COCOA GROWERS' BULLETIN

Number 49 **October 1995**

Contents

Cadbury Limited
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England

EDITORIAL

The first issue of the Cocoa Growers' Bulletin appeared in August 1963 and until 1980 subsequent issues came out regularly every 6 months under the thoughtful Editorship of Ross Wood. He produced 30 issues containing relevant articles in a timely way - a tradition which I regret I have been unable to maintain over the subsequent years. It is therefore with great sadness that I have to record the sudden death of Ross at home in the garden of his lovely house in rural Shropshire on Tuesday 1st August 1995.

For several decades he was the acknowledged world expert on cocoa cultivation. Graduating from Cambridge with a degree in agriculture, Ross joined Cadbury in 1949 as a dairy farm inspector helping our suppliers in the Shropshire area. After two years he moved to work in a similar role with cocoa farmers. On joining the British West African Department of Cadbury Limited at Bournville in 1951, Ross undertook postgraduate training in tropical agriculture in Trinidad and then in 1952, he made several long treks on foot through the forest zone of western Ghana to assess the extent of new cocoa plantings - long before any roads had reached those villages. Over the next 30 years, Ross visited and re-visited every cocoa producing area in the world and his advice was much appreciated by many cocoa growers and their Governments. In 1963, Ross started the Cocoa Growers Bulletin as an information service to cocoa growers world-wide and remained as Editor for seventeen years. He was closely involved in three editions of "Cocoa" - the standard textbook on cocoa cultivation and marketing published by Longmans. Ross finished work on the 4th Edition in 1985, actually three years after his retirement from Cadbury Ltd. So far, this Edition has sold almost 3,000 copies and has been widely appreciated by all those involved in the world cocoa industry.

In 1947 Ross married Elizabeth Greeves (a grand-daughter of George Cadbury) and they had three children : Andrew, Anne and Richard. Ross and Elizabeth have always been active in the Society of Friends in Bournville and more recently in Shropshire. Ross was also closely associated with Woodbrook College for many years. He will be sadly missed by his family, Friends, colleagues and cocoa growers alike.

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

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REVIEW OF PRODUCTION, CONSUMPTION, STOCKS AND PRICES

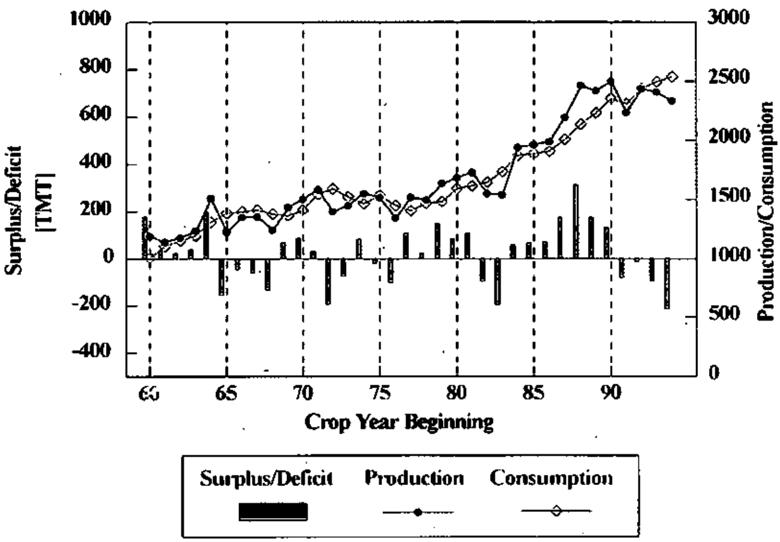
S.A.Wakeling

(October 1994 - September 1995)

PRODUCTION

E.D. & F.Man Limited Cocoa Market Report No.353 reported that World production in 1994/95 would be 2,331 TMT ('000 tonnes), which would be 3.2% down on the 2,407 TMT in 1993/94. Whereas production from West Africa was set to increase by 2.9% (1994/95 against 1993/94), production in the rest of the World was set to decline by 11.1%. The two countries accounting for the bulk of this fall were Brazil and Malaysia. In Brazil the forecast of a 1994/95 crop of 222 TMT, down from 276 TMT in 1993/94 and compared to an average of 365 TMT over the period 1986/87 to 1990/91, was due to a combination of witches' broom disease, poor farm husbandry and farm maintenance and a declining tree stock. In Malaysia the forecast of a 1994/95 crop of 145 TMT, down from a 1993/94 crop of 200 TMT, was due to a combination of the effects of price on yields and poor weather. In Indonesia the forecast of a 1994/95 crop of 245 TMT, down from a 1993/94 crop of 248 TMT, though only a small fall in production was the first fall in production since the 1970s. E.D. & F.Man Limited believe that this fall was due to adverse weather and that future crops will continue the trend towards higher production.

WORLD COCOA SUPPLY AND DEMAND



Source: E.D. & F.Man Limited, Cocoa Market Report No.353.

WORLD COCOA PRODUCTION DATA

Reproduced from E.D. & F.Man Limited Cocoa Market Report No.353
(September 1995)

	1990/ 1991 **	1991/ 1992 **	1992/ 1993 **	1993/ 1994 **	1994/ 1995 (i)
Cameroon	107	108	93 *1*	102 *7*	98
Ivory Coast	769	723 *-1*	785	835 *35*	835
Ghana	293	243	312	255 *5*	307
Nigeria	170	110	130	135 *5*	130
Others	43	31	30 *2*	31 *-1*	28
Total Africa	**1409**	**1215** *-1*	**1350** *3*	**1358** *51*	**1398**
Brazil	377 *-2*	301 *5*	305 *11*	276 *11*	222
Colombia	52	49	50	51 *1*	50
Ecuador	106	82	69	78 *-2*	77
Mexico	43	51 *6*	51 *1*	38 *-8*	38
Peru	11	11	11	9 *-2*	8
Venezuela	16	15	16	18 *2*	18
Others	11	10	12 *2*	12 *2*	13
Total C. & S.America	**616** *-2*	**519** *11*	**514** *14*	**482** *4*	**426**
Dominican Rep.	42	48	52	60 *5*	53
Others	8	9	9 *1*	9 *1*	10
Total West Indies	**50**	**57**	**61** *1*	**69** *6*	**63**
Indonesia	145	167	231 *8*	248 *-2*	245
Malaysia	224 *-1*	217 *-8*	219 *-5*	200 *-5*	145
Papua New Guinea	33	41	39	31 *-7*	35
Others	20	18	20 *2*	19 *1*	19
Total Asia & Oceania	**422** *-1*	**443** *-8*	**509** *5*	**498** *-13*	**444**
WORLD TOTAL	**2497** *-3*	**2234** *2*	**2434** *23*	**2407** *48*	**2331**
% change in production from previous season	3.3	-10.5	9.0 *1*	-1.1 *1*	-3.2

(i) **Forecast.**
****** **Changes since the last edition of the Cocoa Growers' Bulletin.**
Note: **All figures in Thousand Metric Tonnes (TMT).**
Some figures may not add due to rounding.

WORLD COCOA CONSUMPTION DATA

Reproduced from E.D. & F.Man Limited Cocoa Market Report No.353 (September 1995)

	1990/ 1991 **	1991/ 1992 **	1992/ 1993 **	1993/ 1994 **	1994/ 1995 (i)
France	70	67	80	95 *4*	110
Germany (Fed. Rep)	295	306	311 *6*	304 *-2*	278
Italy	56	62	58	65 *3*	67
Netherlands	268	294	309	331 *-2*	355
United Kingdom	145	153	169	170 *1*	159
Others	144	145	144 *1*	156 *6*	158
Total Western Europe	**978**	**1027**	**1071** *7*	**1121** *10*	**1127**
FSU/USSR	83 *1*	25	95	90	80
Other Eastern Europe	84	83 *-3*	75 *-3*	72 *-6*	74
Total Eastern Europe	**167** *1*	**108** *-3*	**170** *-3*	**162** *-6*	**154**
Ivory Coast	115	108	100	110 *5*	110
Others	55	67	65	83 *11*	86
Total Africa	**170**	**175**	**165**	**193** *16*	**196**
Brazil	275 *-5*	216 *-5*	218 *-4*	224 *-6*	196
United States	272 *7*	307	326	317 *5*	347
Others	208	190	187	172 *-6*	184
Total America	**755** *2*	**713** *-5*	**731** *-4*	**713** *-7*	**727**
Malaysia	77	87	99	103 *1*	104
Others	197 *2*	187 *1*	192 *12*	191 *11*	218
Total Asia & Oceania	**274** *2*	**274** *1*	**291** *12*	**294** *12*	**322**
WORLD TOTAL	**2343** *4*	**2297** *-7*	**2427** *10*	**2483** *26*	**2526**
% change in grindings from previous season	5.4 *-0.2*	-2.0 *-0.5*	5.7 *0.8*	2.3 *0.7*	1.7

(i) **Forecast.**

****** **Changes since the last edition of the Cocoa Growers' Bulletin.**

Note: **All figures in Thousand Metric Tonnes (TMT).**
Some figures may not add due to rounding.

CONSUMPTION

E.D. & F.Man Limited Cocoa Market Report No.353 reported that World cocoa consumption (as measured by World grind) would rise to 2,526 TMT, an increase of 1.7% on 1993/94.

They believe that consumption in Western Europe in 1994/95 has been flat rather than in decline. Though grindings in UK and Germany showed falls, they were offset by increased grinding in Netherlands, France and Italy. In Eastern Europe, they propose that consumption has stabilised after the growth in chocolate consumption seen since 1992. In the Americas, the grind has moved from Brazil, where the poor crops have reduced the supply of beans, to North America. They suggest that the North American grind understates consumption since there has been a significant decline in cocoa butter stocks between 1994 and 1995. In Asia, they believe that grindings have grown by 9.2%, spurred on by strong local demand for chocolate products.

STOCKS

E.D. & F.Man Limited Cocoa Market Report No.353 reported that for the 1994/95 season there would be the highest ever annual supply deficit of 218 TMT. 1994/95 also represents the fourth consecutive year of deficit, during which time stocks have fallen by 422 TMT. A reversal in this trend seems less rather than more likely.

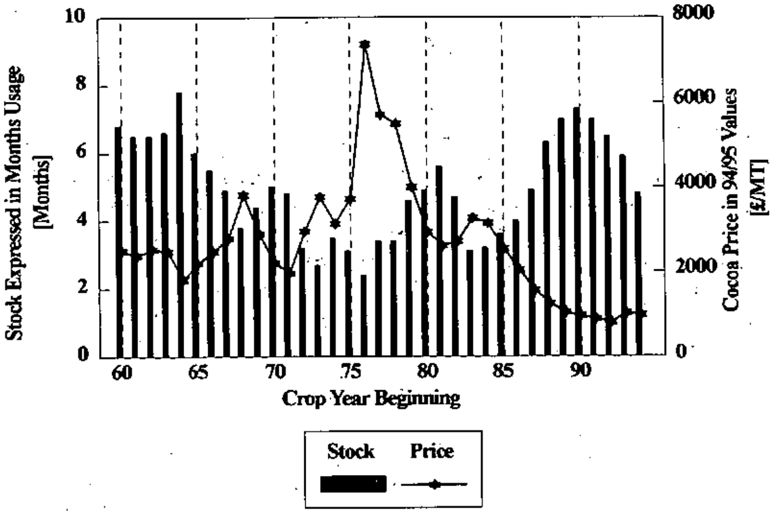
WORLD COCOA STOCK DATA

Reproduced from E.D. & F.Man Limited Cocoa Market Report No.353 (September 1995)

	1990/ 1991 **	1991/ 1992 **	1992/ 1993 **	1993/ 1994 **	1994/ 1995 (i)
Stock change	129 *-7*	-85 *9*	-17 *13*	-100 *22*	-218
Closing stocks **(including buffer stock)**	1425 *-32*	1339 *-23*	1321 *-12*	1221 *10*	1003
Stock/consumption ratio **(including buffer stock)**	0.61 *-0.01*	0.58 *-0.01*	0.54 *-0.01*	0.49	0.4

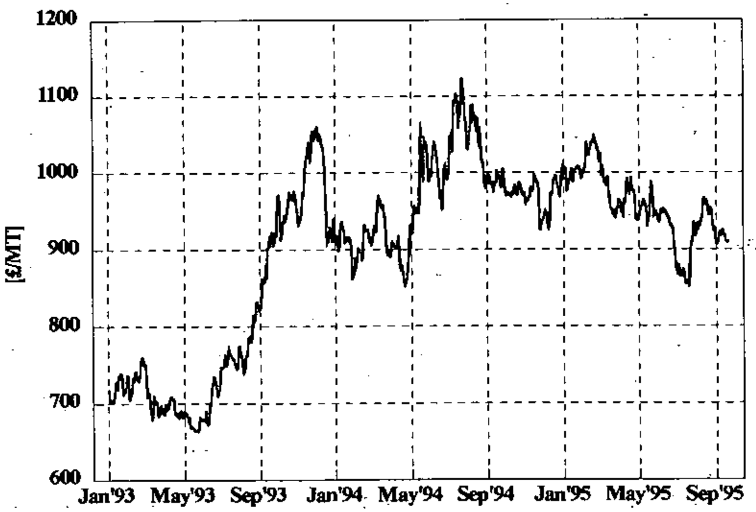
(i) Forecast.
**** Changes since the last edition of the Cocoa Growers' Bulletin.**
Note: All figures in Thousand Metric Tonnes (TMT).
Some figures may not add due to rounding.

WORLD COCOA STOCKS AND PRICES



Prices adjusted to 1994/95 terms ie. adjusted for inflation and currency movement

COCOA PRICES - LONDON TERMINAL MARKET - 2nd POSITION



Source: E.D. & F.Man Limited, Cocoa Market Report No.353.

COCOA CULTIVATION ON P.T.P.P. LONDON SUMATRA INDONESIA ESTATES IN NORTH SUMATRA PROVINCE, INDONESIA

M.J.Redshaw* and Ir. Zulnerlin**

BACKGROUND

P.T.P.P. London Sumatra Indonesia (or "Lonsum" as it is popularly known) was, until July 1994, a wholly-owned subsidiary company of Harrisons & Crosfield PLC. The Company is now under Indonesian ownership and operates 19 estates in North Sumatra and on the islands of Java and Sulawesi extending to 46,000 planted hectares of oil palm, rubber, cocoa, coconuts, tea and coffee. In addition, new oil palm and rubber areas are under development in South Sumatra. Cocoa is planted on 6 estates in the Medan area of North Sumatra and, more recently, in East Java. This article deals with the development of the cocoa area in North Sumatra, which on Lonsum estates now stands at 4,200 hectares.

In the early 1970s, when the plantation industry showed renewed interest in planting cocoa in North Sumatra, the strategy of the Harrisons & Crosfield Group at the time was to concentrate on oil palm on its estates in Malaysia (Harrisons Malaysian Plantations Berhad - HMPB) and on rubber in Indonesia, but also to allow some diversification into other crops. It is with this background that cocoa came to be planted on Lonsum estates around Medan. With hindsight, the diversification away from rubber has been of considerable importance in the subsequent development and performance of the Group's plantation business in Indonesia.

CLIMATE AND SOILS

Situated around 4 degrees north of the equator, on the eastern coast of North Sumatra, the region has a typical tropical rainforest climate. Rainfall of 1,500 to 2,500 mm per annum is well distributed through the year, with most months having in excess of 100 mm rain per month. Relative humidity is high, averaging 85% throughout the year, with a diurnal range of 70% to 95%.

Mean temperatures also vary little during the year, averaging 27°C, with daily minimum and maximum temperatures of 22°C and 32°C respectively. Temperature rarely exceeds 35°C. Daily sunshine duration is around 5 hours (1600 to 1800 hours per annum), which is slightly on the low side for cocoa, although the recorded solar radiation is good at 5.9 $GJ/m^2/year$.

Long-term rainfall records for the three main cocoa estates are given in Table 1. Under such conditions, annual water deficits of 100 to 300 mm are not uncommon at Bah Lias and Rambong Sialang estates, which must be considered a limitation to achieving maximum potential yields.

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** Bah Lias Research Station, P.T.P.P. London Sumatra Indonesia, PO Box 1154, Medan, North Sumatra, Indonesia.

TABLE 1: 1968 TO 1991 MEAN MONTHLY RAINFALL ON THREE ESTATES*
(mm per month)

Month	Rambong Sialang	Bah Lias	Gunung Melayu
January	77	100	134
February	71	81	101
March	84	73	141
April	133	111	155
May	151	135	212
June	101	135	179
July	148	111	193
August	147	158	213
September	225	214	176
October	244	242	330
November	166	183	256
December	147	148	223
Annual Total	**1,694**	**1,691**	**2,413**

This pattern of rainfall has led to marked biannual cropping, with peak crops approximately six months apart, typically in March/April and September to November. Agricultural practices are geared to this cropping pattern.

