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COCOA GROWERS' BULLETIN
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COCOA GROWERS' BULLETIN

Number 40 November 1988

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EDITORIAL

The need for Land Resource Surveys is highlighted in the first article in this issue of the Cocoa Growers' Bulletin. The importance of correctly assessing land capability before attempting to plant crops cannot be understated. In many areas of the world, primary forest is being cleared at an alarming rate and is often only replaced by scrub. We are custodians of this planet for our lifetime and have an obligation to protect our environment for future generations. The widespread exploitation and demolition of primary forest in many countries is fact. The words we read in newspapers and the pictures we see in magazines and on television reflect a reality which we can no longer afford to ignore. Airports in the Amazon Basin do close for several days because the pall of smoke is too thick to be penetrated even by a modern jet airliner. On a single day in August 1988 there were 8,000 fires in the Amazon forest and each one covered an area of several square kilometres. An area of land equivalent in size to Belgium will be cleared and burnt during the 1988/89 burning season in the Brazilian Amazon. A huge area of East Kalimantan Province in Indonesia was devastated by fire in 1985 caused by a slash and burn fire which got out of control. These are unpalatable but inescapable truths. Cocoa planted under suitable soil and climatic conditions can recreate a very similar environment to the exploited primary forest and so should be encouraged under suitable circumstances. However, cocoa will only thrive under appropriate conditions and the suitability of a given area of land must be confirmed, ideally before timber is extracted or before the primary forest is cleared. A systematic well organised Land Resource Survey is the most effective way to determine the suitability of the land for sustainable cocoa cultivation. It should be used by all land-use planners. Modern satellite technology has provided a new set of tools to assist in such surveys. This technology can reduce the cost and increase the reliability of Land Resource Surveys if correctly utilized. It is to be hoped that its adoption will become routine. There are many examples of cocoa being planted in areas of very marginal land especially in South East Asia and Latin America when the world market price was at record high levels. These cocoa trees rarely survived to maturity and the land has now often reverted to bush. It will take many hundreds of years for the bush to develop to secondary forest and for the land to become productive again and maybe this will never happen if the soils are poor. It is to be hoped that all readers of the Cocoa Growers' Bulletin will complete a Land Resource Survey before clearing areas of primary forest to plant cocoa or any other crop.

ISSN 0045-7256

R.A. LASS, Editor

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, Cocoa Department, L64, Cadbury Ltd., Bournville, Birmingham B30 2LU, England.

REVIEW OF PRODUCTION AND CONSUMPTION
April 1987 - November 1988
P. Bingley, Cadbury Limited

PRODUCTION

Our last review was based on Gill and Duffus Cocoa Market Report No. 325, dated April 1987. Their estimate of world production for 1986/87 was 1,932,000 tonnes, some 45,000 tonnes lower than the current estimate, in Report No. 332. The major differences were in the forecasts for Cote d'Ivoire and Malaysia, which were revised by 32,000 tonnes and 14,000 tonnes respectively.

The forecasts for 1987/88 indicate a record crop of 2,164,000 tonnes, (187,000 tonnes greater than the 1986/87 crop) with increases coming mainly from Cote d'Ivoire, Nigeria, Brazil and Malaysia. Cote d'Ivoire achieved another record crop boosted by the extensive new plantings in recent years. The large improvement shown in the table for Nigeria is somewhat misleading. The privatisation of the cocoa industry caused some of the 1986/87 production to be exported in the previous crop year, which makes the 1986/87 figure appear rather low. The actual improvement in the tree crop from 1986/87 to 1987/88 is probably much lower than the 65,000 tonnes shown in the figures. The decline in Ghana's production after three years of recovery coupled with Malaysia's continued expansion will make Malaysia the third largest producer in 1987/88.

Forecasts for 1988/89 appear for the first time in Report 332. The world crop is forecast at 2,284,000 tonnes, more than 5% up on 1987/88. Main areas of growth are Cote d'Ivoire, Ghana, Malaysia and Indonesia. The large increase in production in Ghana is a continuation after a particularly poor crop last season of the upward trend which began in 1983/84.

CONSUMPTION

The Gill and Duffus estimate of 1986 grindings in Cocoa Market Report No. 325 was 1,823,000 tonnes. The current report estimates 50,000 tonnes more than this, which indicates that the recovery period of the early eighties did not halt as had been expected. However, the annual increase from 1985 - 1986 shown in Report No. 332 is much lower than previous years, which does indicate some slowing down of growth in consumption, in spite of declining prices.

The estimates of 1,905,000 tonnes for 1987 and 1,997,000 tonnes for 1988 show renewed response to low cocoa prices. The areas where the major growth in grindings is expected to occur in 1988, are the United States, Germany (FR and DR) and the Netherlands.

STOCKS

Only two out of the last twelve years have shown a level of closing stocks lower than that of the previous year. In 1982/83 stocks declined from 698,000 tonnes to 579,000 tonnes and in 1983/84 declined a further 237,000 tonnes to 342,000 tonnes.

The level of closing stocks has increased progressively since 1983/84 and the end of year stocks forecast for 1987/88 in Report 332 is 727,000 tonnes, the highest since 1965. For 1988/89, the forecast is 908,000 tonnes, which is the highest recorded in Report 332. The Closing Stocks Series appears in the Cocoa Supply and Demand Table (1a), which runs from 1946/47.

INTERNATIONAL COCOA AGREEMENT (since April 1987)

1987 Meetings

8-12 June	A meeting to discuss rules of a cocoa witholding scheme ended without formal agreement.
13-17 June	No concensus was reached on the revision of the intervention price range. Intervention was therefore effectively suspended until the next meeting. (Buffer Stock purchases to 23rd June 1987 were 75,000 tonnes).
11-17 September	There was still no agreement reached on cuts in the support level, but levies were reduced to $30 from $45. Buffer stock operations were still effectively suspended.
30 November-4 December	The meeting attempted to resurrect Buffer Stock buying but still no agreement could be reached over revised intervention prices.

1988 Meetings

13-16 January	A cut in the intervention price to 1485 SDR was finally agreed. Renewed Buffer Stock buying began immediately, with purchases of Malaysian cocoa no longer allowed. The Buffer Stock was holding 150,000 tonnes under the 1986 Agreement by March 1988.
29 February-4 March	Buffer stock buying failed to support prices and agreement was reached to withold a further 120,000 tonnes. However, producers rejected a further cut in intervention price to 1375 SDR and some refused to pay levies owed to the ICCO. Without payment of the levies, the witholding scheme could not begin.
6 - 8 June	A routine meeting of the Executive Committee attempted to deal with the financial problems of the ICCO. Ghana announced that it would freeze all levy payments, in response to the growing number of producers who had suspended payments. Cote d'Ivoire's failure to remit any of its levy payments since the inception of the 1986 Agreement was the major cause for concern.
5 - 16 September	ICCO Council and Executive meetings ended in no agreements and no solution was found to the financial difficulties, neither was progress made on realignment of intervention prices or implementation of the witholding scheme. The next meeting is scheduled for 19 - 27 January.

With his existing funds, the Buffer Stock Manager will probably be unable to rotate stocks adequately. The likely amount of contributions that can be expected this season (based on present regular contributors) will barely meet costs of warehousing and administration for current stocks.

PRICES April 1987 - November 1988

April 1987 - June 1987

Increasing certainty of a good crop and lack of confidence in the ability of the ICCO Buffer Stock to support the market led to a continued downward trend in prices.

June 1987 - September 1987

Concern over dry weather in West Africa and Brazil in early June prompted fairly steeply rising prices, but after mid-July the weather conditions improved and it became clear that there would be another surplus, so the price decline resumed.

September 1987 - November 1987

Concerns over the Bahia main crop, plus good third quarter grindings figures from several major consumers caused only temporary reversals in the overall downward trend in prices, with the market slipping by around £130 to trade in London at its lowest level since 1982.

December 1987 - March 1988

The market rose towards the lower support price of 1485 SDR following the decision to call an emergency ICCO meeting in January 1988. The Buffer Stock started buying on January 19th, but port arrivals in West Africa were increasing fast at this time, and also growing conditions for the Temporao crop in Bahia were reported to be excellent, so the effects were soon offset. The market fell to new lows at the end of March.

April 1988 to June 1988

Early April prices were the lowest for six years. An upward trend followed, since Cote d'Ivoire refused to sell and the Bahia Temporao did not look very promising. Prices recovered by around £40. However, long term recovery was limited by an awareness that new crop would be available from October.

June 1988 to August 1988

Prices continued to come down, particularly during August but the mounting concern over the sales policy of Cote d'Ivoire caused premiums of preferred origins to strengthen. Spot Ghana Amsterdam was offered at a premium of £330 in August and current crop Cote d'Ivoire was offered at a premium of £235. Plentiful supplies of Malaysian cocoa coupled with prospects of a higher surplus next

season weighed heavily on the terminal market, whilst the physical market in West Africa cocoas was almost paralysed by the limited sales by Cote d'Ivoire.

September 1988 to November 1988

Terminal prices have been falling steadily. Limited sales by Cote d'Ivoire and the prospect of another sizeable surplus helped push the market to 12 year lows during September. The ICCO talks in September were expected to be unsuccessful, which encouraged further decline during that period. By the end of September, terminal prices had collapsed to around £700. The supply of preferred origins has continued to be very tight, with premiums for Ghana beans in-store Europe climbing to £450 on December.

In October, Cote d'Ivoire decided to maintain the guaranteed farmer price and followed this with a statement of their determination to continue with an unchanged sales policy. This questioned the markets assumption that the large tonnage of new crop, together with the deteriorating financial situation would compel the Ivoirians to modify their policy before supply problems became acute. Rumours arose of a deal involving a French trading house in the purchase of more than 200 thousand tonnes, some of which would be stored in Europe. The French government denied suggestions that it was to underwrite such an arrangement. However, a deal of some kind remains a real possiblity.

During November, the nearby tightness together with reports of worsening crop prospects, reversed the downward trend in prices. Manufacturers increased their usage of Malaysian beans. Stocks of Malaysian available for tender may well be depleted. These factors have caused an improvement in prices leaving the market around £860 at the end of November.

Month end prices for nearby shipment Ghana cocoa have been:

1987		1988	
January	£1380	January	£1142
February	£1370	February	£1074
March	£1361	March	£ 990
April	£1346	April	£1018
May	£1321	May	£1055
June	£1404	June	£1174
July	£1390	July	£1064
August	£1340	August	£1094
September	£1259	September	£ 921
October	£1222	October	£ 999
November	£1155		
December	£1107		

WORLD COCOA PRODUCTION AND GRINDINGS DATA
Reproduced from Gill and Duffus Cocoa Market Report No. 332
Dated November 1988
(all figures in thousand metric tonnes)

Production	1984/5	1985/6	1986/7	1987/8 (estimate)	1988/9 (forecast)
WORLD TOTAL	1945	1964	1977	2164	2284
Africa	1080	1109	1097	1173	1284
S.America	652	593	573	618	590
W.Indies	52	53	52	57	52
Asia & Oceania	161	209	255	316	358
PRINCIPAL COUNTRIES					
Cameroon	120	118	123	131	130
Ghana	175	219	228	188	255
Equatorial Guinea	8	6	7	7	7
Cote d'Ivoire	565	585	602	655	720
Nigeria	151	110	80	145	125
Brazil	412	376	369	402	378
Colombia	41	48	51	55	52
Ecuador	120	96	76	81	80
Mexico	42	39	40	40	40
Venezuela	15	10	12	14	14
Dominican Republic	39	40	39	45	40
Malaysia	93	125	164	220	255
Papua New Guinea	31	32	32	34	34
Indonesia	22	35	41	43	53

GRINDINGS	1985	1986	1987	1988 (estimate)
WORLD TOTAL	1850	1873	1905	1997
Western Europe	689	678	712	769
Eastern Europe & USSR	243	248	249	222
Central & S. America	407	400	387	406
N. America	226	220	255	266
Australia & N.Zealand	7	6	1	1
Asia	109	144	145	164
Africa	169	177	156	169
PRINCIPAL COUNTRIES				
United States	205	200	236	246
Germany (FR)	207	201	209	228
Netherlands	167	183	196	219
USSR	155	163	153	131
United Kingdom	91	87	95	100
France	42	39	38	38
Brazil	247	236	227	231
Cote d'Ivoire	95	107	95	103

THE APPLICATION OF LAND RESOURCE SURVEYS TO COCOA PRODUCTION

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The FAO/UNFPA/IIASA report on "Potential population supporting capacities of lands in the developing world" (1982) - republished in more popular form as "Land, food and people" (FAO, 1984a) - has shown that land well suited to agricultural production is in short supply in many parts of the world.

Generally speaking, land shortage is not especially severe in the humid tropics where cocoa is grown but these areas cannot expect to escape the effects of land pressures nearby. The resulting expansion of settlement and agriculture into the humid tropics frequently entails the destruction of natural forest developed over hundreds of years and, more often than not, exposes soils of very limited agricultural potential. Thus, despite sufficient rainfall, the capacity of these areas to support a farming population is low. Some tree crops, notably rubber and oil palm, can succeed on some of the poorer soils and would be environmentally preferable to erosion-susceptible food crops. Cocoa, however, is more demanding in its requirements and is more likely to succeed, under average levels of husbandry, on better quality soils. These are usually the younger soils developed from base rich rocks found only in relatively small, scattered areas. The same soils are preferred for human settlement and for most forms of agriculture. In practice, they are likely to be intensively used already.

The cocoa industry must compete with other forms of land-use merely to maintain present production. In a study on the constraints and priorities of research in cocoa production prepared for the World Bank, Lass and Wood (1985) emphasize the need to replace cocoa trees, 'the capital of the industry', as the trees become too old, too damaged by pests and diseases or surpassed by newer varieties. In reporting that replacement has lagged behind needs, these authors recognise that there are many important questions associated with replacement including competition to use available land for alternative crops. Food crops, in particular, are cited for they offer a quicker return on investment. The authors could have added that the governments of many tropical countries place high priority on achieving food self-sufficiency and that in some countries the threatened shortfall in subsistence food production is already apparent.

All these considerations place a premium on obtaining the best possible understanding of the quality of available land as a basis for planning sensible land-use. This can be achieved through a land resource survey.

OBJECTIVES OF A LAND RESOURCE SURVEY

In this article 'land resource survey' is deemed to include fact-finding ('land resource survey 'sensu strictu') and broadly based analysis of discovered facts ('land evaluation').

Hamilton (1981) has summarised the two main objectives of these joint activities in two succinct questions:

- a kind of land-use in mind, where best to do it?
- an area of land at hand, how best to use it?

These questions highlight the essential process of land evaluation; that of 'matching' the characteristics of a tract of land with the requirements of a defined kind of land use. The complex considerations which arise at the land evaluation stage of a survey have been examined in detail by FAO in "A Framework for Land Evaluation" (1976) and in subsequent publications which describe the application of the "Framework" to rainfed agriculture, forestry and irrigated agriculture respectively (FAO 1983, 1984b, 1985).

The procedures of a land resource survey may be applied at any level of detail to assess the potential of a continent or of a farmer's plot. Land itself is so varied that, if an overview of large areas is the objective, only highly generalised findings on land potential would be meaningful. These can be achieved by rather superficial assessments of only a few carefully chosen criteria. At national scale, for example, differences of climate alone may largely dictate where broad groups of crops may reasonably be grown. In contrast, advice on production at the level of a farmer's plot, if it is to be useful, needs to be much more detailed and must consider a much wider range of criteria in much greater depth. Obviously, as the focus of a resource survey narrows geographically so the cost per hectare increases enormously. Two very important conclusions arise from this thought:

Planning the objectives: specific objectives need to be planned very carefully in advance of each survey. In so far as possible, the kinds of land-use to be considered must be foreseen and the level of interpretative detail required to meet the planning objectives must be decided. These issues will determine the range and precision of the factual information to be collected. Flexibility to change these objectives as the survey proceeds will be necessary but the principle goals must be established in advance if the essential minimum of data is to be collected quickly at acceptable cost (i.e. without going over the ground twice).

Phasing the survey: if planning interest extends over a large area but requires that each development alternative be located precisely, the land resource survey is best organised in stages. A campaign to promote cocoa production in a large region, for example, can best start with a rapid land resource overview of the entire area aimed at eliminating parts of the region which, because of climate/altitude, very poor soils, inaccessibility etc are clearly ill-suited at present to cocoa farming. That might involve mapping at scales of about 1 : 250,000. Next, possibly before the overview is complete, a start can be made on more detailed survey of any blocks of land which the overview reveals to be promising. This second stage will focus, in particular, on more subtle differences in the character and distribution of soils but will also acquire additional information

on other aspects of agronomic importance, notably current land-use (mapping at about 1 : 50,000 scale). The second stage may provide sufficient information to start a planting programme or guide priorities in rehabilitating old cocoa. However, if the topography is very complex or the soil quality highly varied, a still more detailed survey may be necessary to locate the best soils precisely (mapping about 1 : 10,000 scale). In the rather unlikely event that irrigation is contemplated a final mapping scale of 1 : 5,000 or even larger may be necessary to establish precise land levels and any subtle distinctions in the moisture/drainage characteristics of the soils. These larger scales of survey would be confined, of course, to limited areas where the earlier stages of the overall study suggest they are necessary.

