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Editorial

This issue contains a major article on witches' broom disease caused by the fungus *Crinipellis perniciosa*, previously known as *Marasmius perniciosus*. This pathogen causes enormous devastation to cocoa plantings in areas where the disease occurs. The fungus, its life cycle and its dispersal and infection mechanisms are all imperfectly understood and it is therefore hardly surprising that control methods are poorly developed even though the pathogen was first identified in 1910.

The disease is currently confined to South America and the West Indies occurring in Bolivia, Colombia, Dominica, Ecuador, French Guiana, Grenada, Guyana, Peru, Surinam, Trinidad, Venezuela and the Amazon Basin of Brazil. It does not occur in the traditional cocoa growing areas of Brazil — in the States of Bahia and Espirito Santo. The risks of the disease spreading are substantial even with stringent quarantine regulations. All cocoa growers should become familiar with the symptoms in order that the disease could be easily recognised if it did by misfortune spread outside its current area of distribution.

We are in the final stages of correcting our mailing list for the Cocoa Growers' Bulletin as indicated in the last issue. Would anyone who has not returned the pink card included in the last issue and who wishes to continue to receive the bulletin, please do so at once. Failure to do this will mean that their name will be deleted from the mailing list with immediate effect.

R.A. Lass, Editor.

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Review of Production and Consumption

REVIEW OF PRODUCTION AND CONSUMPTION

January 1982

A.B. Cook, Cadbury Schweppes Limited

Production

Gill and Duffus's initial forecast of 1981/82 production included in their Cocoa Market Report issued in November 1981 is a record 1,727,000 tonnes, well in excess of the 1,654,000 tonnes finally produced in 1980/81.

Once again the principal source of the increase is expected to be the Ivory Coast where the dramatic rate of increase seen during the last 5 years is forecast to continue. Brazil, although expected to be slightly down on the 1980/81 record outturn of 354,000 tonnes, also continues to show a long term rising trend. Malaysian production is expected to continue to show rapid expansion.

In Ghana and Nigeria the downward trend seems to have been arrested and production is forecast to show some improvement over 1980/81. However, in Ghana there may well be a substantial difference between production and exports due to the worsening evacuation problems. At the end of December 1981 it was believed that less than three-quarters of the 1980/81 production, and virtually nothing from the 1981/82 crop, had reached the ports.

Consumption

Gill and Duffus forecast that 1982 world consumption will be a record 1,625,000 tonnes. The long term trend of increasing world consumption seems to have re-established itself following the difficult years, with high prices, of the mid 1970's.

Stocks

The Gill and Duffus estimate of world stocks at the end of the 1981/82 season is 688,000 tonnes, the highest level since 1965. However in terms of supply and demand it needs to be remembered that a significant proportion of the stock could be held by the Cocoa Agreement Buffer Stock. There could also be sizeable tonnage still up-country in Ghana.

Prices

Month end prices for nearby shipment Ghana cocoa have been:—

1981	January	£955/tonne
	February	£1017/tonne
	March	£1040/tonne
	April	£1064/tonne
	May	£965/tonne
	June	£911/tonne
	July	£1196/tonne
	August	£1268/tonne
	September	£1345/tonne
	October	£1216/tonne
	November	£1158/tonne
	December	£1190/tonne

WORLD COCOA PRODUCTION AND GRINDING DATA
Reproduced from Gill and Duffus Market Report
Dated November 1981
(Thousand Metric Tons)

Production

	1979/80	1980/81 (Estimate)	1982/82 (Forecast)
Africa	1011	1004	1094
America	491	529	499
West Indies	35	41	39
Asia and Oceania	79	80	95
WORLD TOTAL	1616	1654	1727
Principal Countries			
Ghana	280	258	300
Nigeria	169	155	170
Ivory Coast	379	412	450
Cameroon	124	118	110
Equatorial Guinea	6	8	10
Brazil	294	354	320
Ecuador	98	82	80
Dominican Republic	27	32	30
Venezuela	17	14	15
Colombia	30	35	35
Mexico	34	30	32
New Guinea	31	28	30
Malaysia	32	35	45

Grindings

	1980	1981 (Estimate)	1982 (Forecast)
Western Europe	548	595	607
Eastern Europe and U.S.S.R.	211	210	214
North America	154	209	224
Central and South America	359	343	337
Australia and New Zealand	15	15	15
Asia	67	74	80
Africa	139	132	148
WORLD TOTAL	1493	1578	1625
Principal Countries			
United States	142	195	210
Germany (Federal Republic)	158	167	170
Netherlands	133	140	145
United Kingdom	65	85	85
U.S.S.R.	130	125	130
France	48	50	52

In spite of the continuing prospect of world production exceeding consumption, the market rose rapidly during the 3rd quarter of 1981 in anticipation of the Cocoa Agreement buffer stock coming into operation and prices were only just below the nominal support levels of 110 c per lb when it started to buy on September 28th 1981. In the event, the market was somewhat disillusioned when it became apparent that the buffer stock's available funds would be rapidly exhausted and prices eased back, although remaining well above their mid-year levels.

International Cocoa Agreement

The buffer stock started buying on September 28th and in its first two weeks of operation purchased 61,325 tonnes of cocoa and in so doing committed $ 146.5 million out of its available funds of $ 230 million. There was concern that all the available funds would be used up too quickly and the buffer stock withdrew from the market at that point. Since then it has been in the market only sporadically and there has been a deliberate policy of buying direct from origin rather than openly bidding in the market place. Purchases to January 11th 1982 total 73,245 tonnes at a cost of $ 170.5 million.

There have been several attempts to increase the buffer stock's buying capabilities by borrowing additional funds. A current offer of a loan of $ 75 – $ 120 million is due to be considered at a Council meeting on 25th January 1982.

Witches' Broom Disease — A Case Study

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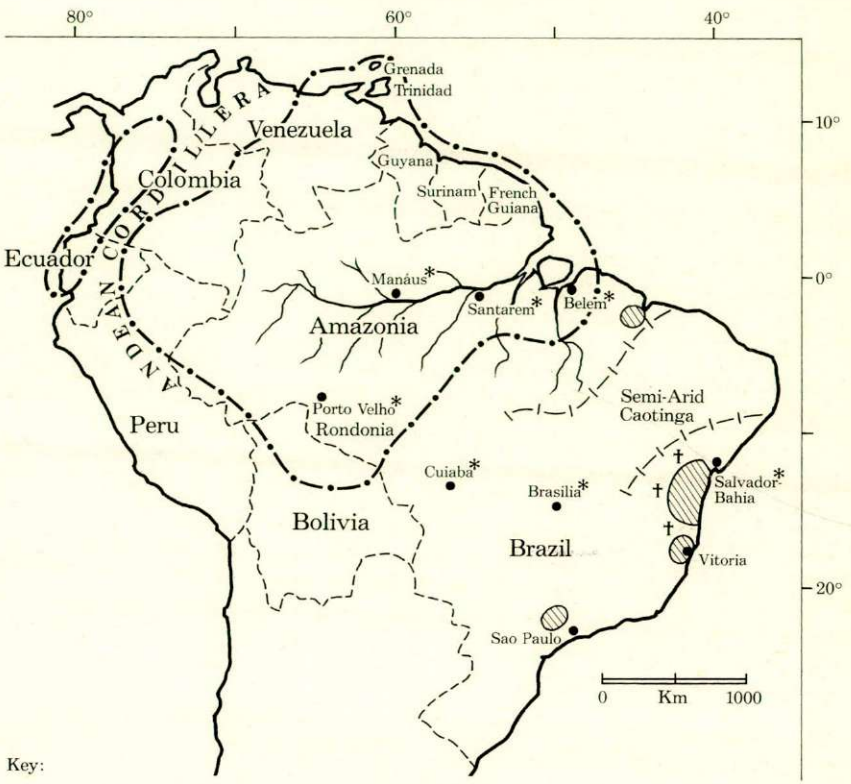
This evocatively named disease is perhaps that most feared by cocoa growers, especially in those areas outside its present range, and either directly or indirectly it has been implicated in the decline or abandonment of cocoa cultivation in several South American countries.

As an example of its destructive capability, I recall an encounter with a Scottish plantation manager from Malaysia who was called in to assess, and as it turned out to wind-up, the affairs of a big cocoa plantation in Ecuador. Incredulity and disbelief at the extent of the witches' broom problem – a disease with which he was unfamiliar – were obvious as he frantically collected pictorial evidence for his report. How did this plantation with all the benefits of experienced management, the financial backing of a large company and an inexpensive labour force reach such a desperate position? Why did the selected clones and hybrids and the subsequent control measures fail? I will attempt to answer these questions with the wisdom of hindsight and from the results of recent research. Hopefully, this plantation can be used as a model from which lessons can be learned both to avoid costly mistakes in the future and to improve existing control methods in established plantations. As with any disease, unless the basic etiological and epidemiological facts are known, measures to control it will be largely empirical.

The Causal Agent

Both the common and scientific epithets are well-coined and forewarn the unwary of the disease potential of the causal agent, *Crinipellis perniciosa*, a member of the Agaricaceae or mushroom family. The pink or red mushrooms (basidiocarps) appear on the infected tissues long after their death and this prolonged incubation period from symptom appearance to sporulation hindered initial investigations of the causal organism and led to erroneous conclusions as to its identity. The true pathogen was discovered and named *Marasmius perniciosus* by Stahel (11) who in the period 1915-20 laid the groundwork for research on the disease and proposed control measures which have yet to be improved upon (11, 12). The pathogen was later transferred by Singer (9) to the genus *Crinipellis*. Recently, three separate varieties have been recognised (8) and at least two pathotypes have been identified (4), so there seems to be considerable variation in both morphology and pathogenicity. The fungus is endemic to the Amazon basin and occurs on cocoa and related species of *Theobroma* and *Herrania* in the understorey of primary rain forest. It has spread from this centre of origin; but is still confined to northern South America and to some of the nearby Caribbean islands (1) (Figure 1). Until recently in Colombia, *C. perniciosa* had been confined to the lowland Pacific region but is now advancing into the more important, upland cocoa-growing areas (2).

Figure 1: Map of Northern South America
to show known distribution of C. perniciosa



Key:

Area within which C. perniciosa has been reported; including wild hosts: Theobroma speciosum; T. subincanum; T. grandiflorum and Herrania spp.

Cocoa-growing areas from which C. perniciosa is absent;

* Quarantine measures at major airports linking Amazonia to Bahia;

† Quarantine measures on major roads into Bahia;

The Disease

There are two excellent accounts of disease symptoms (1, 13) and so the object here is to describe those symptoms not commonly associated with or recognised as witches' broom disease and to follow disease progress from initial penetration to full symptom expression.

The sexual spores (basidiospores) produced by the basidiocarps have the ability to invade any actively-growing (meristematic) cocoa tissue and to provoke a whole range of symptoms depending on the cultivar, the type of tissue involved and its stage of development. Symptom variation is one reason why the pathogen has proved so difficult to control since identification has been based on broom formation following direct bud infection. Cocoa buds are well protected, a fact which becomes obvious when attempting inoculation, and it has now been shown that any part of the unhardened flush is susceptible (3). It is essential to determine the extent of the infection court if disease symptoms and pathogen development are to be interpreted correctly. Thus, if the spores land on the flush during the early stages of extension growth, and are close to the terminal bud, the growing point may be colonised immediately and a terminal broom results. However, the target is small and it appears that the majority of infections occur during the later stages of flushing, before hardening or cuticle formation has commenced. Infected areas become swollen, although those formed during the final stages of flushing may be almost imperceptible, and can be distinguished later by the premature formation of bark. Further development of these infections depends on their position in relation to meristematic tissues and on host vigour. Therefore, to the unpracticed eye, such a flush appears healthy (i.e. broom-free) even though swellings may be present on the stem and leaf petiole or pulvinus.

Late flush infections often remain as discrete swellings and localised necrosis may be the only detectable symptom. Similarly, swellings away from areas of bud activity may not progress further than the production of canker-like symptoms; blackening of the bark and an internal brown-black, moist necrosis. Evidence for non-bud infection and accompanying canker formation can be seen more clearly in hosts other than cocoa. *Theobroma speciosum* and *Herrania* spp. have a single leading terminal bud which, if infected, develops into an extremely large broom resulting in a severe check to growth. However, brooms are rare and most infections occur away from the bud and take the form of swellings on the leaves and stem. *T. speciosum* is abundant in certain forests of the Brazilian Amazon and it is possible to estimate disease intensity by simply counting hanging, dead leaves in the canopy. When such a tree is felled, swollen, blackened cankered areas, each one a separate infection, are visible along the shoots and on the leaf petioles; the latter remain after death and do not absciss. In the extremely large-leaved *Herrania* genus, swellings are often confined to the leaf midrib or veins.

Early flush infections develop more rapidly and consequently swellings are bigger and, if close to a terminal or lateral bud, more likely to develop into brooms. Thus, when the next flush commences the fungus moves with the growing point causing it to produce cells in larger numbers (hyperplasia) and of a bigger size (hypertrophy) than normal and result in a terminal broom. Similarly, infected lateral buds which become active, possibly as a direct result of fungal invasion or more probably following damage to the

terminal bud (by insects etc.), develop into lateral brooms. In extremely fast-growing tissues such as chupons, terminal brooms are infrequent. Almost certainly the fungus penetrates laterally during elongation, but because of the rapid extension the growing point remains uncolonised and continues to produce healthy tissues, infection taking the form of lateral brooms and cankers. These infections have been termed 'grown-through' brooms (11), but lateral infections would be more correct.

The disease cycle in flower cushions is essentially similar, with infection occurring during the period of extension growth from bud initiation to flowering. Infection in the early stages may result in the formation of clusters of abnormal flowers, parthenocarpic pods (chirimoyas) and brooms, but in later stages only a small proportion of the flowers may show symptoms, typically a single swollen erect flower stalk which mummifies and persists. From this initial infection site, the fungus colonises the cushion tissues and the next flowering flush is completely abnormal, the so-called 'star-bloom' (12).

Plate 1: 'Star-bloom' on flower cushion of ICS-39, 4 months after bud inoculation. The initial infection was restricted to a single flower.

Thus, there is a lag phase of at least one vegetative or flowering flush between infection and full symptom expression during which the fungus remains within the tissues awaiting the onset of meristematic activity. Symptom development can be suppressed artificially by preventing flushing and inoculated plants kept under low water regimes have produced brooms many months after initial infection, when flushing commenced at the onset of normal watering (3). Similar dormant or systemic infections have been noted following inoculation of flower cushions.

Essentially, the same story is repeated with pod infection but because growth is determinate there is no secondary infection. Cherelles up to two to three months of age are the most susceptible plant organ. External symptoms on them may develop rapidly and gross external swellings or severe pod distortion may be seen. Pods infected after this period show little evidence of infection and those which have reached full extension growth, somewhere between three to four months, can be considered immune. The spectacular end-products of vegetative infection (i.e. brooms) have tended to overshadow the importance of pod infection but it should be emphasised that *C. perniciosa* is a major pod pathogen in its own right and the author has seen potentially high-yielding cocoa farms in Rondonia (Brazil) with over 90% pod infection. The farmer often assigns these pod losses to *Phytophthora palmivora* (black pod) or *Moniliophthora roreri* ('Monilia' pod rot). Such confusion can be disastrous. In a well managed plantation in the Brazilian state of Para, I have personally seen an expensive fungicide being applied by a sophisticated tractor-drawn mistblower for control of a 'black pod epidemic'. Since all pod infections were due to *C. perniciosa* which had been initiated some two to four months previously, the control measures were a waste of time, effort and materials.

Plate 2: Indurated broom and chirimoyas on *Theobroma subincanum* from Amazonian forest, Acre (Brazil). Note the light coloured basidiocarp on the central pod.

The fungus, in addition to directly penetrating unhardened tissues, has the ability to invade the cambial tissues of woody stems exposed during wounding with the subsequent formation of abnormal callus or gall-like growths and finally brooms, if buds are in close proximity (3).

In all these infected tissues, the final symptom is, of course, death or necrosis of the tissue which begins shortly after active growth has ceased. The fleshy swollen tissues become blackened and quickly lose moisture, eventually becoming dry and hard, or indurated (see Plate 2). Often it is only at this stage that pod infection is detected, some three to four months later. Pods infected at an early age ripen prematurely and irregularly and internally the tissues are compacted, often watery, and necrosis is total. In later-infected pods internal necrosis may be extensive or may be confined to some beans and part of the pod wall; irregular, black, usually sunken lesions appear on the pod surface at maturity. Hence, the farmer may not appreciate the full extent of pod losses until harvest time.

