COCOA GROWERS' BULLETIN

Number 47

May 1994

Contents

Cadbury Ltd
Bournville
Birmingham
B30 2LU
England

EDITORIAL

In this issue of the Cocoa Growers' Bulletin, we publish two articles which are the text of papers presented at a Seminar held in London in 1992, organised by the Tropical Agriculture Association. The conclusions which might be drawn from these papers and the subsequent discussion indicate that:

- Cocoa is a good crop for smallholders;
- Cocoa can give much-needed foreign currency for a number of third world countries many of which are ACP countries;
- Many of these countries would be in even more desperate economic circumstances if cocoa ceased to be an export earner;
- Currently, the most profitable cocoa growing enterprises are those operating on a low-input, low-output, low-technology system;
- Substantial pest and diseases problems exist in all major cocoa growing countries;
- Resources for cocoa research, including conservation and characterisation of cocoa genetic resources are woefully inadequate;
- High-technology growers (such as the Malaysian and Indonesian plantation interests) are no longer investing in R & D for cocoa and indeed many are grubbing up the trees because of the consistently low prices in recent years;
- As the high-technology growers reduce their inputs, an alarmingly high percentage of world cocoa production is once more grown by smallholders using low-technology and applying few, or no, inputs;
- There is a pressing need for the characterisation of existing conserved cocoa genetic resources to select parents for future programme.

In the light of the magnitude of the problems facing the world cocoa industry, this cannot be considered a satisfactory situation. Donor funds are urgently needed to enhance the worldwide cocoa research effort to increase productivity and release more land in the tropical rainforest zones for planting with food crops or alternative export crops. The key to the future prosperity of the world cocoa industry must surely lie in improved planting materials derived from crosses between novel parents selected from material presently existing in field genebanks. Despite the fact that such a high percentage of the world's cocoa production is grown by smallholders, many donors still consider it to be a plantation crop and thus are often not even prepared to consider projects to ensure the long-term viability of the world cocoa industry.

R.A.LASS, EDITOR

ISSN 0045-7256

Cocoa Growers' Bulletin is published twice per annum by Cadbury Schweppes plc as an information service to cocoa growers, plantation staff, extension officers and research workers. It is distributed free with one copy being sent to each name on the current mailing list. Any correspondence including requests for names to be added to the mailing list should be sent to: R.A.Lass, Editor, Cocoa Growers' Bulletin, Technical Development Department V52, Cadbury Ltd, PO Box 12, Bournville Lane, Birmingham, B30 2LU, England.

Cocoa Growers' Bulletin No.47 *May 1994*

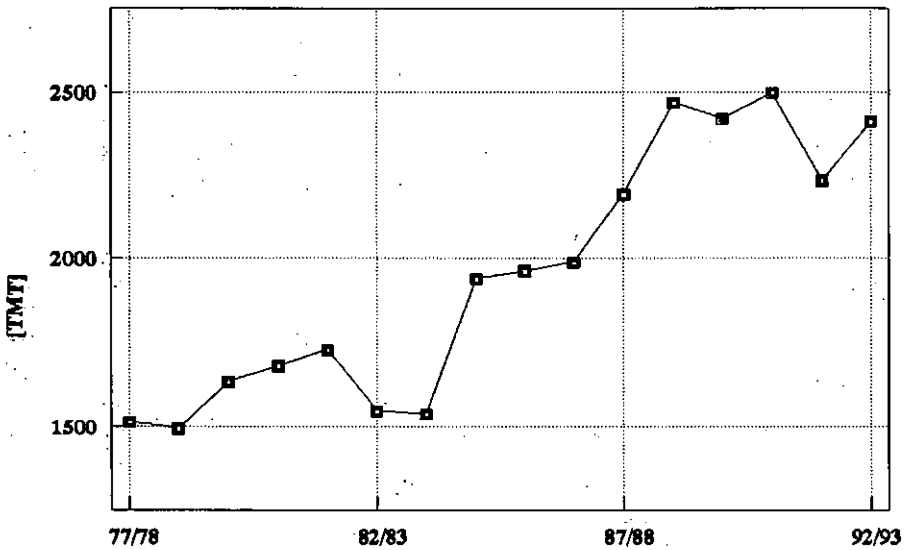
REVIEW OF PRODUCTION, CONSUMPTION, STOCKS AND PRICES

June 1992 - May 1994
S.A.Wakeling
Cadbury Limited

PRODUCTION

In many of the World's cocoa producing countries, the rate of increase in production observed during the 1980s, due to plantings which were made during the late 1970s and early 1980s, has slowed down. The major exception has been Indonesia where production continues to surge ahead as a result of new plantings made during the latter half of the 1980s.

WORLD COCOA PRODUCTION



Source: E.D.& F.Man Limited, World Production of Raw Cocoa

WORLD COCOA PRODUCTION DATA

Reproduced from E.D.& F.Man Limited Market Report No.349
Dated May 1994
(all figures in thousand metric tonnes (TMT))

	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	*1993/94
Cameroon	131	129	121	107	108	92	95
Ivory Coast	667	840	718	796	724	785	800
Ghana	188	300	295	293	243	312	245
Nigeria	150	160	170	170	110	130	130
Togo	9	15	10	7	4	4	4
Others	39	33	35	34	27	25	25
Total Africa	**1184**	**1477**	**1349**	**1407**	**1216**	**1348**	**1299**
Brazil	388	336	355	379	296	294	282
Colombia	59	50	50	52	49	50	50
Ecuador	77	87	101	106	82	69	90
Mexico	44	42	43	43	45	50	46
Peru	12	12	13	11	11	11	11
Venezuela	12	10	14	16	15	16	16
Others	9	10	12	11	10	10	10
Total C.& S.America	**601**	**547**	**588**	**618**	**508**	**500**	**505**
Dominican Rep.	53	43	57	42	48	52	50
Others	11	8	10	8	9	8	8
Total West Indies	**64**	**51**	**67**	**50**	**57**	**60**	**58**
Indonesia	65	102	115	145	167	223	245
Malaysia	227	223	241	225	225	224	220
Papua New Guinea	33	48	41	33	41	39	38
Others	18	21	20	20	18	18	18
Total Asia & Oceania	**343**	**394**	**417**	**423**	**451**	**504**	**521**
WORLD TOTAL	**2192**	**2469**	**2421**	**2498**	**2232**	**2412**	**2383**
% change in production from previous season	10.3	12.6	-1.9	3.2	-10.6	8.1	-1.2

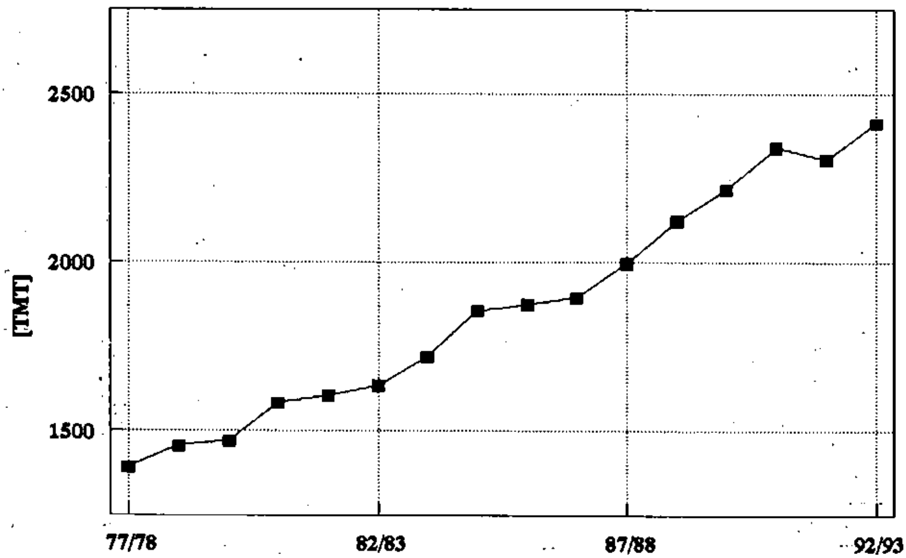
* **Forecast**

N.B. Some figures may not add up due to rounding

CONSUMPTION

The country having the largest influence over World grind during the last 3 years has been the USSR (now known as the former Soviet Union, FSU). In 1991/92 the grind of the FSU fell from 83 TMT to 25 TMT. Since then a major recovery has been underway. E.D.& F.Man Limited Market Report No.349 forecasts that the grind of the FSU will be 100 TMT in 1993/94. Moreover, imports of chocolate into the FSU have increased rapidly since 1991/92 and have been the major reason for the growth of the West European grind over that time period.

WORLD COCOA CONSUMPTION



Source: E.D.& F.Man Limited, World Grindings of Raw Cocoa

WORLD COCOA CONSUMPTION DATA

Reproduced from E.D.& F.Man Limited Market Report No.349
Dated May 1994
(all figures in thousand metric tonnes (TMT))

	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	*1993/94
Belgium	35	41	47	45	46	47	49
France	40	44	59	70	67	81	91
Germany (Fed.Rep.)	225	244	273	295	306	305	313
Italy	46	46	51	56	62	58	60
Netherlands	215	234	241	268	294	309	333
Spain	43	40	42	45	46	44	46
United Kingdom	100	112	120	145	153	169	174
Others	55	59	62	54	53	51	53
Total Western Europe	**759**	**820**	**895**	**978**	**1027**	**1064**	**1119**
Eastern Europe	93	105	89	83	86	78	78
USSR	132	201	106	83	25	95	100
Total E.Europe & USSR	**225**	**306**	**195**	**166**	**111**	**173**	**178**
Ivory Coast	102	110	111	115	109	100	105
Others	71	64	68	55	67	65	66
Total Africa	**173**	**174**	**179**	**170**	**175**	**165**	**171**
Brazil	241	210	239	280	221	222	247
Colombia	46	41	45	47	44	45	46
Ecuador	35	36	44	50	40	30	33
Mexico	40	40	43	43	35	30	28
United States	241	237	265	265	307	324	319
Others	59	58	63	68	71	82	80
Total America	**662**	**622**	**699**	**753**	**718**	**733**	**753**
Japan	40	40	47	52	49	37	39
Malaysia	40	47	72	77	87	99	105
Singapore	40	46	52	51	50	46	48
Others	58	69	76	92	87	96	104
Total Asia & Oceania	**178**	**202**	**247**	**272**	**273**	**278**	**296**
WORLD TOTAL	**1997**	**2124**	**2216**	**2339**	**2304**	**2413**	**2517**
% change in grindings from previous season	5.4	6.3	4.3	5.6	-1.5	4.7	4.3

* **Forecast**

N.B. **From 1990/91 Germany includes East and West Germany**
Some figures may not add up due to rounding

STOCKS

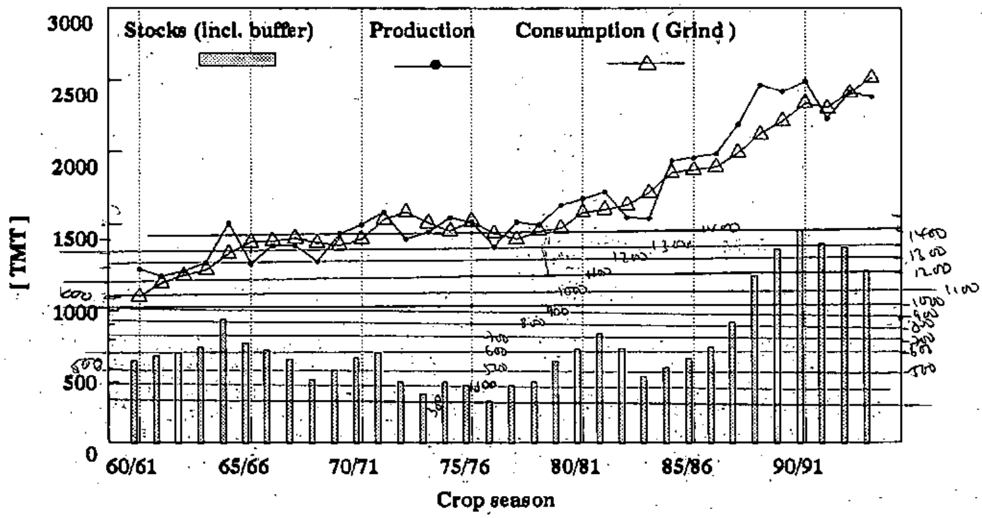
Since the last Cocoa Growers' Bulletin in June 1992, stocks have fallen from the record high of 1990/91. Deficits have occurred in 1991/92 and 1992/93 and E.D.& F.Man Limited in their Cocoa Report No.349 are forecasting a further deficit in 1993/94.

WORLD COCOA STOCK DATA

Reproduced from E.D.& F.Man Limited Market Report No.349
Dated May 1994

	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94
Closing stocks **(including buffer stock)**	826	1146	1326	1460	1365	1339	1181
Stock/consumption ratio **(including buffer stock)**	0.41	0.54	0.60	0.62	0.59	0.55	0.47

WORLD COCOA STOCKS

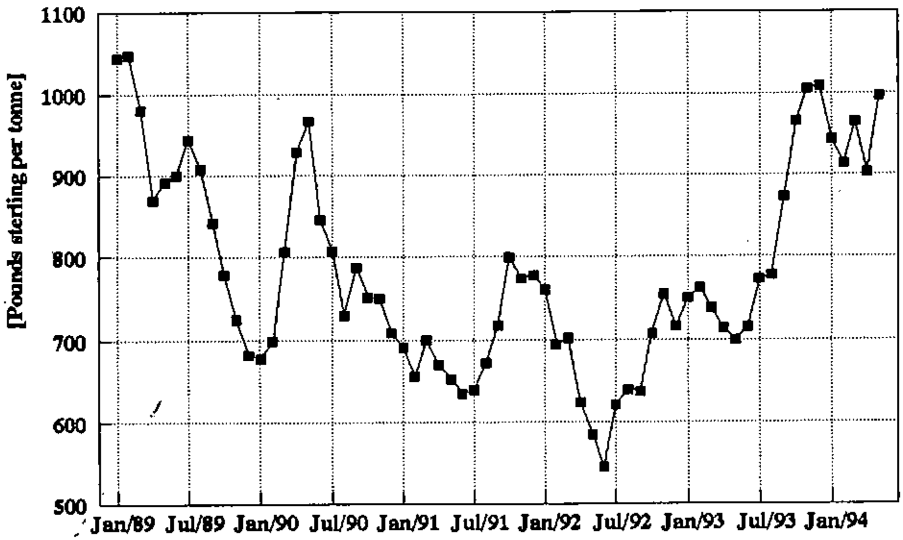


Source: E.D.& F.Man Limited, Cocoa Market Report No.349

PRICES

Since June 1992 prices have steadily increased in response to the supply deficits of the last three cocoa years.

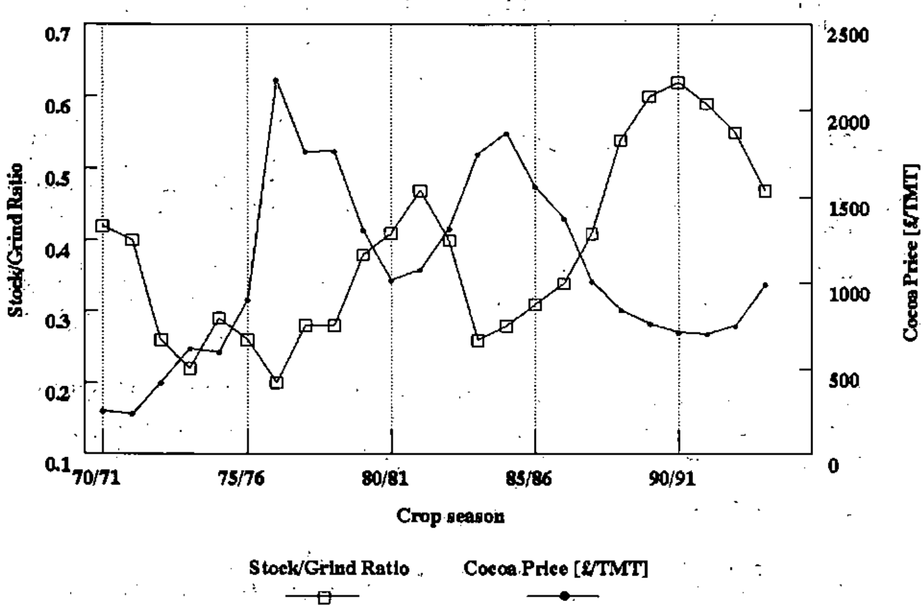
MONTHLY AVERAGE PRICE OF NEARBY SHIPMENT GHANA COCOA



INTERNATIONAL COCOA AGREEMENT

The E.D.& F.Man Limited Market Report No.349 reported that at a special meeting in February 1994, convened by UNCTAD, Malaysia signed the cocoa agreement for the first time, the only major producer no longer a signatory being Indonesia. Consuming countries that have signed the agreement represented 55% of the World's cocoa imports, the major non-signatories being USA and the Russian Federation. The new International Cocoa Agreement came into force on 22nd February 1994. The new ICCA allows for a production management plan designed to achieve a lasting equilibrium between world production and consumption. The production management plan is purely a voluntary arrangement. It aims to bring the stock:consumption ratio down to 20% (compared with over 60% at the end of 1991/92).

PRICES AND STOCKS



Source: E.D.& F.Man Limited, Cocoa Market Report No.349

COCOA: COSTS OF PRODUCTION IN VARIOUS PRODUCING COUNTRIES

E. Bloomfield *

This article is based on a multi-client study undertaken by Landell Mills Commodities Studies Limited (LMCS) entitled "A World Survey of Cocoa Bean Production Costs 1986/87". This study was revised by LMCS in mid 1993 and thus some of the conclusions will have been modified somewhat. However, the general results presented in this article still hold true.

A summary of the results of this study is given in Figure 1. This shows that African producers are, as a whole, the lowest cost cocoa producers, closely followed by South-East Asia.