In planning the objectives and phasing of land resource survey, very careful attention needs to be given to the availability, quality and findings of existing survey information. Few, if any, areas of the world are entirely lacking in such information. It should not be assumed, however, that old maps will be directly relevant or reliable in the context of the new objectives. In particular no map can be spatially more reliable than the topographical base on which it is drawn. The evidence now available from satellite imagery sometimes reveals some alarming displacements in older mapping. Nonetheless, huge savings in time and cost can be made by sensible use of all existing information in conjunction with such modern aids as remotely sensed imagery.

THE APPROACH

The general approach to land resource survey can be illustrated conveniently by reference to a survey project at national scale currently in progress in Indonesia (Wall et al., 1987). This work which is largely financed by the World Bank is being undertaken by the Ministry of Transmigration of the Government of the Republic of Indonesia with technical assistance from the Land Resources Department of the Overseas Development Natural Resources Institute of the UK (formerly called the Land Resources Development Centre). During a period of three years the project has completed and published land resource surveys covering about a million square kilometres in the Indonesian Province of Kalimantan and Irian Jaya. The comments which follow refer to the reported findings of the project in the provinces of East and South Kalimantan - an area of 234,700 sq.km. within which some expansion is planned to the estimated 6,000 ha of cocoa presently planted.

The overall aim of the project is stated (loc cit.) to be the provision of basic information needed for rational, first stage regional planning including transmigration settlement. Two aspects receive emphasis. Firstly, the accurate mapping of all areas that should be conserved for biogenetic reasons or protected because of their erodibility. Secondly, the indication of how remaining land might be used safely for agriculture, forestry, or other defined forms of development.

Three sets of maps are produced (scale 1 : 250,000) showing respectively:

- Land Systems and Land Suitability: 42 broadly different kinds of land are recognised and their suitability for a number of defined uses is displayed.
- Present Land-use: 64 categories include the present legal status of the forest lands in terms of whether they are protected; available for normal or limited timber extraction; or available for conversion to other uses.
- Land Status and Recommended Development Areas: locates existing development projects and indicates blocks having promise for various development possibilities.

The study is seen as only the first stage in a land planning process and seeks, therefore, to identify blocks of land (usually 15,000 ha in size) within which further surveys and investigations can be expected to locate worthwhile areas for specific development activities. At the same time the general suitability of each of the recognised land systems is assessed for each of seven land-uses relevant to transmigration settlement (e.g. , houselots, dryland arable, agroforestry etc) and, separately, for each of fourteen industrial/estate crops including cocoa.

The first, very important stage in the survey was the preparation of a uniform series of reliable base maps. Existing, properly controlled topographical maps were used where available and uncontrolled sources were improved by reference to satellite imagery (Landsat) positioned in relation to any identifiable Doppler stations. Meanwhile, a very thorough search was made for all available thematic information on the area (climate, soils, geology, hydrology etc). This data was compared, contrasted and generally correlated as a basis for recognising and describing the different kinds of land - or 'land systems'.

The land system concept, developed in Australia (Christian and Stewart, 1968), is based on the assumption that different areas of land possessing essentially the same ecological properties (i.e. climate, geology, landform, soil etc) will possess very similar development potential. In the Kalimantan study interpretation of air photography (mainly at 1 : 100,000 scale) provided an initial separation into land systems on the basis of landform as well as mapping of present land-use. Both kinds of interpretation were refined and co-ordinated using the overview offered by satellite and airborne radar imagery, together with all other available sources of environmental data.

Each of the 42 land systems was described and defined in terms of 26 physical characteristics that ranged through attributes of climate and soils to flood hazard, drinking water supply and degree of site fragmentation. The expression of each of these characteristics was classified in terms of its severity - the class separations being determined pragmatically to meet the interpretative needs of the survey - as illustrated by the selected samples in the left hand column of Table 1.

TABLE 1: EXAMPLES OF RECOMMENDED PHYSICAL CRITERIA LIMITS TO ASSESS LAND SUITABILITIES FOR INDUSTRIAL AND ESTATE CROPS

(Selected and adapted from Wall et al., 1987)

Potentially limiting factor	Rubber	Oil Palm	Coconut	Clove	Cocoa
GROUNDWATER QUALITY (g)					
o none	#	#	#	#	#
f fresh	S	S	S	S	S
b brackish/ sulphurous	N	S	S	N	N
s saline	N	S	S	N	N
INUNDATED LAND (i)					
Floodwater risk only					
o none	S	S	S	S	S
l low	S	S	S	N	S
m medium	S	S	S	N	N
h high	S	S	S	N	N
Flood/heavy sediment					
ol low/infrequent	S	S	S	N	N
om medium/common	S	S	S	N	N
oh high/frequent	S	S	S	N	N
CLIMATE (c)					
Rainfall					
mean mm/yr high	N >5000	N>6000	>5000	N >5000	N >3000
mean mm/yr low	N <1500	N<1500	<1250	N <1500	N <1250
Combinations of	OR	OR			
Wet months					
(mean >200mm)	N >3500	N>4000			
and	+ >5000	+>6000			
Dry months					
(mean <100 mm)	>2 dry	+>1 dry	N >1 dry	N >2 dry	N >3 dry
	OR	OR			
	N>6 dry	N >3 dry			
Equivalent to					
Dry months (mean					
< 60 mm)	+ >0 dry	+ >0 dry	N> 1 dry	N >2 dry	N >3 dry
	OR	OR			
	N >3 dry	N >1 dry			
Growing days					
(trees)	N >185	N >275	N >245	N >185	N >200
Temp °C(min.oC)	N < 20	N < 20	N < 20	N < 20	N < 19
SOIL DRAINAGE (w) Min °C					
Drainage class					
e excessive	N	S	S	S	N
w well,mod.well	S	S	S	S	S
i imperfect	S	S	S	S	S
p poor	S	S	N	N	N
v very poor	N	N	N	N	N
SOIL CEC meg/100g (NHO_4Ac at pH 7)					
o v. low (<5)	S	S	S	N	N
l low (5-16)	S	S	S	S	S
m med (17-24)	S	S	S	S	S
h high (25-40)	S	S	S	S	S
v v. high (>40)	S	S	S	S	S

S = SUITABLE (i.e.no constraint) N = NOT SUITABLE # = NOT RELEVANT

For key to other symbols see Table 2.

Table 1 provides examples of the way in which each expression of the physical characteristics was assessed in terms of the requirements of five estate crops (including cocoa) which might be grown in the area. This table is merely an illustrative selection of the criteria evaluated by Wall et al (1987). The assessments are not necessarily valid outside the areas of E. and S. Kalimantan for which they were made. Given the degree of generalisation of the survey it was sufficient to decide merely whether each expression of each characteristic was 'suited' ('S') or 'not suited' ('N') to production of the crop in question. Tables similar to Table 1 were prepared rating land requirements in terms of all the diagnostic characteristics for each of 21 forms of land-use which might be considered as components in different settlement models for the region.

In Table 2 is illustrated the next stage of evaluation in which the recorded characteristics of each land system were assessed in relation to the requirements of each land use type to provide an overall measure of suitability. The assessment goes through an intermediate stage in which the individual land characteristics are examined in terms of the extent to which they reflect, or contribute to, specific limitations (such as poor drainage) on the crop in question. The classification of limitations as suitable, or otherwise, not only assists a subjective judgement of overall suitability but provides a refinement of that judgement. It will be noted, for example, that although five of the land systems in Table 2 are judged to include land 'suitable' for cocoa, the assessment of limitations registers doubts about the nutritional status of the soils in each case. This implies that special attention will have to be given to soil fertility in any follow up investigation aimed at locating planting sites within these systems. It could prove that cocoa production is only to be recommended in these areas if a sophisticated level of management of fertiliser application can be ensured.

In East and South Kalimantan, nine out of the 42 land systems recognised were judged to include land suitable for cocoa production. These systems total 77,026 sq km - very nearly one third of the overall area of 234,530 sq km - but, of course, by no means all of this area is suitable, or available, for cocoa planting. The assessments relate only to the dominant aspects of each system and, as described earlier, further more detailed studies would be needed to determine the distribution of good land for different uses within the system.

This approach of assessing selected land characteristics in terms of crop requirements can be applied equally well in more detailed studies leading to precise site selection for cocoa but the range of criteria to be considered and the complexity of their interactions is too great to be discussed usefully in a short article. Some of the issues to be considered in site selection have been discussed in earlier issues of the Cocoa Growers' Bulletin (Hardy 1971; Murray 1964; Smyth 1966, 1980, Wessel 1970, 1980). Further guidance on general procedures is to be found in FAO (1983) and, with specific relevance to cocoa, in Wood and Lass (1985). Both of these latter publications provide additional useful references.

TABLE 2: FULL SUITABILITY CLASSIFICATION OF SELECTED LAND SYSTEMS IN EAST AND SOUTH KALIMANTAN FOR COCOA. (SELECTED AND ADAPTED FROM WALL et al., 1987)

LAND CENTRE SYSTEM			SUITABILITY FOR COCOA	
No.	Name	Nature	Assessment of limitations: gpictdwnlsf	Overall Suitability
15	Pakau	undulating sandy terraces (1356 km²)	S#SNSNN?SSS	N
19	Sungai Medang	rolling volcanic plains terraces (806 km²)	##SSSSS?SSS	S
20	Teweh	hillocky sedimentary terraces (37,954 km²)	##SSSSS?SSS	S
21	Tewai Baru	hillocky plns/steep terraces (2,642 km²)	##SSSSS?SS$	S
22	Gunung Baju	hillocky karstic plains (1,794 km²)	S#SNSNS?SS$	N
24	Sungai Tabang	hillocky basaltic plains (1,223 km²)	##SSSSS?SSS	S
26	Barong Tongkok	moderately dissected lava flows (1,794 km²)	##SSS?S?SSS	S
27	Maput	assymetric non-o'tated sediment. hills (26,336 km²)	##SSSNS?SSN	N
36	Pendreh	non-orientated sediment mountains (42726 km²)	##SNSNS?SN#	N

KEY:Suitabilities: S = SUITABLE N = NOT SUITABLE # = NOT RELEVANT
$ = SUITABLE FOR ESTATES BUT NOT FOR SMALLHOLDERS
? = MORE DATA NEEDED/NEEDS CHECKING (MAY BE N OR S)

Limitatations:
g = groundwater (quality)
p = potable water (source)
i = inundation
c = climate
t = soil texture
d = soil depth
w = soil drainage
n = soil fertility
l = elevation
s = slope
f = fragmentation

CONCLUSIONS - A LOOK AHEAD

The Kalimantan study shows how rapid land resource survey of large regions provides a first assessment of the relative claims of alternative uses of available land. This may be achievable with respect to cocoa even when expansion of cocoa production was not amongst the objectives originally specified for the land survey. Thus, Chase (1981) was able to extend the findings of Hansell and Wall (1977) on the land resources of the Solomon Islands to provide a guide on land suitability for a number of small holder crops including cocoa. Similarly, Bleeker and Freyne (1981) based their inventory of areas suitable for cocoa in Papua New Guinea on regional land system surveys carried out between 1952-1975 by the Division of Land-use Research of CSIRO. In both countries the information acquired previously on the characteristics of land systems proved adequate for interpretative purposes. To be confident that this will be the case, however, one needs to ensure, as stressed earlier in this article, that each interpretative objective is broadly foreseen at the time of data collection.

Bleeker and Freyne (1981) concluded that production of cocoa in Papua New Guinea, which stood at 32,000 tons in 1981, could be increased to 210,000 tons by using only 20% of the better quality land identified. They believed that this increase in the area under cocoa would not have a significant effect on other forms of land use. This last would not be true in other parts of the world where pressure on land is already severe. If populations continue to increase as predicted it will become imperative to evaluate the relative claims of each alternative use of the better quality lands. Social, environmental and economic considerations (especially marketing location of markets and prices) will be at least as important as production potentials in this evaluation. Regional land resource survey will play an important role, nevertheless, in identifying feasible alternatives for use of land, warning of associated problems and providing guidance on priorities for detailed investigations and local development planning. Getting these priorities right can save a great deal of time, money and needless effort.

Fortunately, as demand for rapid land resource survey increases so does the assistance provided by technology - particularly in the associated fields of remote sensing and computer processing. For example, the fifth generation of Landsat satellite, now in space, carried a 'Thematic Mapper' which records reflected information in seven spectral bands, six of which have a resolution of 30 metres. This capability compares with 80 metre resolution in four spectral bands obtained from the multi-spectral scanner of earlier Landsat satellites and represents a great step forward in aiding interpretation of the Earth's surface - especially when the digitized data in different bands is processed interactively by computer to enhance contrast and correct distortion. Still better ground resolution (down to 10m) is provided by imagery from the new French 'Spot' satellite, which also has a limited capacity to produce paired images suited to stereoscopic examination. This enhanced interpretative capability begins to make satellite imagery directly competitive with conventional aerial photography - not least because

the acquisition of new aerial photographic data might well cost ten times as much (Mitchell and King, 1987).

Radar, from aircraft or from space, is a most valuable adjunct to other forms of remote sensing. As yet, the resulting imagery is, in general, less easy to interpret but the ability to obtain clear pictures regardless of cloud cover or haze is an immense advantage. Radar imagery was helpful in Kalimantan, particularly in building up a broad picture of the topography, and is likely to be equally useful in most areas where cocoa is contemplated.

A regional land resource survey creates, in effect, a geographical information system. Computers have added new dimensions to the way that such a system can be used. They provide storage for the huge amounts of data collected - storage that can be readily accessed by choice as raw data, as interactively processed data or even in the form of digitised maps. For a given site, for example, selected data on soils can be combined with data on climate within a mathematical model to provide a measure of moisture availability to a plant or, using a different model, to assess erosion hazard. In some contexts a stage has been reached at which assessments such as these can be compared with plant requirements and the results combined in an overall assessment of land suitability - for a wider range of plants and management systems than could reasonably be considered before the advent of the computer. Particularly significant has been the rapid development of portable micro-computers with a capacity to undertake most of these tasks. This development allows data to be accumulated, interpreted, tested and communicated at the site of the survey.

All these new developments are aimed primarily at reducing the time taken to perform useful land resource survey work - and, therefore, its cost. All too frequently developers have been unwilling to wait for adequate land resource information. Often, as a result, they have lost their investment but, unfortunately, the real penalties of their haste, expressed as land resources damaged or destroyed, tend to also affect future generations. It is to be hoped that in time, the new methods and technologies of land resource survey will be supported by longer sighted policies to preserve these crucial resources for their best possible present use and also for use by succeeding generations.

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to the Direktorat Bina Program of the Ministry of Transmigration of the Government of the Republic of Indonesia and to the Land Resources Department of the Overseas Development Natural Resources Institute (ODNRI) of the United Kingdom for jointly allowing him to draw so heavily upon the work of Dr David Wall and his team in Kalimantan in preparing this article.

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CONTROL OF THE COCOA POD BORER (CONOPOMORPHA CRAMERELLA)

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INTRODUCTION

Conopomorpha cramerella, the cocoa pod borer (also known as the cocoa moth, and formerly called Acrocercops cramerella), has become the most important insect pest of cocoa in many parts of South East Asia over the past 150 years. It has been an important limiting factor in cocoa production in Indonesia and the Philippines throughout this century. There was some intense research and control activity prior to the First World War by Dutch entomologists and planters in Java (Wessel, 1983), but this declined in the 1920's along with the Java cocoa industry. Interest in the cocoa pod borer increased again after 1980 due to a commercial revival of cocoa in the region, the appearance of the moth in Sabah, East Malaysia in 1980, and its more recent discovery in Melaka, West Malaysia in 1986. These events have made cocoa pod borer control a major concern to cocoa growers in the region.

The cocoa moth is a small brown moth with a wingspan of about 12mm, with bright yellow patches at the tips of the front wings. The moths have very long antennae. Moths in flight have an appearance similar to that of large slow flying mosquitoes. Eggs are yellow-orange, flattened, and just visible to the naked eye (approximately 0.5 x 0.2 mm). Late instar larvae are about 10mm long and creamy coloured while still inside the pod, but greenish after they emerge to pupate. The pupa lies beneath a light brown waterproof silken membrane tightly drawn over a depression on a pod surface or a leaf. Signs of damage in light infestations (such as might occur in early infestations after the moth is introduced into a new cocoa area) consist of small brown hardened tunnels on the inside wall of the pod.

