COCOA GROWERS' BULLETIN

Number 43 **December 1990**

Contents

Cadbury Ltd
Bournville
Birmingham
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England

EDITORIAL

At the present levels of world prices attention is being rightly directed by cocoa growers, government officials and others towards the cost of cocoa cultivation. In an attempt to further this debate and give interested parties a chance to develop reliable methodology, an article proposing a system of estimating costs is presented in this issue of the Cocoa Growers' Bulletin. This methodology could have particular relevance in estimating cocoa production costs on a country wide basis by aggregation of a number of different classes and ages of cocoa holdings in a systematic way. It is hoped that the publication of this article will stimulate further debate and consideration of the technique.

Another cost study entitled 'Competitivite du Cacao Africain' [Jouve, P. and de Milly, H. (1990) Ministere de la Cooperation et du Developpement, Secretariat Permanent des Etudes de l'Evaluation et des Statistiques, 20 rue Monsieur, 75700 Paris] has also just became available. This study looks in considerable detail at cocoa cultivation and marketing in Brazil, Cameroon, Cote d'Ivoire, Ghana, Indonesia, Malaysia and Nigeria. It also tries to make valid comparisons between various parameters of cocoa cultivation and marketing between these seven producing countries despite the obvious difficulties of this procedure. The study concludes that the cost of production for the small African cocoa producer is well below the cost of production on the large and intensive plantations and farms in Malaysia and Brazil. It is therefore optimistic about the prospects for them though does draw attention to the need for improved productivity.

A third paper of interest is entitled 'Malaysian Cocoa Production Costs and their Implications for Future Development and Production Policies'. [Mohamed Musa Jamil, Paper AG/7/WP.9, Advisory Group on the World Cocoa Economy, 7th Meeting, Accra, 18-22 June 1990, International Cocoa Organisation, London]. This paper concludes that the current prolonged low prices will force Malaysian smallholders (growers with less than 20ha) to supplement their income by planting other crops or by livestock farming. Furthermore the very small growers are having particular difficulties as they do not have extra land to plant and so many have been declared bankrupt or have sold out to the large plantations. These plantations may in time replant poorer cocoa fields with oil-palm or rubber if these low prices continue and also reduce input and management costs on the land retained with cocoa.

A new system of reproduction has been utilised for this issue of the Cocoa Growers' Bulletin and this will be employed for future issues. We hope that readers will find the new typeface easier to read. These changes combined with the need for a different system to manage the Mailing List account in part for the fact that this issue of the Bulletin is somewhat delayed. We apologise for this.

ISSN 0045-7256 *R.A. LASS, Editor*

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REVIEW OF PRODUCTION, CONSUMPTION, STOCKS AND PRICES

November 1989 - September 1990
S A Wakeling
Cadbury Limited

PRODUCTION

Our last review was based on Gill and Duffus Cocoa Market Report No. 335, dated October 1989. In their latest Report No. 338, dated September 1990, estimates of world production for 1986/87, 1987/88, 1988/89 and 1989/90 have been increased by 9, 12, 86 and 10 thousand metric tonnes (TMT) respectively. The estimate for 1988/89 has been increased by 86 TMT primarily due to increases in Cote d'Ivoire (increased by 38 TMT) and Indonesia (increased by 37 TMT).

The estimate for 1989/90 indicates a gross World crop of 2420 TMT, a decrease of 2.6% from the record World crop of 1988/89. The largest drop in tonnage terms was Cote d'Ivoire where the estimate of the 1989/90 crop was down 138 TMT from the 1988/89 crop. It is not known whether this decrease was due to the drop in the producer price and hence the fall in the application of inputs, to the liquidity problems at the beginning of the season or whether it was caused by the dry weather at the start of the season. Countries showing increases from 1988/89 to 1989/90 included Brazil, Ecuador and Malaysia.

Forecasts for 1990/91 appear for the first time in Report No. 338. The World crop is forecast at 2427 TMT, up by just 7 TMT on 1989/90. Countries where an increase in the crop from 1989/90 is forecast are Cote d'Ivoire, Indonesia, Malaysia and Papua New Guinea. Countries where a decrease in the crop from 1989/90 is forecast are Cameroon and Ghana.

CONSUMPTION

The Gill and Duffus Cocoa Market Report No. 338 reports data on World grindings of raw cocoa in a 'cocoa year' format (October to September). Previous reports had presented grindings data in a calendar year format.

The consumption of cocoa has continued to grow steadily, however the rate of increase appears to be slowing down, which is primarily a consequence of the economic and political changes currently being experienced in the USSR. The period 1987-91 will show the strongest sustained growth since 1963-67. This demonstrates the positive effect of low cocoa prices upon consumption.

Grindings in West Germany and the Netherlands are forecast to reach record levels.

WORLD COCOA PRODUCTION DATA

Reproduction from Gill and Duffus Market Report No. 338
Dated September 1990
(all figures in thousand metric tonnes (TMT))

	1986/87	1987/88	1988/89	1989/90	1990/91*
Cameroon	123	131	129	125	120
Cote d'Ivoire	620	665	848	710	740
Ghana	228	188	300	295	250
Nigeria	80	150	160	170	170
Togo	13	11	14	12	11
Others	38	40	33	34	34
Total Africa	**1102**	**1185**	**1484**	**1346**	**1325**
Brazil	369	402	343	370	369
Colombia	55	59	50	50	50
Ecuador	71	78	88	95	95
Mexico	39	44	42	43	43
Peru	10	12	12	11	11
Venezuela	12	12	10	11	11
Others	13	10	11	10	10
Total C. & S.America	**569**	**617**	**556**	**590**	**589**
West Indies					
Dominican Rep.	42	53	41	50	50
Others	12	12	8	10	10
Total West Indies	**54**	**65**	**49**	**60**	**60**
Indonesia	56	64	102	110	122
Malaysia	171	227	223	255	265
Papua New Guinea	31	33	47	38	45
Others	20	20	24	21	21
Total Asia & Oceania	**278**	**344**	**396**	**424**	**453**
WORLD TOTAL	**2003**	**2211**	**2485**	**2420**	**2427**
% change in production from previous season	1.0	10.4	12.4	-2.6	0.3

* **Forecast**

WORLD COCOA GRINDINGS DATA

Reproduction from Gill and Duffus Market Report No. 338
Dated September 1990
(all figures in thousand metric tonnes)

	1986/87	1987/88	1988/89	1989/90	1990/91*
Belgium	34	35	41	43	45
France	35	38	47	55	58
Germany (Fed. Rep.)	205	225	244	267	280
Italy	43	46	46	47	49
Netherlands	190	215	231	244	256
Spain	33	43	40	40	41
United Kingdom	94	100	112	119	125
Others	57	55	58	59	63
Total Western Europe	**691**	**757**	**819**	**874**	**917**
Eastern Europe	99	88	99	79	79
USSR	164	132	201	135	100
Total E. Europe & USSR	**263**	**220**	**300**	**214**	**179**
Cote d'Ivoire	100	110	125	120	110
Others	63	71	65	74	83
Total Africa	**163**	**181**	**190**	**194**	**193**
	232	236	201	229	240
America	48	46	41	45	45
Brazil	29	36	37	41	42
Colombia	36	40	40	42	44
Ecuador	227	239	238	266	280
Mexico	57	59	57	58	58
United States	**629**	**656**	**614**	**681**	**709**
Others					
Total America					
	36	39	40	41	43
	36	38	50	68	90
Japan	34	41	46	55	58
Malaysia	52	58	64	82	84
Singapore	**158**	**176**	**200**	**246**	**275**
Others					
Total Asia & Oceania					
WORLD TOTAL	**1904**	**1990**	**2123**	**2209**	**2273**
% change in grindings from previous season	1.4	4.5	6.7	4.1	2.9

*** Forecast**

Consumption in Eastern Europe has been dominated by the USSR, which over the past 5 years it has accounted for two thirds of the total grind in Eastern Europe. This season has witnessed a sharp decline (30%) in bean imports into the USSR, as a result of foreign exchange problems that developed during the first half of the year.

In the United States chocolate consumption continues to be buoyant, particularly in the solid bar sector. Grindings during 1989/90 are set to reach record levels.

STOCKS

The continued production surpluses since 1984/85 have resulted in a large increase in world stocks both in absolute terms and as a proportion of world grind. The forecast for 1990/91 is 130 TMT to add to the 1431 TMT of cocoa stocks at the end of the 1989/90 season. For the first time since 1986 almost all the accumulated surplus is held in the consuming countries, and immediately available for use.

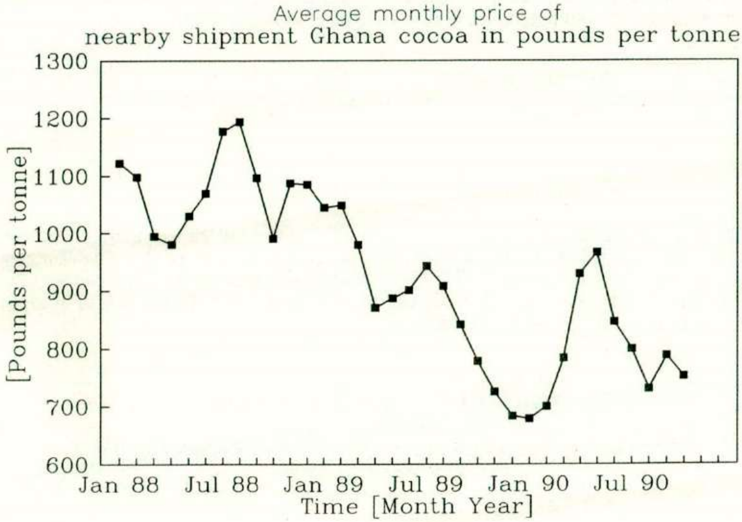
WORLD COCOA STOCK DATA

Reproduction from Gill and Duffus Market Report No. 338
Dated September 1990
(all figures in thousand metric tonnes)

	1986/87	1987/88	1988/89	1989/90	1990/91
Closing stocks	708	907	1244	1431	1561
(including buffer stock)					
Stock/consumption ratio	0.37	0.46	0.59	0.65	0.69
(including buffer stock)					

PRICES

World cocoa prices have fallen in each of the last six seasons in response to surplus production. There is no reason to expect any different response to the seventh surplus anticipated in 1990/91.



Since the last issue of the Cocoa Growers Bulletin (Number 42, December 1989) the price of London and New York cocoa has been volatile. The lows of January and February 1990 (attributed to Ivorien sales and heavy manufacturer buying) were followed by a dramatic rise in prices. This rise which took place from March to May 1990 was in response to a number of factors, principally that the Ivoriens stopped selling, the 1989/90 Ivorien crop tailed off rapidly, reports of poor rains in the Cote d'Ivoire and political unrest in the Cote d'Ivoire. June 1990 saw a rapid fall in cocoa prices due to the Russians reselling previous purchases and a good late pod setting in West Africa. The period from July to September 1990 has seen a gradual decline in prices.

CLONAL PROPAGATION OF CACAO

Leon J. Glicenstein, William P. Flynn, Paul J. Fritz *

INTRODUCTION

In the course of breeding for improvements in the cocoa plant, desirable clones will be developed. How can these desirable cultivars be best propagated so that they may be distributed to the growers?

Traditional methods for propagation of *Theobroma cacao* are growing from seeds, taking cuttings, and utilizing bud grafts (Evans, 1961; Hardy, 1960; Lass and Wood, 1985; Wood and Lass, 1985). Seeds are readily available and produce trees with upright growth habits yielding easily harvested fruits on both trunks and branches. Seed-grown trees have the advantage of allowing good air circulation through the trees and the field, allowing people to easily and efficiently work beneath the canopy and to keep the farm clean and healthy. However, because of extensive heterozygosity, cocoa seeds do not breed true for the phenotype of a desired clone. This problem may be overcome in the future by developing inbred lines with the desired characteristics and producing uniform, seed-derived, F1 hybids. Vegetative propagation of *T. cacao,* either through rooted cuttings or grafting, is most often done using readily available plagiotropic (fan) branches of the canopy. Clonal cocoa trees originating from fan branches grow in a prostrate, dense, bush-like pattern, which unless extensively and repeatedly pruned, are not conducive to good healthy, manageable fields or easy harvesting. Consequently, it would be much more desirable to obtain cuttings or budwood for grafting from orthotropic (chupon) materials because trees originating from this material grow in the upright, more easily manageable pattern characteristic of seed- derived trees. In addition, the tap roots produced with orthotropic cuttings give anchors to the trees and make them less sensitive to water stress (Amefia et al., 1985). Because orthotropic material is usually in short supply, this note describes a method for obtaining large numbers of orthotropic buds suitable for clonal propagation. The method takes advantage of a phenomenon well known to cocoa growers and indeed is often regarded as a nuisance, namely the prolific appearance of chupons on bent or fallen cocoa trees.

MATERIALS AND METHODS

Five year old trees of *T. cacao* were cultivated in 22 gallon containers containing a mixture of 2:3:1-peat: vermiculite: soil in a Pennyslvania State University greenhouse in University Park, PA, USA. The plants were fertilized monthly with one-half strength Peters 10-20-10 fertilizer. The trees utilized in this study were PSU 13 and PSU 26 derived from seeds of open pollinated EQX-100, and UF-667, respectively, collected in the field at the USDA Agricultural Station, Mayaguez, Puerto Rico. They were given PSU (Penn State University) numbers because they are unique clones.

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The cocoa trees were bent into an arch by tying the tops of the trees to the ground. It is important that the orthotropic trunk be arched. After bending, numbers of chupons produced per trunk and number of nodes per shoot were tabulated monthly. Over the one year period of the experiment, apical sections of PSU 13 were removed, leaving two to three noded stubs on the mother plant of each shoot, while entire shoots of PSU 26 were cut, leaving non-noded stubs.

RESULTS

Within one month after bending, buds along the top and side of the arched orthotropic trunk produced multiple chupons (Figures 1 and 2). Flower cushions, when present on the top or sides of the arched trunk, changed from the reproductive to the vegetative phase and also produced multiple orthotropic shoots (Figure 3). Flower cushions have remained vegetative throughout the course of our observations conducted over approximately one year. Two months after bending, PSU 13 had produced 14 shoots with a total of 170 nodes, and PSU 26 had 49 shoots containing 425 nodes. After removing the shoots, buds present on the noded stubs of PSU 13 sprouted, and new shoots were generated, de novo, from the trunk at each cluster of shoots/stumps of PSU 26 (Figure 4). At the end of one year, 624 orthotropic buds had been collected from PSU 13, and 1324 from PSU 26.

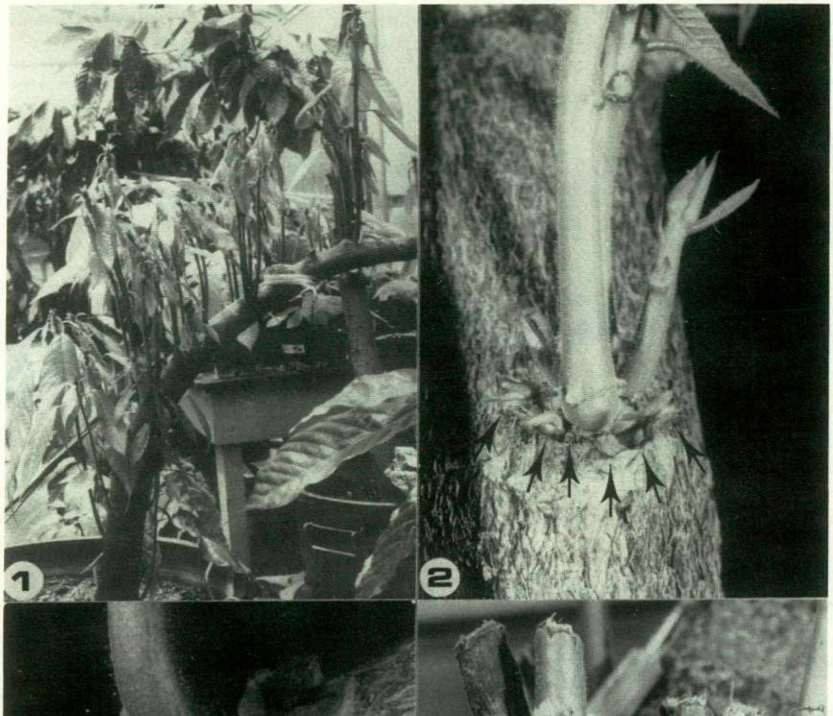
DISCUSSION

The observation that trunks of bent or fallen cocoa trees produce numerous chupons is not new: cocoa growers have always seen it on their farms and have removed the shoots. Brooks and Guard (1952) described orthotropic shoot production, and their rooting, in fallen trees in what appears to be an asexual method of propagation of *T. cacao* in the wild. However, producers of cocoa plants have not taken advantage of this phenomenon to propagate selected cocoa clones as an alternative to using plagiotropic buds with their related problems.

The importance of cocoa propagation by orthotropic cuttings has been recognized by the IRCC in Togo where an extensive program to develop the method has been carried out since 1984. In the initial report on the Togo program, Bertrand and Agbodgan (1989) described various methods to obtain increased numbers of orthotropic shoots, including pollarding (removal of all tree branches), pruning (removal of two or three plagiotropic branches), coppicing (decapitation of trunk 60 cm above the soil), and arching after deep notching 60 cm above the soil. They observed an average of 13.4orthotropic shoots formed after five months with either coppicing or arching with deep notching. It should be noted that merely by bending the trunk, we have obtained more orthotropic shoots in a shorter time.

We have been using these orthotropic shoots as a continuous supply of material for our in vitro propagation experiments (Flynn et al., 1990) and it is clear that the plants produced have the typical orthotropic growth pattern of seedlings. One should also be able to use these shoots as an almost continuous source of orthotropic materials of selected clones for one and two noded cuttings (we have had no trouble rooting single leafed cuttings from this material), and as budwood for grafting.

FIGURES 1 - 4



We have described a method for obtaining large numbers of orthotropic shoots suitable for clonal propagation with bent cocoa trees. We would like to close with some words of caution: in using this system to establish cocoa farms, care should be taken that trees from more than one clone, preferably several, be utilized, in order to prevent a monoculture which could be destroyed by a single pathogen, and would have insufficient opportunities for cross-pollination.

REFERENCES

Amefia, Y.K., Cilas, C., Djiekar, E.K., and Partiot, M. (1985) La multiplication vegetative du cacaoyer. Note sur une methode d'obtention de boutures a enraciniment orthotrope. Cafe Cacao The, XXIX: 83-88.

Bertrand, B. and Agbodjan, A.K. (1989) Le bouturage orthotrope du cacaoyer - premiers resultats et perspectives. Cafe Cacao The, XXXIII: 147-156.

Brooks, E.R. & Guard, A.T. (1952) Vegetative anatomy of Theobroma cacao. Botanical Gazette, 113: 444-454.

Evans, H. (1951) Investigations on the propagation of cacao. Trop. Agric., Trin., 28: 147-203.

Flynn, W.P., Glicenstein, L.J. & Fritz, P.J. (1989) Theobroma cacao L.: An axillary bud in vitro propagation procedure. Plant cell, Tissue & Organ culture (In press).

Hardy, F. Cacao Manual (English edition). Inter-American Institute of Agricultural Science, Turrialba, Costa Rica, 1960, p.395.

Lass, R.A. & Wood, G.A.R. (1985) Cocoa Production - Present Constraints and Priorities for Research. World Bank Technical Paper Number 39, The World Bank, Washington, D.C. USA.

