COCOA GROWERS' BULLETIN

Number 36 September 1985

Contents:

Cadbury Schweppes plc
Bournville
Birmingham B30 2LU
England

Editorial

Increased production or productivity per unit area of land must present cocoa farmers and plantation owners with the best prospects of improved revenue from their crop in the decades to come. To achieve a major increase in production new hybrid planting material is required which has characteristics of early bearing, high yield and low incidence of pest and diseases. Major programmes of plant breeding and genetic resource conservation must be substantially enlarged or in some cases be started in order to give the cocoa farmers and plantation owners new approved hybrids for planting in the twenty-first century.

As cocoa seed loses its viability extremely quickly, its genetic resources can only be conserved in a living form in the field. It seems unlikely that new techniques of germplasm storage will be applicable to cocoa for many years and so cocoa will have a requirement for living collections, or genebanks, for the foreseeable future. In 1980, the International Board for Plant Genetic Resources (IBPGR) designated two Universal Collections as being appropriate for cocoa. These Collections were to be at the Cocoa Research Unit at the University of the West Indies in Trinidad and at CATIE, Turrialba in Costa Rica. The work and prospects of the first mentioned Collection which has been designated the International Cocoa Genebank, Trinidad is described in the article by Dr. Kennedy in this issue of the Cocoa Growers' Bulletin.

There are many areas of the cocoa-growing world where germplasm conservation is an urgent priority before the wild or semi-wild trees are destroyed for all time. However, very great importance must also be attached to a systematic programme of evaluation of the material already collected and its incorporation into the breeding programmes.

This task work of evaluation can no longer be ignored but presently allocated financial resources for this work are pitifully small. A major effort by international agencies to conserve, evaluate and utilize the genetic resources of cocoa to satisfy the requirements of the world's cocoa growers from the year 2,000 is now needed. Significant resources have been assigned by such agencies to breeding new varieties of food crops in the recent past. Should not serious thought now be given to the needs of cash crops on which so many of the world's small farmers depend for their livelihood?

R.A. LASS, Editor.

ISSN 0045-7256

Cocoa Growers' Bulletin is published twice per annum by Cadbury Ltd. 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 mailing list, should be sent to R.A. Lass, Cocoa Department, L61, Cadbury Ltd., Bournville, Birmingham B30 2LU, England.

Review of Production and Consumption

July 1984 – May 1985

S.J. Turner, Cadbury Ltd.

Review of the Market

In the twelve months since our last review, the size of the deficits in 1982/3 and 1983/4 have become both more definite and more substantial.

It is now apparent that the abnormal weather of the last two years has given way to a more typical year in 1984/5 and the consequent recovery in production in key countries will provide a surplus of production over consumption in 1984/5.

The market has remained relatively static in the last twelve months. It would seem that the surplus in 1984/5 has countered the gradual realisation of the worsening deficits in 83/4. Fortunately the confusing statistical situation of the last twelve months does finally appear to have cleared.

Production

Gill and Duffus's latest forecast of 1984/5 production is 1,833,000 tonnes, which shows an increase of 321,000 tonnes over their revised 1984/4 estimate of 1,512,000 tonnes (Report Number 318, June 1985).

Significant improvements are expected in Nigeria (up 35,000 tonnes to 150,000 tonnes) and Ecuador (up 30,000 tonnes to 85,000 tonnes). Record crops are forecast for the Ivory Coast (530,000 tonnes), Brazil (396,000 tonnes) and Malaysia (100,000 tonnes).

Despite an improvement in the crop in Ghana, from 159,000 tonnes to 170,000 tonnes, the downwards trend in production still appears intact at the moment: the higher crop seems to be due only to the kinder weather.

Consumption

The latest Gill and Duffus forecast for 1985 world grindings is 1,716,000 tonnes, compared with an estimate of 1,728,000 tonnes in 1984 and a 1983 level of 1,649,000 tonnes.

Grindings in the major consuming countries are expected to be generally down on 1984 but increased grinding in Eastern Europe, African origins, and the Far East, are expected to partially offset this decline.

Stocks

Gill and Duffus estimate world stocks at the end of 1983/4 at 356,000 tonnes, the lowest level since 1976/7. The Cocoa Agreement Buffer Stock continues to hold 100,000 tonnes of this.

The surplus of production in 1984/5 is forecast at 98,000 tonnes to give stocks at the end of the year of 454,000 tonnes.

Prices

Prices have remained in a broad range since July, affected by currency more than cocoa factors.

Currency and technical factors have been especially significant in the market over the last six months. The price of Ghana cocoa for nearby shipment rose by over £300 in January as the US dollar strengthened before retreating by a similar amount in March/May when the pound recovered.

World Cocoa Production and Grindings Data

Reproduced from Gill and Duffus Market Report 318 Dated June 1985

(Thousand Metric Tonnes)

PRODUCTION	1981/2	1982/3	1983/4 (Estimate)	1984/5 (Forecast)
WORLD TOTAL	1721	1534	1512	1833
Africa	1038	852	852	1027
S. America	520	514	476	603
West Indies	50	51	50	49
Asia and Oceania	113	117	134	154
Principal Countries				
Cameroun	122	106	108	120
Ghana	225	178	159	170
Equatorial Guinea	8	10	10	6
Ivory Coast	457	355	405	530
Nigeria	181	156	115	150
Brazil	314	336	302	396
Colombia	42	40	41	40
Ecuador	85	55	55	85
Mexico	41	42	40	42
Venezuela	17	17	16	38
Dominican Republic	40	40	39	35
Malaysia	60	65	80	100
Papua New Guinea	30	29	28	30

GRINDINGS	1982	1983	1984 (Estimate)	1985 (Forecast)
WORLD TOTAL	1608	1649	1728	1716
Western Europe	620	627	658	644
Eastern Europe & USSR	206	226	218	230
North America	215	210	231	213
Central & S. America	322	338	352	350
Australia & New Zealand	13	12	10	6
Asia	106	107	104	110
Africa	126	129	155	163
Principal Countries				
United States	199	194	209	197
Germany (Federal Republic)	175	180	194	185
Netherlands	148	157	161	155
USSR	125	140	140	150
United Kingdom	88	77	89	95
France	52	53	52	80
Brazil	170	198	214	210

PRICES

Month-end prices for nearby shipment Ghana cocoa have been:—

1984	January	£1965	July	£1727
	February	£1713	August	£1907
	March	£1889	September	£1918
	April	£1998	October	£1999
	May	£2215	November	£1898
	June	£1910	December	£1955
1985	January	£2281		
	February	£2272		
	March	£2110		
	April	£1928		
	May	£1881		

The International Cocoa Genebank, Trinidad: Its Role in Future Cocoa Research and Development

A.J. Kennedy, Head, Cocoa Research Unit, University of West Indies, St. Augustine, Trinidad

Introduction

Breeding programmes for all crop plants rely for their success on the availability of genetic variation in the base population. Cocoa is no exception to this and the problem has been discussed before (Chalmers, 1972; Bartley, 1979; Allen, 1981; Lopez, 1981). These authors have all pointed out the importance of genetic conservation and establishment of international germplasm collections.

A collection of germplasm was begun in Trinidad in the 1930s. This was prompted by the then serious nature of Witches' Broom disease to which no resistance seemed to exist in Trinidad. The first major collection of material was, therefore, made by Pound in Ecuador in 1937 and Peru in 1938. A search for resistance to Witches' Broom disease was the single purpose of collection and it proved to be successful. From this material Scavina 6 and 12 were found to be resistant and were widely distributed. The subsequent events serve to illustrate the importance of obtaining a large, widely based genebank. Due to the existence of different strains of the causal fungus (*Crinipellis perniciosa*) the Scavina resistance was not effective in some areas of South America and there are signs that it is breaking down in Trinidad too. More sources of resistance must be sought urgently. They should ideally be polygenic in nature giving horizontal resistance but not necessarily immunity.

There have been two further collecting expeditions resulting in the introduction of valuable germplasm into Trinidad. In the 1950s a joint Anglo-Colombian project was executed resulting in a collection of wild cocoa, *Theobroma* spp. and *Herrania* spp. (Baker et al., 1954). More recently Chalmers (1968, 1969, 1970) collected material in the Oriente region of Ecuador. Still more recently a collection by Allen (1981) has been made in Ecuador but this material is still awaiting distribution.

This brief historical review of the sources of the germplasm at present available in Trinidad forms the background to the main substance of this paper. It is intended to develop the theme of future utilization and development of this germplasm at local, regional and international levels.

The International Cocoa Genebank, Trinidad

Because of the manner in which collections were made, the germplasm in the International Cocoa Genebank, Trinidad (ICGT) consists of a series of populations. Each population is distinct and designated by a code relating to the location of collection. The major populations are enumerated in Table 1. Some of this material has been distributed widely as individual clones, for example Sca 6, Sca 12, Na 32, Na 34, Pa 7, IMC 60, IMC 67, ICS 1, ICS 6, ICS 8 and ICS 95. The genetic potential of the collection has, however, not been exploited to any extent.

TABLE 1

Contents of the International Cocoa Genebank, Trinidad. The names, country of origin and size of each major population is given.

	Population	Origin	No. of Genotypes
1.	Pound Upper Amazon	Peru	
	Nanay (Na)		301
	Parinari (Pa)		129
	Morona (Mo)		23
	Iquitos (IMC)		53
	Scavina (Sca)		15
2.	Pound Refactarios	Ecuador	969
3.	Imperial College Selections (ICS)	Trinidad	90
4.	Chalmers Oriente	Ecuador	85
5.	Grenada Selections (GS)	Grenada	15
6.	Anglo-Colombian (Spec)	Colombia	43
7.	EET	Ecuador	8
8.	Pound (P)	Peru	21
9.	Brazilian Clones	Brazil	6

The germplasm collection at the Cocoa Research Unit is being reorganized. The trees are presently dispersed over several field sites and planted randomly within sites. All material will be repropagated and established on a recently acquired field station (The University Cocoa Research Station). Many of the trees to be propagated are now well over thirty years old and may present major problems in their re-establishment. Where possible the propagation will be by hard wood cuttings taken directly from the original tree. In many cases it may prove necessary to first bud the required genotype on to a vigorous rootstock in order to obtain material suitable for cuttings. The use of budded trees in the genebank itself will not be adopted since this potentially leads to management problems in the prevention of rootstock chupons growing out to take over the scion.

Each population will be planted as a distinct block, each genotype represented by eight trees. Efforts will be made to conserve as many genotypes as possible. This is important since the genebank is to serve not only Trinidad and the Caribbean region but the cocoa research community globally. There are urgent problems that must be confronted now in Trinidad and elsewhere by exploiting those genotypes that are known to be of value. However, the future will inevitably hold new problems of diseases, pests, environment and cultural practices. All of these are quite unpredictable and will require novel cocoa genotypes to solve them. The value of any individual genotype in the future cannot be predicted by its reaction to present problems.

Distribution of Material from ICGT

Germplasm will be available from the ICGT in two forms. Firstly, budwood of individual clones will be available. These clones may then be incorporated in national breeding programmes or put directly into selection trials. Secondly, and more importantly in terms of the distribution of genes, bulked seed from intercrossing within populations can be distributed to research organizations requesting them. The use of seed from such populations was tried and proved successful when the Upper Amazon Nanay and Parinaris of Pound's collection were transferred from Trinidad to Nigeria (Opeke, 1972).

The main function of a genebank is that it allows the genes held in its deposits to be transmitted to the locations where they may be exploited. Since the germplasm containing those genes must reside in a particular location the expression and evaluation of genotypes is confirmed to the extent allowed by the local environment. Resistance to swollen shoot virus cannot be assessed in Trinidad nor can productivity in the environment of West Africa. It is, therefore, essential that transfer of germplasm ensures that sufficient variation be embodied in that transfer to allow local selection to be effective. This argument applies to all characters. Local adaptation is very important both in choice of a genotype as a parent in a breeding programme and in selection of material for commercial release. The use of seed from within populations to transfer germplasm has many advantages. The most outstanding advantage is that a sample of genes is transferred simply and quickly.

The ideal method for seed production in a population based transfer, as described, would be to allow random mating within each population. This could then be followed by a random sampling of the seeds so produced. The important feature of such a method is that it does not include any selection, conscious or unconscious, in the pairing of pollen and seed parents. The limitations to the actual method used will inevitably be the practical issue of manpower and time. It would seem reasonable, however, if each individual is represented at least once and that no seed is included that may involve pollen from outside the population.

This method of germplasm distribution will maintain the integrity of each population in terms of its gene frequencies. It will also provide variation for the recipient to subject the initial import to adequate selection under local environmental conditions. This may be of major importance in screening for rare genes for example to disease resistance, particular diseases or pathogenic strains that do not exist in the exporting country.

Quarantine

An international genebank must have access to adequate quarantine facilities in order that material may be moved freely into and out of the collection. Although the collection of material in Trinidad is extensive it must be enlarged to expand its genetic base. Already the London Cocoa Trade Amazon Project has collected several hundred clones which are to be transferred to a genebank. There are national collections in many research institutions from Mexico to Bolivia which should also be consolidated in a secure, international collection.

Collection and consolidation on this scale will require a quarantine facility that is able to process a vast amount of material. In order that this can be done at an acceptable cost it is necessary to site this facility in a climate suitable for the open cultivation of cocoa. For this reason Barbados was chosen as the quarantine site. It has no indigenous cocoa industry, air links are excellent with Trinidad and most other countries, its nearest cocoa-growing neighbour is Grenada which is 247 km distant and the year long prevailing winds are easterly making it impossible to receive airborne diseases into the quarantine areas from other Caribbean cocoa-growing territories.

Quarantine Conditions

Material will only be brought to Trinidad from South and Central America, never from Africa or South East Asia. As far as disease considerations are concerned Trinidad is similar to South America. The major diseases of cocoa in South America are:

i) Witches' Broom (*Crinipellis perniciosa*).
ii) Black Pod (*Phytophthora* spp).
iii) Moniliophthora pod rot (*Moniliophthora roreri*).

So far there have been no reports of the occurrence of virus diseases in the Amazon area.

Of these diseases the most important from the point of view of quarantine for movement of material into Trinidad are witches' broom and *Moniliophthora* pod rot. *Moniliophthora roreri* does not occur in Trinidad at present and the pathotype of *Crinipellis perniciosa* found in Ecuador and other Upper Amazon areas is different to that present in Trinidad. The nature of these two diseases makes them relatively simple to quarantine effectively. They may be summarized as follows.

Witches' Broom

i) Basidiospores are the early infective stage of *Crinipellis perniciosa.*
ii) Basidiospores are very short lived and hence severely restricted in their infectivity.
iii) There is a greatly restricted period of host susceptibility; only young newly growing tissue is infected (buds or flushes).
iv) Basidiospores are not produced as a direct result of infection but only as a result of eventual death of infected tissues.
v) Infection leads to easily identifiable host reactions in the production of brooms on fans or cushions or as swelling and hypertrophy in young tissues.
vi) Living, green brooms never produce sporophores.
vii) The time lag between broom necrosis and sporophore production is very long (3—4 months minimum) even in optimum conditions.
viii) Brooms are apparent in the first or second flush after infection.
ix) Infection is not systemic.

Production of brooms in quarantine does not therefore pose a threat since they are easily spotted and the plant destroyed. All infected plants will show up in quarantine within one year (2 or more flushes).

Moniliophthora pod rot

i) The only susceptible part of the tree is the pod, no other tissues are infected.
ii) No pods will be imported into Barbados.
iii) No pods will be set in quarantine.
iv) Only vegetative material will enter or leave the quarantine station.

The facility will allow the rapid collection of material from South America and its eventual dissemination to South American and Caribbean research programmes after evaluation and description in Trinidad. It is recognized that the specialized facilities such as those at Miami will still have a role to play in the distribution of particular clones to countries requesting them where considerations such as virus indexing may be important.

Description and Evaluation

An essential part of the germplasm project is that of evaluation and description of the collections. Evaluation is to be carried out only to the extent of testing for reaction to specific diseases. This implies the use of standardized, meaningful screening methodology for those diseases present in Trinidad. It is one major objective of the Cocoa Research Unit to develop these screening methods.

Description will initially be based on the IBPGR Descriptor List and the collection of data has already begun. When a large body of data is available the descriptors will be evaluated for their usefulness in two ways. First it is essential to be able to assess the genetic diversity of populations and which of the descriptors represent genetic rather than environmental variation. Second it is important to select a subset of characters that allow the maximum differentiation between individual genotypes.

The data once collected will be stored on a computer and handled by an appropriate data base management system (DBMS). The data base must be portable and thus readily available to other users. This means that software that is specific to one computer or uses non-standard formats must be avoided. The DBMS will also be able to provide hard copy of information as requested.

The Future Role of the Genebank

The value of the ICGT to future cocoa research is obvious, in that it can be the source of genes that will allow breeding and selection programmes to progress. For the full potential of the concept of an International Genebank to be realized certain conditions, other than keeping the trees, must be fulfilled. The research programme of the Cocoa Research Unit will be addressed to making the maximum use of the genetic variation within the genebank.

The major constraint, at present, to cocoa production is probably disease. Each producing area has its own particular disease problems. In order that the genepool available in the genebank may be exploited there must be the development of quantitative screening methods to detect resistance genes. Much of the available resistance may be polygenic, hence the need for quantitative methodology. In Trinidad research is directed towards the development of screening methods to select for resistance to witches' broom and *Phytophthora* diseases.

The breeding programme of CRU is directed not at the selection of varieties to release to farmers but rather at detecting the genetic potential of the populations in the ICGT for improvement. All populations cannot be improved for all characters. There must be the genetic variation within the population. By using a population approach to breeding, in conjunction with newly developed screening methods, the potential for response to selection for given populations or groups can be assessed. This information will be of value to both the Trinidad breeding programme and to other users of the genebank.

The work of descriptions and evaluation is a continuous process. As the genotypes are distributed more widely then more information is gathered and can be added to the databank for the genebank. This "sharing" of information must be considered as important since it will allow the genepool to be shared even more efficiently.

Finally there must be a continual search for new germplasm to add to the genebank. Collecting must be done systematically and with reference to where the areas of highest priority are. Initially much useful collecting may be done by simply consolidating material already collected but dispersed in various national collections.

Since the future of research and development in cocoa must rely on the identification of new successful types, the role to be played by a genebank is central. It is hoped that this paper was able to show that that role goes beyond mere collecting and holding of genotypes. A genebank supported by a research programme can greatly increase the efficiency of the exploitation of the genepool, often very expensively acquired.

REFERENCES

ALLEN, J. (1981) Collecting Cocoa in its centre of origin. *Proc. 8th Int. Cocoa Research Conf., Cartagena, Colombia, 1981.*

BAKER, R.E.D.; COPE, F.W.; HOLLIDAY, P.C.; BARTLEY, B.G. and TAYLOR, D.J. (1954) *Report on Cocoa Research 1953.* ICTA, Trinidad.

BARTLEY, B.G.D. (1979) Global Concepts for Genetic Resources and Breeding in Cocoa. *Proc. 7th Int. Cocoa Research Conf., Douala, Cameroun, 1979.*

CHALMERS, W.S. (1968). Cocoa collecting trip to the Oriente of Ecuador – November 1968. *Departmental Report, Cocoa Research Unit,* U.W.I. St. Augustine, Trinidad.

CHALMERS, W.S. (1969). Report of a cocoa collecting trip to the Oriente of Ecuador May 1969. *Departmental Report, Cocoa Research Unit,* U.W.I., St. Augustine, Trinidad.

CHALMERS, W.S. (1970). Report on the collection of *Theobroma cacao* in the Oriente region of Ecuador March – May 1970. *Departmental Report, Cocoa Research Unit,* U.W.I., St. Augustine, Trinidad.

CHALMERS, W.S. (1972). The Conservation of Wild Cacao Populations: The Plant Breeders Most Urgent Task. *Proc. IV Int. Cocoa Research Conf., St. Augustine, Trinidad, 1972.*

LOPEZ, L. (1981). Necesidades de Colectar Poblaciones de Cacao y su Conservacion en un Banco International de germpoplasma. *Proc. 8th Int. Cocoa Research Conf., Cartagena, Colombia, 1981.*

OPEKE, L.K. (1972). The Trinidad-Nigeria Cocoa Introduction Programme 1962–1970. *Proc. IV Int. Cocoa Research Conf., St. Augustine, Trinidad, 1972.*

This paper is produced by kind permission of the Cocoa Producers Alliance, Lagos, Nigeria being a paper presented at the 9th International Research Conference held in February 1984 in Lome, Togo. The Proceedings for this Conference are available from the Cocoa Producers Alliance, Western House, P O Box 1718, Lagos, Nigeria or from P O Box 205, London at a price of US $ 50.00 to participants and US $ 82.00 to non-participants plus postage charge of US $ 20.00 – to Africa, Asia, North, Central and South America, US $ 6.00 to Europe and US $ 5.00 to United Kingdom.

Rehabilitation in Ecuadorian Cocoa Farms

W. Hadfield, INIAP, Estacion Experimental Tropical, Pichilingue, P O Box 24, Quevedo, Ecuador

Present Address: 1 Blackhorse Lane, Swavesey, Cambridge, United Kingdom.

Any attempt to discuss cocoa rehabilitation must first consider what is meant by rehabilitation and if or how it differs from renovation, replanting or infilling. In this article rehabilitation is taken to mean the overall strategy involved in increasing the productivity of existing stands of cocoa without increasing the total area occupied by the crop. This may involve some infilling, some replanting and some renovation of existing trees as well as a variety of other cultural methods.