The cocoa pod borer causes losses to cocoa by boring in the placental tissues of the pod, disrupting the development of the beans. Moths lay their eggs on the surface of unripe pods, larvae emerge and tunnel to the centre of the pod where they feed for about 14-18 days before chewing their way out of the pod to pupate. The feeding results in pods that may ripen prematurely, with small, flat beans, often stuck together in a mass of dried mucilage. The beans from seriously infested pods are completely unuseable, and in heavy infestations over half the potential crop can be lost.

Since the Dutch entomologist Zehntner's pioneering efforts at the turn of the century a considerable amount of research has been done on the biology and control of this pest, and many control methods have been suggested and tried. In the last few years several novel control techniques have been developed, and some are still being tested. These control measures are described later in this article after the description of the rise of the pest itself.

HISTORIC BACKGROUND

C. cramerella occurs only in S.E. Asia and the Western Pacific, and its origin within this area has been the subject of increasing speculation since the turn of the century (Mumford, 1986). It is a pest of cocoa, rambutan (Nephelium lappaceum) and other Nephelium species, kola (Cola spp.), and nam-nam (Cynometra cauliflora). There are no other hosts of economic importance (early references to attacks on litchis were due to taxonomic errors). Cocoa is clearly not the original host, since it has been introduced into the region to which the moth is restricted.

Zehntner (1901a,1901b) thought at first that the cocoa pod borer had originated in Java, but after finding host species other than cocoa, which were present in other parts of S.E. Asia, he couldn't be sure of this. Wardojo (1980) suggested that the pod borer first adapted to cocoa in Sulawesi, or the southern Philippines, based on an early outbreak in North Sulawesi and traffic between those islands.

In 1841 an infestation appeared in cocoa near Manado, North Sulawesi with symptoms typical of cocoa pod borer: dry and blackened pith, small cream coloured "worms", and small black "speckles" (exit holes) on the pod surface (Jansen, 1860). It is possible that an infestation may have been present earlier than 1841, but no record can be found of conditions during the years before 1822. This is probably the first record of cocoa pod borer attack.

While rambutan or nam-nam feeding forms of the species have probably been widely distributed throughout S.E. Asia for centuries, the cocoa feeding form has spread, as Wardojo (1980) suggested, only during the last 100 years, often carried in infested cocoa pods moved by man.

After the appearance of cocoa pod borer at Manado in the 1840's the cocoa industry in North Sulawesi declined rapidly (Toxopeus and Giesberger, 1983). The industry began to move elsewhere, to the Philippines and to Java. There had long been movements of cocoa between Minahassa (N. Sulawesi) and Manila, which could have introduced whole infested pods into the Philippines. About 1880 cocoa was introduced into Central Java on a plantation scale to replace coffee (van Hall, 1949), although there had been some trade in cocoa between Java, Sulawesi, and the Philippines even before that date (Wardojo, 1980). Cocoa pod borer infestations soon appeared in the areas newly planted with cocoa from previously infested regions.

It is possible that a cocoa form of C. cramerella was introduced into Sabah, East Malaysia during the post 1977 "cocoa boom", from Indonesia or the Philippines. A similar introduction from a previously infested area may have occurred in Melaka and Negeri Sembilan in West Malaysia prior to the discovery of cocoa pod borers in those states in 1986. However, in both cases it is also possible that there were local adaptations of rambutan or nam-nam feeders to cocoa. This question is unlikely to be resolved until reliable genetic "fingerprints" can be determined (such work is currently underway by Rita Muhamad and G S Tan at Universiti Pertanian Malaysia).

The infestation in Sabah spread rapidly from Tawau (in southeast Sabah) across the entire state during a three year period (Tay, 1987), and it soon entered Sarawak as well. However, the initial infestations discovered in West Malaysia have been contained, thanks to vigorous quarantine efforts based on experience from East Malaysia (Chin, 1987; Ling, Yew and Koh, 1987). Unfortunately, other scattered outbreaks began to appear in West Malaysia during the first half of 1988 and it may not be possible to extend this vigorous containment and eradication effort to a wider area.

Quarantine and surveillance for C. cramerella remains a major undertaking in areas of S.E. Asia in which the pod borer does not presently affect cocoa, i.e. most states in West Malaysia, Thailand, Sri Lanka, Sumatra, Irian Jaya, and Papua New Guinea. Rambutan or nam-nam borers are already known from West Malaysia, Thailand, Sri Lanka and New Britain (PNG). C. cramerella has also been found, from unspecified hosts, in Western Samoa and the Northern Territory of Australia early in the century (Mumford, 1986). Some cocoa pods are still transported within the region for planting material, and there are frequent instances of rambutans being carried across borders, either for personal use or commercially. Live borers can travel long distances within rambutan fruit; the senior author collected healthy C. cramerella pupae from Thai rambutans in a supermarket at Riyadh, Saudi Arabia in 1986.

CONTROL

Cocoa growers can choose from a range of potential pod borer control measures, any of which can be used in combination for even greater effect. There are seven main control methods potentially available, each of which is now discussed in turn.

Insecticide Spraying

To get good results from insecticide spraying against cocoa pod borer cocoa growers need to get a high rate of kill over more than one generation of moths, without excessive cost or undesirable secondary effects. This requires an appropriate choice of chemical, correct timing, and good targeting.

Since 1981, a wide range of chemicals have been tested against cocoa pod borer in Sabah, Malaysia by R.K. Day, S.H. Ho, the Sabah Department of Agriculture and estate companies. Most commercial insecticides will kill pod borers if suitable doses are applied correctly. However, there are several considerations in choosing an insecticide for use against cocoa pod borers. The larvae and pupae are protected within the pod or beneath a waterproof membrane, and would be difficult to kill even with systemic and vapour acting insecticides. The eggs would require a direct hit by a spray droplet, or they would need to be laid on top of a droplet, which makes them relatively unattractive as targets since many eggs are laid on pods high in the canopy. Adult moths do not feed, but contact insecticides aimed at that stage in the life cycle would offer a reasonable chance of success.

It is undesirable to have a chemical with very long persistence

because of potential secondary ecological effects. For example, the initial results from insecticide spraying in the early 1950's appeared promising, but Giesberger (1983) reported that after five years of continual spraying against pod borers on one estate in Java (from 1958) 1,200 ha of cocoa had to be uprooted as a result of severe stem and branch borer (Glenea novemguttata) attack. Wardojo (1980) also associated these spraying practices with serious attacks from another stem borer (Zeuzera coffeae). Conway (1973) believed that widespread overall spraying of cocoa with endrin and similar chemicals (not for pod borer) contributed to the serious bagworm (Clania spp.) outbreaks in Sabah in the early 1960's.

Apart from long persistence these early spraying programmes also involved non-specific targeting of the sprays throughout the canopy. Many trials (R.K. Day, and subsequently S.H. Ho, unpublished reports) in Sabah have shown good results from spraying contact insecticides onto the underside of lower canopy branches five times at 10-14 day intervals during the low crop period. This kills moths for a period of about 50 days, which is almost the duration of two generations of pod borers.

The method of spraying developed by Day and Mumford is to spray only the daytime resting sites of the moths, the underside of relatively horizontal, lower canopy branches. Sidhu, Sim, and Johney (1987) recommend spraying the pods as well as the branch resting sites, in an effort to kill females during oviposition as well. Both of these targeted programmes should minimise disruption to beneficial insects in the cocoa by leaving large volumes of canopy as an unsprayed refuge. In younger plantings with low branches spraying is best done with a hydraulic knapsack sprayer. In older trees, a mistblower may be needed, or hydraulic sprayers with extended lances. The effectiveness of sprays is likely to be greater in younger plantings where better coverage can be obtained. Clearly with large trees in which mistblowers are used the degree of targeting is not as good as in small well pruned trees sprayed with hydraulic knapsack sprayers.

Deltamethrin at 25 ppm in 100 litres per ha in five ten-day rounds has become a standard against which other treatments are compared. Cypermethrin at 100 ppm gives similar results, as do other pyrethroids, or lindane, at appropriate rates. In Malaysia, branch spraying costs approximately M$25-30/ha per round at 1988 prices, while pod spraying is more variable, depending on the number of pods at each point in the season.

Branch and pod spraying with chemicals of relatively short persistence, carried out only for limited periods, should avoid the problems that occurred in the past with chemicals of long persistence sprayed throughout the year. The timing of sprays in the low crop period has three advantages: it reduces moth numbers during the early part of the following peak crop, thus protecting the most vulnerable stage of the main harvest; it is less likely to reduce the effectiveness of natural enemies and pollinators, which are probably at their most efficient just after the peak crop; and, finally it is a time in the year when labour is least limiting.

It has recently become common in Sabah to spray throughout the year every two weeks, particularly aiming sprays at pods. This practice has shown considerable success with no adverse side effects (apart from cost) after a year of operation (K.V. Johney, pers. comm.). However, as Sidhu, Sim, and Johney (1987) point out, continual exposure to insecticides for each generation of an insect throughout the year increases the likelihood of insecticide resistance developing. If year round spraying is done with mistblowers, then the situation is virtually the same as the catastrophic cases described by Giesberger, Wardojo, and Conway. A cheaper and safer alternative to continual spraying would be to extend the five rounds of low crop spraying to 7 - 8 rounds where infestations are particularly serious.

Sidhu, Sim, and Johney (1987) also describe a system of spraying based on crop infestation monitoring first developed at Ciram Estate, Sabah. In this system 5 per cent of the crop (every 20th row) is examined for pod borer infestation at each harvest round and when infestation levels in a row exceed a preset threshold, four to six rounds of spraying are carried out in the 20 rows either side of the census row. Using this system it is most likely that spraying will be done during low crop periods, since it is at that time that infestations are likely to be highest and to exceed the thresholds. Savings from not routinely spraying areas which are below the thresholds exceed the costs of monitoring, making this a desirable practice.

Mumford (unpubl.) has suggested an alternative form of monitoring, carried out only during the period four to eight weeks before the low crop period, and subsequently at the end of the five rounds of spraying conducted in the low crop period. Monitoring before the low crop determines whether spraying should be done during the low crop period, and monitoring at the end of the five rounds of spraying would indicate if several further rounds should be applied. This system is based on field experiments and computer modelling by Day (1985) which indicate very low returns from spraying during peak crop periods.

Frequent harvesting/husk destruction

In 1980 Mumford observed that many caterpillars emerge from ripe pods both before and after harvest, while relatively few emerge from unripe pods. Since that time it has been recommended practice in East Malaysia to conduct frequent harvesting of newly ripe pods, with rapid breaking, and subsequent destruction of husks by bagging, burying, drying, etc. to reduce the emergence of caterpillars in the field. Wood (1987) maintains that this method of cultural control (which he refers to as "ecological harvesting"), with strict seven day harvest rounds, kept a 41 ha commercial field in Sabah below a level of infestation at which noticeable losses are suffered for all but low crop periods during two years from 1985. He points out the importance of good pruning to ensure that pods can be seen and reached for thorough harvesting.

Apart from reducing the survival of pod borers, frequent harvesting and husk destruction increases the proportion of the crop that is

collected, reduces pod rot in the field, and leaves less ripe pods to attract rodent feeding. Wood (1987) conducted experiments which showed that weekly harvesting yielded more pods over a year than did harvesting at longer intervals.

Sleeving

Sleeving was first suggested by Zehntner (1903), using cotton bags to cover young pods (7-10cm) in seed gardens. The bags are left on the pods until harvest and prevent oviposition on the pods, and so eliminate infestation, if placed on pods before they attract egg laying female moths. In modern times plastic sleeves (small polythene bags, generally) are used by some growers in Sabah, in small holdings in the Philippines (Vanialingam et al., 1981), and on some holdings in Indonesia.

While sleeving protects the pods covered, it does not reduce the population of moths, since they will continue to infest and breed in any unsleeved pods remaining on the trees. Most sleeving is aimed at protecting the peak crop. However, this is the period when infestation levels are lowest, and unless significant losses are expected during the peak, sleeving may not be cost effective.

Rampasan

Zehntner (1903) advised planters that pod borer populations could be reduced by complete stripping of immature and mature pods for a short period during the cropping cycle (a practice known as rampasan which was also applied to control pests on some other crops, such as coffee). In theory, the pod borer's life cycle would be broken by removing all the egg laying sites. Many estates in Java began to practise rampasan during the low crop period, and while control was not complete (since some pods were inevitably left on the trees) planters found some improvement.

There was some debate about the duration and frequency of rampasan, whether it should provide a pod free period of as little as three weeks or as long as two months, and whether it should be done once or twice a year. Strictly in terms of the control effect, the longer the pod free period and the more frequently it is carried out the better. Economic constraints, such as the cost and availability of labour, and the nature of the cocoa cropping cycle largely determined the practice on estates.

In 1980, Wardojo felt that the results of rampasan were not satisfactory in Indonesia, but further research in both Malaysia and Indonesia seems to be reviving interest in this control measure. In Malaysia a small area (144 trees) of the cocoa pod borer infestation at Sua Betong, Negeri Sembilan was left standing after the infestation was discovered and a strict rampasan was carried out early in 1987, with no subsequent appearance of cocoa pod borer (F. Chin, pers.comm.). More strictly managed rampasan has apparently shown some success in Indonesia in recent years, and Wardojo told an FAO meeting on cocoa in October, 1987 that cocoa in Indonesia was being grown with considerations for rampasan in mind, for instance plantings would be made in relatively small, isolated blocks.

Rampasan is probably only a suitable control measure in fairly small and isolated areas of young (or very well pruned) cocoa where stripping can be very efficient (i.e. complete), and where reinvasion from neighbouring estates is unlikely. It would also be important to have a large and reliable labour force to ensure that the rampasan was properly carried out. For cocoa growers who are concerned at the thought of lost pods, a more palatable operation may be a combination of sleeving all easily reached pods and rampasan of the remaining pods, during the low crop period (Shah, 1987).

An exceptional form of rampasan is the elimination of the entire crop, trees and all. This has been employed with reported success in Sumatra (Wardojo, 1980) as an eradication measure to protect further cocoa plantings. The cocoa must be isolated for there to be any effect.

Parasites/other natural enemies

Natural enemies contribute greatly to mortality of pod borers, and a number of attempts have been made over the years to rear or introduce parasites and predators (Ooi, 1987; Lim and Chong, 1987). The greatest natural mortality occurs due to predation, mostly by ants (Day, 1985; Ho, unpublished reports). Day and Ho monitored pupal mortality every four weeks in a field in Sabah for over five years and observed that predation accounted for the death of 50-90 per cent of the pupae each month. Parasitism of pupae was in the range 0-15 per cent. The only other stage prone to significant parasitism or predation is the egg, and they found parasitism by naturally occurring Trichogrammatoidea bactrae fumata wasps generally accounted for very low levels of egg mortality, but on occasions the level of parasitism rose to about 60 per cent. A similar rearing programme involving Trichogrammatoidea spp. undertaken by Nagaraja and others in the Philippines has also ceased due to costs and management difficulties, despite reported successes in reducing pod borer losses.

The most intensive effort to develop pod borer control with natural enemies has taken place in Sabah, in particular by rearing and releasing a naturally occurring egg parasite, Trichogrammatoidea bactrae fumata (Lim and Chong, 1987). Wasps have been released in large numbers on trial plots and Lim and Chong (1987) have reported significant reductions in loss as a result. The numbers of wasps required is quite large, ideally 12,500 to 25,000/ha per day, according to Lim. However, weekly release of this number has also shown some effect in lighter infestations. At one point, there were 14 insectaries operating in Sabah to produce wasps for commercial estates, but almost all of these had closed by 1987 due to difficulties in maintaining adequate cultures of parasites and healthy hosts (the rice moth Corcyra cephalonica), and high costs.

In addition to protecting naturally occurring biocontrol agents (by selective spray targeting and timing, for instance) and rearing egg parasites, Malaysian cocoa growers have begun importing exotic natural enemies as well (Ooi, 1987). P.A.C. Ooi of the CABI Institute of Biological Control has made surveys of pupal parasites of Gracillariid moths related to cocoa pod borer in West Malaysia.

Indonesia, the Philippines, Papua New Guinea, and Sri Lanka. During 1987 three species of these parasitic wasps have been introduced into cocoa fields in Sabah with the help of quarantine authorities from the Sabah Department of Agriculture. It is hoped that some or all of these wasps, and others that may be introduced in 1988, will establish themselves in Sabah and provide an additional level of control with no further management.

Pheromones

In 1981 R.K. Day showed in field experiments that female pod borers produce a pheromone to attract male moths. A mixture of pheromone components was subsequently identified (Beevor et al., 1986) and a synthetic pheromone has been produced by the Overseas Development Natural Resources Institute in London (Beevor, Day, and Mumford, 1986).

The synthetic pheromone has been used on a trial basis to control cocoa pod borer in several estates in Sabah. Trials have involved large areas with 4 traps/ha, 8 traps/ha, and combinations of trapping and spraying. Results reported by Mumford and Beevor (1987) and Ho, Beevor, and Mumford (1987) show good partial control, with losses in trapped areas about two thirds those in untreated areas in two large trials covering hundreds of hectares during 1986. Much better control was achieved using a combination of trapping throughout the season and branch spraying during the low crop periods (losses one third those in untreated areas). Losses plus control costs in trapped plus sprayed (4 traps/ha all year plus 5 rounds of branch spraying in both low crop periods during the year) were estimated to be about half the losses in an untreated area (M$1135 vs M$2216) for a crop expected to be worth M$4000/ha at 1987 prices. Combined losses and costs for trapping plus spraying were also lower than for either spraying or trapping alone.