All the Lonsum cocoa estates are located on volcanic soils derived from liparitic tuff arising from the creation of Lake Toba some 75,000 years ago. These young volcanic soils are well drained and have a good friable structure, with pH in the region of 5.0 to 5.5. Availability of potassium (from K-bearing minerals) and magnesium is generally good, but supply of nitrogen and phosphates is low to moderate and must be provided in the fertiliser schedules.

Towards the eastern coast, the terrain is flat to slightly undulating, making it well suited to cultivation of cocoa. Surface run-off and erosion are potential hazards that need to be guarded against, particularly in the early years of plantings. Overall, the conditions can be considered to be very suitable for cocoa cultivation. Low rainfall leading to depleted soil moisture reserves is the main limiting factor.

PLANTING MATERIALS

In the early 1970s, there was very little primary cocoa germplasm in Sumatra. Some material had been assembled by RISPA (the Research Institute of the Sumatran Planters Association, formerly AVROS) and by the state plantation companies PTP II and PTP VI, comprised of a selection of Upper Amazon

* These are centred on Medan, Sumatra, Indonesia.

hybrid material available in South-East Asia. Hybrid seed was imported from HMPB's Bagan Datoh estate in Peninsular Malaysia for the first commercial plantings on Lonsum estates. Amongst these were several popular hybrid crosses including ICS 40 x Pa 7, GS 29 x Na 33 and IMC 60 x Na 32.

From the outset, it was the Company's intention to develop the capacity to produce its own planting material. The initial introduction was augmented subsequently through exchanges of material and new acquisitions from Kew, Jember (East Java), Mayaguez, Miami and Papua New Guinea. The base population has been carefully screened and tested through a programme of field-testing of prospective hybrid crosses to identify improved material that meets several important criteria as follows:-

- acceptable sustained level of production (minimum 1,500 kg dry beans per hectare per annum) and meets minimum requirements of average bean size (>1 gramme), minimum butterfat content (55%) and minimum shell content (<12%);

- acceptable growth habit without excessive vigour;

- good tolerance to important local pests and diseases (VSD, *Phytophthora* pod rot, *Colletotrichum* leaf disease, *Helopeltis* and pod husk-borer).

A number of Parinari, IMC, UF and Pound selections have proven to be good parents, notably Pa 310. Other good parents are Sca 9, UIT 1, Amz 3-2, Na 32 and GC 29 (imported as GS 29 but this clone differs from the CATIE description).

From using open-pollinated seed collected from selected mother trees in the first commercial areas in the late 1970s and early 1980s, the Company has advanced to producing its own hand-pollinated (HP) hybrid crosses and (open-pollinated) biclonal seed. The progression in planting material and the area planted has been as follows:-

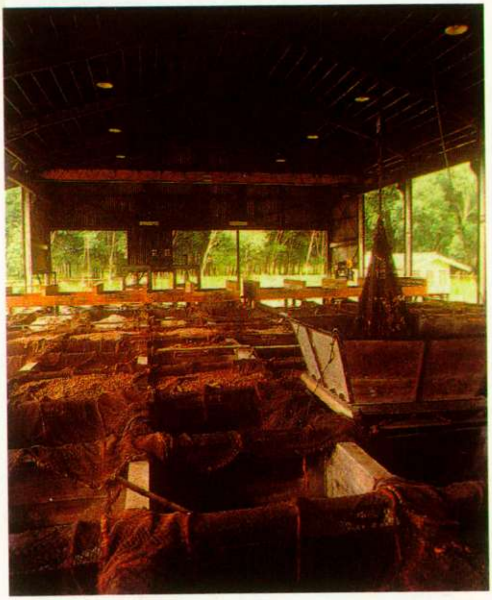
		Hectares	%
1973-76	- F1 UAH hybrid seed ex-Bagan Datoh, Malaysia	277	6.5
1977-87	- F2 open-pollinated seed from Bah Lias commercial plantings	962	22.8
1981-90	- F1 HP hybrid seed ex-Bah Lias	1750	41.4
1987-89	- F1 biclonal and polyclonal seed (mainly Pa x UF, GC 29, Keravat and local BL selections)	607	14.4
1989-to date	- clones	631	14.9

From 1989, selected clones have been planted exclusively. The material includes both recognised international clones and local selections arising from the programme of trials at Bah Lias. The best of these to date are GC 29, UF 11, UF 191, Pa 4, Pa 310, BL 703 and IMC 49.

PLATE 1: HIGH YIELDING CLONAL COCOA TREE AT P.T.P.P. LONDON SUMATRA INDONESIA

PLATE 2: NURSERY AT P.T.P.P. LONDON SUMATRA INDONESIA

PLATE 3: FERMENTATION BOXES BEING FILLED AT P.T.P.P. LONDON SUMATRA INDONESIA



Besides producing its own planting material requirements, Lonsum has established a reputation for supplying seed to the plantation industry in Indonesia. It is now one of the major suppliers of planting material in the country, capable of producing in excess of 12 million high quality HP and Biclonal seed per annum for the Indonesian market. This germplasm is continually upgraded through new acquisitions and selections from the breeding programme.

CULTURAL PRACTICES

Nurseries

Until 1989, the Company had planted only hybrid seedlings, raised in standard polybag nurseries under palm frond or bamboo-strip shade. Using 30 x 20 cm layflat bags, seedlings are ready for planting out at 4 to 5 months. Intensive culling is practised, removing some 25% to 35% of the plants, to ensure that only well-grown healthy material, of good uniformity, is established in the field.

A good deal of attention is paid to filling of the polybags. Only good quality top-soil with pH not less than 4.5 is used It was previously common practice to incorporate one part well-rotted manure to three parts soil, but this has now changed in favour of adding triple super-phosphate (TSP) or NPK compound fertiliser to the polybag soil. This has given good results at several sites, with few micro-nutrient problems (especially iron chlorosis).

A manuring programme based on two-weekly rounds of NPK Mg 15.15.6.4 from 8 weeks after planting the seed is administered. Additional nitrogen or micro-nutrients are applied as foliar sprays, as necessary.

For the production of budgrafted plants, larger 35 x 23 cm layflat bags are used, for a nursery period of 5 to 6 months. Conventional grafting is carried out on 2 to 3 month old seedlings, though there is a tendency now to bud onto more juvenile rootstocks. The seedling is cut back in two steps to half its height once the graft has taken and the stock retained as a support for the developing scion.

Field Establishment

In the early years, cocoa was established on land formerly under rubber cultivation. After completion of the felling and clearing operations both *Flemingia congesta* and *Gliricidia maculata* were established as temporary shade. However, this led to a prolonged non-productive period, frequently more than 4 years between felling the previous crop and bringing the cocoa into production. It also tended to exacerbate pest and disease problems in the establishment period, notably root disease (*Rigidoporus lignosus*) incidence and polyphagous leaf-eating insects. Where cocoa is planted after rubber, considerable attention is given to removing the old stumps and primary roots in order to minimise the incidence of *Rigidoporus lignosus*.

The unproductive period has now been reduced to about two and a half years by establishing a full stand of *Gliricidia* as early as possible after felling. This is achieved by planting 1.2 metre stakes of 2 to 3 year old *Gliricidia* wood just prior to wet periods at the same density as the cocoa points. Four well-spaced shoots are retained to produce temporary overhead shade under which the cocoa can be planted. Regular pruning, weeding and manuring of the stakes is required to effect quick establishment. Failed points are checked and re-supplied on a fortnightly basis. In favourable circumstances, cocoa can be planted 12 months after planting the *Gliricidia*. *Flemingia* is only used now to supplement the *Gliricidia* in less fertile situations, on exposed sites and slopes, and as a source of mulch.

In the last few years, several hundred hectares of cocoa have been very successfully established under oil palms at Gunung Melayu estate. The oil palms are thinned to about 40 to 50 per ha by poisoning soon after planting the cocoa. Any under-shaded patches are supplied with *Gliricidia*, and the area interplanted with coconuts (for the permanent shade). Initial establishment and growth of cocoa is good and uniform. Harvesting of the oil palm bunches can continue up to 18 months after planting the cocoa and the loose fruit collected until the palms are eventually poisoned out as the coconut and *Gliricidia* shade takes over. Minor losses and damage to the cocoa from falling debris and from mammalian pests is considered to be acceptable in view of the very quick establishment and the continued income from the palm fruit. Rhinoceros beetle (*Oryctes*) can, however, be a serious problem to the coconuts in these conditions. This is hard to control.

Planting Patterns

Various planting patterns have been used by the Company at different times:-

1973-75	3.5	x	3.5	m	offset	square	816	trees/ha
1976-85	3.5	x	2.5	m	"	"	1143	"
1986-89	3.6	x	2.0	m	"	"	1388	"
1990-92	3.6	x	3.0	m	"	"	926	"

Attempts at high initial densities, with a view to getting high yields for the first 3 to 4 years, followed by thinning, have largely been unsuccessful. The data in Table 2 from a density trial reflects this.

TABLE 2: YIELD OF FOUR YEAR OLD COCOA SEEDLINGS AT FIVE PLANTING DENSITIES

Number of Trees/Ha	Dry Bean Yield (kg/tree/annum)	Dry Bean Yield (kg/ha/annum)
816	1.78	1,449
952	1.62	1,537
1,144	1.37	1,570
1,428	1.10	1,569
1,633	0.94	1,532

Both trial data and commercial experience have led to the conclusion that an initial and fixed mature stand of around 900 to 1,000 trees per hectare is optimum for currently available hybrid seedling material under local conditions in North Sumatra. Consequently, the fields with stands over 1,000 points per ha have now been reduced to 850 to 950 by gradual removal of poor performers, diseased and damaged points, and other unproductive trees. A planting density of 926 per ha (3.6 x 3.0 m) is preferred for budgrafted plants.

Shade

Budgrafted plants of seedless *Leucaena* clones L2 and L19 were planted as the permanent shade in the early 1970s, but from 1975 coconuts have been used exclusively as permanent shade trees on Lonsum estates. Both tall cultivars and tall x dwarf hybrids have been used.

Despite their longer unproductive period, talls are preferred as they grow clear of the cocoa canopy much sooner, allowing the temporary shade points (*Gliricidia* and remaining *Flemingia*) to be removed at an early stage.

Coconut seedlings grown in polybags or nursery beds are planted out at the same time as the *Gliricidia*, approximately one year before planting the cocoa. The palms provide adequate shade for the cocoa after 4 to 5 years.

Up to 100 coconuts per ha were planted initially (10.5 x 10.5 m offset square), but this has been found to cause excessive shading in the longer term. Such stands have now been systematically thinned through 60-70 to about 45 points per ha. Cocoa yields have increased as a result. Present policy is to plant just 37 palms per ha (18 x 15 m offset square) at establishment. Covariance analysis of data from a fertiliser trial at our Bah Lias Research Station quantifies the effect of coconut shade on cocoa yields:-

Number of Coconuts/Ha	Dry Beans Yield (kg/ha/annum)
35	2,037
70	1,776
105	1,515

In addition to its function as a shade plant, it is considered that coconuts are also helpful in creating a stable environment for beneficial insects, in particular black ants, *Dolichoderus thoracicus*, which are antagonistic to *Helopeltis*, the main pest problem in North Sumatra.

Further benefits from coconuts - apart from the obvious one of providing an income from the sale of nuts or copra - are that the shade is more constant through the year than with dicotyledonous species (which are liable to defoliate in very dry periods) and, also, the shade level can easily be manipulated by pruning fronds.

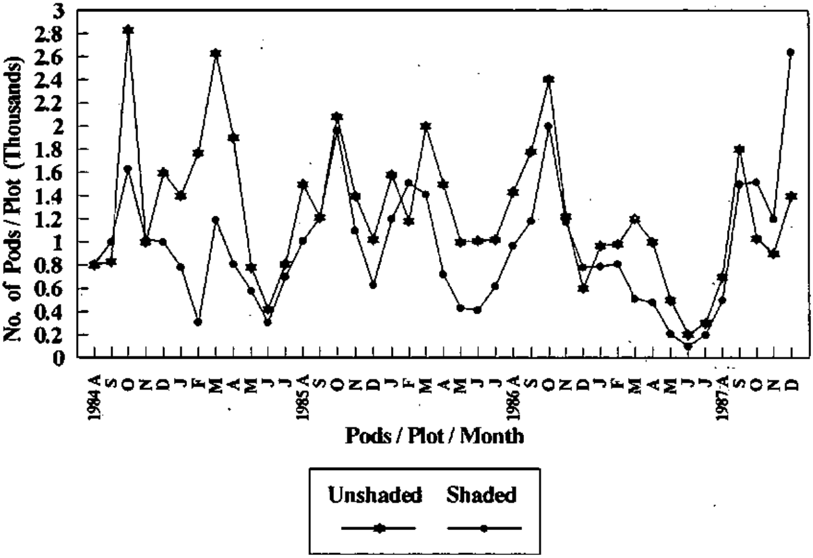
Maintenance

Maintenance of cocoa is aimed at producing a uniform, healthy, balanced stand capable of giving a sustained yield of 1,500 to 2,000 kg dry beans per ha per annum. From the outset, attention is given to all cultural practices. Key aspects are:-

- regular weeding rounds, either manual or using broad-spectrum herbicides (glyphosate, glufosinate, paraquat) to maintain weed-free conditions;
- thinning out and adjusting the shade trees over time to provide just the right amount of shade; a final stand of about 40 coconuts per hectare, evenly spaced, is considered optimal for North Sumatra conditions. Trials have shown that yields can be doubled in the short term by drastic reduction of shade, but it cannot be sustained even with additional fertiliser inputs (Figure 1);
- obtain a regular jourquetting height in seedlings through corrective pruning;
- maintain a full stand of productive plants by supplying any vacancies, replacing unproductive points and overbudding low-yielders with high-yielding clones;
- regular (monthly) removal of chupons;
- routine pruning to achieve a balanced canopy with good access and height control (3.5 metres); experience has shown that this can be achieved by two major pruning rounds annually after the peak crops, and regular "light" pruning rounds every 6 to 8 weeks to remove drooping branches, diseased wood and chupons in order to provide good access and ventilation;
- strict control of harvesting intervals of 7 to 10 days during peak seasons and no more than 14 days in low crop periods;
- regular and routine monitoring of all major pests and diseases in order to detect outbreaks at an early stage so that remedial action can be taken;
- correct timing and placement of recommended fertilisers is considered to be especially important;
- regular maintenance of access paths and collection roads, construction of bunds on sloping land to prevent run-off and keeping land-drains and water-courses clean.

Attention to these agricultural practices is important and is effected through close supervision and monitoring of activities at all levels of the management structure. This is seen as a pre-requisite for the successful and profitable management of plantation cocoa. Particular attention is now being given to progressively upgrading the lower-yielding seedling areas by overbudding with proven high-yielding clones.

FIGURE 1: YIELD OF UNSHADED VERSUS SHADED COCOA



(Shade Removed in August 1984)

Fertiliser Policy

The Company's Research Station at Bah Lias has done considerable work on nutrition for the local volcanic soils. The main requirements are for nitrogen and phosphate. Responses to applications of urea and of triple super-phosphate (or TSP) or rock phosphate is very marked in young cocoa, but the response diminishes with time, as has been demonstrated elsewhere. Potash can be shown to be important in the early years through interactions with both N and P. Responses to magnesium fertilisers have not been seen. The most important trials' results are shown in Table 3.

Quadratic response models are fitted to the observed trial data and yield contour maps for different rates of N and P fertilisers calculated from the response equation. In Figure 2, the path of least cost is superimposed assuming urea and TSP prices of Rp. 220 and 280 per kg respectively. In this case, the optimum fertiliser combination, if crop value is Rp. 1800 per kg, has been calculated to be 196 g urea plus 247 g TSP per tree per year, which is very close to the fertiliser rates giving maximum yield.

In view of these findings and considerations from the economic analysis, the present policy is to give judicious N, P and K dressings during immaturity and early maturity up to the point of canopy closure and the formation of a good layer of leaf litter. Rates are then reduced, recommendations being drawn up annually taking into account the physical condition of the cocoa canopy, the stand per hectare, the degree of overhead shade and the current yield level, in addition to soil analysis data. Typical rates commonly applied are 200 g urea in 3 applications, 200 g TSP in 2 applications and a single round of 50 g muriate of potash per tree per annum.