Before embarking on a discussion of the conclusions, it is important that we put this study in a conceptual framework and examine the methodology used to derive these figures. The methodology will be discussed rather quickly, but we would like to refer you to Fry (1990) for a full discussion.

METHODOLOGY

The objective of the study is to provide the basis for international comparison, which enables us to evaluate the competitiveness of different producers across countries.

There are several choices for presenting the comparisons:

i) number of tonnes cocoa/full time worker;

ii) yield of cocoa per hectare per year;

iii) yield of cocoa over the lifetime of one hectare of cocoa trees.

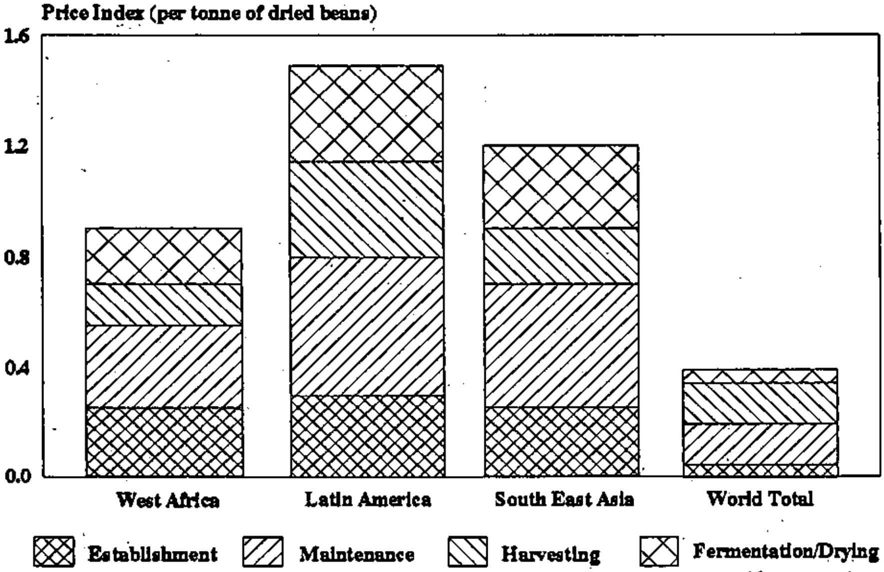
While important, these comparisons tell only part of the story.

We need to use prices to understand the efficiency of production and the opportunity costs of inputs for cocoa versus the benefits or profits from cocoa. For instance, Malaysian cocoa estates could be called high-input as well as high-output cocoa producers. Comparing the prices of inputs and the output will tell us how profitable (or not) is the cultivation of cocoa in Malaysia. For this we also need the costs of production to determine the relationship with selling prices, which we take to be the average free market price from 1951/88.

---

* Economist, Landell Mills Commodity Studies Limited (LMCS), 14-16 George Street, Oxford, OX1 2AF, England.

FIGURE 1: REGIONAL COCOA PRODUCTION COSTS BY COMPONENT (1986/87)



Several problems of methodology present themselves, for instance obtaining reliable data on the various costs which we are comparing. It would be possible to use annual business accounts or to give questionnaires to a number of producers and compare the results with published sources. However, there is no guarantee that this will enable consistent comparisons to be made.

Another possible solution would be to assume that producers reveal their costs through their selling prices, with high cost producers such as Papua New Guinea getting a higher price. Unfortunately, there are a number of institutional distortions such as fixed producer prices and subsidised inputs which invalidate this approach.

In the light of the foregoing, LMCS uses an engineering approach. This starts from detailed and disaggregated listings of inputs used to produce and process cocoa. It attaches local prices to inputs and gets cost estimates. Rather than getting information on total application of inputs, we have adopted the "technical blueprint method", dividing the production process into distinct sub-processes (land preparation, fertiliser application, pruning, weeding, harvesting, fermentation, drying etc). This method distinguishes between several alternative blueprints, ranging from high-technology (high-input/high-output) to low-technology (low-input/low-output) methods for performing these same tasks.

TABLE 1: CHOICES OF TECHNIQUES FOR THE ESTABLISHMENT AND MAINTENANCE OF COCOA TREES

Method of Establishment/ Maintenance	Low-Technology (Low-Input/Low-Output)	High-Technology (High-Input/High-Output)
Clear felling and planted shade		
i) Mechanised	x	x
ii) Labour-intensive	x	x
Thinned forest (labour-intensive)	x	x
Intercropping with cocoa/oil palm etc		
i) Mechanised	x	x
ii) Labour-intensive	x	x
Turrialba/under old cocoa (labour-intensive)	x	x

Source: Anon (1989) "World Survey of Cocoa Bean Production Costs 1986/87". Landell Mills Commodities Studies Limited

We then look at the production methods employed in different sectors of the same country's industry, say high-technology, high-input, high-output, to determine how much labour time, for example, is required to produce a tonne of final output. To derive average production costs for a country, we then use a weighted average of the different techniques and their associated input requirements.

More specifically, we divide the production processes into number of sub-processes. For example: in cocoa establishment, the production process is divided into land clearing, liming, staking, shade planting, fertiliser application, insect control, disease control, weed control, road construction, preparation of drainage/water systems, shade maintenance, nursery construction, filling bags in the nursery, sowing seeds, cultural work in the nursery, planting cocoa and finally, pruning and shaping. Similar disaggregation is used for harvesting and breaking, fermentation, drying and bagging. Altogether 27 main sub-processes are identified. For each process, a variety of alternative techniques are identified, ranging from highly mechanised ones such as in Malaysia to highly labour intensive ones common to West Africa.

Up to twelve alternative techniques can be distinguished for each process in the field, and are summarised in Tables 1 and Table 2. They can be divided into two broad groups, each comprising six techniques. The first group consists of "high-technology" production, and the second of "low-technology" producers. This does not necessarily imply a distinction between largeholder/smallholder; thus, small farmers who prune on a timely basis and adopt good crop husbandry are classified as "high-technology" and estates ignoring these tasks are "low-technology".

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

	Fermentation	**Drying**
a) Low-technology, sun drying	Heap, basket	Sun drying
b) Low-technology, artificial drying	Box with short fermentation cycle and insufficient turning of beans	Small-scale artificial drying
c) High-technology, artificial drying	Box/cascade with full fermentation cycle and 2 or 3 turnings of beans	Large-scale artificial drying with pre-driers as well as driers

Source: Anon (1989) "World Survey of Cocoa Bean Production Costs 1986/87". Landell Mills Commodities Studies Limited

Each process employs a number of inputs (labour, machinery, etc). For the purpose of compatibility, we use inputs per tonne of fermented dried beans, so we are looking at the costs of taking unfermented beans through to full fermentation and drying. A twenty per cent allowance is made for the overheads associated with the administration and management of cocoa cultivation, harvesting, fermentation and drying. Several important methodological points remain to be addressed to achieve consistency; three of these are "economic" issues and three concern agronomic assumptions.

Economic Issue Concerning Interest Rates

The exchange rates taken are official exchange rates, in real terms. The base year and currency is USD for 1986. For interest rates, we take the real rate rather than nominal rate, since inflation rates as well as interest rates for different countries diverge widely as would probably be shown in any comparison between Brazil and Malaysia.

For example, Brazilian cocoa farmers are only willing to invest large sums in new plantings, equipment etc, if they believe that the local price of cocoa will rise sufficiently to cover payments. Taking a nominal interest rate, these payments could appear to be three times the nominal value of borrowing in the first year. However, local prices for cocoa will also be rising due to domestic inflation. Therefore, real interest rates more accurately reflect the true cost of borrowing. We have chosen to estimate all interest payments on the same uniform basis, and to apply to each country's cost estimates an allowance for a real interest rate in 1986 of five per cent. Because interest rates are important, and since establishment occurs many years before tree replacement, we have performed sensitivity analyses using two per cent and eight per cent real interest rates (which is arguably an underestimate in the case of smallholders). This shows how different real rates of interest can influence the investment choices of cocoa farmers facing an average of world cocoa prices estimated to be $2.70/kilo per dry, unfermented beans in 1987 money values.

Economic Issue Concerning Valuation of Capital Stock

We have a choice of valuing capital stock on the basis of historical costs, or on a replacement cost basis. Since we are using real interest rates, it makes sense to use replacement costs, appropriately depreciated, to reflect the amount of wear and tear. These costs are expressed in local currency terms, since it is on those costs which producers base their investment decisions. We use local prices for capital goods as estimates of costs in these countries.

Economic Issue Concerning Valuation of Land

One basis for land valuation is the response in the market value of land to changes in cocoa prices. However, land prices will rise and fall with the cocoa market, and so the costs of production could be considered as always be equal to the cocoa price through changes in land value. Instead, it seems appropriate to look at the opportunity cost of land to the cocoa industry, or, in other words, the value attached to the land in its next best alternative use. This is particularly true for Malaysia, Indonesia and Papua New Guinea (PNG), where oil palm, coconut or rubber are potentially viable alternatives. However, this is difficult in some other cases where there are no alternatives or where there is insufficient price data on the crop. For instance, there is no world market price for cassava or banana. In such situations, it is appropriate to use the cost of the process of getting land into a suitable state for cocoa cultivation, and take annual interest costs associated with these establishment costs to give an equivalent annual rental for the land.

Assumption about the Productive Life of Cocoa Trees

This is an important, but complicated element of the production cost analysis, since cocoa replanting depends on farmers' future expectations of prices, and the cost versus benefit of chopping down or extending the life of a tree for one more year. This study relies on actual observations of replanting among high-technology and low-technology producers. We use two sources of information for this data, namely the ICCO data on age distribution of trees in different countries, and national data collected during field research for this study.

Assumption about the Yield Profile of Trees

Real average and national cocoa yields are not necessarily the appropriate averages of the yield profiles of "high-technology" and "low-technology" farmers, because the pace of new planting has varied widely between countries. For instance, in 1986 Indonesia and Malaysia had a very high percentage of young and immature trees. They had not yet reached the peak of their yield curve, and therefore their expected yields were higher than actual yields in 1986. Ghana and Nigeria were at other end of the spectrum with old trees on the declining section of their yield curves. To take account of these biases, we have "normalised" yields for producers with young, hybrid trees by adjusting for the growth projected (and anticipated by farmers) in average yields over the fifteen years from 1986. Normalisation of yields in this way can mean an increase of up to ten per cent.

Assumption about the Role of Shade Trees

Permanent shade trees, which are a fundamental part of cocoa cultivation, can sometimes have considerable economic value in their own right, such as coconut palm in South-East Asia. It is not clear how the value of these trees should be incorporated into estimates of production costs. For the sake of simplicity, and because of the difficulty of distinguishing and attributing costs and revenues to shade versus cocoa crops, we have assumed that the costs and revenues are not relevant to the economics of cocoa cultivation, except to the extent that management of these forms of shade is specifically geared to the needs of cocoa trees. In other circumstances, the costs of this management are not charged to the cocoa enterprise. We likewise assume no revenue from the temporary shade provided by food crops and plantains/bananas during the establishment phase of young cocoa.

RESULTS

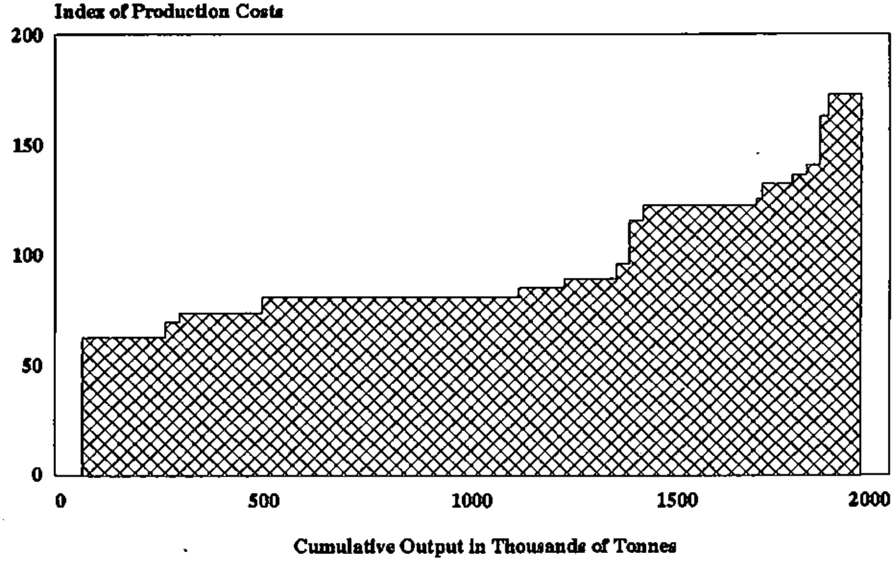
We have measured all costs ex-fermentary, without regard to the costs of movement of bagged beans from the drier. This avoids having to decide on a common point of final purchase for each producer.

There are several ways of diagrammatically representing production costs. One way is by use of the cumulative cost schedule: this is equivalent to a long run supply curve, and represents the full production costs of producers, as depicted in Figure 2.

It is drawn up by ranking all producers in the order of increasing cost, from lowest cost to highest cost. Then, the cost of each producer is plotted against the cumulative output at that cost level (corresponding to total global output which can be produced at break-even or profit at that selling price). Such diagrams can then be plotted to show the full and variable production costs, with a five per cent interest rate.

Before attempting to make comparisons between the costs of production amongst the major cocoa producing countries, it is necessary to distinguish between full and variable costs. Full production costs cover every phase of a tree's life, from the initial clearing of the land through to the collection of the last pod before the tree is chopped down and the process begins afresh, or an alternative crop is planted. This would be akin to the method used for undertaking a full feasibility study of new plantings. Variable costs are the opposite extreme, and represent the choice facing a farmer whose farm is already established and who is concerned solely with covering the operating costs on each year's activities. In the short to medium term, a farmer will continue to maintain and harvest the crop as long as the variable costs are covered by revenues, since the farm is providing a greater return than is possible from closing down the enterprise.

FIGURE 2: CUMULATIVE FULL PRODUCTION COST SCHEDULE FOR COCOA BEANS (1986/87)

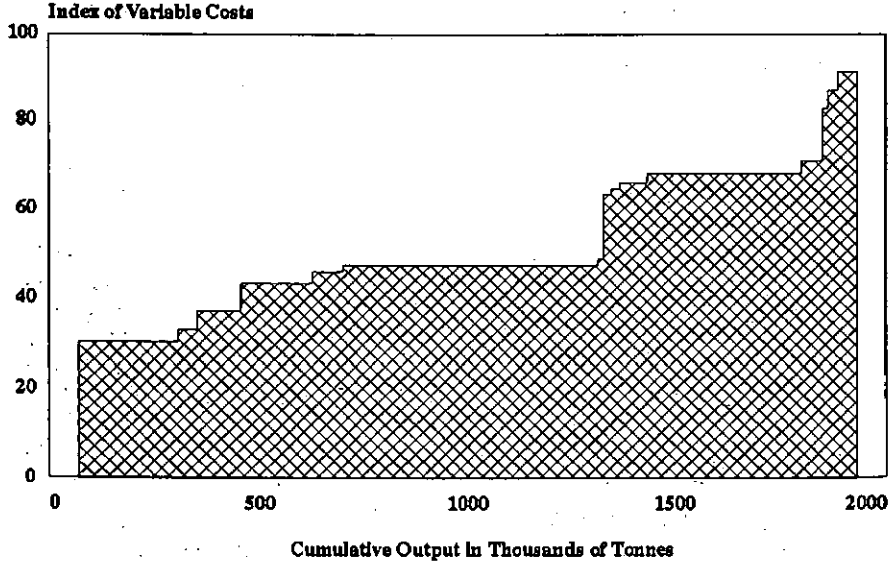


When cocoa prices are depressed, as they have been for the last few years, operating costs are a good indicator of producer behaviour, since the relationship between operating costs and producer prices will determine whether farmers continue to maintain and harvest their existing stock of cocoa trees. This explains why some Malaysian plantations are taking areas which are not producing at least 1.5 tonnes of cocoa per hectare out of production. It also explains why Brazilian farmers have cut back so significantly on inputs of labour, fungicides etc, and thus why their cocoa production has dropped so drastically. These decisions in Brazil were being made before the onset of witches' broom disease in the State of Bahia.

The cumulative cost curve (Figure 2) conveys the competitiveness of producers in the world cocoa economy with each other. It is derived by ranking the lowest to highest cost producer in order of increasing costs. The cost of each producer is then plotted against the cumulative output at that cost level (corresponding to total global output at a profit or break-even point). If there were no costs from fermentary to final consumer, and no government distortions creating a divergence between the export price and producer receipts, the cumulative full cost schedule would represent a medium term investment schedule for cocoa.

As the world cocoa price rises, a larger and larger share of world cocoa output could become profitable for new investors. The flat sections of this curve correspond to the world's major producers, such as the Cote d'Ivoire and Brazil. The thin right hand corner corresponds to PNG and Venezuela, the highest cost producers in our sample.