While trapping is not yet as effective as spraying, it is much cheaper (between M$75-150 ha/yr, compared to about $250-300 ha/yr for two sets of low crop period sprays, 10 spray rounds per year total). Trapping can therefore, be a useful additional form of control. Further improvements in pheromone trapping are expected in the future.

During 1987 a second form of cocoa pod borer was discovered which responds to a different pheromone mixture (P.S. Beevor and D.R. Hall, pers.comm.) and trials are beginning in 1988 to trap both forms in Sabah. The two pheromone mixtures will also offer greater potential for using traps as a quarantine surveillance technique in areas where cocoa pod borers have not yet been found.

Resistant Varieties

Entomologists have been looking for mechanisms of resistance to cocoa pod borer since the pest was identified in Java at the turn of the century (Azhar and Lim, 1987). Djati Roenggo (DR), and other Forastero hybrids, were found to be less susceptible than Criollo cocoas, and it was first assumed that the resistance arose from the smoother, less furrowed surface characteristics of the DR hybrids

(which was thought to make them less favourable for egg laying). It was also noted that the DR pods had harder husks than more susceptible varieties, and this has proved to be the more productive direction for later research.

Day (1985) investigated the effect of pod husk hardness on the mortality of cocoa pod borer larvae and found that the hardness/-thickness of the sclerotic layer of the pod wall was related to the mortality of first instar larvae entering the pod and last instar larvae leaving the pod. Other instars showed little mortality in either hard or soft pods. The sclerotic layer is up to 1 mm thick in some particularly hard varieties, which is about 10 times the width of the head of a first instar larvae. Azhar and Lim (1987) have listed several dozen varieties by hardness category and shown further evidence that hard pods suffer less damage from cocoa pod borer. In one test they found larval mortality at the sclerotic layer was ten times greater in the hardest variety tested than in the softest variety (LAFI 7 vs ICS 98, respectively).

SUMMARY OF CONTROL MEASURES

At present there are two control measures that are essential to control the cocoa pod borer. These are frequent harvesting and destruction of ripe pods and husks to prevent pupation in the field, and selective spraying of the moth resting sites and pods with contact insecticides to kill adult moths during low crop periods and the early part of the peak crop. Both control methods work best with short, well pruned trees. Indeed, with tall, ill-kept trees control will be almost impossible.

The very successful quarantine effort undertaken in Melaka, Malaysia by the Malaysian Department of Agriculture, Dunlop Estates and Sime Darby Estates has been based on these methods, but with continuous and expensive spraying instead of the limited spraying suggested above because of the exigencies of an intended eradication effort.

Several other methods continue to show promise. A second synthetic pheromone mixture is being tested, and both types should be useful for mass trapping and quarantine surveillance throughout S.E. Asia. Exotic pupal parasites have been discovered in an international search and are beginning to be released in new areas. Small areas of cocoa varieties with harder pod walls have been planted on a trial basis in pod borer infested areas and will help to show the benefits of host plant resistance. The ecologically sound practice of rampasan is making a comeback in plantings designed with pod borer control in mind in Indonesia. High density hedgerow planting of cocoa in the region may make methods such as sleeving more practical, and will also facilitate control by harvesting and spraying.

The outlook for cocoa growing in the cocoa pod borer infested regions of S.E. Asia is better than at any time in the past. This is largely due to the vigorous response of the Malaysian cocoa industry and Agricultural Departments to the pod borer during the past seven years. More intensive research has also been conducted by government institutes in Indonesia and by private industry in the Philippines during this period. A regional approach to the cocoa

pod borer problem in S.E. Asia is now called for, particularly in view of the increasing threat of spread to the many new and/or uninfested cocoa growing areas. Despite a relatively optimistic view of the future, the cocoa industry must recognise that this is a pest that requires management, at a cost, and will not go away of its own accord.

ACKNOWLEDGEMENTS

Our research on the cocoa pod borer has been supported by the East Malaysian Planters' Association, the Malaysian Cocoa Growers' Council, the American Cocoa Research Institute, Mars Inc., and the United Kingdom Overseas Development Administration, along with many individual cocoa producers throughout Malaysia. During the Malaysian cocoa industry's pod borer research programme there has been extensive cooperation and collaboration with the Departments of Agriculture in Sabah and Peninsular Malaysia, the Malaysian Agricultural Research and Development Institute, the Universiti Pertanian Malaysia, and the Universiti Sains Malaysia.

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SYNTHESIS OF THE 10TH INTERNATIONAL COCOA RESEARCH CONFERENCE

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The 10th International Cocoa Research Conference was held in Santo Domingo, Dominican Republic from 17th to 23rd May 1987. This resume of the papers presented at the conference was given by Dr Eric Bonaparte at the closing session.

The coverage of such a broad range of scientific disciplines makes any form of synthesis of such a conference a formidable and daunting task. This article therefore focuses attention on the broad findings and areas of achievement in the various disciplines, placing emphasis on the subject matter and on their geographical and Institutional origins, rather than on authors, and while providing some linkage for a broader perception of the relevant subject matter.

The theme of the Conference, "The Rationalization of cocoa culture and the development of more efficient cropping systems" covers several disciplines. It also has economic and socio-economic implications. We are here considering the optimum combination of several factors and of their various interactions, in both space and time. It is, in effect, an exercise in efficient land use.

Cocoa traditionally grows as an understorey plant of various shade tree species, and in combination with food crops during the early years of establishment. It is, therefore, an obvious candidate for agroforestry and agro-sylvicultural research. The growth of cocoa in combination with other crop species involves factors of population density and crop yield; of plant competition and cooperative interaction; of the modification of the microclimate, particularly of the utilisation of solar energy with regard to yield and photomorphogenesis; of the labour input (both quantum and profile) during a defined growth and yield period; and of the ultimate profitability of the enterprise.

The work reported in Brazil clearly shows several possible overstorey shade tree/cocoa combinations and food crop combinations. Crop combinations have been adopted in some of these new plantings, and cocoa is an important component of such combinations. Rubber, peachpalm, clove, jackfruit, brazil nut, and legume trees have been used as shade trees. Avenue planting with Leucaena pruned to provide mulch and shade leads to a reduction in weeding costs, the recycling of nutrients, and the reduction of the fertilizer requirement of cocoa. A range of food crops is also grown in the third layer.

The eventual combination of cocoa with shade/forest species provides an excellent illustration of compatibility and complementarity between various species and at the same time the durability of such multi-storeyed production systems. The essential requirement is the compatibility of the selected shade trees with cocoa.

Diversified crop systems can make more efficient use of labour and equipment over a relevant time span, reduce the cost of weeding that would be required in sole crop stands, make complementary use of soil fertility resources, reduce erosion hazards and increase the land's total productivity on a sustainable basis. Socio-economic advantages lie not only in increasing the overall productivity, but also in avoiding the over-reliance on a single commodity and other risks of monocropping.

The study of the arecanut-cocoa combination in India involving six densities and two levels of fertilizer application, indicated the optimum combination of population densities of the two species for maximum economic returns. The gradual elimination of coffee trees and their successful replacement by cocoa in areas below 1,300m where control of coffee rust is costly and uneconomic was demonstrated by the work in Colombia.

A study reported from Brazil emphasised the suitable architecture of the thornless peach palm as a shade tree for cocoa, in terms of height of trunk and spread of branches which provide adequate shade, reduction of turbulence, the reduction of pest and weed control costs and reduced fertilizer needs.

The replacement of old cocoa with new cultivars has engaged the attention of many workers for several decades. Any decision on methodology should be based on at least two factors: the yield of the existing crop and yield projections of the new cultivar.

The studies in Ghana and Nigeria on the replacement of old virus-infected cocoa with new cultivars demonstrate the variety of available options and the results of the selected options. These show that where cocoa swollen shoot virus is endemic, the total removal of old trees followed by replanting with new cultivars is the only sensible option.

In Cote d'Ivoire the study of cocoa/food crop combinations, using different cocoa population densities, and the planting of food crops in the avenues has demonstrated the economic benefits of multiple cropping to the grower, though significant depletion of potash in the food crop strips necessitated fertilizer application. The second study in Cote d'Ivoire is similar in concept to the above in allowing space for food crops, but introducing other factors, namely complete removal and the removal of the old cocoa in two stages. A cocoa rehabilitation study in Togo consists of the initial removal of half of the old cocoa stock, subsequent total removal four years later, and intercropping with food crops. These cocoa/food crop combinations have the advantage of maintaining the income of farmers during the rehabilitation process.

In Costa Rica, high planting density increased yields for the first few years, weeding costs were reduced, but severe plant competition resulted in low cocoa yields, necessitating the adoption of a number of thinning options. In Venezuela, mechanized and chemical weed control have been used in the overall management of cocoa.

Cocoa agronomy has not benefited from mechanization either of

pre-bearing or of post-bearing field operations, mechanization having been concentrated heavily on post-harvest processing operations. The possibilities of mechanization are inextricably linked with the plant densities (and hence the inter-plant distances) of cocoa and of other crop species, and more particularly of their architecture, by setting limits to manoeuvrability of machines and accessories. Avenue planting, by providing greater inter-plant distances between rows, could provide a wider scope for mechanization not only of weed control as was reported from Venezuela, but also of other operations such as disease and pest control.

The effects of the various cropping and management systems on the development of breeding sites for pollinating insects must not be ignored. Further studies are needed.

Progress continues to be made in the in vitro development of somatic embryoid production and the eventual production of plantlets. The work described from Ghana in collaboration with the International Atomic Energy Agency and work in progress by IBPGR and IRCC emphasize the growing importance of this subject.

More light has been shed on the flush growth of cocoa by the work of the group at Liverpool University. At the time of maximum growth, consumption of carbohydrate by the developing flush exceeds that available from current photosynthesis, and the balance must be supplied from storage. The cessation of leaf production within one flush is thus a likely consequence of carbohydrate limitation. Following a period without leaf growth (interflush) the depleted carbohydrate store will be replenished and with the return to positive carbohydrate balance a further flush of leaf growth can take place. Carbohydrate availability controls flush growth in seedlings in controlled environmental conditions and is likely to be a major factor for mature trees in the field. The size differences between leaves in one flush are due to differences in cell number (not cell size) per leaf and are determined at a very early phase of leaf development.

Approaching the problem from a different angle, the work by the group at Reading University showed a high correlation between free indole adipic acid and stage of leaf development and bud activity, with high levels of both apical buds and leaves at the start of the flush cycle which rapidly diminish as the leaves begin to expand. From the results of the effects of indole adipic acid on bud activity and flush growth periodicity, they suggest a possible role of auxins in the control of apical bud activity and leaf development. They further show that pod growth during the linear phase and the duration of pod growth are simple functions of thermal time.

In Brazil, the study of the annual yield distribution over several years showed that seasonal variations in both rainfall and temperature have an influence on pod setting. In Bahia low temperatures (below 23°C) have an inhibiting effect on cambium growth which is linked to flowering, and this is responsible for the indirect effect on yield seven months later. A similar situation is found in Ghana and Nigeria.

Stress physiology is of importance to cocoa scientists, particularly physiologists, agronomists, and plant breeders, and the papers from Purdue and Liverpool Universities on water and light saturation stress have extended our knowledge on this subject.

Studies in Brazil on nutrient recycling in cocoa agrosystems, the efficiency of phosphates, and the effect of fertilizers and correctives on the soils of Amazonia were reported. Litter from tree legumes and cocoa enhances soil fertility, particularly that of low fertility soils, and it was emphasized that phosphates should meet agronomic, economic and industrial needs. The inoculation of cocoa seedlings with mycorrhiza (Gigaspora margarita) and the persistent superiority of mycorrhizal inoculation over the controls after transplanting adds an important new dimension to cocoa husbandry.

It was demonstrated from work in Cote d'Ivoire that fertilizer doubles the number of flowers with or without irrigation, that pod-setting shows a sharp increase with fertilizer and irrigation, that cherelle wilt occurs most frequently on fertilized and irrigation and trees resulting in 63 per cent more pods from fertilized/irrigated trees than from the control trees.

The efficiency of pollination in cocoa fields is very important for the achievement of the yield potential of trees and hence of farms and plantations. The efficiency of pollination would depend on the pollinating insect species and of their abundance at critical periods the phenology cycle of the cocoa tree.

The low level of pollination in cocoa fields is one of the main factors which limit yields. This is supported by the fact that cocoa trees produce more pods by manual pollination than by natural pollination. The study in Brazil indicated that the Ceratopogoinid midges of the genus Forcipomyia are perfectly adapted to the pollination of the cocoa flower. Of primary importance also is the need to provide adequate breeding conditions for the pollinating insects, including the group Euprojoannisia which are the most common pollinating agents in tropical America, Africa, Indonesia and the Philippines. In this connection, it is necessary to bear in mind the work in Costa Rica on the effects of types of Musaceae, under shaded and unshaded conditions, on the development of breeding sites for Forcipomyia midges.

The study in Togo produced three important facts. Firstly, that the average quantity of pollen produced correlates negatively with the percentage of unpollinated flowers. Secondly, that large numbers of insects present in the flowers induce better pollination. Thirdly, that low cocoa productivity is due partly to under-pollination resulting in low rate of pod-setting and low bean number per pod.

The superiority of manual pollination over natural pollination has been emphasized by work in Brazil, and stresses the importance of management of heavily pollinated trees, for example, fertilizer application for sustained heavy yields.

Witches' broom disease is of great economic importance in the New World. The causal organism is a fungus first described in 1915 by

Stahel as Marasmius perniciosus, and subsequently renamed in 1942 by Singer as Crinipellis perniciosa. The disease is indigenous to the Amazon Basin and is now present in Bolivia, the Amazon region of Brazil, Colombia, Guyana, Ecuador, Peru, Surinam, Venezuela, Grenada and Trinidad. The disease threatens the new plantings in the Brazilian Amazon, and is advancing into the more important upland cocoa-growing areas of Colombia. The vast array of papers presented at this Conference on Witches' Broom disease both in the oral and poster sessions aptly demonstrate the immense range of scientific research in progress aimed at the containment and control of the disease.

The papers from Brazil focus attention on the mechanical control of the disease by sanitation pruning of infected branches and jorquettes and the cost of these operations. The cost effectiveness depended on three variables: the market price of cocoa, the potential productivity of the farm (kg/ha), and the cost of the pruning operation.

Chemical control of the disease was studied in Trinidad, using 15 chemicals in vitro as well as on 3-week old seedlings. Biological control of the disease has been studied at the University College of Wales. The interaction studies show that Xylaria sp. and Nodulisporium gregarium are strong antagonists to C. perniciosa, producing vigorous invasion and lysis of the mycelium.

The role of rain-water in the dissemination of basidiospores of C. perniciosa was studied in Brazil. Physiological and biochemical studies on C. perniciosa were reported from Aberystwyth and Liverpool. The possible role of protoplasts from C. perniciosa for the investigation of the physiological and biochemical interactions, at the cellular level, between the fungus and cocoa during infection and the course of the Witches' Broom disease was discussed.

In view of the global phytopathological significance of the disease, the International Witches' Broom Project (IWBP) was established in 1985 with the objective of developing practical and reliable economic methods of managing the disease in a number of cocoa growing environments. IWBP is a truly international project funded by thirteen member Associations of the International Office of Cocoa, Chocolate and Sugar Confectionery (IOCCC) with the governments of four cocoa producing countries: Brazil, Colombia, Ecuador and Trinidad and Tobago with generous support from both the EEC and ODA. Venezuela and Grenada will also be involved in the project. IWBP is conducting fundamental research at a total of 13 centres in Europe, Latin America, and the United States of America. It has also organised three workshops on the disease already.

At the meeting of the International Phytophthora Group in Itabuna, Bahia, Brazil in November 1985, papers on several aspects of the disease were presented, including the taxonomy of the Phytophthora genus. Important advances have been made in the taxonomy of Phytophthora disease of cocoa since the Cocoa Black Pod Seminar, funded by IOCCC and held at Rothamstead Experimental Station, UK in 1970.

Work at University of California, Riverside provides further details of the taxonomy and distribution of the species of Phytophthora causing black pod disease of cocoa. It is now recognised that at least four species of Phytophthora can cause these diseases, namely P. palmivora, P. capsici, P. megakarya, and P. citrophthora. A fifth species, P. megasperma has been described from Venezuela by L. de Reyes. The species are differentiated by morphological characteristics, size and number of chromosomes and by protein and enzyme patterns.

