# COCOA GROWERS' BULLETIN

Number 17 September 1971
Published twice a year

Contents



Cadbury Limited
Overseas Cocoa Department
Bournville

# Editorial

### Manufacturers and Research

In the second issue of the *Cocoa Growers' Bulletin* the editorial described the development of cocoa research and the critical situation that had arisen in 1963 owing to shortage of senior staff at the main research stations in West Africa and Trinidad. In January 1964 the U.K. industry arranged a meeting for manufacturers from Europe and elsewhere to discuss this situation. As a result of that meeting a cocoa research fund was started under the aegis of the International Office of Cocoa and Chocolate.

The initiation of this fund coincided with the development of resistance to BHC among capsids and the need for this problem to be studied intensively. An international team was appointed and it started work in Ghana and Nigeria in 1965. Arrangements were made with the Ghana and Nigerian authorities for an initial period of three years, subsequently extended by a further three years. During that time the host countries provided housing and laboratory facilities and the International Office paid the salaries and travelling expenses.

The work of this team, which, at its peak consisted of five scientists in Ghana and one in Nigeria, came to an end early this year. Its investigations have covered all aspects of the capsid pest and their place in the environment of a cocoa farm and this intensive team work has greatly broadened our knowledge of this pest and has pointed to new methods of control. A summary of the work of this team is published in this issue.

# Review of Production and Consumption

**June 1971**

**A. P. Williamson, Cadbury Schweppes Limited**

### Production

The main crops in West Africa proved to be very much better than expected and the latest Gill & Duffus figures indicate that total 1970/71 African production will be over 100,000 tons more than was forecast six months ago. World production is now forecast at a record 1,517,000 tons.

The increase in Nigerian production was even greater than predicted six months ago, with the latest estimate indicating a crop 35 per cent greater than last year. In Ghana, Cameroon and the Ivory Coast the increases were much less dramatic although in the Ivory Coast and the Cameroon the steady growth in production continues, with both countries producing record crops. Equatorial Guinea returned to a more normal production level after the sharp drop last year following the political upheavals. There was a big jump in the tonnage coming from Togo and a big increase in the "Other Africa" figure although the latter was heavily inflated by the smuggling of cocoa into Dahomey.

South American production seems generally to have been in line with earlier expectations. In Brazil after a poor main crop, the prospects for the Temperao look good and the 1970/71 forecast has been increased by 23,000 tons. However, in the Dominican Republic another poor crop is now expected.

### Consumption

It is becoming apparent that consumption is beginning to react to the lower prices and the latest forecast of 1971 grindings is 40,000 tons or 3 per cent up on the previous forecast. The principal increase is expected to come from Western and Eastern Europe and the U.S.S.R.

### Stocks

The nominal surplus of world supply over demand in 1971 is now expected to be 135,000 tons. After allowing for the usual one per cent losses this is equivalent to an effective surplus of 121,000 tons compared with 77,000 tons last year.

Based on these figures the carry over of stocks of old crop cocoa at the end of 1971 will be 369,000 tons or the equivalent of three months' usage. Comparable figures in recent years have been:

| | | | |
|---|---|---|---|
| 1959/60 | 274,000 tons | 1965/66 | 412,000 tons |
| 1960/61 | 418,000 „ | 1966/67 | 367,000 „ |
| 1961/62 | 422,000 „ | 1967/68 | 297,000 „ |
| 1962/63 | 424,000 „ | 1968/69 | 174,000 „ |
| 1963/64 | 449,000 „ | 1969/70 | 249,000 „ |
| 1964/65 | 590,000 „ | 1970/71 | 369,000 „ |

While the situation has improved very significantly from the critical situation at the end of 1969 the carry over is still not excessive in relation to the levels that have generally prevailed over the last ten years.

## Prices

The general trend was for the steady decline in prices to continue during the period under review. There was a small rally during the first half of February but this made very little headway and quickly petered out. During March and April prices held steady in the range £230–£250/ton and it appeared as though the market might have bottomed. This did not prove to be the case and in May prices fell away again to reach a low of £210/ton towards the end of May. So far during June prices have been recovering again with the level now standing at around £232·5/ton, and it remains to be seen whether this move can be sustained.

Month end prices for nearby Ghana shipment cocoa have been:

| | |
|---|---|
| January | £250·0/ton |
| February | £230·0/ton |
| March | £232·5/ton |
| April | £228·5/ton |
| May | £211·0/ton |
| June | £232·5/ton |

## WORLD COCOA PRODUCTION AND GRINDING DATA

**Reproduced from Gill & Duffus Market Report dated June 1971**

**(Thousand long tons)**

### Production

| | 1968/69 | 1969/70 | 1970/71 (Forecast) |
|---|---|---|---|
| Africa ... ... ... ... ... | 853 | 998 | 1,116 |
| America ... ... ... ... | 297 | 330 | 317 |
| West Indies ... ... ... ... | 36 | 59 | 41 |
| Asia and Oceania ... ... ... | 40 | 36 | 43 |
| **World Total** ... ... ... ... | 1,226 | 1,423 | 1,517 |
| **Principal Countries** | | | |
| Ghana ... ... ... ... ... | 334 | 409 | 410 |
| Nigeria ... ... ... ... ... | 189 | 219 | 302 |
| Ivory Coast ... ... ... ... | 142 | 178 | 185 |
| Cameroon ... ... ... ... | 102 | 107 | 111 |
| Guinea (Spanish) ... ... ... | 37 | 25 | 34 |
| Brazil ... ... ... ... ... | 163 | 197 | 183 |
| Ecuador... ... ... ... ... | 52 | 54 | 60 |
| Dominican Republic ... ... ... | 21 | 42 | 25 |
| Venezuela ... ... ... ... | 23 | 24 | 25 |
| Colombia ... ... ... ... | 18 | 19 | 21 |
| Mexico ... ... ... ... ... | 26 | 26 | 20 |
| New Guinea ... ... ... ... | 27 | 22 | 29 |

### Grindings

| | 1969 | 1970 | 1971 (Forecast) |
|---|---|---|---|
| Western Europe ... ... ... | 522 | 507 | 522 |
| Eastern Europe and U.S.S.R. ... | 180 | 184 | 197 |
| North America ... ... ... | 282 | 276 | 285 |
| Australia and New Zealand ... | 16 | 17 | 18 |
| Central and South America ... | 149 | 161 | 160 |
| Asia ... ... ... ... ... | 48 | 51 | 56 |
| Africa ... ... ... ... ... | 140 | 137 | 144 |
| **World Total** ... ... ... ... | 1,337 | 1,333 | 1,382 |
| **Principal Countries** | | | |
| United States ... ... ... ... | 265 | 261 | 269 |
| Germany (Federal Republic) ... | 120 | 124 | 127 |
| Netherlands ... ... ... ... | 109 | 113 | 116 |
| United Kingdom ... ... ... | 91 | 81 | 79 |
| U.S.S.R. ... ... ... ... | 97 | 100 | 105 |
| France ... ... ... ... ... | 42 | 39 | 39 |
| **NOMINAL BALANCE** ... ... | —111 | +90 | +135 |

# Underplanting Coconuts with Cocoa in West Malaysia

## PART 2 – MAINTENANCE

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*This article is adapted from a paper presented at the Third International Cocoa Conference held in Accra, November 1969, the proceedings of which are in the Press. This paper is published here as Part 2 (Part 1 being printed in our March 1971 issue) by permission of the authors and the organisers of the Conference.*

### Weed Control

Weed control immediately surrounding the newly-planted seedlings is provided by a heavy mulch of coconut husks, two layers deep and two husks wide, placed around the seedlings but not against them. This mulch has additional value in that it provides nutrients as it slowly decomposes, promotes better rooting of the cocoa, reduces water loss from the soil at a time when the cocoa is most susceptible to water stress and reduces soil temperature. The husk circles also obviate the need for herbicide sprays close to the plant, thus reducing the risk of spray drift damage to the seedlings.

Until the complete canopy restricts weed development, as much use as possible is made of herbicidal weed control. The problems of herbicide application in this type of mixed planting are complicated by the differential response of the two crops and various weed situations requiring different formulations. However, good results can be obtained with herbicides known to be safe for both crops, and a mixture of 2–3 pints Ansar 529 (MSMA) with 5 lb. sodium chlorate in 40 gallons of water has given excellent results for both initial spraying and later upkeep. Addition of Citowett at 1·6 fl. oz. per 40 gallons enhances the wetting and sticking properties of the spray. Application is made using a knapsack sprayer fitted with a Steiner 9506E nozzle, which is designed for accurate band application of herbicides. Every precaution is taken to prevent spray drift onto the seedlings.

During the early stages, weeds are controlled in a strip extending 3 ft. beyond the cocoa canopy spread. Spraying intervals depend on a number of factors, especially weather and further weed development, and the application is normally repeated before 50 per cent regeneration has occurred. Once the canopy has closed, little weed control is required except around the perimeter of the stand.

### Pruning

The initial pruning aims at causing the first jorquette to develop at a height of 5 ft., by monthly inspection and removal of any jorquettes which start to develop below this height. Where a jorquette has developed too low, which will greatly impede subsequent harvesting and maintenance, development of a second jorquette is encouraged. When a satisfactory height has been achieved, growth of further jorquettes is discouraged by removing chupons at monthly intervals, thus holding the plants at the first jorquette. Some damage is caused to the cocoa by fronds or nuts falling from the palms. This can be quite serious when a main shoot of a cocoa tree is damaged and is of great significance in young plantings. As there is thus a risk of losing fan branches from this cause, these are not thinned. Since flowers do not develop from renewed bark, trees badly damaged by falling debris are pollarded below the affected tissue, but only after a jorquette has formed on a chupon which has been allowed to develop. Similarly, when trees lean badly a basal chupon is allowed to develop and, when this has grown sufficiently, the leaning portion is cut off. This procedure is preferable to staking.

### Fertilisers

Little accurate information exists on the nutrient requirements of cocoa grown beneath coconuts in Malaysia (8), and fertiliser trials now in progress should provide much-needed information. The technique of leaf analysis is widely used in rubber and oil palm, but is of no assistance in assessing nutrient requirements of cocoa. Early responses in fertiliser trials have indicated that nitrogen is the main requirement during the immature period in cocoa plantings on these coastal clay soils.

Differential fertiliser requirements by the two crops raises problems of application. Observations suggest a nitrogen and magnesium requirement for both crops, a high calcium need for cocoa, and potassium mainly for coconuts. Coastal clay soils in this area usually contain adequate reserves of available phosphorus. The antagonistic activity of calcium and potassium is capable of inducing an imbalance in available nutrients, which is possibly less critical for coconut nutrition. Indirect reduction of calcium availability may also occur if an acidifying nitrogenous fertiliser such as ammonium sulphate is used (8), so calcium ammonium nitrate is preferred. Up to two years after field planting, fertiliser is applied at six-month intervals (after leaf and flower flushes) in a circle around the young cocoa trees, but thereafter it is broadcast.

### Nursery Pests and Diseases

Problems arising from pest attack in nurseries are slight and can usually be prevented. Rats are excluded by a perimeter fence of wire netting attached to the shade supports. Caterpillars have sometimes been troublesome, and it has been found that these can be harboured by the palm fronds used for shade. The fronds are now sprayed with endrin shortly before planting the germinated seed; since this procedure was adopted the frequency of caterpillar attack has greatly decreased.

Disease is rare in nurseries since a balance appears to have been struck between the moist conditions favouring vigorous growth and the conditions of higher humidity favouring disease development. Occasional attacks by *Phytophthora palmivora* have been recorded in nurseries (3), with adequate control being achieved by a copper-based fungicide.

### Field Pests

Caterpillars quite frequently cause significant damage on young seedlings soon after transfer to the field, and prophylactic monthly sprays with Rogor 40 have been found beneficial. Great attention is paid to protecting the terminal flushes so that growth is not retarded. The dangers of taint from this product are well-recognised, and it is not used more than 12–14 months after field planting. Thereafter, lead arsenate is the favoured spray to be used for caterpillar control, but, if this is not effective, Dipterex SP80 or Sevin 85S are applied. These two formulations are also used for cockchafer beetle control, *Apogonia sp.* and *Lepidoretus sp.* being the two species most frequently encountered.