FIGURE 3: VARIABLE PRODUCTION COST SCHEDULE FOR COCOA BEANS (1986/87)



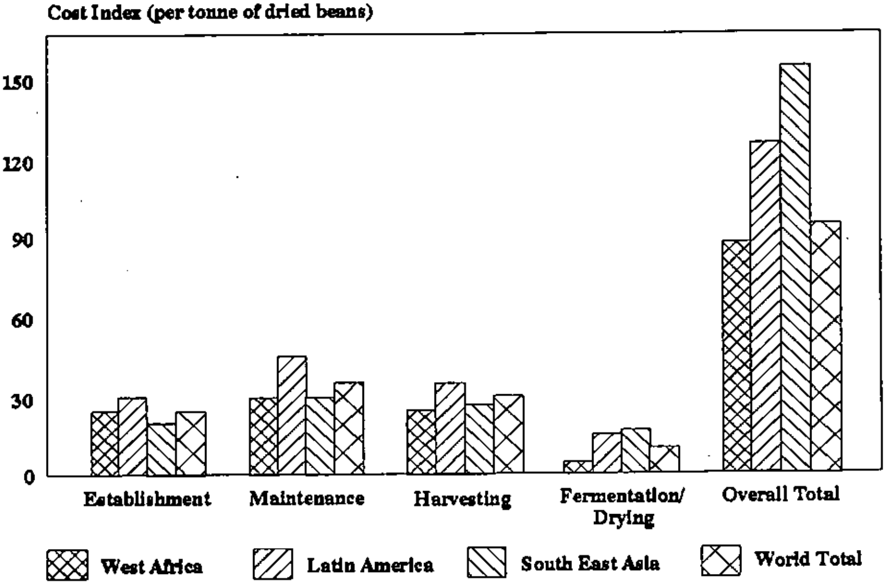
The variable cost curve, depicted in Figure 3, corresponds to a short-term supply curve in the same hypothetical world of no distortions and no transport costs. Again, the long sections of this curve would represent the major producers, while the short, high steps are once again Venezuela and PNG. The contrast between the relatively narrow range covering the majority of full production costs, and the steady increase in the variable cost schedule, implying significantly greater variations should be noted. The various elements of costs are depicted in the individual histograms.

Cocoa production costs by region and by component are presented in Figure 1 and Figure 4. These diagrams show the following:

i) The balance of advantage shifts from South-East Asia towards West Africa as one goes from the phase of farm establishment to the final fermentation and drying of beans;

ii) Worldwide, on average, close to twenty-five per cent of total production costs arise in the establishment stage, forty per cent of costs are from the maintenance of pod-bearing trees, thirty per cent are attributable to harvesting of beans, and almost ten per cent arise from the final fermentation and drying operations.

FIGURE 4: REGIONAL COCOA PRODUCTION COSTS BY STAGE OF PRODUCTION (1986/87)



In the full study (Anon, 1989), we also present histograms for each of the major and medium- sized cocoa producers (fourteen countries in all). We also disaggregate national costs further into labour, fertiliser/chemical, capital and sundry and administration elements. We also calculate the costs and present the results of estimates for 1986/87 crop year with five per cent real interest rates, ranking countries by their variable and fixed costs.

SOME OF THE MAIN CONCLUSIONS OF THE STUDY

1. West Africa is the most cost competitive region. The figure for the region as a whole is quite close to average costs for the Cote d'Ivoire because it is so prominent in the region, although the entire West African band lies within a fairly narrow range. Given West Africa's position as the lowest cost region, it looks like low prices should not be much of a threat. However, our costs are calculated ex-fermentary, and transport and handling costs in West Africa can be high, adding as much as USD 300 per tonne in 1986. West African producers tend to get a lower proportion of the world price than their counterparts elsewhere, due to government intervention. Nevertheless, it is clear from this data that cocoa is a very suitable crop for smallholder cultivation under West African circumstances, especially so since only frequently family labour is used.

2. Results show that in 1986/87 a producer a price of USD 600 would cover the variable costs of all West African producers, as well as Indonesian and Malaysian producers, but no country would be able to cover their full costs of production. No cocoa producer in Latin America was able to contribute towards fixed costs at this producer price.

3. Sensitivity analyses were conducted to examine the effects of (i) a ten per cent wage rate increase; (ii) a ten per cent per hectare increase in cocoa output; (iii) a ten per cent per hectare decrease in cocoa output and (iv) a devaluation of ten per cent against the US Dollar.

These analyses showed that:

i) Increases in wages are very important in terms of their overall impact on costs of production, since labour costs account for a dominant share of total cocoa production costs;

ii) Changes in the yields of cocoa per hectare have a more modest effect on average production costs. This is because there are major items of expenditure, especially at the harvesting, fermentation and drying stages, which are determined per tonne rather than per hectare. For these "per tonne items", changes in yields have no impact;

iii) Exchange rate has a major impact on the calculation of the final production cost in a producing country, because wages are so prominent in total production costs, and the vast majority of costs are fixed in domestic currency rather than foreign exchange. Devaluation is therefore a direct means of significantly reducing production costs and it can reduce the production costs and substantially improve the economic return to these producers;

iv) Cocoa is a good crop for smallholders as the labour component of the cost is high.

REFERENCES

Anon (1989) World Survey of Cocoa Bean Production Costs 1986/87. Landell Mills Commodities Studies Limited, Oxford, UK.

Anon (1993) World Survey of Cocoa Bean Production Costs 1986/87 - 1990/91. Landell Milss Commodities Studies Limited, Oxford, UK.

Fry,J. (1990) A Methodology for the Estimation of Comparative Cocoa Production Costs. Cocoa Growers' Bull., **43**, pp.34-44.

This paper was presented at a Seminar organised by the Tropical Agriculture Association which was held in London on Tuesday 28th January 1992 and is published by the kind permission of the organisers.

COCOA PRODUCTION SYSTEMS: OPTIONS AND CONSTRAINTS

R.W.Smith *

INTRODUCTION

In recent years global cocoa production of about 2.4 million tonnes (Table 1), worth in 1990 some £1.7 billion, has exceeded demand. This has resulted in depressed international market prices, as reflected by international cocoa prices (Figure 1). The increased production has been almost exclusively the result of increased planting, particularly in countries such as Cote d'Ivoire, Malaysia and Indonesia. In traditional cocoa growing areas there has been very little in the way of increased yield per hectare from traditional producers. Some 90 per cent of world cocoa production is grown on family holdings of two hectares or less. In Malaysia, however cocoa is considered a plantation crop and production units can be anywhere between 1,000 and 10,000 hectares. In Indonesia, there are a number of plantations but also a very large number of small family farms, many of which are still to achieve their full mature production. In Indonesia, there are a number of plantations but also a very large number of small family farms, many of which are still able to achieve their full mature production.

The centre of diversity of the genus *Theobroma* lies in the headwaters of the Amazon River, and in early times a natural population of *T.cacao* was spread throughout Central Amazonia. Two major geographic "forms" evolved: the *Criollos* and *Forasteros* and within them, variants have been classified as varieties. A third group, the Trinitarios have been described either as a hybrid between these forms, or as a separate form.

The *Criollo* varieties were first exploited by indigenous Amerindian peoples in prehistoric times. The hardier and more vigorous *Forastero* populations were brought into cultivation more recently, in historic times, and form the basis of today's production in almost all producing areas throughout the world.

TRADITIONAL PRODUCTION SYSTEM

Cocoa has traditionally been grown from seed, sown at stake directly in the field. Establishment has been under thinned, forest shade, following logging and a few (one or three) years of food crop production. Food crops such as maize, cocoyam/taro, yams and cooking bananas (plantains), being the most common in, for example, Ecuador, Jamaica and West Africa. Such farmers have tended to plant their cocoa at a high density of 3,000 to 4,000 individual plants per hectare, largely to increase the probability of a reasonable stand surviving the neglect which followed the abandonment of food farms in the shifting cultivation systems. The high density ensured the rapid formation of a cocoa canopy and early suppression of weeds, thus enhancing the chances of survival. Often three or more

* Senior Agricultural Advisor (Research), Overseas Development Administration (ODA), 94 Victoria Street, London, SW1E 5JL, England.

seeds were planted at each station, allowing for failures in germination and losses due to squirrels and other rodents, but in many cases more than one tree survived and grew through to maturity. This further added to the density of the resulting stand.

TABLE 1: CHANGES IN COCOA PRODUCTION 1977/78 TO 1992/93

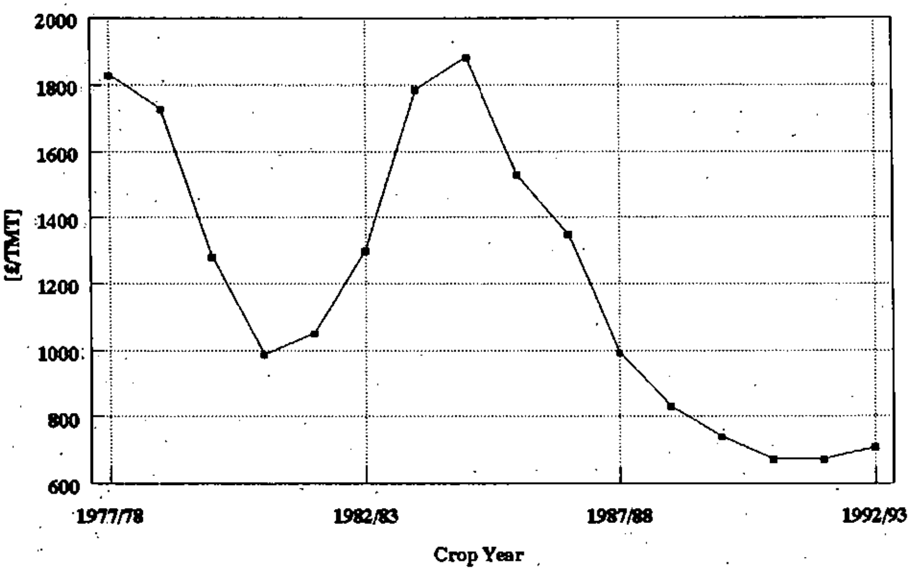
	1977/78	1992/93	Change
Cameroon	107	92	-15
Cote d'Ivoire	304	785	481
Ghana	268	312	44
Nigeria	207	130	-77
Others (Africa)	55	29	-26
Total Africa	**941**	**1,348**	**407**
Brazil	283	294	11
Colombia	29	50	21
Ecuador	79	69	-10
Mexico	33	50	17
Venezuela	18	16	-2
Others (Americas)	22	21	-1
Total C + S America	**464**	**500**	**36**
Total West Indies	**42**	**60**	**18**
Indonesia	4	223	219
Malaysia	21	224	203
PNG	30	39	9
Others (Asia)	10	18	8
Total Asia/Oceania	**65**	**504**	**439**
WORLD TOTAL	**1,512**	**2,412**	**900**

Source: Cocoa Statistics Market Report, E.D.& F.Man Limited, various issues
Units: 000's Tonnes

The high density caused the trees to grow tall, with reduced development of the lateral (fan) branches, and increased the vertical sucker or chupon growth through several tiers of jorquettes. This establishment system encouraged flowering on the main trunks at the expense of the branches, and was particularly suitable for certain Lower Amazon *Forastero* varieties, the most common one of which became known as West African Amelonado. No pruning was carried out, but natural pruning resulted from the die-back of laterals or when the main trunks were lost (for example as a result of mechanical damage from falling shade trees). In the latter cases, the main trunks were usually replaced by the natural regeneration of basal suckers or chupons.

Under these conditions, cocoa established easily and remained buffered from adverse environmental conditions such as drying winds, high in-coming solar radiation and insect attack. Nutrients were rapidly recycled through the development of a deep leaf litter under the cocoa canopy and a healthy biological degradation into organic matter. However (as in its wild native habitat) flower production and subsequent yields were generally low and because of the low yield, demands on nutrients from the inherently infertile soils were also low, enabling the plants to survive, but produce a low yield.

FIGURE 1: LONDON TERMINAL MARKET - 2nd POSITION



Farmer inputs into this simple, environmentally friendly and sustainable production system have been minimal. The main cost to the farmer is his own and his families time involved in harvesting, fermenting and sun-drying the crop. These are, in fact, the only essential inputs in normal circumstances in the absence of major pest and disease attack. For an average West African or Ecuadorian yield of, say 7,500 pods per hectare per year (giving about 300kg of dry cocoa per ha) harvesting is a job easily carried out by the farmer himself with family labour. The opportunity cost, however, of keeping the land under cocoa could be high, especially when prices are low and the price of food crops in the markets are high. In Ghana in the 1980s this resulted in much cocoa being abandonded, or even uprooted, and being replaced by food crops.

Other than harvesting, farmers often need to attend to pest and disease control. In South America, the main need is to remove, by pruning, all 'brooms' which result from Witches' Broom Disease (*Crinipellis perniciosa*), whereas in some parts of West Africa the chemical control of capsids is often essential, as is the cutting out of trees which exhibit symptoms of Cocoa Swollen-Shoot Virus (CSSV) together with their apparently healthy contacts and with their neighbours.

Weeding is only required during the establishment period, or when canopies are thinned by heavy pruning of brooms or parasitic mistletoes, or trees are removed for CSSV control, or when breaks in the canopy let in light which allows the weeds to grow, a situation which can occur when shade trees fall. Gaps in the canopy also occur in West Africa following serious capsid damage.

Smallholder cocoa in many producing countries has been shown to respond readily to simple agronomic interventions such as shade reduction, application of fertilisers in the presence of reduced shade, and weeding during the establishment phase. However, these, together with pest control procedures, are presently not attractive to many farmers because of the poor returns to the inputs and labour costs at a time of low producer prices and in the face of burdensome levies from state controlled marketing boards in some West African countries. In practice, many small growers produce a product of very high quality (for instance in Ghana) using only family labour.

LARGE-SCALE COCOA PRODUCTION

Cocoa farms and estates of up to a few hundred hectares in size were established many years ago in some areas, such as in the Cameroons by the Germans at the turn of the century, in Brazil, in Indonesia and a few places in the Caribbean. Most of these ventures were of limited commercial success, because plantation agriculture was not a traditional practice in most of the cocoa growing countries, and because high capital expenditure is not required for processing of cocoa ie. for the fermentation and drying to produce the cocoa beans of commerce. Hence processing on a commercial scale does not add any material value to the commodity as produced on a small-scale by peasant farmers, in contrast to other major perennial plantation crops such as oil palms, rubber and coffee, all of which require a capital intensive processing facility.

Nevertheless, the need to ferment and dry up to 2,500 tonnes of wet beans per year necessitates significant capital investment in large-scale fermentation and drying complexes by large plantations. Streamlining of harvesting, collection, fermentation and drying of cocoa is necessary, often incurring additional costs. Sun drying is impractical on such a large-scale so oil, charcoal, timber or other materials are used as a source of heat for artificial drying.

More recently commercial cocoa plantations have been established in Brazil, Malaysia, Indonesia and parts of the Pacific, but all have their problems and it has proved difficult to produce cocoa beans of the quality routinely produced by West African smallholders.

In a plantation operation, and in contrast to traditional systems, all inputs including capital, infrastructure, administration, labour and its welfare and materials are fully costed and charged against revenue from sales. A margin is required to pay taxes and reward shareholders for the risk taken. As many costs are related to area of crop rather than to yield, there is a strong pressure to increase the latter.

Increased yields are possible through the application of present technical knowledge. Yields of cocoa in excess of 1.8 tonnes per hectare and even up to three tonnes per hectare are maintained on the best managed estates in the most favoured environments. Cocoa will produce and maintain its maximum yield under greatly reduced shade conditions: that is with increased solar radiation, and freedom from competition by shade trees for both water and nutrients. However, such cocoa must be adequately supplied with both of these, and its canopy must be fully protected against adverse environmental effects such as desiccating winds, as well as from pests and diseases. Optimisation is possible only when soil type, topography and climate approach perfection, all the inputs are available and the plantation is well managed. The necessity for a high standard of management carries high costs. The risk factors are high: especially as the plantation is exposed to vagaries in the market prices, climate abnormalities, and the ever present threat of unexpected disease and pest outbreaks. Cocoa can of course be grown at somewhat lower than a maximum input/ouput situation. In these cases more shade cover becomes desirable, pruning management of the canopy is essential and the balance sheet of inputs versus outputs needs to be carefully calculated to ensure commercially viable profit margins are attainable.

ENVIRONMENTAL IMPLICATIONS

In environments conducive to the cultivation of cocoa, rainfall is frequent and can be heavy and solar radiation levels are usually high. On many soils, exposure and tillage, will lead to environmental deterioration including the loss of organic matter, erosion and the consequent lowering of fertility. The soils are often fragile. The need to maintain a vegetative cover is well documented and perennial crops which maintain an unbroken canopy are excellent for this purpose. Good, pure stand, shaded or unshaded cocoa is an ideal option, which to a large extent mimics the conditions under natural forest vegetation.

Biological diversity under plantation conditions is invariably less than that under smallholder systems. In well managed plantations with a high standard of sanitation and maintenance, there is considerable expenditure on achievement and maintenance of a sustainable ecological balance of pests/diseases/parasites/predators and pollinating midges. The risk of a build-up of pest and disease problems is always present, and these are likely to require intervention to maintain control. Integrated pest management, including stringent harvesting standards and manipulation of ant mosaics are practiced, not least to protect the pollinating midge population. These midges are also believed to depend upon cocoa pod waste and other organic debris to breed, and where this is removed, flower setting and yield could in some situations become reduced. Pests and diseases especially fungal diseases and parasitic mistletoes have become problems in other situations. In West Africa, the ecological balance of ant populations could easily be disturbed under a plantation system, leading to a build-up of the mealybug vectors of the virus diseases. In the Pacific, problems have arisen with the cocoa pod borer (or cocoa moth) populations and other insect pests, though these problems are not restricted to plantations.

Use of fossil fuels for crop drying in plantation systems brings environmental risks. Nowadays, the high cost of fossil fuels (even to gather wood) is giving rise to a need for alternatives such as fuelwood plantations or the use of other agricultural waste products, such as palm kernal shells where they are available.

Under traditional smallholder systems the ecology is more diverse, plots tend to be randomly arranged, are smaller and are influenced to a greater extent by the biological diversity adjacent to them and within them. High levels of sanitation are rarely practised to any great extent and agricultural chemicals are seldom used.

FUTURE TRENDS IN PRODUCTION SYSTEMS

Cocoa production in the future could move either towards plantations or towards smallholdings.

Some of the characteristics of these systems have been described above. The future appears to be dependent on price structures, which respond to market forces, to the availability of new technology for the management of the crop, to the results of scientific research and finally to innovation. Plantations are well placed to apply new technology, but they are likely to respond to market forces. Cocoa plantations have seldom proved to be a consistently good investment for the plantation companies or their shareholders, unlike other perennial tropical crop plantations such as oil palm, rubber, coffee and tea.