The Life Cycle

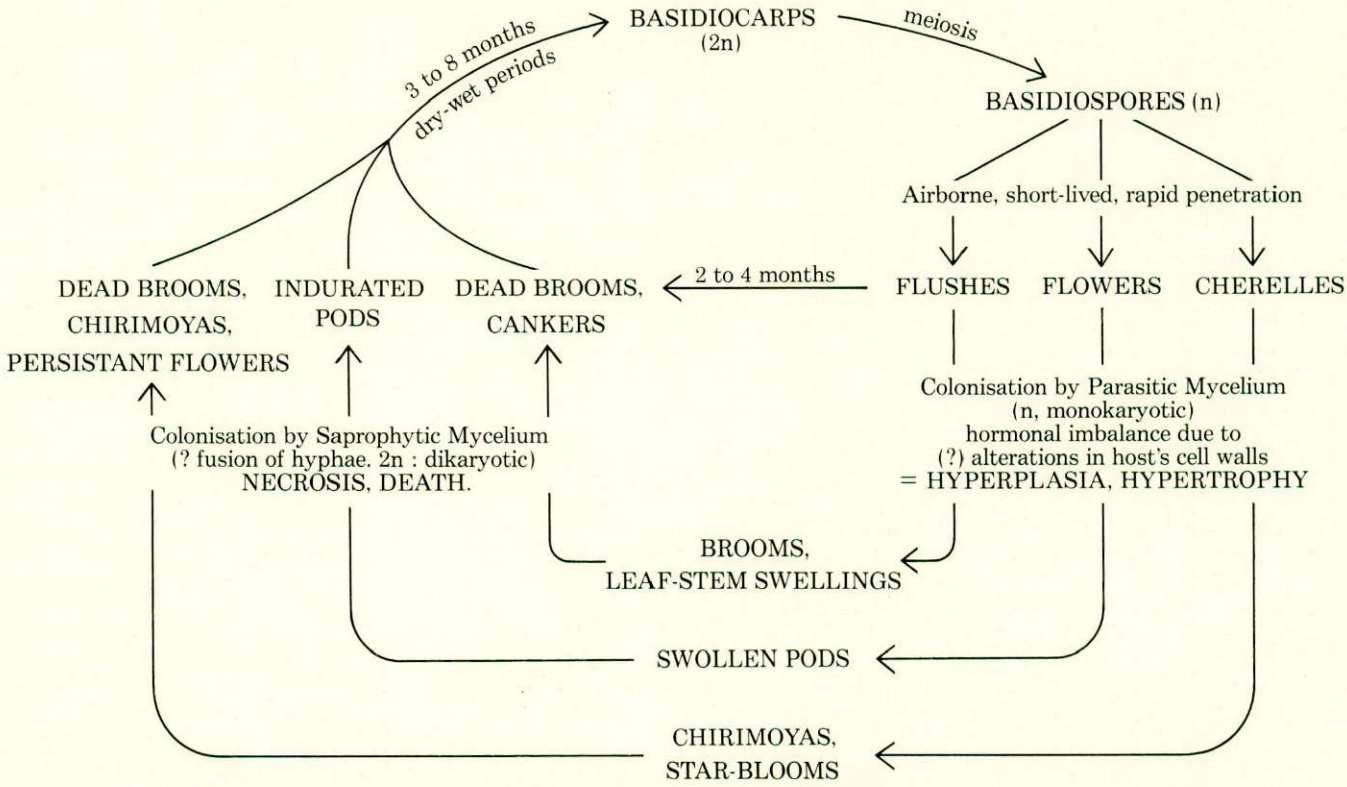
It is only after necrosis that the fungus can complete its life cycle. All dead, colonised tissues are capable of producing basidiocarps and they have even been observed on old peduncles from which a previously infected pod had been harvested. The factors governing basidiocarp production ('sporulation') are still obscure, although alternate wetting and drying is a necessary prerequisite. The time from tissue death to initiation of sporulation (— the incubation period) varies from two to sixteen months but consistent averages of seven to eight months in Ecuador (10) and six to seven months in Brazil (Author) have been reported. Despite detailed experimentation, basidiocarps have never been induced in pure culture, possibly 'sporulation' is triggered-off by certain by-products of broom decomposition.

Once a broom begins to sporulate it can continue to produce crops of basidiocarps regularly during wet conditions for two years or more. Detached brooms on the ground sporulate freely but generally produce significantly less basidiocarps than attached brooms (10), since they are not subject to drying winds and degenerate much more quickly.

The spores are carried by wind and air currents and, although well adapted to this form of dispersal, they are vulnerable to desiccation and survival in direct sunlight is limited to about one hour (11). They are liberated mainly during the early morning following a drop in temperature and increase in humidity and have been detected at considerable distances from cocoa farms using bait plants in addition to mechanical spore traps (10). There is some evidence for limited waterborne dispersal. For example, some cultivars are highly susceptible to cushion infection giving the impression that the fungus had passed systemically from cushion to cushion. Systemic mycelium has not been detected in the intervening tissues (3) and it is suggested that this is the result of multiple infection from waterborne spores. White spore shadows can frequently be seen on the tissues beneath basidiocarps and spores deposited in this manner may be carried by water being channeled down the tree during rainstorms and then becoming lodged amongst flower buds.

The life cycle, therefore, can be conveniently divided into two distinct parts: the first being the colonisation of vigorous host tissues and the harnessing of meristems so that more and bigger cells are produced. This is

Figure 2: Life cycle of *C.perniciosa* in a cocoa plantation



the obligate parasitic or biotrophic phase, the fungus growing with the plant and obtaining nutrients from the living cells. When the normal growth processes of the plant are halted, the soluble nutrients may become limiting, which causes the fungus to invade and kill the tissues, obtaining its nutrients necrotrophically using degradative enzymes typical of a facultative parasite. Morphological examination confirms the presence of two separate fungal mycelia. In green swollen tissues, a thick mycelium grows between the host cells but does not directly invade them, whilst in necrotic tissues the mycelium is much thinner and penetrates the cell walls. This latter is the saprophytic mycelium which grows in culture and is profusely present in dead infected tissues. Induration or hardening of infected tissues probably results from the extremely rapid uptake of water and nutrients by this mycelium as it quickly colonises the dying tissues. The mycelia are also genetically and physiologically distinct (5). The fungus passes through a saprophytic existence before the infective parasitic phase is resumed following meiosis and the production of sexual spores (see Figure 2). The trigger mechanisms for these changes are not yet understood.

Is this information merely academic — nice to know but impractical — or can it be of use to control the disease? If we are to explain the success of the pathogen we must first understand the life cycle and relate this to the situation in the field.

The Ecuadorian Experience

In western Ecuador, the rains begin in mid to late December following an extended five to six month dry season. The flush response of cocoa is massive and almost immediate whilst fungal sporulation lags somewhat behind and requires a sustained period of rainfall before the first crop of basidiocarps is produced, towards the end of December. The flush is hit, therefore, at a relatively later stage and although infection, in the form of stem or leaf swellings, may be heavy this is not reflected in the broom count. To the casual observer the first flush is healthy. During the next flush, those swellings near to growing points develop into terminal and lateral brooms and infection builds up over the season as more dead brooms come into production. The final flush which occurs during the dry season has the highest number of brooms since the flush in the latter part of the wet season was massively infected. Infection of cocoa flowers follows an identical pattern, no infections during the first flower flushes of the wet season, but increasing steadily to maximum symptoms in the dry season as previously dormant and systemic infections are fully expressed. Formation of both vegetative and cushion brooms occur, therefore, a considerable time after infection, confusing the farmer as to their origin in time and space. Logically, the flush at the beginning of the rainy season is free of dormant or systemic infections since the dry season flush escaped infection in the absence of basidiospores. Brooms produced during the dry season do not sporulate during the early part of the wet season (December–January) due to the six to eight month incubation period. The inoculum at this time comes predominantly from broom formed during the previous March–April but initiated several months earlier, so there is almost a one year cycle from initial penetration to sporulation. Thus the life cycle of the fungus is almost in step with the physiological activity of the host.

The aforementioned Ecuadorian plantation was geared for maximum production at an early age; vigorously flowering hybrids intermixed with 'resistant' self-incompatible clones, imported from Trinidad, in unshaded blocks on rich alluvial soils in an open situation. The emphasis was on tree vigour, absence of shade to encourage flowering and reduce competition. Because *C. perniciosa* is strictly a pathogen of meristematic tissues, it is favoured by increased tree vigour, therefore unshaded trees which flush and flower more frequently or more intensely than shaded trees will be at greater risk. If the tree growth periods coincide with fungal sporulation then infection on an epidemic scale will be inevitable. Lack of shade promotes fast drying-out of brooms which reduces tissue colonisation by secondary organisms and greatly increases both the amount and duration of sporulation (10). Furthermore, cultivation of unshaded cocoa in separate blocks without windbreaks creates air turbulence. There is evidence that a characteristic air movement occurs at the edges of a forest or plantation with air flowing close to ground level from the open area into the trees, up under the canopy in an updraught, and then back into the open where it meets the downdraught created by the open situation and thus back into the trees (14). This can give a high chance of infection of flower cushions and pods in addition to foliage.

Excessive or prolonged flowering can be caused by exposure to direct sunlight and by insufficient pollination. There is no doubt that in these 'well-ordered' plantations there are few breeding sites available for pollinating insects. Self-incompatible clones and hybrids under these conditions will be subject to almost continuous cushion activity (flowering) and hence extremely susceptible to cushion infection. Any application of insecticide to combat the pests, which tend to build-up in unshaded monocultures, will further decimate the pollinator population.

Phytosanitary pruning, which was standard practice in large Ecuadorian plantations, has to be thoroughly carried out in order to be effective; necessitating a good knowledge of all the disease symptoms. This was put to the test in an experiment in the Brazilian Amazon, whereby experienced field workers thoroughly pruned a small, heavily infected farm of five year old mixed hybrids and immediately afterwards, examined carefully randomly selected trees and identified the remaining infection sites. These averaged 51 sites per tree. Almost invariably the infections were small, necrotic flower cushions and branch or branch-leaf cankers. Since such infected tissues are capable of producing basidiocarps and perhaps more importantly can give rise to new lateral or terminal brooms, they were designated as 'hidden inoculum sources' not normally spotted by the field worker or indeed recognised as witches' broom disease. Pruning may even exacerbate the disease situation if implemented at the wrong time, by increasing the amount of susceptible tissue (wound entry sites, extra flushing) and stimulating lateral infections which may have remained dormant or stopped at the canker stage. The official recommendation in Ecuador is to leave all pruned material on the ground. Detached brooms continue to sporulate, albeit at reduced intensity and as the spores are in an ideal situation to be lifted by updraughts into the canopy, the detached brooms are still an important source of inoculum.

Once the infection cycle is underway in this cultivation system, there is little hope of saving the plantation. Desperate measures follow which increase rather than decrease infection. For example, more frequent and drastic

pruning is carried out and this often coincides with periods when fungal inoculum is present. Fertiliser may be applied to trees debilitated by excessive flushing and flowering, or by repeated infection. Insect damage and die-back, frequently associated with weakened unshaded trees, will exacerbate tree debilitation and encourage panic spraying with insecticides and/or fungicides. Herbicide application may also be deemed necessary. As the canopy fails to close or breaks-up, the plantation rapidly becomes uneconomic.

Unfortunately, this failure to relate agronomic practices to witches' broom disease is being repeated in the Brazilian Amazon; planting vigorous hybrids based on 'resistant' clones, in open situations, usually adjacent to pasture, without shade on fertile soils. A survey has revealed that 11–13% of the trees are highly susceptible, particularly the free-flowering probably self-incompatible hybrids, and these are important sources of infection for neighbouring trees, especially the pods. Staggering losses (> 90%) have been recorded in some high-yielding farms.

Plate 3: Green broom in the first stages of necrosis on the clone Scavina-12 at Belem (Brazil). This was the first infection to be recorded in a 10-year-old block of Scavina trees. Previous inoculations had ellicited only a hypersensitive reaction.

Host-Pathogen Interactions

Clones resistant to *C. perniciosa* under Trinidadian conditions were exported to Ecuador and Brazil to improve hybrid material. However, resistance quickly broke down in Ecuador and there is evidence that the same is happening in Brazil (Plate 3). The obvious inference is that there exists a wider variation in pathogenicity in Ecuadorian strains of *C. perniciosa* which is supported by the discovery of a less virulent strain on lianas and unidentified forest trees (4). Moreover, inoculation experiments on cocoa with an isolate of *C. perniciosa* from *Theobroma grandiflorum*, widely planted in the lower Amazon for its flavoured endosperm, have shown that pods, flushes and seedlings rarely produce the full symptoms of infection

which would result from inoculation with a comparable cocoa isolate. The reaction is usually of a hypersensitive nature with localised bark formation, necrosis or cankering and only limited hypertrophy (Plate 4). *T. grandiflorum* is extremely susceptible to witches' broom disease and heavily infected trees may be seen adjacent to relatively healthy cocoa trees. Goncalves (7), however, reported no differences in pathogenicity between these strains as tested under greenhouse conditions. Clearly more work remains to be done on strain variation.

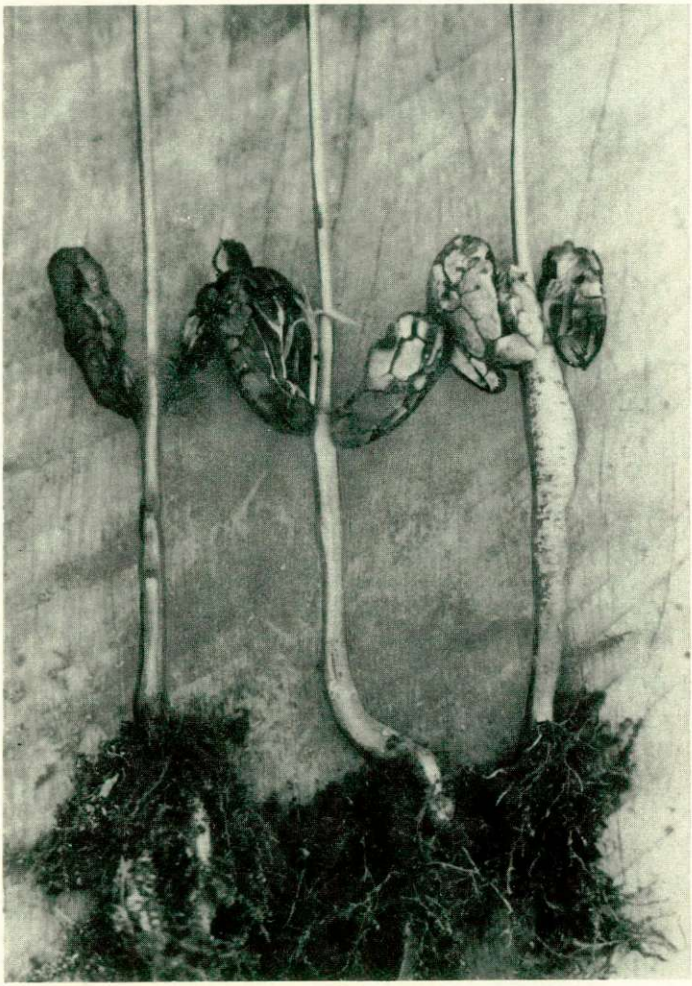


Plate 4: ICS-39 seedlings four weeks after inoculation with strains of *C. perniciosa*. Note the restricted lateral swelling on the left (strain from forest liana), the more general but unspectacular swelling in the centre (strain from *Theobroma grandiflorum*) and the grossly swollen seedling on the right (strain from *T. cacao*).

The success of the pathogen is that it fools the host into accepting it because it does not invade the cells and thus does not elicit an antagonistic reaction. The highly specialised intercellular mycelium has been maintained in culture by providing it with vigorous cocoa callus or extracts of new flushes (5, 6). Certain cultivars work better than others, whilst some are inhibitory. It is thought that there are substances present in young, vigorous cocoa tissues which provide the fungus with the necessary stimulation to stay in the parasitic phase. Variation in the amount of these substances as tissues age, as well as between cultivars, will contribute directly to host susceptibility or resistance. A strain of *C. perniciosa* from *T. grandiflorum* may require higher levels of these stimulatory substances than are present in most cocoa cultivars and in this situation the parasitic phase will be correspondingly short-lived. Adaptation to the cocoa tissues may be rapid in an area of high inoculum density. Scavina (SCA) clones for example are essentially of poor growth form and the non-vigorous flushes combined with a high level of fungal inhibitors (6) may confer resistance to *C. perniciosa* in areas of low pathogenic variation or low inoculum density.

Disease Containment

The art of growing cocoa in areas where witches' broom disease is endemic must be to treat it as an understorey tree rather than an orchard crop. Obviously there has to be a compromise between unshaded, vigorous hybrids and heavily-shaded, slow-growing cultivars: the former will initially be highly productive but rapidly decline following repeated infection; the latter will be unproductive but relatively disease free for a long period of time. Shade is a controversial subject but almost certainly it serves to minimise infection in a number of ways:

– by slowing down the host's physiological processes, and thus flushing and flowering, thereby reducing the amount of susceptible tissue available to the fungus and perhaps by altering the chemical composition of the tissues and making them less suitable for colonisation by the parasitic mycelium;

– by acting as a buffer so preventing large and sudden variations in humidity and temperature and ultimately reducing the amount of fungal inoculum since basidiocarp production and basidiospore liberation are favoured by rapid drying and steep falls in temperature respectively;

– by reducing air movement and thus basidiospore dissemination, because under shade there is a local temperature inversion which creates a laminar air flow holding spores down within the canopy (14).

Moreover, the cultivation of cocoa in less open situations, with shade and surrounded by or intermixed with fruit trees or secondary bush, will encourage pollinating insects by providing additional breeding sites. This in turn should help to stabilise both the intensity and periodicity of flowering through increased pollination and hopefully improve yields, whilst reducing the amount of meristematic tissue available to the pathogen. Almost certainly the conditions in the Ecuadorian plantation were unfavourable for pollinating insects and thus the hybrids were 'out of control' physiologically and ideal targets for *C. perniciosa*. As an added stimulus to increase the populations of pollinators, provision of shade should reduce or eliminate the need for insecticide application against insect pests traditionally associated with cocoa trees which are exposed to direct sunlight, including thrips.

These are positive agronomic measures which can reduce the impact of infection by keeping the trees under control physiologically. I have seen the results of physiological imbalance in trees of *T. speciosum* suddenly exposed to direct sunlight during road construction in the Brazilian Amazon. Massive flowering, probably out of step with the normal patterns of heavily shaded understorey trees, had resulted in almost all the cushions being infected from ground level to almost three metres.

Phytosanitary pruning is necessary to keep the pathogen in check rather than to eradicate it and should be limited to a single annual event, preferably towards the end of the dry season in order to reduce costs and prevent exposure of cambial tissue when fungal spores are present. All diseased tissue should be removed together with about 15 cm of healthy surrounding tissues for vegetative brooms, and a small amount of healthy bark for diseased cushions. Since all infected tissues necrose during the dry season, they are clearly observable in the canopy and can be more easily cut out. Brooms on the ground can sporulate (10) and thus pruned material should be removed and burnt outside the farm. Providing there is a well-defined dry period, the annual prune is sufficient because most brooms will not sporulate until the following rainy season. To start pruning in heavily infected farms is back-breaking work (12–15 trees/man/day) and is initially uneconomic, although it can be combined with the annual structural prune. Any break in the annual pruning schedule could be disastrous and untreated trees are, of course, a threat to neighbouring plantations. Infection will still be present ('hidden inoculum sources') even after the most severe prune, particularly on self-incompatible trees prone to cushion infection. The urgent task is to identify these hybrids and remove the parent clones from the breeding programme. Although the 'resistant' hybrids have proved to be susceptible in areas of high inoculum and/or in conditions favouring the pathogen, they must still form the basis of the planting material since there are no genetic alternatives at the moment nor likely to be in the foreseeable future. They should be given a chance by reducing the inoculum and changing the agronomic practices.