In long term perennial crops such as cocoa, tea, coffee and oil palm, etc., the time/yield curve shows a rapid rise (A), a period of stability (B), and a general decline (C) as shown in Figure 1. The objective of rehabilitation is to arrest the decline (C) and return to the plateau of B, but there are several good reasons to believe that in Ecuador the plateau could be considerably higher than before rehabilitation.

In Ecuador there are approximately 200,000 hectares of cocoa most of which is grown by smallholders. The most distinctive feature of cocoa growing in Ecuador is the climate which is unlike any other cocoa-growing country. On average the year is divided equally between a wet and a dry season but the wet season is relatively sunny while in the dry season the sky is normally overcast. The hours of sunshine and amount of radiation are much lower than in other cocoa-growing countries. Cocoa can flourish under this climate in Ecuador especially where the soil is fertile and the water table is high, but there are considerable variations in the length of the dry season which lead to stress.

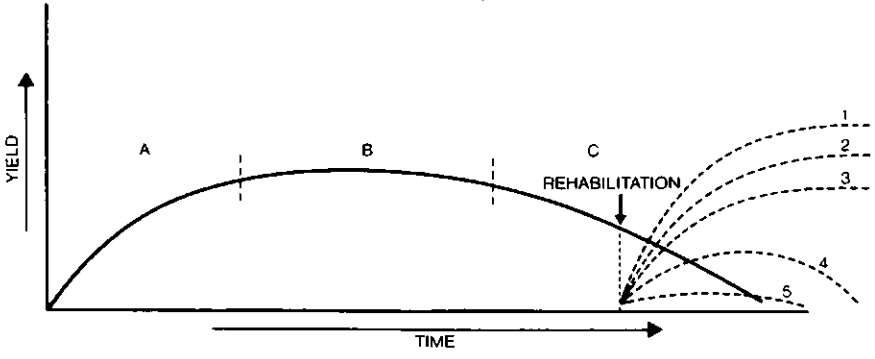
Cocoa in Ecuador still suffers severely from witches' broom and Monilia pod rot, two diseases which devastated the industry during the 1920s and 1930s. There is still no control for these diseases but there has been a remarkable resurgence of production during the past 20 years which may be due in part to the planting of varieties which escape the periods of heavy disease incidence. However yields are usually modest. On the basis of 800 trees per hectare there are about 160 million trees and the total Ecuadorian cocoa crop for the period 1981–82 to 1983–84 averaged 80,000 tonnes. These figures give an average yield of 400 kg per ha. With current knowledge and good extension it should be possible to improve on this poor yield, though it is essential to have an active well trained extension service to pass recommendations on to farmers.

Factors Limiting Yield

1. An important limiting factor is the light climate of the coastal plain which receives far less radiation than any other major cocoa producing country due to a combination of cloud during the rainy season and hazy mist in the dry season. Radiation cannot be increased, but there are ways in which the available radiation can be utilized to better effect than at

present by use of suitable shade trees which do not compete too strongly with the cocoa trees for light, nutrients and soil moisture. The length and severity of the dry season in the coastal plains of Ecuador often limits cocoa production. This means that conservation of moisture is necessary for half the year and removal of excess water is necessary during part of the rest of the year.

2. The usual spacing is 700–800 trees per ha which is lower than optimum. On average there are about 15 per cent vacancies in mature farmers' cocoa with the gaps often in areas with poor drainage or under large dense shade trees. This represents a minimum of 36,000 hectares of completely non-productive land planted to cocoa and these should be infilled at a spacing of 3.0 x 3.0m to increase productivity of the land planted to cocoa.
3. It has been found that on average 25 per cent of existing cocoa trees produce only 5 per cent of the crop and rehabilitation is the opportunity to replace these poor trees with vigorous new seedlings.
4. A number of trees are particularly heavily infected with witches' broom and these trees should be removed from the farm, perhaps with a compensation payment to the farmer, as they will produce few pods and will continue to act as a significant source of inoculum.



GENERALISED TIME-YIELD CURVE FOR PLANTATION CROPS AND THEORETICAL EFFECTS OF REHABILITATION. CURVES 1-3 SHOW VARYING DEGREES OF SUCCESS AND 4-5 THE POSSIBLE RESULTS OF UNSUCCESSFUL SCHEMES.

Figure 1

Nutrition is not a major problem in most Ecuadorian cocoa soils, although there is little doubt that the requirements of replanted cocoa will differ from those of mature areas where a reasonably balanced nutrient cycle operates. In any event, it is most unlikely that fertiliser application will form part of the small farm system in Ecuador in the foreseeable future.

The cocoa rehabilitation scheme in Trinidad was based on a similar programme but used rooted cuttings in place of seedlings. This heavily subsidised scheme was not a success and did not halt the decline of Trinidad's production. It would be unwise to draw a close parallel between Trinidad and Ecuador but the Trinidad experience helps to emphasise the difficulty of putting into practice a scheme which is clearly desirable and appears technically feasible.

The Rehabilitation Programme

The emphasis should be on correcting the factors known to reduce yield by methods within the scope of a small farmer with limited facilities. It must be stressed that these factors are generally interdependent and the success of the operation will depend on all operations being carried out.

1. Shade Reduction

The irregular spacing of shade trees and complete lack of shade management is a major factor in reducing yield on farmers' cocoa in Ecuador. Where shade exists it is usually too dense, because of a large number of shade trees per hectare with canopies which are too dense. Many cocoa trees in Ecuador are 60 years of age and while the shade may have been ideal at planting the shade trees are now 60 years older and where none have been removed the shade is too dense. A number of criteria should be applied to shade reduction. If the sky is not visible from beneath the canopy of a shade tree, it is too dense, and the shade tree should be removed. In Ecuador unsuitable trees for shade include *Persea americana* (Avocado), *Ficus* spp. and *Schizolobium* spp. If shade tree canopies overlap, the tree with the denser canopy should be removed. In addition there should be no more than about 45 shade trees per hectare, evenly distributed through the field and not clustered together as is often the case. Fruit trees, including citrus species which provide very poor shade for cocoa, are often found in Ecuadorian cocoa farms but farmers are most unwilling to remove them. Similarly some *Ficus* trees are very large with dense shade, but are just too difficult to remove.

2. Shade Planting

However, a large part of Ecuadorian cocoa is completely unshaded and consequently suffers from nutrient imbalance and dieback. In unshaded areas, especially those with many cocoa vacancies and gaps in the canopy, temporary shade in the form of banana/plantain should be established on a close planting pattern. At the same time well grown seedlings of *Inga* species should be planted at about 15—18 metres apart in a square pattern or as near to this as gaps permit.

3. Pruning

Cocoa trees which have been badly damaged during the removal of the old shade trees should be heavily pruned, the cuts treated with fungicidal paste and chupons allowed to grow from the base. Two or three chupons can be left, the most vigorous of which should be selected to form the new tree, the rest being cut back in due course.

4. Sanitation

Old Monilia infected and witches' broom pods must be removed from all trees. This will not be easy as so many Ecuadorian cocoa trees are in excess of 10m in height, but their removal is essential in order to reduce overall level of inoculum. However, there is presently no firm experimental evidence available as to the effects of such practice on an individual farm when the neighbouring farms are left untreated. The likelihood is that infection by disease can be greatly reduced by removal of all pods bearing Monilia or witches' broom infections throughout the farm during routine harvesting though this practice must add to the overall costs of farm maintenance. It is

also appropriate to reduce the height of the tallest trees, if possible, and thus assist in future disease control. This would also make for more efficient harvesting.

5. Infilling

No planting of vacancies should be carried out until conditions for the seedlings are adequate. Temporary shade must be established before infilling, as young plants are extremely susceptible to even short periods of moisture deficit. In vacant areas there is almost always a shortage of organic matter in the soil because of low soil moisture levels during the dry season due to lack of shade. Lack of shade causes high soil temperatures, increased evaporation, and destruction of organic matter. The level of organic matter can be increased in various ways either by applying a thick cover of mulch a few months before infilling, by slashing the weeds and spreading them over the soil, or by bringing in cut vegetation or by placing banana leaves or cut banana stems in the bare areas. Plants in large bags can be maintained in nurseries until field conditions are suitable, without root damage.

6. Nursery Conditions

Nurseries should have good overhead shade. Nurseries must be sited as close as possible to the area being infilled to avoid damage during transportation, but must provide facilities for watering. A combination of heavy shade and overwatering will kill off many plants and must be avoided. A high impermeable roof will protect against rain and also reduce infection of the young plants by witches' broom. This is an important factor in preventing infection in the nursery, but may entail frequent watering to compensate for lack of rain.

7. Planting

Planting holes should be large and at the time of infilling, about 200g of superphosphate per plant should be mixed into the hole. Most cocoa soils in Ecuador are short of phosphate, and it is more effective to mix it with soil than to apply on the surface after planting. The breakdown of mulch arising from cutting down weed growth should supply nutrients to a young seedling during its establishment phase. There is at present insufficient data on which to base any other recommendations on fertiliser application. Incorporation of a persistent insecticide into the planting hole will prevent cockchafer damage which can be a serious problem at this stage. The young *Inga* shade trees should also receive superphosphate at the same level, as legumes usually respond well to phosphate.

Chemical Disease Control

There are no chemical methods of controlling witches' broom or Monilia pod rot which are economic for mature cocoa and this is likely to be the case for many years. There is, however, a good case for disease control in nurseries and during the early stages of development after planting. Witches' broom disease frequently causes stunting of plants in the nursery and in some cases a high rate of loss. After planting witches' broom can delay jorquette formation or cause a weak first jorquette which can result in excessively tall trees. Protection in the nursery requires only a knapsack sprayer and a few kilos of fungicide, no expensive maintenance and very little technical ability and is therefore to be encouraged.

Implementing the Programme

To carry out a rehabilitation programme along the lines described over more than 200,000 hectares of cocoa as is necessary in Ecuador is an enormous task and its success will depend both upon the overall strategy to be adopted and detailed execution at local level. Partial implementation is not only unlikely to succeed but may actually worsen the situation if expediency and short cuts are attempted midway through the project. It is therefore essential to examine each stage in some detail.

A 5 year programme evenly spread over the cocoa area is suggested, i.e. 20 per cent of the total area to be dealt with per year, or 1 hectare per year for the smallest farmers. On the basis of a 5 year programme, there are some 40,000 hectares per year to deal with. As it is logical to start on the worst cocoa the initial drop in crop would be less than 20 per cent and most of this could well be made up by improved practices in the remaining 80 per cent of the cocoa. To infill 15 per cent vacancies in 40,000 hectares 4,800,000 seedlings will be required each year of the 5 year programme. If it is decided to replace the 25 per cent non-productive trees as well, this figure rises to 8,000,000 plants. No source of this number of improved hybrids, with known resistance to the major diseases, exists and the only reasonable alternative is for farmers to select their own seed. If this is adopted, the numbers involved become quite manageable, i.e. 120 plants per hectare for infills, and up to 200 plants to completely replace the 25 per cent non-productive trees, a total of 320 plants per hectare. If twice the number of seedlings actually required are raised, there will be ample scope for nursery selection of vigorous plants and the relatively small numbers of seedlings mean that nurseries can be sited close to the area to be infilled and bags large enough to ensure adequate root growth before planting out can be used.

The source of seed is of great importance, as there is little point in planting highly susceptible seedlings into an environment with such high levels of inoculum. It has been pointed out (Edwards, pers. comm.) that apparent field resistance to the major diseases can be observed in some trees while their neighbours show heavy infections. Such trees often appear in short rows suggesting that they were planted from the same pod by the seed at stake method. Local farmers are usually well aware of such trees, and it is from these pods that plants should be raised. The overall result should be an increase in horizontal resistance in line with current thinking of tree crop pathologists and breeders.

Hand-pollination is an obvious way of increasing yield and although this simple and effective practice has not proved popular with farmers, it must be considered as mandatory in a rehabilitation programme. It is an unfortunate fact that flower production in Ecuador is at its lowest at the time of year when pollination would produce pods which will escape the disease period. Trials carried out 8 years ago combining hand-pollination and chemical control, indicated that this could produce economic yield increases.

Control measures would only be applied to just over a metre of trunk per tree, so only a small effort is required, although rapidly expanding pods will require frequent fungicide applications to ensure adequate protection, and the use of a sticker to aid retention of fungicide during the rains. In cocoa with a good canopy, direct rainfall is infrequent, and this helps retention of the fungicide on the pods.

It is obvious that control and supervision of such a scheme is a vital part of this programme and must be adequately staffed and planned. To ensure the full co-operation of farmers some form of incentive scheme must be introduced which will compensate for any loss of income and an intensive propaganda programme to convince farmers of the value of rehabilitation will have to be mounted.

The suggested programme of operations is given in Table 1 and individual years' programmes summarized. There will be differences in the proportion of each stage between farms; for instance it will not normally be necessary to do much work on drainage in volcanic soils and some farms will need to plant more shade trees than remove them. It is because of the intrinsic variability of cocoa farms that rigid programmes are impossible to make, but the sequence of operations and their integration are important. This re-emphasises the need for good supervision of the participating farmers.

TABLE 1
Programme of operations for rehabilitation

PROGRAMME A

1. Select cocoa trees for seed.
2. Prepare nursery & plant seed.
3. Kill off excess shade trees.
4. Prune back damaged cocoa trees.
5. Plant Inga seed in shade nurseries.
6. Plant temporary shade (plantain/banana).
7. Cut out unproductive cocoa trees.
8. Remove monilia pods and brooms.
9. Attention to drainage where needed.

PROGRAMME B

1. Infill all vacancies.
2. Apply mulch on any bare soil.
3. Complete planting of permanent shade.
4. Spray all young plants and chupons
5. Remove monilia pods and brooms.

PROGRAMME C

1. Cut out temporary shade and spread as mulch.
2. Remove monilia pods and brooms.
3. Spray young plants and chupons.
4. Artificial pollination on selected trees.

PROGRAMME D

1. Remove monilia pods during routine harvesting.
2. Artificial pollination in selected trees.
3. Select trees for seed.

Cocoa in Vanuatu

Martin H. Fowler, Ministry of Agriculture, Forestry and Fisheries, Republic of Vanuatu

Introduction

Cocoa was first introduced into Vanuatu (formerly the New Hebrides) by expatriate planters at the turn of the century probably from Sri Lanka. A report of 1912 states that the Red Ceylon variety, probably a Criollo, was preferred by planters. In 1916, two more types of Criollo seed and one Forastero type were introduced from the Dutch East Indies, now Indonesia. The pure Criollo types quickly disappeared and were succeeded by a hybrid cross with the Forastero dominating the hybrid. Most cocoa trees now in the country are derived from the Criollo and Forastero introduced in these early years, and therefore largely resemble the intermediate flavoured hybrid called Trinitario.

Environment

A y-shaped archipelago made up of 80 widely dispersed islands stretching some 800 kilometres from north to south in the South West Pacific (see figure 1). Little or no cocoa is grown in the islands south of Efate (17°S) due to the low temperatures experienced there. The islands of Espiritu Santo, Malo, Malakula and Aoba provide the bulk of the nation's exports of cocoa. The environment on these islands, in terms of the climate and soils, is ideal for cocoa growing. The islands are mainly mountainous in the interior with some high plateaux while the coastal strips provide the main areas for cultivation. As most soils are relatively young and of volcanic origin they are very fertile and have sufficient nutrient status to give good growth and yield. Many of the islands have thick beds of limestone and are surrounded by coral reefs.

The climate ranges from tropical to wet equatorial (depending on the aspect of the island in question) in the north of the country and semi-tropical in the south with a high humidity and a well distributed rainfall.

The cocoa trees bear pods from March to November – the main cropping season being from May to July with a secondary crop during October and November.

History of Production

Good results from the initial cocoa plantings meant that by 1910 cocoa on 30 plantations covered between 225 and 250 hectares. Between 1918 and 1925 there was further expansion though this was restricted in most islands by a labour shortage which, by 1940, had caused the cessation of new plantings in the plantation sector. By then plantation cocoa was estimated to cover 5,000 hectares on some 60 plantations, although some doubt exists as to the accuracy of this figure. Exports in 1939 were 1,955 tonnes, the maximum tonnage ever recorded.

Production has declined ever since – averaging 1,600 tonnes in the 1930s, 1,200 tonnes in the 1940s, 780 tonnes in the 1950s, 690 tonnes in the 1960s and 680 tonnes in the 1970s. This decline is shown in figure 2 and was largely

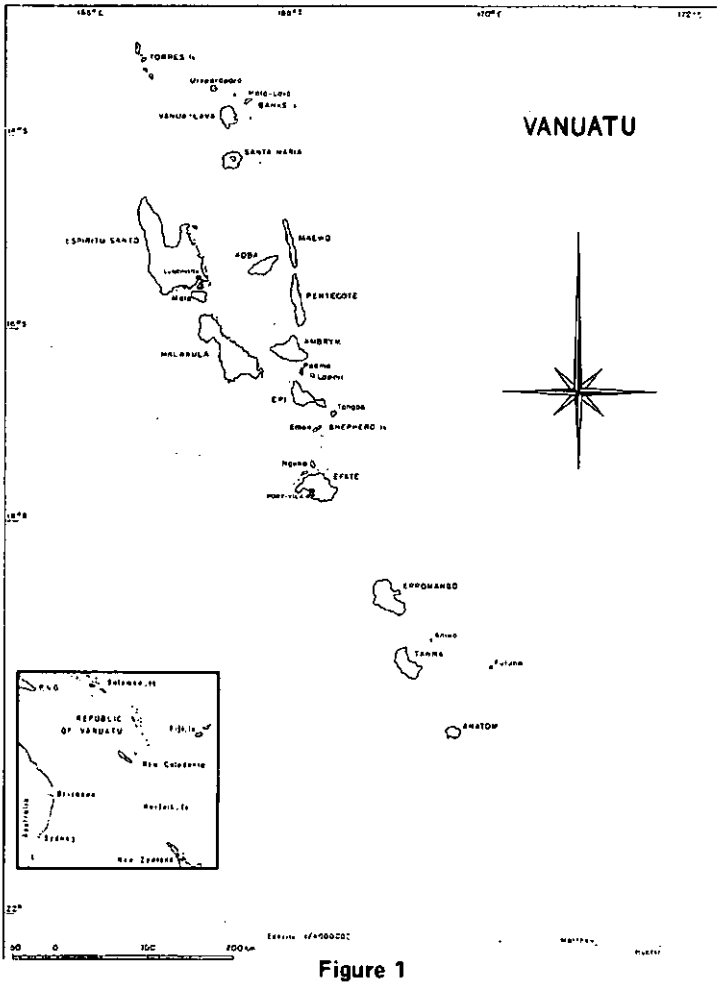


Figure 1

caused by the shortage, and therefore high cost, of labour, labourers having previously been imported from Vietnam to work on the plantations. This meant reduced maintenance of existing cocoa, inadequate pruning of shade trees, increased competition from weeds and little attention to outbreaks of disease and consequently lower yields. With the reduction in labour availability cattle were introduced into cocoa plantations to keep down weed growth between cocoa trees. This practice further reduced cocoa yields as cattle eat all pods within two metres of the ground! The reduction in exports since the 1950s has been minimised by a considerable increase in smallholder production since the Second World War.

Cocoa production is an important export industry — providing an average of 8 per cent of the value of domestic exports from Vanuatu during the last five years. All cocoa is exported as beans since there is no cocoa processing facility in the country.

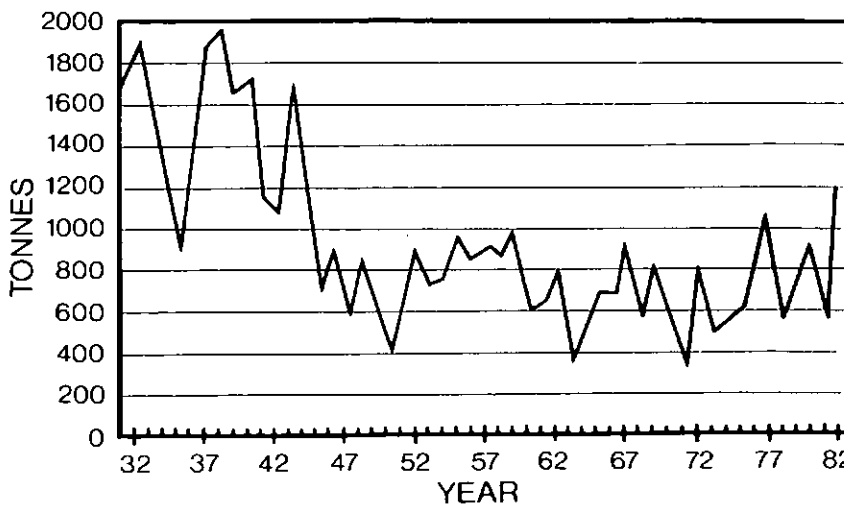


Figure 2

Pests and Diseases

The earliest plantings were made under planted shade trees, particularly the indigenous *Pterocarpus indicus, Erythrina fusca* and *Albizia* spp, on land which had been clear-felled though the practice soon changed to one of planting in partially-thinned forest. Spacing was often highly irregular – usually very close in order to suppress weed growth. However, this meant that the cocoa was induced to shoot upwards instead of spreading outwards and led to a reduction of light and air circulation, resulting in a high incidence of *Phytophthora* pod rot. This is by far the most important disease of cocoa in Vanuatu. The more recent practice has been to interplant with coconuts at 4.5m by 4.5m. *Ustilina deusta* causing a root disease and termites have been reported as being a particular problem among cocoa plantings under partially-thinned forest shade. Most potentially harmful insects and diseases of cocoa cause damage of only minor economic importance in Vanuatu.