If production costs could be reduced sufficiently as a result of adoption of new technology such as:

- i) precocious high-yielding varieties;
- ii) resistance to major pests and diseases;
- iii) varieties well adapted to plantation management and the plantation environment, including intensification, but having desirable quality characteristics;
- iv) processing (fermenting, drying and handling) technology appropriate to the scale of the operation, and
- v) mechanisation;

and subject to availability of labour and suitable land, then the cocoa plantation sector might well advance in the future.

The future of the smallholder sector seems much more promising. The environmentally friendly, robust production system will thrive, providing prices show some improvement from the levels seen in the early 1990s. The chances of this will be improved if the economies of producing countries keep the prices of staple foodstuffs down to the point where there is a comparative advantage in producing cocoa rather than food crops and if foods are readily available in the local markets. Technology for smallholders must also advance in the areas of adequate yield potential under farmer management systems, particularly for low-input systems which rely on integrated pest management involving a high degree of biological control of the major pests and diseases. Better planting material would be most helpful in achieving this.

Cocoa is not amenable to an inter-cropping system, but added value may be generated by the use of multi-purpose shade trees, improved establishment systems using cash crops, the use of legumes to enhance nitrogen nutrition during and after establishment and integrating cocoa fields with non-cocoa crop enterprises, both in farm border areas and on adjacent land. The added value of other products from the cocoa trees, such as animal feed from cocoa pods and human food from the fermentation sweatings, could be an important economic incentive to production.

CONCLUSION

In summary there appears to be great future for smallholder cocoa, but an uncertain one for the plantation sector. Smallholder cocoa growing does, however, need continued research aimed at breeding adapted varieties which can produce well despite the presence of major pests and diseases, also requires the widespread use of integrated pest management, and research into the by-products of the crop.

This paper was presented at a Seminar organised by the Tropical Agriculture Association which was held in London on Tuesday 28th January 1992 and is published by the kind permission of the organisers. The data in Table 1 and Figure 1 has however been updated to include later seasons.

GREEN-PATCH BUDDING ON VERY YOUNG COCOA ROOTSTOCKS AND SIDE-GRAFTING OF MATURE TREES

S.T.K.Yow and D.H.K.Lim *

INTRODUCTION

In the East Malaysian State of Sabah, almost all the early cocoa plantings were with proven high yielding bi-parental crosses. The area under the crop expanded at a rapid rate from 1969 to reach a peak of around 211,000 hectares. A severe outbreak of vascular streak dieback disease (caused by *Oncobasidium theobromae* or VSD) in 1984 led to selection for tolerance of VSD and from the mid 1980s, an increasing proportion of new plantings was with clones. However, if clones and especially seedlings become infected with VSD in the nursery they grow poorly.

The most effective way to protect planting material against infection is to raise it under permanent nursery shelter with plastic roofs (Sidhu, 1987). These are expensive to build and the plastic roofing sheets require replacement at frequent intervals. This increases the cost of a seedling and more so a budding, which takes a longer time to raise. Until recently, all buddings were produced under shelters using the conventional method of greenish-brown budwood and 3 months old seedling rootstocks, which takes at least 6 months to produce a field plantable budding. A new technique based on that of Ramadasan and Yunus (1986) uses 2 week old seedling rootstocks and green patch budding to give field plantable buddings in 4 to 5 months from sowing of seeds. This rapid method increases output from the shelters and substantially reduces costs.

Yields of poorly performing mature seedling trees can be improved by side-grafting with proven VSD tolerant clones. A stick of two or more budeyes is inserted onto one side of the tree.

This paper describes how green-patch budding onto newly germinated cocoa rootstocks is carried out under plastic roofed shelters in the Planting Material Unit (PMU) nursery of the Scientific Department of BAL Plantations Sdn Bhd, in Sabah, Malaysia. It also describes side-grafting onto mature trees. The costs of green-patch and conventional budding are given in detail.

DEFINITIONS

Green-patch budding is insertion of buds from freshly hardened flush growth onto newly germinated seedling rootstocks.

* Scientific Department, BAL Plantations Sdn Bhd, PO Box 135, 91007 Tawau, Sabah, Malaysia.

Conventional budding is insertion of greenish brown buds from the second and third hardened flushes onto three to five month old rootstocks.

Side grafting is insertion of a stick of two or more buds from the second and third hardened flush into mature wood of any age.

GREEN-PATCH BUDDING

Each of the double-sided sloping plastic roofed nursery shelters (Figure 1) is 10.8m x 30.8m = 333m square. Efficient stacking of the polybags substantially improves utilisation.

With conventional greenish-brown budding using 3-4 months old seedlings, the polybags must be arranged in 2-row strips to permit easy working at budding time. There are eight walking paths each 0.45m wide, which occupy 105m square, and after allowing an apron of 0.77m on all four sides (64m square) to prevent rain splash and gain access, the nett available area is 164m square. Each 23cm x 36cm lay-flat polybag occupies 0.0165m square when filled with soil, so the shelter accommodates 9,940 polybags. Two week old seedlings without leaves can be used for green-patch budding. The polybags can be arranged in 4-row strips (Figure 1), with only four paths, which gives 3,492 (35%) more and yet there is still enough space for the budding operation.

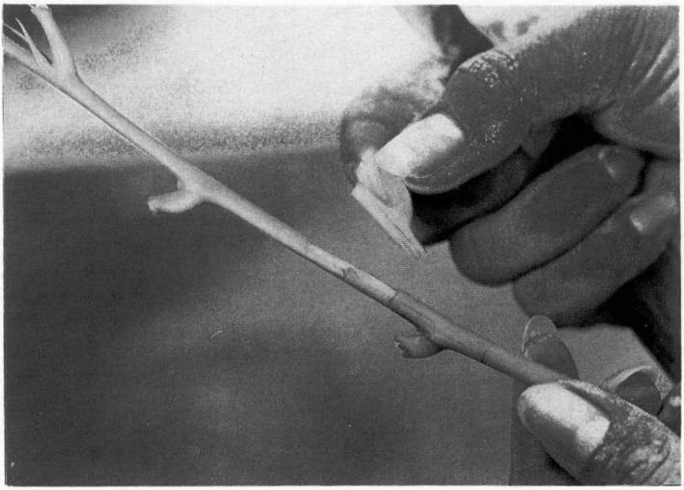
FIGURE 1: PLASTIC ROOFED SHELTER WITH TWO WEEK OLD ROOTSTOCKS ARRANGED IN 4-ROWS STRIPS

Any clone can be budded. Three locally proven VSD tolerant commercial clones are commonly used in Sabah: PBC 123, BAL 209 and BR 25. The mature green terminal shoot of a recently hardened flush (Figure 2) provides the newly mature green bud-stick.

FIGURE 2: RECENTLY HARDENED FLUSH WHICH PROVIDES THE GREEN-PATCH BUDDING MATERIAL

A rectangular bud-patch of dimension 4mm x 10mm (Figure 3) is carefully extracted. The petiole is used to lift out the bud-patch using a gentle sideways and upward motion.

FIGURE 3: EXTRACTION OF BUD PATCH READY FOR INSERTION INTO YOUNG ROOTSTOCK



It is important that the bud-patch is not fully extracted from the bud-stick until the rootstock is fully prepared to receive it, because exposed patches and prepared stocks begin to turn brown within 25 seconds and once they have turned brown they will not take.

FIGURE 4: PREPARING A TWO WEEK OLD ROOTSTOCK TO RECEIVE A BUD PATCH

Rootstocks should be used about 14 days after sowing ie. 8-10 days after emergence, with the cotyledons yet to separate. A panel is opened up just below the cotyledon, as shown in Figure 4, by making a horizontal cut about 4mm wide, the cut barely reaching the cambium.

The bark is then peeled back in a gentle downward motion to expose an opening of about 10mm long to accommodate the bud-patch. When both the bud-patch and the rootstock are ready, the bud-patch is lifted from the bud-stick by holding on to the petiole (Figure 3) and it is immediately inserted into the panel on the rootstock.

The excess bark is cut off to leave a tongue of about 3mm to hold the bottom end of the bud-patch (Figure 5).

Once the bud-patch is neatly in place, the excess petiole is cut off to just above the bud eye (Figure 6).

The bud-patch is bound with a 1cm x 4cm piece of stretchable Nescofilm (Nippon Shoji, Kaisha Limited, Osaka, Japan) (Figure 7).

FIGURE 5: THE PEELED BARK IS CUT OFF TO LEAVE A 3MM TONGUE TO HOLD THE BOTTOM END OF THE SCION BUD

FIGURE 6: NEATLY INSERTED PATCH BUD WITH BOTTOM END HELD UP BY 3MM TONGUE OF PEELED BARK OF ROOTSTOCK AND PETIOLE CUT BACK TO FACILITATE BINDING

FIGURE 7: GREEN-PATCH BUDDING WITH BINDING COMPLETED

The Nescofilm binding is removed after 14 days, the successful buddings sprout 7 to 10 days later (Figure 8) which is about 5 weeks from seed sowing. The buds should then grow actively.

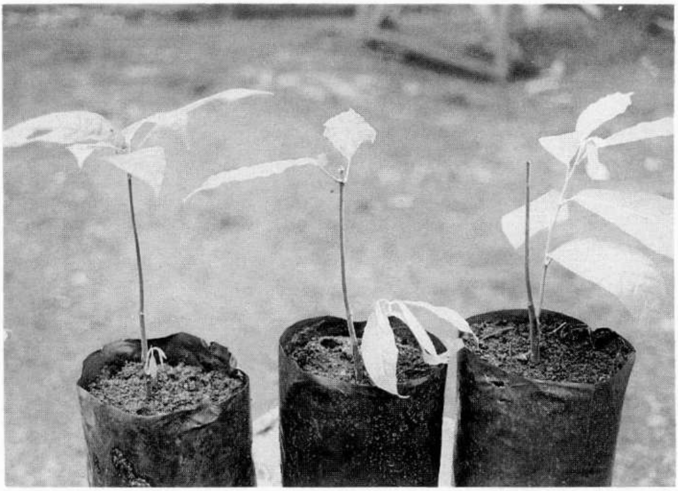
FIGURE 8: BUD BURST 7-10 DAYS AFTER OPENING IE. FIVE WEEKS AFTER SEED SOWING

From the 5th week, careful husbandry is required to ensure uninterrupted growth.

Guidelines for the production of plantable buddings in the shortest time include:

- **i)** retention of all mature leaves on the rootstocks in order to compensate for the rapid loss of cotyledon nutrient. All terminal stock-shoots must be removed regularly (7-10 days intervals) to avoid new growth competing with the scion for light, nutrient and water;
- **ii)** watering must be done daily under plastic shelters. Low pressure watering is necessary especially during and after budding to avoid damage to the young emerging scions;
- **iii)** gradually remove mature stock leaves in proportion to scion growth over a period of two to three months (Figure 9);
- **iv)** manuring should only commence when the first flush of the budding has fully hardened (about 6 weeks after successful budding).

FIGURE 9: REMOVAL OF TERMINAL SHOOTS AND MATURED LEAVES OF ROOTSTOCK



Green-patch budding of two to three week old rootstocks not only reduces cost compared with conventional budding, but speeds up reproduction and maximises utilisation of budwood, especially when sources are limited.

The estimated cost of a budding produced by the green patch method is about USD 0.29 (Table 1) compared with USD 0.46 for conventional budding, including the cost of failures.

TABLE 1: ESTIMATED COST PER NURSERY BUDDING (IN US CENTS (*))

Activity		Green-Patch	Conventional
Land preparation	- clearing, levelling and draining of land.	0.58	0.96
Covers & Shade	- repair to shelter, replacement of plastic sheets and pruning shade trees.	3.08	7.69
Planting & Supplying	- transport of top soil, filling and stacking of polybags, planting stock seeds, watering and budding.	16.54	23.46
Weeding	- hand weeding in and around polybags as well as spraying surrounding area.	0.38	0.77
Manuring	- application of fertilizer in granular form or as foliar spray.	1.73	3.65
Pest & Disease	- mainly prophylactic use of insecticides against leaf eating pests.	0.77	1.92
Pruning & Sanitation	- pruning side and terminal stock shoots, and removal of runts, dead and diseased plants.	3.08	3.85
Infrastructure	- marking, painting and stencilling of marker pegs.	1.54	1.92
Tools	- Equipment such as spraying pumps, wheel barrow, budding knives, paint, paint brushes and nescofilm.	0.77	1.16
Supervision	- to arrange and supervise all nursery operations.	0.38	0.77
		28.85	**46.15**

(*) Exchange rate of RM 2.50 = USD 1.00 has been assumed.

Table 1 shows that the reduction in cost is due to:

i) reduced inputs such as pest protection and manuring for rootstock prior to budding;

ii) more polybags stacked per unit area;

iii) buddings become plantable sooner.

In a commercial scale operation, a worker buds over 200 plants a day using green-patch budding, with an average of over 80% budding success (Table 2).

TABLE 2: BUDDING SUCCESS OF INDIVIDUALS WITH GREEN-PATCH BUDDING FOR THE PERIOD SEPTEMBER 1991 TO JANUARY 1992

Budder	Total Buddings	Success at Opening	Percentage
A	6358	5304	80
B	4009	3354	83
C	5781	4541	78
D	6212	5576	89
E	2922	2384	81
F	6912	6155	89
G	6175	5423	88
Overall	**37369**	**32737**	**88**

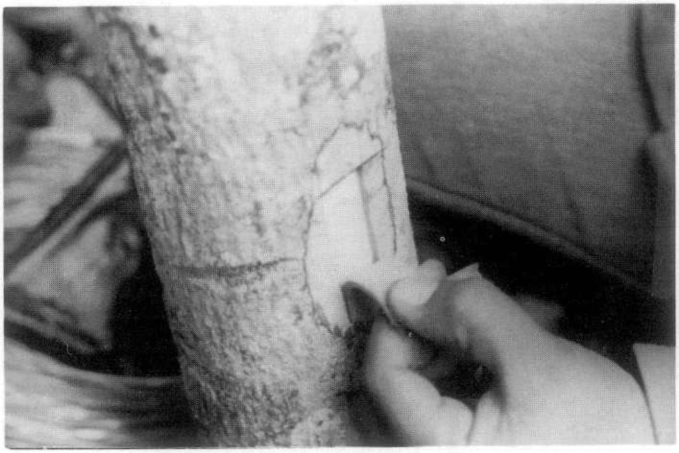
SIDE-GRAFTING IN MATURE COCOA

In this form of vegetative propagation, a matured graftstick of two or more budeyes is inserted onto one side of a mature tree of any age. A necessary qualification is that the bark of the receiving tree must be healthy and able to peel readily. This method of grafting is used most commonly to upgrade the production of poor yielding or non-bearing mature trees that are already planted in the fields. The method was first used on BAL in 1991 and 1992 in seed gardens for conversion of one clone to another.

It is important to select healthy and matured flush growth from fan branches of the desired clone to provide the graft sticks. A worker can prepare at least 600 sticks in a day.

Grafting can be done at any convenient height on the stock tree. A healthy section is selected and the cambium is exposed by cutting into the bark an inverted "U" to receive the graft stick. Where the bark is too thick to work, the top layer may be shaved off before the "U" is cut (Figure 10).

FIGURE 10: MATURE TREE WITH CAMBIUM REVEALED BY PEELING BACK THE BARK



Using a sharp knife make a clean slanting cut at the lower portion of the stick, about mid-way between two nodes (Figure 11).

FIGURE 11: GRAFTSTICK WITH A CLEAN SLANTING CUT AT THE LOWER END

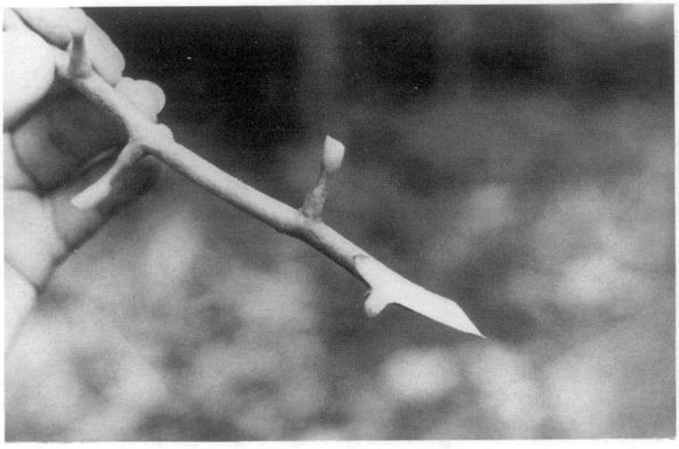


FIGURE 12: GRAFTSTICK INSERTED ONTO STOCK TREE AND HELD UP BY THE PEELED BARK STRIP

Peel down the cut bark of the receiving tree to expose the cambium layer and insert the bud-stick as illustrated in Figure 12.

FIGURE 13: BARK AND GRAFTSTICK BOUND WITH STRONG RAFFIA STRING

Securely bind together the bottom end of the graftstick and peeled bark using a strong piece of raffia string (Figure 13) leaving enough to tie the plastic bag which will be used to cap the stick. About 2m of string is required.

FIGURE 14: GRAFTSTICK COVERED WITH A CLEAR PLASTIC BAG (9 X 19CM FOR AN 11CM BUD STICK) AND TIED WITH THE BALANCE OF THE RAFFIA STRING

Cap the whole graft stick with a clear plastic bag (Figure 14) and secure tightly.

Leave and examine for success after 3 weeks, viewing through the clear plastic bag. The bag can be removed 4 to 5 weeks after grafting if the stick has taken and sprouted new growth (Figure 15). Leave the string to bind the lower end of the graft stick for a further period. This string can be re-used to tie the droopy growth of the successful graft onto the stock tree.