Lindane is still effective for the control of such *Helopeltis clavifer* attacks as occur in Malaya, which seem to occur more on pods than on shoots. At present they are of slight significance when compared with other cocoa areas, but there is the very real danger that attacks by this and other pests may become more severe as the size of plantings increases. Mealybugs and scale insects sometimes require control, and this is brought about either by Albolineum or a kerosene/soap mixture. Where the various formulations do not contain spreading or sticking agents, 0·025 per cent Citowett is added to the spray solution. Knapsack sprayers are used in young plantings but in older stands, sprays are applied by motorised mistblowers.

Once the trees have become well-established, selective insecticide sprays are applied only when appreciable damage is being caused and there is no indication of control by natural predators. This policy is adopted in view of the examples of disturbance in the natural population balance which have occurred, following excessive use of pesticides.

Mammalian pests can be serious if not controlled regularly. Chief amongst these are rats, which are normally present in significant numbers in the coconut stand. Both paper-wrapped and paraffin wax-based baits have been used with success. In each case the poison ingredient is an anticoagulant, usually Warfarin, which is presented in a mixture of maize, fish heads and palm oil. Other mammalian pests are musang (*Arctogalidia sp.*) and squirrels, these being controlled largely by hunting. An unusual and infrequent type of pod damage is caused by birds.

### Field Diseases

Although root diseases caused by *Ganoderma pseudoferreum*, *Fomes lignosus* and *F. noxius* occur on rubber in West Malaysia, this type of disease is very rare in cocoa beneath coconuts, since the forest timbers of the original stand have long since disappeared and there are virtually no infection foci.

Similarly, stem infections occur only infrequently. Pink disease, caused by *Corticium salmonicolor*, can be successfully controlled by spraying with a copper fungicide.* Following branch damage caused by falling coconut fronds or

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*This chemical has, however, proved unsuccessful in controlling more frequent attacks of Pink disease on an estate on Sabah.—Ed.

nuts, thread blight is quite commonly found. This is caused by various fungi, and control is by application of a copper fungicide and pruning dead branches. Leaf diseases are of no economic significance (13).

Most pod rots follow rodent attack and are associated especially with *Botryodiplodia theobromae* and *Fusarium spp.* Experiments have shown that as elsewhere, these fungi are unable to attack undamaged pods, and their incidence appears to be directly related to the efficiency of rodent control.

Black pod caused by *Phytophthora palmivora* has been recorded in areas of cocoa monoculture in Malaya, together with infrequent infection by another species, *P. heveae* (14), but so far these fungi have not been recorded on cocoa under coconuts. There is, however, every likelihood that this apparent absence is merely temporary, since the monsoonal climate of Malaya and the widespread distribution of *P. palmivora* on other hosts favour the development of this pathogen.

By far the most serious disease of cocoa in Malaysia is dieback. This has been especially severe where cocoa of the Amelonado variety was planted, and in such areas dieback has been considered the major factor limiting yield (5). The upper Amazon varieties, and the crosses between these and Amelonado, planted more recently, appear to be more tolerant of, or less susceptible to, the various environmental conditions which seem to favour dieback. The causes of dieback in Malaysia are obscure, a situation which is normal for this particular disease complex (12). In the coastal clay soils where the underplantings are situated, the number of factors possibly associated with dieback are numerous, including a wide fluctuation in the water table, periodic salinity of soil moisture, inhibition of root development in close-textured soils, soil acidity (the range is usually pH 4–5), low total sunlight during monsoon periods and nutrition, especially that of calcium. Many fungi have been isolated from branches affected by dieback but it seems unlikely that they are primary pathogens; diseased tissues from early stages of dieback are frequently without fungal infection, indicating an underlying physiological cause of this condition (13). Lesser branches affected by the disease are pruned off to a distance of about 2 ft. below internal symptoms. In very severe cases the trees are pollarded, with regeneration from basal chupons.

## Harvesting and Processing

The frequency of harvesting rounds varies between 7–14 days, and during each round, diseased pods are removed as well as healthy ripe pods, the diseased pods being discarded. Care is taken not to damage the flower-bearing cushions when pods are removed.

It has been found that fermentation begins more rapidly if beans are left in the unbroken pods for some time after harvesting. Provided rodents are adequately controlled, pods need not be collected on the day on which they were harvested, and up to three days is allowable before collection and breaking. The pod breaking areas are varied at each harvest to avoid local accumulations of husks, which induce nutrient imbalance through release of considerable amounts of potassium. The beans are collected in wicker baskets or boxes for transport to the fermentary.

Deep box fermentation is frequently practised in Malaya. In new situations there have been initial problems of inducing sufficiently rapid fermentation, but such problems have usually had a natural solution once the fermentation boxes have acquired a wide enough microbial flora. Once fermentation starts, progress appears to be identical to that experienced elsewhere. Attempts at tray fermentation in West Malaysia have not been successful.

Sun-drying is widely used, or a combination of sun and artificial drying when necessary. With total sun-drying difficulties have been experienced during the monsoon seasons, which coincides with the peak cropping periods, when the high humidities have led to mould development. A greater emphasis may be placed on mechanical drying in the future.

## Yields and Profitability

The difficulties in forecasting cocoa yields accurately are well known, and the areas of cocoa already in production in West Malaysia are rather small for precise estimates. For these reasons, the yield data given below are conservative, although based on figures already obtained, and the profitability will almost certainly exceed that estimated. As a basis for calculation, it has been estimated that a cocoa stand at the density used beneath mature coconuts can be brought to maturity in less than four years at a cost of under £83·35 per acre (7). More recent results have shown that this period can be reduced to three years and the cost is significantly lower at approximately £62·50, inclusive of factory expenses. Yields of 500 lb. of dry cocoa per acre can be obtained in year 3–4, rising to 900 lb. or more by year 6–7. In practice there would also be a small crop prior to year three, but this has been considered insignificant for the purpose of these calculations.

In assessing combined profitability of cocoa and coconuts, some consideration must be made of a possible depression in copra yield through cocoa competition. Whilst experience elsewhere has been that stands of coconuts yielded more when cocoa was established beneath the palms, this could well have been due to the cocoa constituting a less competitive ground cover than that previously present. One experiment has shown that interplanting with cocoa can depress coconut yield (11); however, it should also be remembered that application of fertilisers to coconuts in West Malaysia is rarely practised, and fertilisers could well offset any détrimental competitive effect. An allowance should also be made for a slight increase in coconut harvesting costs.

An estimate of combined net profits from coconuts and cocoa interplanting has been summarised in Table 2, in which a long-term average price for copra of £70 per ton and a cocoa price of £235 per long ton have been used. For average conditions in Malaya profits should exceed £80 per acre at these prices. Costs have been based on current estate practice in Malaya. At the higher cocoa prices which prevailed in recent years, profits would have been much higher. The margin for a small-holder on good soil and good coconuts is even greater.

Underplanting cocoa has additional attractive features, a major one being that cocoa can be planted without any significant increase in overhead expenditure, thus whereas an oil palm replanting programme requires heavy capital expenditure, a cocoa interplanting could be financed out of revenue from the retained stand of coconuts. It has been estimated that $2\frac{1}{2}$ acres of cocoa interplanting could be achieved for the equivalent cost of one acre of oil palm (with factory). Based on conservative cocoa and copra yield estimates, it has been calculated that it would take 13 years for an oil palm replanting to overtake a coconut-cocoa interplanting in profitability (7).

**Table 2. Estimated profitability from coconut-cocoa interplantings at different copra and cocoa yields.**

| Coconuts | | Combined net profits (£ per acre) | | |
|---|---|---|---|---|
| Yield per acre (lb.) | Net profit per acre (£) | Cocoa yield (lb. per acre) 500 | 750 | 1,000 |
| 600 | 2·00 | 33·50 | 54·00 | 74·75 |
| 1,000 | 12·50 | 44·00 | 64·50 | 85·25 |
| 1,400 | 22·75 | 54·25 | 74·75 | 95·50 |
| 1,800 | 33·25 | 64·75 | 85·50 | 105·50 |
| 2,200 | 43·75 | 74·75 | 95·50 | 116·50 |
| *Correction factor (£) | | 2·25 | 3·40 | 4·50 |

Assumptions: Copra selling price (ex estate) £70·50 per long ton.
Cocoa selling price (ex estate) £235·25 per long ton.

*Correction factor is to be added or deducted for every fall or rise of £10·00 in cocoa price per long ton.

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# International Capsid Research Team

*This research team completed its programme in West Africa early in 1971 and the director of the team for its second phase, Mr. C. A. Collingwood, prepared a summary of its research findings prior to the publication of a final comprehensive report. We publish here an abbreviated version of the summary by permission of Mr. Collingwood and the International Office of Cocoa and Chocolate.*

## INTRODUCTION

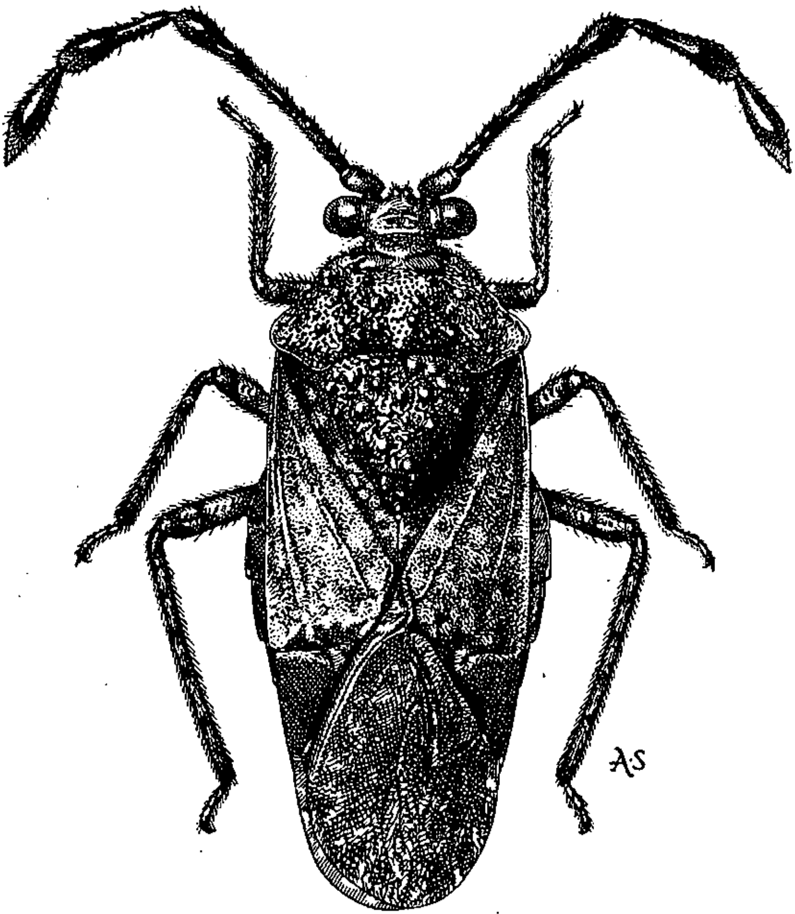
I.C.R.T., sponsored and financed by the International Office of Cocoa and Chocolate, was placed in West Africa in response to the need for further research work on capsid control, with particular reference to the development of resistance to the cyclodiene insecticides in both Ghana and Nigeria by *Distantiella theobroma* and *Sahlbergella singularis* respectively. Because of the relative importance of these pests in the Ghana economy, where various estimates have indicated annual losses due to capsids of the order of 25 per cent or more, the majority of the team members (four) were stationed at the Cocoa Research Institute, Tafo, Ghana, while one member was concurrently stationed at the Cocoa Research Institute of Nigeria. An additional principal objective of the group was to establish a co-operative liaison with cocoa research entomologists of the Institut Francais du Cafe et du Cacao working on the same lines.

The team's work was in two main phases; the first from 1965–68 under Dr. Pickett's direction was largely exploratory and survey in its approach, with the aim of clarifying the more important seasonal and ecological factors affecting capsid populations; the second phase, from 1968–71, while continuing this line, included a more experimental approach and also development work in conjunction with the Ghana Ministry of Agriculture, Cocoa Division staff.