However, *Phytophthora* diseases (black pod and stem canker) occur throughout the cocoa-growing areas and are believed, by some observers, to cause a significant reduction in national yields. The *Phytophthora* fungus is encouraged by the high humidity levels during the wet season and significant losses can occur. Prophylactic spraying is usually considered to be uneconomic. Experience has shown that use of different cocoa varieties (the existing *'Trinitario'* type is known to be susceptible to *Phytophthora* pod rot), and improved management techniques, do reduce losses from *Phytophthora*.

Considerable losses are also caused by rats (mainly *Rattus rattus*) which are believed to be the most important cause of pod losses in most of the islands in Vanuatu. Some surveys of neglected plantations in the late 1960s showed that more than 50 per cent of the pods had been damaged by rats. However, with regular harvesting and control measures, losses of less than one per cent from this pest can be achieved. Damage of less significance is caused by flying-foxes, parakeets *(Psittacidae)* and large white ants (*Neotermes* spp).

Seed

In 1974 the Department of Agriculture began distributing seed to farmers from a collection of 17 selected trees of Trinitario origin at the Agricultural Station at Tagabe in Efate. These trees had been carefully selected over the previous decade from an original sample of 1,550. More than 30,000 seedlings were thus distributed in 1978.

Small quantities of Amelonado seed were imported from the Solomon Islands and Malaysia in the late 1970s and planted both at Tagabe and at the Agricultural Station in Espiritu Santo. They are now bearing and supplementing the supply of Trinitario seed from the local selections. However, Amelonado is not very vigorous or high-yielding and a locally-developed, vigorous, disease-resistant hybrid with large beans is required. Some importations of Trinitario from Papua New Guinea have also taken place and recent importations of clonal varieties have widened the national genetic base. Hopefully new hybrids can be developed from this material in the future.

Spacing and Shade

Much of the smallholder cocoa is overshaded and planted under closely spaced coconuts. As a result, the cocoa does not yield well. The Government policy now is to recommend *Gliricidia maculata* as the temporary shade until the coconuts, planted at 9.0m x 12.0m or 9.0m x 15.0m, are tall enough to provide sufficient shade. The cocoa itself is planted at 3.0m x 3.0m in the coconut inter-rows. Government encourages farmers to interplant with food crops before the cocoa seedlings are put in the ground, thus intercropping with bananas and papaya provide useful temporary shade for the young cocoa seedlings.

Yields

The yields on the original plantations were high; probably close to one tonne per hectare, and indicated the potential of the country for cocoa growing. However, due to decreased maintenance and a lack of replanting with higher yielding varieties, average yields on these plantations are now less than 500 kg per hectare. This compares with the plantings at Tagabe which, under good management, are presently producing the equivalent of more than one tonne per hectare.

Mode of Production

Following the stagnation in cocoa production in the plantations which began in the 1940s, observers noted a growing interest in planting the crop among ni-Vanuatu smallholders which was encouraged by the Department of Agriculture. By the late 1960s, production was thought to be equally divided between the plantation and smallholder sectors and in recent years smallholders have consistently produced three-quarters of export volumes. Most new plantings are now undertaken by smallholders, currently being assisted with project funds from the Australian Government.

As a catalyst to the re-development of the plantation sector which had stagnated since before Independence, the Government set up a joint-venture company with the Commonwealth Development Corporation in 1983 to plant 1,700 hectares of cocoa over a 5 year period. This estate, which is located in Malakula, should produce 3,000 tonnes per annum at maturity.

Research

The Government is establishing a cocoa and coffee research station in Espiritu Santo on 64 hectares of land. The station is being managed by the French Institut de Recherches du Cafe et du Cacao. The station will carry out trials on imported and local cocoa varieties with the aim of developing superior planting material suitable for Vanuatu. It will also investigate management techniques, diseases and insects of cocoa and processing technologies in order that agricultural field staff can have improved production packages to extend to farmers.

Processing and Marketing

The bulk of the cocoa exports have traditionally gone to France. In the 1930s, cocoa from the New Hebrides was highly thought of in Marseilles and sold at a premium. However, the situation had changed by the late 1950s when the exports were disposed of at a discount of up to 10 per cent and there were even threats from the London market of outright refusal to buy cocoa from the country. Presently discounts averaging 30 per cent are reported.

The extremely variable quality of the cocoa from smallholdings and plantations in Vanuatu is the result of irregular harvesting, resulting in over-ripe and diseased pods. Much of the harvest is poorly fermented and, due to the variety of types of fermentaries used (wood or cement vats, holes in the ground, concrete troughs or merely left in the collection bag), a uniform national product cannot be produced. Furthermore, artificial drying is often employed and is often inadequate which has resulted in Vanuatu cocoa having a smoky off-flavour. There is also some sundrying. Nevertheless, some villages do produce high quality cocoa.

Cocoa beans have, in the past, been bought from producers by traders and co-operatives and shipped to the export ports of Port-Vila and Luganville where they have been reconditioned by cleaning and re-drying and then blended and bulked. Since the mid-1960s the Department of Agriculture has been encouraging centralised processing and the installation of new, improved dryers. Recent assistance from the European Development Fund has enabled subsidised fermentaries to be provided to communities and co-operatives.

The Government introduced legislation in 1982, aimed at quality improvement through regulation of cocoa processing and cocoa dealing, combined with the inspection and grading of cocoa prior to export. It is hoped that these efforts will improve the current situation whereby cocoa is discounted by an average of 30 per cent on the world market, compared with the 5—10 per cent which could be expected if the quality was good. The cost to Vanuatu of this poor quality is enormous. A further boost should be given by the price differential for beans of an acceptable quality which was introduced in late 1984. However, small bean size is a major defect which will only be corrected by new plantings with an improved variety.

In 1984 the Vanuatu Commodities Marketing (VCM) Board assumed responsibility for cocoa exports in order to improve returns to the producer and to assist Government in its quality improvement programme by means of price differentials based on quality in addition to other measures. A price stabilisation scheme may be introduced at a later date.

Conclusion

The history of cocoa cultivation has shown that the crop is well suited to the physical environment in most of Vanuatu and that it grows well in association with coconuts, the major crop in the country. Given the current financial and technical support now being given to all aspects of the cocoa industry, exports should shortly begin rising again to the levels recorded in the 1930s. These will contribute to the overall growth and diversification of the Vanuatu economy which is currently excessively reliant upon the export of copra.

Literature Consulted

FRIEND, D. (1978) A Report on the Cocoa Industry of the New Hebrides. Australian Development Assistance Bureau, Canberra.

ANON (1982) Cocoa Development Programme, Vanuatu. Project Findings and Recommendations, FAO, Rome.

ANON (1984) Cocoa Development Project, Department of Agriculture, Livestock and Forestry, Government of Vanuatu, Luganville.

URQUHART, D.H. (1953) Cocoa Growing in the New Hebrides, Technical Paper No. 40, South Pacific Commission, Noumea, New Caledonia.

WILSON, J.S.G. (1966) Economic Survey of the New Hebrides, HMSO, London.

Chemical Control of Phytophthora Pod Rot of Cocoa in Brazil

J. L. PEREIRA, Head Division of Pathology, CEPEC, Itabuna Bahia

INTRODUCTION

In Bahia, Brazil, chemical control of *Phytophthora* pod rot (or black pod) must be considered the most important of all the agricultural practices designed to increase cocoa production. In the absence of chemical control, other forms of inputs applied either singly, or as part of an overall recommendation, would not give a positive cost/benefit return.

It is difficult to estimate the crop loss due to *Phytophthora* pod rot as this varies from year to year and from farm to farm. In the southern part of the State of Bahia, the region responsible for 95 per cent of Brazil's production, an average crop loss has been quoted at 30 per cent (Medeiros 1977), but in areas where climatic conditions favour infection, incidence of disease may attain 100 per cent level, with the peak of infection coinciding with a peak in harvest. This was the case in 1984, when in spite of repeated warnings of a serious epidemic, growers were lax with their spray programmes. Relatively low infection levels in 1980-1983 due to severe drought in the north of the region had led growers to make economies in chemical control by applying less sprays and/or reducing the dosage of fungicide or in some cases by relying solely on crop hygiene practices. While years of low disease incidence do occur, growers have realised to their cost that these are only temporary situations. Control by protective sprays is risky if the programme is not followed in full or if one reverts to a normal schedule only after recording a progressive increase in disease.

The need for routine chemical control was first recognised in Bahia in 1956 (Lellis and Matta 1956) and is equally true today. The enormous task undertaken by CEPLAC (the parent organisation of this Cocoa Research Centre) of renovating 51,118 ha of old plantations, by underplanting with mixed hybrids selected for increased productivity rather than tolerance to disease, must include fungicide sprays in the renovated stands of cocoa. However, attention must be given to other strategies including integrated control for use at farmers' level (Pereira and Cruz 1984). Selection of *Theobroma cacao* resistant to *Phytophthora* spp. has received special attention (Lawrence 1978). This line of research suffered a setback after it was determined in 1980 that screening for resistance should take into consideration all three species of *Phytophthora: P. capsici, P.palmivora* and *P.citrophthora* each with different behaviour in its host/pathogen relationship (Campelo and Luz 1981). The importance of crop hygiene was emphasised as early as 1956 (Cruz and Paula 1956). More recently investigations into the duration of survival of the pathogens in husk piles (Figueiredo *et al* 1982) and the virulence of each species, more particularly its rate of colonization (pod infection to sporulation or complete destruction of the fruit) has added further data (Campelo *et al* 1982, Lawrence *et al* 1982) for more precise field recommendations. Knowledge of these aspects plays a role in reducing inoculum in plantations and determining harvesting intervals (Madeiros 1977) leading to higher production.

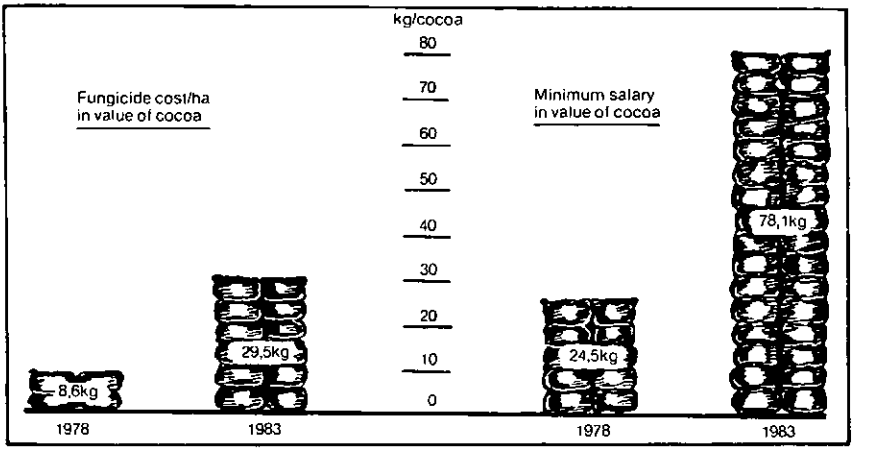


FIG. 1 – INCREASE IN COST OF FARM INPUTS RELATIVE TO COCOA VALUE IN 1978 AND 1983 (PURCHASING POWER IN kg OF COCOA)

High cost of farm inputs and labour, coupled with relatively low international cocoa prices, has led to the use of more advanced technology (Figueiredo *et al* 1984) (Figure 1).

In this article an attempt is made to discuss present recommendations to growers, more specifically the types and doses of fungicides, timing and intervals of applications and finally mode of application. In addition, the present state of knowledge in research and its implications in formulating future recommendations will be analyzed.

CHEMICAL CONTROL

Compared with other cocoa producing countries (principally Africa), Brazil adopted chemical control measures much later. According to Hislop (1964), Von Faber, working in the Cameroons, showed a reduction of 50 per cent black pod losses after application of three sprays of Bordeaux mixture in 1907. In Fernando Po, regular sprays of Bordeaux mixture were applied in the 1930s and soon after in Nigeria (West 1936). In Bahia, Brazil, after the initial experiments in 1956 (Lellis and Matta 1956), routine fungicide applications made a start in the 1960s, with a progressive increase in sprayed area from 10,000 ha in 1970 to 170,000 ha in 1980. Fungicidal control of pod rot is now fully accepted by the growers.

1. Types and Doses of Fungicides

Although the determination of types and doses of fungicides appears to result only from field experiments, other laboratory investigations are necessary specially on the mode of action of fungicides on *Phytophthora* spp. Screening of fungicides for control of *Phytophthora,* from receipt of a candidate product to field recommendations, normally requires three years of investigations. In the first year bio-assay and physical studies of the formulations are made in the laboratory. The second and third years are earmarked for field experiments.

The types of fungicides tested to date include those based on copper and tin, organic compounds and also some systemics (Figueiredo and Lellis 1982, Pereira and Lellis 1982), Copper fungicides (and more recently, in a small way a tin product) make part of field recommendations, but depen-

dency on copper alone may be considered a risk. Therefore, other products have been tested and are alternatives to be used in the spray schedule, if and when they become competitive in price to copper. Copper fungicides have special advantages besides a lower cost of treatment. Their action on fungi is consistent and resistance by fungi to copper products is not expected to build up; in addition they offer a wide spectrum of control with low mammalian and phyto-toxicity and no detrimental effects have been noted on the eco-system.

All copper fungicides are now manufactured in Brazil and the three main compounds in use worldwide, cuprous oxide, copper oxichloride and cupric hydroxide are not only being recommended but also purchased in bulk by CEPLAC for subsidised resale. Cuprous oxide has invariably shown slightly superior control when compared with either copper oxichloride or cupric hydroxide for the same dose of metallic copper. Statistically the difference is not sufficient to justify a lower dose in field use, but cuprous oxide acts as a standard in all fungicide experiments. Although screening formulations of copper is routine and involves large human and financial resources, it is considered necessary to safeguard the interests of the growers, even when relatively small changes in formulation are made. Growers have a choice of thirteen products. Within the three compounds of copper available there exist three formulations (wettable powder, flowable and oil base) and a range of concentrations (10-50 per cent), supplied by seven different manufacturers.

The tin base compound (20 per cent fentin acetate) was introduced for the first time for general field use in 1983, in mixture with a copper fungicide at a proportion of 1:9. The reason for deciding on this mixture of products was a function of the high cost of fentin acetate if used at its normal dose, and the normal precautions due to its toxicity (LD 50: acute oral, rats 125 mg/kg; acute dermal, rats 500 mg/kg). However results of field experiments were particularly interesting, as they showed that reduced quantities of either product in mixtures gave superior control to either of the two fungicides applied at a standard dose. Finally, the work undertaken in Africa in respect to residues in cocoa beans (Massaux 1971) served as a base to finalize the recommendation of fentin acetate.

The dose of copper fungicide applied per spray round was subject to total revision (Pereira *et al* 1983). Before 1980 fungicide sprays were undertaken on the basis of concentration in the tank-mix. Initially, this value was 4 per cent of the product (concentration of the a.i. was not taken into consideration), but in 1982 this was reduced to 3 per cent for economic reasons. Therefore, the quantity of fungicide applied per ha varied with the volume of water. If the volume per ha was reduced the dose per ha was subject to reduction or conversely, if the volume was increased at the same concentration of 3 per cent, the resultant dose per ha was in fact an overdose. Concentration of spray mix as a criteria has little significance in the field because a predetermined concentration of 3 per cent is never maintained for any duration of time due to evaporation or dilution. Dosage was measured on 12 farms and was found to range between 300g and 14 kg/ha of metallic copper.

This resulted from using concentration as a criteria as shown in Table 1. Therefore, the dose of fungicide per tree or per ha was given paramount importance. Virtually all experiments conducted during the existence of

Table 1 - A source of error when concentration is used as a criterion in fungicide applications. (Copper fungicide: 50% Cu^{++})

Concentration (%)	Volume per ha (/ha)	Dosage applied (kg/ha)
3	400	12.0
3	300	9.0
3	200	6.0
3	160	4.8
3	120	3.6
3	40	1.2

this Centre for the control of *Phytophthora* pod rot were sprayed using a volume of 160 1/ha. At this volume, a concentration of 3 per cent product would result in applying 4.8 kg commercial product (50 per cent Cu++) per ha or 2.4 kg metallic copper. From 1981 applications based on dose per ha were tested in the field in diverse experiments to confirm precisely the lethal action of this dose rather than the unspecific "concentration" practice. Since 800 cocoa trees/ha has been considered a mean population stand, a more practical recommendation would be 3 g Cu++/tree (i.e. 2,400 g Cu++/ha divided by 800 trees = 3 g Cu++/tree) (Table 2). Having specified metallic copper, the variation in concentration of commercially available formulations was easily corrected and the dose of metallic copper fixed in field use. The volume of water used clearly has a direct relation to the type of equipment employed. After calibration, the volume per tree or per ha is determined and this quantity of water is then mixed with the specific amount of fungicide required per tree or ha.

Table 2 - Relation when dosage is used as a criterion in fungicide applications. (Copper fungicide: 50% Cu^{++})

Dosage applied (kg/ha)	g Cu++/tree (800 trees/ha)	Volume/ha (/ha)	Unimportant concentration (%)
4.8	3.0	400	1.2
4.8	3.0	300	1.6
4.8	3.0	200	2.4
4.8	3.0	160	3.0
4.8	3.0	120	4.0
4.8	3.0	40	12.0

In the case of the mixture of fentin acetate and copper, the dose recommended is 160 g plus 1,400g a.i. respectively per ha, resulting from two years of field experiments.

Finally, application of a precise dose per tree or ha is common knowledge to researchers and has been quoted in the methodology of *Phytophthora* field experiments many years ago (Medeiros 1977); however a wide discrepancy existed between available information and its application in the field.

2. **Timing and Intervals of Application**

From the early years of chemical control, the timing of fungicide sprays normally followed a calendar schedule during the months of April to August, with applications at monthly intervals (Medeiros 1977). With an increase in epidemiological data it has become possible to recommend to growers a date for the commencement of the spray schedule. Another important contribution to forecasting was made more recently by interpretation of aerial photographs received from the CEPLAC Satellite Tracking Station. The daily photographs register cloud movements and cold fronts originating from the south. With these cold fronts lowering of temperature and increase in rainfall may be expected in cocoa plantations leading to conditions favouring an epidemic.

While it is not intended to suggest that a full effective disease forecasting system is in operation (certainly not comparable to the classic forecasting for *Phytophthora infestans* in Europe), the results obtained are well within the objective. In a disease forecasting system, the main aim is that the grower is not confronted with the unexpected, therefore permitting early planning and timely execution of preventative measures. From about March each year, Extension Department personnel and others attached to a special Farmers' Radio Programme prepare growers to undertake necessary action (purchase of fungicide, servicing of spraying equipment etc) for an imminent disease outbreak. Commencing even earlier, weekly analysis of daily recordings of temperature, rainfall, relative humidity, incidence of disease and cropping levels are plotted by the Plant Pathology Division. With the onset of winter months temperatures normally drop.

Therefore when levels of disease are registered to be progressively increasing in the early stage of an epidemic (but before a 1 per cent level of diseased pods), and the satellite photographs show an advancing cold front, a general warning is given through the main systems of communication.

Certain difficulties are envisaged between a scientific decision to commence a spray schedule and its practical execution in the field. The grower invariably has to make on-the-spot-decisions taking into consideration operational problems or cost/benefit relations. For example in 1983, after short rain spells early in April, the growers took it upon themselves to protect a potential crop and initiate applications early. On the other hand, routine monitoring on experimental sites showed that spraying for the control of *Phytophthora* pod rot could in fact commence later, towards the end of May, the date announced to the growers. This resulted in the application of up to two additional sprays as the epidemic did not conclude early. However in 1984, the inverse occurred as mentioned earlier. The cropping pattern in that year showed poor flowering and fruit set, as a result it seemed logical to the growers

that spray applications were not necessary or uneconomic. In June flowering was abundant with every indication of a good fruit set; but since inoculum levels were not kept low by fungicide sprays (during conditions extremely favourable for infection) the developing pods were exposed and levels of disease were exceptionally high. In 1985 favourable conditions for infection made an early start (1-2 week of April) and growers immediately heeded the recommendation to commence spray treatments.

During the years of relatively low disease incidence, researchers were able to make improvements towards perfecting a system of short-term forecasting but, as epidemiological parameters are sample values for a large region, the growers still have to make their own field decisions. The necessity of accepting changes becomes even more important when the change may be a question of profit or loss. As an example, the balance of the three species of *Phytophthora* at the moment is favourable to growers. The least virulent species *(P. capsici)* is the most predominant (95 per cent of sampled population) whereas the most virulent *(P. citrophthora)* only constitutes a small part of the disease complex (2-3 per cent). If this balance undergoes a change, growers will have to adapt rapidly, possibly involving a complete change in timing and interval.