When it is certain that the grafted stick is properly established, the stock tree is cut back, either progressively or at one go. The cut should be 45-60cm above the union (Figure 16). Apply wound dressing to the cut stumps.

Ensure that new vegetative growth is removed from the stock tree constantly to allow unimpeded growth of the successful side-grafting. At BAL, flowering and cherelle formation occurred 9 months after grafting and harvesting resumed at 12 months after cutback of stock trees.

FIGURE 15: SPROUTED STICK 6 WEEKS AFTER GRAFTING

Skilled workers do 120 - 150 grafts per day expecting 76 - 80% success, with some managing 300, depending on the condition of the bark.

FIGURE 16: ACTIVELY GROWING STICK 3 MONTHS AFTER GRAFTING. UNION STILL TIED WITH RAFFIA

DISCUSSION

Green-patch Budding

Both green-patch budding of very young rootstocks for mass vegetative propagation and side grafting for genetic improvement of existing cocoa fields have the potential for large scale application.

Time saved in the nursery is one advantage of green-patch budding. The conventional practice of greenish-brown budding onto 3-4 month old seedling rootstocks takes a minimum of six months to produce field plantable material, compared with no more than five months for green-patch budding. The significant improvement in nursery utilisation is especially valuable if expensive nursery structures with high maintenance costs are required to protect young material against disease, as they are in Sabah. Failures are much less wasteful of costly space than they are with conventional budding. The unit cost of planting material is reduced by green-patch budding, the benefit increasing as planting densities for clonal cocoa are raised to 1,200-1,500/ha as is current practice in Sabah or to up to 3,333/ha in experimental high density plantings.

The green-patch budding technique increases the uniformity of nursery stock. There is minimal variation in either the age or the developmental stage of the stock and scion, so the buds shoot over a short period and grow at similar rates. In contrast, with conventional budding, the buds shoot over an extended period, cut back times vary and growth is much less even. The greater uniformity of green-patch budded material is especially beneficial at higher planting densities.

Green-patch budding is much less wasteful of budwood because it is all used, whereas with conventional budding the green material is normally discarded. Stock plants produce green budwood quicker and in greater quantity compared to conventional budwood, hence it is more readily available. If budwood is in scarce supply, earlier successful buddings can be cut back at four months to give four or more buds which can be used for further multiplication. Availability of this method of rapid multiplication suggests that micro-propagation is more likely to be a tool in specialised activities such as germplasm management than in large scale planting on a commercial scale.

Side-grafting

Side-grafting allows rapid improvement of cocoa which is unproductive because the planting material has proven to be ill chosen. In Sabah, the epidemic of VSD from 1984 onwards greatly reduced the yield of many seedling plantings. Now that proven productive and VSD tolerant clones are available, these plantings can be upgraded by side-grafting. This is becoming popular with some of the more progressive growers whose holdings in the Tawau and Sandakan areas have been hit hard by VSD. For example, the yield for one smallholder, who planted 130 hectares of seedling cocoa in 1977, fell from 2.22t dry beans/ha in 1987 to about half. In nine months, labour on BAL estate made up to four successful side grafts of two buds each on every tree (1120/ha), using the clone PBC123. In 1992, the second year after grafting, the yield was 1.4t/ha, 1.0t/ha was harvested in the first four months of 1993, with 2.5t/ha expected for the year. The cost was estimated at USD 0.05 per graft. The technique has been used on a smaller scale on BAL to replace clones with excessive production of vegetative material in experimental high density plantings.

REFERENCES

Ramadasan, K. and Mohd. Yunus Ahmad (1986) Recent Advance in Vegetative Propagation Techniques of Theobroma cacao L., *Cocoa and Coconuts*: Progress and Outlook. Proc. Conf. Incorp. Soc. Planter and MCGC, Kuala Lumpur 1984, pp.133-146.

Sidhu, M. (1987) Some Short-Term Investigations into the Management of Vascular Streak Dieback Disease on Young Cocoa in Giram Estate, Sabah, Malaysia. *Planter* 63, pp.47-58.

ACKNOWLEDGEMENTS

The authors express grateful thanks to the Managing Director of BAL Plantations Sdn Bhd for permission to publish this paper. Thanks are due to Dr G.Lockwood for his comments and review during its writing.

HORIZONTAL RESISTANCE TO COCOA DISEASES

N.W.Simmonds *

INTRODUCTION

Most diseases are controlled in most crops most of the time by polygenic resistance (HR, horizontal resistance). Major gene, pathotype-specific resistance (VR, vertical resistance) has often, even usually, failed because overcome by the evolution of new pathotypes. Cocoa Witches' Broom disease provides a good instance of just such a failure (Bartley, 1986). HR in general is stable, not susceptible to new pathotypes and is ubiquitous if sought, but it generally offers less than immunity and must be genetically constructed. HR has recently been comprehensively reviewed by Simmonds (1991). Evidence of HR to three serious cocoa diseases is listed there. Since writing that review, I have come to appreciate that there is more evidence of effective HR in the crop than is generally known: The purpose of this report is to outline recent analyses of published data, not to present a comprehensive review of disease resistance in the crop. Bartley (1986) stated that: "Breeding for disease resistance in cocoa has been, on the whole, very unsuccessful". So it has, but there now appears to be more resistance than was then apparent.

A few words of general explanation may not be amiss. VR has very generally failed because it depends upon single major genes to which the pathogen readily responds by the appropriate mutation. Indeed, the necessary mutation is often 'out there waiting' and failure is virtually instantaneous. So much is common experience, though not simply predictable. VR is very attractive if/when it works well (as, very rarely, it does) because it is easy to breed and offers immunity or near-immunity. HR is polygenic, harder to breed and often less complete in effect but is 'durable' and always constructable. If needed, in practice, the great majority of plant diseases are fairly well controlled thus, because HR has been built up by (often largely unconscious) selection over many generations. Only in the past few decades have these facts become generally appreciated and the essential genetic simplicity (despite polygenic inheritance) become understood (Simmonds, 1991).

DATA SOURCE AND ANALYSES

All the data analysed here are drawn from the Annual Reports on Cocoa Research, (Regional Research Centre), University of the West Indies, Trinidad, 1962-1975. For brevity, I refer to these reports simply by their year of publication (eg. Table 1, 1963-1973). I examined the whole series, looking for data on disease incidence in trials of progenies of well-enough defined parentage to permit genetical inference. The few data available all referred to M x N type matings. Unfortunately, there were no diallel crosses, nor enough parental control clones to permit offspring-parent regression analyses. The analysable crosses gave information on combining ability on three serious diseases, as

---

* University of Edinburgh, IERM, SAC, West Mains Road, Edinburgh, EH9 3JG, Scotland, England.
Present address: 9 McLaren Road, Edinburgh, EH9 2BN, England.

listed below. 'Combining abilities' are statistically additive constants which estimate the capacity of a parent to transmit a quantitative genetic character to its progeny (Simmonds, 1979). The data are imperfect because they are few, because M x N matings are less informative than diallels and because full parental controls were lacking. But results are nevertheless clear enough to be taken seriously.

TABLE 1: DATA ANALYSED

Year	Experiment	Families	Character	r^2
1963	A	3x2 = 6	Deaths % from CW	87
1971	B1	4x3 = 12	Pod losses % from WB	80
1971	B2	4x3 = 12	Trees infected % by WB	90
1972	C1	2x3 = 6	Pod losses % from WB, 2yr	85
1972	C2	2x3 = 6	Pod losses % from WB, 2yr	79
1973	C3	2x3 = 6	Pod losses % from WB	73
1973	C4	2x3 = 6	Pod losses % from BP	95

Years are those attaching to the relevant annual reports. Letters assigned to experiments are arbitrary and associated numbers relate to different bodies of data identified in Column 4. Families are all of orthogonal MxN mating type. The last column r^2, gives the proportions of observed sums of squares accounted for by fitting GCA.

The diseases, with convenient abbreviations, were: Witches' Broom (or WB) disease *(Crinipellis perniciosa)*; Black Pod (or BP) (*Phytophthora palmivora* and probably two or three other species); Ceratocystis Wilt (or CW) (*Ceratocystis fimbriata*). Later I shall refer to the still rather localised Vascular Streak Dieback (VSD or *Oncobasidium theobromae* in Southeast Asia) and Cocoa Swollen Shoot Virus (CSSV in West Africa).

There are two statistical points to make. All the data take the form of percentage infection of pods or trees. Sometimes, angular transformation of such data would be appropriate. But normality of residuals is not of interest in these experiments and the transformations which were tried made no difference to interpretation. Second, the general combining ability (GCA) values fitted (Table 2) represent the simple additive bits of genetical control. If proper analyses, with errors, had been available (they were not), one might have been able to say something about the unpredictable interactive fractions or 'specific combining abilities' (SCA). In the outcome, the GCA were so large that there was little room for SCA. This is rather common experience in regard to HR studies of disease resistance (Simmonds, 1991). However, Gardella et al., (1982) did detect an SCA effect in relation to *Ceratocystis* Wilt.

Given an experiment mean and two estimated GCA values, a family expectation can be stated as D_E = Mean + G_A + G_B, where the G are parental constants. The observed incidence is labelled D_O and residual differences (D_O - D_E = S) are specific, interactive effects (which can not be explored in these data). Dramatically (Figures 1, 2, 4 & 5), the S appear as deviations (all small) from the regressions of unit slope of D_O on D_E.

RESULTS

Seven usable data sets were found (Table 1), relating to HR to the three diseases *Ceratocystis*, Witches' Broom and Black Pod disease. The r^2 values in the last column of Table 1 show that GCA gave rather good accounts of the data. Estimated GCA values are listed in Table 2. Quite casual inspection suffices to suggest rather strong correlations between certain entries which will be discussed again later.

TABLE 2: GENERAL COMBINING ABILITIES (GCA) OF PARENTAL CLONES IN DESCENDING ORDER OF RESISTANCE FOR THE EXPERIMENTS LISTED IN TABLE 1

Expt	Mean	Clone (GCA)
A	6.1	ICS6(-5.1) SCA6(-1.1) ICS1(+0.2) SCA12(+1.0) ICS60(+4.9)
B1	12.4	SCA6(-4.7) ICS95(-2.1) ICS111(-2.1) ICS89(-0.1) ICS88(+1.8) ICS8(+2.8) GS36(+4.3)
B2	70.6	SCA6(-23.8) ICS111(-20.6) ICS89(+1.1) ICS95(+2.1) ICS88(+5.2) GS36(+17.4) ICS8(+18.7)
C1	11.7	SCA6(-2.3) SCA12(-1.0) ICS8(-0.4) ICS6(+0.4) P12(+3.3)
C2	18.8	SCA6(-3.4) SCA12(-0.6) ICS8(-0.5) ISC6(+0.5) P12(+4.2)
C3	18.0	SCA6(-3.5) ICS6(-0.7) SCA12(-0.5) ICS8(+0.7) P12(+4.0)
C4	21.5	SCA6(-6.5) ICS6(-0.8) ICS8(+0.8) SCA12(+1.0) P12(+5.5)

Experiment A refers to CW (*Ceratocystis* wilt); B1, B2, C1 and C3 refer to WB (Witches' Broom, *Crinipellis*); C2 and C4 refer to BP (Black Pod, *Phytophthora*).

The simplest way of judging the inferences to be drawn from GCA estimates is to examine graphs of observed (D_O) against expected (D_E) data points (Simmonds, 1979; for elementary statistical treatment; Simmonds, 1991; for disease examples). Further numerical details are unnecessary because the main results can be presented graphically. Joint means are plotted as asterisks (*).

Figure 1 demonstrates HR to *Ceratocystis* and identifies ICS 6 as a strikingly resistant parent. Figure 2 presents evidence of Witches' Broom resistance in both pods and whole plants in one experiment; plants were more highly infected than pods and SCA 6 contributed resistance in respect of both.

FIGURE 1: COMBINING ABILITY ANALYSIS OF HR TO CW, CERATOCYSTIS FIMBRIATA

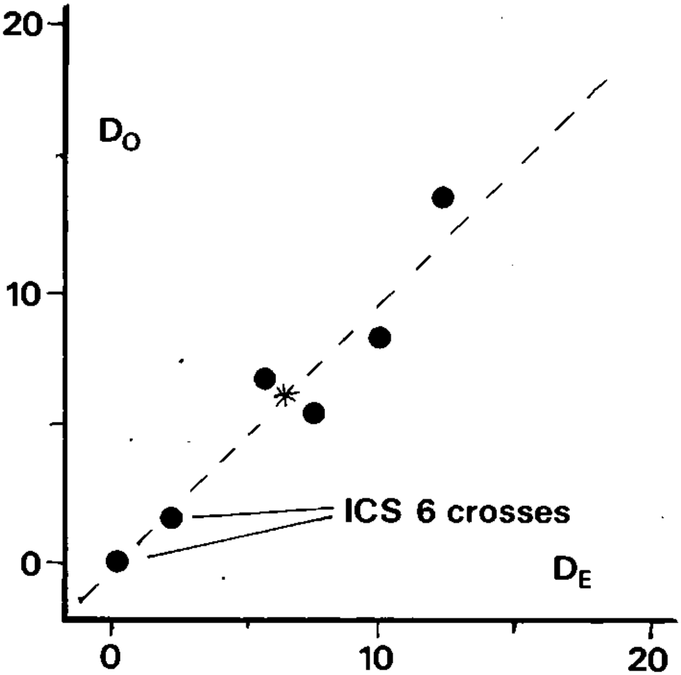


Figure 3 uses the same data as Figure 2 but shows (which is not shown by Figure 2) that pod and tree responses are fairly closely related. This could be important because diseases are known in which different plant parts respond somewhat differently (for example, foliage and tuber reactions of potatoes to blight, *Phytophthora infestans*).

In Figure 4, two data sets show clear evidence of HR to Witches' Broom in the pods and again identify SCA 6 as a resistant parent. Figure 5 does for Black Pod what Figure 4 does for Witches' Broom and in the same experiment (Table 1). Again, SCA 6 confers resistance in the form of non-susceptability of pods to rotting caused by whichever species of *Phytophthora* was involved.

Figure 6 shows that HR to Witches' Broom and Black Pod are fairly highly correlated and that the correlation is plain over two years having different mean levels of infection. Of course this assumes that the two diseases were accurately discriminated at time of recording the data.

FIGURE 2: COMBINING ABILITY ANALYSIS OF HR TO WB, CRINIPELLIS PERNICIOSA, IN PODS (DOTS) AND WHOLE TREES (CIRCLES)

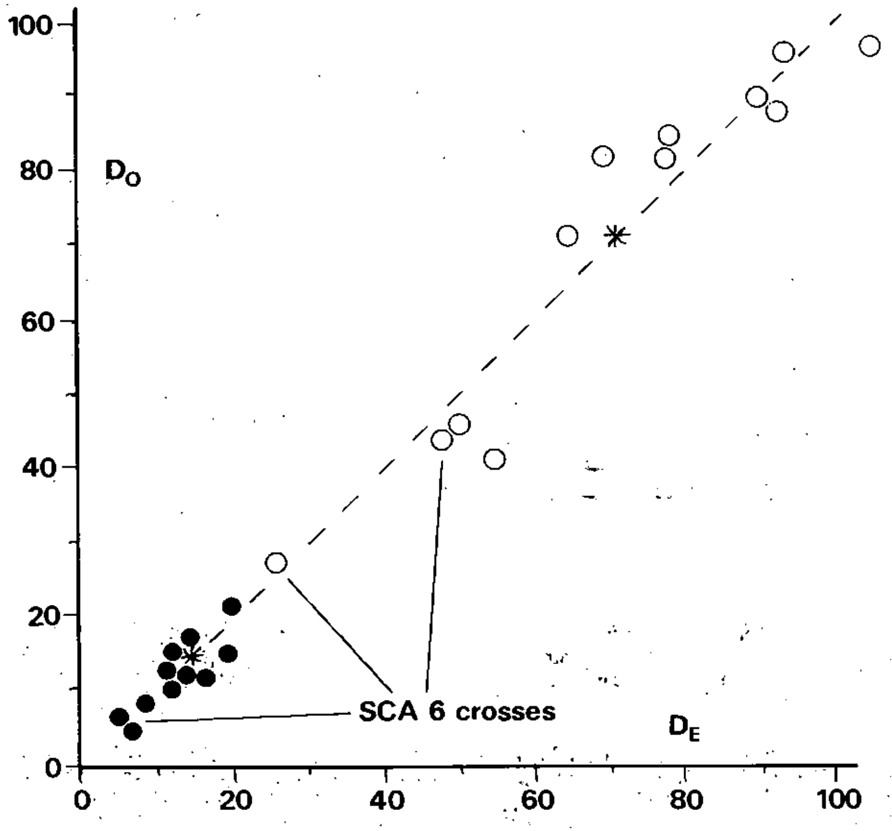
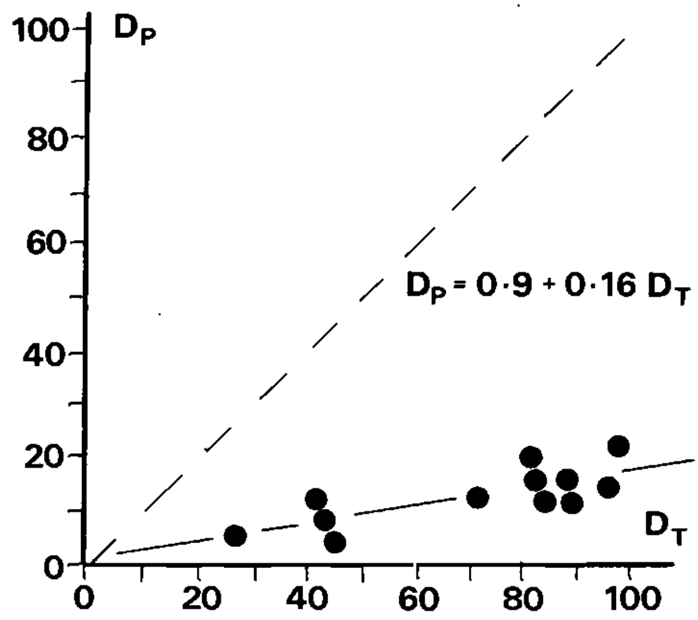