Section II of this report gives a short summary of the main research findings, but the more practical findings can be outlined as follows. The area of capsid resistance to cyclodiene insecticides is continuing to increase in both Ghana and Nigeria, and at some stage in the near future alternative insecticides of another chemical group must be made available to the farmer. The carbamate insecticides propoxur (Unden) and orthobux have passed all taint, residue, capsid effectiveness and crop response tests satisfactorily and are commercially available.

In Ghana mistblower application continues to be practically effective using minimal quantities of five gallon/acre, provided that the machines are used in co-operative groups of three or more, that the terrain is prepared previously by cutting back vegetation in spray alleys, where necessary, at 4 m intervals, and that the machines are sufficiently powered to give effective coverage at nine to ten months in the canopy. Insecticides should be applied from August or September at metres intervals to the end of the year, when capsids are normally doing most damage. June/July spraying followed by a large gap until November is relatively ineffective on small farm units or trial plots.

In Nigeria pneumatic knapsack-type applicators are used to deliver the insecticides at relatively high volume rates, the spray being directed at each




*Adult female, Sahlbergella singularis*

individual tree. Also timing may be somewhat different because of the seasonally earlier development of peak capsid populations.

Management methods, including the successful protection and establishment of young cocoa leading to the development of a good canopy, renders the crop largely self-protective against capsids and at the same time encourages those elements of the fauna, including Oecophylla ants, that help to protect against pest damage. Areas of poor growth, accidental breaks in the canopy and groups of young plants among older trees are particularly susceptible to capsid injury and form foci for the development of more or less extended capsid pockets. In such places spot insecticide treatment, accompanied by the use of temporary shade plants, may be desirable.

## SUMMARY OF RESEARCH

### 1 Capsid Seasonal Cycle and Water Stress

Various sampling methods confirm an annual cycle of abundance. *D. theobroma* has lowest numbers on average in March/April and peaks from October to December. *S. singularis* has lowest numbers in April/May and a delayed but steeper rise to peaks from November to January. Individual trees and small plots may have population peaks in any one month from July to February. Ghana peak populations are generally one or two months later than Nigeria and Cameroon.

The abrupt population decline at the end of the dry season is associated with build-up of water stress in the plant. Capsids are unable to feed and develop normally when a plant nears wilting point. Irrigation through the dry season permits normal development of capsids when surrounding population on unwatered trees dies out and reintroduction of water after a stress period renders the plant more favourable to capsids.

Field populations at the lowest level are maintained on well canopied flushing trees and in small groups of young trees at favourable water-available sites. The delay in seasonal rise after first rains and major flush is attributable to sparse distribution of capsids and wide dispersion. Evidence suggests that cocoa is nutritionally most favourable to capsids during the period of major pod production. In Nigeria high numbers may occur locally in April/May coincident with relatively large early crop development. Factors unfavourable to capsids include prolonged harmattan, which may cause direct death of capsids through excessive water loss, and large diurnal fluctuations in temperature.

### 2 Capsid Activity and Dispersion

Feeding peaks occur in evening and again after midnight. Adults tend to fly more frequently during sunny periods. Adults are generally attracted from shade to light, so that exposed cocoa especially when surrounded by full-canopied shaded cocoa tends to form foci for local population build-up. Mature *D. theobroma* females, but not those of *S. singularis*, adopt a calling posture which has been shown to attract flying males during late afternoons of sunny days.

Records on cocoa of different canopy types through two annual cycles show that build-up is higher on trees of broken canopy than on full-canopied trees. Flight studies show that adults are potentially capable of flying over a range of 2½ miles but normally most movement occurs during third and fourth instars. Capsid populations are normally highly aggregated probably through concentration of eggs on favourable oviposition sites.

### 3 Capsid Pockets and Progression of Damage

Breaks in canopy from mechanical causes, small groups of exposed cocoa surrounded by shaded cocoa or replants in their second or third growth season attract capsids, and become focal points for local population build-up and damage. Effects of capsid feeding include shortening of internodes and proliferation of shoots which form favourable feeding sites. This helps to perpetuate pockets; in addition during the period of greatest capsid increase, humidities within pockets or exposed areas are relatively more favourable. Capsids develop faster and more successfully at RH 70–80 per cent than in conditions approaching saturation. During the dry season humidity may become too low for successful development in the unshaded pocket, and adults move from the pocket into surrounding cocoa. Regenerative growth after rains again renders the pocket more favourable, so that the same group of trees may become heavily attacked year after year while the area of the degraded pocket also increases.

Vegetative recovery after seasonal capsid damage is potentially considerable, but normal flowering and podding can be severely affected as a result of the previous season's damage. Trees watered during the dry season may sustain high capsid populations with relatively little visible damage in the form of dieback. There is evidence that dieback mainly due to secondary fungal organisms can only develop from capsid lesions and extend within a branch when the tree is under stress.

## 4 Effects on Cropping and Varietal Response

Spray trials have shown that successful treatments on degraded cocoa more than double pod counts in the succeeding year compared with untreated controls. On young cocoa in the second and third year of establishment the effects on yield are even more marked, with three- and four-fold increases respectively being recorded on treated plots compared with controls. Estimates of natural loss have varied, but from spray trial results and a general consensus of opinion a present-day estimate of 25 per cent of the national acreage badly affected by capsids in Ghana is, in the absence of treatment, losing 100,000 tons dry cocoa per annum. The first effects of capsid damage on productivity include loss of flower potential, but even in young plants with high recuperative powers including sufficient flower production, cherelle development may be reduced by 50 per cent compared with treated plots.

In an establishment trial untreated Amazon and Amazon x Amelonado hybrids sustained as high capsid infestations as Amelonado on the same plots, but cropping was reduced by 74 per cent, as against 90 per cent on Amelonado, on untreated compared with treated plots. In addition, twice as many dead Amelonado trees were recorded on untreated plots compared with the other varieties. Full-canopied Amazon cocoa, in fact, is largely self-protective against capsids, which do not build up to heavy infestations in conditions of shade and high humidity.

## 5 Capsid Numbers and Species Proportion

Routine hand-height visual counts compared with whole-tree pyrethrum knockdown counts or whole-tree dissection underestimate tree populations by a factor of 12 or more, on average. About 30–40 per cent of the population is found in the canopy above hand-height level. Nevertheless, compared with many other pests, capsid numbers are low relative to the damage they cause, and seldom exceed 5,000 per acre. Because of aggregation a count of 2·5–5·0 per cent of trees visibly infested with live capsids represent a high and damaging population.

The ratios of the two species have fluctuated considerably at Tafo, *S. singularis* was in very low numbers during the years 1964–66 but rose to high levels by the end of 1968 and constituted virtually 100 per cent of the population during most of 1969. In 1970 relative numbers of *D. theobroma* again began to increase. Compared with the main cocoa-growing areas of Nigeria and Cameroon, *D. theobroma* is much more abundant in Ghana and on average is the more economically important of the two species there.

*Severe capsid damage to mature trees in Ghana.*

## 6 Capsid Rearing

Large-scale rearing methods have now been developed for *D. theobroma*. In the laboratory nymphs are reared from first instar to fifth instar on frameworks of chupons in enamel dishes. The sexes are separated until the emerged adults are of an age suitable for mating. Males and females are confined in enamel bowls until mating is observed, and the females are then immediately transferred to oviposition cages of aluminium gauze placed on regenerative chupons of coppiced mature cocoa in the field. Nymphs from the healthy eggs are transferred back to the laboratory as they hatch and the whole cycle repeated. The number of hatched nymphs with this method averaged 20 per female.

With *S. singularis*, laboratory methods are less satisfactory and mass rearing has been most successfully achieved by allowing populations to develop normally in caged coppiced cocoa trees.

## 7 Parasites and Pathogens

*Euphorus sahlbergellae* is a common larval parasite of *S. singularis*. Over a two-year period rates of parasitism (third and fourth instar) have ranged between 15 per cent and 41 per cent both at Tafo and from collections made in Brong-Ahafo and Ashanti. In Nigeria recorded rates have been lower within the range 6–21 per cent. By contrast, such parasitism of *D. theobroma* is very low. On balance, parasitism operates at too low a level to prevent annual build-up of damaging populations.

A highly lethal bacterial disease, *Bacillus sp.*, was discovered at Gambari attacking *S. singularis*. Further tests at Tafo showed the Bacillus to be equally lethal to *D. theobroma* and to *Helopeltis sp.* but not to *Bryocoropsis sp.* A preliminary field test gave inconclusive results, and there are practical difficulties in building up sufficient stocks of bacteria for field testing.

## 8 Predators

A large range of insects and spiders are found on cocoa trees, many of which may at times predate on capsids. Observations and experiments show that predation of capsids by these or other organisms, including some birds and lizards, is casual and accidental, and none are efficient capsid-searching feeders.

Association tests based on a large number of field knockdown samples suggest that, of the ants, only *Oecophylla* and *Macromischoides spp.* are consistently negatively associated with *D. theobroma*, while some other species including the larger *Crematogaster sp.* appear to have an overall protective effect. With *S. singularis* evidence is more conflicting, but on balance ants are not negatively associated with any capsids.

In sum, the mean protection against capsid damage from ants has been estimated at around 16 per cent, with a range of 12–20 per cent at different sites in Ghana. No significant relationships have been discovered with other predator groups, members of which are highly mobile from tree to tree, unlike resident ant colonies, and their net effect has not yet been estimated. The abrupt disappearance of groups of capsids from individual trees or branches under daily or weekly observation suggests that predation, although essentially accidental and haphazard, is statistically important in checking large populations of capsids.

*Oecophylla longinoda* is the more important and dominant of the ant predators, and in Ghana overall average of cocoa trees substantially foraged by these ants ranges from 12–20 per cent. They are relatively more abundant on well canopied cocoa, and to a large extent the negative association with *D. theobroma* is explicable by their differential habitat success, with the capsid being more prevalent on exposed cocoa. Studies of foraging activity suggest that the ant is an inefficient capsid predator. However, any means that encourages full canopy will assist in the self-protection of cocoa against capsids and other damaging insects, and management control to that end rather than deliberate attempts to encourage *Oecophylla* must prove beneficial.

*Crematogaster spp.* have also been studied because of their general importance in cocoa ecology. Directly harmful effects on cropping by destruction of flowers and cherelles have been shown to be very localised and of little economic importance. However, they have ecological significance in relation to mealybug populations, and their behaviour and systematics have been studied. Over 100 species of various ant genera have now been recorded from cocoa and keys to the genera provided. Effects of insecticide treatments have been shown to be transitory or negligible on the commoner ant species, but there is some depressing effect on the abundance of *Oecophylla* by routine gamma BHC treatments.

## 9 Other Insect Pests

Attention has been given to other pests in relation to capsid damage. The psyllid (*Tyora tessmanni*) and leaf hoppers (*Affroccidens spp.*) may effect considerable damage to exposed cocoa. Trees that have been degraded and severely damaged by capsids are particularly vulnerable to attack by these pests and by thrips on regenerative flush growth following rains after the dry season, and special measures other than capsid control may be necessary to ensure successful regeneration. Some preliminary collaborative work on the insecticidal control of the cocoa-pod pentatomid, *Bathycoelia thalassina*, has also been carried out.

## 10 Insecticides

Surveys confirm that resistance to cyclodiene insecticides is a continuing phenomenon; even when insecticide pressure is reduced for one or more years, resistant populations of *D. theobroma* have continued to be detectable, while the cocoa area inhabited by resistant or partially resistant capsids continues to increase. The search for suitable alternative insecticides has been intensified, and so far suitable satisfactory candidate insecticides have been found only within the carbamate group.

Testing has been carried out in four or five successive stages. Contact toxicity by topical application on test insects in the laboratory may be regarded as the first stage. In practice, for quick testing cage-spray screening tests (second stage) have been employed. Twenty-four hour kills of over 90 per cent at standard rates of 4 oz a.i/ac. have been taken as the minimum requirement for further trials; of more than 45 insecticides so far tested, only certain carbamate insecticides have emerged successfully from the screening, apart from the organophosphorus compounds monocrotophos and dicrotophos.