3. Mode of Application

Application of fungicides in water and therefore in the form of a spray, has been the main means of treatment used in cocoa plantations. Recently the use of dust was investigated (Lellis and Figueiredo 1983) and although shown to be effective in the control of *Phytophthora* pod rot with an additional advantage of a high speed operation, its special formulation (7.5 — 10 per cent Cu++) contains a large proportion of inert material and its cost is unacceptable.

With the development of light weight two-stroke engines, motorized mistblowers become the most versatile machines for control of diseases and pests in tree crops in temperate and tropical countries (Clayphon 1971, Higgins 1964, Matthews 1979).

Motorized mistblowers were introduced in Brazil in conjunction with the start of fungicide spraying for the control of *Phytophthora* pod rot (Lellis W T., personal communication). Over the years their benefits justified their use although this system does not offer any comfort to the operator in terms of load (up to 30 kg), vibration and noise. Each unit consumes between 1-2 1 of petrol/oil mixture/hour which adds to the cost of application. Similarly, two-stroke motors have a short life (about 300 hr), require constant repairs and a complete overhaul after every spraying season. The work output under hot, humid conditions may not exceed 150 trees/man/hr and finally one has to accept that motorized mistblowers are fairly sophisticated equipment, at least for an unspecialised labour force. Therefore, in 1979 an alternative to the motorized mistblower was investigated. A return to the simple hose and lance seemed to overcome some of the difficulties inherent in the motorized mistblower. Although the hose and lance system would have been considered a new method of applying fungicides in this region, it is one of the oldest modes of application in the world. In 1885, the vineyards of France were sprayed using simple pumps coupled to primitive nozzles (Horsefall 1956). However as a project the adaptation of this

system for use today, underwent a sequence of investigations from the design board to assembling a prototype, evaluating and improving it and finally its operation and implementation in the region (Pereira *et al* 1983).

A larger number of growers have adopted this system every year because of its advantages. The spray operator does not have to carry any weight, nor is he exposed to vibration and noise. In terms of fuel consumption, the single diesel engine (4.5 - 5.5 hp) that powers a piston pump (maximum output, 40 1/min at 35 kg/cm2) requires one litre of diesel/hr, operating eight lances simultaneously. For similar work output, 8 motorized mistblowers would be required, consuming 8 to 16 1/hr of petrol oil mixture. In addition, diesel engines have a much longer life compared to a two-stroke engine and generally require a minimum of repairs and maintenance. Finally, with adjustments in hydraulic pressure and a change of nozzles, the system may be used for most crop protection practices including the application of herbicides. A complete economic assessment of this system showed, for different hose lengths, a total operating cost which was 58.8 - 67.3 per cent of the cost using motorised mistblowers (Table 3).

Table 3 – Comparative cost analysis between applications made with a motorized mistblower and the hose and lances system.

Type of equipment	Total cost spraying per ha/application*	Percent participation (%)
Motorized mistblower	4,570.99	100.00
Hose and lances for different hose lengths		
– 100 m	3,074.35	67.26
– 200 m	2,711.76	59.33
– 300 m	2,686.15	58.77
– 400 m	2,724.17	59.60
– 500 m	2,767.47	60.54

* CRS, at value of July 1982.

No doubt, in the technology of application, the volume used per ha or per tree has always received special importance and led to the misconception that reduction in volume per ha reflects higher technology and lower cost. In fact, in the 1970s a number of low volume experiments were undertaken and applications made with as little as 20 1/ha were shown to control the disease efficiently (Medeiros 1977). However this form of application never received acceptance on the part of the growers and it was felt that low volume did not offer an economic advantage especially when the diluent increased in cost.

Volumes per ha are deceptive relative values as shown in Table 4. Traditionally between 120-160 1/ha have been considered as medium to high volume in Bahia for the control of *Phytophthora* spp. This was not a function of an upper limit of cover obtained, that is before run-off, but purely as a limitation of the machine. In practice, at 160 1/ha a tankful

Table 4 — Spray volumes per ha for tree crops accepted internationally and in the cocoa region of Bahia.

Terminology	/ha	
	International*	Traditional in the region
High	1000	160
Medium	500-1000	120
Low	200-500	40
Very low	50-200	?
Ultra low	50	20

* Matthews, 1979.

would only treat 65 trees and, after spraying for approximately 22 min, the operator would have to refill the pesticide tank. Higher volumes would increase operation cost and make spraying uneconomic.

In the hose and lance system the operator carries no load and refilling is undertaken using an adaptation to the equipment. A force feed line from the pump injects within the suction tube, attaining a flowrate of as much as 155 1/min (depending on the differential height between pump and water source). A maximum of 10 minutes is sufficient to prepare a quantity of spray liquid for one ha. The pump unit remains stationary for a considerable time while the surrounding area is treated as, with hose lengths of 300 m, 28 ha may be treated from a central point. Each of these points are selected in relation to a source of water. Considering all these facts and after results of field experiments where the motorized mistblower was used as a standard, the volume/ha for the hose and lance system of spraying was defined at 300-400 1/ha.

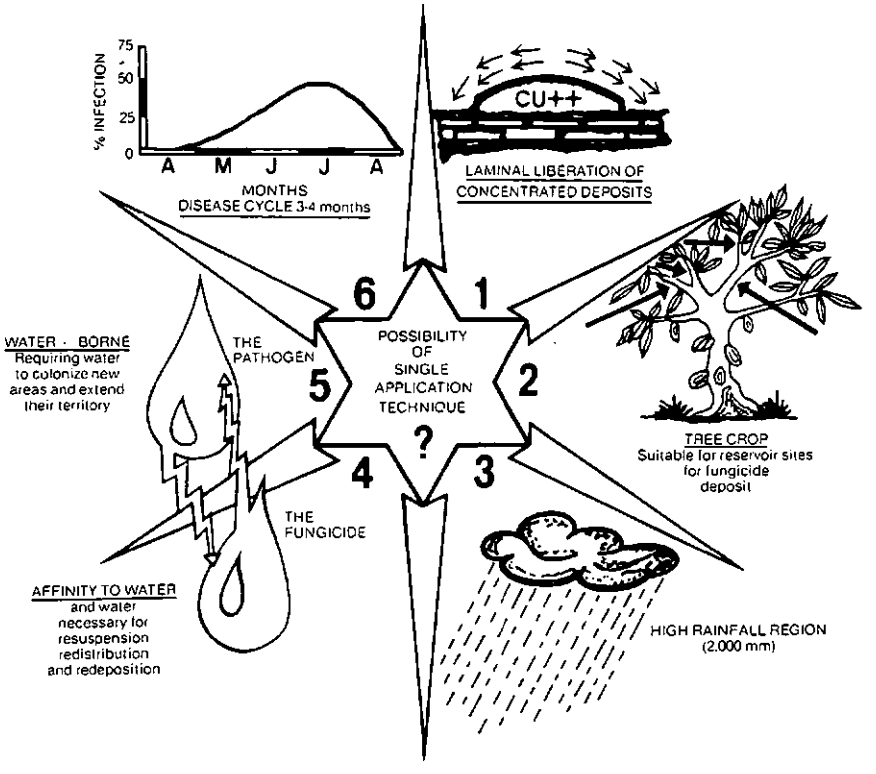
PRESENT STATE OF RESEARCH AND FORMULATION OF FUTURE RECOMMENDATIONS

1. Towards reducing cost of application

In the preceding paragraphs chemical control of *Phytophthora* spp. as practiced by growers received the main emphasis. Some recommendations are easily assimilated when the grower sees an immediate benefit. He has to contend with fluctuations in the market value of his crop and then strike a delicate balance between this unknown variable and others such as inflationary increases in cost of inputs, cropping changes and unpredictable weather conditions. However, it becomes clear that researchers cannot divorce themselves from day-to-day problems of the grower. On the contrary being aware of their problems paves the way to a further influx of technology. One such example is the need for an urgent application of a precise dose per tree or ha. If this becomes common practice then the next transfer of information would be readily implanted.

The theory in the use of protective chemicals presupposes that the toxicant must be deposited in a thin film over the entire surface of susceptible tissue without injury to the tissue; it must adhere tenaciously without being eroded; and it must be released in concentration lethal to the pathogen during the infection period (McNew 1959). This has always

FIG. 2 – SEPARATE ASPECTS IN THE COMPLEX OF FIELD DISEASE CONTROL OF PHYTOPHTHORA POD ROT



been interpreted as repeated fungicide applications at relatively short intervals during a rainy period, directing the spray on selected targets (susceptible pods) positioned on widely distributed branches within the cocoa canopy. However in 1980, separate aspects in the complex of field disease control of *Phytophthora* pod rot were considered in Brazil. In Figure 2 these aspects are considered individually with the aim of visualizing a possible interaction that might offer a reduction on the number of applications. Item 1, *copper fungicide:* its behavour and its action on fungal pathogens has been studied for about a century. Generally its biological efficiency is limited to 3 weeks in normal concentrations, however at high concentrations one may expect laminal liberation from concentrated deposits, where the inner mass of the deposits is protected, offering a longer biological efficiency. Item 2, *tree crop:* the cocoa tree offers suitable sites as a reservoir for fungicide deposits. Item 3, *high rainfall* would permit an erosion of the deposit, liberating fungicide only when conditions are favourable to infection. Item 4, *affinity to water – the fungicide,* being generally wettable powders, requires water to enter for resuspension, redistribution and redeposition. Item 5, *water borne – the pathogen,* is dependent on water to colonize new areas and to extend its territory. Equally important is the necessity of a dynamic state of the fungicide during rainy periods to coincide with the dynamic state of the

Table5 - Reduction in number of fungicide applications for the control of Phytophthora pod rot. (1980, 1981 & 1982)

	Treatments		Infection Arc Sin V%		
CODE	Total Cu++/tree/year Dose/No sprays	Interval (days)	1980	1981	1982
*A	4g x 4 = 16g	30	19.19A	18.81A	12.11A
B	8g x 2 = 16g	60	18.63A	17.66A	13.56A
C	6g x 2 = 12g	60	25.25AB	20.09A	14.77A
D	(12g x 4g) = 16g	90	18.53A	17.05A	13.44A
E	16g x 1 = 16g	-	20.79A	18.81A	13.56A
**F	8g x 2 = 16g	60	16.95A	17.46A	11.54A
T	Unsprayed control	-	37.41 B	27.63 B	29.20 B

* Standard treatment

** Only treatment without a sticker

pathogen and in so doing permit greater opportunity for contact (Pereira 1974). Item 6, *disease cycle*, during the latter half of the four months disease cycle, infection follows a downward trend. Therefore, a massive dose at the start of the epidemic may delay infection for a sufficient period until climatic conditions do not favour infection. To test the theory, one experiment was started in 1980 that continued for 3 years and another in 1981 for a period of 2 years.

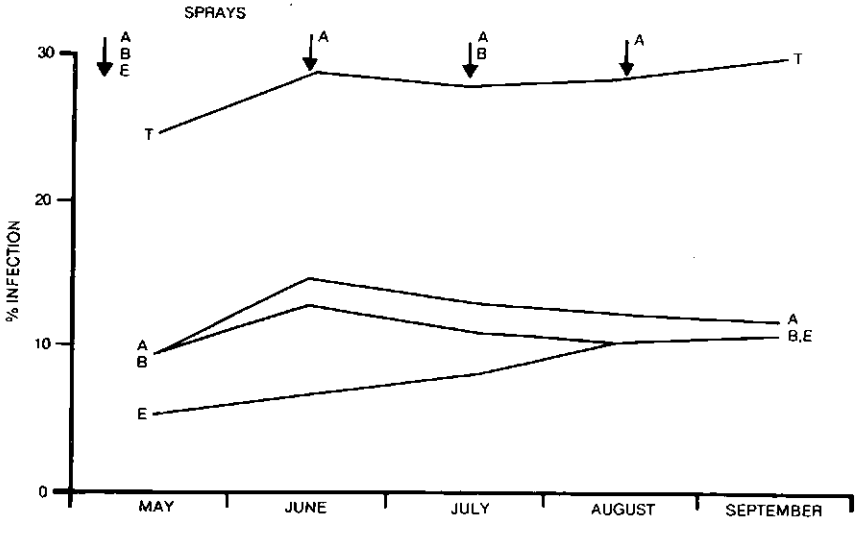
In 1980 the recommended spray schedule was 4 g Cu^{++} applied in 4 applications at intervals of 30 days and this was used as the standard treatment. The experimental treatments and results are shown in Table 5. In the subsequent year the dose and number of applications were reduced to 3 g Cu^{++} each in three sprays at the normal monthly interval (Pereira and Lellis 1982) (Table 6).

Table 6 - Comparisons between 1, 2 and 3 fungicide sprays/year at a reduced dose for control of cocoa pod rot.

	Treatments		Infection Arc Sin V%	
CODE	Total Cu++/tree/year Dose/No sprays	Interval (days)	1981	1982
*A	3g x 3 = 9g	30	21.64A	21.72A
B	4.5g x 2 = 9g	45	21.81A	24.50AB
C	9g x 1 = 9g	-	20.79A	26.85AB
T	Unsprayed control	-	32.14 B	32.83 B

* Proposed economic alternative, only treatment with a sticker.

The results may be summarized as follows: over the 3 year period 2 applications of 8 g each at 60 days interval was always better, but not significantly, compared to 4 or 1 application/season (Table 5); however the disease curve for monthly means for 3 years showed a single application maintained lower infection levels (Figure 3); if 2 applications (8 g x 2 sprays) are made per year at 60 day intervals, results are significantly better during years of higher infection levels, rather than 6 g x 2 sprays (Figure 4); a massive dose applied once only (16 g Cu^{++}) or one massive dose (12 g Cu^{++}) followed by a standard dose (4 g Cu^{++}) 90 days later suggests that the latter is more effective (Table 5, Figure 5). When two identical treatments with or without a sticker were compared the treatment without a sticker was consistently better, suggesting that in the absence of a sticker, infection levels are quickly lowered and maintained low (Figure 6). In the second set of experiments where number and dose of fungicide were reduced, significantly better results were only obtained in the second year when frequent applications were made, suggesting that when the total dose per year is intended to be low then frequent applications are necessary (Figure 7).



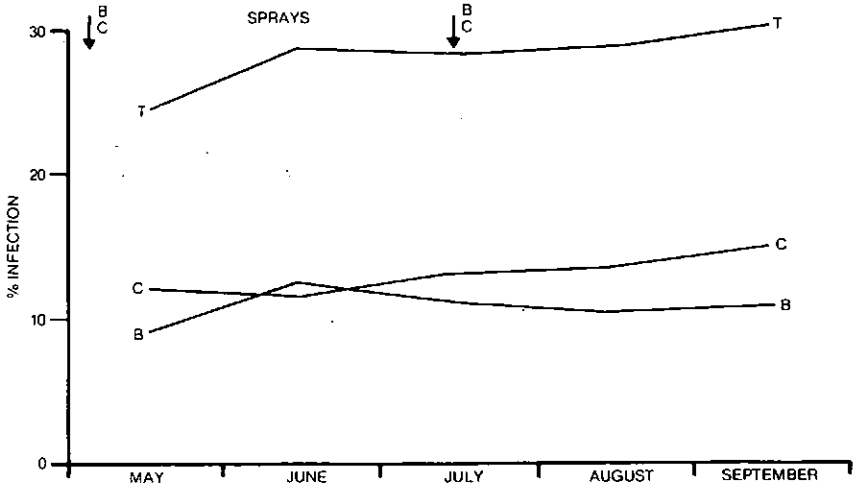
Mean for 1980, 1981 and 1982

FIG. 3 – COMPARISONS BETWEEN 1, 2 AND 4 FUNGICIDE SPRAYS/YEAR FOR CONTROL OF COCOA POD ROT.

(T – control; A – 4 sprays x 4g; B – 2 sprays x 8g; E – 1 spray x 16g)

These results have far reaching significance, but probably the main conclusion is that progressively higher application doses may provide proportionately prolonged coverage of susceptible tissue *or* more concentrated sprays may have a greater influence on primary pathogenic inoculum and consequently delay a rise in infection on pods during the epidemic, *or* the combined effects of both these control processes. The important aspect is that in the case of a water-borne pathogen like *Phytophthora* where a fungicide that has affinity to water is used, omitting stickers results in improved control. Therefore in formulating future

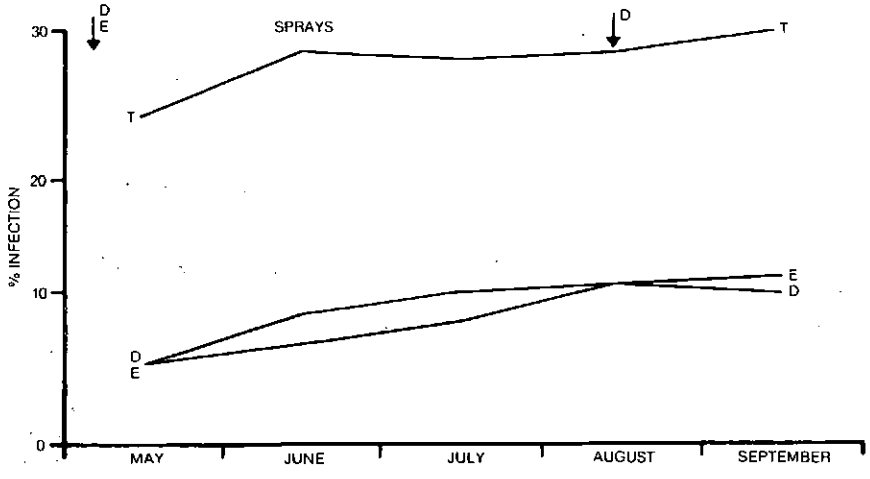
recommendations to the grower these results offer, not only a reduction in inputs in terms of application cost involving labour and machinery, but also permit the release of farm workers during a critical period for more frequent harvesting, causing less diseased fruit and fewer infected beans in diseased pods. Since disease incidence varies in different micro-climatic areas within the region, this data has to be adjusted to meet these situations.



Mean for 1980, 1981 and 1982

FIG. 4 – COMPARISONS BETWEEN 2 FUNGICIDE SPRAYS/YEAR AT TOTAL DOSE OF 16g AND 12g COPPER FOR CONTROL OF COCOA POD ROT.

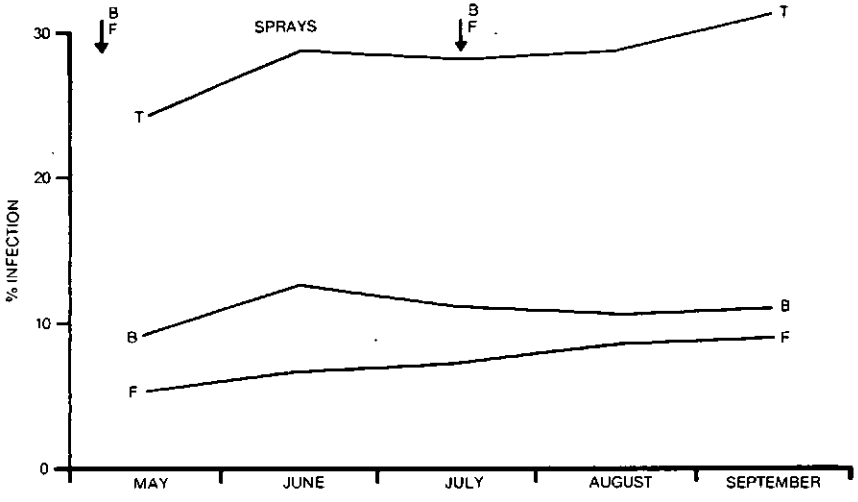
(T – control; B – 2 sprays x 8g; C – 2 sprays x 6g)



Mean for 1980, 1981 and 1982

FIG. 5 – COMPARISONS BETWEEN 16g COPPER APPLIED IN A SINGLE SPRAY OR 2 APPLICATIONS FOR CONTROL OF COCOA POD ROT.

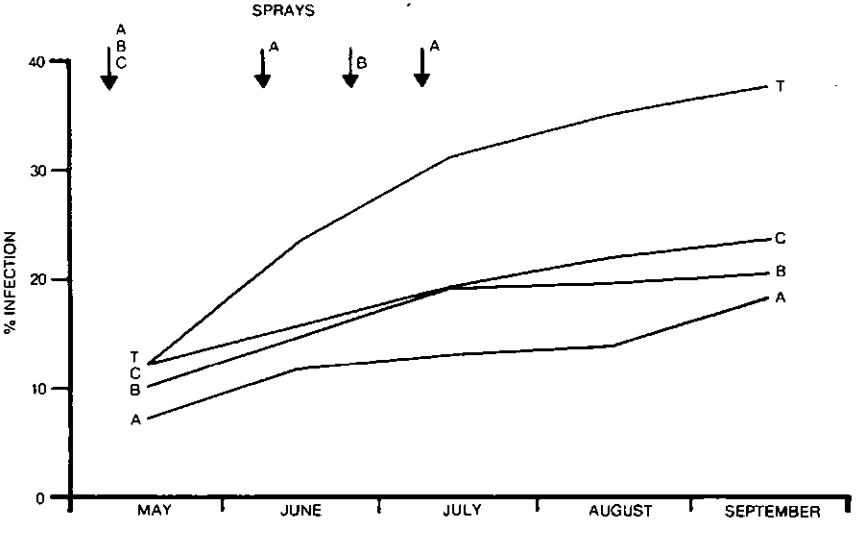
(T – control; D – 12g and after 90 days 4g; E – 1 sprays x 16g)



Mean for 1980, 1981 and 1982

FIG. 6 – COMPARISONS BETWEEN 2 FUNGICIDE SPRAYS/YEAR, WITH OR WITHOUT A STICKER FOR CONTROL OF COCOA POD ROT.