Wood, G.A.R. & Lass, R.A. (1985) Cocoa. 4th Ed., Tropical Agriculture Series, Longman Scientific & Technical, England, 620 pp.

ACKNOWLEDGEMENT

Published as Paper No. 8237, Journal Series, Pennsylvania Agricultural Research Station.

and West Kalimantan, Sebatik Island, South East Sulawesi, Maluku and Irian Jaya (Anon, 1985) (Figure 1). These reports were stimulated by the finding of the disease in an important plantation in West Java, leading to an increase in awareness of the problem and wide distribution of leaflets describing the disease. The recent upsurge in reports also corresponds to a substantial increase in cocoa planting in Indonesia since 1973. The widespread occurrence of VSD is evidence that the causal fungus has been in Indonesia for a long time and has not been introduced only in the last few years. In Papua New Guinea and Malaysia and Indonesia, the disease has been found in isolated cocoa plantations which have been recently established from seed. In these situations it is highly unlikely that the fungus has been blown into the new planting or has been introduced on seed. There is very strong evidence that the disease is not seed-borne (Prior, 1985; Prior, pers. comm.).

It seems therefore that the fungus is transferring to cocoa from a plant indigenous to the region. So far, this plant has not been identified. *O. theobromae* has recently been reported causing a similar disease on several avocado (*Persea americana.*, West Indian variety) seedlings growing near infected cocoa in Papua New Guinea (Anderson, 1989), though it has not been reported on any other host. There are many members of the cocoa family, (Sterculiaceae), and the avocado family, Lauraceae, in the rainforests of South East Asia and these are potential hosts. It would appear that the indigenous host(s) must be widely distributed throughout the region but must have an eastern-most limit in East New Britain. At one location in West Java the disease was not observed, despite regular searching, for a period of two years. Then in 1986 a very high incidence of disease (30%) was observed in seedlings recently planted adjacent to secondary forest. It appeared that this forest was the source of infection. It is proposed to undertake an intensive search for the indigenous host in this and other localities.

In Indonesia, disease occurrence is patchy, with some plantations being disease free while others are very heavily infected (Table 3). For instance, one region in South East Sulawesi, near Kolaka, is very badly infected, with disease incidence as high as that seen in Papua New Guinea, while no disease has yet been reported from the adjacent regions of Pakue and Kendari, despite the fact that cocoa has been grown for a similar period in all regions. The occurrence of the disease is also patchy in the important cocoa growing region near Medan in the Province of North Sumatra. In 1984 Turner (Turner and Keane, 1985) found quite a high incidence of VSD on Turangie Estate. During an inspection in 1985 Keane found that the disease was common on Turangie Estate despite a prolonged dry spell. During that same visit the presence of the disease, albeit with a very low incidence, was confirmed on P.T. Perkebunan VI, an important source of Upper Amazon Hyrbid seed for the rest of Indonesia.

Heavy infestations of the disease also occur in Maluka and East Kalimantan. It is possible that this distribution represents the chance occurrence of disease in new plantings. Alternatively, it may reflect uneven occurrence of the hypothesized indigenous host. A similar patchy distribution has been observed in Papua New Guinea (Prior, 1980).

FIGURE 1: PRESENT DISTRIBUTION OF VASCULAR-STREAKDIEBACK IN INDONESIA, SHOWING DISTRICT AND YEAR OF FIRST RECORD

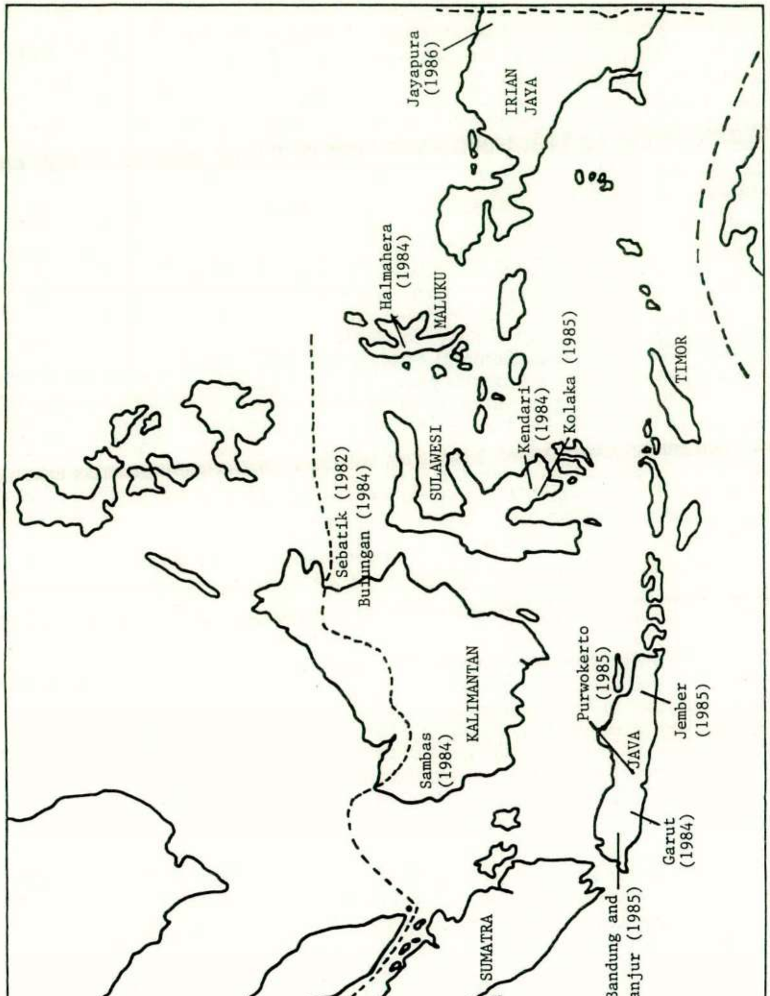


TABLE 3: INCIDENCE OF VSD OF COCOA AT SELECTED SITES IN INDONESIA

Location	Altitude	Rainfall type [a]	Cocoa type	VSD incidence
West Java				
Bunasari-Lendra				
- Cisompet	300	B	Amelonado	Moderate
			Trinitario	Moderate
			UAH	Low
- Cisarua	400-600	B	Amelonado	Low
			Trinitario	Low
			UAH	Low
Sumurbarang	90	C		Low
Bayabang	180	B	UAH	Very High
Rajamanadal	280	B	UAH	Moderate
East Java				
Kajaran	50	C	UAH	Moderate
Kottablater	20	D	UAH	Moderate
Kottablater	20	D	Triniario	No VSD
South East Sulawesi				
Kendari District	25	C-D	UAH	No VSD
Kolaka District				
Tirawuta	25	C-D	Amelonado	Low
Kolaka	0	B	Amelonado	Very High
			UAH	Very High
Wundulako	0	B	Amelonado	Very High
Wolo Tosiba	0	B	Amelonado	Very High
Lasusua	0	B	Amelonado	No VSD
Pakue	0	B	Amelonado/UAH	No VSD

a= According to Schmidt & Ferguson classification

Rainfall type A : Q = 0.000-0.143
Rainfall type B : Q = 0.144-0.333
Rainfall type C : Q = 0.334-0.600
Rainfall type D : Q = 0.601-1.000

$$Q = \frac{\text{number of dry months}}{\text{number of wet months}}$$

wet month : rainfall 100 mm
dry month : rainfall 60 mm

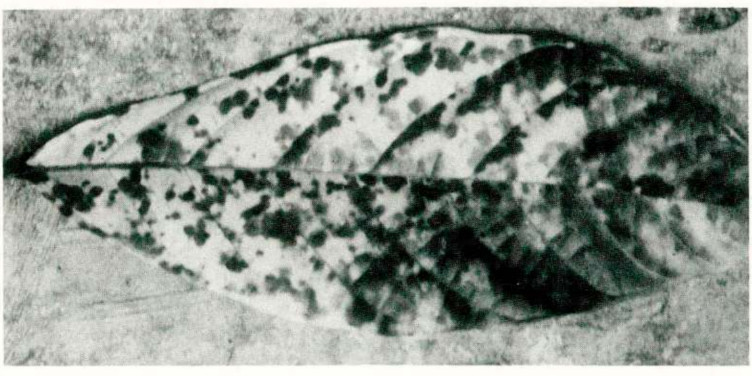
DISEASE SYMPTOMS

Symptoms of VSD in Indonesia are identical to those reported from Papua New Guinea by Keane et al. (1972). The appearance of the first chlorotic leaf, with its distinctive patchy green islands, on the second or third flush behind the growint tip, is typical (Figure 2). In one estate, about four months after the wet season, hundreds of infections showed these early symptoms. In nearly all infections, only one chlorotic leaf was evident. Sometimes this leaf pattern can be confused with the chlorosis of senescent leaves bearing small black algal growths which cause retention of chlorophyll. However, when diseased leaves are removed or the leaf scars scraped, the three leaf traces discoloured brown or black are also distinctive (Figure 3). If a leaf has fallen through natural senescence the three leaf traces will not be discoloured. The disease also causes enlarged lenticels and straking of infected wood. The extent of infection in a branch can be measured by the extent of vascular discolouration in the branch.

In Indonesia the disease also causes secondary symptoms of necrosis of intervienal tissue in the tip leaves (Figure 4). This is thought to be due to restriction of calcium flow to the young flush resulting from the blocking of zylem further down the stem. In Indonesia only rarely has the spread of disease from outer branches into the main stem of a mature tree been observed. This probably reflects the relative early stage of disease development in the cocoa populations of Indonesia.

The fungus has been commonly found growing in the xylem vessels of infected cocoa stems in Indonesia. It has been found in no other tissues in the infected plants. If leaf fall occurs during wet weather, fungal hyphae grow out of the three vascular traces on leaf scars. Eventually these emergent hyphae form the corticioid sporophores of *O. theobromae*. Sporophores found in Indonesia are identical to those found in Papua New Guinea (Figure 5). Basidia have not yet been observed but the basidiospores are identical to those reported by Talbot and Keane (1971). There is no doubt that the disease in Indonesia is very similar to that initially described from Papua New Guinea. A fungus identical in its vegetative characteristics to *O. theobromae* has been consistently isolated from diseased cocoa stems in Indonesia.

FIGURE 2: DISTINCTIVE FIRST SYMPTOMS OF VASCULAR-STREAK DIEBACK, SHOWING GREEN ISLANDS AGAINST A CHLOROTIC BACKGROUND



VASCULAR-STREAK DIEBACK OF COCOA IN INDONESIA

Soekirman Pawirosoemardjo, * Agus Purwantara, * and P J Keane **

INTRODUCTION

Cocoa has had a long history in South East Asia since its introduction to the Philippines by the Spanish in the 1660's. On two occasions single plants were introduced from Mexico (Toxopeus and Giesberger, 1983). The first definite record of cocoa in Indonesia is from 1778 near Jakarta, although the first commercial plantings were in the islands presently known as North East Sulawesi and Maluku from 1822 (Toxopeus and Giesberger, 1983). These early plantings declined due to attack by the mirids, *Helopeltis* spp., and cocoa pod borer moth, *Conopomorpha cramerella,* both of which are serious pests of the present crop in Indonesia. By the 1890's export of cocoa from these islands had ceased. Small areas of cocoa lingered on as a source of planting material. Exports of cocoa from Java commenced in 1884 and continued through to the present time, although again the industry was plagued by pests. Initially, a Criollo type, known as "Java Red", was grown. While cocoa never became a major crop, planting was widespread in Java and was supported by a vigorous research programme. In 1936 all the cocoa in East Java was cut out due to damage by cocoa pod borer (Wood, 1985). In 1938 there was a total of about 6,500 hectares in Java and Java cocoa was recognised for its fine flavour by European manufacturers. In the 1950s, annual exports stood at about 1,000 tonnes. In this period the valuable Trinitario clones DR1, DR2 and DR38, selected at Djati Roenggo estate, and traceable to one single plant introduced from Venezuela in 1888, became widely planted. These were flavour, not bulk, cocoas. Throughout the early period of cocoa production, along with the development of suitable planting material, pests and diseases were of major concern, the main problems being *Helopeltis, Conopomorpha cramerella* and *Phytophthora* canker and *Phytophthora* pod rot.

In the early 1970's there was renewed interest in cocoa, with increased planting on government and private estates in East and West Java and North Sumatra and on smallholdings. Since that time cocoa production in Indonesia has expanded rapidly, as shown in Table 1. Planting and production has increased particularly on smallholdings, with a 12-fold increase in area and 59-fold increase in production over the period 1969-87. In this period yield on private estates has remained at about 0.4 tonne per hectare, but yield has increased from 0.14 to 0.85 tonne/ha on government estates and from 0.06 to 0.28 tonne/ha on smallholdings, reflecting the increasing contribution of plantings coming into bearing and improved cultural methods. Cocoa planting and production in the different Provinces is given in Table 2. The main centres of production are in North Sumatra, in the vicinity of Medan, East Java, South Sulawesi and South East Sulawesi. In East Java and North Sumatra the bulk of the plantings are on Government-owned estates. In 1988, 67 per cent of the total cocoa area and 44 per cent of the production was attributable to smallholders. In South and South East Sulawesi there is great enthusiasm for cocoa planting among smallholders and cocoa production has already caused a substantial increase in the standard of living in many villages. In South East Sulawesi, planted area has expanded from 7119 ha in 1984 to an estimated 57,139 ha in 1990, with production

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TABLE 1: COCOA AREA AND PRODUCTION IN INDONESIA, 1969-1987

Year	Smallholders			Government Estates			Private Estates			Total		
	Area (ha)	Prodn (tonne)	Yield (t/ha)	Area	Prodn	Yield	Area	Prodn	Yield	Area	Prodn	Yield
1969	5,400	330	0.06	6,400	920	0.14	1,200	500	0.42	13,000	1,750	0.13
1979	10,800	1,040	0.10	16,900	7,000	0.41	3,300	590	0.18	31,000	8,630	0.28
1986	52,100	8,600	0.17	28,200	18,500	0.66	9,500	4,000	0.42	89,800	31,100	0.35
1987	71,132	19,756	0.28	29,994	25,428	0.85	10,823	4,699	0.43	111,949	49,703	0.44
Proportion of total	0.63	0.39		0.27	0.51		0.01	0.01				
Increases 1969-1987	x13	x59		x5	x28		x9	x9		x9	x28	

Source: Directorate General for Estate Crops, 1987.

TABLE 2: AREA OF COCOA PLANTED AND PRODUCTION IN THE PROVINCES OF INDONESIA IN 1988. DATA FROM DIRECORATE GENERAL FOR ESTATE CROPS, INDONESIA.

	Smallholders Area (ha)	Production (tonne)	Government Estates		Private Estates		TOTAL	
Acet	580	2	0	0	190	23	770	25
North Sumatra	3,120	648	11,823	11,481	4,027	2,925	18,970	15,054
West Sumatra	733	148	0	0	0	0	733	148
Riau	316	0	0	0	16	0	332	0
Jambi	400	10	0	0	0	0	400	10
South Sumatra	147	2	0	0	0	0	147	2
Bengkulu	3,352	34	0	0	0	0	3,352	34
Lampung	1,712	808	0	0	105	6	1,817	814
West Java	183	29	3,974	1,806	1,384	456	5,541	2,291
Central Java	1,265	0	1,589	825	60	32	2,914	857
Jogjakarta	0	0	0	0	0	0	0	0
East Java	0	0	15,608	11,316	2,786	688	18,394	12,004
Bali	2,074	544	0	0	20	5	2,094	549
West Nusa Tenggara	15	2	0	0	0	0	15	2
East Nusa Tenggara	11,571	1,290	0	0	0	0	11,571	1,290
West Kalimantan	935	147	0	0	8	1	943	148
Central Kalimantan	2,322	40	0	0	0	0	2,322	40
South Kalimantan	181	6	0	0	0	0	181	6
East Kalimantan	4,648	2,031	0	0	0	0	4,648	2,031
North Sulawesi	1,156	43	0	0	0	0	1,156	43
Central Sulawesi	0	0	0	0	300	7	300	7
South Sulawesi	20,000	8,941	0	0	1,223	534	21,223	9,475
South East Sulawesi	21,616	5,125	0	0	0	0	21,616	5,125
Maluku	10,988	2.939	0	0	199	10	11,197	2,949
Irian Jaya	5,401	903	0	0	1,408	30	6,809	933
Jakarta	0	0	0	0	0	0	0	0
East Timor	76	8	0	0	0	0	76	8
TOTALS	92,801	23,700	32,994	25,428	11,726	4,717	137,52 1	53,845

increasing from 2,257 tonnes to 14,231 tonnes in the same period (Sigg, pers.comm.). There are some very large cocoa estates being developed, including one of 10,000 ha in East Kalimantan and several of 3,000 - 7,000 ha in North Sumatra.

Initially cocoa production in Java used mainly fine flavoured clones of Trinitario origin. The more recent plantings have been mainly so-called bulk cocoa using Upper Amazon Hybrids.

The main threat to this rapidly expanding production continues to be from pests and diseases. On the wetter estates in West Java, *Phytophthora palmivora* causes serious stem canker and pod rot, especially on Trinitario clones. Following the recent upsurge in planting, vascular-streak dieback (VSD) has become a serious problem and now threatens cocoa establishment in many parts of Indonesia. VSD was first recognised as a destructive disease of cocoa, clearly distinguishable from dieback induced by stress or pest damage, in Papua New Guinea in the early 1960's (Shaw, 1962; Bridgland et al., 1966a, 1966b, 1967). In several parts of Papua New Guinea the disease destroyed plantations and prevented re-establishment of seedlings. The disease became epidemic there about 10 years after the rapid expansion of cocoa planting in the 1950's. This disease was shown by Keane et al. (1972) and Prior (1978) to be caused by a new genus and species of tulasnelloid fungus - *Oncobasidium theobromae* (Talbot & Keane).

DISEASE DISTRIBUTION

Since the 1960's VSD has been reported throughout South East Asia, in certain provinces of Papua New Guinea, occurring from India to the eastern-most tip of New Britain in Papua New Guinea and as far north as Hainan Island off the coast of China. Despite widespread planting of cocoa and systematic surveys, it has not been reported from the North Solomon Islands and other islands further out into the Pacific Ocean. Until 1988 the disease had not been reported from New Ireland, only about 70 km to the east of New Britain, when it was reported from an area just adjacent to New Britain, to which it had clearly spread only in the previous few years (M. Holderness, pers.comm.). It has not been reported from any other cocoa-growing region, including West Africa, the Caribbean, southern Brazil or the Amazon Basin, the centre of evolution of cocoa. The disease has been reported from West Malaysia (Keane & Turner, 1971; Zainal Abidin et al., 1981). Sabah (Wong Put Ham, pers. comm.; Williams & Liu, 1976), Sarawak (Teo Chan Hock, pers.comm.; Tiong & Kueh, 1984), the Philippines (P N Byrne, pers. comm.), Kerala State in southern India (Chandra Mohanan & Kaveriappa, 1981; Abraham, 1981), Hainan Island, China (Turner and Keane, 1982) as well as from several provinces of Papua New Guinea and Indonesia.