Studies have been carried out in Montpellier of some enzymatic systems of different geographical isolates of Phytophthora, and of cocoa cultivars of varying susceptibility to the disease, in order to provide information on the host parasite interaction in cocoa. Resistant clones show an additional band in their esterases in the slow area after infection. If this difference is established in a large number of resistant and susceptible clones, this variability in esterases could be used in the early selection of cocoa for resistance to Phytophthora.

Two screening methods to identify resistance were studied in Cameroon. The first, an early selection method using cocoa leaves in both nursery and field for pod tolerance to Phytophthora spp. showed that the development of surface necrosis on a leaf inoculated at the VP1 stage allows the separation of clones which corresponds to their susceptibility ranking. The second is the screening of clones for susceptibility to P. megakarya based on the constituents of the pod husk. Further work from Cameroon described the chemical control of Phytophthora using new fungicides and new spraying methods.

The reinfection of replanted cocoa by cocoa swollen shoot virus is a major problem in the rehabilitation of cocoa in Ghana, and the results of reinfection trials on farmers' plots, usually after swollen shoot treatment, showed that infected cocoa trees close to new plantings provide the main source of virus inoculum, and infection of new plantings would be reduced by maintaining a cordon around replanted cocoa accompanied by regular reinspection and treatment of the old cocoa.

The biological and chemical control of Moniliophthora roreri in Costa Rica, using antagonistic epiphytic bacteria and the fungicide chlorothalonil showed that both methods significantly reduced the incidence of monilia pod rot in the susceptible cultivar, but there was no difference between the control and the fungicide and biological treatments in the resistant cultivar.

The effect on early seedling growth by root infecting fungi in Ecuador was described from the University College of Wales. Isolates of Fusarium solani significantly reduced seedling growth compared to the control; F. oxysporium and F. demicellulae had no effect, and Cylindrocarpon destructans caused a significant stimulation of growth.

The differences and similarities between cocoa plants infected by the most common fungi in Venezuela, belonging to the genera

Ceratocystis, Phytophthora, Fusarium, and Botyodiplodia, and the associations between these and boring insects of the family Scolytidae were described. This information provides the basis for recommendations on phytosanitary control.

In the field of genetics and breeding, evaluation of the field resistance of cultivars to Phytophthora palmivora in Ghana has led to the selection of high yielding and resistant trees. Considerable work has been devoted to the variability of pod and bean characteristics of clones, and on the inheritence of some characteristics of the cocoa pod in Brazil, Costa Rica, and Trinidad. Pod and bean characteristics showed high heritability. Studies in Trinidad provided valuable information on the genetic variability within the major populations of the International Cocoa Genebank, Trinidad, and its exploitation in breeding programmes.

In the Dominican Republic the evaluation of local trees for high yielding clones, the performance of hybrid cocoa, and the early development of some hybrids have revealed the existence of high yielding trees and hybrids.

Breeding and genetic analyses in Brazil have led to a better understanding of the incompatibility status of some genetic materials and of the incompatibility system. A significant contribution to our knowledge of the incompatability system emanates from very original work, using self and alien pollen, conducted at Montpellier. This work also explores the role of the incompatibility system in breeding programmes.

Significant progress has been made in the identification of clones by electrophoresis with the objective of finger-printing these clones. Preliminary studies in Cameroon have provided indications of variability among cultivars. In Trinidad, the zymograms obtained from bark tissues and mature leaves were characteristic of the clones studied. Vigorously growing chupons and mature trees of the same clone produce identical, or nearly identical, zymograms. In Togo, differences in electrophorectic profiles of healthy and CSSV-infected trees can be used for the early identification of diseased trees.

Dealing with cropping systems, the agro-economic survey of farms in the Brunca Region of Costa Rica confirmed previous knowledge that cocoa is traditionally grown in association with other economic trees and food crops. The fruit trees (papaya, avocado pear, orange and banana) were found to be very important to the farming economy.

The President of the Chocolate Manufacturers Association of the United States of America provided an insight into consumer research aimed at increasing the consumption of chocolate and confectionery products in a very competitive market.

At Montpellier, work on the development of phenolic compounds in the cocoa bean has added to our knowledge of their biosynthesis. The cocoa bean displays phenolic metabolism resulting in the biosynthesis of anthocyanins and hydroxycinnamic derivatives different from those previously described.

Physico-chemical characteristics of cocoa butter have been described by work in Cote d'Ivoire, Montpellier and the Dominican Republic.

Work in Malaysia provided important information on an integrated approach towards quality improvement of cocoa beans, involving mean bean size, shell percentage, cocoa butter content and reduction of acidity. The work from IRCC described the mechanization of cocoa processing operations involving pod breaking, fermentation, colorometric sorting and vacuum storage, and that from Brazil provided information on the use of an iron furnace dryer.

The subject of cocoa byproducts attracted two principal papers on the use of pod husk as fertilizer in Ghana, and the industrial production, in Brazil, of cocoa juice.

Finally, the paper on statistics from Montpellier provided valuable information on the present state of the art. The objective is to reduce the error variance and to improve the efficiency of experiments in order to permit the detection of given treatment differences with minimal replication.

The present series of International Cocoa Research Conferences have proved to be a most important forum for cocoa scientists to present their research results and to resolve and propose solutions to global scientific problems of importance to the world cocoa industry. The large and high-powered assembly of eminent scientists and personalities from around the globe always adds prestige to these Conferences.

It is to be hoped that scientific research will be adequately funded; by the provision of adequate remuneration and pre-requisites to research workers and the provision of equipment and other facilities for optimum performance. Scientific research must continue to expand the frontiers of knowledge in the various disciplines to meet the current and future challenges of the world cocoa industry: thesis, antithesis, synthesis; hypothesis, observations, new hypothesis, repeated ad infinitum, as we reach for the ultimate truth.

Editors Note:

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THE ENVIRONMENTAL IMPACT OF PESTICIDES - THE ENVIRON DATABASE

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The Overseas Development Administration (ODA) of the UK is involved in a wide range of agricultural development programmes in the tropics. Whilst recognising that pesticides play an important part in the control of agricultural pests and weeds, ODA believes that environmentally sound policies for pesticide use must be adopted if the environment of the future is to be safeguarded. As part of ODA's policy to promote the judicious use of pesticides, the Pesticide Impact Section has been set up within the Overseas Development Natural Resources Institute (ODNRI). This institute is newly formed by the amalgamation of units which include TDRI (Tropical Development and Research Institute) and Land Resources Department (LRD) amongst others. TDRI was previously called TPI (Tropical Products Institute). This Section can provide information and advice on the environmental impact of development projects which involve the use of pesticides. Its staff aim to help scientists, farmers and agricultural administrators from developing countries to choose the most appropriate pesticide for local conditions.

Although staff at the Pesticide Impact Section have the expertise and experience to design and carry out studies on the environmental impact of pesticides, they also have the ability to assist a wider range of people through the use of their computerised database known as ENVIRON. This is a bibliographic computer database of books and scientific articles about the environmental side-effects of pesticides (including herbicides and fungicides) in the tropics. ENVIRON has been designed to provide a rapid and comprehensive information service freely to scientists, farmers and agricultural administrators living in developing countries and working for international development organisations. Gathered within ENVIRON is information which was previously widely scattered throughout the scientific literature. The wise use of such information will ensure that the inefficient and environmentally damaging uses of pesticides are minimised.

Topics covered in ENVIRON include:

* pesticide toxicity to non-targets
* pesticide persistence and residues
* environmental fate of pesticides
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  - evidence of mortalities
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ENVIRON can handle enquiries about the effect of pesticides on non-target organisms (including soils), after first specifying the pesticide (or pesticides), the target pest(s) or non-target organ-

ism(s), or a combination of these. The output consists of a list of references, each of which is followed by an indication of the content of each paper and in some cases a relevant abstract. Depending on the request we also attempt to synthesise the information available to aid the enquirer. At present there are no plans to provide an on-line facility for external users.

For further information about the services of the Pesticide Impact Section, or for a request for information from ENVIRON, please write to: Dr. P Goll, Pesticide Impact Section, Overseas Development Natural Resources Institute, Central Avenue, Chatham Maritime, Chatham, Kent, ME4 4TB, England, United Kingdom. Communication can also be made by facsimile (0634.880066) or by telex (263907 LDNG). However, replies will generally be given by mail. This service is provided free of charge.

COCOA POD HUSK AS A BREEDING SUBSTRATE FOR *FORCIPOMYIA* MIDGES AND RELATED SPECIES WHICH POLLINATE COCOA IN GHANA

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INTRODUCTION

The logical procedure in cocoa cultivation where low level of pollination poses a problem is to seek to improve cultural methods necessary for maintaining high populations of the pollinators. The first step in this direction is to ascertain the breeding places and the flight distance to, and from, the breeding grounds of the insects involved in pollination of cocoa.

The breeding substrates of cocoa pollinator midges have been fairly well documented but earlier investigators have indicated that almost all the genera and/or species have special breeding substrates (Saunders, 1959; Winder, 1977, 1978; Soria et al,, 1978; Soria, 1981; Young, 1982). The large scale use of cocoa pod husk as an ovitrap for *Forcipomyia* and allied species has already been advocated (Brew, 1985). Pod husk is a major crop residue in Ghana. It is left to rot on cocoa farms except for small quantities used in soap manufacture (Adomako, 1975). Ghana produces over half a million tons of dry cocoa pod husk per year (Adomako, 1975; Gill and Duffus, 1982).

This present paper reports the diversity and abundance of cocoa pollinating midges in an area where large quantities of cocoa pod husks are deposited.

EXPERIMENTAL RESULTS

The experiment was carried out on a site of about 0.4 hectares in open ground used as CRIG Husk Dumping Ground (Fig. 1). It is situated 122m to the north and 92m to the west of CRIG experimental cocoa plots R1 and R2. Midge population assessment, especially of the larva and pupal stages, was carried out at the dumping site.

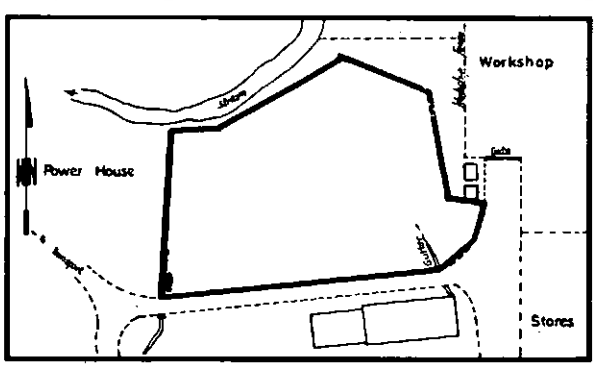


FIGURE 1: Site plan showing CRIG Husk Dumping Ground

Specimens collected from the CRIG Husk Dumping Ground were identified by Dr W.W. Wirth of the United States Department of Agriculture. They comprised a wide range of Forcipomyia and allied species. Among them were Forcipomyia (Euprojoannisia) species, F. ashantii and F. (Lepidohelea) species which are the most efficient cocoa pollinators (Brew, 1985). The fact that such diverse pollinator species were found on only one substrate (cocoa pod husk) suggests that specialization in habitat (Winder, 1977; 1978; Young, 1982) is often the result of competition for limited resources. Large numbers of larvae/pupae were found on the wet and rotting fragments. Often as many as four clusters comprising about thirty larvae/pupae per cluster were found on both sides of a small fragment of wet rotten pod husk measuring about 50 cm^2 (Fig.2). A monthly survey from January to December 1981, showed that they were most abundant throughout the period April to December.

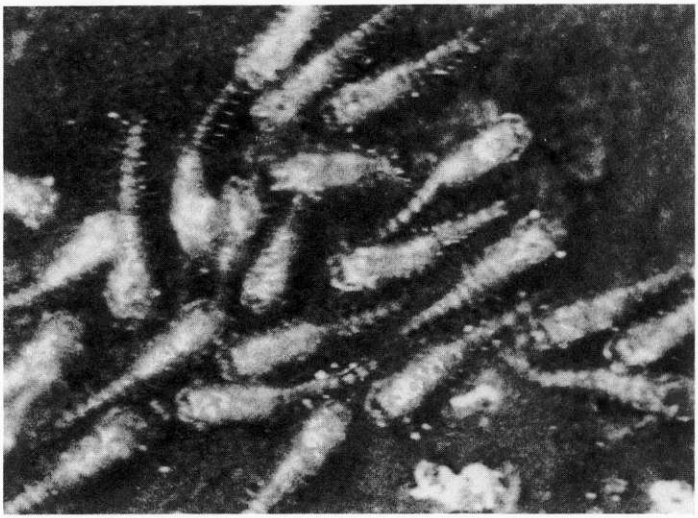


FIGURE 2: Immature stages (pupae) of cocoa pollinator midges on fragments of moist rotting cocoa pod husks

The fact that some species in the immature stages (Fig. 2) were taken from a distance of 122m away from CRIG Cocoa Plots (R1 and R2) is surprising. It may be assumed that the midges flew to the open ground from the farms to breed, attracted mainly by the strong musty scent of the rotting cocoa pod husk. A practical application of the present findings is that breeding substrates such as cocoa pod husk may be dumped within a reasonable distance from the farm or plantation, well beyond the reach of any harmful effects of insecticide applications on the farms. In this way pollinator mortality may be minimised.

There is a pressing need for much more work on pollination of cocoa. It seems highly probable that level of pollinating insects may be a factor limiting yield in a number of cocoa growing environments.

ACKNOWLEDGEMENTS

I wish to thank Dr Daniel Adomako, Deputy Executive Director of the Cocoa Research Institute of Ghana for his help in the preparation of the manuscript. Dr Willis W. Wirth of the US Department of Agriculture identified all the ceratopogonid midges reported in this paper. Special thanks are due to my technicians, Sule Adjani, Franklyn Banney, Asare Amoah, Martin Appiah and Glover Lartey - who helped in the field and insectary experiments. This paper is published with the permission of the Executive Director, Cocoa Research Institute of Ghana, Tafo.

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Retired in September 1988 after serving, since 1974, as Director of the Land Resources Development Centre of the Overseas Development Administration, UK. The first ten years of his professional career, 1952 - 62, were spent in the Colonial Research Service in Western Nigeria mainly engaged in a soil survey of the cocoa growing areas. In 1962 he joined the Food and Agriculture Organisation of the UN where he served as Soil Correlator and, later, Land Classification Specialist in the Land and Water Development Division in Rome until 1974.

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

MAY 1987

Twenty years' results from a shade and fertiliser trial on Amazon cocoa in Ghana.
AHENKORAH, Y., HALM, B.J. & APPIAH, M.R. Cocoa Research Inst. of Ghana, New Tafo-Akim, Ghana - Experimental Agriculture (UK) v.23(1) p.31-39. Jan 1987.
The effects of 3 shade densities, NPK fertilizers and fertilizer-pest/disease relationship on Amazon cocoa in Ghana over a 20-year period are reported. Yields, equivalent to the mean yield from the unfertilized plots, were achieved in about 3, 4 and 6 years in fertilized plots under the no-shade (S_0), medium-shade (S_1) and heavy shade (S_2) treatments, respectively. There were 3 growth phases, each characterised by a different yield trend. No appreciable changes in the exchangeable Ca and Mg were observed during the experiments, but K dropped to 68% from its initial value while the available P of the unfertilized plots and the S_0 plots fell by 38%. Fertilizer recommendations for P and K should take account of overhead shade. The effect of N application was often negative. No direct relationship was observed between fertilizer treatment and the incidence of pest/blackpod/swollen shoot virus (SSV) disease of cocoa. SSV infection was greatest under S_0. Cocoa farms in Ghana cannot maintain high yields (above 1000 kg dry cacao/-ha) beyond 15 years of intensive cropping.

[Effect of the size of explants and growth regulators on the development of the tissues of Theobroma cacao L. var.amelonado, cultivated in vitro]
Influence de la taille des explantats et des regulateurs de croissance sur le developpement des tissues de Theobroma cocoa L., var. amelonado cultives in vitro.
LEGRAND, B. and MISSISSO, E. Ecole des Sciences, Universite du Benin, Lome, Togo - Cafe, Cacao, The v. 30(4) p.239-246. Oct. 1986.
A technique for sterlizing explants taken from orthotropic suckers of cocoa (var. Amelonado) is described. Explants require a minimum size below which growth regulators are necessary to induce rooting and bud bursting. In the medium used, no caullus formation occurred except when zeatin was present. Zeatin promotes a spectacular elongation of buds. IAA (indole acetic acid) only slightly promoted leaf development, while these leaves rapidly dropped. IBA (indole butyric acid) alone or together with IAA substantially promoted leaf development. However, bud growth was not continuous. This dormancy could not be disrupted.