In stage three limited small-scale field trials have followed to determine minimum effective dosage rates and to detect any deleterious side effects. In stage four insecticide performance has been compared in extended field trials with adequate replication but on small acreage plots (½ to 1 ha). In the fifth stage of testing, insecticides which have already been taint and residue-tested are compared on larger area plots of 7 to 9 ha at a number of sites in collaboration with and under supervision of the Ministry of Agriculture, Cocoa Division.

## 11 Assessment Methods

A variety of methods have been compared, including records of fresh damage, numbers of trees infested, numbers and stage of capsids for assessment of immediate effects of treatment both by visual counts and by pyrethrum knockdown on sample trees. For longer term effects, canopy changes and pod counts before and after a treatment cycle are also recorded. Successful insecticides are those which not only give immediate capsid control but also lead to successful regeneration and significantly better pod production compared with untreated controls. Of these, to date only gamma BHC itself, gamma BHC-propoxur mixtures, propoxur and orthobux have passed all tests satisfactorily, but other carbamate compounds still under trial may be almost equally effective.

## 12 Systemic Insecticides

Monocrotophos (Azodrin) and dicrotophos (Bidrin) have been studied because of their high degree of efficiency against all sucking pests and partial control also of biting insects (*Lepidoptera*, *Coleoptera*) on young trees. Application rates have been successively cut down to the use of 15 per cent monocrotophos applied by 3 cm paint brush in a 5 cm band around the tree stem at 2 ft from the ground or just below the first fork.

This simple application method applied during the period of maximum pest damage, i.e., May for general sucking pests and then four further applications from August to December for capsid control, gives highly effective protection of young trees in their second to fourth year from planting.

Spraying with these compounds, although also highly effective, is not recommended because of blood cholinesterase depletion of spraymen, but has been used to demonstrate how even very severely degraded cocoa can be at least partially restored after two sprays.

## 13 Timing of Sprays

Evidence from comparative trials shows that the existing recommendation of June/July spraying followed by November/December permits the development of high capsid damaging populations from September to November and compares unfavourably with an August/September/October/December or a September/October/November/December sequence. General spraying on small unit areas during the months of the year February to July, when capsid numbers are low, gives ineffective control and will not prevent the normal seasonal build-up from August to December.

## 14 Application Methods

An investigation on routine methods employed by spray gangs in experimental and maintenance spraying showed that many small improvements in organisation and efficiency could be suggested. Comparing the various types of mistblower in current use showed that some were too underpowered for use in mature cocoa, while the most effective only reached some 7 m into the canopy. Coverage by sprayers used individually was markedly inferior to that obtained where sprayers were employed in groups of three, suggesting that for ordinary farmer use the organisation of some form of co-operative or group spraying was essential for good results.

In comparisons of actual application methods the T type of application, where the spray nozzle is moved in an arc aimed directly at individual trees from base to crown, gave better and more uniform distribution of the spray than where the spray was directed in a side-to-side movement upward into the canopy. Preliminary trials with fogging devices suggested that a model now in use in warehouses could be adapted for use in cocoa to give effective results that would compare well with normal mistblower use, and that further trials with a suitably adapted model comparing efficiency, material and labour costs were justifiable.

### 15 Economics of Insecticide Use

Treatment of young cocoa five times per year (May, August, September, October, December) with gamma BHC at rates giving approximately 0·5 lbs per acre is estimated to cost, together with labour using pneumatic sprayers, about £2·35 per acre per annum. Using monocrotophos stem painting with five applications of 15 per cent insecticide would cost £4·65 per acre per annum.

Either treatment applied from the second to fourth year from planting would be economic on the assumptions based on trials with Amazon varieties that crop in the third and fourth year of establishment would be increased by a mean total of 395 lb per acre for the two years together compared to no treatment.

In mature cocoa total spraying costs, according to materials used with mistblower applications four times a year, range from £1·75 to £3·45 per acre. Experimentally, yield increases through spraying degraded cocoa have been of the order of 200 lb dried cocoa per acre. On well canopied cocoa not obviously attacked by capsids, the economic advantages of spraying would be less obvious, but at higher cropping levels spray costs would be proportionately very small relative to crop returns, even with the more expensive insecticides.

### 16 Non-Insecticidal Control

Any form of management leading to the formation of a closed canopy will reduce capsid incidence as well as the effects of damage. This, however, will almost certainly necessitate the use of insecticides at least in the early stages of establishment. Other more direct methods of control using pathogens or chemicals other than insecticides are still futuristic. Recent work on pheromone sex attraction in *D. theobroma* shows that mature females of this species adopt a calling posture which attracts flying males during sunny afternoons. Apparatus and methods were devised to ascertain the distance of attraction and to concentrate the actual chemical attractant in solvent for analysis.

ACKNOWLEDGEMENTS

Grateful thanks are due to Dr. E. J. A. Asomaning and Dr. L. K. Opeke, Directors of the Cocoa Research Institutes of Ghana and Nigeria, for their encouragement and support of I.C.R.T. activities and to the staff of these Institutes.

# Cocoa in India

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## Introduction

In most cocoa growing countries, cocoa grows under conditions of fairly well distributed rainfall (50–150 ins. per annum) with short dry seasons which rarely exceed three to four months. In India, the dry months tend to be hotter and more severe than dry seasons in West Africa and there are substantial areas of India where the dry season is too severe to be recommended for cocoa. Irrigation is, however, a practised and proven technique for other tree crops and it is possible to interplant some of these crops with cocoa.

There are no large areas suitable for cocoa to be found in India and considerable care must be exercised in selecting sites. There are, however, a number of relatively small areas of suitable land for both irrigated and non-irrigated cocoa in various parts of South India. At the moment interest in cocoa is centred on the States of Mysore, Kerala and Tamil Nadu – all in South India (see map). The 1971/72 crop is hoped to be 50 tons based on existing plantings.

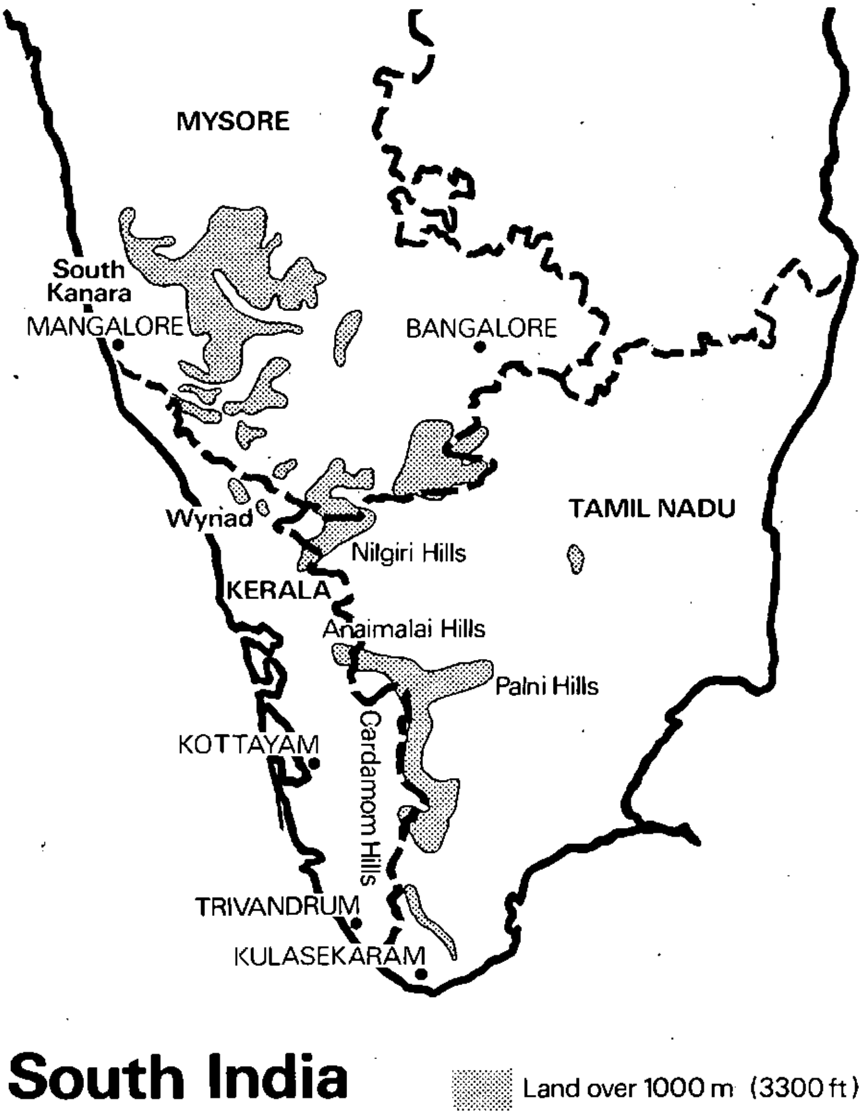
The need for growing cocoa in India rests on the requirements of manufacturers within India and the vital need to conserve foreign exchange. During the past few years imports of cocoa beans have been between 700–1,000 tons a year; this quantity has not been used solely for local consumption and there has been an appreciable export of cocoa products. Nevertheless, 1,000 tons a year is a low figure and the market for cocoa-based products in India would expand considerably, but for the shortage of foreign exchange. The obvious solution is to seek possibilities for growing cocoa in India, and during the past ten years considerable knowledge of the most suitable areas has been gained. It is now considered that India will eventually be able to produce enough cocoa to meet domestic demand.

Cocoa trees can be found in compounds in various towns along the Malabar coast, but these are only of academic interest. The oldest cocoa of any importance is a planting of Criollo trees at the Kallar Fruit Station in the Nilgiris, at an altitude of 1,300 ft. (450 m.). These trees were planted in 1930–35, and they have provided much of the planting material used in India in recent years.

In 1964 there were only about 200 acres of cocoa in India and production of commercial cocoa beans was non-existent. Much planting has taken place since then, so that the present area amounts to 2,500–3,000 acres (4).

## Situations in India Suitable for Growing Cocoa

While the rainfall and its distribution is the major limiting factor, temperature must also be considered in India in view of the great range of altitudes of cultivated land. In South India, in the States already mentioned, temperatures will be suitable for cocoa up to 2,500 feet, but above this height the mean monthly minimum temperature may fall below the accepted limit of 15°C.




*Map of India showing upland areas.*

### Irrigation

Irrigation would obviously overcome the difficulties arising from the long severe dry season that prevails in South India, but the majority of the land that can readily be irrigated is already under cultivation. There are, however, possibilities for inter-planting irrigated areca nuts and coconuts with cocoa.

### Cocoa under Coconuts

The planting of cocoa under coconuts is a well-established practice in New Guinea and Malaya (2, 3) and there seems no reason why the practice should not be extended to India. There are perhaps over one million acres of coconuts in South India, but most of this area is on soils which are totally unsuitable for cocoa. There is a limited acreage of coconuts on deep loamy soils which could also support cocoa. The spacings so far used in India have never approached the Malayan densities, but there seems no reason why they should not yield well under such conditions, provided fertilisers are applied and the moisture conditions are adequate for cocoa.

### Cocoa under Areca nuts

The cultivation of areca nuts (areca nuts are chewed as a stimulant in many parts of India, in addition to being used in local food dishes) is widespread in South India and the general practice is to irrigate the crop. The spacing varies, but in South Kanara, it is commonly 10 × 10 ft., which allows cocoa to be planted in the centre of the square to give a density for both crops of 435 per acre. At this spacing the palms provide heavier shade than is normal for mature cocoa and yields will be reduced, but even the lower yields can be expected to repay the relatively low cost of maintaining cocoa under these conditions. In other parts of South India closer spacings are used in areca nut plantations and these provide dense shade unsuitable for cocoa.

### Cocoa under Thinned Jungle

There are areas of unexploited forest in parts of South India and for the development of such virgin areas planting under thinned jungle gives the fastest means of establishing cocoa. The exploitation of any trees of economic value must be the first step and this would be followed by adjustment of the shade to suit young cocoa. Inevitably there will be gaps in the canopy, and these must be filled at the earliest possible date with planted shade such as Dadap or *Albizzia sp.* Ideally, these shade trees should be established before the cocoa is planted to avoid the need for temporary shade. Temporary shade can be provided by baskets or palm fronds placed round individual seedlings, but at a substantial cost. In some areas Dadap defoliates in the dry season, but if pruned correctly (towards the end of the main monsoon) this effect can be reduced, if not eliminated.