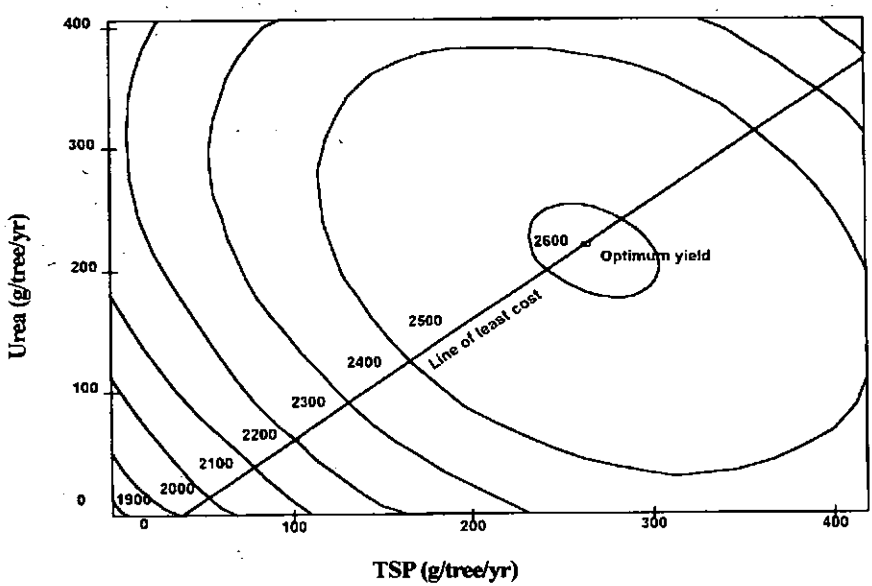
TABLE 3: YIELD RESPONSES IN 3 FERTILISER TRIALS ON VOLCANIC SOILS ON LONSUM ESTATES IN NORTH SUMATRA

Fertiliser Rate (g/tr/annum)		Trial 312 Dry Bean Yield (kg/ha/annum)	Trial 320 Dry Bean Yield (kg/ha/annum)	Trial 325 Dry Bean Yield (kg/ha/annum)
Urea	0	1,160	2,112	2,176
	100	–	2,048	–
	200	1,222	2,081	2,394
	300	–	2,137	–
	400	1,256	–	2,539
TSP	0	991	1,958	2,067
	100	–	1,943	–
	175	1,259	–	2,394
	200	–	2,288	–
	300	–	2,189	–
	350	1,380	–	2,374
Potash	0	1,255	–	2,379
(Muriate)	300	1,178	–	2,414

Correct placement of the fertiliser is considered to be most important to obtaining maximum economic benefits. Up to 5 years of age, all N, P and K fertilisers are applied as an increasingly widening circle to a maximum of 150 cm radius from the trunk. In older plantings, these fertilisers are spread in strips 1.5 metres broad along the rows. Where urea is used (it is the cheapest form of nitrogen in Indonesia), the leaf litter is disturbed by the workers to incorporate it into the surface layer. Where this is not done, considerable losses of N by volatilisation can be expected.

Limestone dust (LSD) or Dolomite is applied depending on the soil pH - 1,000 kg/ha for pH 5.0 to 5.5 and 2,000 kg/ha where pH is less than 5. As with the straight fertilisers, it is spread in circles up to 5 years of age and thereafter in broad strips, but always spread beyond the area of NPK application. Recent investigations have shown that soil pH is often higher in the avenues than down the cocoa tree rows, due to previous manuring practices; in these cases, emphasis is given to overall rather than strip application of lime.

FIGURE 2: YIELD CONTOUR MAP FOR DIFFERENT RATES ON N AND P FERTILISER [COCOA DRY BEAN YIELD (KG/HA/ANNUM)]



Very few problems have been encountered with micro-nutrients, the most important being occasional iron deficiency in nurseries - in particular in budgrafted plants. Ferrous sulphate sprays are given where the symptoms are acute, but there has not been any need to apply corrective measures in the field.

PESTS AND DISEASES

There are a number of important pests and diseases of cocoa in North Sumatra, which can cause serious losses if not detected and controlled effectively. However, with good supervision and management, incidence can be kept at acceptable levels. The strategy adopted by the Company has been to minimise pesticide usage and to use practical biological control measures whenever possible. It is a good example of effective Integrated Pest Management (IPM) on a plantation scale.

Fortunately, two serious pest and disease problems of cocoa elsewhere in South East Asia - cocoa pod borer (CPB) and Vascular streak dieback (VSD) - do not yet present major problems on the Lonsum properties. An outbreak of CPB was eradicated in the early 1970s (Pamata and Pardede, 1979), but it is present in other parts of Indonesia and has recently been recorded again in North Sumatra. VSD can be found in wetter areas of North Sumatra (Turner and Keane, 1985), but does not appear to be particularly virulent locally. Nevertheless, concern over potential problems from CPB and VSD is one reason mitigating against further expansion of the cocoa area in North Sumatra.

In the crucial two years after planting, leaf-eating insects and sap-feeders can seriously damage young cocoa, resulting in slow, irregular early development, and poor tree shape. Notable pests are the scarabaeoid beetles *Adoretus* and *Apogonia* spp, grasshoppers, bagworms (esp. *Cryptothelea* sp.) and the sucking insects *Helopeltis* sp, aphids, jassids, leafhoppers and *Lawana candida*. Where the incidence of these pests is high, it is often necessary to control them by applying regular (4 to 5 days) alternate rounds of contact and systemic insecticides. Experience has shown that spot-spraying of just the shoot-tips of affected points is better than blanket-spraying every plant, as this allows beneficial insects to thrive. Heavy ground vegetation and thick *Flemingia* side-shade tends to encourage pest species and should therefore be kept in check.

In mature cocoa, by far the most significant pests are *Helopeltis antonii* and mammalian pests (rats and squirrels), requiring constant attention Stem-borers (*Zeuzera* sp.) and the "cocoa pod husk-borer" (the yellow peach moth, *Dichocrocis punctiferalis*) are common pests at low incidence, which can become important locally if not contained, especially where the cocoa becomes stressed through lack of shade or poor maintenance. Other incipient pests are a variety of leaf-eaters: the pagoda bagworm (*Pagodiella hekmeyeri*), other bagworms, limacodid caterpillars (*Thosea* spp, *Darna trima*, *Ploneta diducta*), *Orgyia* spp, etc.

Lonsum has gradually evolved effective control measures against *Helopeltis* through biological rather than chemical means (Bakri et al, 1986). Experience in Java in the early part of the century (Van der Goot, 1917) showed that the presence of large numbers of the black ant, *Dolichoderus thoracicus* reduced damage caused by *Helopeltis* feeding on the shoots and young pods of cocoa. The ants are clearly antagonistic to *Helopeltis*. Once the cocoa canopy is closed, populations of black ants can be built up through a variety of measures:-

- providing nesting sites made of bundles of cocoa or coconut leaves;
- introducing their mealybug host (*Planococcus lilacinus*) from which they collect honeydew;
- placing coconut fronds between trees to facilitate movement within the field;
- constructing "bridges" of bundles of coconut fronds between areas of high and low populations, across roads, etc;
- destroying antagonistic ant species (*Technomyrmex albipes* (Smith)) and *Anoplolepis* sp);
- interplanting coconuts in the cocoa

These measures, coupled with minimal use of insecticides, allows the black ants to proliferate. . The result is a stable, balanced environment with acceptably low incidence of *Helopeltis* feeding-damage. The situation needs to be continually monitored, and can be re-dressed by spot spraying of contact insecticides (synthetic pyrethrins mainly) to control "hotspots" followed by rapid introduction of black ants and mealybugs. By such means, *Helopeltis* can be kept in check in mature cocoa for a cost of just Rp. 20 to 30,000 (US $ 10 to 15) per ha per annum.

Of the mammalian pests, it is difficult to distinguish clearly the feeding marks of rats and squirrels. Generally both are present. Rats can be easily controlled by regular baiting with brodifacoum wax blocks. Squirrels (*Callosciurus* sp) are too bait-shy to be poisoned, and are controlled through air rifle shooting, trapping and destroying nests. Locally, civet cats (musang) and monkeys can do a lot of damage. Without control, mammalian pests can cause yield losses as high as 50%.

Diseases are generally not a major problem in North Sumatra. Losses due to root disease (*Rigidoporus lignosus*) of young cocoa trees can be high in patches when planted after rubber when the old stumps and roots have not been removed. Treatment by drenching with systemic fungicides (triadimefon, triadimenol, benomyl) is only partially effective and is expensive. Good sanitation at the time of land preparation and intensive supplying of diseased points are the best means of obtaining a full mature stand. *Ganoderma* sp. have also been implicated in these early losses.

Recently, leaf-spotting due to *Colletotrichum* sp. has become more prevalent, particularly in budgraft plantings, indicating that screening clones for susceptibility to this disease is important locally. This is carried out by our Bah Lias Research Station.

Surprisingly, perhaps, *Phytophthora* pod rot (and other *Phytophthora* symptoms) has not become an important problem in North Sumatra. Affected pods can be seen, especially when peak crops coincide with wet periods, but are usually at a low incidence (a few percent). The worst outbreak to date in North Sumatra was seen in late 1992 on a number of estates. Losses in some fields in nearby estates were as high as 30% to 40%. The reasons for this outbreak are not understood, and clearly there is a risk of it becoming more prevalent locally. Apart from collection and removal of diseased pods, other measures to contain *Phytophthora* pod rot are not usually carried out.

Pest damage to shade trees has been important on occasions. Outbreak of negro bugs on *Gliricidia* proved difficult to contain until a natural fungal pathogen was found. A more serious problem has been *Oryctes* (Rhinoceros Beetle) damage to coconut shade. On one estate, in particular, new coconut plantings incurred 100% failures and a large number of mature palms have been killed. The problem has only been brought under control by intensive sanitation, prophylactic treatment of damaged palms and destruction of breeding sites.

PRODUCTION

Average yields have gradually increased through improvement of the planting material and the adoption of better management practices, and particularly through reduction of shade levels in the last few years. The most recent plantings have been very precocious, giving several hundred kilos of dry beans per hectare in the third year after planting The company average in 1992 was 1,320 kg dry bean/ha. The progression in yield of the various planting materials on Bah Lias estate is shown in Table 4.

The poorer performance of open-pollinated F2 seedlings is evident, where as much as 30% of the stand are very low yielding trees. Such areas are being upgraded by supplying and overbudding low-yielders with high-yielding clones.

TABLE 4: YIELD OF DIFFERENT TYPES OF PLANTING MATERIAL ON BAH LIAS ESTATE (KG DRY BEAN/HA/ANNUM)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
F1 UAH	–	96	357	716	1092	1466	1489	1385	1359	1207	1619	1582	1487	1437	1458	1372	1204	1286	1694	1053	1549
F2 OP	–	80	594	780	919	1045	1153	1211	1154	1211	1154	1279	1304	1347	1387	1300	1368	1133	1014		
F1 HP	–	108	532	935	1091	1149	1291	1403	1350	1649											
Clones	–	110	907	1060	981																

The performance of the hand-pollinated material and, latterly, the clonal plantings has been very satisfactory, with many blocks yielding in excess of 2,000 kg per annum.

The most important factor regarding cultivation of cocoa in Indonesia is the relatively low cost of labour, which is reflected in the production costs. Table 5 gives details, including the average selling price realised since 1977.

TABLE 5: AVERAGE COST OF PRODUCTION AND SELLING PRICE FOR LONSUM COCOA 1977 TO 1994

Year	Cost of Production (Rp/kg Dry Beans)	Average Sale Price (Rp/kg Dry Beans)
1977	1,255	1,698
1978	340	1,258
1979	349	1,680
1980	329	1,321
1981	330	1,033
1982	390	962
1983	593	1,426
1984	546	2,066
1985	656	2,237
1986	556	2,182
1987	770	2,579
1988	1,075	2,177
1989	930	1,837
1990	679	2,080
1991	1,026	1,924
1992	1,316	2,039
1993	1,511	1,963
1994	1,396	2,750

Note: The Indonesian Rupiah was devalued by 50% and 45% in 1978 and 1986 respectively. At the time of writing, the exchange rate was approximately US$ 1.00 = Rp. 2,200.

Although prices have not recovered from the high of 1987, there is still an acceptable margin over cost of production. Presently the net income per hectare is comparable with that from rubber, but considerably less than is being obtained from oil palm on similar land.

A breakdown of production costs (Table 6) over this period shows little change in the proportionate cost of the various components, despite an increase in labour costs in real terms. The proportion accountable to general overheads has increased over the period. The most noticeable change is the reduction in fertiliser costs in 1992, reflecting the much lower rates of urea and TSP now being applied as a result of the findings fiom field trials.

TABLE 6: BREAKDOWN OF PRODUCTION COSTS FOR 1978, 1985 AND 1992 (RP/KG DRY BEANS)

Item	1978	(%)	1985	(%)	1992	(%)
Upkeep and Cultivation	64	(18.9)	106	(16.1)	212	(21.7)
Fertiliser	102	(30.0)	153	(23.3)	115	(11.8)
Harvesting Transport	49	(14.3)	111	(16.9)	148	(15.2)
Processing	39	(11.6)	80	(12.3)	147	(15.0)
General Overheads	86	(25.3)	194	(29.5)	355	(36.3)
Others	–		12	(1.9)	–	
Total	**340**	**(100)**	**656**	**(100)**	**977**	**(100)**

Very encouraging results have been obtained from studies by the Company's agronomists on methods of forecasting yields from commercial areas. This is based on cherelle counts on representative tree samples from the main commercial areas and predictions of survival rates to maturity. Early attempts were unreliable but the procedure has been refined to incorporate rainfall data, so that quite accurate forecasts of the crop anticipated 3 to 4 months ahead can now be made. This has already proven to be of significant commercial benefit.

PROCESSING

Before the construction of automated plants in 1989, Lonsum's cocoa was processed using traditional methods of tiers of wooden fermentation boxes, and either dried in the sun or on wood-burning Samoan driers. Whilst this process was satisfactory for small volumes of beans, it was labour intensive and drying of the beans could take as long as 2 to 3 days in wet weather. The quality of the beans met export specifications, but nib pH was invariably below 5 and with associated astringency and acid off-flavours.

It is now recognised that the problem of low pH, acid beans in South East Asia reflects both field and factory procedures. Our two factories, which have a total capacity of 36 tonnes (dry beans) per day, that now handle the bulk of Lonsum's crop, were designed to tackle quality aspects associated with processing. On receipt from the field, the wet beans are pressed in 750 kg capacity metal cages, reducing their volume by 15%, and retained under pressure overnight. Much of the acid juices arising from the mucilage, which are partly responsible for nib acidity, are expelled. The beans are then fermented for 6 days in 2 x 2 x 0.5 m wooden boxes, lined with nets for lifting by overhead gantry cranes. The beans are turned daily during the fermentation period. Drying is a two-stage process: initial drying for 8 hours at 60°C in a circular drier and finished in a rotary drier for 8 to 12 hours at 60°C to 70°C. Kerosene is used to fuel the burners.

Compared with the traditional fermentary and Samoan driers, beans processed in the new factories have a pH above 5, with less noticeable acid off-flavours and have better chocolate flavour. A typical sample would have the following characteristics:-

No. beans per 100g	-	95
Moisture Content (%)	-	6.9
Nib pH	-	5.2
Shell (%)	-	14.0
Butterfat content (%)	-	55.4
Admixture (%)	-	4.3

A concerted effort was made in 1991/92 to implement the Cadbury-Sime process on a field scale; viz. 10 days pod storage after harvesting, shorter fermentation period in shallow boxes, longer two-stage drying with the final stage using forced air at ambient temperature. Bean quality and flavour was clearly improved, but in the event it was decided to discontinue the method because the premium attracted by the beans did not cover the cost of the extra work involved nor the unavoidable losses through spoilage and germination during pod storage.

MARKETING STRATEGY

Formerly, beans were sold mainly to European processors, and the price was based on the futures market (a discount to West African Beans). The South East Asian process market was relatively new and its capacity relatively small until the late 1980s. Recently more and more of Lonsum's production has been targeted towards quality processors in the Far East, or those buyers willing to pay for beans of consistent quality.

A better understanding of the cropping patterns in North Sumatra and an improved forecasting method has allowed crop to be sold forward, taking advantage of price movements. In view of the still general problem of poor flavour of South East Asian cocoa relative to West African beans, and the large discounted prices (circa £100 per tonne) on the European markets, the present Company strategy is to produce a maximum yield of acceptable quality beans with a high butterfat content, which can be sold to local processors.