(T – control; B – 2 sprays x 8g with sticker; F – 2 sprays x 8g without sticker)



Mean for 1981 and 1982

FIG. 7 – COMPARISONS BETWEEN 1, 2 AND 3 FUNGICIDE SPRAYS/YEAR FOR CONTROL OF COCOA POD ROT.

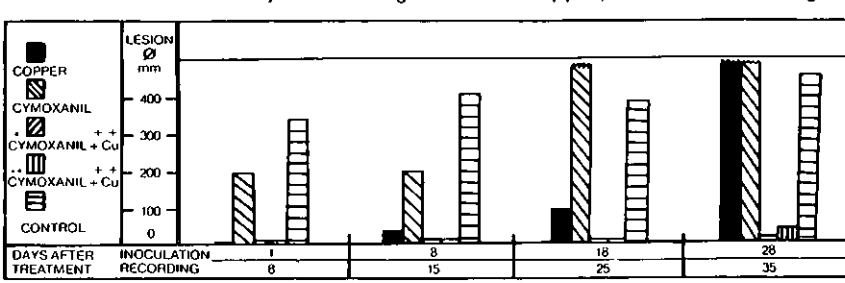
(T – control; A – 3 sprays x 3g; B – 2 sprays x 4.5g; C – 1 sprays x 9g)

If under normal circumstances 3 applications of 3 g Cu^{++}/tree is sufficient to control the disease, then the total value of 9 g Cu^{++}/tree/season is divided into two doses, giving 4.5 Cu^{++}/tree per each of two applications, using as an interval a similar division of the period when protection is

required, or if the schedule covers 3 months the second spray would be applied after 45 days. In some areas up to 6 applications are normally required therefore the value of the total dose (6 x 3 g Cu^{++}) should allow for two applications of 9 g Cu^{++} each. Finally, this reduced application technique may only work if growers are familiar with the means of applying a precise dose per tree or per ha. During the 1985 season, some of the more advanced growers are adopting this system: progressively its implementation will be wider.

2. **Towards reducing the proportion of diseased beans within diseased pods**

So far agricultural inputs in the form of protective fungicides have been examined with the object of providing the grower with the possibility of using the minimum amount of fungicide at low application cost to give maximum control. However, as protective chemicals are used, certain limitations are envisaged after a pod is infected, as there exists no means of preventing a progressive loss of beans within a diseased pod. Since even in fungicide treated areas, losses may reach 20 per cent level this is an aspect of great significance. The actual loss cannot be estimated as disease loss is expressed as a percentage of infection which may or may not reflect total loss of beans within a diseased pod. On the other hand, in the absence of a differential price for quality there is no advantage in protecting fully developed pods. Diseased beans are of poorer quality (Lopez and Pereira, unpublished data) and if at present this does not have a monetary significance, in time it should do so. Over the last 3 years, research has been directed to increasing crop return, by using systemic fungicides with the potential of less diseased beans in infected pods. In fungicide field screening experiments, systemic fungicides are thought to have little advantage since the percentage of infected pods was similar to cheaper protective fungicides. Therefore systemic fungicides as compared to protective compounds were considered uneconomic since they did not result in higher levels of control. However, some experiments have shown a positive correlation between bean loss within diseased fruit and area of lesions suggesting that fungicides with systemic action may yet offer positive crop return if they contain the growth of a lesion. Systemic fungicides on their own have a limited effect on lesion growth, but in combination with copper (Figure 8) show a synergistic action. These studies were made on pods artificially inoculated in the field 1,8,18 and 28 days after treatment with fungicides. A field experiment, over one year involving three systemic products, independently or in association with copper, confirmed that the use of mixtures of systemic fungicides and copper, while not reducing the



* Formulated
** Tank mix

FIG. 8 – FUNGICIDE ACTION DIAMETER OF PHYTOPHTHORA LESION IN mm ON PODS

incidence of disease obtained by copper alone, increased the utilisation of beans from infected pods. Therefore it is economic with the additional benefit of reducing the possibility of the pathogen developing tolerance to systemic products (Figueiredo *et al* 1984).

Therefore in the formulation of future recommendations systemic fungicides in mixtures have a definite role, especially as there is every indication that after four years of abnormal *Phytophthora* years, the growers may have to prepare for normal (severe) years. Systemic fungicides have a part to play under these circumstances.

REFERENCES

Campelo, A.M.F.L. e Luz, E.D.M.N. 1981. Etiologia da podridao-parda do cacaueiro nos Estados da Bahia e Espirito Sando. *In:* Conferencia Internactional de Pesquisas em Cacau, 8a, Cartagena, Colombia, 1981, Cocoa Producers' Alliance, London, pp. 455-459.

Campelo, A.M.F.L., Luz, E.D.M.N. e Resnik, F.C.Z. de 1982. Podridao-parda do cacaueiro no Estado da Bahia, Brasil. I — Virulencia das especies de *Phytophthora*. Revista Theobroma 12 (1) pp.1-6.

Clayphon, J.E. 1971. Comparison trials of various motorized knapsack mistblowers at the Cocoa Research Institute of Ghana. Pest Articles News Summary 17(2) p. 209-225.

Cruz, H.M. de, e Paula, E.M. 1956. A campanha de combate as pragas e doencas do cacaueiro na Bahia. *In:* Reuniao do Comite Tecnico Interamericano de Cacau, 6a, Salvador, Brasil, 1956. Salvador, ICB pp. 277-290.

Figueiredo, J.M., Campelo, A.M.F.L. e Lellis, W.T. 1982. Potencial infectivo de Phytophthora spp. em casqueiros nas plantações de cacau. *In:* Ilheus, BA., Brasil, CEPLAC/CEPEC, Informe Tecnico 1982, p. 46.

Figueiredo, J.M., e Lellis, W.T. 1982. Competição de fungicidas organicos e organometalicos no controle da podridao-parda dos frutos do cacaueiro. *In:* Ilheus, BA., Brasil, CEPLAC/CEPEC, Informe Tecnico pp. 49-50.

Figueiredo, J.M., Pereira, J.L., Lellis, W.T. and Luz, E.D.M.N. 1985. Mixtures of systemic and protective fungicides in the control of Phytophthora pod rot of cocoa. *In:* 9th International Cocoa Research Conference, Lome, Togo, 12-18 Feb. 1984.

Higgins, A.E.H. 1964. The selection of spraying equipment. I — Cocoa Growers' Bulletin no. 3, p. 21-26.

Hislop, E.C. 1964. Black-pod disease, Cocoa Growers' Bulletin no. 2, p. 4-9.

Horsfall, J.G. 1956. Principles of fungicidal action. Walthan MA. USA. Chronica Botanica 279p.

Lawrence, J.S. 1978. Evaluation of methods of assessing resistance of cacao *Theobroma Cacao* L. cultivares and hybrids to Phytophthora palmivora, (Butler) Butler. *In:* Ilheus, BA., Brasil, CEPLAC/CEPEC, Boletim Tecnico 62.

Lawrence, J.S., Luz, E.D.M.N. and Resnik, C.F.Z. 1982. The relative virulence of Phytophthora palmivora and P. capsici on cocoa in Bahia, Brazil. *In:* Conferencia Internactional de Investigacion en Cacao, 8a, Cartagena, Colombia, 1981. Cocoa Producers' Alliance, London, 1982, pp. 395-400.

Lellis, W.T. e Matta, E.A.F. 1956. Competição de fungicidas no controle da podridao-parda dos frutos do cacaueiro. *In:* Reuniao do Comite Tecnico Interamericano de Cacao, 6a, Salvador, BA., 1956. Salvador, ICB. pp. 301-309.

Lellis, W.T. e Figueiredo, J.M. 1983. Polvihamento e pulverização no controle da podridao-parda dos frutos do cacaueiro. Revista Theobroma 13(1) pp. 41-46.

Massaux, F. 1971. Etude des residus de chlorure de triphenyl etain (Brestanol 113 Sn) sur feves de cacao. Cafe Cacao Thé, Vol XV, 221-234, 1971.

Matthews, G.A. 1979. Pesticide application methods. London, Longman, pp. 162-169.

McNew, G.L. 1959. Landmarks during a century of progress in the use of chemicals to control plant diseases. *In:* Holton *et al* eds. Plant Pathology, problems and progress 1908-1958 Madison Univ. of Wisconsin, 42-54.

Medeiros, A.G., 1977. Sporulation of Phytophthora palmivor (Butl.) Butl. *in* relation to epidemiology and chemical control of cacao black pod disease. Thesis Ph.D., University of California, Riverside.

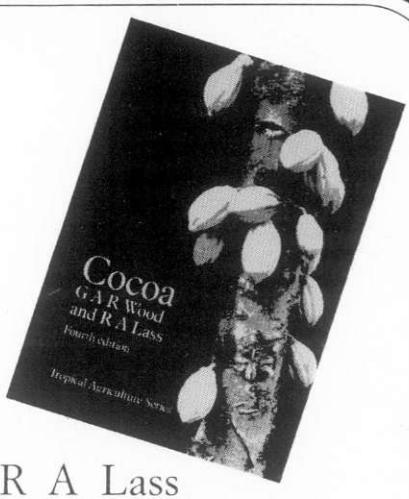
Pereira, J.L. e Lellis, W.T. 1982. Competição de fungicidas cupricos e organicos no controle da podridao-parda dos frutos do cacaueiro. Experimento em larga escala. *In:* Ilheus, B.A., Brasil, CEPLAC/CEPEC, Informe Tecnico p. 50.

Pereira, J.L., Cezar, J. do O, e Filho, E.N.A. 1983. Conceito, desenho industrial, desempenho, operação em cap e economicidade do sistema de mangueira e lancas para tratamentos fitossanitarios em cacaueiro. *In:* Ilheus, BA., Brasil, CEPLAC/CEPEC, Boletim Tecnico 113.

Pereira, J.L. e Cruz, P.F.N. 1984. Novas tecnicas no controle de doencas e pragas do cacaueiro. *In:* Ilheus, BA., Brasil, CEPLAC/CEPEC, Boletim Tecnico 124.

West, J. 1936. Eleventh Bull. Agri. Dept. Nigeria.

New from Longman



Cocoa

Fourth Edition

G A R Wood and R A Lass

The fourth edition of this highly regarded book has been completely rewritten and considerably expanded to cover all aspects of cocoa production in greater detail than ever before, from planting, maintenance and diseases, through to harvesting, marketing and manufacture. Since the publication of the successful third edition in 1975, the rapid increase in the price of cocoa has led to new interest in it as a commercial crop, especially in Brazil and Malaysia. This in turn has led to much new knowledge about the plant, and changes in the methods of its production, as well as some new problems to which research has been devoted. All of these changes are reflected in this latest edition of **Cocoa**, making it of immense use and value to commercial growers, research workers and students of tropical agriculture alike.

G A R Wood has had over 30 years experience of cocoa growing as a Tropical Agriculture Adviser and as a Cocoa Consultant. He was editor of Cocoa Growers' Bulletin from its first issue in 1963 until 1980, and is a member of the Cocoa Advisory Group for Indonesia.
R A Lass is currently Agricultural Manager of Cadbury Schweppes plc and editor of Cocoa Growers' Bulletin. He is involved in many international cocoa research and extension projects and has been employed as a Consultant by agencies worldwide.

Cased Illustrated ISBN 0 582 46352 1
Publication December 1985 Probably £32.00 net

Available from your bookseller. In case of difficulty, or for further information on this and other Agriculture titles, please write to Clive Weatherley, Longman Group Ltd., Longman House, Burnt Mill, Harlow, Essex, CM20 2JE, UK.

Longman

Notes on Contributors

A.J. Kennedy

Born in 1948 in United Kingdom, obtained BSc Honours in Biological Sciences at University of East Anglia, 1971. MSc in Applied Genetics, University of Birmingham, 1973. PhD from University of East Anglia working at John Innes Institute, 1975. Sugar cane breeder in Barbados until 1979; Fruit tree rootstock breeder at East Malling Research Station, Kent until 1982. Then joined Cocoa Research Unit, University of West Indies, Trinidad and has been instrumental in developing the present programme of genetic conservation in Trinidad building on the range of cocoa germplasm present on the island. Appointed Head of Unit 1984.

W. Hadfield

Took a BSc degree in botany at Liverpool University in 1957. Worked in Assam for India Tea Association 1957–74 as botanist/physiologist studying shade and nutrition interactions. Appointed physiologist to INIAP Ecuador working on cocoa at Pichilingue and became leader of the Overseas Development Administration's cocoa project in 1980. This project was set up to study some of the problems of growing cocoa under the unusual climatic conditions existing in Ecuador.

Martin H. Fowler

Born 1953 in United Kingdom, obtained BA Honours Geography, University of Durham, 1975. MSc Agricultural Economics, Wye College, University of London, 1977. Worked from 1977–78 as an Agricultural Economist in the Planning Unit, Ministry of Agriculture, Maseru, Lesotho; then from 1979–81 in the Economic Planning and Analysis Section, Ministry of Agriculture and Co-operatives, Mbabane, Swaziland. In 1981 started as an Agricultural Economist in the Ministry of Agriculture, Forestry and Fisheries, Port-Vila, Vanuatu.

Cocoa Abstracts

Cocoa abstracts are reprinted from 'Abstracts on Tropical Agriculture' published by the Royal Tropical Institute, Amsterdam.

MARCH 1983

(Changes in cocoa production factors caused by the swollen shoot virus. 2. Quantitative evaluation) Modifications des facteurs de production du cacaoyer provoquées par le virus de swollen shoot. 2. Evaluation quantitative. LUCAS, P. and PARTIOT, M. Institut de Recherches du Café et du Cacao, Kpalime, Togo – *Café, Cacao, Thé 26* (4) p. 227–236; October 1982.

Changes in the number of ovules per ovary when the cocoa tree is attacked by swollen shoot disease were studied. The activity of the mechanisms inducing the formation of ovules appeared to decrease as the concentration in available particles of the Agou 1 virus complex increases. Observations on the evolution of the number of ovules per ovary in a diseased tree are compared with hypothetical mathematical viruses present in a plant at a given moment can be estimated.

(Comparative study on the pathogenicity of cocoa infecting species of *Phytophthora* to seedlings of *T. cacao;* analysis of the factors involved in the pathogenicity of *P. palmivora* and *P. megakarya*) Etude comparée du pouvoir pathogène sur semenceaux de *T. cacao* des espèces de *Phytophthora* parasites du cacaoyer: analyse de éléments due pouvoir pathogène de *P. palmivora* at de *P. megakarya*. BLAHA, G. and LOTODE, R. Institut de Recherches du Café et du Cacao (IRCC), Montpellier, France – *Café, Cacao, Thé 26* (4) p. 237–272; October 1982.

The pathogenicity of the black pod disease causing *Phytophthora* spp. on cacao at the seedling stage were compared and analysed. Since the test methods to roots were found to be unsatisfactory, all results were taken from the tests on epicotyls, three principal phases could be distinguished on to which certain pathogenicity factors were superimposed: a first infection phase, characterised by its installation capability; a second infection phase, during which the behaviour of the pathogens can exhibit specific particularities in regard to the reactions of the plant; and a tolerance stage, reflecting a lesser or greater pest specialization of the pathogen. The resistance induced in cocoa was confirmed and the differences in the stability of the resistance induced is one of the most important points revealed during this study to differentiate *P. palmivora* from *P. megakarya*.

The imbibed storage of cocoa (*T. cacao*) seeds. KING, M.W. and ROBERTS, E.H. Faculty of Agriculture and Horticulture, University of Reading, Berkshire, UK – *Seed Science and Technology (Switzerland) 10* (3) p. 535–540 1982.

Moist cocoa seeds were stored under controlled relative humidity conditions or in solutions of polyethylene glycol "6000" of known osmolarity. The best survival, 24 per cent after eight months, was achieved by storage at 20° C and 98 per cent relative humidity (40.6 per cent moisture content) in the presence of Thiram fungicide.

MAY 1983

Directory of germplasm collections. 5. Industrial crops. 1. Cacao, coconut, pepper, sugarcane and tea. WILLIAMS, J.T. and DAMANIA, A.B. International Board for Plant Genetic Resources (IBPGR), FAO, Rome, Italy 53p. December 1981.

For each of the crops mentioned in the title, institutes dealing with genetic collections are listed. Information on curator or person in charge, details of samples, geographic representation, maintenance, availability, and evaluation and documentation is presented as far as this was available.

Effects of burning of rubber timber during land preparation on soil fertility and growth of *T. cacao* and *Gliricidia maculata*. LING, A.H. and MAINSTONE, B.J. Dunlop Research Centre, Batang Melaka, Negeri Sembilan, Malaysia – *Planter 59* 52–59; February 1983.

The land clearing method used in replanting has a profound influence on the establishment and growth of cocoa and *Gliricidia maculata*. Burning of rubber timber resulted in a several fold increase in the supply of available P and the bases K, Ca and Mg to the soils. On the other hand, not only did the unburnt areas not receive additional nutrients from burning but they also suffered from severe soil compaction as a result of mechanical operations during timber stacking. Results indicate a need to re-consider the appropriateness of the current cultural and agronomic practices. It is possible that fertilizer inputs in burnt areas can be reduced during part of the prebearing period of cocoa plantings.

(Economic and social aspects of cocoa pulp juice production) Perfil economico e social da producao de mel de cacau. FERREIRA, H.I.S., TREVIZAN, S.D.P. and DIAS, I.L. Divisao de Ciencias Sociais e Estatica, CEPEC Itabuna, Bahia, Brazil *Boletim Tecnico - Centro de Pesquisas do Cacau* No 97, 38p. 1982.

This study presents economic and social aspects of the production of a cocoa by-product, viz pulp juice, with emphasis on production and production costs, processing methods and finally the willingness of cocoa farmers to produce cocoa juice for sale. The annual availability of cocoa juice oscillates between 53 million and 100 million litres. It was observed that, although the economics of cocoa juice is of little regional importance, there is a large potential to be explored. In the year 1978, only 0.4 per cent of the potential production was processed with extraction costs varying among farmers. It is concluded that perspectives are good, on the condition however that a series of obstacles will be removed for both groups, viz farmers and manufacturers.

(Economic assessment of CEPLAC's activities from 1957 to 1980) Avaliacao economica das atividades desenvolvidas pela Commissao Executiva do Plano da Lavoura Cacaueira no periodo de 1957 a 1980. MONTEIRO, A. Divisao de Ciencias Sociais e Estatistica, CEPEC, Itabuna, Bahia, Brazil *Boletim Tecnico Centro de Pesquisas do Cacau* No 98, 36p. 1982.

The activities of CEPLAC were analysed by evaluating the yield performances of cocoa plantations in the State of Bahia, before and after the introduction of better plantation techniques. The benefits earned by the community through applying the technology, produced by research, to planters were assessed using the Grilliches-Peterson formula. The estimated rates of internal return were 42 and 57 per cent, the former when the global expenses of CEPLAC were taken into account, and the latter when just the amount allocated for supporting research, extension and agricultural education activities in the cocoa region of Bahia, was considered.

Nitrogen cycle of tropical perennial crops under shade trees. 2. Cacao. ARANGUREN, J., ESCALANTE, G. and HERRERA, R. Centro de Ecologia, Instituto Venezolano de Investigaciones Cientificas, Caracas, Venezuela – *Plant and Soil (Netherlands) Nitrogen Cycling in Ecosystems of Latin America and the Caribbean 67* (1–3) p. 259–269 1982.

A cocoa plantation under shade trees was studied in order to estimate N stores in the soil and plantation trees and N fluxes associated with litterfall, decomposition and harvest. The cocoa plants contained 302 kg N/ha of which woody above-ground parts made up 50 per cent and roots and leaves circa 60 kg N. Litter on the soil surface contained on average 37 kg N/ha. Shade tree leaves made up 61 per cent of the total N in the litter on the soil. Mineral soil stores of total nitrogen were 35 t N/ha, 40 per cent of which was found in the first 20 cm depth. Litterfall rates were 20.9 t dry litter/ha/year. The rate of N transfer with litterfall was 321 kg N/ha/yr. N output by harvest was circa 45 kg N/ha/yr, with some 20 kg N/ha/yr returned to the field with pod shells after processing. The net harvest output can be amply compensated for by inputs of shade-tree leaf litter. Much of this may be from deeper soil horizons than those exploited by cocoa.

Dynamics of nitrogen in a shaded cocoa plantation. SANTANA, M.B.M. and CABALA-ROSAND, P. Centro de Pesquisa do Cacau (CEPEC), Itheus, Bahia, Brazil. *Plant and Soil (Netherlands) Nitrogen Cycling in Ecosystems of Latin America and the Caribbean 67* (1–3) p. 271–281 1982.

Mini-lysimeters were installed at depths of 10, 20 and 40 cm and the leachate was collected weekly or after heavy rain. Net mineralisation was measured in soil samples taken at depths of 0–5 and 5–15 cm and incubated for 30 days in plastic bags placed at the site of collection. Leaching was correlated with the amount of rainfall. Ammonification and nitrification were both high during most of the year, nitrification was very rapid especially on the fertilized area. Analyses of *Erythrina* and cocoa litter show that these components make a considerable contribution to the N recycled in a cocoa plantation. High concentrations of total N were detected in soil samples taken close to shade trees and the soil of shaded areas had more than 480 mg N/kg soil than soil of non-shaded areas. Removal of N in harvests can be considerable. It is advisable to take nitrogen-cycle

data into account for fertilizer recommendations.