Fungicide application has never been successful for a number of reasons which include the difficulty of adequately protecting rapidly expanding flush tissues and the absence of any suitable systemic fungicide to eradicate the systemic mycelium once established. Copper-based fungicides may, however, alleviate pod losses if applied directly to the pods at the correct time, during the period of maximum pod setting and pod extension. It is recommended practice in Rondonia to apply four per cent cupric hydroxide in December, January, February and March to developing pods.

These are essentially short-term measures, but what are the long-term prospects of control? From the more detailed but still fragmentary knowledge of host-pathogen interactions, we have a better understanding of how the fungus functions and identification of the factors which promote the parasitic phase should enable us to select more judiciously suitable genetic material. Ultimate control must come about through the use of less susceptible or resistant cultivars. Chemicals which affect genetic changes in fungi are known and it is possible that these could be used to induce the saprophytic phase and restrict growth of the parasite. The approach must be multidisciplinary involving agronomists, geneticists, physiologists, biochemists in addition to pathologists.

Disease Exclusion

It is of interest to every grower in areas where the disease is absent to be aware of the chances of its introduction and, of course, to make himself familiar with the symptoms. Air dispersal although effective has limitations because of spore fragility. If we consider that air speeds in the tropics average three to four km per hour and that the spores are quickly killed by exposure to sunlight then this would give a maximum of 12–14 hours viability under normal conditions, say 40–60 km range. Periods of overcast weather would favour spore survival and considerably increase the effective range, perhaps up to 100–150 km.

The main Brazilian cocoa-growing region in Bahia is free of the disease and is separated from Amazonia by about 2000 km of predominantly dry scrub, ruling out any possibility of natural spread (see Figure 1). There remains the continual problem of disease introduction by man via planting or 'touristic' material. The Brazilian authorities are well aware of the dangers and checks at road blocks and airports, both leaving Amazonia and entering Bahia, are being carried out. Infected premature ripe pods with few external symptoms are an obvious danger, as are beans from certain types of pod infection, which have been shown to carry the pathogen (3). So long distance spread within Brazil is unlikely with the present quarantine restrictions, especially when material is held-over and screened at an intermediate quarantine station. Nevertheless, the emphasis must be on maintaining vigilance

Future Prospects

More workers are becoming involved either directly or indirectly in research on various aspects of witches' broom disease. It is imperative that such efforts should not be wasted – through lack of communication or direction – or sight lost of the ultimate aim of the exercise, which is to effectively contain and control the pathogen. Cooperation, through the exchange of materials (particularly for breeding programmes), experimental results and project ideas, should be actively encouraged. Each affected country or region must, of course, carry out its own epidemiological studies but, to avoid duplication of work, priority projects should be delimited and undertaken in suitable locations. Those involving sophisticated techniques or comparison of pathogen races will have to be assigned to interested countries where the relevant facilities and expertise are available. It is only through such a multidisciplinary and international approach that significant progress will ever be achieved.

References

1. BAKER, R.E.D. and HOLLIDAY, P. (1957) 'Witches' broom disease of cacao (*Marasmius perniciosus* Stahel).' *Phytopathological Paper* No. 2, 1–42. Commonwealth Mycological Institute, Kew.
2. BARROS, O. (1978) 'Algunos aspectos de la 'escoba de bruja' en Colombia.' *El Cacaotero Colombiano* No. 7, 43–56.
3. CRONSHAW, D.K. and EVANS, H.C. (1978) 'Witches' broom disease of cocoa (*Crinipellis perniciosa*) in Ecuador. II. Methods of infection.' *Ann. Appl. Biol.* 89: 193–200.
4. EVANS, H.C. (1978) 'Witches' broom disease of cocoa (*Crinipellis perniciosa*) in Ecuador. I. The fungus.' *Ann. Appl. Biol.* 89: 185–192.
5. EVANS, H.C. (1980) 'Pleomorphism, in *Crinipellis perniciosa*, causal agent of witches' broom disease of cocoa.' *Trans. Brit. Mycological Soc.* 74: 515–523.
6. EVANS, H.C. and BASTOS, C.N. (1980) 'Basidiospore germination as a means of assessing resistance to *Crinipellis perniciosa* (witches' broom disease) in cocoa cultivars.' *Trans. Brit. Mycological Soc.* 74: 525–536.
7. GONCALVES, J.R.C. (1965) '*Theobroma grandiflorum* (Spreng.) Schum. as a source of inoculum of witch-broom disease of *Theobroma cacao* L.' *Trop. Agric.* (Trinidad) 42: 261–263.
8. PEGLER, D.N. (1978) '*Crinipellis perniciosa* (Agaricales).' *Kew Bulletin* 32: 731–736.
9. SINGER, R. (1942) 'A monographic study of the genera *Crinipellis* and *Chaetocalathus*.' *Lilloa* 8: 441–534.
10. SOLORZANO, G.R. (1977) 'Factores ambientales involucradas en la produccion de basidiosporas de *Marasmius perniciosus* Stahel.' Ing. Agr. Thesis, University of Manabi, Ecuador.
11. STAHEL, G. (1915) '*Marasmius perniciosus* nov. spec.' *Bulletin Department van den Landbouw in Suriname* 33: 1–26.
12. STAHEL, G. (1919) 'Bijdrage tot de kennis der krullotenziekte.' *Bulletin Department van den Landbouw in Suriname* 39: 1–34.
13. THOROLD, C.A. (1975) 'Diseases of cocoa', Clarendon Press, Oxford.
14. VAN ARSDEL, E.P. (1967) 'The nocturnal diffusion and transport of spores.' *Phytopathology* 57: 1221–1229.

Experiences with Nursery Budgrafting on Cocoa Estates in Malaysia

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The cocoa crop area in Malaysia has increased dramatically from less than 3,000 ha in 1965 to about 65,000 ha in 1980 (Anon, 1980) and almost all has been planted with hybrid seedlings. However, it is envisaged that clones will feature more prominently in future extensions and in replanting/rehabilitation programmes as various research establishments in Malaysia have embarked on breeding and selection of clones, the best of which are expected to hold several advantages over hybrid seedlings. These advantages might include higher yields of beans per hectare, improved bean size and uniformity, superior resistance to vascular-streak dieback and Phytophthora diseases and better adaptation to specific environments.

In Malaysia propagation of cocoa clones by budgrafting has been preferred to the root cutting technique as budding methods used extensively for rubber and fruit tree propagation have, with minor modifications, proved suitable for cocoa and budgrafts can be produced more cheaply. Budgrafting is favoured as it enables large numbers of seedling-type plants to be produced from limited quantities of chupon material.

This paper considers experiences with budgrafting on estates within the Harrisons & Crosfield Group in Malaysia where a mixture of 2,500 cocoa clones have been established on about 200 ha of the 6,500 ha planted with cocoa crop.

For commercial planting, budgrafting in the nursery is preferred to budgrafting in the field, because the interval between planting and maturity can be considerably reduced when budgrafts are raised to an advanced stage in the nursery and growth following field planting should be more uniform as unthrifty or diseased plants are eliminated in the nursery.

Rootstock

Specific recommendations of rootstocks for individual clones are not available. Within-clone uniformity in growth vigour and yield indicate that differences attributable to rootstock source are small when compared with the variation that exists between clones and so efforts have been concentrated on selecting clones suitable for commercial planting. However, stock/scion investigations are initiated when outstanding clones have been identified. The first stock/scion trial was established two years ago. No significant within-clone growth reactions to the limited range of rootstocks being

evaluated are apparent, but these trials must continue for some time to enable long-term growth and yield responses to be evaluated.

Results of nursery trials have indicated that stocks derived from clones (e.g. UIT 1, UIT 2, ICS 60) that produce large seeds develop with greater vigour and can be budded earlier than stocks derived from clones (e.g. Sca 6, Sca 12, Na 33, Pa 7) that produce smaller seeds. Some seed size variation is found within pods of clones with above-average seeds and so under-sized seeds are rejected before planting, as it is thought that nursery seedling vigour is influenced by seed weight.

The establishment and maintenance of seedlings in the nursery is not dealt with in this paper as the topic has already been considered in detail in this journal (Shepherd, 1976). Black polybags 35 cm long and 23 cm wide (layflat dimensions) are normally used for raising buddings in nurseries. To ensure sufficient material is available for nursery selection, field planting and supplying, it is recommended that the number of seedlings should be 25 per cent greater than the chosen stand per hectare.

Choice of clones

Although no clones are currently recommended for general planting on estates and smallholdings in Malaysia, it is confidently expected that the best clones derived from outstanding seedlings in elite hybrid progenies will out-yield seedling planting material by significant margins. Several clones in the Harrisons & Crosfield clonal trials set up since 1972, have yielded exceptionally well and possess desirable secondary characteristics (including bean size, bean uniformity, satisfactory chocolate flavour and resistance to the major diseases) and the best selections are now being planted in polyclone patterns on about 20 per cent of new plantings on company estates. Clones for specific polyclone groupings are selected on the basis of their similar growth vigour, synchronisation of flowering behaviour, cross compatibility and likely adaptation to the local environment.

Choice of budwood

Investigation with the clones being propagated have yet to confirm whether trees derived from fan buds will out-yield trees derived from chupon buds. Chupon budwood is currently favoured as trees develop normal seedling characteristics and are more easily managed when young, while trees derived from fan buds tend to maintain fan branch growth characteristics and require considerable formation pruning during the second and third years. Whichever type of budwood is used, best budding success and most rapid scion development occur when the parent trees are healthy and well nourished. Ideally the budsticks should be collected from non flowering branches on trees which have no immature foliage. Delays between cutting of budsticks and their utilisation should be minimal and preferably not exceed two days. When the parent trees are available on the same estate, the day's requirements should be cut early in the morning.

Stock age at budding

Trials have been conducted to determine the optimum budding age of stocks for nursery budding, with stocks ranging from only eight days to

eight months old. The green budding technique was successful for all ages, but with due regard to the rate of scion growth and other considerations (e.g. polybag size, ease of management, time in nursery, costs to field, etc.), the budding of 2½–3½ month old stocks is preferred. With younger stocks (see Table 1) the vigour of scion development is inferior and a lower proportion of the plants qualify for field planting. With stocks to be budded at an age greater than 3½ months it is necessary to use larger polybags to prevent the stocks outgrowing the bags. This is likely to happen if plants are retained in the nursery until scions have developed to about 60 cm height, which is considered the optimum stage for field planting.

Table 1

Scion growth in relation to stock age at budding

Stock age when budded	Months after budding	Scion growth (cm)	Scion height (cm)
1 month	6	2.4	44.5
3 months	4	2.6	50.0
5 months	2	1.7	30.2

Budding technique

A modification of the green budding technique that has been applied extensively for propagation of rubber trees (Anon, 1964) is used for budding cocoa seedlings in the nursery. Proficient workers are capable of budgrafting at least 300 nursery rootstocks in a normal working day, obtaining more than 90 per cent success. The steps and relevant points in respect of the cocoa budding operation are shown on pages 23–28.

Step 1 During cutting, the unusable upper part of the shoot is removed and leaves are cut off 1½–2 cm from their point of emergence (see Plate 1). For budding stocks raised in the nursery, budsticks having diameters within the range of 0.5–0.8 cm are preferred. Budsticks must be handled with care and due precautions should be taken to avoid bruising and exposure to high temperatures and dry conditions. If a delay in budding is unavoidable, or the budsticks have to be transported over a long distance, the cut stem surfaces should be momentarily dipped in molten paraffin wax and budsticks wrapped in damp hessian or packed within moist sawdust which has a low resin content.

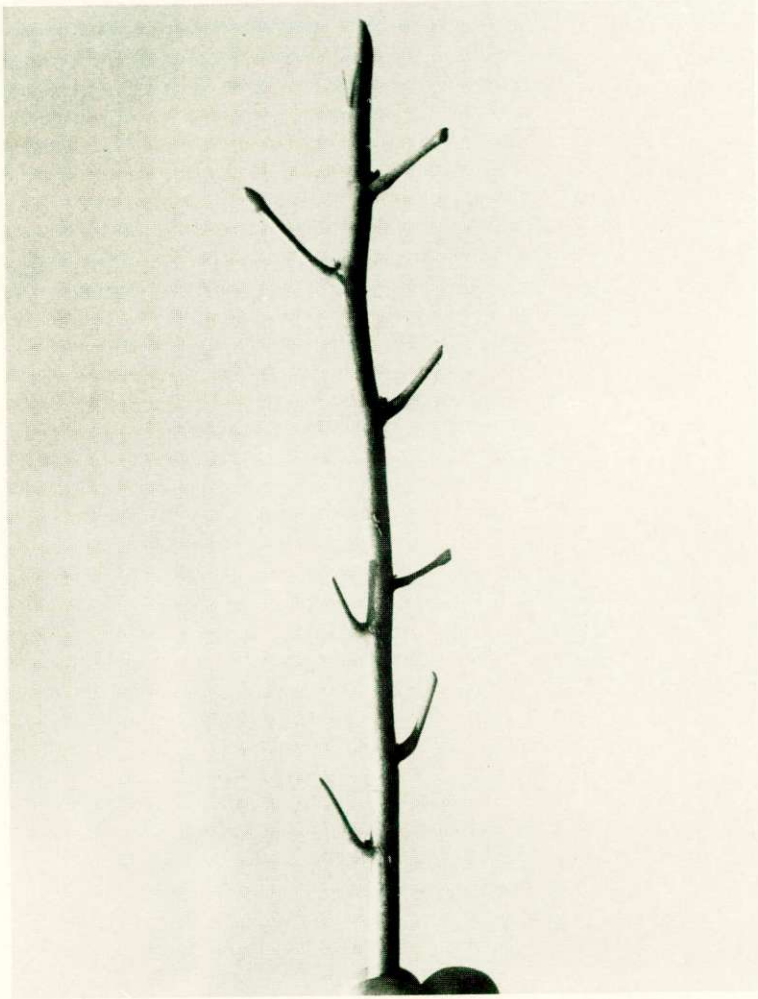

Plate 1: Budstick from fan branch, showing pruned leaf petioles.

Step 2 Only vigorous healthy rootstocks should be used. Using a sharp knife, a 3–4 mm wide horizontal cut is made into the selected rootstock to cambium depth below the cotyledon scar. The bark is then carefully peeled downwards to expose a panel of cambium 3–4 mm wide and 3–4 cm long for receiving the budpatch. Thereafter, the flap is trimmed to 1 cm length to provide a tongue which wil help hold the budpatch in place (see Plate 2).

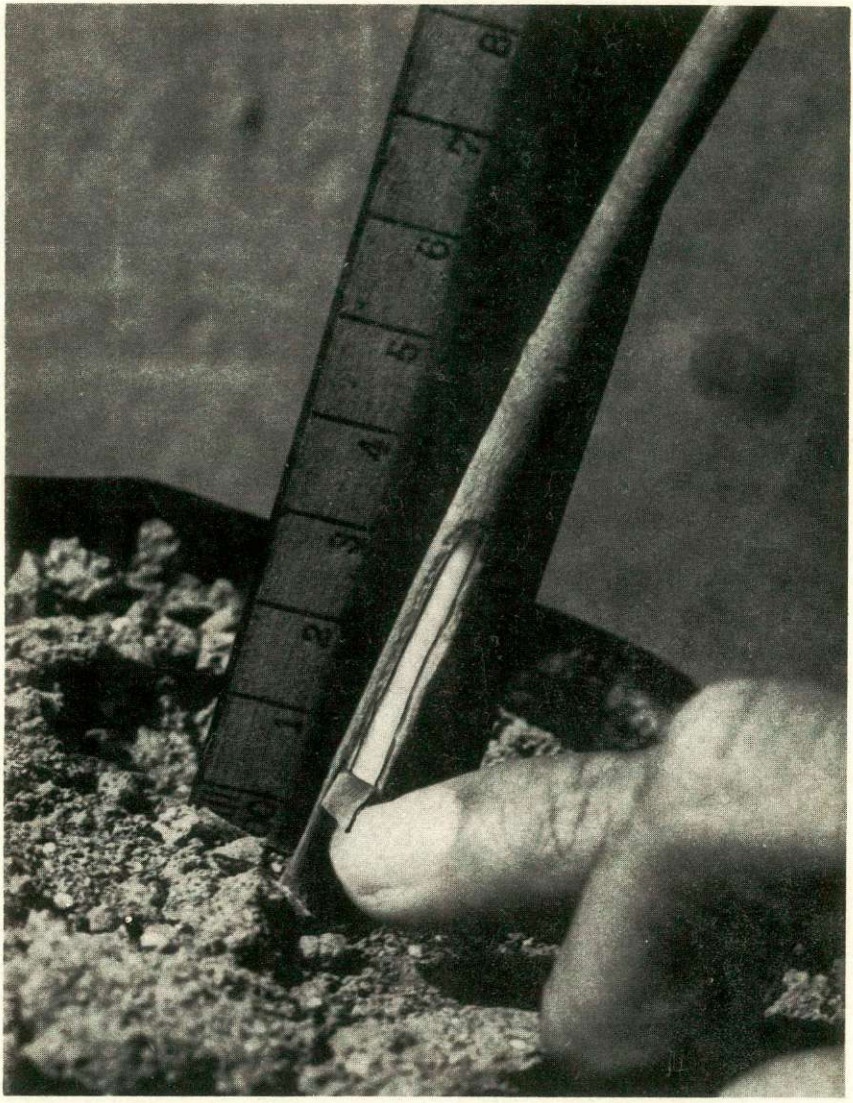

Plate 2: Seedling stock panel opened to receive budpatch. Note short 'tongue' of bark at lower end.

Step 3 A budpatch narrower than the exposed stock panel and with a centrally located bud about 2 cm from its lower extremity is removed carefully from a budstick. Retention of a fairly long portion of petiole until the budpatch is secured against the rootstock panel as in Step 4 is standard practice when working with small budsticks or comparatively young rootstocks. Its removal is facilitated by making vertical cuts to wood depth on either side of the selected bud, followed by horizontal cuts to the same depth. With experience, it is possible to prise the budpatch with intact bud away from the wood (see Plate 3) without adversely affecting budding success.