### Cocoa under Planted Shade

The establishment of cocoa after clear felling will involve more time and expense than under thinned jungle, but does have advantages. The canopy is more even with planted shade and is in rows, making for easy management both of the crop and the shade trees.

Adequate shade is vital for the establishment of young cocoa, especially in areas of marginal rainfall as are found in many parts of India. Many of the problems of establishment that have been experienced in India have been due to over-enthusiasm by farmers in planting before development of an adequate shade regime.

## Cultivation

As the cocoa industry of India is still very much in the pioneering phase, specific methods and techniques peculiar to India have not yet been developed.

It was initially ruled that only Criollo material was to be planted in South India, but the superiority of Forastero material which has been planted in Mysore since 1965 necessitated a review of this ruling in 1970. Forastero material can now be planted in all the southern States with the exception of those areas of Tamil Nadu, where Criollo cocoa is already established. There is no doubt that Forastero cocoa will thrive and yield better under the conditions experienced in India, and thus this change of emphasis is to be welcomed.

Jacob (pers. comm. 1971) considers that selection for drought resistance must be a most important part of any breeding programme for planting material in India. He suggests seven selections from those available at the Cocoa Research

*Mature Criollo cocoa under Areca nuts at the Regional Areca nut Research Station, Vittal, South Kanara.*

*Young cocoa under thinned jungle in Coorg District showing correct use of bamboo baskets in patches of inadequate shade.*

*18-month-old Forastero cocoa under coconuts in South Kanara.*

*2½-year-old Criollo cocoa at 3 m. × 3 m. under Dadap shade at same spacing at Chembra Peak, Wynad.*

Institute of Nigeria which illustrate this character to a considerable degree. These selections are all inter-Amazon hybrids combining high yield with drought resistance and are fully discussed in the 1968-9 CRIN Annual Report (3).

If irrigation water is available in areas of cocoa under planted shade it should be used to establish cocoa by irrigating the young plants during their first, and possibly second, dry seasons. Thereafter the plants may have to rely entirely on rainfall for their moisture supply and this limits plantings to areas of suitable rainfall and soil.

As may be expected from an area of low rainfall and soils of less than average fertility, the tree growth rates are not fast and trees will not come into bearing as soon as in other areas. It is as yet impossible to forecast how yields at maturity will compare with those obtained in traditional areas as few trees have yet achieved maturity, but it is expected to be not less than 700 lb. (300 kg.) dry beans per acre. Techniques of fermentation and drying and quality standards are still being developed to suit Indian conditions.

So far very few instances of pests and diseases requiring control have been recorded but this does not mean that trees will not be subject to damage in the future. Localised attacks by leaf-eating beetles and caterpillars and also by stem borers, the latter especially in the jungle areas, have been noted and in one or two places in India pods have been damaged by a sucking insect, probably a *Helopeltis sp*. The fungus *Phytophthora palmivora* causes a disease of areca nuts and is also the cause of Black Pod disease of cocoa. The spread of this fungus depends on the climatic conditions, especially relative humidity and it is not usually worth adopting control measures unless pod losses are greater than 20 per cent. The present indications are that the main crop of cocoa will not coincide with the periods of high humidity and thus it is possible that routine applications of fungicides will not be necessary.

### Extension and Research

Much encouragement to cocoa cultivation and extension effort has been provided by Cadbury-Fry (India) in collaboration with the Union Ministry of Food and Agriculture, the Indian Council of Agricultural Research and the State Departments of Agriculture or Horticulture. Both the State Departments and Cadbury-Fry (India) produce seedlings at several nurseries and have advisory staff. The latter has also recently set up buying stores as part of the extension effort, based on the Cocoa Centre where methods of cocoa growing are demonstrated to farmers. The Indian Council for Agricultural Research has initiated research work on cocoa, which will be administered through their research station for plantation crops at Kasaragod, Kerala. This work concentrates on breeding and selection to find the best varieties of cocoa for Indian conditions.

### Future

The response of farmers to cocoa – a new crop for India – has been most encouraging and it is to be hoped that further response will follow when some existing plantings achieve maturity. Considerable impetus to planting will have recently been given by the more widespread adoption of Forastero cocoa as suitable planting material. It is expected that the small cultivator will provide the bulk of production, with more limited interest from plantation companies and Government Forestry and Horticultural Departments. The experience elsewhere in the world suggests cocoa responds very well to cultivation on a small scale provided an adequate extension service is available. It is thus of vital importance that the extension and research effort is maintained and increased. Agronomic studies will become of increasing importance.

It is to be hoped that within 10 years cocoa production in India will be adequate to cover present imports, thus conserving foreign exchange and giving farmers a further new cash crop. Increased production after this time will stimulate local demand for raw cocoa and exports of chocolate products. In time raw cocoa may also be available for export.

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# Soil Conditions and Plant Growth

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The chief growth-factors operating in the soil environment of a tree are: root room, water and air supply, nutrient-supply, harmful factors and soil temperature.

### Root Room

This is perhaps the most important of all the growth factors. It is defined as the volume of soil having a suitably porous structure easily penetrable by roots. It is limited laterally by spacing distance and vertically by soil-depth. An "ideal" cocoa soil consists of aggregates of sand, silt and clay, stabilised by humus or other cement, having a total pore-space of about 66 per cent of the soil volume. If the total pore-space of sands, silts, and clays are less than 35, 45, and 38 per cent respectively the soils are too compact to allow root-penetration and are therefore unsuitable for cocoa growing.

### Water and Air Supply

These two factors are complementary. After rain soils retain a certain amount of water up to their "field capacity". The rest drains away leaving part of the pore-space occupied by water, known as "capillary" pore-space, and part occupied by air called "non-capillary" pore-space. For satisfactory soil-aeration, non-capillary pore-space must be greater than 10 per cent of the total volume of the soil and must be rapidly emptied of water after every shower of rain. Soils that fail to meet this requirement are said to have imperfect or impeded drainage.

Living plants with healthy root systems abstract water from a moist soil down to the stage when the force of abstraction equals the retaining force of the soil particles for water. The plant then begins to wilt. The moisture content of the soil at this stage is called the wilting point.

"Available" water is that which theoretically is abstractable by plants; its amount equals the difference between complete saturation and wilting point. "Usable" water is not quite the same quantity; it is measured by the difference between field capacity and wilting point, since plants require non-capillary air for root respiration without which they cannot function.

The chief source of water for plant-growth is rain, although irrigation may be used when rainfall is too low. The amount and rate of delivery of rainfall needed to keep a soil constantly moist at field capacity down to the full depth of the rooting zone depends on the soil's permeability, the magnitude of the capillary and the non-capillary pore-space, and the rate of water loss by evaporation from the soil-surface and by transpiration from the leaves of plants growing in the soil (i.e. evapotranspiration). The rain which falls on the land may be divided up in the following way:—

i. *Interception:* This may amount to over 20 per cent of the rain falling on forest land or on well-shaded cocoa.

ii. *Run-off:* This is negligible in forest and well-shaded cocoa, because the surface litter and crumb layer are highly receptive to water.

iii. *Evapotranspiration:* This depends on atmospheric conditions, viz., air temperature, humidity and wind velocity. This potential value can be measured by some form of evapotranspirometer. The actual evapotranspiration depends on (a) the amount and periodicity of the rainfall (evapotranspiration is greater in the dry season than in the wet season), (b) the presence or absence of vegetation, and (c) the thickness of the rooting zone when vegetation is present, and (d) on the atmospheric conditions.

iv. *Drainage Water:* This percolates through the rooting zone and accumulates as ground-water whose upper surface forms a water-table, or it escapes as springs.

v. *Storage Water:* When a soil carrying a crop is freely drained, the amount of usable water fluctuates between field capacity and wilting point. In order to avoid water stress to the growing plant, the storage water should remain constantly at or slightly above field capacity level when about 10 per cent non capillary pore-space is left to permit adequate root respiration. The total amount of "usable" storage water at field capacity depends also on root room, as well as on these two moisture constants.

Cocoa thrives best in an environment where the fluctuations in water supply are small. Adequate soil aeration is absolutely essential to satisfactory growth of cocoa. Where the annual rainfall is high, for example, over 150 inches a year, only soils having high permeability are capable of supporting thrifty cocoa.

### Nutrient Supply and Harmful Factors

The nutrients required by green plants include the basic and acid radicals both macro, micro and trace. These are supplied by soil minerals, except nitrogen which comes from the air and is fixed in the soil by micro-organisms. The basic radicles are readily leached out of the soil by percolating water, the first to disappear being calcium, then magnesium, and lastly potassium. Of the chief acid nutrients, nitrate is leached first, then chloride, sulphate and phosphate in that order.

A heavily-leached, base-depleted soil develops acidity. When the degree of acidity rises above that represented by pH5·5, toxic aluminium, iron and manganese are liberated and the soil becomes unfavourable for certain crops, notably maize and sugar cane. Other crop plants, tea, coffee and possibly cocoa, can withstand the conditions associated with high acidity, though certain families of weed plants can grow under extremely acid conditions.

The elements iron, manganese, zinc and copper, are "fixed" under alkaline conditions (reaction values above pH 7·5) as insoluble hydroxides, basic carbonates or phosphates. Overliming an acid soil may therefore be extremely dangerous in that it may result in lime induced chlorosis owing to iron shortage. Similarly, the excessive use of soluble phosphate fertilisers "fixes" zinc as insoluble phosphate and many crop plants, including cocoa, may then suffer from zinc deficiency. Thus soil alkalinity may also be harmful to plant growth.

Most crop-plants are productive only within the range pH 5·5–8·5. Whilst cocoa may be found growing in soils of pH below 5·5 or above pH 8·5, it produces maximum crops only when grown in soils of pH 6·5 and this may therefore be regarded as the optimum pH value for cocoa. High acidity and high alkalinity are not in themselves harmful; it is the factors associated with, or developed by, these conditions that are harmful and pH value is the most significant and useful single soil constant for diagnosing the nutrient status of a soil.

The excessive concentration of one nutrient may suppress the uptake of another. Thus, an excessive concentration of potassium may suppress the uptake of magnesium and zinc and the plant may consequently suffer from shortage of these two essential nutrients. The ratio of monovalent to divalent bases ($K+Na$ to $Ca+Mg$) appears to be an important factor in cocoa nutrition and has been specifically investigated in Ghana. When monovalent bases are in excess, the tree fails to thrive and to produce pods due to the suppression of calcium and magnesium, and vice-versa. An exact balance evidently is needed between these entities for maximum growth and production in cocoa.

Where the soil is markedly deficient in essential minor elements, such as iron, manganese and copper, they may be added to the soil or sprayed in solution onto the foliage in readily absorbable form as chelates. These are salts of ethylene-diamine-tetra-acetic acid (EDTA) which contain the basic element in such a form that it is not precipitated in the soil, but is readily taken up by plants.

The amounts of nitrogen (N), phosphorus (P) and potassium (K) removed from the soil by cocoa seeds and husks in a 500 lb. per acre crop of dry beans are 22, 4 and 32 lb. respectively. These are equivalent to a fertiliser mixture consisting of 110 lb. of ammonium sulphate, 54 lb. of single calcium superphosphate and 60 lb. of potassium chloride, or 224 lb. of mixed fertiliser per acre. The need for fertiliser for high production must be accepted in all but the most exceptionally fertile soils, but, in order to determine the fertiliser requirements of any particular site and soil, field experiments of suitable design must be carried out.

The question of shade provision for cocoa depends fundamentally on the nutrient status and root room of the soil in which the trees are growing. When photosynthesis is greatest under high light intensity, the uptake of nutrients should also be greatest in order to fully utilise the carbohydrate by transforming it into protein. This necessitates a well-developed root-system established in a well-aerated soil adequately supplied with water and containing a plentiful supply of nutrients in readily available form. Under high light intensity, the products of photosynthesis if not used up tend to cause severe nutrient imbalance and reduced growth. The length of life of the leaves is thus reduced and repeated leaf-flushing occurs as compensation. In extreme cases the peripheral shoots turn yellow and die. A cocoa tree suffering from this kind of "dieback" assumes a "stag-headed" appearance and eventually sheds all its leaves and ceases to grow; death invariably follows in due course. Under the protection of shade, the demand on the supply of nutrients in the soil is greatly diminished because the lesser amounts of the products of photosynthesis do not require so much nitrogen and phosphate to form protein, nor so much potassium to stimulate growth and to expedite the translocation of carbohydrate to the root system. The important conclusion to be drawn therefore is that shade protection is needed most when soil conditions are least satisfactory and should only be dispensed with when soil conditions are entirely satisfactory.