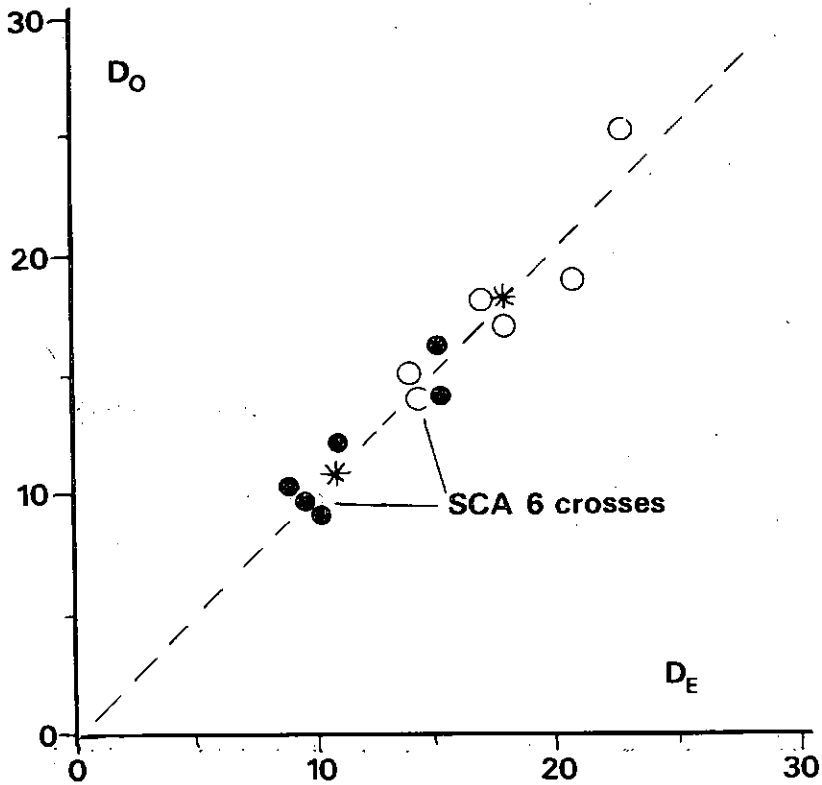
FIGURE 3: RELATION BETWEEN RESPONSES OF PODS (D_P) AND WHOLE TREES (D_T) TO WB [BASED ON SAME EXPERIMENT AS FIGURE 2]



At first sight, correlated resistance to two quite different diseases may seem surprising and, indeed, is rather unusual. But other examples are known (Simmonds, 1991). If the correlation holds up, it will be good luck for the cocoa breeder and might suggest interesting pathological studies.

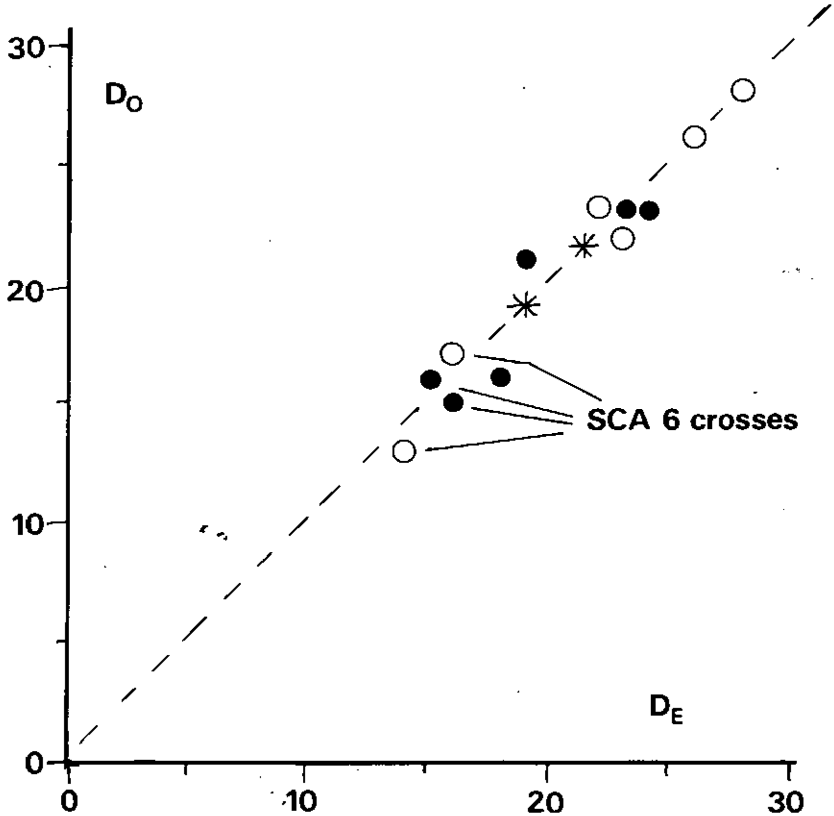
Table 2 identifies clones that confer more or less resistance on progeny, negative GCA levels representing less disease and therefore more resistance. The plant breeder would normally prefer to estimate resistance and therefore to write something like R = (100-D) for percentage data such as these. It is clear that cocoa breeders (like potato breeders, for example Simmonds and Wastie, 1987) should move to such a system but, for the present purpose, it seems appropriate to stay close to the original data.

FIGURE 4: COMBINING ABILITY ANALYSIS OF HR TO WB IN PODS OVER TWO SEASONS (1972 DOTS, 1973 CIRCLES)



The striking fact about Table 2 is that, as some simple graphs and regressions readily show (entries C1-C3, C2-C4), GCA values are repeatable between seasons. Indeed, it would be rather worrying if they were not. In addition in a comparison between (C1-C2) and (C3-C4), the GCA for two different diseases are correlated (as suggested but not proved by Figure 6). Indeed, the relations are strikingly close, with r^2 over 90%, though too few observations to be really satisfactory.

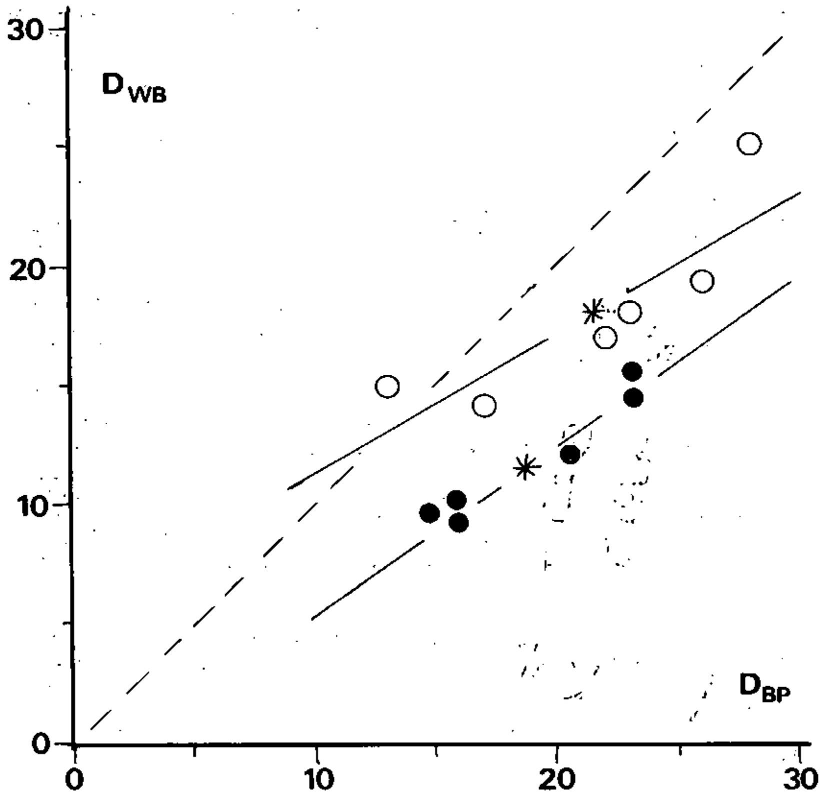
FIGURE 5: COMBINING ABILITY ANALYSIS OF HR TO BP IN PODS OVER TWO SEASONS (1972 DOTS, 1973 CIRCLES)



CONCLUSION

There is now evidence of substantial HR against five of the main cocoa diseases; namely, Witches' Broom (this paper);

FIGURE 6: CORRELATED RESISTANCE TO WB AND BP IN SIX FAMILIES OVER TWO SEASONS (1972 DOTS, 1973 CIRCLES)



Note: The r^2 proportions of SS taken up by regressions are 94 and 72 percent respectively

Black Pod (Tan and Tan, 1990; Simmonds, 1991; citing Sitapei, 1989; this paper); Ceratocystis (Gardella et al., 1982; this paper); Vascular Streak Dieback (Tan and Tan, 1988; Simmonds, 1991; Lockwood pers. comm.) and Cocoa Swollen Shoot Virus (Lockwood, 1981). The evidence mostly takes the form of GCA analysis but there is abundant anecdotal evidence (eg. in Wood and Lass, 1985 and in the Trinidad reports) of repeatable differences between clones and families that can only be interpreted as being due to HR. Reyes and Reyes (1978) give a good example of probable differences between families in respect of *Ceratocystis* response but no acceptable genetical information. It can hardly be over-emphasized that statistically secure genetical evidence is essential for confident diagnosis of HR.

Two caveats should be stated in relation to Black Pod. Several *Phytophthora* species have been (rather erratically) implicated and it has not been demonstrated that cocoa displays responses common to all. Pod rots are the most conspicuous effects but vegetative cankers are also implicated. Thus there may be more than one resistance to be sought. Also, resistance may be confused with disease escape by way of a time-of-bearing effect (Lockwood and Dakwa, 1978).

Another potentially serious disease upon which I have found no breeding information is caused by *Moniliophthora roreri*. It seems to be still spreading in South America (Bartley, 1986). No doubt, HR to it would be swiftly found if systematically sought by appropriate genetical tests.

There is no doubt that, from first principles, resistance to all these diseases could be built up over generations by methods familiar in a multitude of other crops; and, wherever cocoa is efficiently bred, no doubt it will be built up. The general failure noted by Bartley (1986) reflects a long-term failure of comprehension of the facts that a VR immunity against an airborne fungus is a mirage and that HR is always constructable. It must surely be significant that the very competent breeding programmes that are now in place in Southeast Asia quickly identified HR to Black Pod and Vascular Streak Dieback as the bases for control.

An essential condition for effective HR breeding would be the establishment of orderly repeatable testing systems firmly founded upon biometrical-genetic understanding. Unfortunately, it seems that such systems are not yet available for the diseases treated in the Trinidad reports.

REFERENCES

Bartley, B.G.D (1986) Cacao, Theobroma cacao.. FAO, Breeding for Durable Resistance in Perennial Crops. FAO, Rome, pp.25-42.

Cocoa Research Scheme (1962-1975) Annual Reports on Cocoa Research, Regional Research Centre, University of the West Indies, Trinidad.

Gardella,G.S., Enriquez,G.A. and Saunders,J.L. (1982) Inheritance of Resistance to Ceratocystis fimbriata in Cacao Hybrids. Proc. 8th Internat. Cocoa Res. Conf., Cartegena, Colombia, pp.695-702.

Lockwood,G. (1981) Genetic Aspects of Resistance to Cocoa Swollen Shoot Disease in Ghana. Ann. Appl. Biol., **98**, pp.131-141.

Lockwood,G. and Dakwa,J.T. (1978) The Influence of Self-incompatibility on the Time of Harvesting of Cocoa in Ghana in Relation to Loses from Black Pod Disease. J. Hort. Sci., **53**, pp.105-108.

Reyes,L.C. and Reyes,H. (1978) Obtencion de Cultivares de Cacao Resistentes al Hongo Ceratocystis fimbriata. Proc. 6th Internat. Cocoa Res. Conf., Caracas, Venezuela, pp.499-502.

Simmonds,N.W. (1979) Principles of Crop Improvement. Longman Group Ltd, London.

Simmonds,N.W. (1991) Genetics of Horizontal Resistance to Diseases of Crops. Biol. Rev., **66**, pp.189-241.

Simmonds,N.W. and Wastie,R.L. (1987) Assessment of Horizontal Resistance to Late Blight of Potatoes. Ann. Appl. Biol., **111**, pp.213-221.

Sitapei,E.C. (1989) Studies of Resistance in Cacao (Theobroma cacao) to Phytophthora palmivora. Thesis, UWI, Trinidad, pp.234.

Tan,G.Y. and Tan,W.K. (1988) Genetic Variation in Resistance to Vascular Streak Dieback in Cocoa. Theor. Appl. Genet., **75**, pp.761-766.

Tan,G.Y. and Tan,W.K. (1990) Additive Inheritance of Resistance to Pod Rot caused by Phytophthora palmivora in cocoa. Theor. Appl. Genet., **79**, pp.193-199.

Wood,G.A.R. and Lass,R.A. (1985) Cocoa 4th Edition, Tropical Agricultural Series, Longman Group Ltd, London, pp.620.

ACKNOWLEDGEMENTS

My thanks are due to Dr G.Lockwood for helpful comments and references.

NOTES ON CONTRIBUTORS

E.BLOOMFIELD

Born in Boston, Massachusetts, USA; BA in Geography from University of Chicago in 1982; Masters in Public Administration from The Maxwell School of Citizenship; Public Affairs at Syracuse University in 1984; M.Phil in Economics from Oxford University in 1988; 1984-1987: Researcher in the Public Sector Management Unit at the World Bank, Washington DC; 1989 to 1993: Senior Research Economist in cocoa and coffee at Landell Mills Commodities Studies in Oxford, England.

R.W.SMITH

Born in the United Kingdom; First employment in tropical agriculture at WACRI (now CRIG) in Ghana as cocoa research agronomist from 1957 to 1962; Subsequently was crop physiologist/agronomist with the Coconut Industry Board Research Department, Jamaica from 1962 to 1972; Joined the British Overseas Development Administration in 1972 as Assistant Agricultural Research Adviser, and is now Senior Agricultural Research Adviser; Specialises in tropical agricultural research with particular interest in perennial crops; Also, is Chairman of the Bureau for Research on Tropical Perennial Oil Crops (BUROTROP).

S.T.K.YOW

Graduated with B.Agr.Sc from the University of Sydney in 1973; Joined BAL Plantations Sendirian Berhad (a subsidiary company of Commonwealth Development Corporation) as an Agricultural Assistant in December 1974 and promoted to Divisional Manager for cocoa on Mostyn Estate in 1982; Has working experience on other crops, oil palm and rubber, being Relief Manager for estates from April 1987; Since November 1988, and the current time, he has been Manager Planting Materials Unit at BAL Plantations, a post largely responsible for all planting materials for the organisation and for sales, especially cocoa.

D.H.K.LIM

Since graduating, has been involved with agricultural research, starting as a Research Assistant on oil crops at the Kimberley Research Station of Nort-Western Australia in 1961/62 and continued on as Research Officer with BAL Plantations Sdn Bhd since 1964; Has research and working experience on most major tree crops especially on cocoa; Currently, the Scientific Development Officer and Head of Research in the Scientific Department of the Company.

N.W.SIMMONDS

Plant breeder/geneticist with 50 years experience in temperate and tropical agriculture, including much with bananas, sugarcane, rubber, potatoes and less with cocoa; Much experience with disease resistance breeding in various crops. Several books and well over 100 papers; Many years in Trinidad, Hertford and Edinburgh; Currently Emeritus Professor at University of Edinburgh though close to retirement.

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

JUNE 1992

[Study of colouration developed during the cocoa alkalization process]. Etude de la matiere colorante developpee au cours du procede d'alcalinisation du cacao
BIANCHI,J. USTL, Montpellier (France), p.119; 1990
A study was conducted on the influence of alkalization conditions on the final colour of cocoa powder. Processing parameters for colour shade and intensity were: (1) the duration of the application, temperature, nature and concentration of the alkaline agent; (2) the amount of water and oxygen in the medium, and (3) the initial pH of the cocoa beans. Variations in drying time, replacement or improvement of the conventional alkalization process through the use of enzymatic processing did not intensify the colour. The existence of 2 types of compounds was demonstrated: (1) extractable brown-red compounds of which the formation, solubility and intensity increased with the pH, and (2) un-extractable brown compounds that formed in the absence of an alkaline agent, provided that the powder had 20 to 50% moisture content. The soluble staining agent was made up of compounds of various sizes, but of the same colour, a combination of oxidized flavanols and amino compounds.

JULY 1992

The cocoa industry in Malaysia
RAHMAN,A.A.A. Faculty of Economics and Management, Universiti Pertanian Malaysia, Serdang, Selangor (Malaysia) - *Kieler Arbeitspapiere - Institut fur Weltwirtschaft; Universitat Kiel (Germany)* no.449, p.41; Nov 1990
Information is provided on the cocoa industry in Malaysia. The history of the development of the cocoa industry, before and after independence, is outlined, with special reference to the government policies which stimulated its growth. Other subjects discussed include: (1) crop area, production and yield; (2) export, import and prices; (3) local processing, and (4) the marketing channels and the pricing system for cocoa.

AUGUST 1992

Free amino acids in fresh and fermented cocoa beans inoculated with Saccharomyces cerevisiae (wild strain)
OTHMAN,A.S., MOHD,F.P., JINAP,S. and LEE,C.H. Department of Biochemistry and Microbiology, Universiti Pertanian Malaysia, Serdang, Selangor (Malaysia) - *Planter (Malaysia)* v.68(790), p.3-6; Jan 1992
Research was conducted in Malaysia, on the fermentation of cocoa beans inoculated with Saccharomyces cerevisiae. The overall percentage of free amino acids per unit dry weight in the fresh beans was slightly higher than in the control (natural fermentation) and in the inoculated beans. However, the protein content of the control beans was higher by about 17% and 61%, compared with inoculated beans and fresh beans, respectively.