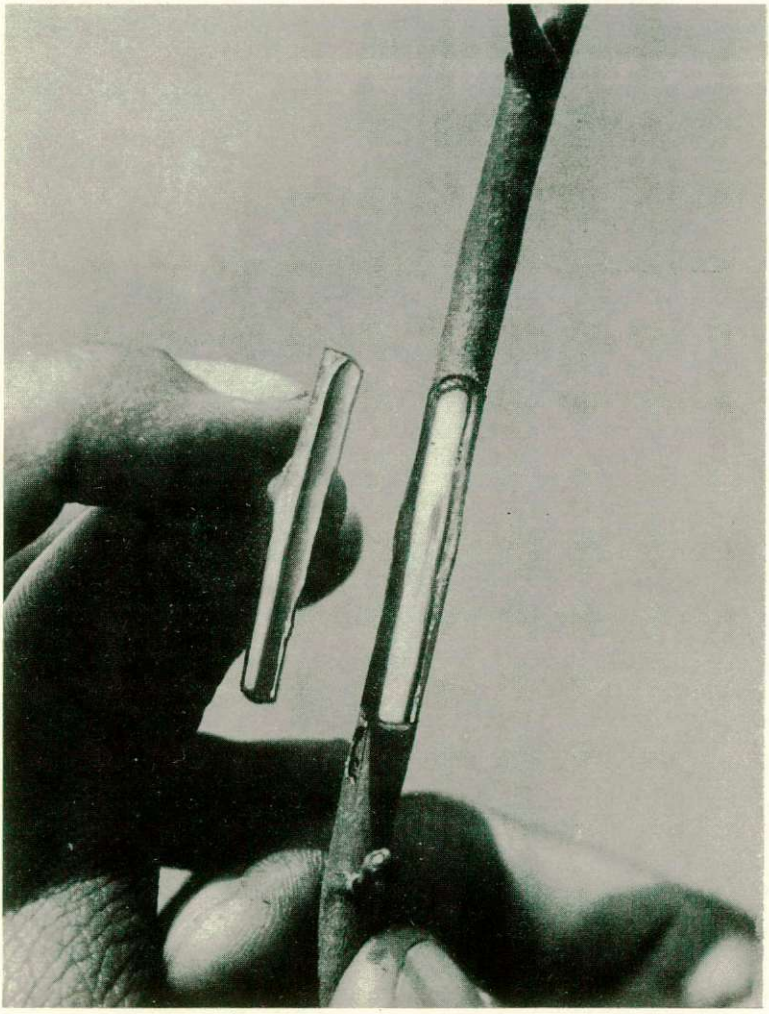

Plate 3: Budpatch extracted from budstick.

Step 4 The budpatch is placed at once against the freshly exposed stock panel (see Plate 4), ensuring correct orientation of the bud which should be above the petiole remnant. Cambial surfaces must not be handled or subjected to lateral or vertical pressures and strict hygiene should be practised to obviate possible contamination with soil or other matter. With the budpatch positioned, its upper extremity is then trimmed to ensure it fits snugly into the stock panel and the remnant of the leaf petiole is pruned back almost flush with the bark surface.

Plate 4: Operator holding budpatch by petiole remnant while placing budpatch against stock panel.

Step 5 Without disturbing the budpatch, it is secured firmly and evenly against the stock panel by means of transparent colourless polythene tape 1.5 cm wide and 0.04 mm thick. Binding starts below the tongue and the tape is wound clockwise and upwards, each turn overlapping the preceding one to ensure satisfactory seal. About 3 cm above the budpatch, the tape is secured with a half-hitch (see Plate 5). Approximately 30 cm tape is required for normal-sized 2½–3½ months old stocks.

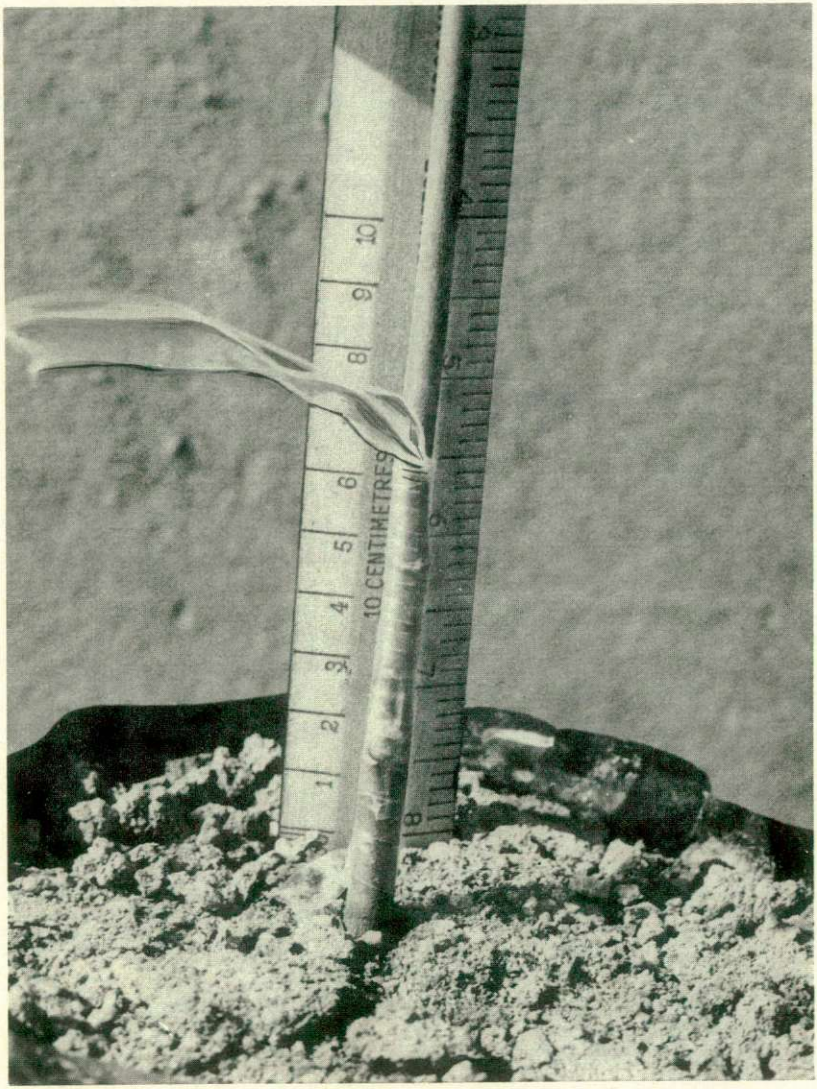

Plate 5: Seedling stock showing budpatch and tape after tying.

Step 6 The tape is removed 14 days after budding, by slicing it vertically with a sharp blade just beyond the lateral extremity of the stock panel. Successfully budded stocks have healthy budpatches and there will be evidence of callus development from their margins. Although the budpatch may appear satisfactorily united to the stock within one week of budgrafting, unacceptable losses may occur if the polythene tape is removed prematurely. Success rate may also be affected if the tape is not opened within three weeks of budding. When the tape is removed the rootstocks are decapitated 7–10 cm from the growing point to promote emergence of the scion.

Step 7 One week after the removal of the tape the rootstocks are partially severed (to about two-thirds of their diameter) by means of an upward sloping cut 6–8 cm above the budpatch. The stock is simultaneously forced to arch over (see Plate 6). The vigour of scion emergence and subsequent development is superior when the stock is only partially severed as leaves on the rootstock continue to contribute to the plant's economy.

Plate 6: An oblique upward cut is made to arch over the stock of a successfully budded plant.

Subsequent Management

Unsuccessfully budded stocks may be rebudded almost immediately, opening a panel on the opposite side of the stem. In the case of failures subsequent to decapitating, stocks may also be rebudded after a recovery period. After the scion emerges, paint is applied to the stock and at a later stage to the scion base to indicate budding success and clone identity. All stock shoots are removed as soon as they appear so that energy is not dissipated in the development of unwanted growth. After one full month, by which time the first scion leaves have hardened and the scion stem has become semi-hard, the rootstocks are cut off 5 cm above the budpatch. As fan shoots are reluctant to grow upright, they may be forced upward by tying them to the snag remaining on the stock and to a 50–60 cm bamboo stake planted firmly into the soil in close proximity to the stock.

Very limited formation pruning of scion growth is done in the nursery as the objective is to maximise plant growth rate. However, chupon-type plants that jorquette prematurely are thumb-nail pruned (i.e. their extremity and jorquette initials are cut off) and renewed upward growth of a shoot emerging close to the top of the decapitated stem is encouraged. In the case of fan buddings, not more than three vigorous side shoots are allowed to develop, the lowest emerging at least 20 cm above the point of scion emergence from the rootstock. Trials are in progress to establish the optimum pruning policies for fan buddings in nurseries and following field planting.

Plants are usually retained in the nursery until 4–5 months after budding. About two weeks before field planting the polybags are rotated about 15 degrees in order to break roots that penetrate into the soil below. Watering is increased to minimise moisture stress and the final watering before field planting is generous. Other nursery practices are similar to those described for hybrid seedlings (Shepherd, 1976).

References

ANON (1964) 'Instructions for green budding rubber trees'. Plrs' Bull. No. 72, 54–60, Rubber Research Institute, Malaya.

ANON (1980) Ministry of Finance, Malaysia, Economic Report 1980–81 Vol 9, 196 pp.

SHEPHERD, R. (1976) 'Establishment and maintenance of cocoa nurseries'. Cocoa Growers Bull. No. 25, 11–16.

The Eighth International Cocoa Research Conference

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General

The 8th International Cocoa Research Conference was held in Cartagena, Colombia on 18–24 October 1981 and was attended by about 400 delegates from some 50 countries including a large contingent from the host country. For the first time Portuguese was added as a working language of the Conference, thereby avoiding many of the difficulties which have been encountered on previous occasions. There were therefore four languages – English, French, Spanish and Portuguese. This was a useful and interesting Conference and the Organisers are to be congratulated.

A total of 62 papers (including seven invited papers) were presented in seven sessions spread over four working days. While this shortening of the Conference no doubt concentrated the minds of participants and may also be inevitable on grounds of cost, the limited time available to authors for presentation of their papers in many cases had an adverse effect, causing them to do less than justice, either to themselves or their audience. Much credit is due to the organisers for the simultaneous translation services which were admirable and for their efforts in ensuring that papers were available in abstract at the commencement of the Conference. Of the 145 papers submitted, 62 were accepted for presentation with a further 25 for presentation at the poster sessions which were included each day. A number of papers were accepted for publication in the proceedings and some were rejected. It is anticipated that the Conference proceedings will be published well in advance of the 9th International Cocoa Research Conference due to be held towards the end of 1983.

Review of Papers

Agronomy

The session opened with an invited paper on intensive systems of fruit production and their relevance to cocoa, drawing attention to developments in high density planting of apples using dwarfing root stocks, the chemical induction of branching and production of flower buds, the use of growth suppressants to replace pruning and of herbicides for weed control. The author pointed out that although the constraints were different, some of these concepts might be applicable to cocoa. A few closer plantings of cocoa had been made but some fundamental research was needed on methods of maintaining high yields at maturity when inter-tree competition would depress yield. Growth regulating chemicals might be tried, but the most feasible approach would appear to be genetic through the selection of precocious clones with moderately vigorous growth, grafted to dwarfing root stocks. Selection should also take account of tolerance to full sunlight, since shade management problems are accentuated in intensive systems.

This was followed by a paper on regeneration of cocoa in Costa Rica by planting improved varieties beneath the shade of the old cocoa trees and removing the latter by gradual pruning as the new plantings mature (the Turrialba method). The overhead shade is not of necessity reduced in this system. Detailed cost benefit analyses over four years were given and this techniques appears to hold promise. Two papers dealt with establishment of seedlings in the field from the nursery. The first comparing two methods of transportation of seedlings to the field – with only a ball of soil compared to a bare root seedling with a wrap of newspaper pre-soaked in a forest top soil leachate solution. The latter method was preferred by farmers and greatly reduced losses of planting material. The second paper compared bare root transplanting with and without the use of anti-perspirant (Mobileaf). Use of Mobileaf gave 90% success in field establishment with seedlings in good condition with their leaf area reduced.

Three papers on pollination showed, firstly, increased pollination when an increased number of ants were involved, by placing ant nests in the trees and that when pollination was by different genera, the use of colour traps could increase the number of pollen grains deposited. The second paper showed that hand pollination with partial removal of phloem 15 cm above ground 45 days prior to pollination in June and July showed a marked increase in yield. A further paper showed that flowering intensity and pollination conditions five months prior to cropping, could alone be used to account for the size of the harvest. The last study include both amelonado and amazon cultivars.

The final paper in the Agronomy section detailed a strategy for weed management through a study of the characteristics of the weeds of the plantations and of the effects of agronomic, biological and chemical aspects of control.

Soils and Nutrition

The introductory invited paper dealt with improvement of the productivity of cocoa in Colombia in relation to the conservation of the eco-system including inter-alia, the conservation of all natural resources, including manpower which is becoming a scarcer resource following the flight to the towns. Through improvements in productivity, Colombia had now become a net exporter of cocoa. Two other papers dealt with nutritional requirements, the first detailing a computer programme in Fortran for calculating the amount of fertiliser in the Ivory Coast required to achieve the recommended balances in the soil and to compensate for the depletion of elements on the basis of the expected harvest. The other dealt with the nutritional diagnosis and classification of representative soils from the cocoa areas of Amazon Basin of Brazil with biological tests to determine the limiting nutrients. The final paper in this section reported the use of a neutron probe to measure the fluctuations in the water reserve beneath a cocoa plantation relative to the climate, leading to arrangements for irrigation based on a simple climatic data.

Physiology

The seven papers presented in the Physiology section together covered many aspects of this discipline. A paper from Liverpool University dealt with the inter-action between root and shoot growth in cocoa seedlings showing

a clear rhythm of root growth observed in plants grown in root observation boxes, with maximum root growth being between flushes of leaf production and development. The role of the shoot in the control of this root growth rhythm was investigated by continually removing young leaves from plants grown in the root observation boxes over a period. Root growth continued at a high rate throughout the period of leaf removal and when leaves were again allowed to grow to full size, the root growth rhythm recommenced. Conversely removal of half the root system delayed the following leaf flush, but the next was accelerated. The paper included a discussion of the theory that flush growth of shoots is a consequence of the inter-action of two potentially continuous processes, shoot and root growth.

A study, reported from Brazil, used twice-weekly removal of leaf buds, young leaves and pods from six year old trees of clone PA30. Four main conclusions were revealed. A marked increase in flowering intensity was shown when all pods of 1 cm or more in size were removed. Fruits of more than 12 cm length exerted a depressing effect on leaf production. It became clear that the period of low flowering noted in Bahia occurred for climatic reasons though the duration of this period was determined by the number of fruits (internal factors) as well as climate (external factors). These results support the theory of internal correlation in organ development already observed in other plants.

A progress report was given from Nigeria on studies of morphogenesis and plant regeneration in tissue cultures of cocoa and *Herrania spp*. Various plant organs have been produced in vitro from specific ex-plants.

Work on reducing the incidence of cherelle wilt by the application of growth regulating substances was also reported from Brazil. Earlier work had established that wilt could be artificially induced by the application of 'ethrel' to the pedicels of young fruit. This method of artificially inducing wilt was used as a screening test to evaluate the potential of growth regulating substances to reduce wilt. Gibberellic acid and various auxins were applied, either in lanolin paste or as an aqueous solution, to fruits of various ages prior to the application of ethrel. Gibberellic acid applied in lanolin paste prevented the wilt of fruits up to 50 days old, but an aqueous spray was only active on fruits up to 10 days of age. Other auxins tried were less successful than Gibberellic acid. Field trials to include methods of application are now required.

Investigators at Purdue University, USA, have been studying alkaloid variation in cocoa. Theobromine and caffeine contents, which account for more than 99% of the alkaloids were determined using liquid chromatography with beans from Ivory Coast and Costa Rica. Catongo Blanco, an albino mutant of cacao from Brazil which has white seeds and white flowers was shown to have high theobromine content and low caffeine content. Pods with segregating seed colour as a result of cross pollination showed higher caffeine associated with purple seeds. However, segregating seed colour and caffeine or theobromine level indicated that the gene for anthrocyanin production is not associated with alakloid production.

The two final papers in this section were in complete contrast. The first dealt with an investigation of potential cocoa photo-synthetic productivity by means of a mathematical model simulating canopy photo-synthesis. The model was used to study the influence of the shade canopy leaf area, the cocoa canopy leaf area, and cocoa tree vigour on potential productivity,

assuming that water, temperature and nutrients are non-limiting to photosynthesis and using a cocoa tree canopy overlaid by a shade canopy. The results illustrate the importance of agronomic practices on potential productivity. Finally, a paper from the ODA cocoa research project in Ecuador dealt with the impact of breaks in the canopy on cocoa farm ecology. The most striking effects of a canopy break were due to the enormous increase in solar radiation which caused high soil temperatures, increased evaporation, soil moisture resistance and a rapid destruction of organic matter. Branches of trees adjacent to the breaks suffered from progressive physiological dieback and the non-productive area produced was more substantial than the vacancy count, caused by the breaks, would suggest. Seedlings replanted in areas which had been left vacant for more than three years made very poor growth.

Pests and Diseases

As on previous occasions, the conference was dominated by the subject of pests and diseases. Twenty papers being presented here, many of them dealing with witches' broom and monilia – demonstrating the concern felt about these diseases in South America. The session was opened by an invited paper on integrated control which referred inter-alia to the use of resistant cultivars and possible action to reduce the favourable effect of the climate on pathogens. This was followed by a paper reporting research in Bahia, Brazil, which had established the dragonfly *Gynacantha bifida* as a pest of the Xyleborus beetle and recommended steps to utilise this knowledge. Another paper, also from Brazil, reported on the evaluation of synthetic pyrethroids to control cocoa aphid. This showed that deltamethrin, permethrin and phenylvalerate showed respectively 98%, 98% and 96% effectiveness after 24 hours. A third paper in this section dealt with the change of Nematode types and levels during the first two years of establishment of young cocoa in Nigeria in a field inter-cropped with yam, maize and cassava. There was evidence that some nematodes had been introduced with the soil from the nursery.