The first official record (Anon, 1985) of VSD in Indonesia was in 1982 from Sebatik Island, off the coast of East Kalimantan. This island is close to heavily infected cocoa in Sabah and it was not surprising that the disease should occur there, considering its widespread, epidemic occurrence in Sabah. The next record was in 1984 from Halmahera Island in Maluku Province where cocoa has been established for a very long time and where there have been no introductions of cocoa planting material for over 20 years. In 1984 the disease was also identified in North Sumatra (Turner and Keane, 1985). In 1984/85/86 the disease was found to be widespread in Indonesia, occurring in West, Central and East Java, East

FIGURE 3: CUT SURFACE OF LEAF SCAR AFTER FALL OF LEAF CAUSED BY VASCULAR-STREAK DIEBACK, SHOWING THE THREE BLACKENED VASCULAR TRACES CHARACTERISTIC OF THE DISEASE. NOTE ALSO SWOLLEN LENTICELS

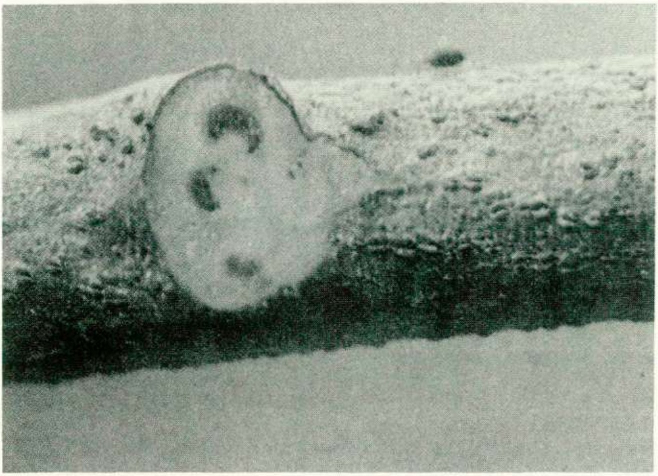


FIGURE 4: INTERVEINAL NECROSIS OF YOUNG FLUSH LEAVES OF COCOA BRANCH INFECTED BY O. THEROBROMAE FURTHER DOWN THE STEM

EPIDEMIOLOGY

High infection rates, similar to those observed on very susceptible cocoa in Papua New Guinea (Keane, 1981), were observed on several estates in Indonesia. At Bunisari-Lendra Estate in West Java (rainfall type B - see Table 3) the proportion of trees infected increased from 0.5% in July 1985 to 3.0% in July 1986. At Kajaran Estate in East Java (rainfall type C) disease incidence increased from 0.03% in August 1985 to 2.6% in July 1986.

Very rapid rates of disease increase have been observed on an unpruned, abandoned cocoa block on Bayabang Estate in West Java. Here disease incidence was observed to increase from 30 per cent in December 1985 to 90 per cent in October 1986. In the period from February to October 1986, disease severity, measured as the proportion of branches infected on 50 marked trees, increased from 11 per cent to 22 per cent. In this block an extremely high level of new infections, with only the first chlorotic leaf evident, was observed in July 1987. This block has had an average rainfall over the last 10 years of 2235 mm per year, which is similar to the rainfall in East New Britain, where disease epidemics were so devastating in the 1960's. However, in the infection period, which would have been from December 1986 to March 1987 (3 to 6 months before the appearance of first symptoms in July 1987), monthly rainfall was relatively low, ranging from 83 to 181 mm. In these months, even though the monthly rainfall was low, the number of wet days per month ranged from 20 to 23. It appears that the number of wet days per month may be more important than the monthly rainfall in determining the amount of infection. At Cisompet (Bunisari-Lendra Estate), a much wetter site than Bayabang in West Java, where mean annual rainfall is about 4500 mm, disease incidence has always been observed to be much lower than at Bayabang. In fact, the 1986-87 wet season at Cisompet was exceedingly wet, with 1000 mm falling in November alone, and yet the upsurge in disease at Cisompet in July 1987 was much less than at Bayabang. This further supports the hypothesis that infection may not be favoured by excessively heavy rainfall as much as by lighter, more continuous drizzle.

The other interesting observation made in West Java is that VSD has a higher incidence at lower altitudes (300m above sea level) than in similar cocoa, under similar rainfall conditions, at higher altitudes (400-600m). It was shown that nocturnal temperatures were several degrees lower at the higher altitudes. This could have a critical effect on the sporulation and infection processes of *O. theobromae,* which occur mainly at night (Keane et al., 1972).

After 2 years of stable, low levels of disease at Bunisari-Lendra Estate, quite high disease incidence was observed in several blocks of seedlings in July 1987. In one block of 15 month old Jember Hybrid seedlings (Trinitario x Scavina), 10 per cent of seedlings were infected in their main stem or main branches. All infected seedlings are expected to die before reaching maturity. In a nearby block of 12 month old Upper Amazon Hybrid seedlings, 4 per cent were infected in their main stems. In a block of 8 month old Upper Amazon Hybrid seedlings at higher altitude, 30 per cent of seedlings were infected in their main stems, and will probably be killed. These infections were all quite new and would certainly have occurred during the previous wet season (November 1986 - March 1987), which was extremely wet.

REACTION OF INDONESIAN COCOA TYPES TO VSD

There is evidence that all cocoa presently being widely planted in Indonesia is at least moderately susceptible to VSD (Table 3). From observations made at Cisompet, West Java, it was evident that an Amelonado type, derived originally from West Africa, was very susceptible while the Trinitario clones (DR clones) were also susceptible (Figure 6). Upper Amazon Hybrid seedlings were generally less susceptible although at certain sites they certainly sustain a very high disease incidence and so cannot be classed as highly resistant (Table 3). In fact, the most devastating disease outbreak in West Java, at Bayabang, has been on Upper Amazon Hybrids (Table 4) derived from seed provided by PTP VI In North Sumatra. On the evidence of the disease incidence at Bayabang, the Upper Amazon Hybrid material originating from P.T. Perkebunan VI is definitely not as resistant as the selections of Trinitario and Upper Amazon clones made in Papua New Guinea. Field trials, under conditions favouring disease, to compare experimentally the resistance of various sources of planting materials are urgently needed in Indonesia.

CONTROL

Sanitation pruning has been implemented on most of the infected estates in Java. On Bunisari-Lendra Estate, pruning is carried out every two weeks by a team of trained disease spotters. This treatment has kept disease at a very low level on this estate, despite the widespread occurrence of disease there since at least 1985 (Figure 6). Each pruning team consists of up to 24 people who each cover about 0.75 ha of cocoa per day. It is now thought that mature cocoa should be pruned every 4 weeks for most of the year. Two-weekly pruning of mature cocoa need be done only during the early part of the wet season. Seedlings up to 2 years old should be pruned every 2 weeks. It is expected that, if planting material with at least a moderate degree of resistance is used, such pruning will effectively control the disease on well managed estates. It should be noted that the greatest apparent infection rates occurred on the unpruned estate at Bayabang and also at the Kajaran Estate which was pruned every 3 months.

On smallholdings it is unlikely that sanitation pruning will be as rigourously carried out as on an estate and therefore much greater effort will have to be put into developing more resistant planting material for that sector. There are a number of cocoa breeding programmes in Indonesia, one of P.T.P. VI, one based in North Sumatra and another at the Research Institute for Estate Crops, Jember. The first work carried out in North Sumatra from 1975 to 1980 involved selection of F1 hybrid seedlings and testing of derived clones. Elite F1 trees were chosen and used to produce open-pollinated F2 Upper Amazon Hybrids. Clones of the elite trees were planted in seed gardens at P.T. Perkebunan VI for production of open-pollinated seed for distribution throughout Indonesia. On Bahlias Estate (P.T. Lonsum) seed was produced by hand pollination of selected clones. Unfortunately, because of the absence of, or very low incidence of, VSD on these estates, none of the parent clones were specifically selected for VSD resistance. The second programme in North Sumatra involves testing of clones introduced mainly from the Royal Botanic Gardens, Kew and Malaysia. These clones include some from Keravat, Papua New Guinea and Malaysia with known resistance to VSD.

FIGURE 5: O. THEOBROMAE GROWING IN THE XYLEM VESSELS OF COCOA

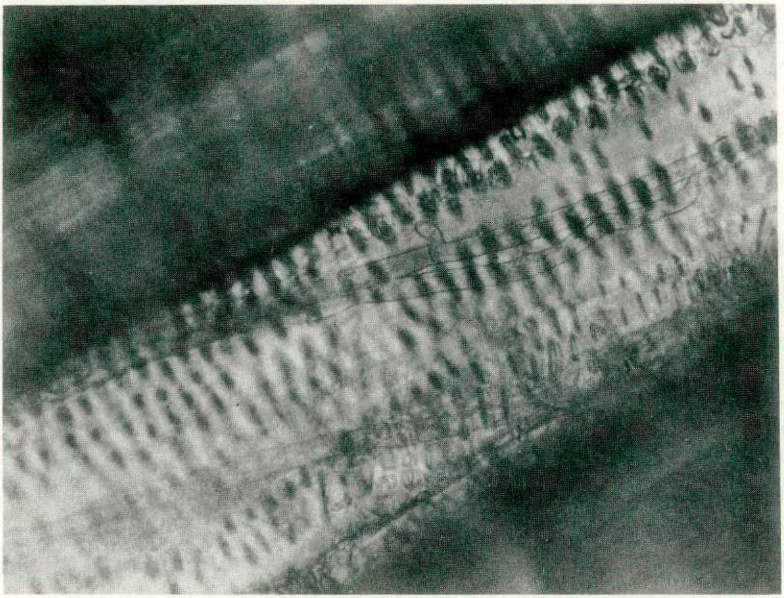
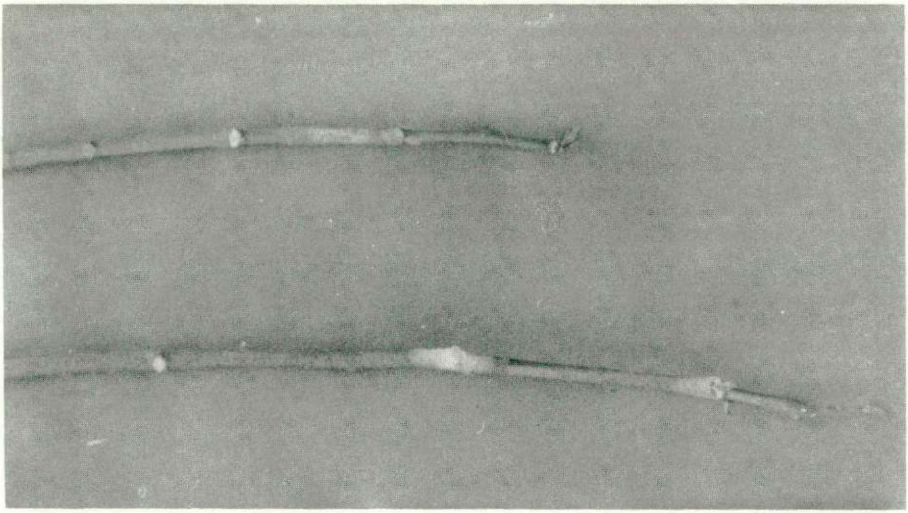


FIGURE 6: EMERGENCE OF MYCELIUM OF O. THEOBROMAE FROM LEAF SCARS OF COCOA STEM WITH VASCULAR-STREAKDIEBACK



The breeding program at Jember has included selection for resistance to VSD and *Phytophthora.* The main attempt to produce disease resistant planting material has involved crossing Trinitario clones developed since the 1920's in Java (the so-called Djati Roengo or DR clones) with the small-seeded, disease resistant Scavina (SCA) clones, recently introduced to Indonesia. The crosses DR 1 x SCA 6, DR 1 x SCA 12 and DR 2 x SCA 12 have shown promising resistance to both VSD and diseases caused by *Phytophthora palmivora.* If the DR clone is used as the female parent, bean size in the progeny is more than adequate. Yields of these hybrid seedlings are more than 1500 kg/ha/year which is double that of the standard DR 2 clone. More recently, Keravat clones with proven resistance to VSD have been incorporated into the breeding and selection programme in Indonesia. This type of resistance, which has remained effective from 1961 to the present time, has been very important in reducing the incidence and severity of the disease in Papau New Guinea.

These hybrids, along with any other planting material that can be collected in Indonesia, will be thoroughly tested for pest and disease resistance in areas where pests and diseases, especially *Helopeltis spp.*, *Conopomorpha cramerella*, VSD and *Phytophthora palmivora* are naturally at high levels.

Development of well-adapted, pest and disease resistant hybrids will be crucial for the future succesful expansion of cocoa growing by smallholders. It is predictable that the rapidly expanding smallholder plantations in places such as Pakue in South East Sulawesi, at present relatively free of pests and diseases, will eventually have to face damaging epidemics. At present the planting material being widely grown by smallholders (e.g. Amelonado material dervied from Sabah) is very susceptible to VSD and *Phytophthora palmivora.* This material will be supplemented by resistant cocoa as soon as possible.

ACKNOWLEDGEMENT

We wish to acknowledge the assistance of the Food and Agriculture Organisation of the United Nations and Drs. Soedarsan and Wardojo, BPP Bogor, in facilitating this work.

REFERENCES

Abraham, C.S. (1981) Vascular streak dieback of cocoa in India. Indian Cocoa, Arecanut and Spices Journal, 4, p.119-120.

Anderson, R.D. (1989) Avocado, an alternate host for Oncobasidium theobromae. Australasian Plant Pathology, 18(4), 96-97.

Anon (1985) Evaluasi hasil identikasi daerah penyebaran penyakit pada coklat (Vascular Streak Dieback) di Kalimantan, Sulawesi dan Maluku [Evaluation for identification and distribution of Vascular Streak Dieback on cocoa in Kalimantan, Sulawesi and Maluku]. Projek pembinaan dan Pengembangan Karantina Pertanian Jakarta, 24p.

Bridgland, L.A., Richardson, J.M. & Edward, I.L. (1966a) Dieback diseases of cacao (Part 1). South Pacific Planter, 1, (6) p.13-20, 28.

Bridgland, L.A., Richardson, J.M., & Edward, I.L. (1966b) Dieback diseases of cacao (Part 2). South Pacific Planter, 1, (7) p.3-6, 22.

Bridgland, L.A., Richardson, J.M., & Edward, I.L. (1967) Dieback diseases of cacao (Part 3) South Pacific Planter, 1, (8) 9-11, p.16-17.

Chandra Mohanan, R. & Kaveriappa, K.M. (1982) Occurrence and distribution of cacao diseases in Southern India. Proc. 8th Internat. Cocoa Res. Conf., Cartagena, Colombia, 1981. pp.445-450.

Keane, P.J., Flentje, N.T. & Lamb, K.P. (1972) Investigation of vascular streak dieback of cocoa in Papua New Guinea. Aust. J. Biol. Sci., 25, p.553-564.

Keane, P.J. (1981) Epidemiology of vascular streak dieback of cocoa. Ann. Appl. Biol., 98, p.227-241.

Keane, P.J. & Turner, P.D. (1971) Proc. Cocoa and Coconuts, Incorporated Society of Planters, Kuala Lumpur, 1971, pp.50-57.

Prior, C. (1978) A method of inoculating young cocoa plants with basidiospores of Oncobasidium theobromae. Ann. Appl. Biol., 88, p.357-362.

Prior, C. (1980) Vascular streak dieback. Cocoa Growers' Bulletin, 29, p.21-26.

Prior, C. (1985) Cocoa quarantine: measures to prevent the spread of vascular streak dieback in planting material. Plant Path., 34, p.603-608.

Shaw, D.E. (1962) Diseases of cacao in Papua New Guinea. The Papua & New Guinea Agric. J., 15, p.79-90.

Talbot, P.H.B. & Keane, P.J. (1971) Oncobasidium, a new genus of tulasnelloid fungi. Aust. J. Bot., 19, p.203-206.

Tiong, R.H.C. & Kueh, T.K. (1984) Studies on some cocoa diseases in Sarawak. Proc. 1984 Internat. Conf. on Cocoa and Coconuts. Incorporated Society of Planters, Kuala Lumpur. pp.1-10.

Toxopeus, H. & Giesberger, G. (1983) History of cocoa and cocoa research in Indonesia. In: Cocoa Research in Indonesia 1900-1950. Archives of Cocoa Research, Vol, 2., Eds. Toxopeus, H. & Wessel, P.C. International Office of Cocoa and Chocolate, pp. 7-34.

Turner, P.D. & Keane, P.J. (1982) Vascular streak dieback of cocoa, FAO Plant Prot. Bull., 30, p.157-158.

Turner, P.D. & Keane, P.J. (1985) Indonesia: Vascular-streak dieback of cocoa. FAO Plant Prot. Bull., 33, pp.41-44.

Van der Plank, J.E. (1963) Plant diseases: epidemics and control. Academic Press.

Williams, T.H. & Liu, P.S.W. (1976) A host list of plant diseases in Sabah, Malaysia. Phytopathological Papers, Commonwealth Mycological Institute, p.67.

Wood, G.A.R. (1985) In: Cocoa, 4th Edition, G.A.R. Wood & R.A. Lass, Longman, 620pp.

Zainal Abidin, M.A., Varghese, G. & Mainstone, B.J. (1981) Vascular streak dieback of cocoa in Malaysia - (1) A survey of its incidence and identification of the pathogen involved. Planter, Kuala Lumpur, 57, pp.3-13.

THE PRIMITIVE COCOA GERMPLASM DATABASE

Michelle J. End *, R.M. Wadsworth *, P. Hadley *

A substantial amount of cocoa germplasm exists in collections around the world. However, it is often difficult to gain information on the origins and location of this plant material. There is currently a need for an International Cocoa Germplasm Catalogue which would allow easy access to information on the material available. A project was initiated in 1988 to start to produce such a catalogue in the form of a computer database for use on IBM PC compatible computers. The first output from the project is a database containing the majority of the records of wild cocoa collected since 1938 and the present location and availability of material resulting from these collections. This Primitive Cocoa Germplasm Database has so far been distributed to 58 organisations in 34 countries.