JUNE 1987

Coconut development in Thailand and its stimulation by cocoa.
DOOTSON, J., RATTANAPRUK, M. and SUWANNAWUTH, W. Chumphon Horticultural Research Centre, Chumphon, Thailand - Planter v.62 (729) p.519-530. Dec 1986.
Coconut plantations in Thailand are low yielding, often failing to meet national requirements for coconut products. The typical Thai Tall coconut has few, large fruits, shows extreme yield heterogeneity and is not precocious. Lack of soil selection and climatic stress limit yields and cause annual and seasonal fluctuations. It is hoped to increase yields by replanting using precocious, homogeneous and high-yielding hybrid varieties, and thorough rehabilitation. Cocoa is a recent introduction to Thailand and it is thought that the use of cocoa as a perennial intercrop can be used to stimulate coconut replanting and, in particular, rehabilitation allowing for crop diversity and increased land unit returns. This is illustrated both in theory and practice. The importance of rigorous varietal selection is indicated. Two strategies for coconut development are required. That for replanting using modern, high input, agricultural techniques, while appropriate, low input technology is better suited to rehabilitation, in anticipation of lower returns.

Extractable copper content of soils under peasant cocoa farms in Ibadan region, Nigeria.
AREOLA, O. Department of Geography, University of Ibadan, Nigeria. Turrialba (IICA) v. 35 (3) p.229-232. Jul. 1985.
The wide spread use of Cu fungicides dates back to about 1960. This study examines Cu accumulation in soils under peasant cocoa farms in Ibadan region, Nigeria. Cu content varied between 0.4 to 12.2 ppm with an average of 2.68 ppm in 60 soil samples, as against 1.37 ppm in the soil of secondary forests. Cu was found in the 15 cm upper layer of the cocoa plantations. Cu content was positively correlated with exchangeable Ca, CEC and clay content, whereas Cu content was negatively correlated with

sand content of the soil. The present Cu levels do not appear to affect the productivity of the cocoa trees.

JULY 1987

Pod growth and its relation to cherelle wilt in cocoa.
UTHAIAH, B.C. and SULLADMATH, U.V. National Agricultural Research Project, Brahmavar, Karnataka, India - Journal of Plantation Crops (India) v. 13(2) p.96-100; Dec 1985.
The physiological fruit drop in cocoa is commonly referred to as cherelle wilt. In Karnataka, India, a field study was carried out to assess the relationship between length and age of the pod, length and diameter of the pod to most susceptible for wilt. The growth of the ICS 1 cocoa pods in terms of length, diameter and weight conformed to a single sigmoid pattern. Under Bangalore conditions, the cocoa pod attains full maturity in 25 weeks from fruit set. The most rapid increase in length of pod occurred between 13 and 18 weeks from fruit set. The highest rate recorded during the 13th week from fruit set. The diameter (8.19 cm) in 20 weeks from fruit set. The cherelles were found to be highly susceptible to wilt during the first 7 weeks from fruit set.

The possible role of abscisic acid-like and other inhibitors in cherelle wilt of cocoa.
UTHAIAH, B.C. and SULLADMATH, U.V. National Agricultural Research Project, Brahmavar, Karnataka, India - Journal of Plantation Crops (India) v. 14(1) p.57-64; Jun 1986.
The endogenous growth promotors and inhibitors at different stages of healthy and wilting "ICS 1" cocoa pods were determined using the oat coleoptile straight growth bioassay. Abscisic acid (ABA) -like substances were found in healthy as well as wilting pods. Wilting pods contained higher levels of ABA-like substances than healthy pods of corresponding growth stages. A high level of ABA-like substance was recorded in the first 7 weeks of pod growth, a period during which the cherelles were highly susceptible to wilt, while very low levels of such inhibitors were present during subsequent stages of pod growth, which, however, increased at maturity. The growth promotor activity in wilting pods was much less than in healthy pods of corresponding stages of growth. Abscisic acid-like substances were maximum (8.75 µg/g) during the second week from fruit set in wilting pods. Hence, it is reasonable to believe that a high ABA content is associated with cherelle wilt in cocoa.

AUGUST 1987

[Results of a second study programme on the susceptibility of cocoa tree mirids to insecticides: effect of temperature in LD 50 calculation]. Resultats d'une seconde campagne d'etude au Cameroun sur la sensibilite des mirides du cacaoyer aux insecticides: influence de la temperature dans le calcul des DL_{50}.
MIRE, P.B. De, IRCC, CIRAD, Montpellier, France - Cafe, Cacao, The v. 31(1) p.35-48; Jan 1987.
A mission was carried out in Cameroon, with a view to training a team in estimating the variation in susceptibility of mirids in cocoa to insecticides used (diazinon and isoprocarb). Observations were made in 20 different locations. It was found that, for calculating LD_{50}, the effect of the variations in temperature have to be taken into account. Low temperatures attenuate the effect of the insecticide. Logarithmic conversions of LD_{50} values in the LD_{50} temperature regression were used to calculate the correction. Results appear to confirm that a simple alternation of the 2 insecticides is not sufficient to bring back tolerance to its basic level.

Some short-term investigations into the management of vascular streak dieback disease on young cocoa in Giram Estate, Sabah, Malaysia.
SIDHU, M., Harrison Malaysian Plantations Berhad, Kajang, Selangor - Malaysia - Planter v. 63(731) p.47-58; Feb 1987.
In Giram Estate, field experiments were conducted in young cocoa to study the efficacy of control measures against VSD caused by the fungus Oncobasidium theobromae. The earliest (9-13 weeks after infection) and most consistent symptom proved to be a deformed chlorotic flush and the simultaneous appearance of raised lenticels on the stem. Polythene roof shelters provided adequate protection in cocoa nurseries. In the nursery, foliar sprays of the systemic fungicides triadimenol and PP 969, applied at weekly and fortnightly intervals, provided 82-100% seedling protection. In the field, monthly soil drenches of triadimenol at 50-100 mg a.i./seedling provided 95% protection to 15 month old cocoa bushes.

Experiments on the chemical control of some insect pests of cocoa in Peninsular Malaysia with particular emphasis

on Helopeltis theobromae.
TUCK, H.C., Harrisons Malaysia Plantations Berhad, Planter v. 63(731) p.67-74; Feb 1987.
In Malaysia, field experiments were conducted to screen several insecticides for the control of the mosquito bug (Helopeltis theobromae), mealybugs and aphids in cocoa. Deltamethrin, permethrin, dioxacarb, propoxur and isoprocarb, at 5, 25, 140, 75 and 156 g a.i./ha, respectively, were found to be effective against H. theobromae in mature cocoa, isoprocarb and propoxur being most cost effective. However, gamma-HCH proved to be more effective than any of these insecticides. All 11 chemicals tested against H.theobromae and aphids in immature field-planted cocoa proved to be effective. Dimethoate, monocrotophos and acephate provided good control of mealybugs with the synthetic pyrethroids deltamethrin and permethrin being markedly less effective.

A review of relationship between shade types and cocoa pest and disease problems in Papua New Guinea.
SMITH, E.S.C. Lowlands Agricultural Experiment Station, Keravat, East New Britain, Papua New Guinea - Papua New Guinea Journal of Agriculture, Forestry and Fisheries v. 33(3-4) p.79-88; Jun 1985.
In Papua New Guinea the permanent overhead shade in cocoa is provided mainly by coconuts and/or Leucaena leucocephala. The major pests and diseases in Papua New Guinea cocoa plantings are described and their relationships to the main shade trees used are reviewed. Evidence is presented to show that many of the present day problems have arisen from the use of Leucaena as a shade tree. In contrast, the widespread practice of interplanting cocoa under coconut palms has considerable economic and managerial advantages and the cocoa generally suffers less from insect and disease attack than cocoa planted alone. It is concluded that the planting of high-yielding, disease resistant cocoa under high-yielding, hybrid coconut palms of at least 3 to 4 years old, should be actively promoted in Papua New Guinea.

Standardisation of vegetative propagation in cocoa.
KESHAVACHANDRAN, R. and NAIR, P.C.S. Kerala University, Vellanikkara, Kerala, India - Indian Cocoa, Arecanut and Spices Journal (India) v. 9(2) p.29-34; Oct 1985.
In order to standardise the methods of vegetative propagation in cocoa, experiments on rooting of cuttings and budding were conducted. Considering the higher percentage of rooting, the number of roots and the average length of roots, a "quick dip" method for 60 sec. in 4000 ppm NAA (naphthalene acetic acid) or 6000 IAA (indole acetic acid) is recommended for producing rooted cuttings. On older rootstocks, the "forkert" method of budding gave up to 60% success when budded on 8 to 9 month old rootstocks. Green budding on 3 to 4 month old cocoa seedlings was found to give 80 to 100% success with "forkert" method.

Growth response of Theobroma cocoa L. seedlings to inoculation with vesicular-arbuscular mycorrhizal fungi.
AZIZAH CHULAN (HASHIM) and RAGU, P. Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - Plant and Soil (Netherlands) v. 96(2) p.279-285 1986.
The effects of vesicular-arbuscular mycorrhiza (VAM) on the growth and P uptake of cocoa seedlings, grown for 100 days in polythene bags, were studied at 5 levels of P fertilization in both steamed and unsterile Bungor Series soil (a fine clayey, kaolinitic isohyperthermic Type Paleudult). The cocoa seedlings responded well to P fertilization and mycorrhizal treatments. Plants inoculated with VAM fungi (Gigaspora spp.) gave the most vigorous growth and higher P in the leaf tissues in unsterile soil compared with plants grown in steamed soil. However, the mycorrhizal effect was significantly more pronounced in plants grown in steamed than in unsterile soil. High levels of P application depressed mycorrhizal development. P fertilizer applied at the rates of 250 and 500 µg/g soil gave maximum root colonization and spore counts in both soil types used.

SEPTEMBER 1987

Advantages, disadvantages and desirable characteristics of shade trees for coffee, cocoa and tea.
BEER, J. Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE), Turrialba, Costa Rica - Agroforestry Systems (Netherlands) v. 5(1) p.3-13 1987.
A review is made of the ecologoical interaction that occurs between shade trees and the perennial crops: coffee, cocoa and tea. These interactions are classified firstly as advantages or disadvantages, and secondly as: effects on crop management; effects on the hydrological cycle: effects on pathogens, insects and climatic conditions;

and effects on soils. References are given for the 20 advantageous and 16 disadvantageous consequences of using shade trees, emphasising publications that that provide original data and useful methodologies. Finally a checklist of desirable characteristics for perennial crop shade trees is presented.

OCTOBER 1987

[Effects of cocoa cropping systems on the chemical properties of Brazilian amazon soils]. Efeitos do sistema de implantacao do cacaueiro nas propriedades quimicas de solos da Amazonia brasileira.
MORAIS, F.I. DE O. and SANTOS, M.M. DOS, CEPLAC, Belem, Para, Brazil - Revista Brasileira de Ciencia do Solo (Brazil) v. 10(1) p.67-70; Jan 1986.

The effect of cocoa, intercropped with different species, on the chemical properties of Brazilian amazon soils was evaluated in 2 experiments located in the north of Mato Grosso State and on the transamazonion highway (Para State). The cocoa plantations used were established in "terra roxa estruturada" and red yellow podzoloic soils under thinned forest, secondary regrowth or intercropped with food crops, oil crops and forest trees after the slash and burn of the natural vegetation. Ashes of the burned vegetation increased pH, exchangeable bases (Ca + Mg and K), soil available P, and also reduced active Al to non-toxic levels in the red yellow podzolic soil. There were no significant improvements in the organic carbon levels up to 12 months after the forest burning. The follow-up of the experiment showed that mixed planting of cocoa with banana, castor bean, pigeon pea and faveira-parica (Schizolobium amazonicum) lengthened these effects.

NOVEMBER 1987

[Pod breaking delay: influence on the yields and quality of raw and roasted cocoa]. Delai d'ecabossage: influence sur les rendements et la qualite du cocoa marchand et du cacao torrefie.
BAREL, M.A., IRCC, Abidjan, Cote d'Ivoire - Cafe, Cacao, The (France) v. 31(2) p.141-150, Apr. 1987.
The impact of pod breaking delay on the various quality and yield criteria has been studied on a mixture of Upper Amazonian x Amelonado hybrids bred in the Cote d'Ivoire and representative of the hybrid production of that country. The pods were opened one, 3, 6 or 9 days after harvesting. The fermentation of the beans, which lasted 6 days, was carried out in wooden sweat boxes, the beans were turned over after 24, 72 and 120 hours. The temperatures were recorded in the centre of the boxes and bean samples taken after 3, 4, 5 and 6 days of fermentation. The results of this study showed that delayed pod breaking: (1) accelerates the rise in temperature in the sweat boxes and obtaining a proportion of brown beans equivalent to 60%; (2) improves pulp hydrolysis; (3) reduces the acidity of the cocoa; (4) improves slightly the yield in raw cocoa and the yield in nibs; (5) has only a negligible influence on the percentage of germinated beans; and (6) does not cause batches of cocoa to be downgraded. The best results are obtained after a delay of 6 days between harvesting and pod breaking.

DECEMBER 1987

Rooting classification and culture responses of some cocoa hybrids.
ODEGBARO, O.A. and ADEDIPE, N.O. Federal Ministry of Science and Technology, Lagos, Nigeria - Turrialba (IICA) v. 36(2) p.197-204. Apr. 1986.
In Nigeria, cocoa is still progagated mainly by seeds. In recent years, the demand for vegatatively propagated planting material has increased. A large number of cocoa hybrids were classified into difficult, intermediate and easy rooters. Significant differences were found in the rooting abilities of apparently similar cocoa types. It was also found that the presence of only one leaf per cutting significantly reduced rooting. Two leaves per cutting were found to be adequate. Reduction in the size of leaves by half was found to have no adverse affect on rooting and the practice even enhanced the survival of the cuttings under the polyethylene sheets. Cuttings taken from the trees at 7-8 weeks after the initiation of flushing rooted best.

Relationship between age of cocoa (Theobroma cacao L.) trees and soil nutrient contents.
OJENIYI, S.O. Department of Crop Production, Federal Univ. of Technology, Akure, Nigeria - Turrialba (IICA) v. 36(2) p.255-258; Apr. 1986.
The relationships between age of cocoa trees and concentrations of organic C, N, available P, exchangeable K, Ca and Mg in the soil profile and surface soil were studied at 3 locations in Nigeria during 3 years. The age of the cocoa trees varied between 4 and 37 years.

Values of soil organic C, N, exchangeable K, Ca and Mg were positively correlated with the age of cocoa trees, while available soil P was negatively correlated. There was a decrease in values of soil nutrient contents when the age of cocoa trees increased to 37 years.

A sudden dieback of cocoa caused by Botryodiplodia theobromae.
ANG BOON BENG, LIM TONG KWEE and TEE SWEE KEE, Harrisons Malaysian Plantations Berhad, Kajang, Selangor, Malaysia - Planter v. 63 (735) p.228-234; Jun 1987.
In early 1982 and mid 1985, a sudden dieback was observed on 8-year old and 4-year polyclonal cocoa trees, respectively, in an inland estate in Selangor (Malaysia), following a period of intense drought. Similar dieback symptoms were observed on budgrafted plants in polybags which were cut back too severely during the dry months. Isolations from disease tissues consistently yielded the fungus Botryodiplodia theobromae. The fungus was pathogenic on budgrafted seedlings when the seedlings were stressed a few days by not watering prior to wound inoculation. The role of prevailing environmental factors on disease incidence and control measures are also discussed.

The role of research and development in plantation profitability. 1. Elements of profitability.
WOOD, B.K. and EDWARD, N.C. Ebor Research, Sime Darby Plantations, Shah Alam, Selangor, Malaysia - Planter v. 63(735) p.235-247, Jun 1987.
A study was carried out on the effects of cost structure, and research and development activities on profitability of oil palm, rubber and cocoa plantations in Malaysia. Whilst relatively cheap labour helps plantation commodities to be competitive, the value of the commodities strongly influences the wage structure. Control of labour cost is a major aspect of competivity. Wages remain a large proportion of production costs, and much of what is said about reducing those costs is directed to reducing the labour component. It seems far better from all points of view to maximize the productivity of a limited area of land, than to expand plantings continually but utilize them inefficiently. It is important to retain a high efficiency to control production costs. In this respect, research and development evidently continues to make breakthroughs.

The role of research and development in plantation profitability. 2. Examples of recent techniques to enhance productivity.
WOOD, B.J. et al. Ebor Research, Sime Darby Plantations, Shah Alam, Selangor, Malaysia - Planter 63(735) p.248-271, Jun 1987.
Recent advances and future prospects in oil palm, rubber and cocoa cultivation in Malaysia are reviewed. There are several significant developments taking place at the present time, including the improvement of productivity of mature areas through better planting material and agronomic practice, the reduction of the nonproductive immature period, better control of losses by more efficient plant protection and exploitation, and by adding value in production both through improving the main product and utilizing by-products. Some give immediate opportunity to increase productivity (e.g. maximization of recovery through proper and timely exploitation systems), while others may take a longer time to achieve their benefits (e.g. methods to reduce the non-productive period between crops).

