old trees). Cacau Atualidades 6, 4, pp. 62-4 (1969).
Replanting with young cocoa plants under the old trees has been successful in Brazil. Shade trees should be eradicated before the young cocoa plants are planted and the old trees should be pruned. Weed and pest control should be intensified and the young trees should be well fertilized. Higher light intensity and the effect of the fertilizers may increase the yield of the old trees considerably.

Tables. See also ibid. pp. 64-7; Batista, A. L. Algumas considerações sôbre métodos de renovação de lavouras de cacau. (Some considerations on methods of renovation of cocoa plantations). Tables.

Ruiz, Z., M., et al. Método colorimétrico para evaluar la resistencia del cacao (Theobroma cacao L.) a Ceratocystis fimbriata (E. & H.) Elliot. (Colorimetric method of evaluating the resistance of cocoa to *Ceratocystis fimbriata*). Turrialba, Rev. Interam. Ciencias Agr. 19, 4, pp. 518-21 (1969).
A new technique developed in Costa Rica to determine the susceptibility of a cocoa clone to the fungus *Ceratocystis fimbriata* is described. With this method the degree of chlorosis induced in the leaves of artificially inoculated small branches is measured colorimetrically. The method which was tested nine times during a period of six months, proved to be as efficient as, but giving more reproducible results than the method developed by Delgado and Echandi. English summary. Tables. Five refs.

Sáenz E. Jiménez. Relação entre o ataque de nematóides e a morte súbita do cacauero na Bahia. (The relation between nematode attack and the sudden death of cocoa in Bahia). Cacau Atualidades 6, 1, pp. 2-7 (1969).
Two different pathologic conditions may lead to the sudden death of cocoa plants in Bahia, Brazil. One is the disease caused by the fungus *Ceratocystis fimbriata*, the other by a disease of unknown etiology. Investigations have revealed that the root system of these latter diseased plants were affected by a parasite that can be controlled by a nematicide, Nemagon. Other host plants of the disease are the tomato and the "cajazeiro", *Spondium* sp., the shade tree generally used in cocoa farms in Bahia. Tables. Photos.

Schmidt, C. T. The biological problems of cacao in S. Tomé e Principe. Garcia de Orta 15, 4, pp. 495-500 (1967; received 1970).
The occurrence and biology of insects of cocoa, and damage of insects and rats to cocoa in São Tomé and Principe (Portuguese terr.) in 1965 are recorded briefly. The following insect pests were noted: *Selenothrips rubrocinctus*, *Anomis leona* (*Agrotidae*), *Eulophonotus myrmeleon* (*Negalopygiadae*), *Earias biplaga*, *Characoma stictigrapta*, *Mesohomotoma tessmani* and *Asterolecanium pustulans*. It is recommended: (1) to plant superior cocoa types protected initially with insecticides; and (2) to start a programme of biological control. Portuguese and French summaries. Two refs.

Silva, P., and Abreu, J. M. de. A broca da bananeira na região cacaueira da Bahia. (The banana borer in the cocoa region of Bahia). Cacau Atualidades 6, 2, pp. 22-5 (1969).
The preliminary results are presented of a study of the geographical distribution and levels of infestation of the banana stem borer in the cocoa region of the State of Bahia, Brazil. In the region many old plantations are being replanted and banana is used as a shade tree. A severe borer infestation does not only affect the bananas, but also the cocoa trees as they may lose their temporary shade just at an age when they need it most. To prevent a borer infestation it is recommended to plant non-infested plant material, to dip the plant material in an emulsion of aldrin WP in water at 0·15%, and to treat the plant holes with insecticides to prevent future attack. Infested stools should be treated with the

same aldrin emulsion and this should be repeated every six months; heavily infested stools should be eradicated. Graph. Map.

November 1970

Drover, D. P. A preliminary survey of cocoa nutrition in relation to dieback disease in Papua-New Guinea. Exp. Agr. 6, 1, pp. 33-40 (1970).
In the absence of any definite evidence on a pathological cause of the dieback disease, a preliminary survey was made on the nutrient status of cocoa leaves from five localities in the Territory of Papua and New Guinea. The K and Mn contents of the leaves were generally very high, while Mg, Cu and Fe contents were often low. Though there was no apparent relationship between the nutritional status of the tree and the incidence of the disease, nutrient imbalances such as found could render the tree more liable to the disease attack. Mechanical as well as some chemical analyses of some surface cocoa soils are presented. Tables. 22 refs.

Toxopeus, H., and Wessel, M. Studies of pod and bean values of Theobroma cacao L. in Nigeria. I. Environmental effects on West African Amelonado with particular attention to annual rainfall distribution. Neth. J. Agr. Sci. 18, 2, pp. 132-39 (1970).
All pod and bean values except pod length/width ratio and weight of oven-dried shell and seed-coat per bean were affected by season. Pods developed in a period of considerable water stress showed much lower values than pods developed during periods of adequate water supply. Under conditions of water stress the positive correlations between most pod characters disappeared. The mean weight, however, of oven-dry beans was independent of any other pod value, irrespective of water supply to the trees. The mean weight of cured beans was highly correlated to the total rainfall of the first four months of pod development. Tables. Graphs. 12 refs. To be continued.

García R., F. Efecto de la poda en los arboles de cacao. (Effect of pruning on cocoa trees). Rev. Cafetera Colombia 18, 145, pp. 27-33 (1969).
A small-scale experiment was conducted in a monoclonal cocoa planting established with rooted cuttings, at 1,370 m altitude in Colombia, to study the effect of pruning on pod and dry bean yields. Pruning immediately reduced dry bean yields over two separated 12-month periods with 975 and 645 kg dry beans/ha respectively. Growers are advised to avoid severe pruning; however, young chupons should be eliminated monthly at each harvesting round. Tables. Graphs. Photo. Three refs.

Wessel, M. Intake and export of nutrients in cacao leaves. Trop. Agr., Trinidad 47, 2, pp. 167-70 (1970).
Pot trials with cocoa, conducted in Nigeria, showed that the development of a new flush of leaves removes 39% of the P and 25% of the K from the matured leaves of the preceding flush. Intake of N and Mg by these leaves was reduced by 22 and 50% respectively. K translocation caused a 70% increase of Ca intake of preceding flush leaves. Complete removal of all mature leaves severely retarded growth and development of the immature flush, whereas removal of all but the youngest mature flush did not significantly influence its nutrient concentrations. Tables. Fig. Three refs.

Clerk, G. C. The spread and control of black-pod disease of cocoa. Cocoa Marketing Board Newsletter 44, pp. 25-7 (1970).
In this article on black-pod disease (*Phytophthora palmivora*) of cocoa the following items are reviewed: crop damage; symptoms; ecology, fungus growth and spore formation; hibernation and dissemination of the infection within the tree and from tree to tree; attack of other parts of the tree; and control. At present black-pod is controlled by spraying with fungicides, by agronomic practices, and by crop sanitation. In the future the disease possibly will be controlled by the use of systemic fungicides and/or resistant varieties. Photos.

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