The database has been produced using Ashton Tate's dBase IV. It has been distributed in the self-contained RunTime form so that the users do not need to own dBASE IV to access the information. The structure of the database is illustrated in Figure 1. It is made up of eight related files (square boxes), each of which contains information in a number of fields (round-cornered boxes). Files can be linked by common fields (links shown by dotted lines) so that they behave almost like a single file. The files are:

EXPEDITION: details on each expedition including the organisers and collectors involved

ORIGIN: details on the collection site of each accession

LOCATION: details on the present location and availability of germplasm

STATION: details of germplasm collections

DESCRIPTORS: details on the morphological characteristics of the clones collected on the expedition

REFERENCE: contains the full reference to the sources referred to in the expedition and location files

FORMAT: details of the different formats of the collection name encountered, e.g. LCTEEN is a format of LCT-EEN

SYNONYMS: details of the synonyms of the collection names and numbers encountered in database preparation

The **FORMAT** and **SYNONYMS** files allow clones to be referred to by any of the names that have been found during the compilation of the database

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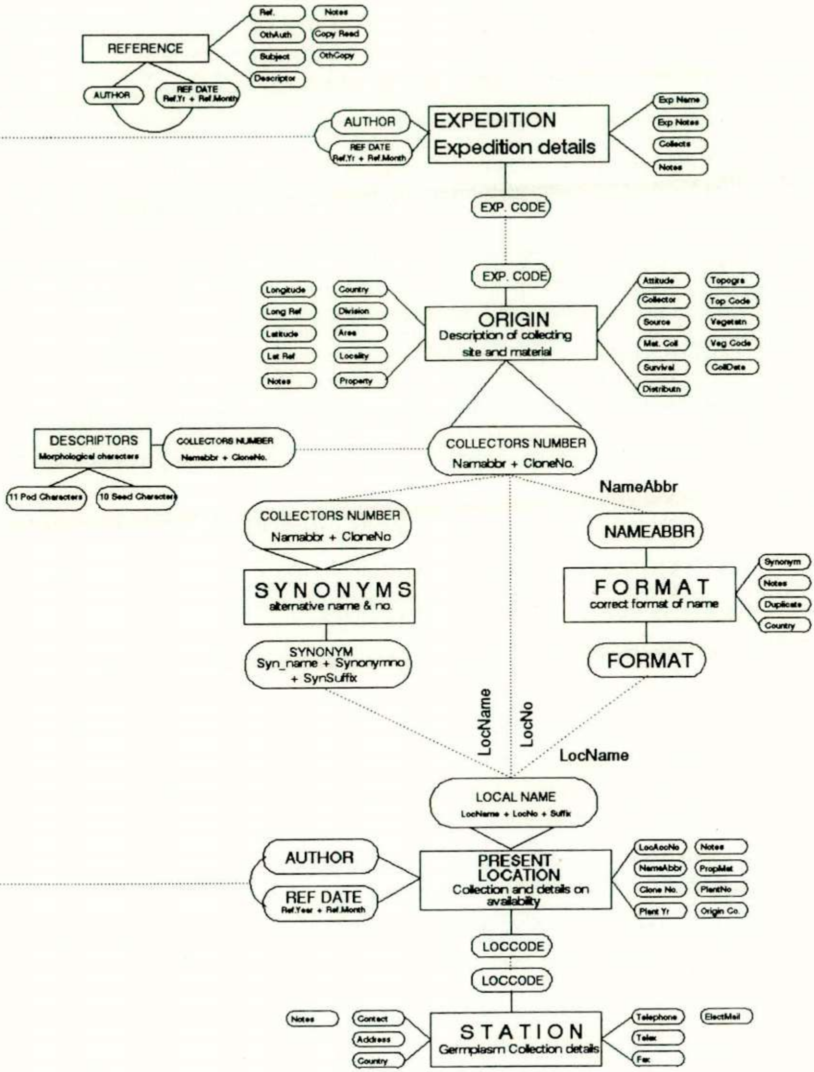
FIGURE 1: THE STRUCTURE OF THE DATABASE



The information in the database is accessed by making choices in a series of menus displayed on the computer screen. The user can choose to view all of the information held in any one file or produce a report which contains selected information from one or more files. For example, a user wishing to obtain information about a particular clone could list details of the collection site of the clone (Table 1), the present location of a clone (Table 2), or produce a list of addresses of the locations where the clone is held (Table 3). Reports may also be generated on:

(i) where, when and by whom a clone was collected from the wild

(ii) a list of all the material collected during a collecting expedition

(iii) a list of cocoa material collected between given map coordinates, in a specified area or along a certain river

(iv) a list of all the primitive clones held in a specified germplasm collection

(v) a list of clone names, their origins and their synonyms

TABLE1: A SAMPLE OF THE TYPE OF INFORMATION THAT THE DATABASE CONTAINS ON THE COLLECTION SITE OF A CLONE

CLONE NAME: LCT-EEN **NO.:** 11

EXPEDITION:	London Cocoa Trade Amazon Project		
REFERENCE:	ALLEN, J.B., (1987). London Cocoa Trade Amazon Project. Final Report Phase Two. Cocoa Growers' Bulletin, 39. Eds. R.A. Lass and S. Sanderson.		
COLLECTORS:	JBA - J.B.Allen, JB - J.Baquero, JC - J.Cabrera, RM - R.Mera, JS - J.Strudwick, GS - G.Sobel, AI - A.Illanes, MR - M.Raffauf, LHP - L.H.Purdy.		
COUNTRY:	ECUADOR	**DIVISION:** Napo	**AREA:**Coca
LOCALITY:	Via Acua km2. Coca 2km along R. Napo		
PROPERTY:			
LATITUDE:	0°28'S	**LONGITUDE:** 76°50'W	**ALTITUDE:**200m
TOPOGRAPHY:	flat	**VEGETATION:**mixed cultivation	
SOURCE:	natural habitat	**MATERIAL:**seed	
SURVIVAL:	yes	**COLLECTION DATE:** 19/05/80	
NOTES:	slightly infected by Witches' Broom disease.		

As of March 1990, the primitive germplasm database contains information on over 2814 separate accessions of wild cocoa and the current location of over 3000 clones originating from these collections. This information has been gathered from published expedition reports and clone lists in addition to information received through personal communications. It is hoped that research stations and genebanks will further participate by supplying updated information on their clone collections. We have already received some useful feedback from users who have suggested ways in which the database can be improved and who have pointed out inconsistencies in the data. We hope to distribute a revised version of the database including these amendments in the near future.

The database can be used to provide information on the number of collections made by each expedition and the number of different clones thought to be surviving from these collections (Table 4).

TABLE 2: A SAMPLE OF THE INFORMATION THAT THE DATABASE HOLDS ON THE PRESENT LOCATION OF MATERIAL DERIVED FROM AN ACCESSION OF WILD COCOA

LOCAL NAME: LCTEEN **NO.:** 11

ORIGINAL NAME:	LCT-EEN **NO.:** 11 **SUFFIX:** /S9
LOCATION:	International Cocoa Genebank, Trinidad
ADDRESS:	Cocoa Research Unit, University of the West Indies, St Augustine, Trinidad
TELEX:	24520 **TELEPHONE:** (1.809) 663-1364
REFERENCE:	KENNEDY, A.J. (1987). Catalogue of the Cocoa Genebank Trinidad, Cocoa Research Unit. The University of West Indies, St Augustine, Trinidad & Tobago.

Material has been collected as budwood, cuttings or pods. Where pods have been collected, each seedling has sometimes been given a separate clone number. This is the case for the collections made by Pound and accounts for the high number of different clones. Although the Pound collections have been widely distributed and form the basis of many breeding programs, only a small number of clones are known to have survived from many of the other early expeditions. It is likely that much of this material has been lost or remains only in field collection sites for which we have no information. One of the major problems in such germplasm collections is that the identity and origins of many clones have become confused with time.

The Brazilian organisation CEPLAC has organised an extensive collecting programme in the Brazilian Amazon region. Material has been collected from over 970 trees in this region over the last 25 years. Recently, large amounts of material have also been collected from regions of Colombia, Ecuador, French Guiana and Venezuela during expeditions supported by IBPGR, LCT, IRCC and other donors. Much of this material has not yet been distributed to the major germplasm collections.

TABLE 3: A SAMPLE LIST OF THE GERMPLASM COLLECTIONS HOLDING MATERIAL DERIVED FROM AN ACCESSION OF WILD COCOA

ORIGINAL NAME:	LOCAL NAME:	LOCATION:
LCT-EEN11	LCTEEN11	International Cocoa Genebank, Trinidad
LCT-EEN11	LCTEEN11	USDA, Mayaguez
LCT-EEN11	LCTEEN11	Quarantine Unit, Barbados

TABLE 4: The collecting expeditions that have taken place since 1938 with the total number of accessions made and number of surviving clones. Notes on each expedition generally include the collecting institute and the area covered by the expedition. The major colleting institutes were Assocacao Brasileira de Credito e Assistencia Rural (ABCAR), Cocoa Research Institute of Ghana (CRIG), Comissao Executiva do Plano da Lavoura Cacaueira (CEPLAC), Departmento Especial da Amazonia (DEPEA), Institute Francais de Cafe et Cacao (IRCC), Instituto Intermericano de Coopercaion para la Agricultura (IICA), Instituto Nacional de Investigaciones Agropecaurias (INIAP), Ministerio da Agricultura (Brazil) (MA), Overseas Development Agency (ODA), University of the West Indies (UWI).

Expedition	Date	Country	Area Visited	Number of Accessions	Number of Survivors
Pound Trinidad	1937-38 1942-43	Brazil, Peru, Ecuador	R.Amazon and Upper Amazon Tributaries	c.50	IMC 64 MO 26 NA 292 PA 138 POUND 10
DesRosiers & Buchwald EETP.	1948	Ecuador	R.Napo	26	2
Anglo-Colombian Trinidad.	1952	Colombia	Inc R.Putymayo, R.Caqueta & R.Apaporis	48	17
Doak, Ampuero & Buchwald, EETP	1958	Ecuador	Archidona & Tena	4	1
Doak & Zambrano, EETP.	1961	Ecuador	Archidona & Tena	43	0
Soria, Turrialba.	1964	Peru, Bolivia	Iquitos & Alto Beni	10	5
Vello CEPLAC/IICA/ CRIG.	1967	Brazil	R.Jamari, R.Acre & R.Branco	56	41
Vello CEPLAC/UWI	1967	Brazil	Ilha do Carerio, R.Branco & R.Morona R.Jurua, Cruzeiro do Sul.	33	18

Expedition	Date	Country	Area Visited	Number of Accessions	Number of Survivors
Chalmers UWI/INIAP.	1968	Ecuador	R.San Miguel, R.Aguarico, R.Coca	50	13
Vello CEPLAC/MA.	1968	Brazil	R.Jari, Cachoeira de Santo Antonio	103	11
Chalmers UWI/INIAP.	1969	Ecuador	Coca, Lago Agrio	28	8
Smithsonian S.I./Turrialba	1969	Colombia	R.Orteguaza, R.Caqueta, R.Putamayo, R.Amazonas.	9	0
Chalmers UWI/INIAP.	1970	Ecuador	Coca, Lago Agrio, R.Aguarico	42	12
Nascimento CEPLAC/ IPEAAO/ABCAR.	1971	Brazil	R.Solimoes, Ilha de Tarara	5	5
Chalmers UWI/INIAP	1972	Ecuador	R.Bobonaza, R.Curaray, R.Nushino, R.Tiputini, R.Vallano	75	2
Carletto CEPEC/INIAP/ IFCC.	1973	Ecuador	Francisco de Orellana (Coca), R.Napo, R.Payamino	16	0
Chalmers UWI/INIAP.	1973	Ecuador, Peru Brazil	R.Tapische, Iquitos, R.Ucayali	87	14
Machado CEPLAC/DEPEA /IICA	1976	Brazil	R.Ji-Parana	c.16	9

Expedition	Date	Country	Area Visited	Number of Accessions	Number of Survivors
CEPLAC CEPLAC/IICA /ODA.	1977	Brazil	Cacoal, Alenquer, Altamira, Baracarena, Alta Floresta, Jari, I.do Careiro	c.24	19
CEPLAC CEPLAC/DEPEA /IICA	1978	Brazil	R.Munim, R.Itapecuru, Tome-Acu, Belem, R.Iaco.	>13	13
CEPLAC CEPLAC/DEPEA /IICA	1979	Brazil	R.Iaco, R.Caete, R.Macaua, R.Tucurui, R.Tocantins	c.73	24
Allen London Cocoa Trade.	1980	Ecuador	Amazon basin.	437	123
CEPLAC CEPLAC/DEPEA /IICA	1980	Brazil	R.Purus, R.Chandless, R.Acre, Ariquemes.	c.164	81
CEPLAC CEPLAC/DEPEA /IICA	1981	Brazil	Ariquemes, R.Tarauaca, R.Envira, R.Purus, mid-region R.Solimoes	c.175	76
CEPLAC CEPLAC/DEPEA.	1982	Brazil	Ariquemes, R.Solimoes, R.Javari, R.Curuca, R.Quixito, R.Itacoai, R.Ica, R.Japura.	c.291	162
CEPLAC CEPLAC/DEPEA /IICA	1983	Brazil	Ouro Preto, Jaru, Ji-Parana, R.Japura.	c.193	63
IBPGR/ICA.	1983	Colombia	Pacific coast of S.Colombia	76	49

Expedition	Date	Country	Area Visited	Number of Accessions	Number of Survivors
CEPLAC CEPLAC/DEPEA.	1983	Brazil	Ouro Preto d'Oeste	c.187	58
CEPLAC CEPLAC/DEPEA /CENARGEN /IICA.	1984	Brazil	Ji-Parana, R.Xingu, R.Acara, R.Uatuma.	c.280	194
Clement IRCC.	1984	Guyane		98	*
CEPLAC CEPLAC/DEPEA.	1985	Brazil	Ji-Parana	c.127	57
Ocampo Corp. Araracuara	1985	Colombia	R.Caqueta, R.Apaporis	139	2
France-Venezuela Maracay Agr. Fac /IRFA-CIRAD /IBPGR	1986	Venezuela		38	13
IPBGR IBPGR/Est. de Formento Los Brillantes.	1986	Colombia	Franje Transversal del Norte Digesa Guatemala El Peten, Malactan, San Marcos	293	80
Sallee, IRCC.	1987	Guyane	Haut Camopi	249	236
IBPGR IBPGR, U. Simon Bolivia, U. Central de Venezuela, FONAIAP.	1988	Venezuela	R.Amazon.	20	*
				Total No. Collected c.3577	Total No. Surviving c.1427

*** Does not include Pound clones.**

We hope to be able to add to and correct the information in the database as it becomes available. At the same time we are collecting information on improved cultivars (selected material) and morphological, yield and disease resistance characteristics of clones for the more comprehensive International Cocoa Germplasm Database. To demonstrate the potential of such a database for handling morphological information, character descriptors for a small sample of clones (the LCT-EEN clones) have been entered into the Primitive Germplasm Database. The user may search for clones which possess a combination of these characters. This sample may give some idea of the full potential of the database to supply information of use to cocoa breeders.

If you would like more information on the database or would like to contribute information to be included into the database, please contact us at the address at the head of this article.

ACKNOWLEDGEMENTS

This project is funded by the Biscuit, Cake, Chocolate and Confectionery Alliance (BCCCA) with support from the International Board for Plant Genetic Resources (IBPGR). We would like to thank the following for their invaluable help during the project: Dr J B Allen, Dr B G B Bartley (CEPLAC), Mr E T Beauchamp (BCCCA), Dr D Clement (IRCC Cote d'Ivoire), Cocoa Board of Ghana, Dr M Contreras (FHA), Dr A B Eskes (IRCC, Montpellier), Dr A J Kennedy (Former Head, Cocoa Research Unit, Trinidad), Mr J Konopka (IBPGR), Mr R A Lass (Cadbury Limited), Dr E Lleras Perez (ICA Bogota), Dr G Lockwood (CDC), Dr Musa (MARDI), Dr F Ocampo Rojas (ICA Palmira), Dr G R Patterson (Hershey Foods), USDA Miami and Dr J Vessey (KP Agriculture).

A METHODOLOGY FOR THE ESTIMATION OF COMPARATIVE COCOA PRODUCTION COSTS

James Fry *

The estimation of cocoa production costs raises several tricky questions, if the results are to be used - as they usually are - as the basis for international comparisons. However, the effort to answer such questions is essential if one hopes to arrive at an adequate framework within which to compare competitiveness in two or more countries producing the same end-product under very different circumstances.

In order to bypass the problems posed by production cost estimates, some people prefer to present any comparisons in purely technical terms; for example, they make comparisons on the basis of the number of tons of cocoa produced per full time worker; the yield of cocoa per hectare per year; or the yield of cocoa over the lifetime of one hectare of cocoa trees.

Economic theory tells us that this represents only part, a small but undoubtedly important part, of the full story. In the final analysis, the best guide to the efficiency of production in a specific context is the demands that production places upon scarce resources. Prices (strictly speaking, from a professional economist's point of view they should be shadow prices, reflecting the principles of cost benefit analysis) represent the simplest, and best, way to take adequate account of the relative values of different scarce resources. To translate this into practical terms, it does not matter whether Malaysia, for example, obtains one of the world's highest yields per hectare, if those yields can only be achieved by making costly investments in chemical and fertiliser inputs, as well as paying high salaries to estate managers, and if land and labour have to be withdrawn from work on other estate crops and a burgeoning industrial economy. Ultimately, the logic of the market economy that governs production in Malaysia and most other cocoa producing countries, is that the costs of producing cocoa, and their relationship to selling pries, should determine whether it is advisable to devote Malaysian resources to cocoa production, provided the prices used in that calculation are not seriously distorted by government intervention, or some other external factor.

1. THE VALIDITY OF PRODUCTION COSTS AS A BASIS FOR PROJECT APPRAISAL

The comparison of production costs can thus readily be defended as an appropriate means - and even as the sole justifiable means - for assessing one country's competitive advantage vis-a-vis another; but one needs to include another stage in the argument before one can justify using international comparisons of production costs as one of the main criteria for judging the long term viability of a project. It is, of course, reassuring to know that a project or a nation can produce cocoa at a lower cost than, say, 70% of the remainder of world production; but this is not relevant if the price of cocoa on the world market, which ultimately corresponds to the true foreign exchange benefit from extra production (in economic terminology, "the opportunity cost") of cocoa by the potential producer, is even

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lower on average. Therefore, one needs to know how world production costs compare with average free market prices before one can feel comfortable about using production costs competitiveness as the principal means of evaluating a project.

2. METHODS OF ESTIMATING PRODUCTION COSTS

The major problem that arises in arriving at production cost comparisons lies in uncovering the costs that are to provide the data to be compared. One possible solution is to work from the annual business accounts of operating companies. Another solution is to submit questionnaires to producers and to gleam tidbits of information from published sources, from which to piece together a comprehensive picture. Neither of these is any guarantee whatever that the estimates will have been prepared on a consistent basis.

A more ingenious approach is the one that starts from the premise that cocoa producers reveal their costs via selling prices. High cost producers - e.g.,Papua New Guinea - have high selling prices; low cost producers typically face low domestic selling prices. Unfortunately, while this correlation between production costs and selling prices is broadly correct, the real world of cocoa is beset with institutional distortions, as well as those caused by government subsidies for inputs and marketing expenses, or government intervention in exchange rates and other vital elements of production.

The only method of evaluation that seems to avoid the major pitfalls inherent in the alternatives is the use of what is conventionally referred to as an engineering approach to costings. Starting from the detailed and disaggregated listing of the inputs that are used to produce and process cocoa, one can attach local prices to each of the inputs, to arrive at a true cost estimate. The difficulty is that one has only moved towards a comprehensive, yet consistent, approach at the price of acquiring a need for vast amounts of detailed micro-economic input and price data.

3. THE ENGINEERING APPROACH

Having opted for the engineering approach, one still faces two major alternatives in deciding how to proceed. One can aim for perfection, in seeking to get information on the total application of certain inputs to the cocoa industry in a country - from which one can derive precise data on the average utilisation of these inputs per unit of output; or can adopt what might be called the "technical blueprint" method. Under this alternative, one divides the production process into a large number of distinct sub-processes (e.g., land preparation, fertiliser application, pruning, weeding, harvesting, fermentation, drying, etc.) and distinguishes several alternative "blueprints", ranging from low technology (low input-low output) to those that use a high technology (high input-high output method) for performing the same task. It then becomes a matter of detailed knowledge of the production methods employed in different sectors of the same country's industry to determine how much unskilled labour time, for example, is required to produce a ton of final output. As a hypothetical example, one might have a country employing four different techniques for cocoa establishment. Possibly 40% of the total cocoa area might use low technology methods of cocoa establishment using "high tech" methods with the clear felling of the land with the assistance of bulldozers and requiring, say, an average of 45 days of unskilled labour time per hectare in the second year; 30% of the area could be established with "lowtech" methods under coconut, using, say, 53 days of unskilled labour per hectare;

and the remaining 10% of the area could be established using "high tech" Turrialba techniques requiring 80 days of unskilled labour two years after planting. (These labour inputs are realistic estimates for the techniques described.)