Design and development of small drier for cocoa beans. BABOO, B. Central Plantation Crops Research Institute, Kasaragod, Kerala, India, *Journal of Plantation Crops 10* (2) p. 109–113; December 1982.

A tray type, through-flow dryer was designed and developed for drying up to 40 kg of fermented cocoa beans. The dryer can be operated on electricity (single phase), biogas burner or kerosene wick stove. During the rainy season 40 kg fermented beans were dried from an initial moisture content of 115 per cent (db) to 8 per cent (db) in 60 hours. The dryer gave a heat utilisation efficiency of 53 per cent when operated on electricity. The cost of the dryer worked out to Rs. 1000/– and drying cost Rs. 0.50 per kg of dry beans.

JUNE 1983

(Determination of the genotypes of incompatibility or compatibility in several cultivars of cocoa). Determinacion de los genotipos de incompatibilidad o compatibilidad en varios cultivares de cocoa. TERREROS, J.R., CHAVARRO, G. and OCAMPOS, R.F. Faculdad de Agronomia, Universidad Nacional de Colombia, Palmira, Colombia – *Revista del Instituto Colombiano Agropecuario (Colombia) 17* (3) p. 93–99 September 1982.

To study the floral genetic formula for incompatibility or compatibility, 15 cocoa cultivars were used as parents in the production of improved cocoa seed. Twenty self-pollinations in each of the 15 cultivars, besides 20 cross-pollinators using pollen from 6 cultivars, the floral genetic formula of which is already known, were made. The data registered 15 days after pollination were analysed. The genotypes determined are enumerated.

(CEPEC Technical Report 1981) CEPEC Informe Tecnico 1981. Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – 350p. 1982.

This report contains the research results of the cocoa, cattle raising and crop diversification programmes carried out by the various divisions of CEPEC in 1981. The results of the cocoa research programme of DEPEA (Departamento Especial da Amazonia) are also presented.

(The cultivation of cocoa) El cultivo del cacao. CASTILLO S, J.L. *Revista Cafetalera*–ANACAFE (Guatemala) No 218 p. 10, 12, 14–18, 20–22 May 1982.

As an alternative to coffee growing information is given on the cultivation of cocoa. The ecosystem, nurseries, propagation, planting, cultivation practices, pests and diseases and their control, harvesting, post-harvest handling, storage and international markets are discussed.

(Cocoa pod rot *(Monilia roreri)* and its economic effects for Guatemala) La moniliasis del cacao y sus efectos economicos para Guatemala (Moniliasis o podredumbre acuosa del cacao) (*Moniliophthora roreri*). CAMPOLLO, H. – *Revista Cafetalera* – ANACAFE (*Guatemala*) No 218 p. 26–30 May 1982.

The danger of Monilia pod rot for an expanding cocoa area is outlined in view of the occurrence of this disease in neighbouring countries. Described are symptoms, resistance, life-cycle, epidemiology, control (sanitary and chemical methods) and social aspects. Recommendations are given on coping with the danger of the development and spread of *Moniliophthora roreri*.

Studies on the feeding value of agro-industrial by-products and the feeding value of cocoa pods for cattle. SMITH, O.B. and ADEGBOLA, A.A. Department of Animal Science, University of Ife, Ife, Nigeria, *Tropical Animal Production (Mexico) 7* (4) p. 290–295 1982.

Two cattle studies were carried out to determine the maximum level at which cocoa-pod, an agricultural by-product, could replace maize or sorghum in cattle fattening diets. In the first experiment, 3 groups of 12 cattle each were fed 3 diets containing 0,20 and 40 per cent cocoa pods for 112 days, while in a second study, 3 other groups were fed diets containing 0,30 and 60 per cent cocoa-pod for 84 days. A trend of increasing feed intake and decreasing weight gains with increasing cocoa-pod levels was observed. Nevertheless, differences in weight gains and feed utilization only reached significance above the 40 per cent dietary cocoa-pod level. Moreover, feed costs were lower for all cocoa-pod diets compared to the control. Apparently, cattle can profitably utilize fattening diets containing up to 40 per cent cocoa-pod in place of maize or sorghum.

(Weeds in a cocoa plantation due to herbicides) Perubahan jenis gulma akibat pemakaian herbisida di kebun cokelat. BASUKI, A., SOEDARSAN and RUSWANDI. Balai Penelitian Perkebunan Bogor, Bogor, Indonesia. *Menara Perkebunan (Indonesia) 48* (5) p. 133–138 October 1980.

The impact of continuous application of herbicides with the same active ingredient in cocoa plantation is studied, discussed and compared with that of the mechanical weed control. The latter did not result in a shift in the species of the regenerated weeds, but weed growth was suppressed for only 2 months. Application of paraquat controlled weed growth for 1–2 months and continuous applications of paraquat led to the dominance of broadleaved weeds. The mixture of paraquat and diuron, however gave better results: it suppressed not only the growth of nutsedge (*Cyperus kyllingia*) and grasses (*Poaceae*) but also other weed species propagated with seeds. Glyphosate application suppressed the growth of nutsedge and grasses but continuous application of glyphosate led to the dominance of weed species propagated with seeds. Better results were obtained if glyphosate was mixed with napropamide.

JULY 1983

(Possibilities of biological control of monilia pod rot of cocoa) Posibilidades del control biologico de la moniliasis *(Moniliophthora roreri)* del cacao. BRAVO O., N. and VICTORIA K, J.I. Universidad Nacional de Colombia, Palmira, Colombia – *Acta Agronomica (Colombia) 31* (1–4) p. 133–141 February 1981.

The antagonistic action of 23 antibiotics, 6 bacterial cultures and 6 fungal isolates against *Moniliophthora roreri* was assayed in vitro. Furthermore, the antagonistic capacity of two selected bacterial cultures was assayed during different periods of exposure before and after transplanting the fungus. The action of one bacterial culture against the fungus when inoculated in cocoa pods was assayed before and after the application of the bacterial suspension. The antibiotics, 4 of the bacterial cultures and 6 fungal isolates showed no significant inhibitory effect on the development of *M. roreri* in vitro. The remaining 2 bacterial isolates produced a high degree of inhibition both in the in vitro and the in vivo assay, especially in prophylactic treatments.

(Structure of populations of Phytophthora spp. parasites of cocoa and other perennial crops in Ivory Coast) Structure des populations de *Phytophthora* spp. parasites du cacaoyer et autres cultures perennes, en Cote d'Ivoire. BABACAUH, K.D. Ecole Nationale Supérieure Agronomique, Abidjan, Ivory Coast. *Café, Cacao, Thé 27* (1) p. 41–56 January 1983.

Phytophthora populations from cocoa, rubber and mango trees were studied in Ivory Coast. The study revealed that the conventional taxonomic criteria are not always equally reliable. The length/width ratio of the sporocysts is a clonal marker. The other criteria, including biochemical ones, enable the 2 species to be distinguished viz., *P. palmivora* (ensu attacking both cocoa and mango trees and *P. citrophthora* parasitizing rubber, cocoa and mango.

Nematodes associated with cocoa hybrids and clones in Bahia, Brasil. SHARMA, R.D. Centro de Pesquisa Agropecuaria dos Cerrados, EMBRAPA, Planaltina, D.F., Brazil – *Publicacao – (Sociedade Brasileira de Nematologia: 6 Reuniao Brasileira de Nematologia)* No 6, p. 85–93 1982.

A preliminary survey for plant parasitic nematodes was conducted during 1979. A total of 37 soil and root samples was collected from the rhizospheres of 26 cocoa genotypes (10 hybrids and 16 clones). The %age frequency of occurrence of nematode species in the sample was: *Helicotylenchus dihystera* (70.3), *Meloidogyne incognita* (48.6), *Dolichodorus minor* (45.9), *Helicotylenchus* spp. (35.1), *Rotylenchulus reniformis* (35.1), *Xiphinema* sp. larvae (35.1), *Hemicycliophora loofi* (16.2), *Macroposthonia onoensis* (10.8), *Helicotylenchus multincinctus* (8.1), *Peltamigratus holdemani* (8.1), *Hemicriconemoides* sp. (2.7), *Longidorus* sp. (2.1) and *Trichodorus* sp. (2.1). *H. multicinctus, P. holdermani* and *H. loofi* are reported for the first time in association with cocoa from the State of Bahia, Brazil.

(Effect of weed control on the vegetation of an area at CEPEC) Efeito do controle de plantas invasoras sobre uma vegetacao na area do CEPEC. VINHA, S.G. DA, PEREIRA, R.C. and MULLER, M.W. Divisao de Botanica, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 12* (3) p. 123–124 July 1982.

The result of repeated applications of herbicides and mowing of weeds in an area being prepared for a cocoa plantation at the Cacao Research Centre, Ilheus, Bahia, Brazil, was evaluated by comparing the treated area with an adjacent untreated area. Weed control increased the number of plant species but reduced the total biomass. The vegetation of the treated area retained per square metre, 3.66g Mg, 8.65g Ca, 7.42g K and 2.13p P in its biomass, whereas these values were 12.14, 27.01, 50.11 and 7.87g respectively, in the untreated area. More nutrients were available in the soil in the treated area than in the untreated

area. The above-ground biomass in the untreated area was 2262 g/m^2 and 95.2 per cent of this provided by the grass *Brachiaria mutica*. In the untreated area the above-ground biomass was 214 g/m^2 with *Ludwigiaryssopifolia*, *Torulinium odoratum* and *Commelina nudiflora* representing 31.5, 21.1 and 17.4 per cent of this total, respectively.

Women's work in the food economy of the cocoa belt: a comparison. GUYER, J.I. African Studies Center, Boston University, Brookline, Massachusetts, USA – *Working Papers No 7*. 35p 1978.

This paper is an empirical study of the cultural context and historical development of the division of labour by sex in 2 farming systems of the W. African cocoa belt: the Yoruba of W. Nigeria and the Beti of S.C. Cameroun. The former can be classified as a male, the latter as a female farming system. However, in both cases both sexes contributed to agricultural activities and did productive work outside agriculture.

(The cocoa psyllid in the South Central Province of Cameroon: identification of the psyllid: brief study of the morphology of the different stages of development) Le psylle du cacaoyer au centre-sud du Cameroun: identification du psylle morphologie sommaire des differents stades de developpement. MESSI, J. Faculte des Sciences, Universite de Yaounde, Yaounde, Cameroon – *Cafe, Cacao, The 27* (1) p. 57–66; January 1983.

In the South-Central Province of Cameroon, psyllids (*Mesohomotoma tessmanni*) are the major pests of cocoa. This paper presents detailed information on the morphology of the different development stages of this insect.

Studies on the damage to young cocoa seedlings by the cocoa psyllid *Tyora tessmanni* (Aulmann) (Homoptera: Psyllidae). IGBOEKWE, A.O. Cocoa Research Inst. of Nigeria (CRIN), Ibadan, Nigeria – *Cafe, Cacao, The 27* (1) p. 67–70; January 1983.

Investigations conducted in Nigeria on the nature of damage caused to young cocoa seedlings by the psyllid are reported. Feeding and oviposition habit of the insect cause damage to the vascular bundles of leaves and buds.

(Effect of soil and foliar application of fertilizers on the development of cocoa seedlings) Efeito de adubacoes do substrato e foliar na formacao de mudas de cacau. FASIABEN, M.C.R., COSTA, J.D. and DEMETRIO, C.G.B. Escola Superior de Agricultura 'Luiz de Queiroz' Universidade de Sao Paulo, Piracicaba, Sao Paulo, Brazil – *Revista de Agricultura 57* (3) p. 171–181: November 1982.

Compared were: an organic fertilizer (Hiper Humus) at 50 kg/m^3 of soil, the inorganic fertilizers superphosphate and potassium chloride at 2.5 and 0.5 kg/m^3 of soil respectively, and a foliar fertilizer (Wuchal, 9-9-7 formulation) applied four times at monthly intervals at a concentration of 2 per cent. The comparisons were based on seedling development characteristics (plant height, stem diameter, stem-root and total dry matter weight, and stem/root ratio). The results showed that the organic fertilizer inhibited the increase of root as well as of total dry matter weight. Foliar application showed no effect.

(Weeds in cocoa plantation of different ages in the Cacao Research Centre, Ilheus, Bahia, Brazil) Plantas indesejaveis em cacauais de idades diferentes na area do Centro de Pesquisas do Cacau (CEPEC), Bahia, Brasil. LISBOA, G. and VINHA, S.G. DA Divisao de Botanica, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Revista Theobroma 12* (3) p. 135–140; July 1982.

Comparative studies on the herbacious vegetation under cocoa trees of two different ages, through a transect method, showed that monocots represent nearly 50 per cent of the soil cover in both areas. *Paspalum conjugatum* was the most common species in both areas followed by *Commelina diffusa* in new plantations (i.e. ± 5 years old) and *Setaria poiretiana* in the old one (i.e. ± 60 years old). Diversity indexes showed that, in the old plantation, the most common species were not dominant in relation to the less common species, while the opposite occurred in the new plantation.

(Evaluation of synthetic pyrethroids in the control of *Hoplophorion pertusum* Germar (Homoptera: Membracidae) a pest of cocoa in Bahia) Avaliacao de piretroides sinteticos no controle de *Hoplophorion pertusum* Germar (Homoptera: Membracidae), praga do cacaueiro na Bahia. ABREU, J.M. DE and MILANEZ, J.M. Divisao de Zoologia Agricola, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 12* (3) p. 149–153; July 1982.

Field trials were carried out to evaluate the efficacy of synthetic pyrethroids in the control of *Hoplophorion pertusum*, a pest of cocoa plantations in Bahia, Brazil. The results showed that population densities varied from 381 to 1526 insects per tree. Efficacy of Decis (decamethrin) at the dosages of 5, 7.5 and 10 g.a.i./ha were 98, 97 and 90 per cent respectively, 48 hours after spraying. Efficacy of Pounce (permethrin) at the dosages of 100, 125 and 150 g.a.i./ha were 97, 99 and 98 per cent respectively, 24 hours after application. Efficacy of Belmark (fenvalerate) at the dosages of 50, 100 and 150 g.a.i./ha were 97, 97 and 99 per cent respectively, 24 hours after spraying. The results of an experiment which was undertaken to compare the pyrethroids showed that efficacy of Decis, (5 g.a.i./ha) were 98, 98 and 96 per cent respectively, 24 hours after spraying.

The foraging activity of some West African cocoa farm ants. MAJER, J.D. Department of Zoology, University of Ghana, Legon, Ghana – *Revista Theobroma 12* (3) p. 155–162; July 1982.

The daily foraging pattern of three important Ghanaian cocoa farm ants was monitored on three occasions. The pattern of *Tetramorium aculeatum* was basically unimodal and nocturnal although foraging sometimes continued into late morning. *Cremastogaster depressa* activity was largely diurnal during cool, dull conditions, but became more nocturnal during warmer periods. In areas where these two species co-existed, the peak of *T. aculeatum* activity shifted and foraging time was reduced; *C. depressa* was unaffected by the presence of *T. aculeatum*. The activity of a third species, *Polyrhachis laboriosa*, was diurnal and bimodal. It is suggested that in addition to there being a patchwork mosaic of ants in cocoa, the trees are foraged by a succession of ants throughout the entire day.

(Selected edaphic-climatic factors for cocoa zoning in South East Bahia, Brazil) Fatores edafo-climaticos seletivos ao zoneamento da cacauicultura no Sudeste de Bahia. SA, D.F. DE, ALMEIDA, H.A. DE and SILVA, L.F. DA. Divisao de Climatologia, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 12* (3) p. 169–187; July 1982.

The potential for cocoa growing in the South east region of Bahia was studied, analysing the interaction pattern: soil-climate-plant. Three major areas were initially recognised: (1) a relatively narrow belt of land, 45-47 km wide, covering approx. 33,000 km^2. This is the cocoa region of Southeast Bahia, characterised as the most suitable; (2) an area of approx. 30,000 km^2 considered moderately adequate for cocoa; and (3) an area of about 25,000 km^2, considered inadequate. An additional area of about 6500 km^2, where one of the growth components was not ideal, could be planted with cocoa with certain restrictions.

The relative virulence of *Phytophthora palmivora* and *P. capsici* on cocoa in Bahia, Brazil. LAWRENCE, J.S., LUZ, E.D.M.N. and RESNIK, F.C.Z. DE Divisao de Fitopatologia, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 12* (3) p. 189–198: July 1982.

Phytophthora palmivora was found to be consistently more virulent than *P. capsici* on attached and detached pods, germinated seeds and seedling stems of a range of cocoa types. Since *P. capsici* is probably the predominant species on cocoa pods in Bahia, it was concluded that future routine screening for resistance should be carried out with both species. Among 20 cultivars screened for resistance to *P. palmivora* and *P. capsici*, EET 59, Scavina 6 and UF 713, showed most promising resistance to both species. Not all cultivars showed the same reaction to infection by the two species, the most notable example being cv. Catongo which was classed as moderately resistant to *P. capsici* but susceptible to *P. palmivora*.

(Response of 'Catongo' cocoa to levels of fertilizers in Southern Bahia, Brazil) Respostas de cacaueiros 'Catongo' a doses de fertilizantes no Sul de Bahia, Brasil. CABALA ROSAND, P., SANTANA, C.J.L. DE and MIRANDA, E.R. DE. Divisao de Geociencias, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 12* (4) p. 203–216; October 1982.

Five levels of N, P_2O_5 and K_2O were applied on 8 plantations during 1971–80. Large effects of P were recorded, mainly with 90 kg P_2O_5/ha. Considerable effects of N were also found in the first 3 years. K became important after the first 6 years at levels of 120 kg K_2O/ha. Low production levels were recorded in 4 trials with yields declining in the last 2 years. Yields remained high in the other 4 areas. Leaf samples and soils showed considerable treatment effects in 1980 and an increase of exchangeable Al and Al saturation in the complex. There was also a Ca and Mg reduction compared with soil samples from non-experimental areas. The exchangeable Al and Al saturation increased progressively with depth, while most of the nutrients were greater in the surface layer. In the 4 low yield areas, the Al saturation, Fe and Cu were considerably higher than in the high yield areas, which showed higher amounts of Mn.

(Aerial spraying for the control of cocoa black pod disease in Bahia, Brazil) Pulverizacao aerea no controle da podridao parda do cacaueiro na Bahia, Brasil. RAM, A. and MEDEIROS, A.G. Divisao de Fitopatologia, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 12* (4) p. 231–239; October 1982.

An experiment was conducted to compare the efficiency of aerial spraying by helicopter with conventional spraying employing motorized knapsack mistblowers. The trial consisted of five treatments with six replicates located in different municipalities. Both methods of application maintained a dose equivalent to 4 g of a.i./tree/application of two formulations, copper oxychloride emulsified in oil (Kauritol) and cuprous oxide (Cobre Sandoz). It was shown that no significant difference existed in disease control by the two spray systems tested, while these were better than the control. The cuprous oxide and copper oxychloride in different formulations presented equal efficiency in disease control. The results suggest that aerial spraying is a viable alternative to conventional spraying of cocoa for control of black pod in Bahia.

(Chemical control of *Corticium salmonicolor*, causal agent of pink disease of cocoa) Controle quimico de *Corticium salmonicolor* agente causal do mal-rosado do cacaueiro. RAM, A., BASTOS, S.T.G. and FIGUEIREDO, J.M. Divisao de Fitopatologia, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 12* (4) p. 241–247; October 1985.

Results are presented from detailed investigations with Bayleton (triadimefon), Plantvax (oxycarboxin) and Peprosan (30 per cent copper oxychloride + 10 per cent maneb + 10 per cent zineb). The fungicides were applied at three concentrations and two intervals with seven replicates. Single tree plots were used in which one infected branch showing the first or second stage of infection was marked at the start of the disease season. Data was recorded fortnightly and the rate of superficial mycelial growth of the pathogen was noted. Peprosan was the most efficient (88.69 per cent), followed by Bayleton (59.70 per cent) and finally Plantvax (50.82 per cent). The higher concentrations gave better results in all cases while the shorter interval of 15 days was more promising than that of 30. For Peprosan at its higher concentration of 1 per cent a.i. the results were similar when applied at 15 or 30 days intervals, suggesting that for economic and practical reasons the longer interval was more advantageous.

AUGUST 1983

(The relationship between farm size and productivity in the cocoa region of Bahia) Estrutura fundiaria e productividade na regiao cacaueira da Bahia. TREVIZAN, S.D.P. Divisao de Ciencias Sociais e Estatistica, CEPEC, Itabuna, Bahia, Brazil) – *Boletim Tecnico – Centro de Pesquisas do Cacau No 103*, 20p. 1982.

The relationship between farm size, area of cocoa and production and productivity was analysed. Data from a survey of 16,780 cocoa plantations in Bahia in 1980 were utilized. Tabular analysis and Gini coefficient were utilized to measure the land distribution. To measure the relation between productivity and area, the Pearson correlation (r) was employed. A strong negative correlation (–71) was observed between farm size and productivity; the correlation between area under cocoa and productivity (–0.47) was also significant. It is concluded that small cocoa growers have proportionally higher output than the larger cocoa farmers.