As the cocoa tree grows from the seedling stage, the amount of natural self-shading and the relationship between light intensity, overhead shade requirement and nutrition also changes. Not only will there be increasing need for nutrients but also for an alteration in the ratio between the different individual nutrients. For example, there will be a lesser need for nitrogen and a greater need for potassium. Under the most favourable soil conditions, cocoa grown without shade produces much greater crops than cocoa grown with shade, but fertilisers will generally have to be applied to maintain high production in unshaded cocoa.

### Soil Temperature

Air temperature and soil temperature greatly affect the rate at which chemical processes proceed in the plant and in the soil. Root activity in particular, is largely controlled by soil temperature and bud activity by air temperature.

The uptake of water and nutrients by cocoa roots diminishes rapidly at temperatures below 15°C (60°F). This marks a lower limit to successful cocoa cultivation and to the altitude at which cocoa may be grown. In general, temperatures below 15°C occur at altitudes above 2,500 ft. near the equator, but many exceptions to this rule are known. The most suitable temperature range for cocoa is 21° to 30°C (70° to 86°F) for mean monthly minimum and maximum respectively.

In Trinidad and in Ghana experimental evidence indicates that cocoa trees flush excessively at air temperatures above 28°C (82°F). The reason for this is unknown; it is believed to be a leaf hormone effect. In Costa Rica, excessive flushing occurs when the daily range of temperature exceeds 9°C (16°F).

### Conclusion

The size of the cocoa crop is determined by interaction of the environmental or ecological factors. Any one or more of these factors may limit production in relation to the theoretical maximum.

# Notes on Contributors

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Long experience of British crop pests as an advisory entomologist in the Ministry of Agriculture Advisory Service. Many papers published on investigations dealing with various aspects of crop pest control, and on distribution and taxonomy of ants.

Released from duties as Regional Entomologist, S.E. England, to take up three-year contract as leader of I.C.R.T. in Ghana, 1968–70. He resumed duties as Regional Entomologist, Yorks. and Lancs. Agricultural Developmental Advisory Service in 1971.

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Was born at Bradford, educated at the Bradford Grammar School and at Cambridge University. His first post was Government Lecturer in Agricultural Sciences in Barbados. After the First World War, he was appointed Professor of Chemistry and Soil Science at the Imperial College of Tropical Agriculture in Trinidad at its inception in 1922 and served there until retirement in 1956. He was afterwards employed in the I.C.A. programme at the Inter-American Institute of Agricultural Sciences in Turrialba, Costa Rica, where he organised several annual courses of instruction in cocoa-growing and processing. He is now back at the University of the West Indies in Trinidad as part-time lecturer.

# Cocoa Abstracts

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

December 1970

**Brown, C. P. Short run static price and income effects of cocoa control.** J. Development Stud. 6, 3, pp. 267-82 (1970).

Using conventional assumptions of price control by buffer devices, several aspects of control of trade in cocoa by buffer funds, buffer stocks, and export quotas are explored with the provisions of the Draft International Cocoa Agreement in mind. The effects of a constant farmer price and a fluctuating farmer price, as well as those of buffer funds and export quotas are discussed. Tables. Figs. 55 refs.

**Bartley, B. G. D. Annual yield correlation in cacao and their significance in selection.** Proc. Trop. Region Amer. Soc. Horticult. Sci. 12, 16, pp. 257-66 (1968; publ. 1969).

In 2 progeny trials with cocoa in Trinidad, individual tree yields for 9 years were grouped into 3-year periods corresponding to definite stages in production. Correlations between the mean yields for each period were positive and most coefficients were significant for the 11 varieties studied. Relationships in the uniform clonal populations were similar to those of the segregating populations indicating that much of the association between periods could be attributed to non-genetic causes. Correlations of the period of ascending production with the later periods decreased as the age of the trees increased due to a marked change in the ranking of individual tree performances. Phenotypic selection in the first years of production was unsatisfactory as a measure for later performance. Spanish summary. Tables. 10 refs.

January 1971

**Blackman, R., and Rake, A. What is holding up a cocoa agreement?** Afr. Development, June, pp. 12-3 (1970).

Developments and actual situation which may lead to an international cocoa trade agreement are discussed. Producers, once divided, are now closer to agreement aiming at production and price control would work. The development and prospects of the cocoa production of W. Africa, in particular of Ghana, are briefly reviewed. Graphs.

**Ahenkorah, Y. A study of the distribution of root activity of mature cacao (Theobroma cacao L.) using the $P_{32}$ soil injection technique.** Ghana J. Agr. Sci. 2, 2, pp. 97-101 (1969).

In Ghana, the distribution and activity of the roots of mature trees of 4 different cocoa varieties (spaced at $3 \times 3$ m) was studied, using the $P_{32}$ soil injection technique. The results indicated that the specific activity of $P_{32}$ and the mean total P in the top canopy and below-canopy leaves varies inversely with the depth of injection of $P_{32}$ (2.5, 7.5, 30 and 45 cm). The main effects of injection depth, variety, aspects and date of sampling are all highly significant and similar for most of the (depth $\times$ other factor) interactions. Regardless of varietal differences in $P_{32}$ leaf contents, root activity was found to be approx. 10 times greater in the top soil (2.5 cm) than at lower depths. French summary. Tables. Six refs.

**Lodos, N. Minor pests and other insects associated with Theobroma cacao L. in Ghana.** Ghana J. Agr. Sci. 2, 2, pp. 61-72 (1969).

Available information is presented on 80 less important insects known to feed on or to be associated with cocoa trees in Ghana, including notes on observations made by the author over the period 1964-68 concerning incidence, distribution, damage, biology and host plants. The insect orders have been listed in phytogenetic sequence. The families, genera and species are presented in alphabetical order. French summary. Fig. Photos. 13 refs.

**Adegboye, R. O. Procuring loan through pledging of cocoa trees.** Nigerian Geogr. J. 12, 1-2, pp. 63-76 (1969).

In W. Nigeria the practice of pledging cocoa trees began between 1920 and 1930, when it became illegal to pledge human beings. The purpose of this study, which was conducted in the cocoa growing areas of W. Nigeria, was: (1) to observe the factors that lead to pledging of tree crops, (2) to describe the process by which the pledgee/pledger relationship is established, (3) to evaluate the use of pledging as a loan procuring mechanism with respect to redemption problems, (4) to explore some of the loan procuring opportunities alternative to pledging, and (5) to suggest ways by which the present pledging system can be improved Tables. Map. Five refs.

**Dominguez, R. P. F. Cura de pequeñas cantidades de cacao mediante el uso de cestos de fibra vegetal.** (Small-scale fermentation of cocoa using plant fibre baskets). Rev. Fac. Agron., Venezuela 5, 2, pp. 97-109 (1969).

Results are presented of micro-fermentation trials with different cocoa types conducted in Venezuela. A number of 8 small fibre baskets of 500 g capacity were placed in a larger fibre basket currently used for the method called "Fermentador Caucagua". The data revealed that the test method is not of general practical significance for cocoa improvement research. However, in special cases when using types of cocoa such as Criollo, Criollo x Forastero or Trinitario, the method can give a percentage of well-fermented beans of over 70, after 8 days of fermentation. English summary. Tables. 14 refs.

**Meursing, E. H., and Terink, J. L. Cacaopoeders voor industriele verwerking: kwaliteitskenmerken en specificaties. Hun belang; hoe ze te interpreteren.** (Cocoa powders for industrial processing: quality requirements and specifications. Their importance, how to evaluate them). Koog-Zaandijk (the Netherlands), N.V. Cacaofabriek De Zaan, 1969. 71 pp.

This booklet discusses the quality specifications for cocoa powders. A special interpretation of the following specifications is given: fat and moisture contents, pH, degree of fineness, shell percentage, microbiological requirements, taste, flavour and colour. Bacteriological specifications are also discussed. The booklet is concluded with some analytical methods for testing cocoa powder. Tables. Photos. 11 refs.

February 1971

**Spoon, W. Cacao van Sabah (Noord-Borneo).** (Cocoa from Sabah, N. Borneo). Banket, Chocolade, Suikerwerken 38, 6, pp. 187-9 (1970).

Information is presented mainly on the development of the cocoa industry of Sabah, Malaysia since 1953, and of Sabah cocoa imports in the Netherlands since 1964. Tables. Photos. 10 refs.

**Nunes, M. A. Um estudo comparativo de resistência à secura em cacaueiros.** (A comparative study of drought resistance in cocoa plants). Estud. Agron. 8, 3, pp. 115-8 (1970).

Potted plants of 3 types of cocoa known in São Tomé as "laranja-amarelo" (LA), "amelonado-vermelho" (AV), and "amelonado-amarelo" (AA), were submitted to artificial water stress conditions with a view to measuring their resistance. The AV type proved to be the most resistant one. According to the results obtained, this could be interpreted in terms of stomatal behaviour and transpiration rate. From author's English summary. French summary. Graphs. Six refs.

March 1971

**Toxopeus, H., and Jacob, V. J. Studies on pod and bean values of Theobroma cacao L. in Nigeria. II. Number of beans per pod, with special reference to the natural pollination process.** Neth. J. Agr. Sci. 18, 3, pp. 188-94 (1970).

From studies in Nigeria it is concluded that inadequate fertilisation of the ovules of the cocoa flowers, seems to be the main cause of variability in the number of beans per pod. The frequency distribution in the main crop of a monoclonal block was found to be skewed. Tables. Graph. 11 refs.

April 1971

**Ventocilla, J. A. Efeito do BHC sôbre as mosquinhas Ceratopogonídeas polinizadoras do cacaueiro.** (Effect of BHC on the cocoa-pollinating *Ceratopogonidid* flies). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 287-90 (1969).

The results of a field trial in Brazil to study the effect of aerial treatment of flowering cocoa plantings with BHC dust (1 %) on population activity of pollinating *Ceratopogonidid* flies (*Forcipomya spp.*) were statistically analysed. There were no significant differences between treatments, and the population of pollinating insects was not affected by BHC application. Number of *Ceratopogonidid* flies was correlated with number of typical pollen masses on the cocoa flower stigmas. English summary. 17 refs.

**Alvim, P. de T., et al. Alguns estudos sôbre as relações de água, solo e crescimento do cacaueiro.** (Some studies on water, soil and growth relationships of the cocoa plant). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 316-24 (1969).

The results of cocoa soil-plant-water relations studies in Bahia, Brazil, are reviewed. Special attention is given to the water deficiency problem of cocoa seedlings raised in pots when exposed to direct sunlight. It was demonstrated that leaf scorch can be controlled by application of reflecting paint to the upper leaf surface. Nutrient solution experiments confirmed that the cocoa plant is less tolerant to poor soils than the rubber plant. Off-season shooting of buds could be reduced by leaf clearance and ringing of the twigs; leaf fall due to water stress possibly is the main cause for periodicity in cocoa budding under the conditions prevailing in Bahia. English summary. Tables. Graphs. 12 refs.

**Toxopeus, H. Establishment ability of cocoa progenies in Nigeria.** Euphytica 19, 3, pp. 327-33 (1970).

Establishment of cocoa farms in Nigeria with the W. Afiican Amelonado type is difficult mainly because of a severe dry season of 3-4 months. In 3 field trials, good heritable establishment ability was found in the wild Upper Amazon populations Nanay, Iquitos and Parinari, in Trinitario populations and the Scavina progeny. From author's summary. Tables. Five refs.

**Besse, J. Bilan des travaux de sélection et d'amélioration du cacaoyer en Côte d'Ivoire.** (Status of cocoa selection and improvement work in the Ivory Coast). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 57-70 (1969).