SEPTEMBER 1992

[The cocoa world market: world market orientated development and national steering policies of the producing countries. 1. World market, Malaysia, Brazil. 2. Africa]. Der Kakaoweltmarkt: Weltmarktintegrierte Entwicklung und nationale Steuerungspolitik der Produzentenlander. 1. Weltmarkt,

Malaysia, Brassilien. 2. Afrika
HANISCH,R. (ed) and JAKOBEIT,C (ed). Rat im Institut fur Internationale Angelegenheiten, Universitat Hamburg, Germany - *Schriften des Deutschen Ubersee-Instituts, Hamburg (Germany)* no.5-6, v.1(520), p.2, 393; 1991
The 2 volumes of this study deal with the cocoa world market and the most important producing countries: Brazil and Malaysia (vol.1), Ghana, Nigeria, Cameroon, Equatorial Guinea and the Ivory Coast (vol.2). The central question relates to potential changes and the developmental consequences of cocoa production for export. This question is dealt with at 3 levels: (1) historical and quantitative aspects of development of the cocoa world market; (2) distribution of revenues among social groups and participants directly and indirectly involved in the various countries, and (3) linkages and effects of distribution on the economy and society in the producing countries. State and government policies in the cocoa sector are analysed, with an attempt to contribute to comparative policy research. In the first chapter of vol.1,the cocoa world market is discussed and results of the country studies are provided.

OCTOBER 1992

Commodity marketing institutions in the Pacific Islands: a case study of Papua New Guinea
COULTER,H.K. - *Discussion Paper - Institute of National Affairs (Papua New Guinea)* no.51, p.151; Mar 1992
A study was conducted on the performance, role and potential of commodity boards for cocoa, copra and coffee in Papua New Guinea (PNG), in facilitating private investments in agriculture. It includes an overview of the private sector involvement in agriculture in PNG during the 1970s and 1980s. The theory and origin of commodity boards are briefly reviewed, followed by a description of the establishment of the major PNG commodity boards, and detailed profiles of each board. The performance of the boards is examined in terms of operating efficiency, regulatory performance (product quality and price stabilization) and industry support measures. The scope for improving the efficiency of commodity boards in PNG and in selected Pacific Island countries (Western Samoa, Tonga and the Solomon Islands) is outlined.

Cocoa, pineapple and sugar cane waste for ethanol production
SAMAH,O.A., NOR,O.M., RAHMAN,A.R.A. and SALLEH,A.B. Department of Biochemistry and Microbiology, Universiti Pertanian Malaysia, Serdang, Selangor (Malaysia) - *Planter (Malaysia)* v.68(792), p.125-128; Mar 1992
A study was conducted in Malaysia to determine the amount of ethanol that can be attained from cocoa, pineapple and sugar cane processing wastes. Maximum levels of 98g of ethanol/l were attained in cocoa juice and 70.1g/l in pineapple juice, respectively, by Saccharomyces cerevisiae (wild strain) grown in continuous cultures. The overall effect of a higher dilution rate decreased the biomass yield whilst the percentage of sugar consumption was greater at low dilution rates. However, in batch cultures, immobilized cells of Saccharomyces cerevisiae were capable of producing 36g of ethanol/l in cocoa waste and 49g/l in sugar cane, respectively, after about 15 to 20-hours of incubation.

NOVEMBER 1992

[Performance of the "Burareiro" 3x3m dryer for cocoa]. Desempenho do secador "Burareiro" 3x3m na secagem do cacau
CUNHA,J. Centro de Pesquisas do Cacau, Comissao Executiva do Plano da Lavoura Cacaueira (CEPLAC), Itabuna, Bahia (Brazil) - *Agrotropica (Brazil)* v.2(3), p.157-164; Sep 1990
A technical description is provided of a dryer for cocoa beans, developed in Bahia, Brazil. Based on the Burareiro 2x2m

artificial cocoa dryer with an iron furnace, suitable for small farmers, the Burareiro 3x3m was developed for medium size farms (16.3% of the farms in the region). The average temperature of the drying air immediately below the drying platform was 62°C, and due to the ease of mixing, carried out every 2-hours, the drying process was very uniform, with an average variation of 1.94% wet basis. Because of the reduction in the construction cost per m^2 (18.7%), the new dryer is affordable for medium and small farms. Its performance and capacity is suitable for 67.9% of the medium size farms, all small farms and burareiros (cocoa farmers producing less than 6,000kg per year) in a phase of increasing production.

[The effect of pod storage on the quality of dry cocoa beans]. Pengaruh penyimpanan buah terhadap mutu biji kakao kering
ALAMSYAH,T.S. - *Buletin Perkebunan (Indonesia)* v.22(2), p.85, 137-145; Jun 1991
Research was conducted in Indonesia, to improve cocoa bean quality by storage for various periods of time and subsequent fermentation. Storage of pods for 3 to 9-days, followed by a 5-day fermentation period in which the beans were turned every 48-hours, raised the bean pH above 5, and raised the fermentation index to more than 1.0.

[Postharvest pod-storage influence on bean fermentation and kernel acidity of cocoa]. Influencia do periodo de pos-colheita do fruto no tempo de fermentacao e acidez do cacau
DIAS,J.C. and AVILA,M.DA.G.M. Departamento da Amazonia Oriental, Comissao Executiva do Plano da Lavoura Cacaueira (CEPLAC), Belem, Para, Brazil -*Agrotropica (Brazil)* v.2(3), p.145-150; Sep 1990
As cocoa pods are not usually opened on the day they are harvested, the possible effects of this delay on the required length of bean fermentation and on the resulting kernel acidity were investigated in Para, Brazil. Seeds were extracted from pods that had been stored for periods of 1 to 5-days and fermented for 7-days. Samples were taken daily during fermentation to determine the total sugars, acidity and pigments. In this period, the total sugar content of the pulp dropped steadily and ranged between 79.4% and 87.81% of the initial content. The values of the pigment index for all treatments indicated an acceptable level of fermentation from the sixth day onwards. In the last 3-days of fermentation, the titratable acidity ranged from 14.16 to 16.47 meq NaOH per 100g kernels, but no significant differences between the storage periods were found.

Agricultural price instability: impacts programmes and policy options. Asian experience
Agriculture and Rural Development Division, ESCAP, Bangkok (Thailand) p.312; 199?
The impacts of low agricultural export prices at the farm level in developing countries in Asia are studied. The programmes initiated by selected countries to lessen the impact of low prices are also discussed, and the general policy options that a country might plan and execute are identified. The study is based on information in 6 country studies. Each country study focuses on one specific agricultural export commodity that is important for the country concerned. The methodology followed includes analysis of primary and secondary data collected during field visits to determine the actual impact on farmers. The countries covered and commodities studied are: Bangladesh for jute and jute goods, Indonesia for palm-oil, Malaysia for cocoa, the Philippines for sugar cane, Sri Lanka for tea and Thailand for cassava.

Insect species of stored cocoa beans in Peninsular Malaysia
SIVAPRAGASAM,A. Cocoa and Coconut Research Division, Malaysian Agricultural Research and Development Institute

(MARDI), Sungai Sumun (Malaysia) - *MARDI Research Journal (Malaysia)* v.18(1), p.81-87; Jun 1990

Insect species occurring in stored cocoa beans were determined in Malaysia, for both estate and buyer beans. The major species, based on adult and immature numbers, were Tribolium castaneum, Oryzaephilus mercator, Lasioderma serricorne and Corcyra cephalonica. The species composition and the relative abundance of the major species were similar for the estate and buyer beans. The mean number of adults per sack of 62.5kg was 0.74 and 3.51, for estate and buyer beans, respectively. The dispersion pattern of adults in the sacks was highly aggregated for both estate and buyer beans. The immature stages of insects, which are not easily detected during preliminary inspection, could be a source of residual infestation and cross-infestation of other products (such as copra) during shipment. All cocoa beans for export should be fumigated, regardless of adult insect numbers.

Hydrocyanate, oxalate, phytate, calcium and zinc in selected brands of Nigerian cocoa beverage

AREMU,C.Y. and ABARA,A.E. Department of Biochemistry, University of Calabar, Cross River State (Nigeria) - *Plant Foods for Human Nutrition (Netherlands)* v.42(3), p.231-237; Jul 1992

In Nigeria, hydrocyanate, oxalate, phytate Ca and Zn were determined in 5 brands of cocoa beverage which were coded NC, BT, PN, CT and CA. The following values (in mg per 100g dry matter) were found: hydrocyanate 5.40-9.64, oxalate 68-146, phytate 590-750, Ca 28.7-116.4 and Zn 0.516-0.675. The computed phytate:Zn, Ca:phytate and (Ca)(phytate)(Zn) molar ratios ranged from 89 to 132, 0.80 to 3.01 and 0.64 to 3.03, respectively. The toxic levels of hydrocyanate and oxalate and the significance of the molar ratios in predicting the bioavailability of dietary Zn, are discussed.

Potential for potash production from cocoa-pod husk in Nigeria

ODUWOLE,O.O. and ARUEYA,G.L. Cocoa Research Institute of Nigeria, Ibadan, Nigeria - *Agrotropica (Brazil)* v.2(3), p.171-175; Sep 1990

The potential for potash production from burnt cocoa-pod husk (CPH) was examined in Nigeria. Dried CPH was burnt in an incinerator, and the crude ash was transferred to a gas kiln and kept for 40 to 60-minutes at 700-710°C to ensure complete ashing. The ash was mixed with water and boiled for 20-minutes. The mixture was filtered and the filtrate was dried. The economic feasibility of a small scale processing unit (14kg of potash/day) is also examined. The profitability of the small scale production unit at different prices, costs and operating capacities shows that the method has economic potential.

JANUARY 1993

[The main characteristics of the cocoa marketing channels in Cameroon]. Caracteristiques principales de la filliere cacaoyere camerounaise

LEBAILLY,P. - *In: 10. Seminaire d'economie et de sociologie* - CIRAD/MES, Montpellier (France) p.711-719; 1990

Cocoa ranks with coffee as the main export crop of Cameroon. In spite of discouraging price prospects on the world market, cocoa cannot be abandoned. It is a pillar of the agricultural economy in the forest zone, and the main source of cash income for numerous growers. The main characteristics of the commodity chain are presented. An analysis of cocoa production is provided. With the exception of a few areas, growing is non-intensive, growers are old and black pod rot is spreading rapidly. Changes in production and prices to producers are discussed. Participants are grouped into 6 categories, viz. growers, agents, cooperatives, exporters, ONCPB and NPMB (National Produce Marketing Board), and processors. A calculation was made of commodity chain costs and domestic costs of DRC resources on the basis of a bibliographic study and information gathered on production, supervision, marketing and exports.

FEBRUARY 1993

[Fatty acid composition of cocoa butter and the effect of some factors]. Komposisi asam lemak pada lemak kakao dan beberapa faktor yang mempengaruhinya
PRAWOTO,A.A. Balai Penelitian Perkebunan Jember (Indonesia) - *Pelita Perkebunan - Balai Penelitian Perkebunan Jember (Indonesia)* v.5(3), p.97-105; Oct 1989
In Java, Indonesia, research was conducted into the fatty acid composition of cocoa butter. Cocoa butter contains the fatty acids of the C14, C16, C16:1, C17, C18, C18:1, C18:2, C18:3 and C20. Of these, C16, C18 and C18:1 are the main fatty acids, their contribution is more than 96%. Fine flavoured cocoa butter has a percentage of unsaturated fatty acids compared with bulk cocoa butter. The percentage of unsaturated fatty acid increases with increasing humidity and with a lower average daily temperature. The percentage of unsaturated fatty acids of beans harvested in the early season (May-June) is higher than that of those harvested in the late season (Nov-Dec). However, the influence of harvesting season on the degree of fatty acid saturation is small. Indonesian bulk cocoa has a higher percentage of saturated fatty acids than cocoa butter from Ghana, but for the Indonesian fine flavoured butter the percentage is almost the same. In comparison with Malaysian cocoa butter, the percentage of saturated fatty acids of Indonesian fine flavoured butter is lower, but Indonesian bulk cocoa butter has a higher percentage of saturated amino acids.

[The improvement of cocoa bean quality by a broken fermentation method]. Peningkatan mutu biji kakao metode permentasi terputus
YUSIANTO and WAHYUDI,T. Balai Penelitian Perkebunan Jember, Java (Indonesia) - *Pelita Perkebunan - Balai Penelitian Perkebunan Jember (Indonesia)* v.5(4), p.131-139; Jan 1990
To improve the quality of Indonesian cocoa a broken fermentation method was applied. Fermentation was interrupted for 2, 4 and 6-hours on the first, second, third and fourth-day. The treatment was sun-drying of the cocoa beans during the interruption. The broken fermentation method could improve quality, especially the degree of fermentation, and it could also decrease the acidity of cocoa bean. The treatments affected pH, volatile acid content, non-volatile acid content, total acid content, volatile acid ratio, cut test results and percentage of reducing sugars. The experiment proved that fermentation with a resting time on the first or second-day of 2 to 6-hours were the best treatments for the ratio and percentage of reducing sugar/total sugar content of cocoa beans.

[A study on optimum duration of fermentation and soaking of fine flavoured cocoa beans]. Optimasi lama fermentasi dan perendaman biji kakao mulia
SULISTYOWATI and SOENARYO Balai Penelitan Perkebunan Jember (Indonesia) - *Pelita Perkebunana - Balai Penelitan Perkebunana Jember (Indonesia)* v.5(1), p.37-45; Apr 1989
An experiment to optimize the duration of fermentation and soaking of fine flavoured cocoa beans and to study the possibility of using chemical fermentation indexes was conducted in Java, Indonesia. The treatments included 4 periods of fermentation (2, 3, 4 and 5-days) and 3 periods of soaking (0, 2 and 4-hours). The fermentation indexes used were N index, sugar index, anthocyanin index and an index by cut test. The optimum fermentation duration was 4-days. Soaking treatments had no influence on the cut test or the anthocyanin index, but tended to decrease the N index and sugar index. The recommended soaking duration was not more than 2-hours. The N index, sugar

index and anthocyanin index could all be used to support the cut test. The optimum level of anthocyanin index for fine flavoured cocoa beans requires further study.

MARCH 1993

Microbial populations and products formation during fermentation of cocoa beans

SAMAH,O.A., IBRAHIM,N. and ZALEHA,R.N. Department of Biochemistry and Microbiology, Universiti Pertanian Malaysia, Serdang, Selangor (Malaysia) - *Planter (Malaysia)* v.68(797), p.395-399; Aug 1992

The changes in microbial populations and some of the major products formed during cocoa fermentation in Malaysia are described. The maximum number of colonies observed for lactic acid bacteria was 8,800,000 cells/g of cocoa beans, and that of acetic acid bacteria was 13,000,000 cells/g after 34 to 40-hours of incubation. Spore forming bacteria appeared to be dominant towards the end of the fermentation period. The major acids found were acetate and lactate; other acids such as aspartate, malate and citrate, and alcohols were also detected.

APRIL 1993

[The performance of the "Tubular" dryer, with forced airflow, for cocoa drying]. Desempenho do secador "Tubular", com ventilacao forcada na secagem do cacau

CUNHO,J. Centro de Pesquisas do Cacau, Comissao Executiva do Plano da Lavoura Cacaueira (CEPLAC), Itabuna, Bahia (Brazil) - *Agrotropica (Brazil)* v.3(1), p.39-43; Jan 1991

The "Tubular" dryer, traditionally used for artificial cocoa drying in the southern region of Bahia, Brazil, has natural convection as its working principle. The dryer has a low efficiency and a high cost of construction. A fan-driven airflow system was added to the dryer. The advantages include: (1) a large increase in drying capacity; (2) a much better drying uniformity if the product; (3) an increase in the lifetime of the furnace and heat exchange parts; (4) a large increase in overall drying efficiency; (5) a reduction in fuelwood consumption, and (6) a better balance between the drying capacity and the initial investment. The fan is made by metal workshops in the region, and its costs are only 5.7% of the total costs of the dryer.

[Characterisation of yeasts and moulds isolated during the fermentation process of cocoa beans in Costa Rica]. Identificacion de hongos filamentosos y levaduras aislados durante la fermentacion de almendras de cacao (Theobroma cacao) en Costa Rica

CASCANTE,M., GARCIA,V. and MARIN,G. Universidad Nacional, Heredia, Costa Rica - *Agronomia Costarricense (Costa Rica)* v.15(1-2), p.177-180; Jan 1991

The yeast and mould flora developed during the fermentation of cocoa beans of the criollo and forastero genetic types was studied in Costa Rica. Thirty-eight yeast strains were identified and it was possible to establish the early alcoholic phase in both cocoa types. The yeasts isolated during this stage were Saccharomyces cerevisiae, Saccharomyces chevalieri and Saccharomyces microellipsoideus. Filamentous fungi developed at the end of the alcoholic phase, most of them belonging to the genera Penicillium, Exosporiella, Geotrichum, Fusarium, Rhizoctonia and Rhizopus.

[Cocoa consumption in Czechoslovakia]. La consommation cacayere en Tchecoslovaquie

IOCC, London, United Kingdom, p.40; 1991

Information is provided on the situation of Czechoslovakia, one of the major consumers of cocoa of Eastern Europe, in the world cocoa economy. Subjects dealt with include: (1) cocoa consumption trends and trade structure (customs tariffs and import system); (2) market characteristics and structure of the sector; (3) cocoa consumption outlook, effects of recent and on-going political and economic changes, and cocoa consumption forecasts; (4) econometric models of cocoa and chocolate consumption in Czechoslovakia; (5) useful addresses (ministry administration and factories), and (6) information on laws regulating the cocoa trade.