Consideration towards further flavour improvement are secondary at the present time, and this is unlikely to change unless there is a clear financial incentive to producing beans with improved flavour.

CURRENT AND FUTURE PROSPECTS

Net income from cocoa presently in Indonesia is around US$300 per hectare per annum (after depreciation). This compares with US$350/ha for rubber (at 1,500 kg DR/ha) and US$1,250 for oil palm (at 6.8 tonnes palm products/ha). Under the present economic climate of a long-term decline in commodity prices and a fairly rapid increase in labour costs in Indonesia, it is clear that profits will only be maintained through careful control of costs, through improvements in productivity and by increasing yields per unit area. In the shorter term, there is perhaps more scope for improving the economic performance of cocoa than of rubber or oil palm, by rapidly introducing improved planting material and improving labour productivity.

Presently, it is difficult to present a good economic argument for planting anything other than oil palm, where it can be suitably grown. However, the Company has decided upon a crop mixture that should help to cushion the vagaries of commodity price fluctuations: 55% oil palm, 30% rubber, 10% cocoa and 5% other crops (tea, coffee, coconuts). In the shorter term, we feel the Company is well placed to take advantage of the expected upturn in cocoa prices as a result of falling production in West Africa and Malaysia. Cocoa should continue to have a good future in Indonesia, provided that labour rates do not rise too rapidly, but it is likely that plantation cocoa will have to be intensified through upgrading, higher planting densities and higher inputs (fertilisers, crop protection measures) in order to maintain profitability.

In support of these aims, Lonsum continues to fund research on cocoa agronomy, nutrition and crop protection, and is committed to a breeding programme to produce improved hybrid and clonal material.

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THE COLLECTION OF CRIOLLO COCOA GERMPLASM IN BELIZE

V.Mooleedhar*, W.Maharaj* and H.O'Brien**

INTRODUCTION

Cocoa is known to have been closely associated with culture and religion in the ancient Mayan civilisation which occupied the area that is now southern Mexico, Guatemala, northern Honduras, El Salvador and Belize. There is archaeological evidence showing that advanced agricultural techniques were used by the Maya who cultivated maize, beans, squash, chilli peppers as well as cocoa. Cocoa beans were used as currency for trade and commerce though food and drink preparations from the cocoa bean were used exclusively by the ruling class, usually on ceremonial and religious occasions.

The Mayan civilisation was widespread in Belize from ancient times until the 16th and 17th centuries where they controlled a significant portion of Belize and cultivated the fertile areas of the western part of the country as is shown in the recent discovery of massive ruins such as Naj Tunich and Caracol along the border with Guatemala. Other important ruins in this region are Xunantunich and Chan Chich.

Because of the importance of the cocoa plant to the Mayans, it is suspected that selected genotypes were widely distributed especially in the area along the Guatemalan border. The areas best suited for the survival of these "relic populations" would have been in the protected valleys and along rivers in sheltered areas (Figure 1).

In 1981, a meeting of the Working Group of Genetic Resources of cocoa sponsored by IPBGR agreed that the relic Criollo populations in the area near to the Belize/Guatemala frontier should be a priority for collection and conservation (Anon, 1981).

A preliminary survey of the cocoa germplasm in Belize by staff of the Cocoa Research Unit (CRU) of the University of the West Indies in 1992 (Mooleedhar and Maharaj, 1992) provided positive evidence that in addition to several generations of more recently cultivated plants, there existed remnants of indigenous Criollo germplasm - the so-called "relic populations". Funding was generously provided by the Biscuit, Cake, Chocolate and Confectionery Alliance (BCCCA) and Government permission was granted to carry out a survey of the genetic variation of relic Criollo populations in Belize and to collect germplasm from these populations during 1994.

The Ministry of Agriculture of the Government of Belize, kindly provided a counterpart (Hugh O'Brien) to work alongside the CRU personnel. The collection mission was undertaken over a six week period beginning on the 14th of March 1994 and was divided into two phases; Phase I prospected the Cayo district of north-western Belize and Phase II prospected the Toledo district of south-western Belize.

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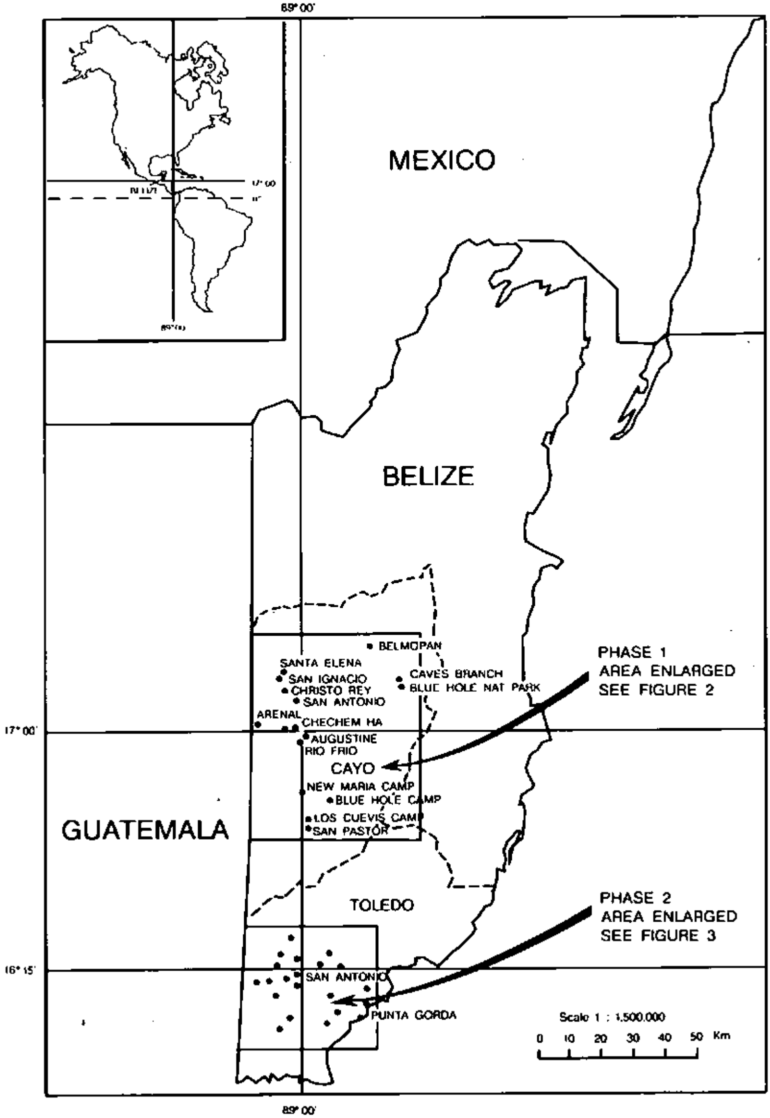
FIGURE 1: MAP OF BELIZE SHOWING AREAS PROSPECTED FOR WILD COCOA GERMPLASM



Preparation for the expedition included background reading on Belize (Anon, 1983; Anon, 1992; Mallan, 1993) which proved most valuable.

COLLECTION EXPEDITION - PHASE I

Information was gathered from local sources on the probable location of "relic populations" of Criollo trees. The sources included Mahogany hunters and "chicleros" who traverse the forest areas extensively. Based on these personal interviews, prospective sites at Rio Frio, Los Cuevis, Blue Hole, Barton Creek and Arenal in the Cayo district were identified (Figure 2).

The expedition departed from San Ignacio on the 18th of March 1994 by Land Rover towards Augustine. Members of the party included Kevin Moro and Isidro Bol of the Belize Defence Force; two porters - Daniel Sosa and Edward Ayala; Hugh O'Brien of the Ministry of Agriculture; Vish Mooleedhar and Winston Maharaj of the Cocoa Research Unit, University of the West Indies, Trinidad.

The group travelled for two hours to Augustine and carried out a three hour search in the area of the Rio Frio. One wild tree was found along the Rio Frio in close proximity to a large cave. This accession was referred to as "Rio Frio". The approximate altitude at this location is 400 m. The group continued on for several hours and arrived at Los Cuevis late afternoon. An overnight camp was set up in this area.

Los Cuevis is located 27 km south of Augustine along the major access road - the Chiquibul road. The following morning the party divided into two groups and prospected a 5 sq. km area between Los Cuevis and San Pastor. The area was relatively flat with cohune palm as the predominant vegetation. No cocoa plants were found and it was decided to move on to the Blue Hole area.

The party departed from the New Maria camp area for the Blue Hole camp at about 3:00 pm. An overnight stop was required before arriving there on the 20th of March. Blue Hole camp is located 23 km south east of Augustine close to the Raspaculo River. A 1.5 sq. km area was prospected on the Sunday evening and Monday morning. Again, no cocoa trees were found. The party returned to San Ignacio late on the 20th of March to restock and review information on the prospective sites.

On the 21st of March, prospective sites in Santa Elena and Arenal were explored and some very interesting material was found (reported as being cultivated in the wild in Guatemala). Several wild types were found at Che Chem Ha Falls. Four types were collected within the vicinity of Caves Branch which is located 40 km east of San Ignacio along the Humming Bird Highway. Three samples of budwood referred to as Blue Hole #1, #2 and #3 were collected 2 km away from Caves Branch. One pod was collected from Blue Hole #3. The altitude in this region is approximately 100 m.

The material collected on this expedition is listed in Table 1 and some characteristics by which the accessions might be identified in future are shown in Table 2.

Material was collected from the progeny of a wild type situated on the farm of Juanita Coc in San Antonio (Cayo). San Antonio is located 11 km south east of San Ignacio at an altitude of 150 m.

FIGURE 2: MAP OF THE CAYO DISTRICT SHOWING AREAS VISITED AND NUMBER OF ACCESSIONS COLLECTED IN PHASE I OF THIS EXPEDITION

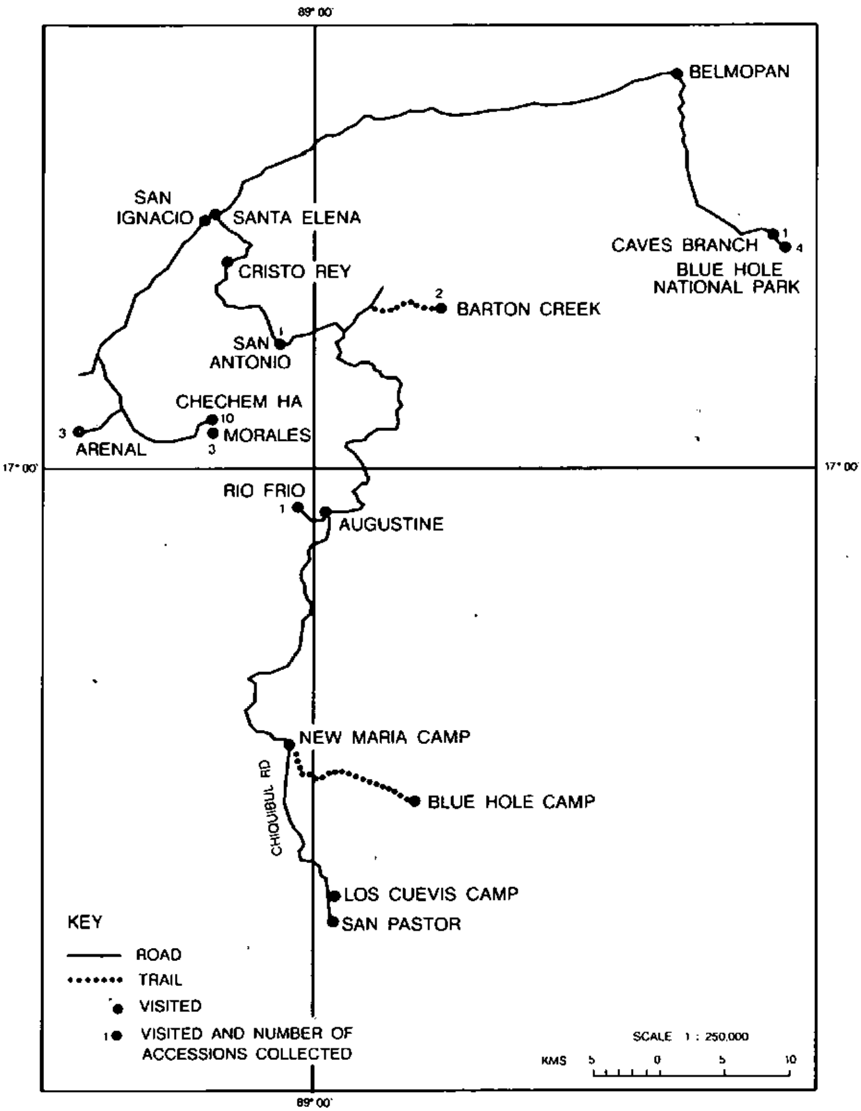


TABLE 1: SUMMARY OF GERMPLASM COLLECTED

Phase I

District	Location	Sample Name	Number and Type of Samples Collected
Cayo	Rio Frio	Rio Frio	1-budwood
	Caves Branch	Caves Branch	1-budwood
	Caves Branch	Blue Hole Nat. Park	3-budwood
	Caves Branch	Blue Hole Nat. Park	1-seed (from #3)
	San Antonio	Juanita Coc	1-budwood
	Che Chem Ha	Che Chem Ha 1-9	9-budwood
	Che Chem Ha	Che Chem Ha	1-seed (from #1)
	Che Chem Ha	Morales #1, #2	2-budwood
	Che Chem Ha	Morales	1-seed (from #2)
	Barton Creek	Barton Creek #1, #2	2-budwood
	Arenal	Arenal #1, #2, #3	3-budwood
		Sub-Total	**22-budwood/3-seed samples**

Phase II

District	Location	Sample Name	Number and Type of Samples Collected
Toledo	Prasco Ha	Banana Creek	8-budwood
	Prasco Ha	Banana Creek	4-seed (#1, #3, #4, #8)
	Laguna	Irideo Bolon	9-budwood
	Laguna	Irideo Bolon	3-seed
	Big Falls	Pedro Sam	2-budwood
	Big Falls	Big Falls	2-budwood
	Santa Cruz	Santa Cruz	1-budwood
	Aguacarte	Agucarte	1-seed
	Santa Elena	Santa Elena	3-budwood
		Sub-Total	**25-budwood/8-seed samples**
		GRAND-TOTAL	**47-budwood/11-seed samples**

TABLE 2: SUMMARY OF FEATURES OF MATERIAL COLLECTED

Accession	Description
Caves Branch Large	Vigorous tree, no flush pigmentation.
Blue Hole Nat. Park	Small tree, dark flush pigmentation.
Blue Hole Nat. Park	Large 7 year old seedling tree.
Blue Hole Nat. Park	Large old tree, with un-pigmented flushes and pods. Pods also rough, cylindrical and tapering, with white and light purple seeds.
Rio Frio	A small tree with pale green leaves, un-pigmented flush.
Che Chem Ha #1	Tall tree with un-pigmented flushes. Small un-pigmented oval pods with large plump grey pigmented seeds.
Che Chem Ha #2	Small tree with un-pigmented flushes.
Che Chem Ha #3	Small tree with un-pigmented flushes.
Che Chem Ha #4	Medium sized tree with un-pigmented flushes.
Che Chem Ha #5	Small tree with un-pigmented flushes.
Che Chem Ha #6	Very small tree with un-pigmented flushes.
Che Chem Ha #7	Tall slender tree with un-pigmented flushes.
Che Chem Ha #8	Very large old tree with 2 basal trunks, un-pigmented flushes.
Che Chem Ha #9	A tall, slender tree growing vigorously with un-pigmented flushes.
Juanita Cox	A small 5 year old tree.
Che Chem Ha #1 (Morales)	A large vigorously growing tree with numerous chupons and light pigmented flushes.
Che Chem Ha #2 (Morales)	A tall vigorously growing tree with numerous chupons and light pigmented flushes.
Arenal #1	A young vigorously growing tree with light pigmented flushes.
Arenal #2	A young vigorously growing tree with light pigmented flushes.
Arenal #3	Vigorously growing tree with light pigmented flushes.
Prasco Ha #1	An extremely tall tree with small, slender un-pigmented pods very plump, grey pigmented seeds.
Prasco Ha #2	A tall tree with no flushes.
Prasco Ha #3	Tall, single-trunked tree with no flushes. A small oval un-pigmented pod with plump cream and grey mottled seeds.
Prasco Ha #4	A tall tree with small roundish, un-pigmented smooth pods, seeds pigmented grey.
Prasco Ha #5	An extremely tall tree, main trunk unbranched.
Prasco Ha #6	A large tree with un-pigmented flushes. Pods are small oval and pigmented on their ridges. Very large plump heavy seeds with a grey-white pigmentation.
Prasco Ha #7	A small tree with light pigmented flushes.
Prasco Ha #8	A tall inclined tree with un-pigmented flushes. Small oval, pigmented pods with heavy and large white/light purple pigmented seed.