Under these circumstances, the hybrid technique corresponding to an exact microcosm of the country at large will comprise a weighted average of four techniques just described. Thus, it will attach a 40% weight to the 87 days per hectare technique, a 20% weight to the 45 days per hectare technique; a 30% weight to the 53 days per hectare technique; and a 10% weight to the 80 days per hectare technique. This is equivalent to a hybrid 67.7 days per hectare technique, calculated as $0.4 \times 87 + 0.2 \times 45 + 0.3 \times 53 + 0.1 \times 80$.

Presenting the analysis in this way shifts the focus of concern from detailed nationwide statistics to a good understanding of the choice of techniques - the book of "blueprints" - open to all producers, and the eventual selection of the different techniques that is decided upon by individual producers. If both of those are correct, then the production input information should be good. Provided the price data are equally good, one can feel quite happy about the final estimates.

More formally, in simple algebraic terms, we divide the production processes into a number of sub-processes. To take just the example of cocoa establishment, the process would be divided into land clearing, liming, staking, shade planting, fertiliser application, insect control, disease control, weed control, road construction, preparation of drainage/water systems, shade maintenance, nursery construction, filling bags in nursery, sowing seed, cultural work in nursery, planting cocoa, and finally pruning and shaping. A similar form of disagregation can be used for cocoa maintenance, for harvesting and breaking, for fermentation, and for drying and bagging.

Altogether there are 27 main sub-processes identified in the agricultural side of cocoa production (often sub-processes were composed, in turn, of a number of distinct activities, such as land clearing, disease control, etc., each with their own techniques, ranging from the highly mechanised to the very labour-intensive). Let us denote each of these sub-processes by the index $i[i = 1,2,3,..27]$.

For each process, a variety of alternative techniques can be identified, ranging from highly mechanised ones, as in Malaysia, to highly labour-intensive, as in West Africa. Up to 12 alternative techniques can be distinguished for each process in the field. The distinctions are summarised in the following tables.

In essence, twelve major different techniques can be distinguished in the analysis of field operations. These can be divided, however, into two broad groups, each comprising six techniques. The first group consists of "high technology" production, the second is made up of "low technology" producers.

The allocation between "high tech" and "low tech" production is one that can evolve during the course of a study. Initially, we adopt a simple breakdown between estates and smallholders, but it would soon became apparent that there exist many large farms that are operated with considerably less sophistication than many small family operations. To resolve this difficulty, we adopt a more subjective, qualitative approach, based upon the guidance of senior agronomists and industry experts. Thus, small farmers who were attentive to the timely pruning of trees and who adopt good crop husbandry in general are classified as "high tech", and estates who ignore these tasks are considered to be "lowtech".

The six techniques are identified separately under both the "low tech" and "high tech" headings are as follows:

1. Clear felled lands, with planted shade and a high degree of mechanisation.
2. Clear felled lands, with planted shade and a low degree of mechanisation.
3. Thinned forest.
4. Planting under coconuts (or - to a lesser extent - oil palms, etc.) with a high degree of mechanisation.
5. Planting under coconuts etc. with a low degree of mechanisation.
6. The Turrialba method of planting under established cocoa trees.

TABLE 1: CHOICES OF TECHNIQUES IN THE ESTABLISMENT AND MAINTENANCE OF COCOA TREES

Method of Establishment/ Maintenance	Level of Technology Low Technology (Low Input-Low Ouput)	High Technology (High Input High Output)
Clear Felling & Planted Shade		
(i) Mechanised	X	X
(ii) Labour-intensive	X	X
Thinned Forest (Labour-intensive)	X	X
Intercropping with Coconut/Oil Palm etc		
(i) Mechanised	X	X
(ii) Labour-intensive	X	X
Turrialba/Under Old Cocoa (Labour-intensive)	X	X

TABLE 2: CHOICES OF TECHNIQUES IN THE FERMENTATION AND DRYING OF COCOA BEANS

		Fermentation	Drying
a)	Low Technology Sun Drying	Heap, Basket	Sun Drying
b)	Low Technology Artificial Drying	Box with short fermentation cycle & insufficient turning of beans	Small scale artificial drying
c)	High Technology Artificial Drying	Box/Cascade with full fermentation cycle & 2 or 3 turnings of beans	Large scale artificial drying with pre-driers as well as driers

Let us denote these alternatives by the index t[t = 1, ...,12].

Each process employs a number of inputs. These include labour (of various levels of skill), a wide range of machinery, chemicals, fuels, fertilisers and other materials. All of these inputs will make a contribution to production; but, for some, the contribution is best seen as an input per unit of area (i.e.,so many days of use per hectare); for others, the contribution is per ton of agricultural product (i.e., so many days of use per ton of wet cocoa beans); and for others, it is per ton of final dried beans. To ensure comparability, fermented dried beans should be considered to be the final product of cocoa production; thus, we examine the costs of taking unfermented Latin American beans through to full fermentation and drying.

In algebraic terms, the methodology can be understood better by distinguishing between the contribution of the 12 main inputs used in the production of cocoa. Each of these inputs can be denoted by the index j [j = 1, ...,12].

Therefore, where q measures the quantity of the input in question, q_j can be interpreted as the quantity of input j that is required to perform a particular task.

The entire range of inputs for a task can be represented by a vector combining all the quantities, in the notation:

$$[q_1,q_2,\ldots,q_{12}].$$

For sub-process i, the inputs can be distinguished as:

$$[q_1(i),q_2(i),\ldots,q_{12}(i)];$$

and where one wants to identify one technique (t) rather than another, the appropriate notation will be:

$[q_1^t(i),q_2^t(i),\ldots,q_{12}^t(i)]$;

Algebraically, this is written in shorthand as the vector $[q_j^t(i)]$.

All that one needs to proceed from this vector to estimated of production costs for each sub-process is to multiply the quantity of each input by its price. Accordingly we can prepare for each country the vector of local prices of each input $[p_j]$, where p measures the price per unit of product j.

The product of

$$[q_j^t(i)] \times [p_j] = q_1^t(i)p_1 + q_2^t(i)p_2 + \ldots + q_{12}^t(i)p_{12}$$

can be interpreted as the cost of undertaking sub-process i, using technique t.

It is worth emphasising that this approach aims to describe the results of the decisions that have been made by producers, not to prescribe what would be the lowest cost method for producing cocoa. Nevertheless, it should be apparent that one of the great advantages of the engineering cost methodology is that it lends itself readily to linear programming, and therefore that it can be used to determine when the time might be ripe for a change in technique, such as a shift towards mechanisation.

The collection of the necessary technical and price data for the estimation of production costs is a time-consuming, but not particularly taxing , task. Nevertheless, there are several important issues of methodology that have to be resolved if full consistency is to be achieved in international comparisons. Six of these are sufficiently important to justify special mention: three are essentially of technical interest to economists; they are the treatment of interest rates, the valuation of capital, and the valuation of land. The remaining three issues are more specifically of concern to cocoa agronomists: they are the assumptions regarding the productive lifetime of cocoa trees, the yield profiles that apply to individual trees, and the treatment of the role of shade trees.

4. THE TREATMENT OF INTEREST RATES

When several different countries' costs are being compared, there are exchange rate, interest rate and inflation rate differences to be taken into account. Exchange rate differences are comparatively straightforward to handle: one chooses some appropriate date or period and converts values into a common currency at the exchange rates ruling at that time.

Interest rate and inflation rate divergences tend to cancel one another out; unfortunately, they do not balance one another perfectly. Nevertheless, generally speaking, a country with high interest rates also has high inflation rates; therefore, real interest rates (the cost of borrowing funds after the deduction of that proportion of the interest rate it required merely to compensate the lender for the ravages of inflation) are much closer to one another than are nominal rates.

For economic analysis, it is self-evident that real interest rates are more relevant for production cost estimates than are nominal rates - in comparing, say, Malaysia with a nominal interest rate in single figures and negligible domestic inflation, to Brazil, with a 400% nominal rate and inflation of a similar (or multiple) order of magnitude. However, one faces a surprising amount of hostility from people who say that, since they are having to pay out cash on the basis of nominal interest rates, it should be nominal interest rates that are applied to historical values of capital investment in a project.

Among governments that prepare their own production estimates, there is not one, to our knowledge, that applies real interest rates to their valuation of capital. The USDA is typical in plumping for the application of nominal rates to estimates of the value of capital investment in its own production cost studies of US crops. This is fine, where the objective is to estimate the current year's outgoings for a typical producer under the unrealistic assumption that all capital is borrowed. However, it fails to take into account the future gains from inflation that will be enjoyed by the investor as inflation boosts the nominal value of the cocoa produced from existing capital and erodes the real value of any outstanding fixed interest debt.

To understand why purely inflationary gains should not be included within estimates of cocoa production costs, one can consider the case of producers in Brazil. Brazilian cocoa farmers are only willing to invest large sums in new plantings and in new equipment because they believe that the prospect of a regular annual quadrupling of the local market price of cocoa makes it worthwhile to pay out treble the entire nominal value of any borrowings in the form of interest payments in the first year.

At present, the average age of the capital investment in Brazil's cocoa sector is comparatively high, while that in the Malaysia cocoa sector is much lower. Thus, the high domestic rate of inflation implies that the depreciated historical cost of capital in Brazil will appear to be absolutely negligible as a proportion of replacement cost, while the depreciated historical cost for Malaysia will be high proportion of local replacement costs. The disparities are so great that the application of nominal interest rates to those historical costs will be insufficient to bring the two estimates into line with one another.

Our preferred solution to this problem is to estimate all interest payments on the same uniform basis, and to apply to each countries' cost estimates, an allowance for the real interest rate. In this way, the effects of inflation will be netted out of the results. However, exactly which real interest rate to apply raises some problems of its own. One choice could be to apply the actual nominal interest rate deflated by the rate of inflation: this generates negative real interest rates in many countries, where the inflation rate exceeds the cost of credit to the cocoa sector. The dilemma posed by this approach is that it is impossible to gauge exactly what were lenders' expectation of inflation when interest rates were determined for any study. A borrower's willingness to pay high interest rates depends partly upon its own anticipation of the trend in the inflation rate. Rather than become bogged down in guesses about producers' forecasts of inflation rates, we would suggest that the real interest rate in all countries is set at a positive 5% per annum.

5. THE VALUATION OF THE CAPITAL STOCK

The other side of the decision regarding the interest rate to be applied to the production cost estimates is the selection of the method adopted to value the capital stock invested in the cocoa industry. There are essentially two alternatives that suggest themselves. The capital stock could be valued on the basis of historical costs; or it could be valued on a replacement cost basis. The historical cost of capital is as much a victim of inflation as is the interest rate. The historical cost of capital, tied up primarily in the establishment costs of trees, in a country like Brazil or Peru is negligible, when translated into current prices. If nominal interest rates have to be applied in interest cost calculations, then it is arguable that historical costs should be adopted as the valuation of capital, since the one tends to offset the other. Where the arguments in favour of the use of real interest rates are accepted, however, one requires a valuation of capital that is not tied to the historical pace of inflation. This means using the replacement cost of capital, appropriately depreciated to reflect the amount of wear and tear that it has suffered. (The use of replacement cost together with nominal interest rates is incorrect, and has the effect of over-stating costs.)

The choice between historical and replacement cost as the basis for the valuation of capital is one that will be familiar to many readers. Another choice, which has only come to the fore as a result of recent exchange rate volatility, will seem more novel. This concerns the decision whether to value capital goods in local currency or in terms of dollars.

In the case of current inputs, no-one would suggest that such a choice is a major cause of concern. If a currency is considered to be over or under-valued, then the costs of labour and other current inputs will be corresponding biased upwards or downwards; but the conversion at the existing exchange rate must be accepted as the reality, since the cocoa industry has to pay for such inputs at prevailing local prices.

Thus, for example, if the Venezuelan Bolivar is over-valued and some local inputs look very expensive when expressed in dollars, we take the view that we should not try to correct for the over -valuation of the Bolivar; if Venezuelan farmers have to pay high price for inputs this will inevitably make their operating production costs high and uncompetitive, and our results will reflect this reality.

With capital investments, the benefit from an investment lasts for a number of years; therefore, it would seem inappropriate to tie the cost of items such as depreciation to year-to-year changes in the exchange rate of particular countries, if this means that the dollar value of depreciation costs lurches wildly from one year to another. Accordingly, we favour a longer term prospective, and assume that the cost of capital goods follows the US index of capital goods prices, denominated in US dollars.

However, it is apparent that capital goods prices for vehicles, agricultural machinery, etc. in some important cocoa-producing countries, notably Brazil, have remained well below the prices for similar products in other countries. Contrary to our original expectation, trade has not eliminated differences in price. Accordingly the persistence of these disparities may require that an adjustment to local capital goods prices should be applied to the estimates of costs in these countries.

6. THE VALUATION OF LAND

The valuation of land is a highly emotive issue, with the cocoa industry abounding with examples of government intervention in, or traditional social barriers to, the transfer of land. Instinctively, one feels that the market price - where it can be discovered - should be a good candidate for the price of land; but this choice would be very wrong indeed in many instances. To understand this, it is helpful to consider what happens if the price of cocoa suddenly increased in a certain country. The costs of production presumably have not risen, therefore the profits from cocoa production will increase. If nothing else changes, the beneficiary will be the owner of the land (assuming that the owner also farms the land), and the market value of the land will move ahead in response. Yet this is merely a reaction to higher cocoa prices, not an increase in costs caused by other factors.

In the long run, provided the market value of land is allowed to adjust to changes in the price of cocoa, one will find that the costs of production of cocoa will always tend to equal the final selling price. (It is arguable that the costs of production are likely to acquire an upward momentum of their own if selling prices enjoy a long period of strength, and that it could take a very long time for costs to react subsequently to a period of price stabilisation or weakness. This may explain some of the difficulties that have affected the cocoa industries of various Central and Southern American countries in the past ten years.)

In order to avoid the danger of an empty and circular definition of the valuation of land, it is necessary to devise a definition that has some economic validity. The most satisfactory is "the value attached to the land in its next best alternative use" - or more simply "the opportunity cost of the land to the cocoa industry".

Unfortunately, this definition does not take one's understanding much further in many cases. Cocoa land is typically reserved exclusively for the production of cocoa. There are a few countries, e.g., Malaysia, Indonesia and Papua New Guinea, where competition between cocoa and other crops is such that a market value of land cannot really be considered to be determined by its cocoa production. Elsewhere, one or other of two alternative approaches suggest themselves. Where other crops are grown in the cocoa-growing areas on a significant scale, and it is possible to obtain information on their land rental systems - which should, in the long run, be related to the profitability of alternative crops on the same land - then it seems appropriate to apply market values to the rent for land. The alternative, in the absence of great competition for cocoa-growing land, is to treat the process. The costs of clearing land and preparing associated infrastructural works can be estimated, and annual interest costs can then be associated with these establishment costs to arrive at an equivalent annual rental for the land. It is therefore appropriate to assume that land values are assumed to reflect the costs of clearing land and establishing cocoa trees. For South East Asian producers, however, where land can be used for coconuts, oil palms or rubber just as easily as for cocoa the land values are implied from calculating the return from the next most profitable alternative crop.

7. THE PRODUCTIVE LIFETIME OF COCOA TREES

One the most complicated elements in the analysis of cocoa production cost is the dimension of time. Unlike annual cereal crops, for which all operations from planting to harvesting and marketing are completed within a matter of months, the economics of tree crops like cocoa can only be understood within an inter-temporal framework. Producers have to make an investment that can reach thousands of dollars per hectare long before starting to receive any return to their efforts.

The interest rate and the rate of profit to the farmer represent the reward for making the initial investment in establishing a cocoa farm. The extent of this reward is typically quite sensitive to the length of the productive lifetime of individual trees. One presumes that farmers make their own trade-offs between extending the lifetime of a cocoa tree by a further year and chopping down old trees in order to start again with the establishment of a brand new field of cocoa. In principle, the production costs model provides a mechanism with which to compute the life of a cocoa tree that optimises the returns to the individual farmer, but such an exercise would require full knowledge of the farmer's cocoa price expectations. Lacking detailed information about these expectations, we has to rely upon actual observations of replanting practices among "high tech" and "low tech" producers in each country.

8. THE YIELD PROFILE OF COCOA TREES

The productive lifetime of the cocoa trees has to be related to the yield profiles during the same lifetime. However, the average national cocoa yields observed in reality are not necessarily merely the appropriate averages of the yield profiles of "high tech" and "low tech" producers. This is because the pace of cocoa plantings has been far from uniform in different countries. At one extreme are the two fast expanding South East Asian producers, Indonesia and Malaysia, whose stock of cocoa trees is still heavily biased towards young and immature trees; at the other extreme are some West African producers, such as Ghana and Nigeria, whose trees are typically old and on the declining section of their yield curves.

Interpretations of the yield profiles have to take account of these biases. For those producers who are biased towards young, immature trees, one has to realise that it would be misleading to judge their performances on the basis of actual yields. One presumes that the producers themselves are looking forward to the years of higher yields and take full account of this in their cost computations. For this reason, any study should "normalise" the yield estimates for producers with young trees (in practice this applies only to hybrid tree populations) by adjusting for the growth projected in average yields over the next fifteen years.

9. TREATMENT OF THE ROLE OF SHADE TREES

Shade trees are an integral part of the cultivation of cocoa. Some shade trees are temporary, such as bananas, cassava, cocoyams. Others are permanent, and in some cases - notably coconut palm in South East Asia - have a substantial economic value in their own right.

Where shade trees have an economic value, it is not yet clear exactly how they should be incorporated into the estimates of production costs. Farmers tend to view cocoa and the shade crops as joint products, and rarely make a sharp distinction as to which returns accrue to one crop or another. Economists, trained on the notion of "opportunity cost", ask how total productive costs and revenues per hectare compare with one another, first, where cocoa is cultivated, and second, where cocoa is not cultivated.

For a number of reasons, both pragmatic (notably the difficulty of distinguishing the costs and revenues atributable to the shade crops, and attaching prices to food crops for the farmer's own consumption) and theoretical, it is appropriate to assume that the costs and revenues relating to shade crops are not relevant to the economics of cocoa cultivation, except to the extent that the management of these forms of shade is specifically geared to the needs of cocoa trees. Where such management occurs, the costs of this management are charged to the cocoa enterprise.

10. PRESENTATION OF THE RESULTS

The presentation of the results from the productive costs exercise provides a different challenge. From the methodological point of view, the only really knotty issue is the precise point at which to measure costs for comparative purposes. In many respects, the most suitable basis to adopt would be the repective costs faced by different producers in delivering their cocoa to a common point of final purchase. Thus it has been suggested that one should compare the costs of delivering beans to Rotterdam or New York.

A moment's reflection reveals the problems reaised by this approach. Not only do different exporters have different distributions of sales between alternative export markets, but there is a major contrast between producers who sell the bulk of their output almost all of their production.

These differences in producers' circumstances lead us to favour the approach whereby all production costs are measured ex-fermentary, without regard to the costs of distribution of bagged beans from the drier. Consequently, all costs of bringing beans from up-country to export warehouses and from the export port to the importer should be excluded from any comparative study.

EDITOR'S NOTE:

The text of this paper has been modified somewhat from the introductory chapter of a major multi-client study prepared by Landell Mills Commodities Studies in 1989 and entitled 'A World Survey of Cocoa Bean Production Costs, 1986/87.