The remaining papers, dealing with witches' broom, monilia and black pod, were unfortunately not grouped together thereby losing some of their impact. A paper from Imperial College, UK, described work on evaluation of the pathogenic races of *Crinipellis perniciosa*. Isolated from twelve sites in Brazil, Ecuador, Colombia, Trinidad and Venezuela, had shown six compatibility groups and there was evidence that the isolates of *C. perniciosa* from Ecuador were different from other isolates and that within these groupings further races might be differentiated. This work was associated with another paper from the same origin dealing with the water balance as a factor in the production of basidiocarps of *C. perniciosa*. The work showed that dry brooms subjected to a regime of 8 hours wet at 100% humidity and 16 hours dry produced basidiocarps on 92% of the brooms in successive flushes throughout the experiment. Basidiocarp production appeared to be linked with the water content of the broom which was about 50% in the wet period and 15% in the dry period. Work from Colombia reported the in-vitro evaluation of 40 fungicides for control of witches' broom and monilia. The final results showed that the systemic fungicides Bayleton, Plantvax, Sicarol and Vitavax, tested as inhibitors of mycelial growth of *C. perniciosa*, were the most effective, and of the protectants Baycor and Difolatan were the most

effective. The systemics Sicarol, Bayleton and Plantvax also gave a positive and highly significant correlation between mycelial growth, conidial sporulation and germination of *M. roreri*. The protectants, Euparen and Difolatan, also demonstrated their effectiveness.

Four papers on Monilia dealt respectively with the development and effect of the disease in Costa Rica showing its impact on two farms, while a paper from Colombia, where Monilia is estimated to cause the loss of one third of the total cocoa output, showed that the disease can be partially controlled by recommended procedures. Work was also reported on fluctuations in the spore population of Monilia and their viability over a complete infection cycle. The findings showed that the spore population of a sporulating mycelium increases rapidly from the first until the ninth day, then stabilizes until the twentieth day before decreasing markedly. The spores retain their viability until the sporulating mycelium has practically disappeared at about 80 days. A simple and quick method was reported from Venezuela to evaluate the efficiency of fungicides as anti-sporulants against Monilia. The products Maycor, Peltar, Difolatan, Captan, Penco Mangol and Bravo seemed promising for inhibiting sporulation of the fungus up to three days after the treatment under conditions of high humidity.

Three more papers described research in Colombia on witches' broom disease. The first of these demonstrated that the monthly average of broom formation in Uraba province over five years showed a peak in the months of December and January and a minimum in May and June. This indicated that broom formation followed a well-defined annual cycle broadly influenced by rain distribution, the physiological state of the tree and maximum and minimum periods of basidiocarp formation. It was possible to establish that formation of brooms in the field is correlated with the production of basidiocarps two months previously. A second paper described a two year study of the monthly distribution of broom formation and the relation of this to other climatic and economic factors. Observations were made between March 1979 and March 1981 of the monthly total of new infections for separate layers in the tree. Two plots each of 40 trees were used, the first with Criollo cocoa approximately 20 years old, and the second of hybrid cocoa approximately seven years old. Quantitative differences in the data were explained as differences in susceptibility of the two populations under study with the disease being more virulent on Criollo than on hybrids. In many ways, the most intriguing paper on witches' broom was from Pichilinque, Ecuador, where an experiment designed to map the spread of *C. perniciosa* was invalidated due to the presence of contaminating airborne inoculum coming from non-determined sources in excess of one kilometre away. However, the experiment showed that dead brooms generally require three to four months exposure to wet conditions before basidiocarp production is initiated; Suspended brooms produce significantly more basidiocarps than those on the ground due to the inhibitory effect of drying winds on the rate of decomposition; brooms on the ground still constitute an important source of inoculum, particularly in open situations subject to heavy dew or mist and should be removed and destroyed following a phytosanitary prune; basidiospores are common in the air between 22.00 and 04.00 hours following an increase in relative humidity and a decrease in temperature and are probably blown considerable distances; all parts of an unhardened flush are susceptible to infection and there is a sequence of

symptoms which usually ends in the formation of a broom in a later flush cycle.

Two of the papers on black pod disease dealt with *Phytophthora spp.* in the cocoa growing regions of Brazil and the first of these reported tests of 2425 isolates showing them divided between *Phytophthora palmivora, Phytophthora capsici* and *Phytophthora citrophthora*. Of these, *P. capsici* seems most prevalent in Bahia. Inoculation tests showed that this was, however, less virulent than *P. palmivora*. Work from Brazil reported tests of five new organic fungicides with low volume use. The research was to reduce the number of applications, save manpower, fuel and thus reduce the cost of spraying operations. An interesting paper from Ivory Coast reported on work designed to find out whether the resistance of some *Theobroma spp.* to attacks by *Phytophthora spp.* could be linked to the presence of phytoalexins which are thought to be one component of plant resistance to disease. Such a substance of high fungitoxicity was found in the stems of *T. grandiflorum, T. microcarpum, T. speciosum* and in a species of *Herrania*. A similar substance of weaker activity was detected in other *Theobroma ssp*. Finally, from Trinidad, two new inoculation methods of cocoa seeds for evaluating resistance against *P. palmivora* were described.

Extension

Eight papers were presented in this session and included two invited papers dealing respectively with the transfer of technology to cocoa farmers in Latin America and West Africa. A paper from Nacional Chocolate of Colombia described the work they have done over the past 22 years to help Colombia return to its status as a net exporter of cocoa. Four other papers dealt specifically with the progress of a pilot cocoa extension project in the Dunkwa district of Ghana, extension in the Alto Beni region of Bolivia, rural extension in Bahia and Espirito Santo in Brazil, and extension in the Ivory Coast. A final paper compared the economic efficiency, in terms of extension input, of two groups of cocoa growing enterprises in Brazil.

Genetics and Breeding

The section of the conference devoted to genetics and breeding displayed the subject in all its aspects including the important first stage of germplasm collecting described by the two invited speakers. The first speaker pleaded for the establishment of international cacao germplasm collections and the formation of a board as soon as possible to set them up. The next speaker described a systematic wild cocoa germplasm collecting project currently in progress in the Oriente region of Ecuador, funded by the London Cocoa Trade to celebrate its 50th anniversary. Unlike any previous wild cocoa collecting project, this one is firmly based on arrangements to establish the material in its area of collection before material is distributed via quarantine to other research stations for use in their breeding programmes. In this way losses of the material have been minimised. The session then proceeded to the complexities of cocoa breeding with papers on a partial diallel evaluation of selected clones, others on the comparison of hybrids and on genotype-environment interaction in a number of clones. An interesting paper dealt with the inheritance of clonal resistance to *Ceratocystis fimbriata* in hybrids. A paper from Togo reported a simple biological indexing test monitoring the development of the number of ovules

per ovary, this number being significantly reduced when the cocoa is infected with swollen shoot virus. A paper from Ivory Coast described behavioural studies of young cocoa trees under attack from psyllids, bollworms and thrips, which gives a very clear indication of their susceptibility to mirids. This points the way to making early selection of cultivars tolerant to mirid attack.

Fermentation, Storage, Marketing and Quality

The session opened with a paper presented on behalf of the International Office of Cocoa and Chocolate describing the ways in which manufacturers assess cocoa material for flavour, value, texture and purity. The speaker emphasised that, in an increasingly regulated world, it is necessary for research workers to be fully aware of the quality standards required by chocolate manufacturers. A paper from Malaysia reported investigations aimed at mitigating the acidity of Malaysian cocoa and improving the chocolate flavour. The work showed that use of a quick method of substrate reduction (24 hours standing of fresh beans followed by pressing), additional yeast inoculum and a 45 cm depth of ferment (as opposed to standard 90 cm depth) each decreased non-volatile acidity of nib. The effects of yeast and depth were highly significant. Volatile acidity was not affected, but non-volatile acidity was reduced by 57%.

Past conferences have often included details of cocoa pod breakers and a new machine developed in Brazil was described in a paper and demonstrated to the Conference on film. The machine operates by splitting pods lengthwise in two equal parts and the separator, consisting of a revolving tubular sieve of polyhedral section fitted with rods, shakes the beans loose so that they pass through a sieve mesh. The husks are expelled from the free end of the sieve. It is suggested that this machine working from a one horsepower motor with a single operator can open 3,000 pods per hour.

Two papers dealt with new methods for protecting cocoa beans against mould by combination treatments of heat and radiation, the first of these showing that a treatment combination of heat at 80°C, relative humidity at 85 per cent, and 4.0 kGy gamma irradiation proved to be the best combination. In a comparison of quality parameters, no statistical differences were found between treated cocoa and control for colour, odour, or taste, nor did the combination treatment cause any change in the quality of the cocoa butter from the beans. It would, no doubt be useful for consumers to evaluate samples of such treated beans through organoleptic testing if there is any chance that such methods might be used in the future. The final paper of the conference dealt with cocoa storage in polythene bags 0.1 mm thick with a capacity of 60 kg to test the possibility of increasing the storage time of cocoa beans on the farm. The work showed that this type of bagging could be used to store cocoa on the farm provided that the beans are bagged in a sanitary condition and with a moisture content no higher than 7.5%.

Notes on Contributors

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Born Liverpool, UK, 1944. B.Sc., Botany Honours, Queen Mary College, London University, 1965; M.Sc., Plant Pathology, Exeter University, 1966; Ph.D., Mycology, Keele University, 1969.

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From April 1980 to present working as Forest Mycologist at Commonwealth Mycological Institute, Kew, England, on diseases of Central American pines.

R. Shepherd

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Born in England in 1927. Joined the Cocoa, Chocolate and Confectionery Alliance in 1962 after working in the UK Scientific Civil Service and other trade associations. Responsible for administering the Alliance's activities on behalf of the UK chocolate industry in cocoa affairs, particularly cocoa research. Secretary, Cocoa Research Policy Committee of the International Office of Cocoa and Chocolate and also administrator of the Cocoa Research Association, Ltd., Ghana Cocoa Growing Research Association, Ltd. and London Cocoa Trade Amazon Project.

Cocoa Abstracts

Cocoa abstracts are reprinted from "Abstracts on Tropical Agriculture" published by the Royal Tropical Institute, Amsterdam.

September 1980

The cocoa podborer: a major hindrance to cocoa development WARDOJO, S. Research Inst. for Estate Crops, Bogor, Indonesia – *Indonesian Agricultural Research and Development Journal (Indonesia)* v. 2(1) p. 1-4, 21 1980.

The cacao pod borer, Acrocercops cramerella (Lepidoptera, fam. Lithocolletidae), is a major pest of cacao in Java. Up to the present no control method can be considered satisfactory. Life habits, damage and losses and control measures are discussed. Estimated yield reductions are of the order of 65 to 82 per cent. The pest also exists in the Philippines.

Cocoa pod rot disease; assessment of crop losses ADEBAYO, A.A. Cocoa Research Inst. of Nigeria (CRIN), Ibadan, Nigeria – *Turrialba (IICA)* v. 30(1) p. 57-61; Jan 1980.

A comparison is made between disease incidence and crop losses in cacao in view of the high crop protection costs in this crop. About 90 per cent of all pods infected by Phytophthora palmivora or Botryodiplodia theobromae are non-fermentable. However, only 30 per cent of the pods affected by Fusarium spp. are non-fermentable. In the latter case a straight conversion of disease incidence to crop loss is not justified.

(The influence of soil horizons in growth of cacao seedlings) Influência dos horizontales do solo no desenvolvimento de plântulas de cacau SILVA, L.F. DA; PEREIRA, C.P. Divisão de Geociências, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Revista Theobroma (Brazil)* v. 9(3) p. 85-92; Jul 1979.

An experiment with cacao seedlings grown in artificially constituted soils demonstrated the importance of the B-horizon.

(Effect of various sources of phosphorus on the growth of cacao seedlings) Efeitos da aplicação de diferentes fontes de fósforo no crescimento do cacaueiro em casa de vegetação MORAIS, F.I.; SANTANA, C.J.L. DE; PEREIRA, G.C. Divisão de Geociências (DIGEO), Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Revista Theobroma (Brazil)* v. 9(3) p. 119-128; Jul 1979.

A greenhouse pot experiment conducted on an acid cacao soil from Bahia comparing various sources of P, demonstrated the value of rock phosphate as a low cost alternative. Liming increased the growth and improved the efficiency of P fertilizers.

(Screening fungicides in vitro against Crinipellis perniciosa (Stahel) Singer, the causal agent of cacao witches' broom disease) Seleção "in vitro" de fungicidas a Crinipellis perniciosa (Stahel) Singer, causador da "vassoura-de-bruxa" do cacaueiro BASTOS, C.N.; MEDEIROS, A.G. Divisão Especial da

Amazònia, Commissão Executiva do Plano da Lavoura Cacaueira (CEPLEC), Belém, Pará, Brazil — *Revista Theobroma (Brazil)* v. 9(3) p. 129-135; Jul 1979.

The in vitro testing of the effect of 41 fungicides on Crinipellis perniciosa showed that some fungicides were highly effective at rates as low as 10 ppm a.i. while other fungicides were fungitoxic only at 50 or 100 ppm a.i.

Studies on the genus Forcipomyia. 4. The neotropical species of the subgenus Warmkea (Diptera: Ceratopogonidae) WIRTH, W.W.; SORIA, S. DE J. U.S. National Museum, Washington, D.C., U.S.A. — *Revista Theobroma (Brazil)* v. 9(4) p. 137-161; Oct 1979.

This paper revises the classification of subgenus Warmkea, genus Forcipomyia, which are important pollinators of cacao.

(Effect of substrates and foliar spray with fertilizers on the growth of cacao seedlings) Efeitos da adubação foliar e de substratos no crescimento de plântulas de cacau MORAIS, F.I.; SILVA, L.F. DA; MARIANO, A.H.; SOUZA PINHO, A.F. DE; Divisão de Geociências, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil — *Revista Theobroma (Brazil)* v. 9(4) p. 163-171; Oct 1979.

Mixtures of sugar-cane press cake and local soils were shown to be good substrates for cacao seedlings, and foliar sprays of 0.5 per cent urea applied 2 months after germination and at 15-day intervals thereafter were as effective as NPK fertilizers.

(Effect of aluminium on nutrient uptake and concentration in cacao) Efeito de alumínio sobre a absorção e concentração de nutrientes em plântulas de cacaueiro EZETA, F.N.; SANTANA, M.B.M. Divisão de Geociências, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil — *Revista Theobroma (Brazil)* v. 9(4) p. 173-184; Oct 1979.

Some oxisols and ultisols in Latin America are rich in aluminium. Studies on cacao grown in nutrient solutions showed that high levels of aluminium reduced uptake of N, P, Ca and Mg but increase K absorption while nitrate accumulated in the plant tissue.

(Hyperparasitism by the fungus Dactylium sp. of Crinipellis perniciosa (Stahel) Singer, on witches' broom disease of cacao) Hiperparasitismo do fungo Dactylium sp. a Crinipellis perniciosa (Stahel) Singer em "vassoura-de-bruxa" do cacaueiro BASTOS, C.N. Departamento Especial da Amazònia, Commissão Executiva do Plano Da Lavoura Cacaueira (CEPLAC), Belém, Pará, Brazil — *Revista Theobroma (Brazil)* v. 9(4) p. 197-200; Oct 1979.

The fungus Crinipellis perniciosa which is the causal agent of witches' broom disease was found to be parasitized by the fungus Dactylium sp. (— Cladobotrytum Nees), which renders the Crinipellis spores non-viable.

Annual report for the year 1978/79 International Cocoa Organization, London, UK — 36 p. 1979.

This annual report for 1978/79 discusses the membership of the International Cocoa Organization, the work of the International Cocoa Council, the operations of the economic provisions of the International Cocoa Agreement, the present world cocoa situation, and the 1979 United Nations Cocoa Conference.

(Ivory Coast, the number one cocoa producer) Ivoorkust, cacaoland nummer één ANON. — *Landbouwwereldnieuws (Netherlands)* v. 35(9-10) p. 123-125; 30 May 1980.

Cacao production in Ivory Coast has risen from 82,000 t in 1961/62 to approximately 330,000 t in 1979 because of a higher productivity and an increased area under cacao and notwithstanding the damage caused by, especially, capsids. The policies with regard to production, pricing, processing and exports are briefly described.

October 1980

An introduction to the cocoa & coconut industries of Malaysia. Published to mark the 1978 International Conference on Cocoa & Coconuts in Kuala Lumpur June 21-24, 1978 Malaysian Agricultural Research & Development Inst. (MARDI), Serdang, Selangor, Malaysia — 58 p. 1978.

This booklet provides brief information on cacao and coconut research and development, cultivation and processing in Malaysia. It also includes crop statistics and a bibliography on the two crops.

Studies on rodent damage to cocoa in south India: identification of their damage BHAT, S.K. Regional Station, Central Plantation Crops Research Inst., Vittal, Karnataka, India — *Planter (Malaysia)* v. 56(648) p. 101-104; Mar 1980.

Studies were made to distinguish squirrel (Funambulus spp.) and rat (Rattus rattus) damage on cacao pods to assess their economic importance in the field. Squirrels had the tendency to make oval holes in the central or terminal portion of the pods, while rats made oval or round holes near the stalk region of the pod.

(Study on the pollination of cacao on the basis of insect traffic: mathematical model and simulation) Etude de la pollination du cacaoyer à partir du trafic des insectes: modèle mathématique et simulation REFFYE, P. DE; PARVAIS, J.P.; COULIBALY, N.; GERVAIS, A. Institute Français du Café et du Cacao (IFCC), Bingerville, Ivory Coast — *Café, Cacao, Thé (France)* v. 24(2) p. 83-100; Apr 1980.

A quantitative study on cacao pollination based on operational research theory led to the conclusion that the distribution of pollen on the styles can be forecast with precision if certain conditions are met and that natural pollination could be reconstructed by simulation.