TABLE 2: SUMMARY OF FEATURES OF MATERIAL COLLECTED (CONCLUDED)

Accession	Description
Santa Cruz	Large tree with numerous chupons on river bank. Very lightly pigmented leaves.
Santa Elena #1	Tree inclined over river bank with non-pigmented flushes.
Santa Elena #2	Tree inclined over river with non-pigmented flushes.
Santa Elena #3	Tree top burnt out. Light pigmented flushes.
Pablo Sam #1	A tall tree very vigorous with non-pigmented flushes. A small, oval, rough and pigmented pod. Seeds are plump with a faint brownish-white pigmentation.
Pablo Sam #2	A tall tree with un-pigmented flushes. Pod is oval, rough and un-pigmented. Plump seeds with a brownish-white pigmentation.
Irideo Bolon #1	A small tree with dark flushes. A small pod with grey pigmentation.
Irideo Bolon #2	A vigorous tree with light pigmentation. Small non-pigmented pod; seeds are mottled grey.
Irideo Bolon #3	A small tree with dark flushes. A small pod with grey pigmentation.
Irideo Bolon #4	A vigorous tree with light pigmentation. Small non-pigmented pod; seeds are mottled grey.
Irideo Bolon #5	A small tree with light pigmentation.
Irideo Bolon #6	Light pigmented flushes.
Irideo Bolon #7	A small tree with light pigmented flushes.
Irideo Bolon #8	A tall tree with light pigmented flushes.
Irideo Bolon #9	A very small tree with light pigmented flushes. Pods are small, oval and pigmented. Seeds are plump with a mottled light purple colour.

Nine types were collected from the area of Che Chem Ha Falls which is located 15 km south of San Ignacio. Another two types were collected on the Morales estate nearby, as these were thought to be progeny of the Che Chem Ha wild types.

We prospected the Barton Creek area on the 24th, 25th and 26th of March 1994. Barton Creek lies in the direction 13 km Northeast of San Ignacio and 4 km directly east of the Chiquibul road. Two wild types were collected from the vicinity of the river at Barton Creek, however no descriptive data was recorded.

Three samples referred to as Arenal #1, #2 and #3 were collected here. This area is 16 km Southeast of San Ignacio at an altitude of 100 m.

The materials were transported by air from Belize on the 28th of March and arrived at the CRU Cocoa Quarantine Facility in Barbados on the 29th of March and were re-propagated by grafting.

COLLECTION EXPEDITION - PHASE II

The second phase of collection concentrated on the Toledo district in south-western Belize, a region in which knowledge about cocoa and its cultivation is more widespread. This was identified as having a high priority for collection (Anon, 1981). Several days were spent collecting anecdotal information from personal interviews with persons who frequent the forest such as Juan Cho, Cerillo Ikal, Lucio Sho and E.Chune and verifying the existence of wild types. This yielded several prospective sites: Aguacarte, Salamanca, Big Falls, San Antonio and Nim Li Punit (Figure 3).

The expedition began on the 9th of April and departed Punta Gorda for San Jose and Salamanca. One group consisting of Irideo Bolon (Ministry of Agriculture), Thomas Tzac (Guide) and Florencio Cowo (Porter) departed for Laguna, north of Jimmy Cut on the 9th of April. The remaining group of Kevin Moro and Perfecto Nal (both of the Belize Defence Force) and CRU personnel established a camp at Salamanca This group examined wild trees with Juan Cho, Cerillo Ikal and discussed a visit to other wild trees with Lucio Sho.

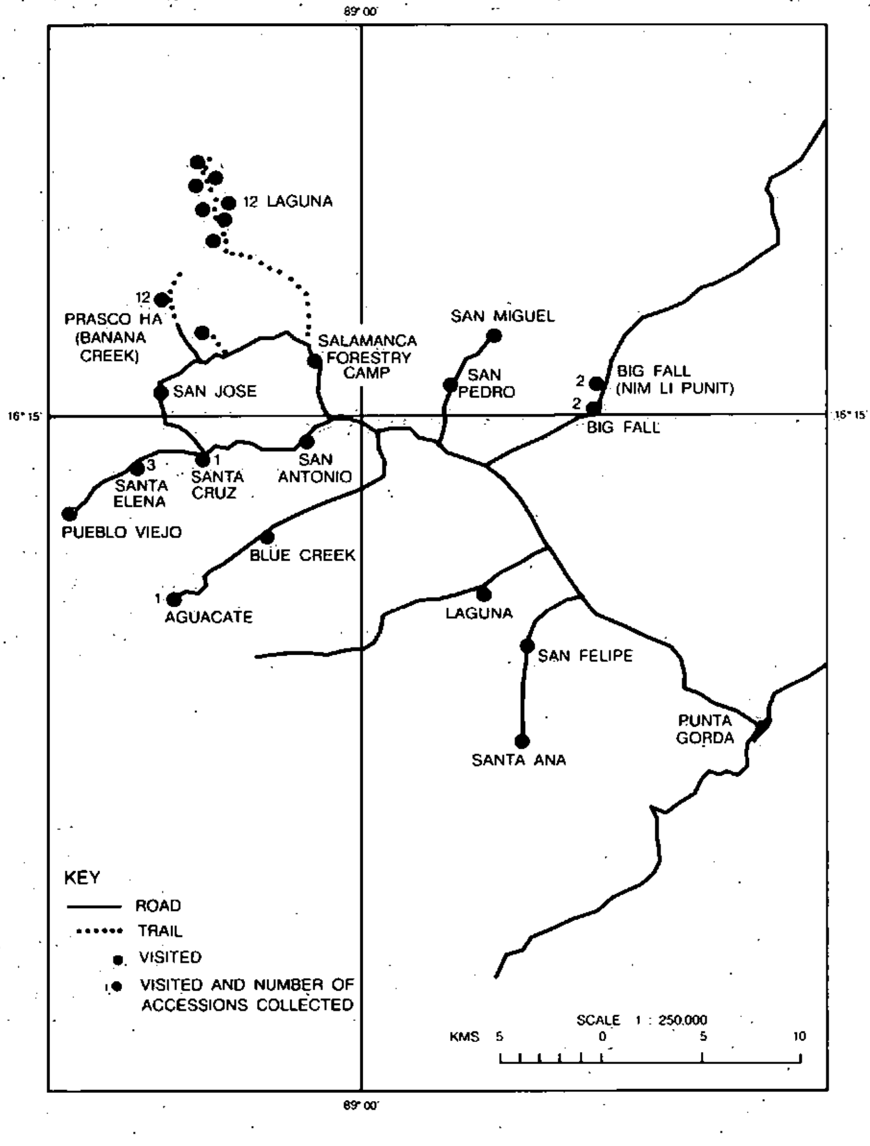
On the 10th of April, a small party (W.Maharaj, V.Mooleedhar and K.Moro) explored an area 3 km west of Salamanca with Lucio Sho and found a wild type. Later that day the group saw two wild types at Big Falls (Big Falls #1 and #2) and one at Nim Li Punit (Pedro Sam #1 and #2).

The following day, the 11th of April, a small group (V.Mooleedhar, P.Nal and E.Chune) prospected a steep gully area in Santa Cruz where one wild type was found and budwood collected. The others visited San Pedro and San Miguel expecting to find wild types but without success.

On the 12th of April, a collection party (V.Mooleedhar, W.Maharaj, K.Moro, P.Nal, T.Tezac and G.Tezac) prospected an area 5 km north of Jimmy Cut along the "new logging trail" in an area called Prasco Ha (Banana Creek). This area is within the Maya Mountains at an altitude of about 300 m. An extensive search covering a 4 sq. km area was carried out. Cocoa probably from a true "relic population" was found as a well established under-storey plant and fairly evenly distributed within the forest flora. Several different types (especially #5 and #6) were found and a population density study was carried out. The wild cocoa trees were generally very tall (15-25 m) with very large main stems. These trees appeared to be very old and could also represent a rejuvenated chupon of an even older original plant. It was very difficult to collect good quality vegetative material since the trees are not actively growing as they received so little light. Budwood was collected from eight types referred to as Banana Creek #1 to #8. Pods were collected from #1, #3, #4 and #8.

On the 14th of April, a party (I.Bolon, R.Tzac and F.Cowo) visited Laguna, 10 km Northeast of Salamanca. This area is well within the Maya Mountains at an altitude of 300-400 m and is typical tropical rainforest in mountainous terrain. Three distinct pod shapes were encountered. Again, the wild types were very tall with very large trunks. The canopy of these trees are very small and pods are borne high up on the trunks. Nine samples were collected on tributaries of the Rio Grande and were called Irideo Bolon #1 to #9 as shown in Table 2.

FIGURE 3: MAP OF THE TOLEDO DISTRICT SHOWING AREAS VISITED AND NUMBER OF ACCESSIONS COLLECTED IN PHASE II OF THIS EXPEDITION



On the 16th of April, V.Mooleedhar collected two wild types near to the Maya ruins at Nim Li Punit, 16 km east of San Antonio. One wild type was collected from the bank of the Big Falls river and material from an interesting tree in the pasture of Vicente Ack. On the same day, W.Maharaj and K.Moro collected wild material with Edward Chune about 1.5 km north of Santa Cruz on a tributary of the Rio Blanco. Again on the 16th of April, one sample of wild material was also collected from Aguacarte and three samples were collected with Elario Choc in Santa Elena which is 10 km west of San Antonio.

Materials from Phase II were taken from Belize on the 19th of April and arrived in Barbados on the 20th of April 1994. The material collected is listed in Table 1 and some characteristics by which the accessions might be known are shown in Table 2. After two years observation at the Barbados Quarantine Facility, the accessions will be re-propagated and established in the International Cocoa Genebank, Trinidad (ICG,T) which is designated by IPGRI (ex IBPGR) as a Primary Collection Depository (Anon, 1981; Anon, 1984). ICG,T is described by Kennedy and Mooleedhar (1993).

DISCUSSION

Factors Influencing Present Day Distribution of Relic Populations of Criollo

Several factors have contributed to the depletion of the wild Criollo population, which also account for the present day pattern of distribution of the trees in the wild. Amongst these factors are:-

i. **Natural Disasters:-** Belize lies within the "hurricane belt" of the Caribbean and has been regularly hit by these storms at least since records began in 1787. Twenty one hurricanes have hit the country in varying degrees of intensity. Two hurricanes (Hattie in 1961 and Greta in 1978) caused considerable damage. A direct consequence of hurricanes is the extensive damage to the forested areas, especially on mountain ridges and the prevailing slopes. The wild cocoa, as an under-storey plant, is particularly easily damaged by hurricanes, since strong winds would cause upper storey hardwood trees to fall over and damage the plants in the lower storeys.

ii. **Removal of Forest Trees (Logging):-** Logging in Belize started up around the 1700s. Trade for dyes and timber, became very important, with the Mahogany trade becoming the lifeblood of the country. The plundering of virgin forests has continued over a period of three hundred years and has had a significant effect on the forest structure. Wild cocoa trees are no longer found in areas where logging was concentrated because of (a) the indiscriminate destruction to under-storey trees in the operation of logging and (b) the inevitable changes to the micro-climate in heavily logged areas. The relic Criollo cocoa trees are sensitive to increased levels of sunlight and low humidity. Removal of the significant amounts of overhead shade and the resultant drier conditions causes dieback of the wild cocoa plants. This was observable at Nim Li Punit in Toledo.

iii. **Milpa Farming System:-** This traditional farming system uses the destructive "slash and burn" method of clearing forest for planting crops followed by shifting cultivation. When cleared areas become infertile, the farmers move on and this system has resulted in significant deforestation of large areas around rural villages. The only areas that remain unaffected by Milpa farming are those that have geographical barriers such as rivers and creeks or steep slopes and gullies. On a few occasions wild trees were found in inaccessible patches which were completely surrounded by areas subjected to Milpa. The Milpa system could well have been responsible for the destruction of many wild cocoa plants.

Criollo Populations

It is now evident that true relic Criollo cocoa populations still exist in the wild in Belize. These populations are relatively large, widely distributed in some ecological zones and are self-perpetuating as an under-storey forest species. One area of particularly high density is the south-western region of the Maya Mountains close to the Guatemalan border. It appears that these wild types are highly adapted to a very specific ecological zone. The typical environment is characterised by tall, dense, virgin forest with rich humic soil layer in upland areas of up to 500 m in altitude. These areas receive very heavy rainfall in the wet season.

The wild trees seem to be usually associated with Mayan ruins, probably because they were cultivated or looked after by these ancient civilisations. Wild cocoa is found on the ruins at Nim Li Punit and around Caracol and other areas known to be populated at one time by the Maya.

It is clear that there are further collecting opportunities to bring more of this genetic diversity into International Cocoa Genebanks.

EXPEDITION ORGANISATION

This collecting expedition which took place over a short time was successful and operated on a limited budget and so it is useful to outline the methodology that was employed. There is some preliminary work that must be completed before embarking on an actual collection trip. In particular a thorough familiarisation with the geographical aspects of the country such as climate (rainfall pattern and temperature), relief (soil types, mountains, rivers etc.), vegetation (forest, virgin forest, secondary forest), road (main roads, secondary road, trails, paths etc.) and alternative air routes (airline, schedules, stopovers etc.) is necessary. In addition in the case of Belize, it is clearly useful to know on the locations of Mayan ruins and understand something of the historical background to the country (Anon, 1983; Anon, 1992; Mallan, 1993).

Collection of information on cocoa involved personal interviews with village elders who are familiar with the forests and even the wild cocoa plant. Families have usually occupied or lived in a particular village for several generations. The personal interview is intended to locate wild cocoa, ideally to find out the exact location according to landmarks, distance, caves, rivers etc. Information on morphological features of such plants (such as pod shape, colour and colour of cut beans) helps to verify their identity.

The discovery of wild cocoa is always exciting, but doubly so when one collects samples either vegetatively or by seed and have them successfully re-propagated in a safe environment such as a quarantine station. Determining the maximum number of days vegetative material of the age and quality available can potentially be kept and still have a good chance of successful re-propagation is imprecise, but essential. The number of days between collection and re-propagation depends on the technique of preservation and quality of budwood collected. Long-term preservation (5-8 days) requires methods that minimise sap loss, such as careful waxing of cut ends, preventing moisture loss by wrapping in moist tissue and sealing in polythene bags. An inspection of stored vegetative material is required at two-day intervals to monitor moisture levels and sap loss. The amount of moisture needed for budsticks to remain 6-8 days in storage is an intuitive decision based on experience of collecting/transferring/ re-propagation of cocoa vegetative material. Too little moisture leads to drying out of budsticks and too much moisture causes budsticks to rot. As soon as materials were collected, they were properly prepared for storage for 6-8 days. Essential materials were carried to ensure this was possible and could be completed in a timely manner. These included: wax, labels, fungicide, insecticide, tissue, polythene bags etc. The budsticks were re-packed after 7-8 days storage to ensure a good chance of survival. They appeared fresh and the buds were still viable. All vegetative material was "wedge" grafted onto seedling rootstock.

The prospection for cocoa germplasm and subsequent transfer from the country of origin (in this case Belize) to a quarantine station must conform to local and international regulations. In Belize, a permit is required from the Forestry Department to enter Forest reserves in order to collect germplasm and the types and quantities collected must be declared. To introduce the cocoa germplasm into Barbados for quarantine purposes at the CRU, Cocoa Quarantine Facility in Barbados, an import permit from the Ministry of Agriculture, Barbados is required and the germplasm must be accompanied by a phytosanitary certificate from the country of origin (ie Belize in this case). Since the import of *Theobroma* species into the United States is strictly prohibited and import permits are not issued to non-residents, the USDA Plant Quarantine Services in Miami were informed in advance that cocoa germplasm was being transferred from Belize to Barbados via Miami, USA but was merely in transit. It was necessary to make arrangements for these matters well in advance to ensure the smooth transfer of collected germplasm.

It is of great importance that full passport data (Anon, 1981; Anon, 1984; Allen and Lass, 1983) should be recorded in the field at the time of collection in order to provide essential information to breeders several decades into the future. Examples of the complete passport data sheets for a sample accession is shown in Tables 3 and 4. Copies of these sheets will be retained at CRU and in the Ministry of Agriculture, Belize. In due course, relevant data will be forwarded to the International Cocoa Germplasm Database.