JANUARY 1988

Trial shipment of cocoa, copra and coffee from Papua New Guinea to Europe to evaluate the use of ventilated containers.
SHARP, A.K. and GREVE, J. VAN, Division of Food Research, CSIRO, North Ryde, New South Wales, Australia - Technical Paper - CSIRO Division of Food Research (Australia) no, 48, 22p. 1986.
Two shipments of condensation-prone commodities in naturally-ventilated containers were made from Papua New Guinea to Hull, UK, arriving in early and mid-spring, respectively. In the first shipment 2 CSIRO-modified containers carried cocoa, and in the second, coffee was carried in 2 Adamson "Vent Boxes". Temperatures, humidity, condensation and changes in moisture content were monitored. Two additional containers in the first shipment carried copra, but were not monitored in detail. All containers were stowed below deck. Moisture sensors detected a slight, short-lived condensation in one container of coffee during a cold spell while in port in Rotterdam, but no damage attributable to condensation was observed in any container.

The microflora of fermenting cocoa beans in the State of Bahia, Brazil.
RIBEIRO, N.C.A., BEZERRA, J.L. and LOPEZ, A.S.F. CEPLAC, Belem, Para,

Brazil - Revista Theobroma (Brazil) v. 16(1) p.47-55; Jan 1986.
In a survey of the microflora of fermenting cocoa beans, the following 16 species of fungi were identified: Aspergillus fumigatus, A. niger, Lasiodiplodia theobromae, Fusarium moniliforme, F.oxysporum, Mucor racemosus, Mucor sp., Paecilomyces varioti, Peniccillium citrinum, P.implicatus, P. sinosum, Thievaliopsis ethaceticus, Trichoderma viridae and 3 different isolates of Mycelia sterilia. The highest percentage of diversity occurred in the beginning of the fermentation (from 0 to 44h). After this period there was a predominance of A. fumigatus and M. racemosus up to the end of the process. A study in vitro of the effect of temperature on the growth has shown that most of these fungi have a major development between 30 and 45°C and a slower development at 50°C, although this temperature was not lethal for 60% of these isolates after an exposure of 96h. All species were able to produce acids through hydrolisis of glucose, mannose, sucrose, mannitol, fructose, xylose, galactose, arabinose, cullulose, and from ethanol. Organoleptic tests of the product showed normal smell and appearance, with strong chocolate flavour and acceptable acidity.

[Residue levels of BHC (HCH) in cocoa beans in Bahia, Brazil]. Niveis residuais de BHC (HCH) em amendoas de cacau na Bahia, Brasil.
BERBERT, P.R.F. and CRUZ, P.F.N. CEPLAC, Itabuna, Bahia, Brazil - Revista Theobroma (Brazil) v. 16(1) p. 39-45; Jan 1986.
The level of BHC (gamma-HCH) residues was determined monthly, during 1983, in cocoa beans collected from exporter's warehouses. BHC residues were detected in all samples analysed, the monthly average levels varying from 0.05 to 0.2 ppm. These results showed that the residual levels are below the tolerance limit of the majority of importing countries (0.5 to 1.0 ppm) and within the limit established by Brazil for Gamma BHC (1.0 ppm). In addition, the results suggest that a significant decrease in the residue level occurs only 60 days after the insecticide application.

Influence of different densities of cocoa and oil palm on yield performances of cocoa.
KOLADE, J.A., Cocoa Research Inst., of Nigeria, Ibadan, Nigeria, Turrialba (IICA) v.36 (3) p.345-353, Jul 1986.
In Nigeria 3 mixed cropping systems with cocoa and oil palm were studied viz: sole blocks of cocoa and oil palm with 1595 cocoa and 83 palm trees/ha (X); alternate strips of the 2 crops, with 1688 cocoa and 81 palm trees/ha (Y), and a hollow square arrangement omitting alternate palm trees/ha (Z). No significant differences were found within treatments in the rates of establishment, growth, and development of cocoa seedlings. Initially, within 4-5 years after establishment, no significant, differences in yield between the treatments were observed, but in the 5 years following remarkable differences were noticed when treatment Z outyielded treatments X and Y with mean ratios of 3.1 for Z:X. and 5.1 for Z:Y. The observed depression in yield of cocoa is offset by the synergistic yield effect of the 2 crops. Infestations of Phytophthora palmivora and pod damage by mammals were similar in all spatial treatments. The hollow square planting (Z) is recommended to farmers wishing to underplant oil palm with cocoa.

EVANS, H.C. and PRIOR, C. Institute of Biological Control (CIBC), CAB International, Slough, Berks, UK - Outlook on Agriculture (UK) v.16(1) p.35-41, 1987.
Cocoa pod diseases inflict huge losses in the crop. In this review, only the major pod diseases are discussed. These are Phytophthora spp., witches' broom disease, caused by the fungus Crinipellis perniciosa, and frosty or watery pod rot (also called moniliasis or Monilia pod rot) caused by Moniliophthora roreri. Besides chemical treatment which is not always economical, disease management through quarantine, crop sanitation and incorporation of resistance into new planting material are discussed.

[Cocoa pollination in Reconcavo Region region of Bahia, Brazil. 2. Assessment of mistblower pollination]. A polinizacao do cacaueiro no Reconcavo Baiano, Brasil. 2. Avaliacao do metodo do ventilacao forcada. CEPLAC, Itabuna, Bahia, Brazil, Revista Theobroma, (Brazil) v.16(1) p.31-38 Jan 86. SORIA, S. de J., PINHO, A.F. de S. and PEIXOTO, E.S. CEPEC, Itabuna, Bahia, Brazil.
In Bahia, mechanized pollination of local cocoa cultivars, using a portable knapsack mistblower was tested, because the activity of pollinating insects is poor. The flowers were blown during the early hours of the day on 4 alternating days. Results indicated that mechanical pollination with the mist-

blower almost doubled fertilization rate. Number of fruits per tree increased to 10.39 fruits/tree in the treated plot as against 5.71 fruits/-tree in the control. Mistblower pollination seems to be a promising technique when applied to self-compatible varieties.

The effect of different particle sizes of sawdust and forest topsoil on germination, growth and development of two cacao varieties in the nursery.
CHINWUKO, U. and LUCAS, E.O. Department of Agronomy, University of Ibadan, Nigeria, Turrialba (IICA) v. 36 (3) p.307-314, Jul 1986.
In Nigeria a nursery experiment was carried out for 24 weeks using sawdust of different particle sizes added to topsoil, and using topsoil alone to test the germination, growth and development of the cocoa varieties F_3 Amazon and Amelonado. Results revealed that the only beneficial effect of the sawdust/topsoil mixture was faster germination. In other measurements, such as morphological parameters, dry matter production, growth rates and nutrient uptake, seedlings grown in topsoil alone gave better results, F_3 Amazon seedlings grew more vigorously and performed better than Amelonado seedlings in all the parameters examined, presumably because of the earlier establishment of effective leaf area by F_3 Amazon. Nutrient uptake by the seedlings of both varieties was highest in the leaf, followed by the stem and then the roots. K uptake was highest, followed by N, Ca, Mg and P in the order of decreasing uptake.

[Conservation of cocoa seed viability. 1. Fifty years of study, a bibliographic revue]. Conservacao da viabilidade da semente de cacau. 1. Cinquenta anos de estudos, uma revisao bibliografica.
FIGUEIREDO, S.F.L., Universidade do Estado do Rio de Janeiro, Brazil, Revista Theobroma (Brazil), v.16(1) p.17-29 Jan 86.
This work is a careful literature review of the 50 years of study, since 1934, of various world research centres to find the best means of conserving the viability of cocoa seeds.

FEBRUARY 1988

[Some aspects of the propagation of cocoa by micro-cuttings]. Quelques aspects du microbouturage du cacaoyer.
BERTRAND, B. Institut de Recherches du Cafe et du Cocoa (IRCC), Kpalime, Togo - Cafe, Cocoa, The (France) v. 31(3) p.175-182; Jul. 1987.
In Togo a study was carried out on the propagation of cocoa by micro-cuttings to improve the bud break phase of the axillary bud of the orthotropic cuttings, and to study the phase in which buds develop into small stems. The most favourable growth stages for bud break proved to be I_2, I_3 and F_1. For the cuttings taken at these stages, the dormant stage of the axillary buds was broken by massive applications of cytokinin and the buds were elongated by increasing the exogenous auxin contents and by applying gibberellic acid. The bud break rates ranged from 80 to 100% and transplanting the explants into the elongation medium resulted in balanced elongation of the cuttings in 70% of the cases.

[Mesohomotoma tessmanni infestation on cocoa and kola during the first 5 months of seedling growth]. Comportement des plantules de cacaoyer et de colatier agees de moins de six mois aux attaques des psylles Mesohomotoma tessmanni.
MESSI, J., Universite de Yaounde, Cameroon - Cafe, Cacao The, v.31(3) p.211-216; Jul 1987.
In Cameroon experiments were conducted to study the life-cycle of the psyllid Mesohomotoma tessmanni on cocoa and kola seedlings during the first 5 months of crop growth. Seedlings of Cola acuminata and Cola nitida are attacked by M. tessmanni as soon as the first flushes appear. Damages on kola trees are similar to damages described on cocoa trees. Young kola trees allow the full development of M. tessmanni. The main manifestations are on C. acuminata and C. nitida, respectively : fecundity: 34.73%, eggs: 57% and 56%, duration of incubation of eggs: 7-8 days, duration of larval development: 13-16 days, larval mortality 86% and 81%, survival percentage from eggs to adults: 69% and 10%. During the first 5 months, cocoa seedlings do not suffer from attacks of M. tessmanni. The main manifestations of pest resistance are mortality of nymphs, inhibition of development of ovaries, shortness of the life of adult insects, inhibition of the development of ovaries and inhibition of the ovoposition of adults. Kola seedlings are severely attacked during this period by the psyllids.

[Planting pattern in intercropping of plantain and cocoa]. L'association cacaoyer - bananier plantain. Etude de dispositifs.

LACHENAUD, PH., IRCC, Abidjan, Cote d'Ivoire - Cafe, Cacao, The (France) v. 31(3) p.195-202; Jul 1987.
In the Cote d'Ivoire a 3-year intercropping experiment was conducted to study planting methods and planting densities in plantain, and their effects on intercropped cocoa. An economic analysis was carried out to assess the gross annual returns. The cocoa crop was a mixture of Upper Amazon x Amelonado hybrids; Corne plantains were used. From the results obtained 2 treatments are recommended: (1) planting 1 plantain/cacao tree in the inter-row with both spp. planted at the same time; and (2) the same planting pattern with the cocoa planted 7 months later than the plantains. However, intercropping with 1 plantain/-cocoa tree in the inter-row is not advisable in areas with a low rainfall, as plantains may compete with the cocoa trees in times of drought. K and P fertilizer requirements are discussed.

MARCH 1988

[Utilization of cocoa by-products in Brazil]. Situacao atual da utilzacao de subprodutos de cacau no Brasil.
LOPES, S.A.F., FERREIRA, H.I.S. and LLAMOSAS, A., CEPEC, Itabuna, Bahia, Brazil - Boletim Tecnico - CEPEC no.133, 26p. 1985.

In Brazil about 3.6 million tonnes of fresh cocoa pods were harvested during 1982/83, producing 399,000 tonnes dry beans, 2.9 million t of pulp + husks and 54 million litres of juice. Only 10% of the fresh pods was commercialised, the rest was more or less wasted. The various uses of cocoa by-products are discussed. From the juice a jelly can be made, and a small industry makes alcohol from the pulp. The husks make an excellent cattle feed. Studies on the economy of methane production from pod husks showed unfavourable returns. The bio-digested residue had no fertilizer value. A plant for the recovery of cocoa butter from diseased pods is in operation. Further research is presented in the form of an integrated programme.

[Rehabilitation of cocoa deteriorated by witches' broom through the canopy renovation method]. Rehabilitacion de poblaciones de cocoa deterioradas por escoba de bruja mediante el metodo de "renovacion de la copa".
GRISALES, A. and CUBILLOS, G. Chocolateria Luker, Medellin, Colombia - Cacaotero Colombiano no. 31, p.3641; Dec 1985.
In some parts of Colombia, witches' broom disease of cocoa (caused by Crinipellis perniciosa) is a limiting factor to cocoa production. Rehabilitation of 25-year-old-trees, seriously affected by the disease, through total or partial removal of the aerial part of the tree, was examined. It was shown that this method allowed the return to productivity of the tree. The index disease/tree/month of 0.29 showed that the disease could be reduced to tolerable levels. The diseased material which was left on the ground did not seem to have pathogenic importance, since it was unable to build up the disease on the newly formed canopy.

[Residual levels and persistence of pirimiphos-methyl in stored cocoa beans] Niveis residuais e peristencia de pirimifos-metil em cacau armazenado.
BERBERT, P.R.F., ABREU, J.M. DE AND SORIA, S. DE. J., CEPEC, Itabuna, Bahia, Brazil - Revista Theobroma v. 15(3) p.133-140, Jul 1985.
In Brazil, the residues of pirimiphos - methyl were determined and their persistence monitored at different times after doses of 550 and 1100 mg a.i./60 kg of cocoa beans were applied externally on the bags (treatment 1) or directly to the beans treated in a layer of 10 cm thick (treatment 2). Residues in treatment 2 were, one day after treatment (T + 1) 5.1 and 10.6 ppm for the 550 and 1100 mg dosages, respectively. These levels were 3.1 and 6.1 ppm at T + 8. They were reduced to one third at T + 60. Later on, after absorption by the fat, degradation was more slow. For treatment 1, levels were 0.15 and 0.28 ppm at T + 1 respectively, attaining 0.10 and 0.21 ppm at T + 90. It is concluded that residues found in treatment 1 at any time and those encountered at T + 8 in treatment 2, can be considered acceptable.

APRIL 1988

Spatio-temporal variations of soil properties under cocoa interplanted with kola in a part of the Nigerian cocoa belt.
EKANDADE, O. Department of Geography, University of Ife, Ife, Nigeria - Agroforestry Systems (Netherlands) v. 5(4) p.419-428 1987.
Spatio-temporal variations in properties of soil under cocoa interplanted with kola in 15-and 40 year old plots were considered in a part of the Nigerian cocoa belt. The study shows

that no significant variations in many soil properties when both cocoa and kola were 15 years old. However, significant variations in many soil properties wre recorded when cocoa and kola were 40 years old. At that time, soil conditions from sample points directly under kola and between kola and cocoa were similar, while soil from the sample point directly under cocoa differed significantly, in most respects, from the other 2 points. Soil properties appeared to improve under kola over time while the converse was the case under cocoa. It is suggested that these differences resulted from apparent differences in growth habit and nutrient extraction of kola and cocoa over time.

Population studies of the Malaysian wood rat (Rattus tiomanicus Miller) in a cocoa-coconut plantation.
KAMARUDIN, K.A., MARDI Serdang, Selangor, Malaysia - MARDI Research Bulletin v. 14(1) p.7-13; Apr 1986.
A 2-year population study of the Malaysian wood rat, Rattus tiomanicus, was carried out in a cocoa-coconut plantation in Perak, Peninsular Malaysia, which has been rat-poison free for 1.5 years. During the study live traps were used. The rat population varied between 151 and 216 animals/ha and was considered to be stable. The survival rates between the 17-19 days trapping intervals ranged from 0.5 - 1.0. The recruitment to the population was mostly by means of birth and equally divided among sexes. The proportion of potential breeders was comparatively high (65% - 100%). The mean growth rate of the population between the trapping intervals varied between the r(instantaneous rate of increase) values of -0.36 to 0.27.
MAY 1988

Coffee, cocoa and pepper under coconut.
MATHES, D.T. - Coconut Bulletin (Sri Lanka) v. 31(1) p.9-11; Jun 1986.

The relative costs and returns from coffee, cocoa and pepper under coconut in Sri Lanka are presented. The net return from coconut and coffee (over 7 years) was 171, from coconut and cocoa 246 and from coconut and pepper 262. Research carried out showed clearly that there were no adverse effects on the coconut crop due to the intercropping, provided both crops were properly managed.

JUNE 1988

Modification of a pair of secateurs into a multi-purpose tool.
YEOH CHEANG CHU, FOP Management SDN Bhd., Sandakan, Sabah, Malaysia - Planter, 63, (739) p.464-465; Oct. 1987.
A pair of secateurs (Topman model) can be modified into a multi-purpose tool for high canopy pruning, normal water shoot and low canopy pruning, and harvesting of cocoa pods. This modified tool is highly practical and effective as an alternative to the rambutan-cutter and the harvesting knife. A worker can carry out his or her work more effectively with a single tool than having to carry several tools for a combined job e.g. low and high canopy pruning, with harvesting incorporated during the low-yield period. The feasibility and efficiency of the modified tool were tested and proven in the cocoa plantations in Malaysia.