WITCHES' BROOM DISEASE OF COCOA IN THE STATE OF RONDONIA BRAZIL : HISTORICAL PERSPECTIVES AND PRESENT SITUATION

Henry A. Laker and Jay Wallace da Silva e Mota *

INTRODUCTION

Commercial cooca production in Rondonia started in the 1970's with a government initiative to populate the Amazonian region. Land divided into lots of 50, 100 or 500 ha each were distributed to immigrants mainly from Southern Brazil. Cocoa was among the perennial crops considered suitable substitutes for the rain forest ecosystem and capable of providing good economic returns (Silva, 1984). Its cultivation became one of the principal agricultural activities in Rondonia in 1976 at the start of the PROCACAO programme designed to expand Brazilian cocoa output mainly through new plantings in Amazonia. Cocoa area increased from 52 ha in 1971 (Afonso, 1986) to 38,300 ha in 1983 (Silva, 1984) partly encouraged by government loans for new plantings during 1975 to 1982. Municipalities named Theobroma, Cacaulandia and Cacaieiros confirm the high status of the crop during this period of colonization of Rondonia. Presently, Rondonia is the second major cocoa producing state in Brazil.

HISTORICAL PERSPECTIVES

The endemic presence of witches' broom disease in the Brazilian Amazonia region was first revealed by Alexandre Rodrigues Ferreira in 1785. During a botanical expedition from Belem in Para to Cuiaba in Mato Grosso, he noted that expansion of commercial cocoa production in the region was being limited by the devastating "lagartao" disease (Silva, 1987).

More recently, the potentially destructive effect of witches' broom disease (caused by *Crinipellis perniciosa*) was initially not appreciated. Consequently, few farmers implemented the recommended phytosanitary pruning of infected tissues during the early years when yields were still rising (Rudgard, 1986). With the rapid increase in host population, some of which were very susceptible to the pathogen, witches' broom attained epidemic proportion in 1976 (Afonso, 1986). Unable to cope with the problem, some farmers abandoned their plantations leaving sources of inoculum for other farms in close proximity to the abandonded ones.

The Campaign for the Control of Witches' Broom disease (CAVAB) was instituted in 1977 to prevent dissemination of *C. perriciosa*to areas as yet unaffected, principaly in the States of Bahia and Espirito Santo. Posts for inspecting plant materials leaving Rondonia were established in Porto Velho and Vilhena. In the same year, 340 farmers in the State of Rondonia were trained in phytosanitary pruning and fungicide application as part of CEPLAC's intensive campaign to promote control of the disease (Alencar et al., 1988). This thrust was not sustained in subsequent years. Thus in a 1982 survey, witches' broom disease was found on more than 90% of 341 plantations which had cocoa older than 3 years.

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This survey indicated increasing disease intensities but also showed that losses could be reduced to tolerable levels. This encouraged CEPLAC in 1983 to establish "An Action Plan to control witches' broom disease", whose key points were :

- Motivation of cocoa growers to adopt cultural control practices;
- Training farm labourers to identify disease symptoms and to eliminate diseased materials during pruning rounds;
- Extension of credit to farmers with cocoa older than four years for financing control practices;
- Development of an expanded and rational research programme aimed at reducing disease losses.

This programme is subsequently called the "Action Plan".

During the lifetime of the "Action Plan" (1983-85), 2,530 farmers and 12,470 rural labourers were trained on disease control on cocoa (Alencar et al., 1988). Credit sufficient to facilitate control on 35,080 ha was made to a total of 2,221 farmers.

RESEARCH ON WITCHES' BROOM DISEASE.

Investigation on the disease in Brazil intensified with the establishment in 1977 of the CEPLAC Special Department for Amazonia (DEPEA). The following studies were conducted in Rondonia :

Epidemiology

A series of experiments in Ouro Preto determined the micro-climatic parameters and phenology of the disease. Relationships were established between pod, shoot and floral cushion infections and host phenology, presence of inoculum and climate variations (Andebrhan, 1984; 1985; Rudgard, 1986; 1987).

Cultural Contol

More than 60 chemical formulations were screened against *C. perniciosa* in laboratory, greenhouse and field trials in Rondonia during the 1980's. Many demonstrated strong activity "in vitro" but exerted insignificant control in the field (Laker and Rudgard, 1989). In general, copper based formulations applied every two weeks throughout the period when pods are susceptible, significantly reduced losses. Activity in the field was also shown by systemic formulations belonging to the triazole group. In contrast, the organic protectants showed negligible activity, probably due to the combination of poor tenacity, host growth and inappropraite application techniques (Laker and Rudgard, 1989).

Biological Contol

A metabolite produced by *Cladobotryum amazonense* suppresseed germination of spores of *C. perniciosa* and a wide range of tropical pathogens in laboratory tests (Bastos et al., 1986). The antibiotic also protected cocoa seedlings from infection by *C. perniciosa* in a greenhouse trial. Suspensions of conidias of another potential biocontrol agent, *Trichoderma* viride significantly reduced sporulation when sprayed onto dry brooms (Bastos, 1987). However, neither the antibiotic nor *T. viride* have as yet demonstrated notable control of witches' broom disease in the field.

Resistance

The cocoa seed gardens in Ouro Preto were established in 1977 with IMC 67, PA 150, P 7, P 12, BE 8, BE 9, BE 10, SIC 328, SIC 813, SIAL 169, SIAL 505, SCA 6, ICS 6, MA 11 and MA 12 among the predominant clonal parents. Hybrids from these and other clones have been evaluated for yield and disease resistance in Rondonia since 1978. Some of the cocoa accessions collected during botanical expeditions within the Amazonia region are also being assessed in Ouro Preto.

FIGURE 1: MAP OF RONDONIA STATE SHOWING COCOA GROWING AREAS

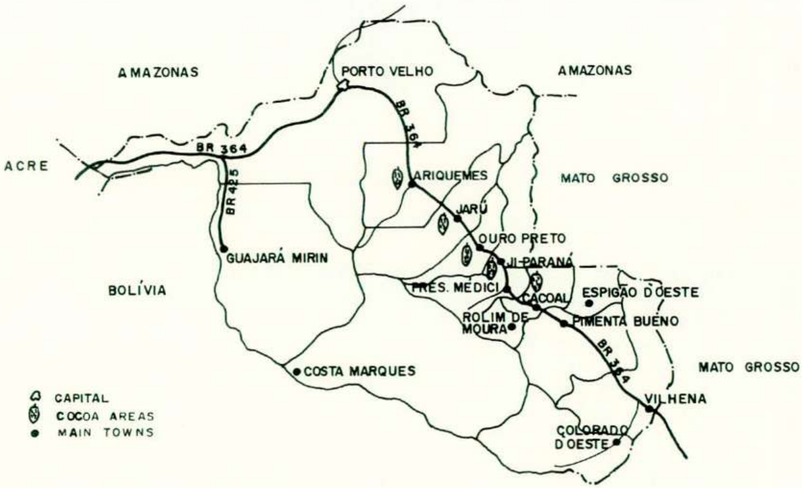
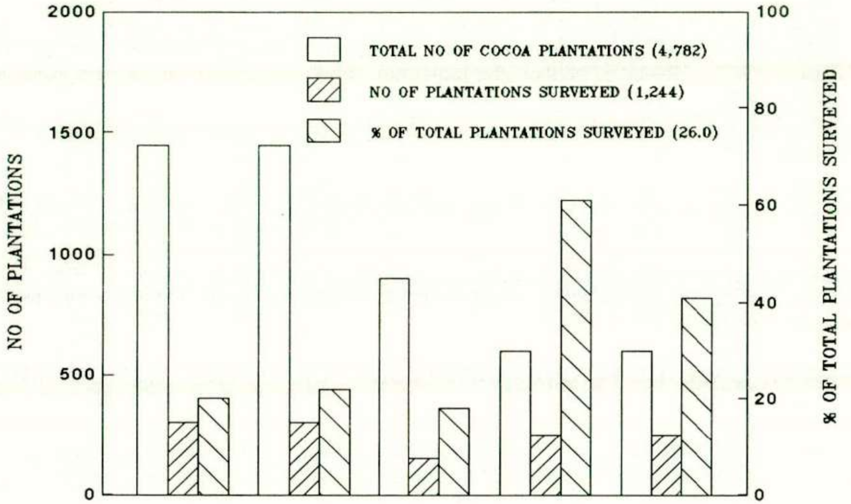
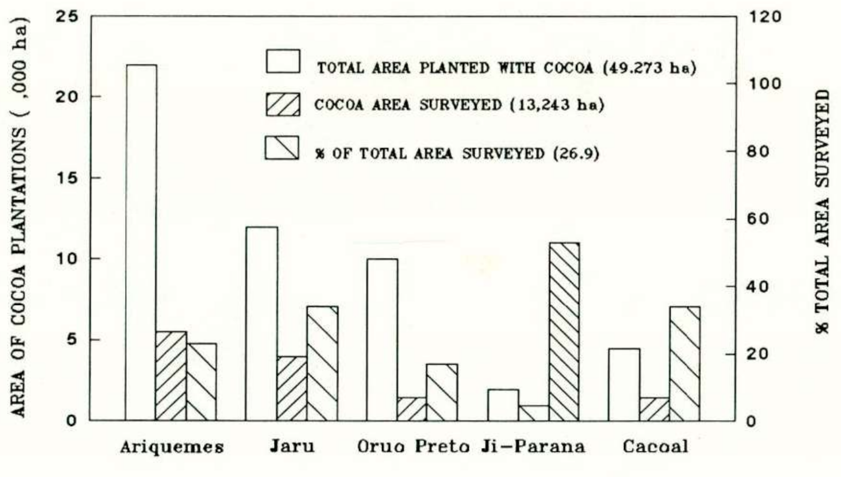


FIGURE 2: THE NUMBER AND AREAS OF COCOA PLANTATIONS ESTABLISHED WITH CEPLAC ASSISTANCE IN MUNICIPALITIES OF RONDONIA





Intergated Control

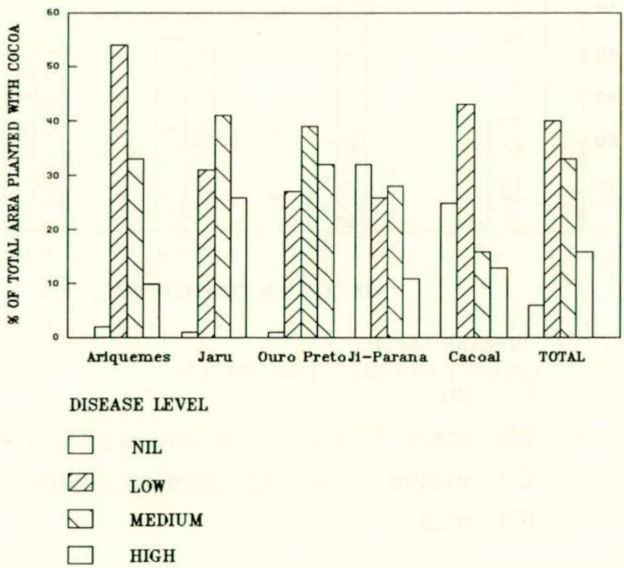
Recent emphasis has been on the combined use of phytosanitation and fungicides or biocontrol agents.

CURRENT SITUATION

Information compiled by the CEPLAC Extension Division during routine farm visits in 1989 were analysed to update the witches' broom status in the State of Rondonia. Disease levels on the plantations wre rated on the following scale based on the number of brooms on the majority of trees :

0 Nil:	absence of symptoms;
1 Low:	presence of a few (<20) vegetative brooms;
2 Medium:	presence of many (>70) vegetative brooms and none or only a few floral cushion brooms;
3 High:	presence of many vegetative and floral cushion brooms.

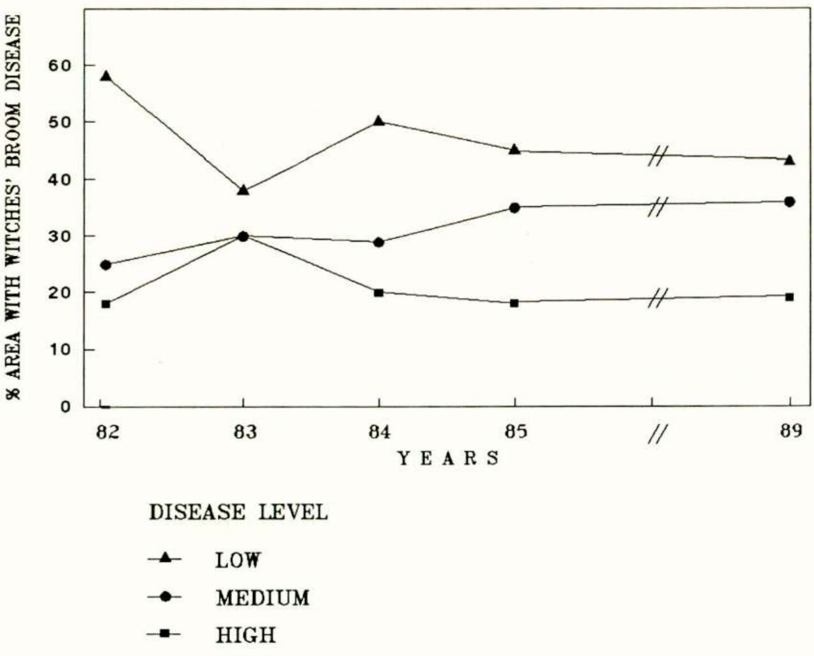
FIGURE 3: WITCHES' BROOM DISEASE LEVELS IN VARIOUS MUNICIPALITIES OF RONDONIA



Surveys of the witches' broom disease situation in the State of Rondonia were conducted annually from 1982 to 1985. The disease was observed on all cocoa fields older than four years during the 1982 survey (Alencar et al., 1988). Medium and high disease levels were noted on 40% of these holdings in 1982 (Figure 6). This proportion rose to 54% at the end of the "Action Plan" and was found to be still around this level during the 1989 survey. The two factors probably responsible for this stability in disease intensity are increased distribution of seeds from parents considered highly productive, but moderately resistant to the disease and the widespread practice of phytosanitation.

About 62 million seeds from crosses between the various genotypes in the seed gardens were freely distributed to growers in the States of Rondonia, Amazonas, Acre and Mato Grosso between 1979 and 1989 (CEPLAC, unpublished). These were predominantly used for new plantings and replantings. However, high pod losses still occur on these materials (Figure 5) in spite of their pollinations being timed to avoid periods of peak inoculum presence.

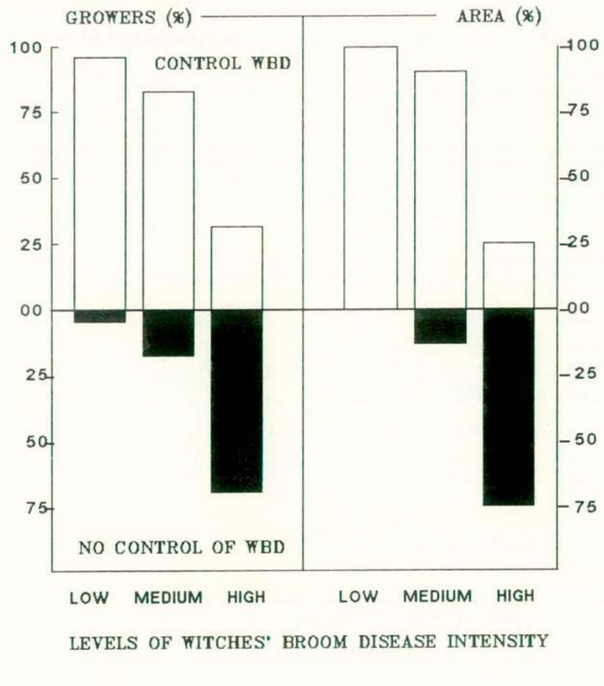
FIGURE 6: PERCENTAGES OF AREAS WITH DIFFERENT LEVELS OF WITCHES' BROOM DISEASE IN RONDONIA



By the end of 1985, pruning was regularly done in almost 80% of the plantations in Rondonia. A slightly higher percentage of growers were still committed to the practice during the current survey. It is notable that whereas pruning is done in nearly all areas with a "low"disease rating, about 75% of the plantations where it is not practiced have a "high"disease intensity (Figure 7). Similarly, the high pod losses registered in the seed gardens in 1985 (Figure 5) was probably caused by cessation of control practices during 1983 and 1984 (CEPLAC, 1987). With the resumption of phytosanitation in 1985, a significant decline in disease intensity was noted in subsequent years.

The effectiveness of pruning in recovering cocoa production on plantations devasted by witches' broom disease and the economic returns from the practice were evaluated on two 5 ha holdings in the Municipalities of Ouro Preto and Jaru from 1985 to 1989. Both sites had cocoa at least eight years old and were characterized by high incidences of infected shoots and floral cushions and annual pod losses exceeding 80%.

FIGURE 7: WITCHES' BROOM LEVELS ON PLANTATIONS WHERE DISEASE CONTROL IS PRACTISED OR NOT PRACTISED



Following CEPLAC supervised prunings, the number of brooms fell sharply after a year at both locations. The proportion of diseased pods declined to 15% of total production in the third year in the trial in Jaru (Mascarenhas and Almeida, 1989). In the assessment in Ouro Preto, pod infection in the third year fell to 28% and yield exceeded four times the value recorded in the first year (Albuquerque et al., 1990). At both sites, expenses for disease control were less than 30% of variable costs but profitable returns were first registered in the third year. The average price for a kg of cooca in Rondonia during 1989 fell from approximately US $1.00 in March to US $ 0.35 in November. With such drastic price falls at a time when labour costs are stable, phytosanitation soon became uneconomical again.

TABLE 1: THE ECONOMIC IMPACT OF WITCHES' BROOM DISEASE OF COCOA IN RONDONIA IN 1989

Items	Values
Productive area of cocoa (ha)	43,010.00
Potential production (ton)	45,897.00
Estimated current production (ton)	32,560.00
Losses due to witches' broom (%) (i)	29.10
Estimated losses due to witches' broom (ton)	13,337.00
Estimated value of losses due to witches' broom disease in 1989 (US$) (ii)	12,166,590

NOTES:

(i) Source : Albuquerque et al., (1990)

(ii) Based on cocoa prices on the New York Stock Exchange market on 29/12/1989 of US$ 913 per ton.

ECONOMIC IMPACT OF WITCHES' BROOM DISEASE

The State of Rondonia has approximately 43,000 ha of cocoa at a productive stage. The potential cocoa production of the State can be calculated based on the areas of the crop of various ages, the known potential production of cocoa of similar ages and the prevalent level of witches' broom disease (Table 1). Yield losses for areas with "low","medium" or "high" disease levels were estimated at 20, 30 or 50% of production respectively. We estimate that in 1989, lost revenue due to witches' broom disease exceeded US $12 million.

CONCLUSIONS

Cocoa remains an important commercial crop in Rondonia. Its destiny is likely to be closely linked with growers' ability to profitably combat witches' broom disease. Most farmers recognize that losses can be restricted within tolerable limits through phytosanitation. This is however a labour intensive process and its efficiency is governed by labour costs, cocoa yields and world market prices. The recent sharp falls in cocoa prices have left many farmers disenchanted with the crop. This negative attitude is aggravated by a substantial price disparity for dry cocoa between Rondonia and Bahia. Cocoa prices in Rondonia declined to 50% of the Bahia prices in November 1989 and reached 30% during February 1990 (CEPLAC, unpublished). Although many small scale producers will continue to operate even with marginal returns, farm activities are likely to be restricted to harvesting only. A prolonged period of such low prices which result in inefficient, or no disease control, will inevitably lead to future upsurges of witches' broom disease.