CONCLUSION

The collection mission was successful both in locating areas where wild Criollo plants still exist in Belize and in collecting genetic material from these plants. It is now apparent that the Criollo plants are widely distributed in some zones, particularly in the eastern slopes of the Maya Mountains and an effort to examine the extent of the distribution and genetic variability of these Criollo in the wild would be of considerable value.

TABLE 3: AN EXAMPLE OF DATA RECORDING FORM (FRONT): SITE AND TREE CHARACTERS

COCOA RESEARCH UNIT : COLLECTING EXPEDITION, BELIZE (MAR/APR 1994)				**(1.1) PREFIX**	*BLZ Banana Creek*	**No.**	*# 3*
(1.2) DATE	**DAY** *13*	**MT** *4*	**YR** *94*	**(1.3) COLLECTOR**	*V.Mooleedhar & W.Maharaj*		
(1.4) MATERIAL COLLECTED		**PODS**	*(2)*	**FLOWERS**		**BUD STICKS**	
(2.1) LOCATION	*Prasco Ha Area :*	*6km North West off Jimmy Cut along new logging trail*	**(2.2)**	**ALTITUDE (m)**		*400*	
			(2.3)	**LAT.**	*16°17'*	**LONG.**	*89°06'*
(2.4) PROPERTY ETC.			*Primary Forest*				
(3.1) TOPOGRAPHY			*Flat*				
(3.2) HUMIDITY							
(3.3) VEGETATION/LAND USE			*Forest Reserve*				
(3.4) ADJACENT COCOA			**CULTIVATED**			**WILD**	
(4.1) TREE HABIT/CONDITION			*Single Trunk*				
(4.2) HEIGHT (m)			*15*	**CANOPY DIAMETER**			*5.5*
(4.3) TRUNK GIRTH (cm)		**BASE**	*48*	**at 1.5m**			*38*
(4.4) WITCHES BROOM INFECTION		**NIL**		**LOW**		**HIGH**	
(4.5) BLACK POD		**NIL**		**LOW**		**HIGH**	
(4.6) OTHER DISEASE/PEST REACTION							
(4.7) SHADE		**ABSENT**		**LIGHT**		**DENSE**	
(4.8) FLOWERS		**ABSENT**		**FEW**		**NUMEROUS**	
(4.9) PODS		**ABSENT**		**FEW**		**NUMEROUS**	
(4.10) FLUSHING				**ABSENT**		**PRESENT**	
(4.11) FLUSH PIGMENTATION		**ABSENT**		**LIGHT**		**DARK**	
(5.1) OTHER OBSERVATIONS *Branching at 8m next to very large tree*							

TABLE 4: AN EXAMPLE OF DATA RECORDING FORM (BACK): POD AND SEED CHARACTERS

PODS	SAMPLE	1	2	3	4	5	MEAN
(6.1) LENGTH (mm)		*13.5*	*11.6*				*12.6*
(6.2) DIAMETER (mm)		*7.5*	*6.6.*				*7.1*
(6.3) RATIO L/D		*1.8*	*1.76*				*1.78*
(6.4) HUSK THICKNESS (mm)		*13*	*10*				*11.5*
(6.5) TOTAL POD (g)		*290*	*185*				*238*
(6.6) WET WEIGHT SEEDS (g)		*65*	*50*				*57.5*
(6.7) HUSK WEIGHT (g)		*220*	*130*				*175*
(6.8) NO. OF SEEDS		*28*	*30+1*				*29*

(6.9) BASAL CONSTRICTION	NIL		MEDIUM		SEVERE	
(6.10) APEX FORM	ROUNDED		POINTED		VERY POINTED	
(6.11) RUGOSITY	SMOOTH		ROUGH		VERY ROUGH	
(6.12) FURROW DEPTH	SHALLOW		MEDIUM		DEEP	
(6.13) PIGMENTATION	ABSENT		WHITE	R F	PIGMENT	R F
(6.14) SHAPE	ROUND L/D<1.5		OVAL L/D 1,5-3,0		LONG L/D>3.0	
(6.15) POD TYPE	CUNDEAMOR ALEMONADO		ANGOLETA CALABACILLO		OTHER	

(6.16) DISEASE/PEST

(6.17) OTHER OBSERVATIONS

SEEDS	1	2	3	4	5	6	7	8	9	10	MEAN
(7.1) LENGTH (mm)	*19*	*22*	*24*	*22*	*22*	*21*	*23*	*23*	*20*	*21*	*21.7*
(7.2) WIDTH (mm)	*14*	*14*	*16*	*15*	*16*	*15*	*14*	*14*	*14*	*13*	*14.5*
(7.3) THICKNESS (mm)	*12*	*9*	*8*	*9*	*8*	*9*	*10*	*9*	*12*	*11*	*9.7*

(7.4) WEIGHT WITHOUT PULP AND TESTA (g)

(7.5) PIGMENTATION *Cream Mottled with Grey*	LIGHT PURPLE	*100%*	MEDIUM PURPLE DARK PURPLE	

(8.1) DISCRIMINATING OBSERVATIONS
Leaves

(9.1) DISCRIMINATING OBSERVATIONS
Flowers

(10.1) OTHER OBSERVATIONS

It is clear that there were other areas in Belize where "relic populations" of Criollo plants could also be found. Some of these areas are Caracol, Corozal and Aguacarte. There are reports that along the Rio Mondo, there are raised fields which were planted with cocoa by the Mayans. The collection of germplasm from these areas should also be carried out.

It is recommended that the Government of Belize should encourage local collection to conserve this important genetic resource and identify specific location(s) for the in situ preservation of the relic Criollo populations. In situ conservation in Nature Reserves or National Parks is a viable method in appropriate circumstances.

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COMPARATIVE OBSERVATIONS ON CONTROL OF SOME PESTS AND DISEASES OF COCOA COMMON TO INDONESIA, MALAYSIA AND PAPUA NEW GUINEA

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INTRODUCTION

In September 1992, three Pathologists and one Entomologist from the Cocoa and Coconut Research Institute (CCRI) of Papua New Guinea (PNG) visited cocoa plantations and research centres in Indonesia and Malaysia (Table 1). The aim of the visit was to compare strategies for controlling or preventing pests and diseases common to Indonesia, Malaysia and PNG. This report does not attempt to document every aspect of cocoa cultivation seen during the visit, nor is it an attempt to assess the condition of individual plantations. The report highlights strategies used to control pests and diseases observed during the visit and contrasts these with methods used in PNG.

It must be emphasised that the views expressed are based on a very brief visit to these two countries and so our observations maybe incomplete and so some erroneous statements may have resulted. However, the cocoa industry in all three countries is under similar pressure to reduce costs against a similar background of losses caused by pests and diseases and their control. If this paper encourages further dialogue and exchange of information, it will have served its purpose.

It is anticipated that some of the plantations visited have removed substantial areas of cocoa since our visit due to economic pressures, but the observations remain relevant.

PATHOLOGY

Vascular Streak Dieback (VSD)

VSD continues to be of concern to all three countries, with severe damage still occurring from time to time. At present there are no cost-effective chemicals for controlling VSD so far indicated. This has put considerable pressure on scientists to develop alternative strategies to control VSD, and results to date are very encouraging. So much so, that cocoa can now be grown in areas previously considered to have too high a disease incidence and the techniques developed do not require the use of chemicals.

One of the most striking sights during the visit to Malaysia was the severe damage caused by VSD, although it should be noted that the group specifically requested to see the worst VSD areas in the country. The symptoms of VSD were different to those found in PNG, although this has not

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been reported before. The VSD in Malaysia showed far more necrosis than is seen in PNG. Completely necrotic leaves remained attached to the branches, whereas in PNG, leaves fall prematurely with only limited necrosis, if any at all. Furthermore, the characteristic yellowing of leaves with green spots was not as obvious in Malaysia as it is in PNG.

TABLE 1: LOCATION OF PLACES VISITED, MEAN ANNUAL RAINFALL AND MEAN ANNUAL NUMBER OF RAINY DAYS FROM 1988 TO 1991

Places Visited	Rainfall (mm)	Rainy Days
Rambong Sialang (Lonsum), Sumatra, Indonesia	1,539	121
Bah Lias (Lonsum), Sumatra, Indonesia	1,837	132
MARDI, Hilir Perak, Peninsular Malaysia	1,864	n/a
United Plantations, Hilir Perak, Peninsular Malaysia	n/a	n/a
Blenheim & Perak River Estates, Hilir Perak, Peninsular Malaysia	n/a	n/a
Smallholder Plot, Hilir Perak, Peninsular Malaysia	n/a	n/a
Sabak Bernam (Guthrie), Peninsular Malaysia	2,079	92
Merlimau (Sime Darby), Malacca, Peninsular Malaysia	1,871	123
Jasin Lalang (IOI), Malacca, Peninsular Malaysia	1,715	126
BAL Plantations, Tawau, Sabah, Malaysia	2,654	182
Quoin Hill, Tawau, Sabah, Malaysia	n/a	n/a
Ladang Sabah, Sandakan, Sabah, Malaysia	3,240	189
CCRI, Keravat, Papua New Guinea	2,612	247

These symptoms as described above for Malaysia were even seen on Keravat material growing in Malaysia, so the variations are unlikely to be due to cocoa genotype. The difference in symptoms and behaviour of the pathogen in culture (Dennis, 1991) provide evidence that Malaysia may have a different strain of the pathogen, and therefore strict quarantine measures must remain in force for the importation of new cocoa planting material into both Malaysia and PNG. We were fortunate enough to see Keravat clones growing in several high VSD areas in Malaysia. In general the material was extremely healthy, with KA2-101 showing almost no VSD infection at all. K82 was also performing very well in high VSD areas. Sadly, PNG growers are so far reluctant to grow clones, preferring instead the more convenient growth habit of the hybrid seedling.

Nurseries which prevent VSD infection in developing plants were seen in commercial use in two locations in Malaysia, at Blenheim and BAL Estate. These facilities consist of a plastic covering over the nursery which is extremely effective in preventing VSD infection. Although this was first proposed and published in PNG in 1967 (Anon, 1967), it has only been recommended as a practical technique in recent years (Sidhu, 1987; Anon, 1991a; Keane and Prior, 1991; Dennis and Keane, 1992) and consequently this technique of VSD prevention has never been adopted in PNG. It is cost-effective, simple, 'environmentally friendly' and it works, but despite this the quest for chemical control continues in some countries. The plastic covering achieves results by excluding rain and reducing dew formation, thus minimising the occurrence of conditions suitable for infection of the susceptible flush leaves (Keane et al., 1972). A reinforced woven plastic cover (Sarlon - Solargro) was in use at Blenheim Estates to eliminate problems of the sheets tearing during high winds and also to extend the life of the plastic sheets. The principal of covering the flush leaves has also been used in the field at CCRI and at Quoin Hill, particularly to assist with establishment of infills. Small umbrellas have been used over the seedlings in the field to prevent VSD infection, and although effective, high costs restrict their use by farmers.

During the two week visit only one of the plantations visited, Blenheim Estates, routinely carried out pruning rounds solely for VSD. No other growers deliberately prune just for VSD control and no growers follow the PNG recommendation of splitting branches open to reveal the extent of infection and cutting branches 30 cm below the end of the visible streaking (Prior, 1980; Anon, 1991a). This is due to the substantial cost and also because in many cases they would be pruning every single branch, if the recommendation was followed precisely. Instead severely damaged branches tend to be pruned during a normal canopy pruning round. A similar situation exists in PNG but this tends to increase the number of infections and may prove to be deleterious to yield after many years or during periods of stress.

By far the most successful strategy of control has been the selection of VSD tolerant clones. It is accepted that the ability of a tree to tolerate infection is vital especially in light of the lack of pruning. Previous selection criteria in PNG concentrated on recording the number of infections, removing infections every 2 weeks and recording the extent of streaking (Tan & Tan, 1988). Unfortunately, this meant that tolerance was never tested and that the result of not pruning infections regularly on individual genotypes was never assessed. In Malaysia the importance of selecting for tolerance has been realised but devising a truly adequate measure remains a challenge, although it has been discovered that vigour is an important component of tolerance (Tan & Tan, 1988; Dennis, 1991; Dennis & Keane, 1992). Results in the field are spectacular and clearly this is the best direction for research to take. It was interesting to note that in Malaysia, VSD tolerant clones were being selected by individual plantations rather than relying on one central organisation to screen all material, as is the case in PNG. Thus, in Malaysia, plantations had locally selected material as well as introduced material, but it was sometimes observed that a clone that was rated as VSD tolerant in one place was actually rejected in another because of poor performance. PNG could do well to follow the Malaysian example and encourage local selection of superior clones rather than attempting to screen material for all environments, which would be prohibitively expensive.

Although it is well established that tolerance to VSD can be enhanced by management practices (Dennis & Keane, 1992), there was little evidence of this at many of the places visited where in which VSD damage was severe. The level of shade was often very low compared to PNG conditions. We visited during the dry season when the shade was light and this undoubtedly added to the stress of the cocoa and may in part explain the severe damage seen at nearly all locations. In fact, our first impressions of the damage was that it really was not VSD damage at all, but insulation damage due to inadequate shade. However, closer examination at each site confirmed that it was VSD damage. This under-shading combined with a prolonged dry season and poor soils may account for some of the damage observed, particularly in Peninsular Malaysia. While light shade is recommended in PNG (Dennis & Keane, 1992) it must be remembered that most cocoa growing areas of Malaysia have lower rainfall and lower number of rainy days then PNG (Table 1), so water stress is likely to be less severe and not exist for shorter periods in PNG. Furthermore, in PNG, soils are generally fertile and most cocoa is, if anything, over shaded.

In many locations in Malaysia, the VSD problem was being tackled with the aid of mature field budding. Highly VSD tolerant clones were selected locally and bud wood or bud patches grafted onto mature cocoa in the field. Results of this technique were spectacular, particularly on the smallholder block we visited. The emphasis was, however, on selection of local clones for bud wood. This ensures that the budding is suited to the local conditions, both pathological and environmental. This material was also used for infilling rather than attempting to protect infills with chemicals which are expensive to apply and only partially effective.

Phytophthora pod rot

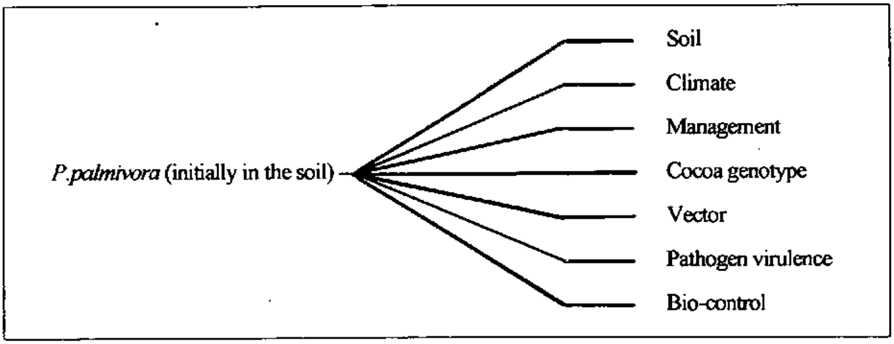
Phytophthora pod rot is currently the most important yield-limiting factor in the PNG cocoa industry, with total annual losses estimated at up to 40% of the nation's crop (Anon, 1992). However, seasonal losses can easily be as high as 100% on susceptible clones during unfavourable climatic periods. These losses can be financially crippling in a year of high incidence and while chemicals are widely used by plantations they are at best only partially effective, and often do not work at all. Smallholders, who produce over half of PNG's export cocoa, tend not to use fungicides.

A main aim of the visit was to see how Malaysian and Indonesia growers cope with *Phytophthora* pod rot, but at no location we visited was there a problem comparable to the one seen by many growers in PNG. The challenge is to confirm why there was no *Phytophthora* pod rot problem and whether the answer can provide a solution to PNG's current crippling losses from this disease. There are many factors which may explain the absence of a severe problem at the places visited (Table 2).

Soils:- Cocoa is grown on a range of soils in both PNG and Malaysia, and the importance of soil type could not be determined from this visit. However, it is known that certain soils can suppress pathogens. For example, *P.palmivora* root rot of pawpaws can be controlled by the addition of suppressive soils to the planting holes (Agrios, 1988). *P.palmivora* was definitely present in the soil as evidenced by finding seedling blight in the nurseries at BAL Estates and Perak River Estates, but whether the populations are suppressed is unknown.