Bibliography of cocoa in Papua New Guinea. SMITH, E.S.C. (Comp). LAES, Department of Primary Industry, Keravat, East New Britain, Papua New Guinea – *Lowlands Agricultural Experiment Station, Keravat (Papua New Guinea)* 37p; September 1982.

In a number of appendices information is presented on: cocoa information printed and distributed by LAES; general texts on cocoa; publications on cocoa from the Solomon Islands as well as from Irian Jaya, Indonesia; miscellaneous publications concerning cocoa in Papua New Guinea; visual aids on cocoa in Papua New Guinea and Cocoa Acts and Regulations in Papua New Guinea.

Cocoa. ADOMAKO, D. Cocoa Research Inst. New Tafo-Akim, Ghana – *Outlook on Agriculture 12* (2) p. 83–89; 1983.

This review article on cocoa describes scale and geographical pattern of cultivation and processing, and the control of pests and diseases.

Acceptance of farm technology amongst peasant cocoa farmers in Nigeria. MONU, E.D. Faculty of Arts, Brandon Univ., Brandon, Manitoba, Canada – *Quarterly Journal of International Agriculture (Germany F.R.) 21* (3) p. 250–261; July 1982.

Adoption of 3 recommended farm practices by some cocoa farmers from Ondo and Oyo States is examined. Results showed that while 53 per cent adopted cutting of virus-infected trees only, 45.3 per cent used the knapsack spraying machine. Moreover only 10.1 per cent used the recommended wooden trays for fermenting cocoa beans. Generally farmers who adopted cutting of VIT had greater contact with extension agents and external sources of information. Those who used the KSM were more likely to come from Ondo state and owned larger farms. Finally those who adopted the wooden trays for cocoa fermentation were younger and had greater contact with extension agents. Characteristics of these farm practices are examined to explain the differential relationships between the independent variables and adoption of the 3 practices.

Cocoa, coffee and tea; producer co-operation for structural change. SILVA, L. DE. *Reprint Series – United Nations Conference on Trade and Development* No 30, 31p. 1982.

This paper examines the trends over the last 2 or 3 decades in the world tropical beverage economy, provides some brief statistical guidance on its present shape, and pinpoints a few salient features in the production, processing, marketing and distribution of cocoa, coffee and tea, which might be improved to benefit developing exporting countries. In this connection the rationale for a concerted approach is discussed, together with international financing, international commodity agreements and the concept of a "strategic" commodity. Policy conclusions for better co-operation between tropical beverage exporting countries are drawn.

(Fertility of diagnosis and classification of cocoa soils in Amazonia) Diagnose nutricional e classificao de polos representativos dos polos cacaueiros da Amazonia. NEVES, A.D. DE S., CAMPOS, A.X. DE and BARBOSA, R.C.M. Departamento Especial da Amazonia, CEPLAC, Belem, Para, Brazil – *Boletim Tecnico – Centro de Pesquisas do Cacau* No 102, 16p. 1982.

Soil surveys were undertaken to identify and classify soil units in the new planting areas of Brazilian Amazonia. Cocoa seedlings were used as an index crop for determining nutrient deficiencies. The biological assays were assessed under greenhouse conditions. It appeared that all the soil types were deficient in phosphorus. Eutrophic podzolic soils also showed potassium deficiency. Yellow and red latosols were also deficient in potassium, calcium and magnesium, and cocoa seedlings expressed by symptoms of zinc deficiency. None of these soils responded to nitrogen, sulphur or boron.

A preliminary inventory of areas suitable for cocoa production in Papua New Guinea. BLEEKER, P. and FREYNE, D.F. Division of Land Use Research, CSIRO, Canberra, Australia – 51p. 1981.

This preliminary inventory of soils, terrain and climate suitable for cocoa production shows that the country has extensive additional areas of land available which can be brought into production. A summary of these estimated areas, together with the percentage areas at present under crop is given in a table for each of 13 provinces. The Northern and West New Britain in particular appear to have large tracts of land available which are highly suitable for production. These are relatively accessible and with low population densities. Other areas with high suitabilities such as North Solomons and West Sepik Provinces are either currently used or inaccessible.

SEPTEMBER 1983

The digestibility of cocoa husk-based diets fed to sheep. OTCHERE, E.O., MUSAH, I.A. and BAFI YEBOA, M. Department of Animal Science, University of Ghana, Legon, Ghana – *Tropical Animal Production (Mexico) 8* (1) p. 33–38. 1983.

Significant decreases in dry matter, crude protein, ether extract and nitrogen free extract digestibilities and total digestible nutrients occurred in the wethers with increase in the level of cocoa husks substitution.

Potential productivity of tropical perennial crops. CORLEY, R.H.V. Bekasawit Clonal Oil Palm Research Unit, Banting, Selangor, Malaysia – *Experimental Agriculture (UK) 19* (3) p. 217–237. July 1983.

This paper reviews the yield and productivity of several tropical perennial C3 species and estimates their potential yields. Some factors which limit productivity have been identified and suggestions have been made for further improvement. Considerable increases in productivity should still be possible, since the potential energy fixation rate for such crops is estimated to be about 1.2 TJ/ha/annum. The dry matter equivalent of this energy varies between species; the oil crops and rubber in particular, have large energy contents in their respective economic products. Hot leaf

temperatures appear to limit productivity in some crops, while unfavourable partitioning of assimilates limits yield at the large leaf area indices necessary to maximise dry matter production. Respiratory losses are large in these crops and selection for smaller respiration rates could lead to considerable improvements in their productivity.

18th ANNUAL REPORT 1982 Research Dept., United Plantations Berhad, Teluk Anson, Perak, Malaysia 103p; February 1983.

The activities of the United Plantations Research Department for the year 1982 are described under the headings: (1) oil palm – breeding and selection, cultural practices, nutrition; (2) coconuts – breeding and selection, cultural practices, nutrition; (3) cocoa – breeding and selection, nutrition; and (4) crop protection.

Cocoa: Breeding and Selection. Research Dept., United Plantations Berhad, Teluk Anson, Perak, Malaysia – *In: Annual Report 1982.*

In this section the following activities on cocoa breeding and selection are reported: (1) germplasm introductions; (2) clonal observations and evaluations trials; (3) Fo x F_1 (3-way) progeny trials; and (4) F x F progeny trials. Cocoa germplasm in the form of budwood, imported in a joint effort between interested members of the Malaysian Cocoa Growers' Council, comprised 12 clones from Mayaguez, Puerto Rico, and another 9 clones with proven tolerance to VSD disease from Papua New Guinea. The search for ortets – a term defined as the original single ancestor of a clone – continued throughout the year with the aim of developing clonal material for commercial exploitation. To date, 397 such orters have been selected for further testing. Some early selections are showing promise, particularly with respect to the bean size and pod value.

Cocoa: nutrition. Research Dept., United Plantations Berhad, Teluk Anson, Perak, Malaysia – *In: Annual Report 1982* p. 84–87 1982.

The results of the following cocoa nutritional trials are presented in this section: (1) 3^2 x 2 NPK trial on mature cocoa under old dwarf coconuts; and (2) source of nitrogen for cocoa trial. The importance of applying rock phosphate is now supported by the results from the NPK trial, in which a significant yield response to phosphate was recorded. The 2nd trial confirms the suitability of urea as a nitrogenous fertilizer for cocoa on coastal soils. The significantly lower leaf nitrogen content 6 months after application, when compared to ammonium nitrate and ammonium sulphate, emphasises the importance of applying urea under favourable weather conditions and on time.

(The use of response surface in cocoa fertilizer experiments in Bahia, Brazil) O emprego da superficie de resposta ne interpretacao de experimentos de adubacao na cultura do cacau na Bahia. NICOLELLA, G., CAMPOS, H. and CABALA ROSAND, P. CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (1) p. 1–13; January 1983.

Yield figures over 9 years of 5 NPK fertilizer field trials conducted with cocoa were used in Brazil to calculate the polynomial regression with and without interactions. The analysis was carried out for each year, for all field trials in the same year and for each experiment in all years. The economic rates of P_2O_5 for Agua Sumida and Itabuna soils lie between 90 and 135 kg per ha. These were calculated from a surface section in which N and K were maintained at constant levels.

(Dusting and spraying in the control of black pod cocoa) Polvilhamento e pulverizacao no controle da podridao parda dos frutos do cacaueiro. LELLIS, W.T. and FIGUEIREDO, J.M. DE. Divisao de Fitopatologia, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (1) p. 41–46; January 1983.

In Bahia, the effectivity of the control of black pod disease in cocoa by means of dusting and spraying with Cobre Sandoz was studied. The following formulations were used: Cobre Sandoz W.P. (cuprous oxide with 50 per cent of metallic Cu) and Cobre Sandoz D.P. (cuprous oxide with 10 per cent of Metallic Cu) applied at the rate of 3 g of a.i. per tree per application. Both formulations were found to be efficient in controlling the disease. Since most plantations in Southern Bahia face costly transport of water, the use of Cobre Sandoz D.P. is advantageous.

Witches' broom disease of *T. cacao* in Brazil. 1. Inoculation of ungerminated seeds. ANDEBRHAN, T. Departamento Especial da Amazonia, CEPLAC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (1) p. 47–49; January 1983.

Ungerminated seeds of cocoa, infiltrated under vacuum with a spore suspension of the witches' broom fungus *Crinipellis perniciosa* and then pre-germinated before planting, produced hypertrophied hypocotyls and developed hypertrophied axillary buds. This inoculation technique could be useful in mass-screening of individual plants for their reaction to infection by *C. perniciosa.*

(Incidence of fungi of the *Aspergillus flavus* group in stored cocoa seeds) Incidencia do fungos do grupo *Aspergillus flavus* em sementes de cacau armazonado. BASTOS, S.T.G. and CAMPELO, A.M.F.L. Divisao de Fitopatologia, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (1) p. 63–65; January 1983.

Stored cocoa from 5 different localities was examined for the presence of fungi of the *Aspergillus flavus* group. *A. flavus* was found to be present in 4 of the 5 areas, but none of the 104 strains produced aflatoxins.

Comparative chemistry and microbiology of cocoa fermentation in India. BALASIMHA, D., BHAT, N.T. and BOPAIAH, B.M., Central Plantation Crops Research Inst., Vittal Karnataka, India – *Journal of Plantation Crops 11* (1) p. 55–59; June 1983.

Acidity in cocoa beans is a serious defect as it imparts a raisin-fruity off-flavour to the finished chocolate. Indian cocoa beans are usually acidic due to defective harvesting, fermentation and drying. An improved processing method was developed to overcome the acidity problem. Microbiological and chemical changes that occur during the processing of cocoa beans are compared and discussed.

Experiments on the profitability of chemical black pod control in Papua New Guinea. MCGREGOR, A.J. LAES, Department of Primary Industry, Keravat, East New Britain, Papua New Guinea – *Tropical Pest Management 29* (2) p. 129–136; June 1983.

Trials were conducted on commercial plantations and at the Lowlands Agricultural Experiment Station, Keravat, to determine the effectiveness of metalaxyl and cuprous oxide fungicides in controlling black pod disease of cocoa. Spraying costs and pod yields were recorded to assess the profitability of spraying at the different sites. Only in mature blocks planted with selected seed in areas with severe black pod and no other severe pest or disease problems was spraying economical. Provisional spraying recommendations are given based on the findings of these and previous trials.

OCTOBER 1983

(Insects in cocoa beans and products) Insecten in cacaobonen en cacaoprodukten. SCHULTEN, G.G.M. and ROORDA, F.A. Department of Agricultural Research, Royal Tropical Inst., Amsterdam, Netherlands – 33p; January 1983.

In this publication various data are presented in connection with insects on cocoa and products. These include the life-cycle of these insects, their control and methods to prevent the infestation with insects. For the identification drawings are available of the most important species.

(Preliminary results of a progeny trial on some interclonal hybrids of cocoa in central Java) Hasil pendahuluan pengujian keturunan beberapa tanaman cokelat hibrid antar klon di Jawa tengah. SOENARYO and SOEDARSONO Balai Penelitian Perkebunan Bogor, Bogor, Indonesia – *Menara Perkebunan 48* (6) p. 163–170; December 1980.

Eight hybrid progenies and open pollinated progenies of Amelonado and Purbovo were tested against DR 2 clone as control, at four locations in Central Java. Except the SCA 8 x DR 2 progenies, all the hybrids showed a significantly better growth and precocity and a higher yield during the first year than Amelonado, Purbovo and DR 2. ICS 60 x SCA 12, DR 2 x SCA 12 and SCA 6 x ICS 6 consistently gave the most satisfactory results at all testing locations.

The producers' price system and the coffee and cocoa trade at village level in West-Africa. MUNTJEWERFF, C.A. African Studies Centre, Leiden, Netherlands *Quarterly Journal of International Agriculture 22* (2) p. 163–178; April 1983.

This price study on purchase of cocoa and coffee was conducted in Nigeria, Ivory Coast, Ghana and 5 regions of Cameroon over 2 years. The results show that farmers in Nigeria, Ghana and 3 regions in Cameroon received 0.7 12.7 per cent less than the official farm-gate price whereas in the other areas they received 1.3 – 8.6 per cent more. Causes of these differences are discussed.

The transport of cocoa and coffee in freight containers: an experimental shipment from Papua New Guinea to Australia. July/August, 1980, to investigate, 1. The use of ventilated containers to prevent condensation, 2. In-container disinfestation with carbon dioxide generated from dry ice. SHARP, A.K. and GREVE, J. VAN S. Division of Food Research CSIRO, North Ryde, New South Wales, Australia – *Technical*

Report – Department of Primary Industry (Papua New Guinea) No 81/3 54p. March 1981.

The problem of condensation on the interior surface of containers of coffee and cocoa, that are shipped into cold regions was investigated, as well as the efficiency of disinfection of these products with carbon dioxide during the journey. There was no evidence of condensation in any container while on board the ship. After discharge from the ship condensation occurred in nine of ten general-purpose containers and in two of the three 'open-sided' containers but in none of the six prototype vented containers. In-transit disinfection with carbon dioxide generated from dry ice was shown to be effective with coffee and cocoa in suitably gas-tight containers, but very few such containers are in service in the Papua New Guinea trade at present.

(Hormones and growth regulators in coffee and cocoa cultures) Hormones et regulateurs de croissance dans les cultures de cafeiers et de cacaoyers. CAMBRONY, H.R. and SNOECK, J. Institute de Recherches du Cafe et du Cacao, Paris, France – *Cafe, Cacao, The 27* (2) p. 113–120; April 1983.

In a review of hormones and growth regulators in coffee and cocoa cultivars, the authors briefly describe various trials, for example the propagation of cocoa, forcing of crown formation in cocoa, and physiological control trials against cocoa tree cherelle wilt.

An economic evaluation of a cropping system: the case of cocoa grown in combination with oil-palm. AFOLAMI, C.A. and AJOBO, O. Cocoa Research Inst. of Nigeria, Ibadan, Nigeria – *Cafe, Cacao, The 27* (2) p. 121–126; April 1983.

This study examines whether pod loss due to pests and diseases in cocoa, grown in combination with oil palm, nullifies the increase in pod yield that arose from the cropping system. The experimental design is a randomised block design of six blocks and three treatments: pure stands or control, avenue plantings and hollow square plantings. Annual yields of healthy pods, black pods and damaged pods, taken for the period 1968/79 were used for analysis. Results showed that the absolute number of damaged and black pods was greater on cocoa grown in combination with oil palm, but the increase in yield of healthy pods in the cropping system was higher than the pod loss due to pests and diseases.

(Cocoa protein fractions before and after roasting: influence of fermentation) Les fractions proteiques du cacao avant et apres torrefaction: influence de la fermentation. BAREL, M., GUYOT, B. and VINCENT, J.C. Laboratoire de Chimie-technologie, Institut de Recherches du Cafe et du Cacao, Montpellier, France – *Cafe, Cacao, The 27* (2) p. 127–144; April 1983.

The influence of fermentation on the protein fraction in cocoa beans was studied. The subjects covered were: the evolution of the protein fractions during fermentation, the origin of the amino acids concerned in the formation of aromatic compounds and the determination of the minimum duration of fermentation. The results of this study indicate that the total extractible protein content decreases linearly during fermentation; the majority of the free amino acids in the fermented cocoa comes from fractions A and E. Fraction F, which is particularly rich in glutamic acid, liberates amino acids on the third day of fermentation. Glutamic acid represents a large part of the amino acids in cocoa. The influence of fermentation on the protein composition of the beans after roasting is clearly apparent. Fermentation duration of five days was sufficient to obtain a good quality product.

Symptomatology of *Colletotrichum* disease of cocoa in India. MOHANAN, R.C. and KAVERIAPPA, K.M. Mangalore Univ., Mangalore, Karnataka, India – *Planter 59* p. 333–338; August 1983.

Cocoa leaves showing leaf blight, shot hole or irregular leaf spot as well as the rotting of cocoa pods were examined and cultures of *Colletotricum* spp. found were prepared and identified. Pathogenicity of the isolates was tested on Forestero variety by artificial inoculation. In all cases the symptoms of the fungus disease could be reproduced on the leaves of seedlings. The isolates from pods produced only leaf blight and shot hole symptoms.

Initial screening of fungicides for the control of vascular streak dieback disease on nursery cocoa plants. CHUNG GAIT FEE. Ebor Research, Agri-Bio Corp., Batu Tiga, Selangor, Malaysia – *Planter 59* p. 339–343; August 1983.

Cocoa nurseries and particularly the young seedlings are prone to infection by the fungus *Oncobasidium theobromae* which causes vascular streak dieback. Sulphur, copper oxychloride, tridemorph, benomyl, biterianol, iprodione, pyracarbolid and dichlorbutrazol, applied at 7 or 14 days' intervals were tested against the disease. Only biterianol 25 per cent wp, sprayed at a concentration of 0.05 per cent a.i. gave complete protection at both intervals tested.

The white plant-hopper: an occasional pest of cocoa in Sabah. MANJIT SIDHU Research and Advisory Dept., Hap Seng Plantation Sdn. Bhd., Tawau, Sabah, Malaysia – *Planter 59* p. 344–351; August 1983.

The biology and nature of damage inflicted by the white hopper *Colobesthes falcata* is described. In areas where populations of the pest were found to be very high, a substantial amount of damage to young shoots, flowers, cherelles and mature pods can occur. Damage to young shoots is related to the egg-laying habit of the pest whereas the continuous feeding of both adults and nymphs can lead to flower damage and cherelle fall. Bionomics of the white hopper are linked to weather cycles and natural control. As appreciable numbers of the pest declined on their own, a policy of non-intervention was pursued.

Interrelationships of damaged cocoa pods to yield, rat populations and harvesting intervals. KAMARUDIN, K.A. Malaysian Agricultural Research and Development Inst., Kuala Lumpur, Malaysia – *Planter 59* p. 352–354; August 1983.

The interrelationships between number of damaged cocoa pods to harvestable (ripe) pods, rat population densities and harvesting intervals were appraised in the fields. There was association between number of damaged pods to all three variables; however their correlations were considered weak to moderate. In combination, these three factors explained only 42 per cent of the variability in total damage to cocoa pods.

An egg parasite of the cocoa pod borer *Acrocercops cramerella* recorded in the Philippines. NAGARAJA, H., EASAW, P.T. and VANIALINGAM, T. – *Planter 59* p. 355–357; August 1983.

A. cramerella is a serious pest of cocoa in Indonesia, the Philippines and recently in East Malaysia. Samples of pods yielded eggs of the pest which appeared to have been parasitized. Records of parasite emergence holes and hatching were taken. Results indicated that an undescribed species of Trichogrammatoidea (Hymenoptera) can exert a high level of parasitism. The parasite is being augmented for the biological control of the cocoa pod borer.

A survey of cocoa dryers in East New Britain. HARWOOD, C., HENDERSON, M.F. and HALDANE, J.H. – *Planter 59* p. 362–369; August 1983.

Utilizing new technologies, solid fuel (copra by-products, bush firewood, thinnings of cocoa shade trees, rejected timber, fuel wood plantations) drying is now cheap, clean and easily managed. High efficiency burners can be integrated into present drying systems. Diesel burners can be left for emergency use in many cases. Average time to recoup the capital expenditure is about 4 to 6 months, depending on the volume of produce dried. It is stated that reduction of plantation costs is essential and that the new solid fuel burner cost can contribute significantly to this.

Introducing the 'Sabah Dryer'. SCHWARTZ, P.B. – *Planter 59* p. 370–376; August 1983.

Work carried out on a large cocoa estate on a new design dryer unit is described. This so-called 'Sabah-dryer' combines the principles of the wood burning Samoan dryer with the high air volumes which are necessary for large scale drying of beans. Except for the diesel engine fan unit, all construction work was done in local workshops. Details of construction, operation and costs are presented.

Shoot regeneration from callus derived from embryo axis cultures of *T. cocoa* in vitro. ESAN, E.B. Cocoa Research Inst. of Nigeria (CRIN), Ibadan, Nigeria – *Turrialba (IICA) 32* (4) p. 359–364; October 1982.

Callus was induced from the plumule regions of mature cocoa seeds when the embryo axis was cultured on a basal medium, composed of Murashige and Skoog salts, calcium nitrate supplement, sucrose, bacteriological peptone, naphthalene acetic acid, kinetin and inositol. When this callus was subcultured after 50, 60, 70, 80 and 90 days respectively on the basal medium, modified to contain white's vitamins, adventitious buds were differentiated in vitro.