A revision of the marketing system for cocoa in Rondonia is desirable. Greater involvement by producers in marketing cooperatives could lead to more favourable prices for growers. Small to medium scale cocoa based industries need to be established to reduce export costs and increase consumption of the commodity in the State, thereby contributing to stable prices. Substantial increases in both the quality and quantity of cooca beans form Rondonia is necessary to attract exporters. Quality improvements can be achieved through installation of central fermentaries and differential pricing of cocoa based on grades. Cocoa output can be raised in the medium term through better management practices and intensive disease control. In the long term, expansion of the crop area to the 100,000 ha target set in the PROCACAO programme will result in a strong and viable industry within the State of Rondonia.

RECOMMENDATIONS

The following ideas are presented by the authors for consideration and debate:

1. The witches' broom disease situation is dynamic and requires constant monitoring. The impact of the "Action Plan" on farmers, methods of cocoa production and of disease and pest control in Rondonia should ideally be evaluated in a technical survey. Future control strategies could then be defined on these findings.

2. Greater importance in the cocoa breeding and selection programmes should be directed at securing sources of resistance to the disease. It is particularly important for more accessions in the germplasm bank in Belem to be screened for potential sources of resistance.

3. Selection of genotypes for vigour and precocity should be encouraged. This could ensure several crop harvests before yields are affected by the disease.

4. High pod losses due to witches' broom disease in the cocoa seed gardens demonstrate the need for regular re-evaluation of the hybrids being distributed to growers. In addition, farmers should be encouraged to replace highly susceptible progenies with relatively moderately resistant hybrids.

5. Research could examine intensive cropping, involving high density planting of cocoa followed by progressive elimination of less productive trees after several harvests. Intensive land use involving cultivation of cocoa simultaneously with other commercial crops to increase returns per unit area and diversity sources of income could be studied.

6. A search for alternate disease control methods which enable economical returns despite the prevalent low prices should be pursued with greater vigour.

7. Improvements in cocoa prices in Rondonia could perhaps be achieved through the installations of small to medium scale cocoa based industries to stimulate internal demand for the crop. The establishment of marketing cooperatives in which growers are active participants could lead to more favourable prices for producers. Increased production of high quality beans should ideally be encouraged to attract exporters. This could be achieved through installation of central fermentaries and differential pricing of cocoa based on quality.

REFERENCES

Afonso, F.M.A. (1986) As terras do cacau em Rondonia. Brasilia, 113 pp.

Albuquerque, P.S.B. de, Coelho, J.A., Andebrhan, T. & Griep, D.N. (1990) Avaliacao da poda fitossanitaria na recuperacao de rocas de cacau altamente infectada por Crinipellis perniciosa.

Alencar, M.H., Silva, C.A., Almeida, L.C., Peixoto, J.C.S. & Silva, P. (1988) "Vassoura-de-bruxa" do cacau. Ministerio da Agricultura, Brasilia, 104 pp.

Andebrhan, T. (1984) Epidemiologia da vassoura-de-bruxa nos polos cacaueiros da Amazonia Brasileira. In : CEPLAC/DEPEA Informe Tecnico, p 46 - 56.

Andebrhan, T. (1985) Studies on the epidemiology and control of witches' broom disease of cocoa in the Brazilian Amazon. Proc. 9th Internat. Cocoa Res. Conf., Togo, 1984 p 395 - 402.

Bastos, C.N., Neill, S. & Horgan, R. (1986) Antifungal activity of a metabolite produced by Cladobotryum amazonense. Fitopatologia Brasileira, 11, 733 - 736.

CEPLAC (1987) Relatorio anual de atividades da Estacao Experimental Ouro Preto, CEPLAC/DEPEA/DIRON, Ouro Preto do Oeste, 36 pp.

Laker, H. & Rudgard, S.A. (1989) A review of the research on chemical control of witches' broom disease of cocoa. Cocoa Growers' Bulletin, 42, 12 - 24.

Mascarehas, G.C.C. & Almeida, A.D. de, (1989) Resultados do controle da Vassoura-de-bruxa na unidade de validacao de Jaru, Periodo 1985/1989. CEPLAC/DEPEA/DEPOC, 2 pp.

Rudgard, S.A. (1986) Witches' broom disease of cocoa in Rondonia, Brazil : pod losses. Tropical Pest Management, 32, 24 - 26.

Rudgard, S.A. (1987) Witches' broom disease of cocoa in Rondonia, Brazil : infection of vegetative flushes and flower cushions in relation to host phenology.. Plant Pathology, 36, 523 - 530.

Silva, L.F. da (1984) O cacaueiro como alternativa agricola para a Amazonia Brasileira. CEPLAC/DEPEA/ASCOM 25 pp.

Silva, P. (1987) Cacau e lagartao ou vassoura-de-bruxa : registros efetuados por Alexandre Rodrigues Ferreira nos anos de 1785 a 1787 na Amazonia. CEPLAC/CEPEC Boletim Tecnico, 146, 21 pp.

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COCOA ABSTRACTS ARE REPRINTED FROM 'ABSTRACTS ON TROPICAL AGRICULTURE' PUBLISHED BY THE ROYAL TROPICAL INSTITUTE, AMSTERDAM

JANUARY 1990

[A practical attempt at improving cocoa fermentation by direct inoculation with micro-organisms] Tentative pratique d'amelioration de la fermentation du cacao par inoculation directe de micro-organisms.
SANCHEZ, V.J.E. Campo Agricola Experimental Rosario Izapa, INIA/Centro de Investigaciones Agricolas del Sureste (CIASE), Tapachula, Chiapas, Mexico _ *Cafe, Cacao, The* v. 33(3) p.157-164; Jul. 1989.
A study was conducted in Chiapas, Mexico, to determine the effect of inoculation with micro-organisms on the fermentation of cocoa. A batch of 100 kg fresh beans was inoculated with Torulopsis candida C 30 at the beginning of the fermentation and with the bacteria Acetobacter sp. B-46 24h later. A second batch was inoculated with Brettanomyces claussenii C-Y31-2-2 at the beginning of the fermentation. During the fermentation the changes in temperature, the pH of the pulp, volatile acid content, internal colour of the beans and micro-organism populations were observed. The first treatment and the control behaved in similar ways. The second treatment reached its maximum fermentation temperature 24h later and the volatile acid content was different. The bean quality was slightly better for the second treatment. The chocolate from treatment 1 was more acid, more astringent and less pleasant than the chocolate made from the control. The chocolate from treatment 2 had the same quality as the chocolate of the control.

[Propagation of cocoa by orthotropic cuttings. Initial results and prospects]. Le bouturage orthotrope du cacaoyer. Premiers resultats et perspectives.
BERTRAND, B. AGBODJAN, A.K. Institut de Recherches de Cafe et du Cacao (IRCC), Kpalime, Togo - *Cafe, Cacao, The* v. 33(3) p.147-156; Jul. 1989.
Vegetative propagation of cocoa using orthotropic stem cuttings has been carried out in Togo since 1984. Bending young cocoa plants encouraged the production of orthotropic shoots which, when used as cuttings, produced orthotropic taproots. Orthotropic cuttings of this type were compared with young plants grown from seed without taking their genetic origins into consideration. The establishing ability, plant vigour, plant height and earliness of the cocoa plants were recorded. Different techniques for obtaining orthotropic cuttings from a selected tree in the plantation are described. These cuttings can be obtained with or without manipulation of the mother plant. The technique of cutting back the mother plant proved to be effective.

FEBRUARY 1990

Modelling agroforestry systems of cacao (Theobroma cacao) with Laurel (Cordina alliodora) and cacao with poro (Erythrina peoppigiana) in Costa Rica. 4. Water balances, nutrient inputs and leaching.
IMBACH, A.C., FASSBENDER, H.W., BOREL, R., BEER, J. and BONNEMANN, A. Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE), Turrialba, Costa Rica - *Agroforestry Systems (Netherlands)* v. 8(3) p.267-287 1989.
In Costa Rica, the water balances for the agroforestry systems of cocoa with Cordina alliodora or Erythrina peoppigiana were caluculated using measurements taken during 4 years (1983-1987) of the following parameters; climatic conditions (precipitation, evaporation) and soil properties (texture, soil moisture tension, hydraulic conductivity, variations in the soil

moisture content). Weekly samples of percolated water were taken from March 1986 - March 1987 using lysimetric capsules at 100 cm soil depth. The N, P, K, Ca and Mg concentration were determined to calculate the annual leaching losses. Precipitation samples were taken to determine the corresponding annual nutrient inputs. The annual rates of nutrient leaching losses were estimated to be 5.7,0.5,24.6 kg/ha for N, P, K, Ca and Mg, respectively, under the cocoa/E. peoppigiana system and 5.6,0.5,1.4,5.4 and 6.5 kg/ha for N, P, K, Ca and Mg, respectively, under the cocoa/C. alliodora system.

Cocoa (Theobroma cacao L.) in Papua New Guinea.

PANMAN, J. Department of Tropical Crop Science, Agricultural Univ., Wageningen, Netherlands 62 p.: Aug 1988.

An essay was made on cocoa in Papua New Guinea. After a general description of the region and agricultural activites, the literature review focussed on the cocoa crop. Special attention was drawn to the cropping systems with cocoa such as intercropping with coconut and other food crops. Major cultural practices were described, and illustrated by means of a case study of smallholder practices in the Buin area. Some important plant diseases (including vascular streak dieback, Phytophthora pod rot and bark canker) and pests (including moths, bugs, weevils and beetles) are mentioned. Information on research items such as crop agronomy, crop protection and processing technology is provided.

Integrated management of insect pests of cocoa in Malaysia.

WOOD, B.J. and CHUNG, G.F. Ebor Research, Sime Darby Plantations, Shah Alam, Selangor, Malaysia - *Planter (Malaysia)* v. 65(762) p.389-418: Sep 1989.

The insect pests in cocoa are dealt with, with the main emphasis on the mirid bugs (especially Helopeltis spp.) and the cocoa pod borer Acrocercops cramerella. Integrated pest management methods to control these and other minor pests in cocoa are dealt with.

Use of the black cocoa ant to control mirid damage in cacao.

KHOO, K.C. and CHUNG, G.F. Department of Plant Protection, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - *Planter (Malaysia)* v65(762) p.370-383; Sep 1988.

The black cocoa ant Dolichodorus thoracicus (syn. Dolichodorus bituberculatus) is capable of reducing the damage caused by mirids belonging to the genus Helopeltis attacking cocoa in Malaysia and Indonesia. The effect is probably caused by deterrence rather than by active predation. The ants nest in various places and they colonize artificial nests made of polythene bags stuffed with cocoa leaf litter and placed on trees where the ants are active. Honeydew from the mealybug Cataenococcus hispidus is the main food source for the blank ant. Other ants antagonistic to D. thoracicus have to be controlled before the introduction of the blank ant. Possible detrimental effects that may arise from the ant introduction are discussed in the context of the ant as a vector of cocoa viruses.

MARCH 1990

Effect on some environmental factors on the seasonal occurrence of the cocoa shield bug, Bathycoelia thalassina (Herrich-Schaeffer) (Hemiptera: Pentatomidae) in Nigeria.

OMOLE, M.M. Cocoa Research Inst. of Nigeria, Ibadan, Nigeria - *Turrialba (IICA)* v.38(2) p. 133-136; Apr 1988.

In Nigeria, the seasonal occurrence of the cacao shield bug, Bathycoelia thalassina, was monitored on cocoa between 1979 and 1982 to determine the relationship between its abundance and some environmental factors. The insect population has 2 frequency peaks, in Feb-May and Aug-Nov. There was no difference between the percentage mature pods and cherelles (immature pods) attacked by the insect, and there was no indication of feeding preference for either the mature pods or cherelles. The relationship between the abundance of the insect pest and pods, cherelles, mean monthly rainfall, relative humidity and temperature were erratic and not significant. It was suggested that the numbers of the pest might be significantly affected only by the severity of the factors.

Notes on phenological patterns of flowering and flower-feeding beetles (Coleoptera: Chrysomelidae) in two clones of cacao (Sterculiaceae: Theobroma cocoa L.) in Costa Rica.

YOUNG, A.M. Invertebrate Zoology Section, Milwaukee Public Museum, Milwaukee, Wisconsin, USA - *Turrialba (IICA)* v.38(2) p.143-148; Apr 1988.

In Costa Rica, cocoa cv. Pound 7 and UF 613 were studied to assess the relationship between temporal patterns of floral abundance, floral herbivory and beetle abundance in cocoa, and to evaluate the possible impact of floral herbivory in cocoa on the potential for natural pollination. The total number of flowers produced appeared very similar between the clones, and a very low incidence of floral herbivory was observed. No positive correlations were found in either cocoa clone between (1) the abundance of flowers and beetles; (2) the total flowers and the incidence of damaged flowers; or (3) the incidence of damaged flowers and the abundance of beetles. The observed, very low numbers Colapis sp. and Monolepta sp. might have precluded detecting a positive relationship between flowers and beetles. The extent to which these beetles are specific to cocoa flowers could not be ascertained. Observed levels of both beetles and floral damage from their herbivory are too low to have a significant negative impact on natural pollination.

Agronomic research on cocoa in Jamaica 1950-1980 and current research trends.

FAGAN, H.J. and TOPPER, B.F. Faculty of Agriculture Unit, University of the West Indies, Mona, Kingston, Jamaica - *Tropical Agriculture (Trinidad and Tobago)* v.65(4) p.290-294; Oct 1988.

Agronomic research in cocoa in the 1950's in Jamaica was almost entirely devoted to the introduction, propagation and establishment of different varieties imported manily from Trinidad and St Vincent. Field evaluation of these introductions led to the adoption of a few medium-to high-yielding varieties, but the later discovery of their susceptibility to black pod disease (Phytophthora palmivora) restricted their use as parents in breeding programmes. The resulting germplasm base of the cocoa industry is very narrow. However, the observed slow growth of the pathogen in the pod tissues of the susceptible variety ICS 60 permitted its use and resulted in the production of PA 150 x ICS 60 as the best-yielding local hybrid. Nutrition experiments mainly dealt with the effects of N, P and K on the yield of cocoa cultivated with or without shade, and with liming of acid soils.

APRIL 1990

[Cocoa pest control in Bahia, Brazil] Manejo de pragas do cacaueiro.

ABREU, J.M. DE, NAKAYAMA, K,. BENTON, F.P., CRUZ, P.F.N.DA, FERRAZ, E.C.A., MENESES, M. and SMITH F, G.E. Centro de Pesquisas do Cacau, Itabuna, Bahia, Brazil - CEPLAC, Brasilia (Brazil) 32 p. 1989.

A guide is presented dealing with pest control measures in cocoa in Brazil, with special emphasis on integrated pest control. The biology of 10 important pests, including thrips (Selenothrips rubrocinctus), Monalonion spp. (chupanca), Percolaspis ornata, Xylosandrus morigerus, several caterpillars, including Stenoma decora and Peosina mexicana, ants (Atta spp.), spider mites (Tetranychus mexicanus), scale insects, such as Planococcus citri and Coccus sp. and some storage pests (Ephesia cautella, Ahasverus advena) attacking cocoa in Bahia, Brazil, are reviewed. Furthermore, the most appropriate time of sampling methods and methods of treatments in case the threshold value has been reached are discussed. Plant damage caused is also mentioned. Chemical control of thrips, for instance, has to be initiated when 2-3 thrips per leaf or 10% of the fruit showing thrips colonies, have been counted. The guide is provided with good colour photographs.

[Fertilizing of young cacao plants in the nursery]. Fertilisation des jeunes cacoyers en pepiniere.
KONAN, A. and JADIN, P. Station d'Abengourou, Institut de Recherches du Cafe et du Cocoa (IRCC), Abengourou, Ivory Coast - *Cafe Cacao, The* v.33(4) p.229-234; Oct. 1989.
A study was conducted in the Ivory Coast to determine the effect of 3 rates of N and P fertilizers applied to young cocoa plants in the nursery on the plant growth and on the later development of cocoa in the field. In the nursery, growth measurements showed that P has a significant positive effects on plant growth wheras N caused high mortality. In the open field P had a beneficial after-effect and the detrimental effect of N was reduced.

Responses of seedlings of two varieties of Theobroma cocoa to wind.
SENA GOMEZ, A.R. and KOZLOWSKI, T.T., Centro de Pesquisas (CEPLAC), Itabuna, Bahia, Brazil - *Tropical Agriculture (Trinidad and Tobago)* v.66(2) p.137-141; Apr.1989.
In Bahia, Brazil, it was found that the response of 150-day-old cocoa seedlings to wind varied with variety, wind speed, and sequential cycles of calm followed by windy days. In var. Catongo and Catongo/Sial, wind speeds of 3.0 and 6.0 m/s caused abscission of leaves, tearing, marginal and interveinal browning, bruising of leaf tips, as well as curling and necrosis of leaves, with most injury induced by the highest wind speed. Stomata of both varieites were more widely open on windy than calm days, and generally were wider at wind velocities of 1.5 and 3.0m/s than at 6.0 m/s. Wind altered transpiration, with the transpiration rate of both varieties declining as the wind speed increased, apparently in response to a lower leaf-to-air vapour pressure gradient associated with the cooling effect of wind on the leaves. Wind also induced dehydration of shoots of both varieties. Such dehydration was not correlated with transpiration rates, presumably because wind caused extensive injury to the leaf epidermis, thereby accelerating shoot dehydration.

MAY 1990

Reactions of cocoa (Theobroma cocoa) seedlings and clonal plants to isolates of Crinipellis perniciosa in Trinidad.
LAKER, H.A. Cocoa Research Unit, Trinidad and Tobago - *Tropical Agriculture (Trinidad and Tobago)* v.67(1) p.43-48; Jan 1990.
The response of cocoa seedlings and clonal plants to isolates of Crinipellis perniciosa was assessed in Trinidad. Comparisons were made of morphological reactions caused by the isolates on cocoa seedlings from open and controlled pollinations and on clonal plants. The histopathological effect of the isolates was assessed on seedlings. Significant differences between some of the isolates on the open-pollinated progeny and the highly resistant reaction of clone SCA 6 indicated absence of pathotype A. It is concluded that only pathotype B exists on the island. The implications of this finding for breeding programmes for resistance to witches' broom disease and quarantine regulations for cocoa are discussed.

[Cocoa: market structure and prices]. De wereld van de cacao.
HOEKSTRA, O. and REM, P. Agricultural Univ., Wageninen, Netherlands 210 p; Aug. 1989.
The production, trade and consumption of cocoa, as well as the central role for the price as the result of the structure of the market and the behaviour of its participants is reviewed. In this market traders and consumers have a much stronger position than producers. Influencing factors to the

price fluctuations are discussed separately. Recently prices are at a very low level mainly because of the large supply, the huge stocks and the steadily growing demand. Attention is also paid to the policies of producing and consuming countries of trying to get more influence on the prices. These attempts do not seem to have much success and the agreements have not been able to stabilize prices near the level aimed at. Part 2 of the report covers the situation of cocoa industry in the Netherlands and the signifcance of the Netherlands in the international markets of cocoa and cocoa products.

Asexual propagation of cocoa (Theobroma cacao).

NAGABHUSHANAM, S. and NAIR, R.V. Regional Station, Central Plantation Crops Research Inst., Vittal, Karnataka, India - *Journal of Plantation Crops (India)* v.16(2) p.143-145; Dec 1988.

A study was conducted in Karnataka, India, to develp an easy technique for the vegative propagation of cocoa using cleft grafting and patch budding. The scions were taken from the fan branches. Patch budding gave a success rate which varied from 18-37% and cleft grafting gave an average success rate of 12%. High success rates (37% and 35%) were obtained with patch budding in the months with high relative humdiity and rainfall (June and August).