Climate:- Places with a range of different weather patterns were visited (Table 1), but it is interesting to note that CCRI had the highest average number of rainy days per year. This is undoubtedly important for promoting sporulation and thus more inoculum would be available for dispersal over a longer period of time. Even the wettest place visited, Ladang Sabah, reported annual losses of only 5 to 10% without use of any fungicides. Such low losses would be more than acceptable to PNG farmers. However, many other countries have high *Phytophthora* pod rot losses under climates far drier than Malaysia and with similar rainfall distributions, ie. a distinct wet and dry season (Lass, 1985). In Malaysia conditions were wet enough for VSD to spread which requires very prolonged wet conditions (Keane, 1981) compared to *Phytophthora* pod rot spread which can occur in as little as 48 hours after infection (Thorold, 1972).

TABLE 2: SEVEN IMPORTANT FACTORS INVOLVED IN PHYTOPHTHORA POD ROT DISEASE EPIDEMIOLOGY



Management:- Practices in Malaysia were generally more favourable to preventing spread of *Phytophthora* pod rot than in PNG, but even the best managed cocoa in PNG can still have problems with this pathogen. In Malaysia, shade was generally much lighter than in PNG, but the cocoa canopies were very similar. Harvesting techniques and harvest frequency were the same as PNG. As in PNG pod husks were left on the ground at most places visited and it is known from work at CCRI that these pod husks can become infected on the ground and act as sources of inoculum. No fungicides were used for *Phytophthora* pod rot control in Malaysia except at Ladang Sabah where a spray programme has only recently been budgeted for.

Cocoa Genotypes:- These differ between Malaysia and PNG, and this may be a very important factor for *Phytophthora* pod rot control. Malaysian cocoa is largely of Amazonian x Amazonian hybrids or Amazonian clones. Whereas in PNG the cocoa is largely Trinitario x Amazonian hybrids. We visited places in Malaysia with Keravat clones that are highly susceptible to *Phytophthora* pod rot, such as KA2-101 and KA5-201, and one clone K24-106 which is extremely susceptible, but there was no sign of a *Phytophthora* pod rot problem on these clones similar to that seen at CCRI. It is interesting to note that screening for *Phytophthora* pod rot resistance was never a priority at the places visited. The

Amazonian material may have a strong *Phytophthora* pod rot resistance or factors other than cocoa genotype may be important in preventing *Phytophthora* pod rot.

Vectors:- We did find *Phytophthora* pod rot in several places and it was interesting to note that when we did, it was always associated with the two insect groups - tent building ants and Scolytid beetles, suspected of being vectors of *Phytophthora* pod rot in PNG. Scolytid beetles were implicated by Prior (1984) in canker development. Their involvement in the spreading of *P.palmivora* both on the tree and on the ground, where they are found infesting diseased pods in large numbers in PNG, is currently under investigation. McGregor and Moxon (1985) identified tent building ants as being vectors of *P.palmivora* by incorporating viable propagules in their tent building materials. These are currently under investigation at CCRI. Whether or not these potentially important vectors are widespread and occur in large numbers in Malaysia could not be determined during this visit.

Pathogen Virulence:- It is not known whether the same strain of *P.palmivora* is present in both Malaysia and PNG. It is possible that Malaysia has a less virulent strain, however there has been considerable selection pressure for virulence for many decades, and it would be unlikely that a strain with low virulence would remain the dominant population for such a long period of time. Strain differences are now being investigated, but if the strains are different it raises the question of how the population has remained stable over time under such huge selection pressure.

Biological Control:- It is possible that a naturally occurring biological control system exists in Malaysia, such as the one described in Costa Rica (Galindo, 1992). In this case, an epiphytic bacteria was isolated from healthy pods from a tree in an area with a high level of *Phytophthora* pod rot. In a preliminary trial, spraying the bacteria onto pods gave better protection than copper fungicide sprays. The bacteria is antagonistic to the development of *P.palmivora* and occurs naturally in Costa Rica. In particular, one block at BAL Estates would be worthy of further investigation. The block was behind the main nursery and was irrigated, and removal of the leaf litter revealed saturated conditions. Some pods were even developing into the soil layer and yet were not infected. Conditions were ideal for *Phytophthora* pod rot, and in PNG even the most resistant genotypes would be unlikely to remain uninfected in these conditions. A naturally occurring biological control system would certainly explain the absence of a severe *Phytophthora* pod rot problem.

ENTOMOLOGY

Mirid damage to cocoa in Papua New Guinea is found in nearly every area of the mainland and islands although the distribution of genera and species is restricted and localised. *Helopeltis clavifer* is probably the most widespread and damaging species on the mainland, while three species of *Pseudodoniella laensis* on the mainland and *P.typica* and *P.pacifica* occur on the islands. Past and current mirid control measures are mainly chemical with very few practical examples of effective biological control although it has been known for some years that the `crazy' ant *Anoplolepis longipes* was effective against mirids and the coreid bug *Amblypelta* (Room & Smith, 1975). Generally the effort to establish *Anoplolepis* was found to be 'too difficult in PNG' for large plantations unless they were fortunate to have this ant naturally established in their cocoa blocks. Nevertheless, there is hardly a single plantation in PNG that has been able to maintain a sufficiently dense population of ants to adequately protect their cocoa from mirids.

It was of considerable interest to observe large-scale commercial developments in both Indonesia (Bah Lias Estate) and Malaysia (Sabak Bernam, Kumpulan Guthrie) using the black ant *Dolichoderus thoracius* principally against the mirid *Helopeltis clavifer*. Entwistle (1972) comments that this ant was deliberately used to protect cocoa against mirids as early as 1908.

The success of the current use of *D.thoracius* against mirids in both Indonesia and Malaysia is spectacular and even though its taken nearly 100 years to prove that, with sufficient effort, very large cocoa developments (2,500ha) can be protected against mirid attack and with almost no running costs once the ant is properly established. Establishment costs for the ant of approximately M68* dollars (Malaysian) per hectare are to be compared with M50** dollars per annum per hectare for insecticide control of mirids. No significant negative effects of *Dolichoderus* were reported in either country. Unfortunately, the black ant *Dolichoderus* does not appear to be recorded in PNG but further study is clearly merited. In parts of Peninsular Malaysia, there is considerable interest in establishing *Dolichoderus* because it may also be effective against the cocoa pod borer (CPB) *Conopomorpha cramerella* (Snell).

The cocoa industry in Malaysia is suffering severely under the current low cocoa prices but the damage and losses incurred by *Conopomorpha* have further crippled the industry. In PNG, a single collection exists of a specimen identical to CPB recorded on Nam-nam in the 1930s, but from that date no further specimens of this insect have been recorded. The crop loss plus cost of chemical and cultural control methods now practised in Malaysia (approximately 40% of total production costs) would bankrupt the plantation industry in PNG and seriously affect the small farmers who produce the majority of the cocoa in PNG. It was disappointing to learn that after a very large investment in CPB control from both commercial and government agencies, effective biological control systems (via parasitoids and pheromones) are proving difficult to implement because of the current low cocoa price. The effort the Malaysian cocoa industry has put into biological control of CPB is commensurate with the size and value of their industry. The testing of equipment and pesticides on BAL Plantations resulted in reduced spraying costs and doubled the area treated per-man-day (Lay and Shah, 1991).

Weed control in young and light or unshaded cocoa results in the elimination of some beneficial weed species which sustain micro-hymenopteran parasitoids in the field. This practice in PNG's cocoa and in Malaysia and Indonesia makes the establishment of parasitoids difficult and environmental improvement within and around the cocoa blocks should assist in establishing biological control agents.

As an example, in PNG's oil palm developments they enjoy an almost unique situation where small herbaceous beneficial weed species are encouraged to grow along road sides and harvesting paths to provide essential nectar to enable a range of parasitoids to be self-sustaining. Not a single hectare of PNG's 70,000 hectares of oil palm has been sprayed against a range of pests common to oil palm

* $M68 = $US27.

** $M50 = $US20.

developments throughout the region, including Malaysia. If biological control is to be an effective tool against a pest with the population density of the CPB, then it probably requires a self sustaining system, as in the use of the black ant against mirids.

It is hoped that the black ant, where well established, may reduce cocoa pod borer damage to below economic threshold. If it does not the regular spraying against CPB will affect the black ants chief source of food - mealybugs, and induce resistance in the mirid population.

Another interesting aspect of pesticide use against cocoa pod borer in Malaysia was the apparently neutral affect on cocoa pollination. If commercial cocoa relies on the midges (Ceratopogonidae) in Malaysia, then a similar situation exists in PNG as reviewed by Entwistle (1972), namely that insecticides often do not appear to adversely affect pollination.

However, it is difficult to imagine how insect pollinators could escape the spraying of cocoa with a tractor mounted mistblower, observed in action on one plantation. Similarly, other plantations sprayed all piles of broken pods which in areas infected with cocoa pod borer were brought to the roadside. Another plantation had for many years removed all cocoa pods for breaking in a central location and only after grinding the pod husks are they returned to the plantation. This practice left no suitable site for midge breeding in what was anyway a relatively dry area. These observations pose two questions - how important is insect pollination in commercial stands of cocoa and what degree of self incompatibility actually exists in the plantation?

The coconut rhinoceros beetles and black palm weevils, are of major importance to cocoa growers in PNG as the majority of cocoa grown in PNG is under permanent shade of coconut. A range of hybrid coconuts was introduced to PNG in 1975 but were immediately attacked on trial plots by rhinoceros beetles. In trials recorded by CCRI (Anon, 1990; Anon, 1991b), mortality in hybrid coconuts was as high as 80% after 15 years with losses of 20% to 30% in the first three years. Some local tall varieties in the same trials were equally affected.

The situation in PNG is further complicated by the occurrence of two species of rhinoceros beetles. *Scapanes australis* occurs throughout the mainland and islands with four sub-species extending into the Solomon Islands. *Oryctes rhinoceros* invaded PNG in 1942 (Catley, 1969), but has remained on a few off-shore islands and on half of New Britain island and it has never been recorded on the mainland of PNG.

In the examination of hundreds of dead or dying hybrid coconuts, it was discovered that in nearly every case death of the coconut was caused by secondary invasion by the PNG black palm weevil, *Rhyncophorus bilineatus*. In East New Britain, where both Scapanes and *Oryctes* occur together, they damage hybrid coconuts in almost equal proportions.

In Indonesia and Malaysia, although a very high percentage - sometimes in excess of 80% of the coconuts showed obvious *Oryctes rhinoceros* damage symptoms to the crowns, hardly any dead or dying coconuts were seen during the visit. The source of *Oryctes* in both countries was usually from neighbouring oil palm developments - *Oryctes* breeding in oil palms dying of *Ganoderma* or in empty fruit bunches and other piles of organic material in the oil palm plantations.

Plantations in Malaysia and Indonesia recognised the importance of the black palm weevil, *Rhyncophorus schach* which breeds preferentially in damaged coconuts, but will breed in felled or poisoned oil palms (Wood, 1968). According to Wood (1968), *R.schach* is not often found in *Oryctes* damaged oil palms unless it is very heavily damaged This is also an interesting comparison with PNG where only one record exists of *R.bilineatus* larvae in oil palm, which was in an area of massive damage following the removal of crown tissue for tissue culture at Dami Oil Palm Research Station.

It is standard practice to remove any dead or dying coconuts from whatever cause and to render them unusable by *Rhyncophorus* and this is thoroughly carried out in both Indonesia and Malaysia. Several estates said that they only had local problems with *Rhyncophorus* where the estate bordered village developments. This aspect of cultural control has not been effectively addressed in PNG, but it will have to follow the Malaysian and Indonesian example, before PNG can proceed with hybrid coconut programmes. In areas of PNG with Sago Palm (*Metroxylon sagu*), it is unlikely that control of *Rhyncophorus* would ever be possible.

The very severe damage by *Oryctes rhinoceros* on coconuts, observed in both Indonesia and Malaysia prompts the question as to whether the baculovirus originally from Malaysia, that is still working so successfully in PNG against *Oryctes* is still as virulent in these countries. Entwistle (pers. comm.) has suggested that every 5 to 10 years, a new strain of baculovirus ought to be introduced if *Oryctes* damage levels are observed to increase.

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ROSELLINIA IN COCOA

S.Cadavid*

INTRODUCTION

Root decay caused by species of the fungus *Rosellinia* spp. constitutes one of the more serious problems that threatens the production of cocoa in Colombia. This fungus is apparently present naturally in the soil, being found in all the cocoa areas of the country. The disease is generally found in small patches, finally causing the death of the greater part of the trees in the plantation. Only the most resistant individuals survive. The problem is not new. Duque (1952) notes that it was present in 1931 in cocoa, coffee and shade trees in the departments of Antioquia, Caldas, Cundinamarca, Santander and on the Cauca Valley. In these regions it is known by the names of "Llaga negra" (black wound), "Llaga estrellada" (shattered or starred wound), podredumbre negra (black rot), Lamparon (grease-spot), and also as *Rosellinia* spp. (In this text this last common name is used to refer to the disease, as *Rosellinia* spp. is the pathogen).

The information available on the recognition and possible control methods for *Rosellinia* spp. is minimal. In Colombia, the only published research was carried out on coffee during the 1960s. The present article it is intended to draw attention to *Rosellinia* spp. in cocoa by a literature review and the results of preliminary investigations carried out by ICA in Manizales, at the Luker farm and at the La Margarita estate (Palestina-Caldas). Our purpose is not to alarm cocoa growers, but to explain the situation to help them to avoid and control the pathogen. The more that is known of the enemy, the greater will be the possibility of success in combating it.

IMPORTANCE

Very few cocoa trees, once infected by *Rosellinia* spp. are able to survive. The pathogen propagates itself principally by contact between roots of diseased and healthy trees. The dead trees form patches which grow larger as the production of inoculum increases (Figure 1). The roots or stumps of shade trees are the site of the original focus of the disease. The pathogen multiplies in the soil in all sorts of organic residues (Figure 2).

Rosellinia spp. can seriously affect a cocoa plantation. A count carried out at the La Margarita estate in February 1987 (at 1300 m.s.n.m.) is shown in Table 1. The seven-year-old planting occupies an approximate area of 15 hectares with 13 foci of trees killed by *Rosellinia* and other pathogens. In some of the foci less than a half of the initial population has survived.

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TABLE 1: NUMBER OF FOCI AND NUMBER OF COCOA TREES AFFECTED BY *ROSELLINIA* SPP. AND OTHER DISEASES OF THE TRUNK AT LA MARGARITA (PALESTINA-CALDAS, MAY 1987) (i)

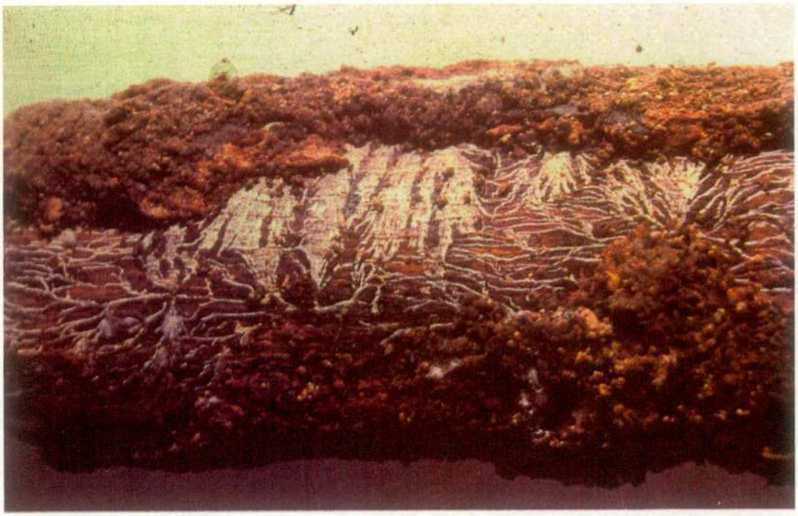
Lot No.	Total Number of Trees (ii)	Number of Foci	Total	Number of Trees in the Foci: Rosellinia	Number of Trees in the Foci: Other Diseases (iii)
1	8,520	6	1,161	372	8
2	6,350	5	364	141	8
3	3,897	1	175	43	3
4	6,480	1	184	21	8
Total	**25,247**	**13**	**1,884**	**577**	**27**

(i) Cocoa was planted without shade at 2 x 2 m in 1980;
(ii) Number of trees in December 1985;
(iii) "Mal de Machete, Cancer del tronco, Mal rosado".