(Behaviour of some clones under manual pollination: ovular fertility and early flower shedding) Comportement de quelques clones en pollinisation manuelle: fertilité ovulaire et chute précoce des fleurs pollinisées MOSSU, G. Institut Français du Café et du Cacao (IFCC), Bingerville, Ivory Coast — *Café, Cacao, Thé (France)* v. 24(2) p. 113-120; Apr 1980.

Under saturated manual pollination conditions using pollen known to be compatible, it was possible to specify the ovular fertility of cacao clones. Physiological wilting was found to be independent of the number and stage of development of the seeds: early shedding of fruits seems to be the result of a defect causing their unsuitability for fertilization.

(The swollen shoot disease of cacao in Togo: the various forms of the virus and their economic consequences) Le swollen shoot du cacaoyer au Togo: les différentes formes de viroses et leurs conséquences économiques CASTEL, C.; AMEFIA, Y.K.; DJIEKPOR, E.K.; PARTIOT, M.; SEGBOR, A. Institut Français du Café et du Cacao (IFCC), Lomé, Togo – *Café, Cacao, Thé (France)* v. 24(2) p. 131-146; Apr 1980.

This paper gives a qualitative analysis of the development of swollen shoot of cacao in Togo and its effect on growers' revenues, and makes suggestions for a strategy for its control.

(Report of activities during 1979) Rapport d'activité 1979 Institut Français du Café et du Cacao (IFCC), Paris, France – 114 p. 1980.

Research activities on coffee, cacao, kola and tea during the year 1979 were recorded. Genetic improvements, cultural practices, plant protection measures and improvement of the quality of commercial produce in various countries, including Ivory Coast, Togo and Cameroon, are reviewed.

Establishment of Gliricidia maculata in Bungor series soil WILLS, G.A. Jasin Lalang Estate, Jasin, Malacca, Malaysia – *Planter (Malaysia)* v. 56(649) p. 128-136; Apr 1980.

A description is presented of the establishment of Gliricidia maculata as a shade tree for cacao. The effect of soil type on establishment is described. Cuttings should be 2.5-5.0 cm in thickness, cut at right angles, waxed at the top, dipped in dieldrex at the bottom, planted 15 cm deep especially during dry periods in a loose soil at 1.5 x 3 m spacing to be gradually thinned to 12 x 12 m in later years. Establishment of Cajanus Cajan as a nurse shade is indicated, as well as the ground cover maintenance and the control of the shade trees.

November 1980

(The fertility of the cacao soils of Colombia) Generalidades sobre la fertilidad de los suelos en las zonas cacaoteras colombianas GARCIA OCAMPO, A. Centro Experimental Palmira, Instituto Colombiano Agropecuaria (ICA), Palmira, Colombia – *Cacaotero Colombiano (Colombia)* no. 10, p. 15-30; Sep 1979.

Results of a soil fertility study on the cacao soils in Colombia based on soil analysis data from some 2400 soil samples are discussed with particular attention to pH, exchangeable Al, Ca, Mg, organic matter, P and K contents.

(On the origin of cacao, Theobroma cacao L., Sterculiaceae) Sur l'origine du cacaoyer, Theobroma cacao Linné, Sterculiacées Laboratoire d'Ethnobotanique et d'Ethnozoologie, Muséum National d'Histoire Naturelle, Paris, France – *Journal d'Agriculture Traditionnelle et de Botanique Appliquée (France)* v. 26(3-4) p. 171-180; Jul 1979.

It is concluded that the two main groups of cultivars, i.e. Criollo and Forastero, have differentiated from a common origin in the upper Amazon area. Forastero may have been domesticated by the Indians in pre-Columbian times.

(Cacao production in the world economy) La production cacaoyère dans l'économie mondiale BRAUDEAU, J. Institut Français du Café et du Cacao (IFCC), Paris, France – *Journal d'Agriculture Traditionnelle et de Botanique Appliquée (France)* v. 26(3-4) p. 217-232; Jul 1979.

The production, consumption and trade of cacao are discussed with emphasis on the last ten years which saw the decline of cacao production in Ghana and Nigeria and its development in Ivory Coast and Brazil, and the increase in the processing of cacao in producing countries.

(Current trends in cacao research and recent developments in the improvement of cacao production) Les tendances actuelles de la recherche cacaoyère et les acquis récents dans l'amélioration de la production du cacao LIABEUF, J. Institut Français du Café et du Cacao (IFCC), Paris, France – *Journal d'Agriculture Traditionnelle et de Botanique Appliquée (France)* v. 26(3-4) p. 247-265; Jul 1979.

Research on the production and local processing of cacao is reviewed against the background of the global economic importance of the crop.

Rat species survey in cocoa FINDLAY, G. Samoan-German Crop Protection Project, Apia, Western Samoa – *Alafua Agricultural Bulletin (Western Samoa)* v. 5(2) p. 59-61; Apr 1980.

The rat population on Samoan cacao plantations was found to be composed of 87.3 per cent Rattus exulans, which is also the most harmful species, 11.5 per cent Rattus norvegicus, and 1.2 per cent Rattus rattus. Damage can be reduced by removal of the undergrowth.

Annual report 1975-76 Cocoa Research Inst., Tafo, Ghana – 250 p. 1978.

This report describes the administration and management of the Cocoa Research Institute, Ghana, and its substations, and the research carried out in the fields of agronomy, breeding, plant protection, soil science and physiology in 1975/76.

(Pest control in cacao) Control de plagas en cacao RINCON SEPULVEDA, O. – *Cacaotero Colombiano (Colombia)* no. 7, p. 35-38; Mar 1979.

For a number of reasons some 30 per cent of the cacao harvests in Colombia is lost due to pest and disease incidence. The main insect pests include: borers (Xyleborus spp.), bugs (Monalonion spp.), various leaf-sucking insect species, black bug (Mecistorhinus spp.) and cutting ants (Atta spp.). This article presents some information on the type of damage and species involved, and on biological and chemical methods of control.

(The effect of climatic and biotic factors on the population dynamics of Forcipomya spp. and cacao pollination in Bahia, Brazil) Las relaciones de variables climáticas y bióticas con la dinámica de población de Forcipomya spp. (Diptera, Ceratopogonidae) y la polinización del cacaotero en Bahía, Brasil SORIA, S. DE J. Divisão de Zoología, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Cacaotero Colombiano (Colombia)* no. 9, p. 41-46; Jun 1979.

This article briefly reports studies conducted in Bahia, Brazil, on the effect of climatic parameters on the population density of Forcipomyia midges which are responsible for pollination of cacao. Air temperature, soil

moisture conditions, rainfall and sunshine patterns appeared to mainly determine the population density of this insect.

(Guide to the control of witches' broom and Monilia pod rot) Guía sobre control de la escoba de bruja y la Monilia Departamento de Fomento, Compañía Nacional de Chocolates S.A., Medellín, Colombia – *Cacaotero Colombiano (Colombia)* no. 10, p. 7-14; Sep 1979.

Practical guidelines are presented for growers in Colombia on the control of pod rot (Monilia roreri) and witches broom disease due to the fungus Crinipellis perniciosa in cacao.

Malaysian cocoa: some observations on its quality and value Cocoa Association, London, UK – *Planter (Malaysia)* v. 56(650) p. 189-192; May 1980.

This article provides information on the quality and value of Malaysian cacao as compared with Ghana cacao. The Malaysian cacao is considered inferior in respect of dry nib yield, fat yield, bean size and quality/flavour. Much Malaysian estate cacao is well prepared and as good as cacao produced anywhere else in the world. Some estate and most smallholder cacao, however, is not well prepared and steps should be taken to introduce grading standards so that buyers of Malaysian cacao know what they are getting. The grades should conform to the FAO grade model ordinance. It is also proposed that parcels should be classified according to bean size, for instance as no more than 110 beans per 100 g and over 110 beans per 100 g.

December 1980

Cocoa: a summary of some recent and current experience, and some suggested specifications for trials on inland soils in Kelantan VIVIAN, L.A. State Land Development Board, Kelantan, Malaysia – *Planter (Malaysia)* v. 56(648) p. 88-100; Mar 1980.

Detailed information is presented on cacao in respect of planting materials, nursery procedures, field practices, harvesting and processing in Malaysia for persons interested in starting a cacao plantation.

World market trends and prospects for cocoa OKORIE, A.; BLANDFORD, D. Department of Agricultural Economics, Cornell Univ., Ithaca, New York, USA – *Cornell International Agriculture Mimeograph (USA)* no. 73, 63 p.; Sep 1979.

This study analyses cacao production, consumption, imports and exports, and producer and consumer policies. It presents an empirical analysis of the demand for cacao and on this basis makes projections of cacao consumptions and revenue in the 1980s.

(A method for the isolation of the fungus Monilia roreri) Un método de aislamiento del hongo Monilia roreri, Cif y Par BAROS, N.O.; SANCHEZ, L., J.A. Departamento de Fomento, Compañia Nacional de Chocolates S.A., Medellin, Colombia – *Cacaotero Colombiano (Colombia)* no. 11, p. 27-40; Dec 1979.

Studies conducted in Colombia showed that isolation in pure cultures of the fungus causing pod rot in cacao, Monilia roreri, is no longer a problem. The method which was most successful is described. Infected pods 1 to 3

months of age were washed in running water, disinfected with 1 per cent sodium hypochlorite, treated with 40 per cent alcohol and flamed with an alcohol burner. Then small pieces of infected tissue were removed from the pod and transferred to the culture medium.

(Cocoa and a new international division of labour) Cacao en een nieuwe internationale arbeidsverdeling SCHUURS, F. Catholic Univ., Tilburg, Netherlands — *Rapport — Onderzoeksproject IRIS. IVO. Katholieke Hogeschool Tilburg (Netherlands)* no. 12, 182 p.; May 1980.

The report presents a study on the cacao processing industries, the prospects for cacao processing industries in cacao producing countries and the consequences for the cacao consuming countries of this development. The need for restructuring the cacao industry in the Netherlands is discussed.

(Higher earnings from using certified seed and applying better cultural practices) Gane más sembrando semillas mejoradas y manejando bien el cultivo MORENO P, L.J. Compañía Nacional de Chocolates, Medellín, Colombia — *Cacaotero Colombiano (Colombia)* no. 13, p. 9-11; Jun 1980.

Interest in cacao growing in Colombia is increasing. The use of early and high-yielding hybrids, resistant to witches' broom disease (caused by Marasmius perniciosus), is recommended. Hybrids with good tolerance of witches' broom from ICA (Colombian Institute of Agriculture) include SCA-6 x IMC-67, ICS-6 x SCA-6, TSA-654 x ICS-6 and EET-96 x SCA-6.

(Monilia pod rot of cacao) La moniliasis del cacao CAMPUZANO, H. — *Cacaotero Colombiano (Colombia)* no. 13, p. 21-24, Jun 1980.

Monilia roreri, causing Monilia pod rot of cacao can bring about 30 to 40 per cent yield losses in Colombia. External symptoms of the disease, etiology, epidemiology and control measures are discussed.

(Study on antiphycomycete systemic fungicides with a view to controlling black pod disease due to Phytophthora spp. in cocoa trees: search for a laboratory method of screening seedlings) Etudes des fongicides systémiques anti-phycomycètes en vue de la lutte contre la pourriture brune des cabosses du cacaoyer due à Phytophthora sp: recherche d'une méthode de tri sur plantules en laboratoire DAGUENET, G. Laboratoire de Phytopathologie, Institut Français du Café et du Cacao (IFCC), Abidjan, Ivory Coast — *Café, Cacao, Thé (France)* v. 24(3) p. 195-202; Jul 1980.

This paper describes a screening method for systemic fungicides against Phytophthora sp. in cacao based on their efficiency and translocation in young seedlings.

January 1981

Utilisation of cocoa by-products as animal feed HUTAGALUNG, R.L. and CHANG, C.C. University of Malaya, Kuala Lumpur, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts. Kuala Lumpur, Malaysia, June 21-24, 1978* p. 447-456 1980.

Experiments were undertaken with poultry and pigs to evaluate the feeding value of cocoa husk-based diets. It is estimated that out of 16,835 t of dry cocoa beans produced in Malaysia in 1976, 2525 t of shells and 11,953 t of pod husks are available. Dry pod husks and shells contain 6.4 and 20.4 per cent protein, 1.5 and 60.0 per cent fat, and 27.1 and 11.7 per cent

crude fibre, respectively. Chicken fed with a diet containing 10 per cent cocoa husks showed similar responses in gains and feed efficiency as compared with those on the control diet. Addition of cocoa husks to the diet beyond the 10 per cent level depressed body weight gains and feed/gain ratio. Feeding pigs with pod husk-based diet gave favourable gains, feed efficiency and carcass quality compared to those on the control. The use of cocoa by-products as animal feed in the livestock industry would represent a significant gain to the cocoa industry.

The feeding value of by-products from cocoa and coconuts in diets for farm livestock DEVENDRA, C. Malaysian Agricultural Research and Development Inst. (MARDI), Serdang, Selangor, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 457-471 1980.

By-products from cocoa (cocoa pod husk, CPH) and coconuts (coconut cake or copra cake, CC) are major basic ingredients in feeding systems for livestock. Both by-products are suitable for feeding ruminants (cattle, buffaloes, goats and sheep) and non-ruminants (pigs and poultry). Chemical compositional data are given for each by-product. In view of the low crude protein content (about 6.0 per cent) and high crude fibre content (about 31.0 per cent) in CPH, it is more suited to feeding ruminants. CC has a higher crude protein content (about 18.0 per cent) and is considered a medium quality protein source suitable for feeding non-ruminants as well. Balance studies with sheep fed graded levels of CPH indicated that 30—40 per cent levels were optimal in molasses-based diets. Several studies have shown that very high levels of CC (up to 90 per cent) can be used to feed ruminants, but with non-ruminants lower levels, up to 40 per cent with lysine and methionine supplements, are optimal.

Determination of pod and bean characters in progeny trials with cocoa LOCKWOOD, G. and EDWARDS, D.F. Cocoa Research Inst., Tafo-Akim, Ghana — *Tropical Agriculture (Trinidad and Tobago)* v. 57(4) p. 289-300; Oct 1980.

A simple and reliable technique for making sample fermentations from individual progenies at every harvest from breeding trials with cocoa is described. These fermentations permit accurate estimation of wet-to-dry weight conversion ratios, mean bean weights, average bean number per pod and pod values. Results obtained are illustrated with data from 6 trials and show that unless pod values are determined accurately, serious errors in yield estimates can arise. The 4 characters studied varied with progenies but there was no interaction between progenies and seasons. Mean bean number per pod was low in several progenies of Upper Amazon. This result is discussed in relation to the pollination and fertility of cocoa.

Growth and nutrients composition of monocrop cocoa plants on inland Malaysian soils THONG, K.C. and NG, W.L. Dunlop Research Centre, Batang Melaka, Negri Sembilan, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 262-286 1980.

Growth of cacao plants was very rapid during the first 3 to 4 years in the field, after which a steady growth was recorded. The lamina of the leaf was the most important nutrient sink for all elements while the branch + stem

component is the other major nutrient storage sink. The abundance of nutrients accumulated by the plant in situ was in the order of K > N > Ca > Mg > P > Mn > Zn. Distribution of roots indicated that cacao was a surface-root feeder, while most of the lateral roots were found in the surface soil layer (0-30 cm) and closest to the plant base (0-46 cm). On inland soils in Malaysia, a cacao crop of 1000 kg dry beans + husks/ha removed the following nutrients per year: 31.0 kg N, 4.9 kg P, 53.8 kg K, 4.9 kg Ca, 5.2 kg Mg, 0.11 kg Mn and 0.09 kg Zn. The importance of K and N in growth and production of cacao is strongly indicated.

Bionomics and control of some lesser known insect pests of cocoa in Sabah SHAH, S. BAL Estates, Tawau, Sabah, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 295-307 1980.

In recent years damage to cocoa has been caused by various insects in Sabah which were either not recorded previously on the plant or had been seen as species of minor importance elsewhere. Outbreak of Ceroplastodes chiton, a homopteran, was the result of an extensive spraying operation against a geometrid, Buzura suppressaria and was eventually controlled by its natural enemies, after they had time to multiply to sufficient numbers. Manipulation of spraying schedules in case of a lycaenid, Nacaduba normani was found effective in controlling the larvae which had appeared in fields continually under insecticidal sprays. Amongst Coleoptera, a trunk-boring cerambycid, a polyphagous curculionid and the irridescent beetle appeared as important pests. Out of a number of chemicals tried against the curculionid, DDT appeared effective. The most convenient way to control the irridescent beetle so far appeared to be insecticidal sprays.

Cocoa diseases in Malaysia and Indonesia: their present and potential importance TURNER, P.D. and SHEPHERD, R. Harrisons Fleming Advisory Services Ltd., London, UK — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 308-321 1980.

The current cacao situation is summarized. Disease in nurseries is currently almost totally avoidable. Root disease incidence is presently low, with occasional attacks including those by Ganoderma pseudoferreum, Phellinus noxius and Rigidoporus lignosus. Losses from pod rots have been slight in all areas, despite the widespread distribution of Phytophthora palmivora. The most important disease in some plantings is vascular-streak dieback (Oncobasidium theobromae), necessitating use of resistant planting material particularly some Upper Amazon hybrids. The importance of the widespread virus disease of the swollen shoot group in Indonesia is still uncertain. There is a need to ensure that more virulent pathogens from Africa and Latin America continue to be excluded from Asia.

Thinning and vascular streak dieback control in high-density cocoa plantings under coconuts JAYAWARDENA, M.P.G.S., PATMANATHAN, M. and RAMADASAN, K. Kuril Plantations, Teluk Anson, Perak, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 322-339 1980.

High-density cocoa plantings under coconuts at about 1500 points/ha on 2 estates in Lower Perak have not come up to expectations. The higher

early yields anticipated have generally not been realized, and plant growth and vigour has been adversely affected. An abnormally high incidence of vascular-streak dieback (VSD) caused by Oncobasidium theobromae has been observed and has posed problems with a thinning programme. The programme was initiated in early 1976 when cocoa prices were unduly high. Much thought had to be given not only to bring the spread of VSD under control and to improve yields in the long term, but also to ensure that the measures adopted would involve minimal crop loss during and immediately after implementation. The history of these plantings is reviewed, their present condition is assessed and the methods of rehabilitation employed to-date are described, with an indication of costs involved in VSD control.