JUNE 1990

Evaluation of fungicides against vascular streak dieback, white thread blight and pink disease of cocoa.

SINGH, G. United Planations Berhad, Teluk Intan, Perak, Malaysia - *Journal of Plant Protection in the Tropics (Malaysia)* v.6(1) p. 19-24 Apr 1989.

In a nursury trial in Malaysia 15 systemic fungicides were screened against vascular streak dieback of cocoa caused by Oncobasidium theobromae. Tridimefon applied as a monthly soil drench gave excellent protection against the disease with only 0.7% of the seedlings succumbing to the disorder compared with 90% in the check. Foliar application was not very effective with 62.7% of the seedlings developing the disease. White thread blight caused by Marasmiellus scandens and pink disease caused by Corticium salmonicolor are generally minor diseases of cocoa, but can become problematic during the rainy season and in instances where insufficient attention has been given to pruning. Two trials were conducted in 1985 to evaluate the efficiacy of a number of fungicides against three diseases. Oxycarboxin was most effective against white thread blight whilst pink disease was effectively controlled by cuprous oxide, carboxin, oxycarboxin and benodanil. Tridemorph was, however, only moderately effective.

Chemical control of Helopeltis theobromae (Mill) and crop loss assessment in cocoa.

CHUNG, G.F. and WOOD, B.J. Research, Sime Darby Plantations, Shah Alam, Selangor, Malaysia - *Journal of Plant Protection in the Tropics (Malaysia)* v.6(1) p. 35-48; Apr 1989.

In Peninsular Malaysia, chemical control of Helopeltis theobromae on cocoa is generally needed and gamma-HCH at 250 g a.i./ha (repeated at 2 weeks) is the conventional method. Three trials were conducted to develop alternative control strategies. Two different strategies were compared in single estate-demarcated blocks (6-44 ha). Census for fresh damage to cherelles, pods, and sheets, was done monthly on 1 tree in 10, 1 row in 10. In the "plot response" (PR) each plot of 10 x 10 centred on the census tree sprayed conventionally whenever the tree had fresh damage. In the "threshold response" (TR) the entire block was sprayed when 25% of the plots had fresh damage. In the PR treatment a total of 104-155% of the area of the block was treated. In the TR treatment the block was srayed twice in both 1985 and 1986. In both strategies, the proportion with fresh damage was less than in the untreated block, whilst the number of pods produced from Feb. 1985 to Jan. 1987 was 296% of the untreated block in

PR and 202% in TR. In the second trial cocoa was aerially sprayed with gamma-HCH. In the third trial 18 insecticides including synthetic pyrethroids, carbamates, organophosphates and insect growth regulators were compared. Lambda - cyhalothrin (7.5 f a.i./ha) and dioxacarb (120 g a.i./ha) gave better control than gamma-HCH; the others were less effective.

JULY 1990

Influence of season on harvest pattern, pod and bean characters of cacao under areca-cacao mixed cropping system.

BOPAIAH, B.M and BHAT, K.S. Regional Station, Central Plantation Crops Research Inst. Vittal, Karnataka, India - *Indian Cocoa, Arecanut and Spices Journal (India)* v 12(3) p.79-81; Jan 1989.

The influence of the season on the harvest pattern, and the pod and bean characters of cocoa were studied in a arecanut-cocoa mixed cropping system in Karnataka, India. Two harvest peaks were recognized: April to July (71.04%) and Nov.-Dec. (17.76%). The wet season (June-August) accounted for 42.75% and the remaining 57.25% was harvested during the dry period. The studies on the pod characters indicated that the pod weight was low in the wet season as compared with the dry season. Analysis of the bean characters revealed a high pulp percentage and lower total soluble solids and bean weight in the wet season as compared with the dry season.

AUGUST 1990

Occurence of the entomogenous fungus Metarhizium anisopliae var. anisopliae on Lawana conspersa, a pest of cocoa.

LIM. T.K., CHUNG, G.F. and CHIN, C.L. Department of Plant Protection, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - *Planter (Malaysia)* v. 66(766) p. 29-32; Jan 1990.

During the wet months of Nov. and Dec. 1986, a rapid proliferation of Lawana conspersa was observed in a cocoa estate in Selangor, Malaysia. This was followed by a sudden decline in the population. The decline in the population was caused by a green, muscardine fungus which was identified by isolation, cultural, light and scanning electron microscopy studies to be Metarhizium anisopliae var. anisopliae.

An analytical assessment of agroforestry practices resulting from interplanting cocoa and Kola on soil properties in south-western Nigeria.

EKANADE, O. and EGBE, N.E. Department of Geography, Obafemi Awolowo Univ., Ife, Nigeria - *Agriculture Ecosystems & Environment (Netherlands)* v. 30(3-4) p. 337-346; Apr 1990.

A study was conducted to determine the soil properties under cocoa and kola intercropping at varying planting arrangements and to assess the implication of such interplanting for land use planning and management purposes in cocoa growing areas of Nigeria. The planting arrangement were: (1) a row of kola between 2 rows of cocoa; (2) a single row of kola between 2 rows of kola; (3) 2 rows of cocoa; and (4) a kola stand close and adjacent to 2 cocoa stands in a row. Field layout 4 was the most beneficical to the topsoil chemical properties, and the bulk density was the lowest (1.35 g/cm3) and the total porosity was the highest (69%).

An appraisal of mixed cropping trial on arecanut and cocoa.

BHAGAVAN, S. and BHAT, K.S. Regional Station, Central Plantation Crops Research Inst., Vittal, Karnataka, India - *Journal of Plantation Crops (India)* v. 17(1) p. 10-17; Jun 1989.

A field study was conducted in Karnataka, India to study the effects of 6 different spacings on the yields of arecanut and cocoa in mixed cropping. These data were analysed to find the optimum spacing for each of the crops. Yield per plant was highest when arecanut was spaced at 2.7 m x 2.7 m (7.59 kg) and when cocoa was spaced at 5.4 m x 5.4 m (22.14 kg). In the mixed cropping system as a whole, though there was a yield decrease for the individual plants, a maximum yield per unit area was obtained with a spacing of 2.7 m x 2.7 m (10 260 kg/ha arecanut and 14 460 kg/ha cocoa) due to a higher planting density.

Pollination biology of Theobroma and Herrania (Sterculiaceae). 3. Steam-distilled floral oils of Theobroma species as attractants to flying insects in a Costa Rican cocoa plantation.
YOUNG, A.M., ERICKSON, B.J. and ERICKSON, E.H. Invertebrate Zoology Section, Milwaukee Public Museum, Milwaukee, Wisconsin, USA - *Insect Science and its Application (Kenya)* v. 10(1) p. 93-98 1989.
Steam-distilled floral oils from several species of Theobroma (Theobroma cocoa, Theobroma simiarum, Theobroma mammosum and Theobroma speciosum) were tested using McPhail traps, in an abadoned Costa Rica cocoa plantation to determine the levels of attraction for flying insects. In each of the 3 bioassays, the traps were inoculated with floral scents at 1, 10, and 100 ppm, while controls were inoculated with a 10% solution of chloroform solvent in distilled water. Of a total of 223 Diptera captured were Cecidomyiidae, of which Mycodiplosis ligulata, Aphodipolsis triangularis and Ledomyia sp. comprised 59% of the total; 88% of al midges captured were females. Only 7% of the total were known cocoa-pollinating midges of Ceratopogonidae, all females; 16% were Phoridae. No discernible differences were found in the attraction of midges to the floral oils tested. Small numbers of several species of Trigona bees were also attracted to the floral oils.

The extraction and partial purification of cooca storage proteins.
PETTIPHER, G.L. Reading Scientific Services Ltd, University of Reading, Reading, UK - *Cafe, Cacao, The (France)* v.34(1) p.23-26; Jan 1990.
Two storage proteins were identified in cocoa (relative molecular masses (Mr) of 48 000 and 28 000). The cocoa storage protein extracted from unfermented cocoa cotyledons. These proteins were degraded preferentially during fermentation. The storage proteins were relatively insoluable at pH 5,0and 7.2but soluble at pH 10.0. An extraction and partial purification method for the storage proteins is described based on their soluability characteristics at different pH values.

Evaluation of brodifacoum against the Indian black rat (Rattus rattus wroughtoni) in cocoa.
BHAT, S.K. and SUJATHA, A. Central Plantation Crops Research Inst., Kasaragod, Kerala, India - *Tropical Pest Management* (UK) v. 35(3) p. 286-288; Jul 1989.
Brodifacoum (a second generation single dose anticoagulant) was evaluated against the black rat (Rattus rattus wroughtoni), a major rodent pest of cocoa in Kerala, India. Laboratory feeding trials using brodifacoum (0.005%) was blocks showed 100% mortality in these rats by 1 day feeding. The active ingredient consumed varied from 0.35 mg to 9.17 mg/kg body weight. The mortality occurred from the third day to the tenth day of feeding with a maximum on the fifth day in females and on the sixth day in males. One, 2 and 3 baitings with brodifacoum baits at intervals of 10 days between baitings reduced the rat population by 76%, 95% and 97%, respectively, in cocoa plantations. Moreover, 100% reduction in the damage was achieved by 2 baitings.

SEPTEMBER 1990

Yields of cocoa/kola intercrops in Nigeria.
OLADOKUN, M.A.O, and EGBE, N.E. Cocoa Research Inst. of Nigeria, Ibadan, Nigeria - *Agroforestry Systems (Netherlands)* v.10(2) p.153 - 160 1990.
The yields of 2 intercropped cocoa/kola plots were compared with the yields of 2 monoculture plots in Nigeria. It was found

that 1.75 ha of monoculture plot gave the same crop yield (kg/ha) as 1.00 ha of mixed crop. The cocoa component started fruiting earlier than kola and also continued to yield annually so there was no crop failure in any year.

OCTOBER 1990

Calcium chloride modification of cocoa seedling response to water stress.
KOLADE, J.A. Agronomy Div., Cocoa Research Inst. of Nigeria (CRIN), Ibadan, Nigeria - *Agriculture International (UK)* no. 3, p. 49-50; Mar 1990.
A study was conducted in Nigeria to evaluate the influence of $CaCl_2$ on growth parameters such as plant height and leaf number and to determine the potential of $CaCl_2$ as a transpiration suppressant. The treatments, additional to normal irrigation, were the application of 4 ml of solution containing 0, 1, 3 and 5% $CaCl_2$ at 3-day-intervals for 30 days. No adverse effects of the $CaCl_2$ treatments on the plant height and leaf number were observed. Calcium chloride treated plants showed greater tolerance to water stress, obtained a greater turgidity and had a lower transpiration rate than increasing $CaCl_2$ concentrations.

[Black pod disease of cocoa in Cameroon: analysis of a resistant character observed in the field]. La pouriture brune des cabosses du cacaoyer au Cameroon: mise en evidence d'un caractere de resistance au champ.
DESPREAUX, D., CLEMENT, D. and PARTIOT, M. Institut National de la Recherche Agronomique (INRA) CIRAD, Versailles, France - *Agronomie (France)* v. 9(7) p. 683-691 1989.
The natural evolution of the black pod disease (caused by Phytothphora megakarya) in Cameroon was analysed for 3 years in cocoa trees planted in 1974. The analyses of variance were carried out on the potential yield (ripe and black pods), on the effective yield (ripe pods) and on the losses (percentage of black pods). The results showed the existence of a genetic form of resistance under field conditions. The losses were less important for the clone UPA 134 progenies than for the other families. The same phenomenom was also observed to a lesser extent for the clone SNK 413. The UPA 134 progenies were also the best pod producers. Nevertheless, the transmission of resistance and productivity does not seem to be linked. Both characters are of an additive type. The origin of the resistance character is discussed.

[Production and profitability of cacao in Guaviare, Colombia: analysis of a slow development] Produccion y rentabilidad del cacao en el Guavaire: analisis de un despegue lento.
MOLIJN, B.F. - *Colombia Amazonica (Colombia)* v. 4(1) p. 123-141; Sep 1989.
The state of cocoa plantations in the region of the river Guavaire, Colombia, was surveyed. Attention was paid to the environmental conditions, methods of cultivation, profitability and credit. The soil of most plantations was not suitable for cocoa production. There was a large variation in the conditions of the plantations. Cocoa is considered a crop of minor importance. A cocoa plantation with banana (for shading) gives only low returns; without banana trees, the returns are negative.

NOVEMBER 1990

25th annual report 1989.
Research Dept., United Plantations Berhad, Teluk Intan, Perak, Malaysia. 103 p.; Feb 1990
A report on the activities developed by the United Plantations Berhad Research Department in Malaysia in 1989 in the fields of oil palm, cocoa, coconut, tissue culture and crop protection is presented. The rainfall figures over 1969-89, sunshine records for the years 1979-89, production and sales of oil palm seeds, cocoa seeds,

coconut hybrid seednuts and fertilizers are reviewed. The research on breeding, selection, plant nutrition, crop protection measures, including trials on Helopeltis sp. in, and vascular streak dieback of cocoa, is discussed.

Land-use by immigrant Baoule farmers in the Tai region, south-west Cote d'Ivoire (Ivory Coast).

BUDELMAN, A. and ZANDER, P.M. Rural Development Programme, Royal Tropical Inst., Amsterdam, Netherlands - *Agroforestry Systems (Netherlands)* v. 11(2) p. 101-123 1990

The cropping system of immigrant Baoule farmers in the rainforest area of south-west Ivory Coast is discussed. The area harbours one of the last substaintial rainforest reserves of humid West Africa. The park area is threatened by farmers in search of land. Soils in the area typically have a low nutrient content (particularly P and K), low soil pH values, a low cation exchange capacity, and, locally, high levels of gravel. In the Baoule cropping system fields are kept under perennial crops, mainly cocoa, after having been used for food crop cultivation during the first 2 years. Yam, the most important food crop, is grown on mounds. Next to the inherent poverty of the soil, this cropping technique, which disrupts the structure of the top soil is seen as one of the causes for low yields of cocoa on Baoule farms in the area. Yields per ha amount to 60% of that of the national average. Measures to improve the agricultural production system include: introduction of crop species adapted to adverse soil conditions (eg. rubber (Hevea), oil palm); to buffer cocoa plantations through planting of shade trees; to apply fertilizers, and to make use of nitrogen fixation.

Feeding behaviour and the damage caused by Bathycoelia thalassina (Herrich-Schaeffer) (Hemiptera: Pentatomidae).

OWUSU MANU, E. Cocoa Research Inst., Tafo, Ghana - *Cafe, Cacao, The (France)* v. 34(2) p. 97-104; Apr 1990

The feeding behaviour, frequency and amount of feeding and damage caused by the pest Bathycoelia thalassina on cocoa in Ghana is described. Bathycoelia thalassina feeds directly on the developing beans of cocoa. the penetration of the stylets of the bug results in a disruption and disorganization of the cells in the pod husk. The salivary secretions help to digest the contents of the beans. Feeding is a continuous process and lasts 15-60 min. The beans of smaller pods suffer more damage than those of larger pods. The insects are less gregarious, but feed heavily in the third instar stage.

DECEMBER 1990

[Breeding cocoa for productivity in the dry season; using clonal selection to avoid black pod disease]. L'amelioration de la productivite du cacoyere (Theobroma cacao L.) en saison seche: methode de lutte contre la pourriture brune par la strategie d'esquive.

NGAMBI NDJAMA, J.M., TONDJE, P.R. and NGO NDONG, A.F. Station de Recherches Agronomiques de Nkolbisson, Yaounde, Cameroon - *Revue Science et Technique (Cameroon)* v.2(2) p. 89-97; June 1986

A pilot study was conducted for 2 years on exploiting the ability of some cocoa cultivars to fruit out the rainy season. The situation leads to low black pod disease which affects cocoa yield. In a clonal trial involving 7 cvs. the yield was estimated by the number of pods per tree and on the sensitivity to an abnormally dry season. An analysis of the results revealed a genotypic effect and the possibility of ranking revealed those cultivars. But this ranking did not take into account the different gene pools involved. the yield of all cvs. fell during the 2nd year. Nevertheless ICS 95 was the best clone. Two breeding strategies are discussed. The first, clonal selection on the basis of pod number per tree, was limited by the constraints of vegetative propagation. The second method dealt with screening clones on the basis of components involved in fruiting during the dry season, then crossing the best selection cultivars. In both cases, a study of the stability and inheritance of those traits is a priority.

[Verticillium wilt of cocoa] Marchitez del cacao por Verticillium dahliae.
GRANADA, G.A. Programa Fitopatologia, Instituto Colombiano Agropecuario (ICA), Palmira, Colombia - *Cacaotero Colombiano (Colombia)* v.12(37) p. 17-28; Dec 1989
The presence of the fungus Verticillium dahliae, the causal agent of wilt, on cocoa hybrids and on clones ICS 1, ICS 6 and TSH 792 was observed in Colombia for the first time. Epidemiological aspects and possible control measures are reviewed.

A Verticillium entomopathogen on the cocoa pest, Lawana conspersa in Malaysia.
LIM, T.K. Department of Plant Protection, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - *Journal of Plant Protection in the Tropics (Malaysia)* v.6(3) p. 189-192; Dec 1989
A Verticillium fungus close to Verticillium lecanii is reported for the first time causing an epizootic of Lawana conspersa (Hemiptera: Flatidae), a pest of cocoa from a mature cocoa field in Selangor, Malaysia.

[The pod borer of cocoa] El perforoador de la mazorca del cacao.
VELEZ, R. AND CUBILLOS, G. Facultad de Ciencias, Universidad Nacional de Colombia, Medellin, Colombia - *Cacaotero Colombiano (Colombia)* v.12(37) p. 43-47; Dec 1989
The larvae of the pod borer Synanthedon theobromae (Lepidoptera) can cause up to 50% fruit (pod) damage in cocoa plantations in Colombia. Biology, classification, aspects of the damage caused and pest control measures are highlighted.

[Performance of semi-continuous cocoa depulper] Desempenho de extratores semi-continuos para polpa de cacau.
PASSOS, F.J.V., FREIRE, E.S. and ROMEU, A.P. Centro de Pesquisas do Cacau, Itabuna, Bahia, Brazil - *Boletim Tecnico - Centro de Pesquisas do Cacau (Brazil)* no. 163, 15 p. 1989
Two prototypes of semi-continuous depulpers for cocoa seeds were designed and tested in Bahia, Brazil. These models basically consisted of a horizontal cylinder with perforated walls and a rotating axle with rubber paddles for removing the pulp. A good performance was attained and no major damage to the product was observed. The capacity of the models was 24-40 kg seed per batch and 190-320 kg of pulp/h for the larger one and 12-20 kg seed per batch and 99-180 kg of pulp/h for the smaller model.

[Cocoa production costs: development of standard costs in September 1987] Custos de producao de cacau: comportamento dos custos padroes em setembro de 1987
FERREIRA, H.I.S. Centro de Pesquisas do Cacau, Itabuna, Bahia, Brazil - *Boletim Technico - Centro de Pesquisas do Cacau (Brazil)* no. 162, 48 p. 1989
A cocoa production cost monitoring methodology is presented. An evaluation is made of the economic returns from technologies, including variables such as profitability, technology, yield and production costs, for Brazil in September 1987. The criteria for economic evaluation of some technologies and single agricultural practices employed in cocoa are defined.

Printed by Haines Clark & Co. Ltd., Gooch Street, Birmingham B5 7HE England.