The cocoa yield and quality improvement programme of the Ivory Coast started 7 years ago. It is still based on artificial hybridisation between Upper Amazon cocoa plants and Amelonado or Trinitario clones. To decrease the effect of certain obstacles and to improve experimental accuracy, planting is now done under natural cover, number of replications is increased and observations start before the production phase. Three of the hybrids obtained yielded more than 2,500 kg dry beans/ha/year over a 3-year period (4.5 to 6.5 years after planting). Girth of 1.5 to 2.5-years-old plants was highly correlated with total production of the first 3 yields. Portuguese and English summaries. Tables. Graphs.

**Soria, J., and Esquivel, O. Algunos resultados del programa de mejoramiento genético de cacao en el IICA-Turrialba.** (Some results of the cocoa breeding and selection programme at the IICA, Turrialba). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 35-42 (1969).

The cocoa improvement programme and achievements of the Interamerican Institute of Agricultural Sciences, Turrialba, Costa Rica, are described. The germ plasm collection now covers 260 clones and populations, and most of the wild *Theobroma* and *Herrania spp*. Some 30 high-yielding clones have been selected; these are being tested in the field together with the best of the introduced clones. Bi-clonal hybrids between clones of different origin generally show great initial vigour, precocity in production, and a high yield potential; this is in contrast to hybrids of clones of the same origin. English summary. Tables. Graphs. Nine refs.

**Soria, V. J., and Esquivel, O. Observaciones sôbre resistencia del cacao a Phytophthora, Ceratosystis, buba floral y "dieback", en Costa Rica.** (Observations on resistance of cocoa to *Phytophthora*, *Ceratocystis*, flowery gall, and dieback in Costa Rica). In: Memórias da segunda Conferência de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 174-6 (1969).

The main results obtained so far in Costa Rica of cocoa disease resistance testing and breeding are presented. The clone UF-613 showed resistance to *Phytophthora palmivora*, and the clones SPA-9, Pound-12, IMC-67 and PA-121 were found to be resistant to *Ceratocystis fimbriata;* inoculation tests with progeny plants from a cross between a resistant and a susceptible clone, or between 2 susceptible clones, revealed that susceptibility is a dominant characteristic. Hybrids of crosses between flowery gall resistant and susceptible clones showed greater resistance when the male parent was resistant. English summary. Eight refs.

**Pinto, G. C. P., et al. Seleção de matrizes superiores nos cacauais da Bahia.** (Selection of high-yielding cocoa mother trees in Bahia). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 105-13 (1969).

More than 1,200 cocoa trees were observed for productivity and pod rot (*Phytophthora palmivora*) resistance in Bahia, Brazil. A number of 197 outstanding trees were selected first. After that, re-selection was done on an accurate statistical basis, and 28 exceptional trees were found. Of these, 14 selections are tested in a variety trial, recently laid out. The following criteria form the basis of the selection work: (1) average annual production of at least 4 kg of dry beans and 100 fruits per tree; (2) fruit index: maximum of 40; and (3) average percentage of pod rot infected fruits: maximum of 12. English summary. Tables. 22 refs.

**Rocha, H. M., and Mariano, A. H. Seleção de cultivares de cacau resistentes a Phytophthora palmivora (Butl.) Butl.** (Selection of cocoa cultivars resistant to *Phytophthora palmivora*). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 166-9 (1969).

The preliminary results are presented of field and laboratory tests conducted in Bahia, Brazil, on the degree of resistance to *Phytophthora* pod rot of 20 cocoa clones of the CEPEC germ plasm collection. The cultivars SCA-6, UF-613, EEG-8, CAS-1, and several SICs of the Catongo series displayed a considerable degree of resistance to a local *P. palmivora* strain. Methods of research applied are discussed. English summary. Tables. 10 refs.

**Nya Ngatchou, J., and Lotode, R. Variabilité de la précocité chez les premiers hybrides obtenus au Cameroun et recherche d'une correlation entre le diamètre des troncs à un age donné et la précocité des hybrides.** (Variability in precocity of the first hybrids obtained in the Cameroon Rep. and search for a correlation between girth at a given age and precocity of the hybrids). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 98-101 (1969).

The results of a cocoa variety field trial in the Cameroon Rep. showed that combinations with an Upper-Amazon parent are more precocious. On the basis of girth measurements and figures for precocity, it was concluded that there is a positive, significant correlation between the precocity of the families and their average girth. The correlation is more pronounced at 22 months than at 12 months after planting. Portuguese and English summaries. Tables. Two refs.

**Murray, D. B., and Jones, M. R. Cocoa rehabilitation schemes in Trinidad and Grenada.** Ann. Rep. Cacao Res. 1969, pp. 43-6 (1970).

A farm survey was conducted in Trinidad and Grenada to study the agronomic, economic and social problems of cocoa rehabilitation schemes. The information obtained highlights, among others, the paucity of management on cocoa farms, the effect of soil type and cultural practices on yield, and the importance of a credit/subsidy system adapted to the size of the farms. Although research has provided some of the answers to produce high yields, much remains to be done, particularly in the field of soil regeneration and maintenance of soil fertility. Finally, it is stated that the planning of agricultural policies (social and economic changes) requires careful consideration. Tables.

**Manço, G. R., and Medeiros, A. G. Considerações sôbre a "morte súbita" do cacaueiro na Bahia.** (Observations on "sudden death" of cocoa trees in Bahia). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 237-40 (1969).

Literature on "sudden death", a disease of cocoa of unknown origin, is reviewed. The distribution of the disease in Bahia, Brazil, the symptoms, and the results of recently conducted research are discussed. Some facts are mentioned which might suggest new approaches in research. English summary. Table. Photos. 12 refs.

**Muller, R. A., and Lotode, R. Essai de mise au point d'une méthode rapide d'appreciation de l'efficacité des fongicides contre la pourriture brune des cabosses du cacaoyer due à Phytophthora palmivora (Butl.) Butl., dans les conditions naturelles.** (Development of a rapid method for evaluating the effectiveness of fungicides against cocoa pod rot due to *Phytophthora palmivora* under natural conditions). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacao 19 a 26 de Novembre de 1967, pp. 189-203 (1969).

A method earlier developed in the Cameroon Rep. for the screening of fungicides against *Phytophthora* pod rot in cocoa is reviewed. Based on the results of several experiments, it was concluded that application of this method allows the evaluation of fungicides against *P. palmivora* within a short period of time and at low costs. Portuguese and English summaries. Tables. Graphs. Two refs.

**Ruiz, Z. M., et al. Relación entre la destrucción de la clorofila y el grado de susceptibilidad del cacao al hongo Ceratocystis fimbriata (Ell. & Halst.) Hunt.** (Relation between the chlorophyll destruction and the rate of susceptibility of cocoa to the fungus *Ceratocystis fimbriata*). In: Memórias da segunda

Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 177-80 (1969).

A new method of evaluating cocoa resistance or susceptibility to the fungus *Ceratocystis fimbriata* was developed and tested in Bahia, Brazil. The method, which is based on the colorimetric determination of the degree of chlorosis induced in leaves of small branches by artificial inoculation, appeared to be as efficient as that developed by Delgado and Echandi, and has the advantages of being strictly quantitative and yielding more reproducible results. English summary. Tables. 11 refs.

**Medeiros, A. G. Diretrizes para o contrôle da podridão parda, Phytophthora palmivora (Butl.) Butl., do cacaueiro na Bahia.** (Measures to control pod rot of cocoa, *Phytophthora palmivora*, in Bahia). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 204-12 (1969).

Chemical control of pod rot (*Phytophthora palmivora*) in cocoa, in Bahia, Brazil, proved to be not economical the last few years. Experiments revealed that 2 sprayings of Oleocuivre and/or Copper Sandoz (4%) during the May-June period, or 2 sprayings with Copper Sandoz (4%), applied to the pods on trunk and branches using Kiekens sprayers were effective. Seriously infested areas can be economically treated this way. Elimination of all pods at the end of the harvest period, pruning, shade reduction, drainage, regular removal of infected pods, and gathering and stacking of the refuse, are practices recommended for both seriously infested and moderately infested areas. English summary. Tables. Graphs. 29 refs.

**Lodos, N. The role of insects in cherelle wilt in Ghana.** In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 283-6 (1969).

Recent field observations in Ghana showed that insects are one of the factors causing cherelle wilt in cocoa. Young cherelles (up to 2 cm in length) are mainly attacked by aphids, psyllids, ants or beetles and cherelles between 2 and 10 cm in length by other insect species. The type of damage caused by different insects under the conditions prevailing at Tafo is described. Portuguese summary. Table. One ref.

**Silva, P., et al. Estudos recentes sôbre a entomologia do cacaueiro na Bahia e no Espírito Santo.** (Recent studies on the entomology of the cocoa tree in Bahia and Espirito Santo). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 253-9 (1969).

Entomological problems with respect to the cocoa tree in the State of Bahia, Brazil, are dealt with. Taxonomic aspects are restricted to certain groups of pests, including mirids, ants, and phytophagous insects. Bio-ecological problems are discussed in relation to the population dynamics of cocoa insects. The effects of different methods of pesticide application on the entomofauna of the cocoa tree, phytotoxicity, and on residues in commercial cocoa beans were investigated. English summary. Table. Graphs. Fig. Eight refs.

**Lavabre, E. M. Les travaux de recherches sur les mirides des cacaoyers en Afrique occidentale (Bilan et perspectives).** (Research on cocoa mirids in W. Africa (present status and prospects)). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 260-3 (1969).

A review is given of past and recent cocoa mirid control research in W. African countries; mainly on lindane substituting insecticides, methods of pesticide application, and seasonal fluctuations of insect populations. Occurrence of mirid resistance to lindane, some opposition to chlorine-containing insecticides, and a renewed interest in integrated control methods have led to intensification of basic research on cocoa mirids. Preservation of the useful entomofauna, the use of systemic insecticides and breeding for resistance are areas of investigation which may lead to satisfactory solutions. Portuguese and English summaries.

**Laryea, A. A. Field trials with carbaryl against cyclodiene resistant mirids on cocoa in Ghana.** In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 296-303 (1969).

In Ghana, carbaryl and lindane were tested on a large scale against cocoa mirids. Analysis and study of the results showed that carbaryl gives a better knock-down effect than lindane of mirids resistant to lindane and cyclodiene insecticides. However, rate of build-up of mirids treated with carbaryl was so high that lindane appears better in the long term. Sevin needs to be applied 4 to 8 times at 7- to 14-day intervals, and good coverage is essential (tree method of application). The use of carbaryl may be restricted to areas with resistant mirids. Side-effect studies should be completed before carbaryl can be recommended. Portuguese summary. Tables. Graphs. 15 refs.

**Youdeowei, A. Timing insecticide application to control the cocoa capsid Sahlbergella singularis Hagl. in Nigeria.** Int. Pest Control 12, 5, pp. 13-6 (1970).

In Nigeria, trials were conducted to compare 2 schedules of spraying cocoa against *Sahlbergella singularis*, viz. in the dry season and in the wet season. Lindane was applied at the rate of 170 g commercial product per ha, at the rate of 144 litres. Three applications during the dry season period April-May (and if necessary 1 in Aug.) gave better control than 3 applications in the wet season during Aug.-Oct. Therefore, it is suggested to spray during the dry season, instead of during the wet season as is recommended at present, when the capsid population is at its lowest level. It is advantageous to spray during the dry season, because there is less work to do during that time than during the wet season. Graphs. Fig. Photo. 10 refs.

**Silva, P. Nôvo método de aplicação do BHC no combate à formiga de enxerto, praga do cacaueiro.** (New method of applying BHC for control of the gardener ant cocoa pest). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 291-5 (1969).

The gardener ant, *Azteca paraensis bondari*, is a serious cocoa pest in Bahia, Brazil. Control methods recommended so far have not given satisfactory results. A new method is to inject 15 to 16 g of 1% BHC into the nests. The method appears to be more efficient than classical control methods and is more economic and practical as well. English summary. Table. Graph. Photos. Seven refs.

**Memôrias da segunda Conferência Internacional de Pesquisas, em Cacau 19 a 26 de Novembre de 1967; ed. by L. C. Cruz, et al.** (Proceedings of the second International Cacao Research conference 19-26 Nov. 1967). Salvador and Itabuna (Bahia, Brazil), CEPLAC, 1967; publ. 1969. 544 pp. Tables. Graphs. Figs. Photos. Many refs.