Some aspects of monoculture cocoa establishment on an estate in Peninsular Malaysia KHOO, K.M. and SERGEANT, C.J. Sime Darby Plantations, Kuala Lumpur, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 345-353 1980.

The planting of monoculture cocoa on the coastal plain of the west coast of Peninsular Malaysia is described. In the process, established techniques of crop husbandry had often to be varied and new techniques evolved. Main areas of innovation were: the setting up of a seedling nursery under oil palms; use of older planting material than was usual in the industry; the large-scale use of Albizia falcata as short and medium-term shade. Many other types of shade were also tried. It is concluded that monoculture cocoa can be successfully established on coastal clays.

Early experiences in large-scale cocoa planting in FELDA LEE, A.K. and YEONG, W.L. Federal Land Development Authority, Kuala Lumpur, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 354-367 1980.

Adopting the pattern of land development experiences in clearing jungle for the planting of rubber and oil palm, FELDA (Federal Land Development Authority) started clearing the jungle, at a modest hectarage, for the planting of cocoa in late 1969. With the experiences gained during these few years in the management of jungle-clearing for cocoa planting, and the husbandry and agronomic requirements of the crop, the hectarage cleared for cocoa planting increased tenfold by 1977. The choice and requirement of planting material, nursery practice, shade requirement, spacing and plant density, labour and other input requirements and problems faced in large-scale development for cocoa planting are discussed.

Preliminary efforts to improve the quality of cocoa beans SHAMSUDIN, S., IDRUS, A.Z. and HASSAN, M.H. Malaysian Agricultural Research and Development Inst. (MARDI), Serdang, Selangor, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 415-424 1980.

Preliminary efforts to improve cocoa bean quality by fermenting in boxes with increased size of gap spaces on the sides and bottom yielded dried beans with good pH (5.3). Fermentation batches amounted to about 450 kg. These techniques are expected to be useful for adoption by smallholders as the method used was based on their usual practices.

The criteria and mechanism for the removal of cocoa bean acidity LIAU, H.T.L. Agricultural Research Centre, Tuaran, Sabah, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 425-439 1980.

The methods for the elucidation of the criteria for the removal of cocoa bean acidity previously reported are now described in detail. The acid removed is shown to be acetic acid and the mechanism of its removal is by oxidative degradation within the tissues. The outward migration of the acid as a result of the large pH gradient created by the requirement for the availability of oxygen also contributes to the final cotyledon pH.

Cocoa marketing: some pertinent problems in Peninsular Malaysia DERMAN, I. Harrisons & Crosfield, Kuala Lumpur, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 472-483 1980.

Cocoa is a relatively new crop in Malaysia and signs are already pointing towards its ultimate build-up as the third major crop after rubber and oil palm. The fervour in expanding cocoa cultivation began in 1965 when existing planted acreage was around 2950 ha; by 1975, however, the area under cultivation had expanded more than tenfold. A corresponding increase was recorded in its production which stood at an estimated 17,000 tonnes in 1975, from a mere 1000 tonnes in 1965. Observers are currently placing Malaysian production at around 50,000 tonnes by 1984/85. Although this tonnage will only represent around 3 per cent of the world total production, it is vital that Malaysia should now gear itself to improving agricultural practice, quality and marketing technique to allow for a healthy growth of the industry.

February 1981

(The use of diuron in coffee and cocoa nurseries in the Ivory Coast) Utilisation du diuron en pépinière café et cacao on Côte d'Ivoire SNOECK, J. Institut Français du Café et du Cacao (IFCC), Abidjan, Ivory Coast — *Troisième Symposium sur le Désherbage des Cultures Tropicales, Dakar, Senegal* vol. 2, p. 340-346 1978.

Weeding of coffee and cacao is very laborious, requiring 50 mandays per month per ha. Trials were conducted applying 600, 900 and 1200 g of diuron 80 per cent a.i./ha, 6 days before the transplanting of the young coffee seedlings (T-6). Weeds were indeed controlled for 3 months, but complementary hand weedings were still necessary. In a cacao nursery, diuron 80 per cent was applied at dosages of 0.83, 1.250 and 1.666 kg/ha at S-2 (2 days before sowing) and this was repeated at S + 1. It was shown that all the treated plots were nearly free of weeds for a period of 6 to 8 months, without any signs of phytotoxicity. Chemical treatment was shown to be 66 per cent cheaper than hand weeding.

(Cameroon: the marketing system for coffee and cacao) Cameroun: le système de commercialisation du café-cacao LENGLART, J. — *Construire Ensemble (Upper Volta)* no. 3, p. 10, 14 1980.

In Cameroon the marketing of coffee and cacao depends in general on supply and demand in a long chain between producer and consumer. In the

country itself there are already the producer, the buyer and the exporter. However, marketing cooperatives have been established to protect the interests of the producer. In 1955 a price stabilization fund for cacao was established under the direction of the Ministry for Planning. Its organization and workings are described and discussed.

(Soils and fertilization of cacao in the department of Antioquia) Suelos y fertilización del cacao en el departamento de Antioquia CADAVID, V, S. Departamento de Fomento, Compañía Nacional de Chocolates, Medellín, Colombia – *Cacaotero Colombiano (Colombia)* no. 14, p. 7-17; Sep 1980.

The department of Antioquia produces about 3200 t of cacao with an estimated 350 kg/ha on the average. This low productivity is due to low-yielding planting material, bad cultural practices and low soil fertility. The results of about 500 chemical soil analyses are discussed and the ensuing fertilizer recommendations are recorded.

(Effect of increasing rates of soil applied Mg on growth of cacao seedlings) Efecto de varias dosis de magnesio aplicadas al suelo sobre el crecimiento de plántulas de cacao QUICENO, O, J.; NARANJO, A, G. and GARCIA, O, A. Centro Experimental Palmira, Instituto Colombiano Agropecuario (ICA), Palmira, Colombia – *Cacaotero Colombiano (Colombia)* no. 14, p. 26-39; Sep 1980.

Seeds of cacao var. ICS 60 x SCA 12 were sown in polythene bags containing soil with high levels of Ca, Mg and K. Magnesium sulphate was added at rates between 0 and 38.9 meq. per 100 g of soil. One hundred and twenty days after sowing the young seedlings were uprooted and analysed for Ca, Mg and K content. Height, stem diameter, foliar area and number of leaves were also determined. The results obtained indicated that best seedling development was obtained in soils with a Ca/Mg ratio between 1:1 and 1:2. Ca/Mg ratios of 1:3 and 1:4 had adverse effects on plant growth.

Effect of boron, calcium, and magnesium on cherelle wilt in cacao UTHAIAH B.C. and SULLADMATH, U.V. Division of Horticulture, University of Agricultural Sciences, Bangalore, Karnataka, India – *Journal of Plantation Crops (India)* v. 8(1) p. 24-28; Jun 1980.

Studies with 9 year old Upper Amazon trees showed that foliar concentrations of Ca, B and Mg could be increased 3-7 fold. B foliar and soil dressings could raise leaf B from 11 to 88 ppm, leaf Ca could be raised from 0.85 to 2.7 per cent by applying lime and leaf Mg could be increased from 0.12 to 2.20 per cent by soil and foliar Mg gifts. Wilting pods contained 40 ppm B as against 20 ppm in healthy pods. Also healthy pods contained 1.86 per cent Ca and 0.25 per cent Mg as against 1.10 per cent and 0.14 per cent respectively for wilting pods. Ca alone could carry 55 per cent more pods to maturity and reduced wilt by 1 per cent.

Nematodes associated with Theobroma cacao YUEN PAK MUN Malaysian Agricultural Research and Development Inst. (MARDI), Serdang, Selangor, Malaysia – *MARDI Research Bulletin (Malaysia)* v. 7(1) p. 54-58; Apr 1979.

In random sampling of 3 cacao varieties (Amelonado, Upper Amazon and Sabah mixed hybrid), 7 genera of phytoparasitic nematodes were recorded, of which Helicotylenchus and Rotylenchulus were most common.

Of these 2 genera, R. reniformis showed a host preference for Tephrosia rather than cacao when both were planted together. In Malaysia, no species has yet been proved to be pathogenic to cacao.

Effects of thinning of coconut stand on the performance of coconuts and the underplanted cocoa on coastal clay soils in Peninsular Malaysia KHOO, K.T. and CHEW, P.S. Highlands Research Unit, Kelang, Selangor, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 143-157 1980.

Data from two trials on coastal clay soils of Peninsular Malaysia showed that reduction in the density of an established coconut stand affected the performance of both the coconuts and the underplanted cocoa. Yield responses in both crops were evident by about one year after thinning. Manuring influenced the thinning effects on both crops. The coconut palms and cocoa plants also competed with each other for nutrients.

March 1981

Intercropping cocoa and oil palm LEE, A.K. and KASBI, H. Tun Razak Agricultural Research Centre, Federal Land Development Authority (FELDA), Jerantut, Pahang, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 158-171 1980.

In a feasibility study of intercropping cacao and oil palm using various combinations of avenue planting, 3 intercropped treatments were tested against their respective monocrop controls. The most promising treatment appears to be the one with single row oil palm at 10 m x 7 m (143 palms/ha) interplanted with a single row of cacao at 10 m x 2.5 m (400 trees/ha). The hedged planting of oil palm has not resulted in any depression of its yield. The yield of cacao on the other hand corresponds almost proportionally to its respective planting density in the various treatments. A simple cost-benefit analysis indicates that monocropping of cacao gives a better return than monoculture of oil palm, but the returns can be comparable when the latter is suitably intercropped with cacao. However the trial has entered only its 7th year.

Imbibed storage of cacao seeds in osmotic solutions GOLDBACH, H. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica — *FAO Plant Genetic Resources Newsletter (FAO)* no. 43, p. 16; Oct 1980.

Experiments were carried out in Costa Rica to imbibe seeds with abscisic acid solutions to inhibit germination. To delay germination of cacao seeds with such inhibitors failed. However storage in solutions of high osmotic potential gave better results. When cacao seeds were stored in solutions of PEG 6000 (polyethylene glycol) which had osmotic potentials of -13 to -15 bars, their root tips emerged, but did not continue to grow. They germinated quickly afterwards and produced healthy seedlings. Experiments have started to distribute commercial quantities of hybrid cacao seeds, imbibed with PEG 6000 solutions.

World cocoa bean production to be above record 1979/80 harvest DULL, R.E.T. Foreign Agricultural Service, USDA, Washington, D.C., USA – *Foreign Agriculture Circular, Cocoa (USA)* USDA-FCB 3-80, 17 p.; Nov 1980.

World cocoa bean production for 1980/81 is forecast at 1.63 million t, a record due to higher production in Brazil and Malaysia and notwithstanding lower yields in Africa. World stocks are expected to increase and prices to remain low. Details on production, consumption and stocks are provided by country.

Some studies on mammalian pests in cocoa planted under coconuts HAN, K.J. and SUBASH BOSE Highlands Research Inst., Syarikat Penyelidikan Pertanian Barlow Boustead Sdn. Bhd., Kelang, Selangor, Malaysia – *Perak Planters' Association Journal (Malaysia)* p. 102-109 1979.

Mammalian pests cause very serious losses in cacao under coconuts. Up to 92 per cent of the crop on the trees may be damaged. The rats and squirrels also cause damage to the coconuts, which appear to be a principal food source to the rodents. Rats were the main problem in cacao, especially Rattus tiomanicus. Only very few R. argentiventer appeared to feed on the cacao. The squirrels were far fewer than the rats. Extent of damage to cacao pods was found to vary greatly with the cacao cropping season. Baiting with warfarin baits reduces incidence considerably but not completely. Trapping has been tried with some success against squirrels and shooting for civets appeared to be the most effective method for the latter.

Monocrop cocoa on inland soil WILLS, G.A. Jasin Lalang Estate, Melaka, Malaysia – *Perak Planters' Association Journal (Malaysia)* p. 72-77 1978.

This paper is a description of techniques found to be necessary in one particular area in the planting of monocrop cacao. As everybody knows, planting techniques must vary according to soil types, climatic conditions, terrain and so on. For instance, techniques employed in South Malacca or in North Johore might be totally unsuitable either for the Selangor coastal plain or for Sabah where the rainfall distribution is more even. Further technical developments must also occur as knowledge of cacao planting increases in different areas. In the writer's opinion an even greater variety of techniques will, and must, develop throughout Malaysia in future years.

Cocoa breeding and selection investigations at Prang Besar Research Station ANG, B.B. and SHEPHERD, R. Research and Advisory Scheme, Harrisons & Crosfield, Kuala Lumpur, Malaysia – *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 3-17 1980.

This paper considers breeding and selection methods used for production of superior cocoa seedling progenies and clones. The authors indicate that there is considerable scope for production of cocoa clones, especially for planting in environments where vascular-streak dieback (VSD) could prove troublesome. Results of seedling progeny trials reveal significant difference in progeny vigour, susceptibility to diseases, yield capacity and bean size.

Performance of some cocoa hybrids under exposed conditions LEE, A.K. Tun Razak Agriculture Research Centre, Federal Land Development

Authority (FELDA), Jerantut, Pahang, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 18-31 1980.

Twenty-three hybrid progenies were used against the common Sabah seed garden (SG) mixed hybrids. Progeny differences were observed in their response to establishment under fully-exposed conditions. All the Upper Amazon crosses involving Nanay — Parinari and most of the Trinitario — Upper Amazon hybrids had relatively good establishment ability. On the other hand, the two Amelonado — Trinitario hybrids and one of the Amelonado — Upper Amazon crosses involving Pa 35 established and yielded very poorly under the same conditions. Many of the varieties tested have yielded as well as, if not better than, the Sabah SG hybrids, particularly those from the Trinitario — Upper Amazon crosses tested; the Trinitario/ Parinari family appeared to give the best bean size and yield. The existence of a large amount of variation in the Trinitario — Upper Amazon group of hybrids offers good prospects for further improvement of yield and bean size through breeding and selection.

Performance of Amelonado cocoa on basalt soils in Sabah PHILLIPS, T.A. and ARMSTRONG, K.B. Commonwealth Development Corporation, London, UK — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 32-43 1980.

Within Malaysia considerable emphasis is currently placed on the use of vigorous or precocious Amazon hybrid planting material to the total exclusion of Amelonado cocoa. Past experience with Amelonado Cocoa in Peninsular Malaysia justifies this action. However, under suitable soil and climatic conditions in Sabah a marked improvement in the yield of Amelonado cocoa was achieved by management techniques involving the organized reduction of overhead shade coupled with fertilizer applications and pest control. Commercial yields of suitably managed Amelonado cocoa are currently seen at levels not less than and, in certain blocks, higher than that of Sabah Amazon hybrids. Whilst differences in ease of management, time to maturity and susceptibility to disease exist between these two types of cocoa, the result achieved in Sabah convincingly demonstrates the high yield potential of mature Amelonado material under optimal conditions.

Production of rooted cuttings under Malaysian conditions RAMADASAN, K. Malaysian Agricultural Research and Development Inst. (MARDI), Hilir Perak, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 44-56 1980.

The following methods of producing rooted cacao cuttings were investigated: (a) Trinidad-type bin propagators, (b) closed polybag units (Nichols' method and Gnanaratnam's method), (c) mist propagation units, (d) polythene sheet propagators, and (e) mist humidification units. Success rate was comparatively low in the closed polybag propagators. Based on actual performance to date, Nichols' method was the most expensive. Mist propagation was rather costly due to high capital outlay and running costs. Rooted cuttings produced by the polythene sheet method and the Trinidad-type bin propagator were comparable in cost with seedlings and were cheaper than buddings. Considerable scope is seen for mist propagation and mist humidification.

Shaping of clonal cocoa plants derived from fan shoots RAMADASAN, K.; YUMUS AHMAD, M. and SHARIF AHMAD, M. Malaysian Agricultural Research and Development Inst. (MARDI), Serdang, Selangor, Malaysia – *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 65-92 1980.

Buddings and cuttings derived from readily-available fan material result in low plants with a diffuse branching system and an asymmetrical growth habit. Therefore, before fan material can be employed in large-scale vegetative propagation of cocoa in Malaysia, there is a need to work out appropriate pruning and/or training procedures to manipulate the branching system so as to obtain well-shaped trees. Trials demonstrated significant differences in pod yield and stem girth which were attributable to clonal variation, pruning regimes and pruning frequencies. Canopy development was greater in plants which were pruned less frequently. It is recommended that formation pruning be delayed for at least one year in the field. The primary pruning operation could be followed by relatively light maintenance pruning at two monthly intervals. Training would be useful for clones which do not possess an upright growth habit.

Environmental requirements of cocoa with emphasis on responses to shade and moisture stress ALVIM, P. DE T. and ALVIM, R. Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 93-111 1980.

The main factors which control growth and yield of cocoa are reviewed taking into account published information on soil and climate of representative producing areas as well as the results of some recent studies on physiological responses of this crop to shade, wind and moisture stress. Suitable ecological conditions for growing cocoa are defined in terms of physical and chemical properties of soils, temperature, regime, volume and distribution of rainfall and shade manipulation. Experiments under field conditions and in a wind-tunnel indicated that the beneficial effect of shade in young plants appears to result mainly from protection against mechanical damage by wind (defoliation caused by rupture of leaf pulvinus). The role played by moisture availability in the control of growth rhythms (flushing), flowering and cropping pattern of cocoa is also reviewed.

Light requirements of cocoa: a review OWUSU, J.K. Cocoa Research Inst., Tafo Akim, Ghana – *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 112-121 1980.

Recent evidence shows that free sugar levels in shaded cocoa are regulated by sunshine hours; that is light is a limiting factor in shaded cocoa. The well-known effect of shade-removal on the performance of cocoa, i.e. stimulation of flowering, pod setting, leaf flushing, higher growth rates and increased yield may now be explained in terms of carbohydrate build-up. These findings emphasise the need for shade management and a proper balance between shade and light requirements for optimal yield. The need for comparative data on yield of cocoa under various recommended shade trees is also emphasised.