[A study of the cocoa industry in Congo: the second technical assistance programme of the World Bank]. Etude de la fillere cacao: deuieme programme d'assistance tecnique de la Banque Modiale

BDPA SCETAGRI, Paris (France), p.204; 1990

The current level of cocoa production in the Congo is much lower than the possibilities offered by the human and agricultural potential. After analysis and diagnosis of production, proposals are made concerning technical support for production (plant protection), marketing price policies and support measures. A short-term programme for stimulating production is proposed, as well as middle and long-term measures requiring fundamental reorganisation of production. Cocoa in the Congo is in a critical situation due to declining production resulting from a worsening of the sanitary situation and the indifference of growers. In addition, production costs are high and export quality is deteriorating. Production, which is concentrated in the Sangha region, has decreased rapidly from 3,000t in 1977 to 1,300t in 1987. Short-term measures for improving quality include better drying and transport conditions. Marketing costs should be reduced by a better organisation of collection and improvement of the network of roads. In order for production to be stimulated, priority must be given to the control of cocoa black pod rot. Over 6 or 7 years these short-term measures should be enough to recover a production volume of about 3,000t. Long-term measures, such as the organisation of marketing, phytosanitary control, support for production and training are expensive and difficult to justify under the current economic conditions.

[Report on a mission to Venezuela (4-14 Aug 1991): a project proposal for the improvement of Porcelana cocoa production and quality]. Rapport de mission au Venezuela (4-14 aout 1991): proposition de projet pour la restauration de la production et de la qualite du cacao Porcelana

MOSSU,G. - CIRAD-IRCC, Paris (France) p.25; 1991

Cocoa growing is widespread in Venezuela, and Porcelana cocoa is both uncommon and particularly appreciated by users for its aromatic excellence and exceptional quality. It is the most expensive of all types of criollo cocoa in the country. However, criollo cocoa is increasingly being supplanted by a Trinitario hybrid of lesser quality, but better agricultural characteristics (viz. earlier, more vigorous and higher yielding). This project's objectives are to improve cocoa yields and quality in Venezuela, and particularly to revitalise Porcelana cocoa production. The base of operations is a pilot plantation set up in the Sur del Lago region. There are 3 main components in the project: (1) research aimed at improving earliness, yields and market quality of Porcelana cocoa beans; (2) the development of improved crop management and processing methods for better quality, and (3) the training of people involved in the cocoa industry, from researcher to grower, including development workers. An economic analysis is made of the project, and a schedule of operations is provided.

[Report on a mission to Venezuela (Nov 1991): a project for the improvement of Porcelana cocoa yields and quality]. Rapport de mission au Venezuela (novembre 1991): projet pour la restauration de la production et de la qualite du cacao Porcelana

MOSSU,G. and TREBEL,M. - CIRAD-IRCC, Paris (France) p.21; 1992
Information is provided on a project for reviving Porcelana (finest criollo) cocoa yields and quality using pilot plantations based in the Sur del Lago region of Venezuela. Major components of the project (research, development and training), actions to be taken, strategies to be employed in terms of manpower (IRCC, FONAIAP and the Universities) and sites (Chama station) are discussed. A description of the resources and the institutional and financial framework (IRCC, French Ministry of Foreign Affairs and Palmaven S.A.) is included.

MAY 1993

School section: the chocolate trail
- *British Overseas Development (UK)* no.25, p.2-3; Sep 1992
General information on cocoa, including a description of a small farm producing cocoa in Ghana, research on cocoa, and its resource materials, is provided. A world map is given showing the growing areas of cocoa.

[Liquidation of the prince's jewellery: issues involved in the liberalisation of the coffee-cocoa industry of Cameroon]. La liquidation des joyaux du prince: les enjeux de la liberalisation des filieres cafe-cacao au Cameroun
COURADE,G., GRANGERET,I. and JANIN,P. - *Politique Africaine (France)* no.44, p.121-128; 1991
Cameroon's reform of its coffee-cocoa industry is reaching its final stage. The ONCPB (Office National de Commercialisation des Produits de Base), which was the stabilization structure for all products grown on small farms, was dissolved in June 1991. Functions formally carried out by this organisation have been taken up by various parties in the commodity chain, including the new ONCC (Office National du Cafe et du Cacao). An analysis of new prospects resulting from this liberalisation of the industry is presented, for growers, civil servants, operators and aid organisations.

JUNE 1993

Studies on cocoa processing. 3. Cotyledon pH as an index of fermentation
BOPAIAH,B.M. Regional Station, Central Plantation Crops Research Inst., Vittal, Karnataka, India - *Indian Cocoa, Arecanut and Spices Journal (India)* v.14(4), p.145-147; Apr 1991
The use of the cotyledon pH of cocoa beans as an index of fermentation was investigated in Karnataka, India. The results indicate that the termination of fermentation could be decided by monitoring the cotyledon pH. Depending on the method of drying, the following pH range is suggested for the termination of fermentation: (1) sun drying, pH 4.8-5.1; (2) slow artificial drying, pH 4.9-5.2 and (3) quick artificial drying, pH 5.2-5.3.

AUGUST 1993

Eat more chocolate
HERBERT,T. - *CDC Magazine (UK)* no.3, p.8-10; 1992
Cocoa growers are facing serious problems because of its low market prices. The price of dry cocoa beans was reduced to less than half from the price in the 1980s. The reason for this decline and the effects they have on the investments on Commonwealth Development Corporations (CDC) projects are examined. Investments in some 10,000ha of plantation cocoa on 5 projects (2 in Papua New Guinea and 1 each in Malaysia, Indonesia and the Solomon Islands) were made by CDC. Topics discussed are: over-production, how do the present low prices affect CDCs cocoa projects, how do CDCs production costs compare with those of other major producing countries and a future outlook.

Evaluation of cocoa-pod husks on performance of rabbits
RIDZWAN,B.H., FADZLI,M.K., ROZALI,M.B.O., CHIN,D.T.F., IBRAHIM,B.M. and FARIDNORDIN,B.I. Department of Biology, UKMS, Sabah, Malaysia - *Animal Feed Science and Technology (Netherlands)* v.40(2-3), p.267-272; Jan 1993
The influence on growth performance and digestibility of rations mixed with cocoa-pod husks at either 100 or 300g/kg was studied in Malaysia, using growing French white rabbits. Except for feed consumption, the results indicate that there was no significant difference in final body weight, weight gain and feed conversion efficiency among rabbits receiving both levels of cocoa-pod husks in their rations. A slight decrease in energy digestibility, however, was observed when crude fibre contents increased, especially in the ration incorporated with 300g/kg cocoa husks.

Prospects for the world market until the year 2005: report by the UNCTAD secretariat and the secretariat of the International Cocoa Organisation
UNCTAD, Geneva, Switzerland - United Nations, New York (USA), p.318; 1991
Possible trends in the world supply of and demand for cocoa up to the year 2005 were determined. An attempt was made to identify and examine underlying factors affecting supply and demand. Various scenarios were elaborated for the production and consumption of cocoa by the major countries and for the world as a whole. An anlysis is made of cocoa production in 10 major producing countries which currently account for over 90% of the world production. A general analysis is made of economic factors affecting cocoa production. An annex is included with a detailed description of cocoa cultivation and harvesting, to improve the understanding of the methodology applied in estimating production costs. The analysis of the demand side includes major global trends in grindings, international trade in cocoa and cocoa products, final consumption of cocoa and stockholding behaviour. The main manufacturing characteristics and structure of the cocoa processing and chocolate industry are described. A detailed analysis is included of demand performance in 14 individual countries from all consuming regions.

SEPTEMBER 1993

Performance evaluation of a medium-scale cocoa dehulling and winnowing machine
ADEMOSUN,O.C. Department of Agricultural Engineering, Federal University of Technology, Akure, Ondo State, Nigeria - *Agricultural Mechanization in Asia, Africa and Latin America (Japan)* v.24(2), p.57-60
A description is provided of a medium-scale cocoa dehulling and winnowing machine with a capacity of approximately 1,000kg of cocoa beans/h, which was developed in Nigeria. A performance test of the machine was conducted. The machine is easy to operate. The only adjustment required on the machine is the roller clearance. The optimum roller clearance was determined. The machine was found to have high dehulling and winnowing efficiencies at the optimum roller clearance. The dehulling and winnowing efficiency of the machine are 98.36 and 95.5%, respectively.

OCTOBER 1993

Agroindustry profiles. Cocoa
BROWN,J.G. (ed) - *EDI Working Papers - Economic Development Institute, World Bank (USA)* no.030/140, p.32; 1991
A review of the cocoa processing industry is provided. The profile examined the industry from harvesting of raw materials to primary and secondary processing and, finally, marketing. It traces several primary processing steps including pod opening, fermentation, drying, sorting, and distribution; secondary processing steps include cleaning, roasting, winnowing, nib grinding, prossing, cocoa powder, and chocolate production. Marketing aspects

are covered, including prices, quality factors, market barriers, and product substitution. A bibliography of useful references is provided. Annexes, consisting of a glossary, a data sheet on indicative cocoa yields and conversion factors, examples of investment and operating costs, and metric/US conversion tables, are included at the end of the profile.

[Mission report - Indonesia (8-17 February 1992)]. Rapport de mission en Indonesie (8-17 fevrier 1992)
VINCENT,J.C. - CIRAD-IRCC, Montpellier (France) p.135; 1992
A mission was conducted to Indonesia, to improve contacts with the IPARD (Indonesian Planters Association for Research and Development), to set up cooperation in coffee and cocoa postharvest technology, and to solve quality and processing problems, in the framework of collaboration between CIRAD and AARD (Indonesia Agricultural Agency for Research and Development). The appendices contain descriptions of the cocoa postharvest technology research programme, the Bogor Research Institute for Estate Crops programme, the master research plan for this institute for 1990-1994, and the master research plan for the Jember Research Institute for Estate Crops for 1992-1996.

[Influence of the turning frequency and interval on cocoa fermentation and chocolate quality]. Influencia da frequencia e intervalos de revolvimentos sobre a fermentacao do cacau e qualidade do chocolate
SCHWAN,R.F., LOPEZ,A., SILVA,D.O. and VANETTI,M.C.D. Centro de Pesquisas do Cacau, Comissao Executiva do Plano da Lavoura Cacaueira (CEPLAC), Itabuna, Bahia, Brazil - *Agrotropica (Brazil)* v.2(1), p.22-31; Jan 1990
The effects of the frequency of turning the cocoa mass on the fermentation process and on the organoleptic characteristics of chocolate were evaluated in Bahia, Brazil. The 4 fermentation treatments were: (1) turning at 24, 48, 96 and 144-hours after the start of the process (FT); (2) spreading of the beans in a 10-cm layer, transfer to the fermentation box after 24-hours, and turning after 72, 88, 96 and 144-hours (FCE); (3) a first turning at 72-hours after the start of the fermentation process, and 2 subsequent turnings at 120 and 144-hours (FAR), and (4) turning the fermenting mass twice a day (FRF). The duration of the processes was 168-hours. Variations of temperature and oxygen tension of the fermenting cocoa mass were determined and microbiological (pulp), chemical (pulp and cotyledon) and sensorial (chocolate) analyses were made. Only the initial turnings induced significant increases in the oxygen tension of the cocoa mass. The variation in the concentration of total acids varied in accordance with the production and consumption of the acids by microorganisms and also by the evaporation of volatiles. Based on an inspection of the external colour of the beans, the end of the fermentation process was observed at 144-hours for FT, 116-hours for FCE, over 164-hours for FAR, and at 120-hours for FRF. The sensorial analysis of chocolate showed that the best sample was from FRF after 120-hours of fermentation.

[Chemical composition of cocoa butter and related fats and oils]. Composition chimique du beurre de cacao et de graisses apparentees
LECERF,J.C. Institute National Polytechnique de Toulouse, Toulouse, France p.162; 1990
Research was conducted on the major chemical constituents of cocoa butters from different sources, cocoa bean shell lipids and 6 industrial fats and oils used in chocolate making as substitutes for or equivalents to cocoa butters, to be able to identify and quantify possible mixtures. Fatty acids were analysed using gas chromatography and triglycerides by using HPLC. These methods provided poor identification of mixtures. Study of the

unsaponifiable fractions showed specific profiles for each fat and oil. There are few tocopherols in cocoa butter and none in industrial butters. The sterols and triterpenic alcohols were separated using HPLC and thin layer chromatography, identified by NMR and SM, and analysed using gas chromatography. These constituents are excellent criteria for identifying mixtures. The cycloartenol and triterpenic alcohol predominating in cocoa butter are absent in other fats and oils. Lupeol, which is the major constituent of triterpenic alcohol found in replacement fats and oils, does not occur in cocoa butter, its presence is proof of foreign fats and oils having been added to cocoa butter.

NOVEMBER 1993

Fermentation products in cocoa beans inoculated with Acetobacter xylinum
SAMAH,O.A., PUTEH,M.F., SELAMAT,J. and ALIMON,H. Department of Biochemistry and Microbiology, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - *ASEAN Food Journal (Malaysia)* v.8(1), p.22-25; Jan 1993
Cocoa samples from a mixed Sabah hybrid inoculated with Acetobacter xylinum were evaluated in Malaysia. The organism was chosen because it can promote early death of the bean during fermentation, besides triggering enzyme action. Variations in pH, temperature, organic acids content and flavour were monitored. The pulp and cotyledons from treated beans had a slightly higher pH than the control beans towards the end of a 6-day fermentation period. Treated beans had higher levels of acetic acid and lower chocolate flavour than the control beans.

DECEMBER 1993

The proteases of ungerminated cocoa seeds and their role in the fermentation process
BIEHL,B ET AL. Botanisches Institut, Technische Universiti Carolo Wihelmina zu Braunschweig, Braunschweig, Germany -*Angewandte Botanik (Germany)* v.67(1-2), p.59-62; Apr 1993
Ripe, ungerminated cocoa seeds reveal an extraordinary high proteolytic activity. It was found that the vacuolar storage protein is digested during fermentation. This is a post-mortem proteolysis depending on the variable pH value (4.0-5.5) in the seed which is established by acetic acid absorbed from the fermenting pulp. Inhibitor studies revealed an aspartic endoprotease and a serine expotrotease. It is suggested that these proteases are responsible for the predominant release of hydrophobic amino acids and a large number of oligopeptides, being specific cocoa flavour precursors.

Biochemical changes during fermentation of cocoa beans inoculated with Saccharomyces cerevisiae (wild strain)
SAMAH,O.A., PUTIH,M.F. and SELAMAT,J. Department of Biochemistry and Microbiology, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - *Journal of Food Science and Technology (India)* v.29(6), p.341-343; Nov 1992
In Malaysia, the effect of employing a selective microorganism in cocoa fermentation was investigated. The overall pH profile of the cotyledons of cocoa beans inoculated with Saccharomyces cerevisiae during fermentation was slightly higher than of control beans. The percentages of glucose remaining in the pulp of both inoculated and control beans at the end of fermentation were 20% and 3%, respectively. Ethanol and acetic acid production were generally higher in inoculated beans. The intensity of the chocolate flavour obtained from inoculated and control beans was almost the same. However, in inoculated beans, bitterness was reduced by 28%.

The international cocoa trade
DAND,R. International Cocoa Organisation, London, UK - Woodhead Publishing, Cambridge (UK), p.383; 1993
Over the past few years, the cocoa market

has had to alter its manner of operation. Continued low prices, fewer companies trading and both the perceived and real element of dealer credit risks have brought about the change. The cocoa market is far more sophisticated than it was even 10 years ago, and despite the low prices cocoa is still the fifth largest food commodity exported from developing countries. Starting with the history of European and North American development of cocoa, its agronomics and marketing, the actual and future markets and their contracts (the details of which form the appendices), together with the supply of and demand for the produce, its quality and lastly, its processing, are covered.

JANUARY 1994

Preparation of a successor agreement to the international cocoa agreement, 1986. United Nations Cocoa Conference, Geneva, 21 April 1992
UNCTAD, Geneva, Switzerland, p.18; 1992
Information on cocoa production on an international level is provided, which served as a background for the formulation of a new agreement to succeed the 1986 International Cocoa Agreement. An introduction on various aspects of cocoa production in the world is followed by notes on principal features of previous cocoa agreements, structure and functions of the International Cocoa Organisational (ICCO), and negotiation of a successor agreement to the International Cocoa Agreement. Annexes are presented showing gross production of cocoa beans by country, 1988/89 to 1990/91, cocoa consumption by final consumer by country, 1987/88 to 1989/90, net exports of cocoa beans and cocoa products in beans equivalent, 1987/88 to 1989/90, net imports of cocoa beans and gross imports of cocoa products in beans equivalent, 1987/88 to 1989/90, and ICCO daily price and the price bands of the International Cocoa Agreement of 1972, 1975, 1980 and 1986.

APRIL 1994

Effect of clone and temperature on acetic acid diffusion and death of cocoa beans
JINAP, S. and DANKER, R.M. Department of Food Science, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - *ASEAN Food Journal (Malaysia)* v.8(4), p.139-144; Oct 1993
The effects of clone and temperature of fermentation-like incubation of cocoa beans on acetic acid diffusion and bean death were determined in Malaysia. Cocoa beans of clones ICS and KKM 17 were incubated in 50 and 150 mM acetic acid at 45°C for 14-hours. For the temperature study, ICS 95 was incubated at 35, 45 and 55°C. The rate of acid diffusion was not necessarily related to bean size. At 35°C, the diffusion rate was significantly lower than at 45°C or 55°C. However, at 45°C and 55°C, the diffusion rate and the condition required for bean death to occur were the same. At 45°C, bean death occurred when the bean contained 0.66-0.67% acetic acid, had a titratable acidity of 7.40-7.48 Meq NaOH/100g beans, and a pH of 5.15-5.16. As the incubation temperature increased, the acidity required for bean death to occur decreased.

This issue of Cocoa Growers' Bulletin
has been printed on recycled fibre
to assist in protecting the environment.

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