This report includes the 77 working papers, discussions and recommendations of the second International Cacao Research Conference held at Salvador and Itabuna, Bahia, Brazil from 19 to 26 November 1967. The papers submitted were arranged under the following headings: Selection and breeding (19 papers); Diseases and disease resistance (9 papers); Phytopathology (9 papers); Entomology (9 papers); Physiology (9 papers); Rehabilitation (3 papers); Soils (14 papers); Quality (3 papers); and International co-operation (2 papers). Each of the documents (28 in Portuguese, 31 in English, 9 in Spanish and 9 in French) contains English and Portuguese summaries. Several of the papers will be abstracted separately.

May 1971

**Boyer, J. Influence des régimes hydrique, radiatif et thermique du climat sur l'activité végétative et la floraison de cacaoyers cultivés au Cameroun.** (The effect of moisture, radiation, and thermal conditions of the climate on the vegetative activity and flowering of cocoa trees in Cameroon). Café Cacao, Thé 14, 3, pp. 189-201 (1970).

Results are presented of observations on the effect of climatic factors on growth and flowering of cocoa under different shade conditions in a cocoa planting near Yaoundé, Cameroon. Rainfall pattern and solar radiation intensity proved to be important factors. Soil moisture conditions clearly governed flushing. Trees under shade and without shade behaved differently. Solar radiation may act as a limiting factor in flushing, flowering and fruit set. Introducing shade conditions when cocoa trees are not sufficiently covered, seems recommendable. English, Spanish and German summaries. Graphs. Photos. 19 refs.

**Zevallos, A. C. Estudos sôbre o sistema radicular do cacaueiro e as oscilações do nível do lençol freático na Bahia.** (Studies on the cocoa root system and the fluctuations of the water table in Bahia). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 467-9 (1969).

Investigations in Bahia, Brazil, revealed, among others, that on clay soils of the cocoa region, cocoa root differs very little, whereas on the "grumosol" soils, roots penetrate to greater depths. This latter fact could be attributed to the greater depth of the A-horizon and a better aeration in the lower levels due to cracking of the soil. From these studies and observations on water table fluctuation it is concluded that depth of the water table largely influences the production of cocoa trees. English summary. Table. Graph. Four refs.

**Gavande, S. A. Influence of soil moisture regimes on oxygen diffusion and water use by cocoa.** In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 431-5 (1969).

A pot trial was conducted in a greenhouse in Costa Rica to compare the effect of different soil moisture regimes on oxygen diffusion rate, soil temperature, water uptake, early shoot growth, and root development of cocoa growing in different soil series. It was found that soil moisture influenced oxygen diffusion rate, soil temperature, water use, and growth of cocoa in all soil series. Volcanic ash soils, as compared to latosolic and alluvial soils, retained more water and diffused more oxygen (particularly at low soil moisture levels). Consequently cocoa plants showed better growth on volcanic soils. Portuguese summary. Graphs. 19 refs.

**Pinto, G. C. P., et al. Seleção de matrizes superiores nos cacauais da Bahia.** (Selection of superior cocoa trees at the cocoa plantations in Bahia). Pesquisa Agropec. Brasileira 4, pp. 13-21 (1969).

The cocoa selection programme, which started in 1953 on cocoa plantations in Bahia, Brazil, resulted in a selection of 197 trees for further testing. From the sum of indices, allotted to these clones for yield, pod number and index, percentage pod rot (caused by *Phytophthora*), tree competition, degree of shading and stem appearance, 28 clones with the highest scores were chosen. Positive correlations ($r=0.327$ and 0.462) were found between yields of early selected clones, planted in 1958 in a clonal trial and yields of the parent trees. Promising clones with high scores and a high production in this trial were: 325, 339, 382 and 088, yielding, respectively, 3.4, 2.2, 2.0 and 1.8 kg dry beans/tree/annum, between 1964-66. English summary. Tables. 23 refs.

**Jacob, V. J., and Opeke, L. K. Studies on the effect of hormones on the rooting of cuttings of various clones of cocoa (Theobroma cacao L.).** In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 336-8 (1969).

Two experiments in Nigeria to study the effect of hormonal treatment on rooting of cuttings of different cocoa clones showed that: (1) the polythene sheet method was as successful as treatment with hormones; and (2) the rooting performances of the different clones were significantly different. Reference is made to the rooting of kola (*Cola spp.*) cuttings without the use of hormones. Portuguese summary. Tables. Six refs.

**Toxopeus, H. Seasonal trend of the rooting success of cuttings of cocoa clones in Nigeria and the relation with establishment ability.** Euphytica 19, 4, pp. 426-9 (1970).

Results are presented of rooting success of cuttings of cocoa clones. In Nigeria, they showed different patterns of success in the course of a year. The correlation coefficient between rooting success during the dry season and establishment ability in the field of 18 Trinitario clones was 0.82. Nursery experience indicated that Upper Amazon clones do not show this relation. Table. Graph. Six refs.

**Soria, J., and Paredes, A. Renovación bajo plantaciones viejas de cacao.** (Renewal under old cocoa plantings). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 365-8 (1969).

A new scheme is presented of year-to-year practices for cocoa replanting. Old cocoa trees are used as temporary shade, and the old trees are removed gradually up to the 4th year when the new plants have almost closed their canopies. The scheduled practices include: elimination of shade and cocoa trees, picketing, planting and cultural practices. Total costs of replanting using the new system does not differ from those using the traditional "supplying" method of renewal; however, income from the old cocoa trees is almost enough to finance the replanting process. Portuguese and English summaries. Appendixes. Table. Five refs.

**Ahenkorah, Y., and Akrofi, G. S. The status of an amelonado shade manurial experiment (K1) at Tafo.** In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 325-30 (1969).

The set-up of a shade × fertiliser field trial in amelonado cocoa at Tafo, Nigeria, is described, and a brief history of the previous treatment of cocoa in this field is given. The soil analysis data (of 1957 and 1967), annual yields (up to 1966/67 season), and the pest control scheme are presented. Depletion of available P over the 10-year period is real, and this may explain the increasing percentage effect of fertiliser on unshaded cocoa. Shade and fertiliser effects averaged 145% and 45% over the 10-year seasons, respectively. Optimum yield was obtained from the combined effect of shade removal, fertiliser application and irrigation. Portuguese summary. Tables. Graph. 14 refs.

**Egbe, N. E. The effects of some temporary shade plants of cocoa on certain nutrient contents of the soil.** In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 333-5 (1969).

In Nigeria, samples of soil under different temporary shade plants for cocoa were analysed to determine C, N, and exchangeable Ca, Mg and K contents. The soil under the shade of 2 *Musa spp.* had lower contents of exchangeable cations, in particular K, and lower C/N ratios than the soil under the shade of papaya or cassava. The soil under the shade of cassava had not been depleted much of its N, Ca, Mg and K contents. Portuguese summary. Table. Seven refs.

**Cabala-Rosand, F. P., et al. Deficiências minerais e efeitos da adubação na região cacaueira da Bahia.** (Mineral deficiencies and effect of fertilising in the cocoa region of Bahia). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 436-42 (1969).

This paper summarises the results of main experiments, which formed the start of the cocoa fertilising programme in S. Bahia, Brazil. Micro-plot tests with maize revealed that P is the most deficient element in the various types of soil. N, K and Mg deficiencies were less marked. Results obtained with beans as test plant were also included. Fertiliser × shade trials conducted in 21 adult cocoa plantings revealed highly significant effects from shade removal combined with fertiliser application. The importance is stressed of Ca, Mg and Al in available form in expanding cocoa growing in Bahia. English summary. Tables. Graphs. Figs. Seven refs.

**Miranda, E. R. de, and Prado, E. P. do. Influência da umidade disponivel sôbre o aproveitamento de duas fontes de fósforo por plântulas de cacau.** (Effect of available moisture on the utilisation of 2 sources of phosphorus by cocoa seedlings). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 476-80 (1969).

In a pot trial in a greenhouse in Bahia, Brazil, the effect of 4 soil moisture levels of P-deficient "tabuleiro" soil on P-uptake by cocoa seedlings from 2 different P-fertilisers (natural phosphate and 3-superphosphate) were studied. No statistical differences between the 2 P-sources were found. The 50 and 75% soil moisture contents gave significantly better responses to P-fertiliser application over the 0 and 25% soil moisture levels. $P_2O_5$ solubility in the soil was higher after applying natural phosphate than after applying 3-superphosphate; however, cocoa seedlings developed satisfactorily with both P-fertilisers. English summary. Tables. Graphs. 15 refs.

**Leston, D. Recent advances in cocoa entomology in Ghana.** Cocoa Marketing Board Newsletter 46, pp. 15-6 (1970).

A cocoa entomology discussion group met at Legon, Ghana, in June 1970. The discussions were dominated by the opinion that insects do not spread black pod rot (*Phytophthora palmivora*). The discovery of 2 distinct capsid parasites and predators, ants in particular. Ants play an important role not only in the swollen shoot virus (SSV) and capsid problems, but also in the spread of pod rot (*Phytophthora palmivora*). The discovery of 2 distinct capsid diseases suggests possibilities for non-chemical control. Study of capsid sex behaviour may lead to alternative control measures. Another discovery was that at least 4 different *Helopeltis* species exist. Some form of integrated capsid and SSV control problems are briefly discussed.

**Muller, R. A., and Njomou, S. E. Contribution à la mise au point de la lutte chimique contre la pourriture brune des cabosses du cacaoyer (Phytophthora palmivora (Butl.) Butl.) au Cameroun.** (A contribution to the improvement of the chemical control of black pod rot in cocoa (*Phytophthora palmivora*) in Cameroon). Café Cacao, Thé 14, 3, pp. 209-20 (1970).

In Cameroon, the effectiveness of different organic fungicides and different formulations and application methods of Cu-fungicides were tested to improve the control of pod rot (*Phytophthora palmivora*) in cocoa. The results showed, among others, that organic tin compounds are valuable. Triphenyltin hydroxide solution (0.04% a.i.) was more effective than the commonly used 1% tetracupric oxychloride (50% Cu). The tests with copper fungicides resulted in separate recommendations for the central and southern zones of E. Cameroon, and for the western zone of E. Cameroon and W. Cameroon. English, German and Spanish summaries. Tables. Graphs. One ref.

**Bruneau de Miré, Ph. Observations sur les fluctuations saisonnières d'une population de Sahlbergella singularis au Cameroun.** (Observations on the seasonal fluctuations in a population of *Sahlbergella singularis* in Cameroon). Café Cacao, Thé 14, 3, pp. 202-8 (1970).

Data on observations on the ecology and biology of the mirid *Sahlbergella singularis* conducted in 3 cocoa fields in Cameroon during 4 years, were computerised. The results, presented in fluctuation curves, indicated, among others, that the decline in multiplication was not directly caused by climatic conditions, but by biotic factors. Whereas maturing pods were commonly believed to favour capsid multiplication, the information collected indicated that the opposite is true. English, German and Spanish summaries. Table. Graphs.

**Wessel, M., and Toxopeus, H. Seasonal influences on pod and bean values of West African amelonado cocoa.** In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 351-5 (1969).

Studies conducted in Nigeria on the effect of season on cocoa bean characteristics mainly showed that midcrop season (May-June) beans are smallest, shell percentage is very high, and fat content of the nib is low. Bean weight and fat content of the nib increase, and shell percentage decreases after Aug., to reach a peak in the first part of the main crop season (Sept.-Nov.). These results are important for research programmes aimed at quality improvement. Microtechniques used in measuring bean values are described. Portuguese summary. Tables. Graphs. Six refs.

**Vincent, J. C. Influence de differents traitements technologiques sur la fermentation du cacao.** (Effects of different technological treatments on cocoa fermentation). In: Memórias da segunda Conferência Internacional de Pesquisas em Cacau 19 a 26 de Novembre de 1967, pp. 510-8 (1969).

Investigations are conducted in the Cameroon Rep. to evaluate the effect on fermentation of factors possibly involved in the process of mechanical dehusking. Results are presented of preliminary studies to determine the effects of: washing of the beans (separation of husks and beans by floating and stirring); the presence of pod debris and tissue in bean masses; furthermore, the cumulative effect of both factors are determined. Portuguese and English summaries. Tables.

Printed in England by Hudson Buckler & Webb Group, Birmingham B3 2JD