New developments in shade for hybrid cocoa in Sabah LIM, D.H.K. BAL Estates, Tawau, Sabah, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 122-142 1980.

A trial was laid down in 1969 to evaluate the performance of Amazon hybrid cocoa when these were protected by lines of various shade trees planted along plot boundaries, and compare this method with the conventional practice of shading throughout. In the trial, Gliricidia maculata shade trees were used as initial shade. Various permanent shade trees were also planted within the plots and along plot boundaries during field planting of the cocoa. A programme of progressive pruning and thinning of the Gliricidia as the cocoa developed made it possible to compare the performance of plots of cocoa growing under uniform overhead shade and cocoa growing in relatively open conditions within 'box-shape' plots with shade trees only on the periphery. Results up to the end of August 1977 showed that nurse shade ceased to be of major importance once the cocoa matured and formed a closed canopy.

Cocoa nursery manuring investigations TEOH, C.H. Prang Besar Research Station, Harrisons & Crosfield, Kajang, Selangor, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 193-207 1980.

The growth of cacao seedlings in polybag nurseries is profoundly influenced by the choice of soil used for filling bags and fertilizer applications. This paper discusses results of 3 experiments and 2 observation trials in 1974/75. Munchong soil (pH of 4.7) was rated the most suitable of the 3 inland soils evaluated. Incorporation of ground limestone at about 15 g/bag promoted vigorous seedling growth. Application of oil palm bunch ash was phytotoxic. Seedling development can be further enhanced by fortnightly applications of a compound fertilizer 12/12/17/2 with trace elements. Vigorous growth can also be promoted by weekly foliar fertilizer applications. The sensitivity of young cacao seedlings to nutrient imbalances and phytotoxicity symptoms was clearly demonstrated.

Fertilizer responses of cocoa on coastal clay soils in Peninsular Malaysia KHOO, K.T., CHEW, P.S. and CHEW, E. Highlands Research Unit, Kelang, Selangor, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 208-223 1980.

Results from a 3^4 NPK Ca factorial fertilizer trial laid out in 1971 on cocoa planted in 1970 in double rows down the middle of coconut avenues, and supporting evidence of fertilizer responses from two other trials also on underplanted cocoa on coastal clay soils showed that the cocoa responded to applications of nitrogen, potassium and calcium fertilizers. Significant NK interactions on yield were also obtained. Calcium limestone applications raised the pH of the soil.

Fertilizer responses of cocoa over six years from planting of monocrop cocoa on a Bungor Series soil MAINSTONE, B.J. and THONG, K.C. Dunlop Research Centre, Bahang, Melaka, Negri Sembilan, Malaysia — *Proceedings of the Int. Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia, June 21-24, 1978* p. 243-261 1980.

A Bungor Series sandy clay loam was chosen for a N, P, K and Mg fertilizer experiment with cacao. First rubber was mechanically felled and after burning, soil was pre-treated with rock phosphate and dried bowl sludge. Next a lateral shade of Sesbania punctata was planted. Three months later cacao seedlings were placed in planting holes treated with rock phosphate. Two months later the first differential fertilizer treatment was applied. During the first 2 years only N treatment had a slight beneficial effect upon growth. Over the 4 years of harvesting K gave markedly superior production of dry beans. In general the best yields came from plots which received all of the nutrients involved in the treatments. The need for balanced nutrition was apparent.

15th Annual report 1979 Research Dept., United Plantations, Berhad, Teluk Anson, Perak, Malaysia – 57 p.; Feb 1980.

This report gives an account of the activities of the United Plantation Research Department (Malaysia) for the year 1979. The research activities are grouped in the following fields: (1) oil palm breeding and selection, agronomy, nutrition and fertilizers; (2) coconut breeding and selection, agronomy, nutrition and fertilizers, pests and diseases; (3) cocoa breeding and selection, nutrition and fertilizers; (4) miscellaneous investigations. The report also includes a chapter on highlights of research and another on extension and advisory activities.

14th Annual report 1978 Research Dept., United Plantations Berhad, Teluk Anson, Perak, Malaysia – 77 p.; Feb 1979.

Various activities of the United Plantations Research Department (Malaysia) for 1978 are reviewed. These include: (1) oil palm breeding and selection, agronomy, nutrition and fertilizers; (2) coconut breeding and selection, agronomy, nutrition and fertilizers, and diseases; (3) cocoa breeding and selection, agronomy, nutrition and fertilizers; (4) soil and foliar investigations; (5) extension and advisory services. The annual report also includes highlights of research for 1978.

April 1981

(Comparative economic analysis of mechanical and chemical weed control and hand weeding in cacao plantations of Recôncavo Baiano) Análise econônica do controle mecânico e manual-químico das ervas daninhas em áreas para cacau no Recôncavo Baiano MONTOYA, L.J. and PINTO, A.F. DE S. Divisão de Socioeconomia, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Boletim Técnico – Centro de Pesquisas do Cacau (Brazil)* no. 74, 16 p. 1980.

The economics of a combination of mechanical and chemical weed control was compared during 3 years with the traditional weeding methods of hand weeding and the application of herbicides in a cacao plantation (Theobroma cacao) interplanted with banana (Musa sp.). On the basis of October 1979 prices, it was shown that the total weeding costs for mechanical plus chemical weed control were slightly below those of the traditional weeding methods. Consequently mechanization of weeding can be recommended.

Problems and prospects of chemical control of plant diseases BYRDE, R.J.W. ET AL. Long Ashton Research Station, University of Bristol, Bristol, UK — *FAO Plant Protection Bulletin (FAO)* v. 28(3) p. 92-106 1980.

The discovery of Bordeaux mixture in the early 1880s may be considered as the first important landmark in the history of chemical control of plant diseases. In this article an appraisal of the current technology of disease control by chemicals and an evaluation of its future role in crop production is made. Successes and failures in chemical control, problems in contemporary chemical control (phytotoxicity, human health and environmental hazards, and pesticide resistance in pathogens), the need for new chemical control agents and main areas for research are reviewed. (Special Report no. 1 of the Committee on Chemical Control, International Society for Plant Pathology.)

Using the predatory ant, Oecophylla smaragdina, to control insect pests of coconuts and cocoa STAPLEY, J.H. Ministry of Agriculture and Lands, Honiara, Solomon Islands — *Information Circular — South Pacific Commission (SPC)* no. 85, 7 p; Jun 1980.

The use of the naturally occurring predatory ants, with the exception of Oecophylla smaragdina, has largely been overlooked as a possible means of biological control. The biology of predatory and other types of ants is discussed. The activity of O. smaragdina against the pest Amblypelta cocophaga, the nut fall bug of coconut, is described and control measures to protect it against antagonistic ants like Pheidole megacephala are discussed. The effects of O. smaragdina against pests of cacao such as Panthorhytes biplageatus is also discussed.

(CEPEC technical report 1979) CEPEC informe técnico 1979 Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil — 456 p. 1979.

During 1979, CEPEC studied ways for increasing the productivity of both cacao plantations and alternative crops, including rubber, oil palm, coconut, black pepper, guarana and sugar-cane. In addition phytopathological, socio-economic, statistical, climatic and soil fertility items were investigated.

(Pathogenicity of Helicotylenchus dihystera in cacao) Patogenicidade de Helicotylenchus dihystera (Cobb) Sher em cacao L. CAMPELO, A.M.F.L. and GALLI, F. Divisão de Fitopatologia, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil — *Revista Theobroma (Brazil)* v. 10(1) p. 5-14; Jan 1980.

Inoculation studies with the spiral nematode Helicotylenchus dihystera demonstrated the effect of the level of infestation on potted cacao plants and on the survival of the nematodes in the absence of a host plant.

(Faunistic study of coleoptera and hemiptera associated with cacao trees in the State of Pará) Estudo faunístico de coloópteras e hemípteras associados ao cacaueiro no Estado de Pará GARCIA, J. DE J. DA S. and SILVEIRA NETO, S. Departamento Especial da Amazônia, Comissão Executiva do Plano da Lavoura Cacaueira (CEPLAC), Belém, Pará, Brazil — *Revista Theobroma (Brazil)* v. 10(1) p. 15-23; Jan 1980.

The insect fauna of the cacao growing areas of Bragantina and Guajarina was found to be different in both numbers and diversity.

(Chemical control of insect infestation in stored cacao, Bahia, Brazil) ABREU, J.M. DE and WILLIAMS, R.N. Divisão de Zoologia Agrícola, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Revista Theobroma (Brazil)* v. 10(2) p. 51-60; Apr 1980.

The effects of insecticide sprays and phosphine fumigation, alone and in combination, on insect infestation of stored cacao were studied also in relation to method of application and duration and frequency of treatment.

(Control of Monilia pod rot in the cacao plantation 'Cacaoteras del Dique') El control de la moniliasis en 'Cacaoteras del Dique' BARROS, N, O. Departamento de Fomento, Compañia Nacional de Chocolates, Medellión, Colombia – *Cacaotero Colombiano (Colombia)* no. 15, p. 31-44; Dec 1980.

A phytosanitary review of this cacao plantation since its establishment in 1967, is made. Monilia pod rot, caused by Monilia roreri, was first observed in 1971. Six years later disease incidence was 52.8%. A field experiment was carried out to study the efficacy of various cultural practices on disease incidence, including 4 weeding rounds and 6 pruning rounds (with immediate disinfection of the pruning wounds) per year, careful drainage, regulation of shading and the collection of both diseased and ripe pods every 8 days. It was shown that all these cultural practices, especially the collection of diseased and ripe pods, increased yields by 250 kg dry beans/ha in the second year of application.

(Calculation of the fertilizer needs of cacao trees) Calcul des besoins en engrais des cacaoyers LOTODE, R. and JADIN, P. Division de Biométrie, Institut Français du Café et du Cacao (IFCC), Montpellier, France – *Café, Cacao, Thé (France)* v. 25(1) p. 3-24; Jan 1981.

Soil analysis data fed into a computer program enable the calculation of fertilizer recommendations for cacao in the Ivory Coast in relation to soil and agronomic conditions.

(Influence of insecticide treatments against cacao tree mirids on pollination conditions) Influence des traitements insecticides contre les mirides du cacaoyer sur les conditions de pollinisation LUCAS, P. and DECAZY, B. Institut Français du Café et du Cacao (IFCC), Yaoundé, Cameroon – *Café, Cacao, Thé (France)* v. 25(1) p. 29-36; Jan 1981.

In Cameroon, the control of mirids in cacao plantations by the fogging or atomization of insecticides reduced the pollinating insect population for a period of, respectively, 2 or 8 days. An artifically-created airstream has little effect on pollination and only after prolonged action.

(Cacao extension activities in Togo) La vulgarisation cacaoyère au Togo DEUSS, J. Soc. Nat. pour la Rénov. et Dév. de la Cacaoyère et Caféière Togolaises, Lomé, Togo – *Café, Cacao, Thé (France)* v. 25(1) p. 37-44; Jan 1981.

The role of extension in cacao production in Togo is placed within the socio-economic context of the industry and the feasibility of its rejuvenation.

(Fermentation of cacao beans in a triple phase fluidized bed) Fermentation des fèves de cacao en lit fluide à trois phases JACQUET, M., VINCENT, J.C.

and RIOS, G.M. Laboratoire de Chimie-technologie, Institut Français du Café et du Cacao (IFCC), Montpellier, France – *Café, Cacao, Thé (France)* v. 25(1) p. 45-54; an 1981.

Two methods were investigated in this study on the development of a new method for the fermentation of cacao in an aqueous medium.

(Grafting of cacao by a terminal slit) Greffage du cacaoyer en fente terminale GERVAIS, M. Institut Français du Café et du Cacao (IFCC), Divo, Ivory Coast – *Café, Cacao, Thé (France)* v. 25(1) p. 55-59; Jan 1981.

This paper describes and illustrates a method for the grafting of cacao in nurseries.

(Vegetative propagation of cacao) Pembiakan vegetatif pada tanaman coklat ANWAR, S. and HUTOMO, T. Balai Penelitian Perkebunan Medan, Medan, Indonesia – *Bulletin Balai Penelitian Perkebunan Medan (Indonesia)* v. 11(1) p. 4, 39-44; Mar 1980.

This paper reports the results of an experiment on rooting of cacao cuttings, using four types of hormones and three kinds of media. The best results were obtained with a combination of top soil and IBA (indole butyric acid) at 0.5 g dissolved in 100 ml 50 per cent alcohol. A positive correlation was found between the number of leaves and the number of roots formed.

(Phytosanitary survey of areas affected by cacao canker caused by Phytophthora in the States of Bahia and Espirito Santo) Levantamento fitossanitário das áreas afetadas pelo cancro de Phytophthora do cacaueiro nos estados da Bahia e Espirito Santo PEREIRA, J.L., PIZZIGATTI, R. and MANDARINO, E.P. Divisão de Fitopatologia, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Boletim Técnico – Centro de Pesquisas do Cacau (Brazil)* no. 72, 46 p. 1980.

Following heavy flooding of cacao plantations during 1978/79, a survey of cacao canker disease incidence, caused by Phytophthora palmivora, was made, when the rivers had returned to their normal level. An area of about 22 500 ha was surveyed, showing 12.30 per cent of the cacao trees to be dead, 21.24 per cent which could not be saved and 47.29 per cent which could be recuperated by treating the canker wounds with fungicidal pastes. It is concluded that P. palmivora incidence, as a consequence of flooding, was extremely heavy.

(Aspects of production and area distribution of cacao in Bahia state) Aspectos da distribuição da produção e área de cacau o estado da Bahia VERGARA, J.R.A., MONTEIRO, A. and ALVES, F.A. Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Boletim Técnico – Centro de Pesquisas do Cacau (Brazil)* no. 75, 21 p. 1980.

Various agricultural statistics relating to cacao plantations in the Bahia region are given, including cropped area, production and productivity. 78.6 per cent of the total farms produced under 22 500 kg of cacao and 76 per cent of farms had less than 30 ha. Of the total production the 'buraras' and small farms contributed 36 per cent. Counties that had the biggest and lowest cacao production are identified. Information is given on area in production, area with growing cacao trees, productivity, number of farms and recent expansion of the agricultural frontier.

(Structural and operational characteristics of common cacao storage depots in southern Bahia) Características construtivas e funcionais de armazéns convencionais para cacau no Sul da Bahia SERODIO, R. DOS S. and PRADO, E.P. DO Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Boletim Técnico – Centro de Pesquisas do Cacau (Brazil)* no. 76, 27 p. 1980.

Bahian cacao destined for exportation, is kept and delivered in jute sacks and stored in common depots. These buildings are usually deficient as far as structural, pest control and operational aspects are concerned. These aspects are reviewed in this paper and control measures are indicated. The relevant climatic parameters of the region are presented, showing the natural difficulties in keeping this product beyond a certain period of time. Structural and operational aspects for the successful storage of sacked cacao in a common depot are detailed. Design and operation measures are presented.

May 1981

Vascular streak dieback of cocoa in Malaysia. 1. A survey of its incidence and identification of the pathogen involved ZAINAL ABIDIN, M.A., VARGHESE G. and MAINSTONE, B.J. Faculty of Agriculture, Unversiti Pertanian Malaysia, Serdang, Selangor, Malaysia – *Planter (Malaysia)* v. 57(658) p. 3-13; Jan 1981.

This paper reports on the incidence of vascular streak disease in Malaysia and on methods of inoculation. Symptomatology of immature and mature cacao stands is described. VSD was found wide-spread on Peninsular Malaysia as well as in Sabah. The pathogen is described including morphological features and growth characteristics. Techniques useful for isolation and identification are discussed.

World cocoa bean production to exceed record 1979/80 harvest Foreign Agricultural Service, USDA, Washington, D.C., USA – *Foreign Agriculture Circular. Cocoa (USA)* USDA-FCB 1-81, 24 p.; Mar 1981.

World cacao bean production for 1980/81 is expected to be above the record 1979/80 outturn; it is estimated to be 1 647 000 ton; cocoa bean grindings for 1981 are expected to increase to around 1.52 million tons, but they will still remain well below anticipated world production levels, indicating a buildup in world stocks for the fourth consecutive year. Consumption of cacao continues to be adversely affected by high costs for sugar and other ingredients, inflation, the economic slowdown in major importing countries, and the use of substitute and extenders. Because of the bearish supply-demand situation, world cacao prices have been steadily declining from their record high levels in 1977. New York cacao bean prices averaged $1.72 per pound in 1977, $1.53 in 1978, $1.44 in 1979 and fell sharply to $1.14 last year and to 88 cents per pound in February 1981.

Epidemiology of Phytophthora on cocoa in Nigeria: final report of the International Cocoa Black Pod Research Project GREGORY, P.H. (Ed.) and MADDISON, A.C. (Ed.) Commonwealth Mycological Inst., Kew, Surrey, UK – *Phytopathological Papers – Commonwealth Mycological Institute (UK)* no. 25, 188 p. 1981.

This book, the final report of the International Black Pod Research team, gives an account of the research work carried out by the team during the period of assignment 1973-1979. The results are then discussed under the following headings, the black pod Phytophthora, development of the epidemic, Phytophthora in soil: movement of inoculum, ants as vectors, relation between black pod and weather, tree-base treatments, spraying experiments on cocoa farms and control strategy.

Zinc deficiency in cocoa: diagnosis and correction MOHANAN, R.C., MENON, M.A. and YADUKUMAR, N. Regional Station, Central Plantation Crops Research Inst., Vittal, Karnataka, India — *Planter (Malaysia)* v. 57(660) p. 120-124; Mar 1981.

A widespread occurrence of severe deficiency of zinc on cacao plantings in India is reported. Foliar symptoms included chlorosis, crinkling of leaves with wavy margin, little leaf, sickle leaf and premature abscission of leaves. Twig symptoms included rosette and dieback. A mixture of zinc sulphate and lime when applied as a foliar spray corrected the deficiency in two-year old cacao plants under field conditions. Foliar sprays of a mixture of zinc sulphate and lime at five different concentrations were tried. Though all the concentrations had beneficial effects, best results were achieved with 0.3 per cent zinc sulphate and 0.15 per cent (w/v) lime.

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