Breeding and selection of cocoa clones.
SAPIYAH, S., JAMADON, B. and MUSA, M.J. MARDI, Hilir Perak, Malaysia - Malaysian Applied Biology v. 16(1) p.157-160, Jun 1987.
MARDI started the cocoa breeding and selection programme in 1972. Two types of planting material have been developed, namely hybrid progenies and clones. Progress in clonal development was enhanced by the development of efficient methods of vegetative propagation and clonal management. A total of 1014 ortets were selected at Hilir Perak and 418 clones derived from these ortets are at various stages of evaluation. In early 1986, 5 of these clones were released for commercial planting. In addition, 78 clones were evaluated at Jerangau and 36 were selected as potential clones. Five clones were released in 1983 and another 3 in 1986 as commercial clones. Besides yield and yield components other traits have lately been given due emphasis in clonal selection including tolerance to vascular streak dieback (VSD), Phytophthora diseases, cocoa pod borer and drought as well as superior cocoa butter characteristics.

The cocoa mirid in Peninsular Malaysia and its management.
KHOO KHAY CHONG, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - Planter, v. 63 (740) p.516-520; Nov. 1987.
The cocoa mirid Helopeltis theobromae is the most important insect pest of cocoa in West Malaysia. Until recently there has been little research on this insect, despite its importance. Recently a reliable rearing technique

has been developed. This technique combines laboratory rearing of nymphs and caging of adults in pods in the field. Research findings are presented with respect to: symptoms and damage; chemical pest control, and biological pest control. No parasites have been recorded on H. theobromae. Attempts to employ natural enemies were unsuccessful, except for the black cocoa ant.

[Variations in natural pollinisation of cocoa in Togo: influence on the pod seed filling rate]. Etude des variations de la pollinisation naturelle du cacaoyer au Togo: influence sur le remplissage en graines des cabosses.
CILAS, C., MISSISSO, E. and DUFOUR, B. IRCC, Kpalime, Togo - Cafe, Cacao, The v. 31(4) p.283-290; Oct 1987.
In Togo the distribution of pollen grains on the styles, the mean amount of pollen produced in the stamens, the populations of insects which visited the flowers, and floral production were monitored over 2 years on a plot of hybrid cocoa trees. The mean number of pollen grains produced in the stamens varied with time and was negatively correlated with the percentage of unpollinated flowers. The number of insects trapped in the flowers influenced pollination; the number of microdipteras, thrips and ants were negatively correlated with the pollen scarcity index, which implies that an increase in the insect population leads, on average, to a drop in the pollen scarcity index and, therefore, to better pollination. Aphids did not seem to be involved in natural pollination. The pollen scarcity index which was calculated from the distribution of pollen grains on the styles, was correlated with the index calculated from the distribution of seeds per pod observed 5 months later. By improving pollination conditions and observing the pollination differences between the trees, it should be possible to improve cocoa production.

Plantation industry and the recent recession.
LIM, Y.B. - Planter v.63(741), p.564-575; Dec 1987.
In 1986, rubber (Hevea) and palm oil accounted for 19.3% of Malaysia's total export earnings. The estate subsector owned some 34% of the total rubber and oil palm crop area in the country. The recession presented an opportunity for the strong companies to further expand their hectarages and obtain greater economies of scale. There are threats of protectionism, coming from the USA, and the EEC; this prompted the Malaysian government to initiate a publicity campaign aimed at the American public. Labour costs are relatively high compared with other rubber and palm oil producing countries in the region. The erosion of the margin between revenues and the cost of production should instill in the planters a greater sense of cost reduction through mechanization. In the field of crop diversification, cocoa proved to be feasible alternative crop. In 1960 only 10,000 ha were planted with cocoa; in 1986 the cocoa area had increased to 307,000 ha. It will not be long before Malaysia assumes dominance in this crop as well. Trends in prices are presented in palm oil and rubber.

Profitability analysis of a farming system in Africa.
BOATENG, M., RATCHFORD, C.B. and BLASE, M. Utah State Univ., Logan, Utah, USA Agricultural Systems (UK) v. 24 (2) p. 81-93, 1987.
An analysis is presented of the assumptions that in a traditional farming system food production is primarily for home consumption and is not competitive with export crop (cocoa) production. Government planners and policy makers must look at the total operations of a farmer to understand the role of food crop production. In the case of Ghana in 1981 they needed to seek ways to make cocoa production relatively more profitable if the goal of increased cocoa production from small farms were to succeed. The analysis indicated why farmers were devoting scarce resources, particularly labour, to producing food crops in Ghana in 1981. Food crops were the most profitable both (1) in 1981 and (2) when the flow of income from the life of the trees was considered. Clearly, the farmers demonstrated that resource allocation was rational. The government purchase price of cocoa was only 30% of the price required to make the cocoa system as profitable as the food crops systems. An actual decline of cocoa production in Ghana was observed.
Rehabilitation of cocoa in Nigeria: physical and moisture retention properties of old cocoa soils.
AYANLAJA, S.A. Cocoa Research Inst. of Nigeria, Ibadan, Nigeria - Tropical Agriculture (Trinidad and Tobago) v. 64(3) p.237-240, Jul 87.
To investigate the causes of the early decline of cocoa trees, a study was made of the physical properties of the soils of 9 representative cocoa farms in Southern Nigeria. The following aspects were evaluated: soil moisture retention; root-penetrable soil depth;

soil texture; drainage and amount and distribution of rainfall. For only 5 out of the 9 farms investigated, these properties were suitable to support profitable cocoa production. The other farms were sited on inferior soils, with physical properties that cannot support the healthy growth of cocoa trees. Adequate determination of soil physical characteristics, to ascertain soil suitability, should precede the establishment of rehabilitation of cocoa farms.

JULY 1988

Modelling agroforestry systems of cacao (Theobroma cacao) with laurel (Cordia alliodora) and poro (Erythrina poeppigiana) in Costa Rica. 2. Cacao and wood production, litter production and decomposition.
NEUVELDOP, J., FASSBENDER, H.W. AND ALPIZAR, L. Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE), Turrialba, Costa Rica - Agroforestry Systems (Netherlands) v. 6(1) p.37-48 1988.
During 7 years (1979-1985) cacao harvests (bean and husks) have been recorded for agroforestry systems of Theobroma cacao under Corida alliodora and Erythrina poeppigiana shade trees. The mean oven dry cacao yields were 626 and 712 kg/ha/a cacao beans under C. alliodora and E. poeppigiana, respectively. Harvests have gradually increased over the years and the plantation has now reached maturity. Annual extraction of N, P, K, Ca and Mg in fruits, which is relatively small, was calculated on the basis of chemical analyses. At the age of 8 years, the C. alliodora trees have reached 26.7 cm diameter (DBH) and 14.0 m in height. Mean annual growth (from age 5 to 7) is 14.6 m^3/ha/a. Natural plant residue production has been measured for 4 years (Nov 1981 Oct 1985). Under E. poeppigiana it has reached a value of 8.91 t/ha/a and under C. alliodra 7.07 t/ha/a. The shade trees have contributed 57 and 47%, respectively.
Transference and decomposition rates are high and important in the "nutrient cycles". The nutrient content of the litter was analysed and corresponding average yearly transfers are given.

Modelling agroforestry systems of cacao (Theobroma cacao) with laurel (Cordia alliodora) and poro (Erythrina poeppigiana) in Costa Rica. 3. Cylces of organic matter and nutrients.
FASBENDER, H.W., ALPIZAR, L. AND HEUVELDOP, J. Georg-August-Universitat zu Gottingen, Gottingen, Germany F.R. - Agroforestry Systems (Netherlands) v. 6(1) p.49-62 1988.
Models for cycles for organic matter and nutrient elements (N, P, K, Ca and Mg) are presented for the agroforestry systems of cacao (Theobroma cacao) with Cordia alliodora or Erthrina poeppigiana in Turrialba, Costa Rica. For the models, system reserves (soil, humus, vegetation divided into leaves, brances, stems, fine roots, fruits) and transfer between compartments (production and deocmposition of litter residues) inputs (fertilizer, rainfall) and outputs (harvests) of the system are considered. The implications of the models are discussed in detail. Aspects of net primary production in the systems studied are considered. N fixation is calculated on the basis of balances. Analaysis of soil water showed high variations that coincided with rainfall patterns and pruning of the E. poeppigiana.

Edaphic component of the environmental degradation resulting from the replacement of tropical rain forest by field and tree crops in SW Nigeria.
ADEJUOWN, J.O. AND EKANDADE, O. Department of Geography, University of Ife, Ife, Nigeria - International Tree Crops Journal (UK) v. 4(4) p.269-282 1987.
Mature tropical rain forest is in a state of dynamic equilibrium with its soil conditions, and the micro and macro-climate. Data collected in the cacao producing areas of SW Nigeria showed when this forest is removed and replaced by field or tree crops, the balance between vegetation and soil breaks down, and this leads to instability and a considerable deterioration in soil quality. An index of soil deterioration was derived and showed the following percentage declines for field and tree crops, respectively: bulk density, 28% and 31%; total porosity, 12% and 18%; pH, 16% and 13%; organic matter, 29% and 26%; nitrate N, 35% and 27%; available P 19% and 19%; Ca 24% and 41%; Na, 50%, 50%; K, 27%, 43%; Mg, 36%, 47%; cation exchange capacity, 36%, 34%, and base saturation, 5.4%, 8.7%. This study is one of the first attempts to assess soil deterioration on peasant farmers' cacao and fallow (field crops) plots.

Role of insects in the pollination of cacao flowers.
IBRAHIM, A.G. AND HUSSEIN, A.M. Department of Plant Protection, Universiti Pertanian Malaysia, Serdang,

Selangor, Malaysia - Pertanika (Malaysia) v. 10(1) p.103-106; Apr 1987.
In field experiments in northern Peninsular Malaysia the flowering, pollination and fruit set of 4 to 5 year old, Sabah cacao hybrid intercropped with coconut was studied. The cacao trees produced 4553 ± 687 flowers/plant over a 6-month period. However, effective pollination (i.e. fruit set) was only 5.2% and more than 77% of the fruits did not reach maturity due to cherelle wilt. The exclusion of insect pollinators by caging the cacao flowes resulted in no pollination. During the day, between 0800 and 1600h the cacao flowers were mainly visited by Cecidomyiids and Forcipomyia species.

AUGUST 1988

[Thermic processing technology of juice and nectar sugar of cacao pulp] Obtencao e perspectivas do processamento termico do suco e nectar do polpa do cacau.
PASSOS, F.J.V., PEREIRA, V. DE.P., PASSOS, F.M.L. and ROMEU, A.P. CEPEC, Itabuna, Bahia, Brazil - Boletim Tecnico - Centro de Pesquisas do Cacau (Brazil) no. 137, 29p. 1986.
In Brazil, the production of 1 ton dry cacao beans leaves about 400-425 kg of pulp. The cacao bean production in the State of Bahia, concentrated on an area of 91,859 km amounted to 264,677 tonnes in 1984, results in considerable quantity of fermenting waste product. A very small part of this pulp is processed into jams, vinegar or juices. In this publication, the input requirements for collecting and transporting the pods and methods for pulp extraction, processing and preservation of pulp and juices, are dealt with.

SEPTEMBER 1988

The Cocoa Rehabilitation Project in Western Samoa: need for attention to social context and institutional incentives.
ANDREWS, L. Islands/Australia Working Paper - Australian National University (Australia) No. 2., p.50, 1987.
During 1983, cacao represented 15% of Samoa's exports. Exports of cacao have declined in the last 10 years, as has the quality of the cacao produced. Reasons for this decline include poor cultural practices; too little replanting and cultivation of low-yielding varieties. This paper analyses the incentives and disincentives for smallholders in adopting the recommended cacao variety Amelonado and improved cultivation methods. It is found that rates of return are virtually similar (17.9%/year) for both the highinput/high return management approach being promoted by the Rehabilitation Project and the low-input/low return approach which farmers seem to prefer. A Cocoa Suspensory Loan Scheme, utilizing aid funds, increases the rate of return for farmers from the high-input/high-return approach; but a series of social and economic factors are analysed which may justify the apparent preference for the low input/low-return approach.

OCTOBER 1988

[Research into yeasts able to ferment cocoa by the three-phase process] Recherche de luvures capables de fermenter le cacao par voie triphasique.
SANCHEZ, J.E., GUIRAUD, J.P. and GALZY, P. Ecole nationale Superieure Agronomique (ENSA), Montpellier, France - Cafe, Cacao, The (France) v. 32 (2) p.141-148; Apr 1988.
In France 18 strains of yeasts isolated during traditional cocoa fermentation and 7 acidogenic strains with good fermenting capacities were studied with a view to improving the 3-phase cacao fermentation process. The heat resistance, pectinolytic capacity, influence of aeration and fermentation kinetics of the yeasts were analysed. From the results obtained, 2 wild strains, Saccharomyces chevalieri and Torulopsis candida, and a mutant of S. chevalieri with a respiratory deficiency can be recommended. The acidogenic strains have not given good results since they have no pectinolytic capacity, which is a characteristic feature of the yeasts.

[Some diseases of cacao] El cacao y algunas de sus enfermedades.
CUBILLOS, Z.G. Compania Nacional de Chocolates, Medellin, Colombia - Cacaotero Colombiano (Colombia) v. 9 (33) p.15-30; Dec 1986.
It is estimated that yield loss of cacao, due to diseases, is of the order of 20.8%. The most serious diseases in Colombia are Monilia pod rot, caused by Moniliophthora roreri (syn.Monilia roreri), witches' broom caused by Crinipellis perniciosa (syn. Marasmius perniciosus), stem canker, due to Phytophthora spp. and pink disease, caused by Corticium salmonicolor. Disease symptoms, dispersal, and the methods of management for each disease are recorded.

Comparative merits of cocoa pod and shoot as food sources of the mirid, Helopeltis theobromae Miller.
AWANG, A., MUCHAMAD, R. and KHOO KHAY CHONG, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia - Planter (Malaysia) v. 64(744) p.100-104, Mar 88.
Helopeltis theobromae, a major pest of cacao in Malaysia, obtain their nutriments in the juvenile and adult stages by sucking the sap from foliar shoots and pods. The present study was carried out to investigate the comparative merits of these sources of food on the development, survival and fecundity of the pest. The 3 nymphal instars tested, viz, third, fourth and fifth, experienced higher rates of development and survival when caged on pods compared with foliar shoots. In the case of adults, their longevity and fecundity were much higher when they were caged on pods than on shoots. The results showed that as a source of food for the nymphs, shoots were inferior to pods; the availability of pods are critical to adult mirids for maximum longevity and fecundity.

[Mixed cropping of cacao and banana in the coastal area of Bahia, Brazil] Sistema de producao banana/cacau para o Reconcavo Baiano.
CORDEIRO, Z.J.M. EMBRAPA, Curz des Almas, Bahia, Brazil - Documentos - Centro Nacional de Pesquisa de Mandioca e Fruticultura, EMBRAPA, (Brazil) No. 21, 24.
Cacao is a very important crop in the Reconcavo Baiano, Brazil. Banana is recommended as an intercrop, furnishing some provisional shade and money as a cash crop. A description of the region is given. The size of the cacao/banan plantation is between 5 and 100 ha or more. The banana intercrop contributes up to 25% of the establishing costs of the cacao plantation. The establishment of banana, recommended varieties such as cv. Mysore, Prata, Prata Ana and Pacovan, the various cultural practices, and harvesting and transport techniques are reviewed.

[Fertility and fertilization of cacao soils in Sao Tome] Fertilite et fertilisation des sols a vocation cacaoyere de Sao Tome.
JADIN, P. Service d'Agronomie, Institut de Recherches du Cafe et du Cacao (IRCC), Montpellier, France - Cafe, Cacao, The (France) v. 32 (2) p.111-126, Apr 1988.
In Sao Tome, the area under cacao is about 24,500 ha. However, the cacao plantations are old with low productivity. In 1985, an agro-pedological mission provided an opportunity for collecting composite samples of soil from various cacao plantations in the country. Analysis of these samples made it possible to determine the fertility of these soils and assess the value of mineral fertilization. The cacao soils are rich, with surplus P and Mg. In order to improve, the output of the cacao plantations, K fertilization wa planned after improving the cultural techniques. By comparing the field observations with the analyses, it has been possible to outline new studies concerning the part played by shade of legumes and B deficiency.

Crop tolerance and mixed weed control in cocoa with basta.
PURUSOTMAN, R., TSUE, C.C.T. and LANGELUEDDEKE, P., Hoechst Malaysia Sdn. Bhd. Kuala Lumpur - Malaysia - Planter (Malaysia) v.64(745) p.171-179; Apr 1988.
In Malaysia basta (proposed common name of the active ingredient glufosinate-ammonium) was sprayed on 3 and 5 month old cacao seedlings planted in polybags by 3 different methods; stem application only, application to stem and lower leaves, and application overhead. In the first method, product concentrations of at least 2% were well tolerated, in the other methods stronger phytotoxic symptoms were observed. In weed control trials in young plantations, basta at 1.5 to 2.5/1 ha gave longer lasting control especially of Paspalum conjugatum and Paspalum commersonii as compared with paraquat at 2.8 l/ha or hand weeding.

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