FIGURE 1: PATCH CAUSED BY *ROSELLINIA PEPO*. IN THE BACKGROUND A TREE WITH ADVANCED SYMPTOMS

FIGURE 2: MYCELIAL GROWTH OF *ROSELLINIA PEPO* ON THE SOIL SURFACE

FIGURE 3: FAN AND STAR FORMS OF *ROSELLINIA PEPO* UNDER THE BARK OF A COCOA STEM



To determine the total number of trees infected with *Rosellinia* spp. shown in Table 1, checks were carried out on randomly selected roots with a radius of 20 cm around the collar of each tree. The total number of trees in each focus ranges between 34 and 475. In the largest focus, the pathogen was found in 30% of the sample. As not all the root system was examined, it is very likely that the number of trees in each focus affected by the disease is greater than that registered in Table 1. At La Margarita during 1986, 182 trees died from *Rosellinia* spp. From the number and location of the foci it is very likely that the disease had originated from the infected roots of the coffee plantation which was there before the cocoa was established.

Waterston (1941) mentions the following three species of *Rosellinia* spp. as causes of infections in cocoa: *R.bunodes* B. et Br., *R.pepo* Pat. and *R.paraguayensis* Starb. The first two are the more virulent and aggressive. Under cultivated conditions *R.pepo* mainly attacks cocoa and *R.bunodes* attacks coffee. However, both species can affect the same plant at the same time.

HOSTS

In general *R.pepo* has a more restricted range of hosts and distribution than *R.bunodes*. In addition to cocoa and coffee, the following species are mentioned as susceptible to *R.pepo*:-

Persea gratissima, Gaertnner	*(Aguacate)*	Avocado
Artocarpus communis Forst	*(Arbol del pan)*	Breadfruit
Erythrina spp	*(Bucaros o pisamos)*	Various Names
Inga spp	*(Guamos)*	Various Names
Myristica fragrans Moutt	*(Nuez moscada)*	–
Citrus aurantifolia	*(Lima)*	Lime
Afanus indicus Spreng	*(Guandul)*	–
Cassia fistula L.	*(Canafistula)*	Cassia
Cannavallia gladiata Dc.	*(Frijol canavalia)*	–
Musa sapientum L.O. Kze.	*(Banano)*	Banana
Manihot utilissima Pohl	*(Yuca)*	Yuca
Hymenaea courbaril L.	*(Algarrobo)*	–

PATHOGENIC SPECIES

The pathogenicity of *R.pepo* was first reported in *Hymenaea courbaril* in about 1908 on the island of Guadaloupe.

Among the species with high resistance to the two species of *Rosellinia* are believed to be:-

Panicum maximum Jacq	*(Pasto Guinea)*	Guinea grass
Mangifera indica L.	*(Mango)*	Mango
Saccharum officinarum L.	*(Cana de azucar)*	Sugarcane
Citrus aurantium L.	*(Naranja agria)*	Orange

The following species are apparently immune:-

Cocos nucifera L.	*(Cocotero)*	Coconut
Glyricidia maculata	*(Matarraton)*	–
Tradescantia spp.	*(Suelda o Cadillo)*	–

Nevertheless, at the Luker farm (Salazar, pers.comm.) *Rosellinia* spp. have been found to affect *Glyricidia*. Consequently the pathogenicity of *R.bunodes* and *R.pepo* in both the mentioned hosts and in other species used mainly as cover or shade trees needs to be confirmed through artificial inoculations.

SYMPTOMS

The trees attacked by *Rosellinia* spp. present symptoms above ground similar to those caused by other root diseases (Figure 1). There is a progressive yellowing of leaves, withering, defoliation, drying up of branches and death of the tree. By the time the first symptoms are visible, the fungus has already colonised and destroyed a large part of the root system. The diagnosis of the pathogenic species of the fungus is made by the appearance and colour of the mycelium on the roots.

When dealing with *R.bunodes*, mycelial filaments, at first white and later black, appear at the base of the trunk and in the roots, and these later give way to a dense covering which grows on the bark. The filaments also penetrate into the woody tissue of the roots: on cutting them, the hyphae appear in the form of black points and stripes.

In attacks of *R.pepo*, the base of the trunk is surrounded by a thick greyish to black mycelial fan. On the roots there appear mycelial filaments, which are initially smokey grey and then black, and which later form a covering with a woolly appearance. Under the bark can be seen mycelial arrangements of a white or yellow colour in the form of fans or stars (Figure 3). This last characteristic constitutes the most certain diagnosis of the disease.

PREDISPOSING CONDITIONS

The most important factors for the spread of *Rosellinia* spp. are the availability of inoculum and of susceptible hosts. The transmission takes place through the mycelium that grows on the remains of infected plants in the soil. Apparently, the ascospores and conidia are of little importance in the dissemination of the disease. Experimentally, it has been shown that *Rosellinia* spp. do not grow in waterlogged soils or in soils which are close to saturation. The fungus develops more readily in the absence of light, in sandy soils which are rich in decomposing organic matter and have a humidity of 50 to 70%. The fungus grows at between 7°C and 33°C, with an optimum of 25°C to 27°C. There was no effect in the soil pH range 4.5 to 8.5 and so it seems that the fungus can grow at almost any soil acidity. It appears that *Rosellinia* spp. prevails in soils low in available phosphorous (under 40 ppm) and is unaffected by doses of lime at up to 2 tonnes per hectare.

TABLE 2: RESPONSE OF YOUNG COCOA (i) TO INOCULATION WITH *ROSELLINIA PEPO* AT LUKER FARM, 1987

	Inoculated	Number of Plants Infected (ii)	Died
Clones			
EET 8	10	10	8
ICS 1	10	10	6
ICS 40	10	10	6
ICS 95	10	10	6
IMC 67	8	8	2
P 7	10	8	0
PA 121	10	10	7
Pueblo Quemado	10	10	6
R 30	10	10	7
SC 6	10	10	5
TSH 565	10	10	9
TSH 792	10	10	9
UF 613	10	10	0
Hybrids			
EET 48 x IMC 67	10	10	3
EET 62 x IMC 67	20	18	0
ICS 95 x IMC 67	11	6	1
IMC 67 x EET 62	20	16	4
P 7 x Catongo	20	17	3
P 7 x ICS 6	20	17	1
PA 46 x IMC 67	20	18	1
SPA 12 x ICS 39	10	10	7
TSA 654 x ICS 6	10	10	6
UF 613 x Catongo	10	10	2

(i) Plants of 5 to 14 months at date of inoculation;
(ii) Count made six and a half months after inoculation.

CONTROL

To date there are no reliable methods of control. The recommendations to adopt any practices are based on isolated observations : mostly without experimental confirmation. Some measures which may help to prevent the spread of the disease are indicated below, but there is little, if any, proof of experimental successes.

It is essential to minimise the inoculum in the soil: the trees which are attacked should be uprooted and burnt in situ. The pathogen should be kept very much in mind when it is intended to establish a cocoa plantation - even ón virgin land. To encourage aeration and adequate exposure to the sun, shade should be reduced, the base of the cocoa tree trunks should be cleared of vegetable material and frequent weed control should be practised. Applications of lime directed to the soil in the area of feeder roots of diseased trees, have not been effective in preventing or controlling the disease. Suspect trees should be isolated by means of trenches that enclose also 2 or 3 rows of apparently sound healthy trees - as these might already be affected. The trenches should have a depth greater than the rooting zone: the earth extracted should be deposited towards the interior of the designated area.

It is estimated that an infected area of soil should be allowed to rest for at least a year before establishing a new plantation in the same place. The new plantings should be made as far as possible with seemingly resistant plants. ICA is attempting to determine the most suitable materials. Preliminary results (Table 2) suggest that hybrids based on IMC 67, P7 and UF 613 are the most tolerant. These clones are also characterised by being highly resistant to the disease known as "*Ceratocystis fimbriata*" (Mal de Machete). A research project is currently being prepared with a view to devising effective and economic treatments that will control the disease in cocoa and shade trees infected by the pathogen.

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Borneo illipe, a fat product from different Shorea spp. (Dipterocarpaceae)
BLICHER MATHIESEN,U. Institute of Biological Sciences, Aarhus University, Aarhus, Denmark - *Economic Botany (USA)* v.48(3), p.231-242; Jul 1994
Fats extracted from kernels of Shorea species from the tropical rainforests of Kalimantan and Sumatra, Indonesia, are traded under the name Borneo illipe. The fat is used in chocolate formulations. Kernel fat analyses of different Shorea species are presented, including data on fat content, glyceride composition and fatty acid composition. To assess the future potential of the naturally occurring tree populations, distribution maps of 5 Shorea species are included. The majority of kernels collected are from Shorea species in the section Pachycarpae. Fat characteristics of Shorea species in this section show differences in fat quality in relation to their use as exotic sources in Cocoa Butter Equivalent (CBE) formulations. Data on the quantities of Borneo illipe kernels exported from Sarawak and Kalimantan are included.

MARCH 1995

Fostering sustainable development in the commodity field. Experiences concerning environmental effects of commodity production and processing: synthesis of case studies on cocoa, coffee and rice
UNCTAD, Geneva, Switzerland, p.33; Sept 1993
The environmental effects of commodity production are discussed, based on 5 case studies. The case studies deal with cocoa production and processing in Nigeria, coffee and cocoa production and processing in Brazil, coffee production and processing in El Salvador and Costa Rica, cocoa and coffee production in Cameroon, and rice production in Thailand and the Philippines. The environmental effects of agriculture on the soil, water, air, forest cover, biodiversity and human health are covered. The determinants of these environmental effects are analysed. These include determinants inherent in agricultural production and processing (such as input use and waste utilisation), and determinants external to the production and processing activities (such as market conditions and environmental regulations). Cocoa, coffee and rice are produced or could be produced without harming the environment. Production of these crops could even improve the natural resource base. Policy implications are outlined, and an annex on ecological rice farming in China is included.

The effect of import liberalisation of cocoa beans on Malaysian cocoa industry
MAT NASIR SHAMSUDIN. Faculty of Economics and Management, Universiti Pertanian Malaysia, Serdang, Malaysia - *Borneo Review (Malaysia)* v.4(2), p.97-112; Dec 1993
The economic implications of import liberalisation of cocoa beans on the Malaysian

* For administrative reasons, we have decided to cease publication of these Cocoa Abstracts. In so doing we would like to record our appreciation to the Royal Tropical Institute for their permission to publish them over recent years.

domestic demand, imports, export prices and domestic prices. The reduction of import tax would encourage domestic utilisation and processing of cocoa beans. The reduction of import duty on cocoa beans would not severely affect production and domestic prices, and would only marginally reduce exports.

Influence of treatments with cupric fungicides on the mineral composition of cocoa trees

LIMA,J.S. Instituto de Quimica, Universidade de Sao Paulo, Sao Paulo, Brazil - *Agrotropica (Brazil)* v.5(3), p.43-51; Sept 1993

The influence of Cu surplus on the mineral composition of cocoa trees was studied in Bahia, Brazil in 1990. The nutrient content of the cocoa trees was analysed in 3 plantations, in 1 of which agrochemicals had not been applied (A), and 2 plantations which had been treated with cupric fungicides for 5 and 16 years, respectively (B and C). The elements Cu, Fe, Zn, Mn, P, Ca, Mg, K, C and N were measured in the soil and Cu, Fe, Zn, Mn, P, Ca, Mg and K were measured in tree samples. The nutrient contents of the vegetative tissues reflected those of the soil, but after a fungicide application the concentration of micronutrients in plant parts varied. Alterations in the nutrient contents of the trees in plantations B and C were observed 1 week after a fungicide application (an an interval of 1 year after the last fungicide application). The most evident alterations (eg. Mg decrease in beans and Ca increase in roots and beans) were observed in plantation C.

[Adaptability and stability of cocoa cultivars]. Adaptabilidade e estabilidade de cultivares de cacaueiro

MARTINS PINTO,L.R., LOPES,U.V., MONTEIRO,W.R. and PEREIRA,M.G. Centro de Pesquisas do Cacau, Itabuna, Bahia, Brazil - *Agrotropica (Brazil)* v.5(3), p.53-63; Sept 1993

The adaptability and phenotypic stability of 10 cocoa cultivars were evaluated at 6 different sites in cocoa producing areas of the States of Bahia and Espirito Santo, Brazil, with different soils and climates. The plant characteristics evaluated were number of healthy pods/plant, moist seed weight/ha and moist seed weight/pod. Variability was observed among various crosses for both adaptability and phenotype stability for all 3 characteristics studied. Hybrids of cv. Scavina displayed great adaptability and an average stability in all environments. The performance of hybrids of ICS 1 was only high in the environments which were most suitable for cocoa cultivation and their phenotopic stability was below average.

APRIL 1995

[Preliminary study to optimize cocoa roasting parameters: aroma precursor consumption, pyrazine development, organoleptic quality]. Etude preliminaire de l'optimisation des parametres de torrefaction du cacao: consommation des precurseurs d'aroma developpement des pyrazines, qualite organoleptique

MERMET,G., CROS,E. and GEORGES,G. - *Cafe, Cacao, The (France)* v.36(4), p.285-290; 1992

The free amino acid content of cocoa nibs exhibits a decreasing linear relationship with temperature for roasting duration of 25 minutes. Their consumption is less than 40% at 140°C. The ratio of sugar (fructose and glucose) consumption to free amino acid consumption is about 3 for the most aromatic cocoas and exceeds 2 as long as off-flavours associated with excessive roasting are absent from the sample. The reducing sugar content is believed to be the factor limiting aroma development. No simple relationship seems to exist between pyrazine content and organoleptic quality.

[Role of phenolic compounds in the development of soluble colouring matter during alkalinization of cocoa]. Role des composes phenoliques dans le developpement de la matiere colorante soluble au cours de l'alcalinaisation du cacao

BIANCHI,J., CROS,E. and PONTILLON,J. Groupe Polyphenols, Narbonne, France - Bulletin de Liaison du Groupe Polyphenols (France) v.16(2), p.92-95; 1992

The flavan-3-ols of the cocoa bean are precursors of soluble colouring matter that develops during alkalinization. When this soluble colouring matter is fractioned on gels it produces several fractions of the same colour. However, they are not polymers of the same basic unit. The insoluble amino and polyphenol compounds of the bean also participate in forming soluble colouring matter.

The contribution of genotype to cocoa (*Theobroma cacao* L.) flavour

CLAPPERTON,J., YOW,S., CHAN,J., LIM,D., LOCKWOOD,R., ROMANCZYK,L. and HAMMERSTONE,J. - *Tropical Agriculture (Trinidad and Tobago)* v.71(4), p.303-308; 1994

The possibility of genetic effects on cocoa flavour was investigated. Consistent differences in flavour attributes, especially cocoa flavour intensity, acidity, sourness, bitterness and astringency were found among the West African Amelonado variety (AML), 4 Upper Amazon clones (Iquitos Mixed Calabacillo 67 (IMC 67), Nanay 33 (NA 33), Parinari 7 (PA 7) and Scavina 12 (SCA 12)) and a Nicaraguan "Criollo" (UIT 1) all grown in Sabah, Malaysia. The flavour of UIT 1 was distinctly different from the West African standard, being characterised by intense bitterness and astringency associated with caffeine and polyphenols. It also had the most acid taste. These attributes were ameliorated by prolonged storage of the pods before processing the wet beans. The 6 genotypes also differed in bean size and butter fat content. The differences in flavour were independent of the differences in bean size. The results demonstrated a significant contribution of genotype to flavour in addition to effects of processing.

[The colonial cocoa system in Central America]. L'economie coloniale du cacao en Amerique Centrale

TOUZARD,J.M. - *Reperes. Developpement Rural (France)* p.95; 1993

After outlining the pre-Colombian cocoa economy, the evolution of the cocoa supply in Centra America during the 3 centuries of Spanish rule is examined. Productive cycles with respect to transformations in the production and exchange systems are analysed. The conclusion confirms a contemporary hypotheses: the decline of cocoa production was primarily due to the endogenous blocking of access to production factors. Utilisation of production factors without regard to renewal had irreversible consquences for the whole productive system. This study is complemented by previously unpublished historical documents.

[Somatic embryogenesis and plant regeneration from flower parts of cocoa, Theobroma cacao]. Embryogenese somatique de cacaoyer Theobroma cacao L. a partir de pieces florales

LOPEZ BAEZ,O., BOLLON,H., ESKES,A. and PETIARD,V. - *Comptes Rendus de l'Academie des Sciences. Serie 3 (France)* v.316(6), p.579-584; 1993

Somatic embryogenesis was induced on explants from immature flower buds of Theobroma cacao. The influence of hormonal composition and duration of induction have been evaluated. Embryogenesis rate was variable among explants from various genotypes. Leaved and rooted plantlets were developed from somatic embryos.

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