(Results from the tissue cultures of some estate crops) Hasil yang telah dicapai dengan kultur jaringan beberapa tanaman perkebunan. NURITA and TORUAN, Balai Penelitian Perkebunan, Bogor, Bogor, Indonesia – *Menara Perkebunan 48* (6) p. 171–174, December 1980.

Root formation on callus from young shoots of clonal rubber plants can be induced in a modified Nitsch and Nitsch medium. Callus of young shoots of coffee formed embryoid bodies in Linsmaier and Skoog medium and developed into young coffee plants after being transferred to a modified

Gresshof-Doy medium. Callus of young shoots of cocoa developed well after being transferred into subculture medium of the same composition as that of the first stage of callus induction. The medium used was a modified Murashige and Skoog medium. Coconut embryos can grow into seedlings after several stages of cultivation in liquid and solid media.

An investigation on the biology and control of *Indarbela disciplaga* in Sabah. MANJIT SIDHU and CHOW KOK POON, Hap Seng Plantation Sdn. Bhd., Tawau, Sabah, Malaysia – *Planter 59* p. 358–362; August 1983.

I. disciplaga can be recorded as a new borer on cocoa. The borers feed on bark at night, spinning characteristic webs composed of broken wood particles and frass. During the day, the larvae reside under these webs or in tunnels within the wood. As many as 15–20 borers may be found infesting a single tree. Damage to bark, flowers, flower cushions and underlying wood can be serious, often leading to poor flower setting and death of branches above the point of entry. Control was achieved by implementing a "search and destroy" strategy employing both chemical and cultural means. In areas where levels of borer parasitism were found to be high, control measures were called off, in order to ensure that neither insecticide spraying nor the manual removal of borers had any detrimental side-effects on natural enemy regulation.

NOVEMBER 1983

A systematic description of cocoa clones. 1. The discriminative value of quantitative characteristics. ENGELS, J.M.M., CATIE, Turrialba, Costa Rica – *Euphytica 32* (2) p. 377–385; June 1983.

Data from 25 possible distinctive quantitative flower and pod characteristics were collected from 32 cocoa clones and analysed statistically. The discriminative value of each of them was calculated by using Duncan's new multiple range test to obtain a discriminatory value 'D' which was adjusted to allow for correlations with other characteristics. It is concluded that quantitative characteristics, which usually have a higher agronomic interest than qualitative ones, are also helpful in characterizing and identifying varieties or clones.

A systematic description of cocoa clones. 2. The discriminative value of quantitative characteristics and the practical compatibility of the discriminative value of quantitative and qualitative descriptors. ENGELS, J.M.M., CATIE, Turrialba, Costa Rica – *Euphytica 32* (2) p. 387–396; June 1983.

A method is presented for calculating the discriminative value of qualitative descriptors, based on the number of taxa pairs that a certain descriptor can separate and on the amount of information that this descriptor shares with other descriptors of the same study. To make this method compatible with the calculation of the discriminative power of quantitative characteristics, statistical tests are proposed to enable a comparison between both types of characteristics. The data from 32 cocoa clones are used to demonstrate the methodology for 15 qualitative characteristics of leaves, flowers and fruits of the cocoa tree. The combined use of qualitative and quantitative descriptors in the calculation of their respective discriminatory power is also presented.

(Cocoa down stream industries) Industri hilir komoditi cokelat. HARUN, A. – *Buletin Balai Penelitian Perkebunan Medan (Indonesia) 13* (1–2) p. 15–23; March 1982.

In the estates, cocoa processing is confined to the production of dry cocoa beans. The manufacture of processed cocoa such as chocolate, cocoa butter, cocoa cake or cocoa powder and chocolate sweets has not yet been started. In order to boost the cocoa industry through product diversification and by-product utilization, the possibility of manufacturing and exporting cocoa in the form of processed goods should be investigated. This paper discusses the manufacturing of cocoa powder and the possible utilization of its by-products.

(Effect of weed control practices and nutrients on the competition between alang-alang *(Imperata cylindrica)* and cocoa seedlings *(T. cocoa)* var. Amelonado) Pengaruh beberapa metode pemberantasan gulma dan pemupukan terhadap kompetisi antara alang-alang dan kecambah tanaman cokelat. SUNARWIDI – *Buletin Balai Penelitian Perkebunan Medan 13* (1–2) p. 25–34; March 1982.

Results of an experiment on cocoa in the Philippines showed that control of alang-alang can be better achieved by rolling than by eradication by hand or by chemical means. Rolled alang-alang served as green mulch in conserving soil moisture. It appeared that alang-alang sheet also served as a nurse plant to the young cocoa seedlings. Application of fertiliser increased the competitive ability of alang-alang, but it did not do so when the alang-alang sheet also served as nurse plant to the young cocoa seedlings. Application of fertiliser increased the competitive ability of alang-alang, but it did not do so when the alang-alang was rolled. On the basis of these findings the author advocates the adoption of this method when controlling alang-alang in plantations.

(Effect of shade and nutrients on the competition ability of cocoa seedlings and alang-alang *(Imperata cylindrica)*). Pengaruh naungan dan pemupukan terhadap daya saing tanaman cokelat dan alang-alang. SUNARWIDI – *Buletin Balai Penelitian Perkebunan Medan (Indonesia)* v. 13 (1–2) p. 35–43; March 1982.

Results of an experiment in cocoa in the Philippines showed that the growth of cocoa seedlings and leaf chlorophyll content increased with the reduction in light intensity from 100 per cent (unshaded) to 68 per cent and 33 per cent light transmission. However the growth of alang-alang decreased with decreasing light intensity. With decreasing light intensity the competitive ability of cocoa increases, while that of alang-alang decreases. Shade trees in cocoa plantings are thus essential. Fertilizer application could not eliminate the adverse effect of sunshine on cocoa growth performance.

(The germination of cocoa seeds *(T. cacao)* as influenced by storage period and seed position in pods) Pengaruh lama penyimpanan dan letak biji pada pod terhadap daya kecambah benih cokelat *(T. cacao)*. LATIF, S. – *Buletin Balai Penelitian Perkebunan Medan 13* (1–2) p. 45–50; March 1982.

Results of the experiment showed that moisture content of the cocoa seeds was not affected by storage up to 28 days, but the position of the seeds in the pod showed a significant difference in the moisture content. The longer the seeds were stored, the higher the percentage of damaged seeds and not growing seeds, and the lower the percentage of germination and plant height. Seeds from the middle part of the pod showed the best results, i.e. lowest percentage of damaged and non-growing seeds and highest plant height and percentage of germination.

(Concept, industrial design, performance, functioning and economics of engine operated land sprayers in cocoa) Conceito, desenho industrial, desempenho, operacao em campo e economicidade do sistema de mangueira e lancas para tratamentos fitossanitarios em cacaueiro. PEREIRA, J.L., OLIVEIRA, C., J. DE and ANDRADE FILHO, E.N. Divisao de Fitopatologia, CEPEC, Itabuna, Bahia, Brazil – *Boletim Tecnico – Centro de Pesquisas do Cacau* No 113, 59p. 1983.

Motorised mistblowers, conventionally used in the control of black pod disease of cocoa have been considered to be efficient in the application of fungicides. However, they are noisy and use relatively much fuel. The concept of using a diesel engine, coupled to hydraulic pump to supply a pressurized constant flow through a predetermined number of hoses, connected to lances with nozzles appeared to be a functional and economic solution. The new system offers a number of advantages, such as its speed of operation with comfort to the spraying operators and its lower computed cost of application, resulting in a saving of up to 50 per cent on the present method.

(The agreement on basic products: advances and restrictions. The cases of the coffee, cocoa and sugar) Los acuerdos sobre productos basicos: logros y restricciones. Los casos del cafe, cocoa y azucar. VALLE, S. DEL and SALAZAR, R. – *Problemas del Desarrollo (Mexico) 12* (47–48) p. 105–149 1982.

Different types of trade agreements and treaties established by Third World countries, in defence of their basic exports are analysed, with special reference to coffee, cocoa and sugar. Their efficacy in confronting the complex web of legal restrictions and economic sanctions imposed by the industrialized nations, particularly the US and the European Common Market, is also reviewed.

DECEMBER 1983

(Progeny trial on some cocoa interclonal hybrid progenies at Kalidurен estate. 1. The growth rate and precocity) Pengujian beberapa keturanan hibrid antar klon cokelat di kebun kalidurен. 1. Kecepatan pertumbuhan dan awal masa berbuah. SOEDARSONO, Balai Penelitian Perkebunan Bogor, Bogor, Indonesia – *Menara Perkebunan 49* (4) p. 87–91; August 1981.

A progeny trial was conducted on the Kalidurен estate. Fourteen cocoa interclonal hybrid progenies were tested against DR 2 clone as control. DR, DRC and GC clones were used as female parents and ICS and SCA clones as male parents of the hybrids. The growth rate, precocity and data of some components of yield were presented in this paper.

(N.B. 'ABSTRACTS ON TROPICAL AGRICULTURE' WAS NOT PUBLISHED DURING 1984)

JANUARY 1985

(Evaluation of weed control methods in cocoa) Avaliacao tecnico-economica de differentes metodos de controle de plantas invasoras do cacaual. LIMA, L.P. FERREIRA, H.I.S. and MULLER, M.W. Centro de Pesquises do Cacau, CEPLAC, Belem, Para, Brazil – *Boletim Tecnico – Centro de Pesquisas do Cacau* No 111, 21 p. 1983.

Efficiency and economics of chemical weed control in cocoa were compared with mechanical and hand weeding. The herbicides applied were simazine + paraquat at 3.0 kg + 0.2 l a.i./ha and diuron + paraquat at 2.4 kg + 0.2 l a.i./ha. Putting the mechanical weeding cost at 100 it was shown that hand weeding rated at 93 per cent, simazine + paraquat at 63 per cent and diuron + paraquat at only 45 per cent. Chemical weed control proved to be the least expensive.

FEBRUARY 1985

(Cacao drying as related to thin layer drying) Secagem de amendoas de cacau relacionada as teorias de secagem em camada delgada. CUNHA, J. Divisao de Tecnologia e Engenharia Agricolas, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (2) p. 67–81; April 1983.

Thin layer drying tests with cocoa beans were carried out in a multi-unit dryer in order to establish drying curves for temperatures of 50, 57.7, 60, 70, 74 and 75°C and a constant air flow of 9.14 m/min. The results are in agreement with earlier research, showing 3 different drying periods, including a period with a constant drying rate and 2 periods with decreasing drying rates. Values of the equilibrium moisture content and the drying constant were determined and theoretical drying curves were calculated and compared with experimentally established curves. Linear regression equations were developed, making it possible to predict the course of thin layer drying of cocoa beans.

(Storage of cocoa beans in plastic bags) Armazenamento de cacau em sacos plasticos. PRADO, E.P. DO, SANTOS, S.R. DOS and ABREU, J.M. DE. Divisao de Tecnologia e Engenharia Agricolas, CEPEC, Itabuna, Bahia, Brazil – *Revista Theoboma 13* (2) p. 83–97; April 1983.

Polyethylene bags of 0.05 mm thick, each filled with 60 kg cocoa beans was used to study the possibility of prolonged periods of storage on the farm. Jute bags also containing 60 kg cocoa beans served as a standard. The content of both bags was infested with 25 pairs of larvae of *Ephestia cautella* and 50 adults of *Tribolium castaneum*. In the polyethylene sacks, during 12 months of storage, neither mould development nor noticeable insect attacks occurred, while the beans stored in jute sacks were already unfit for export after 8 months of storage. *E. cautella* was able to survive in the polyethylene bags. In the final evaluation of the produce the beans with an initial moisture content of 6.6 per cent (wet basis), maintained an average moisture content of 7.1 per cent in the polyethylene bags and their classification as Superior Grade for export.

(Dosage and interval of application of copper fungicides in the control of cocoa black pod disease) Dosagens e intervalos de aplicacao de fungicidas a base de cobre no controle da podridao parda do cacau. LELLIS, W.T. and FIGUEIREDO, J.M. DE. Divisao de Fitopatologia, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (2) p. 99–104; April 1983.

Two field trials were carried out with the aim of comparing the efficacy of Cobre Sandoz (cuprous oxide with 50 per cent Cu) and Kauritol (cuprous oxichloride with 35 per cent Cu as an oil base formulation) against pod rot *(Phytophthora palmivora)* of cocoa. The fungicides were sprayed at concentrations of 1 and 4 per cent (c.p.) at intervals at 30, 45 and 60 days during the period from April to July. It was shown that both compounds were more efficient when sprayed in the concentrations of 2 and 4 per cent i.e. at rates of 3200 and 6400 cm^3/ha.

(Advances in the control of cocoa black pod disease in Bahia, Brazil) Progressos no controle quimico da podridao parda do cacaueiro na Bahia, Brasil. LELLIS, W.T., FIGUEIREDO, J.M. DE and PEREIRA, J.L.M. Divisao de Fitopatologia, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (2) p. 105–111; April 1983.

The history of the control measures against black pod disease *(Phytophthora palmivora)* of cocoa since 1954, is reviewed. Agricultural practices in combination with copper based sprays of fungicides, such as Cobre Sandoz, Cuprosan and Kauritol were recommended in those days. Later on organic fungicides such as Melprex (dodecil), Terrazole (tiadazoll and Captan were tried. Research on the formulation of the fungicides made it possible to apply low volume sprays (20 l/ha) using mineral oils as carriers. The use of hose and boom spraying equipment resulted in lower spreying costs per ha as compared with the formerly much used mistblowers.

(Research and control strategies of the cocoa pod borer) Strategi penelitian dan pemberantasan penggerek buah cokelat. WARDOJO, S. Balai Penelitian Perkebunan Bogor, Bogor, Indonesia – *Menara Perkebunan- (Indonesia) 49* (3) p. 69–74; June 1981.

The cocoa pod borer *(Acrocercops cramerella)* is one of the major species that has adapted successfully from its original host plant to cocoa. It is primarily the life habit of the larva which makes this pest difficult to control. Immediately after hatching it bores into the pod and remains there until it reaches the prepupal stage, when it tunnels out to pupate. This life habit enables the larva to escape from the attacks of its natural enemies and insecticides, and to disperse passively over long distances. This paper describes some control strategies and indicates priorities of relevant research.

(Some factors affecting the viability of cocoa seed) Beberapa faktor yang berpengaruh terhadap daya hidup benih cokelat. RAHARDJO, P. Balai Penelitian Perkebunan Bogor, Bogor, Indonesia – *Menara Perkebunan 49* (3) p. 65–68; June 1981.

The main factors affecting the viability of cocoa seed are (a) temperature, (b) relative humidity, (c) moisture content, (d) activity of fungi and (e) aeration. Cacao seed can retain its viability for at least one month if stored under conditions as follows: a relative humidity of circa 100 per cent; a moisture content of the seed of circa 50 per cent; a temperature range for 18 to 30°C and free from fungal attack. It is suggested that a favourable aeration will prolong the viability for more than one month.

(Drying of cocoa in a platform type unit with and without recirculation of air) Secagem de cacau em secador tipo/ plataforma com e sem recirculacao de ar. MCDONALD, C.R. and FREIRE, E.S. – *Boletim Tecnico – Centro de Pesquisas do Cacau* No. 118, 19p. 1983.

Application of a reduced non-circulation air flow gave efficiencies at least as high as with recirculation when drying at or near 60°C. At 70°C the application of recirculation resulted in some increase in efficiency. Overall thermal efficiency values for the no-recycle runs was independent of drying air temperature. With recirculation, however, the degree of cocoa loading and to a lesser extent the drying air temperature were important in determining system efficiency. The drying rate curves of the runs carried out showed three distinct periods, corresponding well with previously published results. Drying rates during the initial periods were lower than expected, though during the final period, the usual exponential fall in drying rate took place.

MARCH 1985

The effects of shading regimes on the growth of cocoa seedlings *(T. cacao)* HARUN, R.M.R. and KAMARIAH, H.I. Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia – *Pertanika (Malaysia) 6* (3) p. 1–5; December 1983.

Cocoa seedlings were grown under full sunlight or under 30,55 or 80 per cent, shade during the first 5 months in the nursery. 80 per cent shade during the first 3 months and gradually reducing shade after that gave optimal dry weight accumulation. This interaction between age and shading regime was brought about by changes in net assimilation rates in response to self shading as the plant aged and also to the effects of leaf production in response to different light intensities. Totally unshaded condition was detrimental to plant growth. Shading practice has to take into account the balance between capacity for leaf production and optimal capacity for assimilation.

Interactions of soil amendments and complex fertilizers. 2. Effects on the growth of cocoa seedlings. SHAHBUDDIN, M.F. and GOH, K.J. Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia – *Pertanika (Malaysia) 6* (3) p. 6–11; December 1983.

Growth parameters – plant height, stem diameter, leaf number and leaf area were assessed at intervals of four weeks up to eighteen weeks. The dry matter yields of leaf, stem, root and their sum were determined at the end of the experiment. Individual applications of the materials used did not enhance growth of cocoa seedlings. However, incorporation of GML and complex fertilizers significantly increased plant height, stem diameter, leaf number and leaf area. Similar effects were obtained for dry matter yields. Liming alone improved root development but not the vegetative dry matter yields. Agrosil treated seedlings showed stunted growth and reduced dry matter yields. The above conditions were improved by the applications of complex fertilizers 12:12:17:2 + TE and 16:18:12:5 + TE.

Cacao. *Revista Cafetalera* – ANACAFE *(Guatemala)* No 237 p. 28–32; December 1983.

The ecological growing conditions of cocoa are similar to those existing in the humid rainforests, i.e. conditions with partial shade, high humidity and the presence of mild humus layers. Climate, soil and fertilizer requirements, the occurrence of deficiencies, the application of leaf fertilizers, the cultivation under shade and pruning systems are reviewed. A highly efficient system of fertilizing is to apply a mulch consisting of cuttings of elephant grass *(Pennisetum purpureum)* or Guinea grass *(Panicum maximum)*, which received the normal dosage of fertilizers.

APRIL 1985

Proof of pathogenicity of *Crinipellis perniciosa* to *T. cacao* by using basidiospores produced in vitro culture. PURDY, L.H., TRESE, A.T. and ARAGUNDI, J.A. Department of Plant Pathology, University of Florida, Gainesville, Florida, USA – *Revista Theobroma* v. 13 (3) p. 157–163; July 1983.

Greenhouse studies, on inoculation of adult cocoa plants with basidiocarps of *Crinipellis perniciosa*, conducted in Brazil showed conclusively that this pathogen causes witches' broom disease in cacao trees.

(Effect of defoliation on the phenological behaviour of shaded and unshaded cocoa trees) Influencia da remocao foliar sobre a fenologia de cacaueiros expostos ao sol e a sombra. LEITE, R.M. DE O. and MULLER, M.W. Divisao de Agronomia e Producao, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (3) p. 203–210; July 1983.

Studies on the phenological behaviour of shaded and unshaded 50 and 12 year old cocoa trees with respect to defoliation, conducted in Bahia show that the intensity of flowering and flushing, both in young and old trees, was greater in unshaded plants. More cherelle wilt in old cacao trees under shade was probably related to lower photosynthetic activity. Defoliation tended to decrease yields in young unshaded trees. Light defoliation apparently benefitted yields of shaded and unshaded cocoa trees.

(Nitrogen requirements in a cocoa agrosystem) Requerimentos de nitrogenio em um agrossistema de cacau. SANTANA, M.B.M. and CABALA ROSAND, P. Divisao de Geociencias, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (3) p. 211–221; July 1983.

Studies on the reutilization of N in the N-cycle of a 17 year old cocoa plantation shaded by *Erythrina fusca*, conducted in Bahia showed that more than 8 tons of plant material per hectare fell on the soil within one year. This is approximately equivalent to 140 kg N/ha representing 6 to 8 times the N content in 1000 kg of dry cocoa beans. Most fallen residue had 50 per cent of its dry matter decomposed within 6–9 months. Data are presented on soil NO_3 and NH_4 in relation to depth time and distance from shade tree trunks.

(Effect of nitrapyrin (N-serve 24 E) on soil nitrification and the growth of cacao plants) Efeito da nitrapirina (N-serve 24 E) na nitrificacao do solo e no desenvolvimento de plantas de cacau. SANTANA, M.B.M. and EZETA, F.N. Divisao de Geociencias, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (3) p. 223–231; July 1983.

A greenhouse study on the effect of nitrapyrin (2-chloro-6 (trichloromethyl) pyridine), conducted in Bahia showed that at concentrations of 10 ppm nitrapyrin nitrification was inhibited and growth of cocoa plants stimulated while nitrapyrin at 50 ppm cause phytotoxic effects to develop.

Factors associated with cocoa bean acidity and the possibility of its reduction by improved fermentation. LOPEZ, A.S.F. Divisao de Tecnologia e Engenharia Agricolas, CEPEC, Itabuna, Bahia, Brazil – *Revista Theobroma 13* (3) p. 233–248; July 1983.

Studies on agents causing cocoa bean acidity conducted in Bahia showed that free acid content, especially acetic acid, are related to pH changes during fermentation. In fully fermented beans (6 days), volatile acetic acid is the principal free acid, with a n-volatile acids less important. In case of only 3–5 day fermentation a reverse situation may occur.

MAY 1985

Studies on cuttings in cocoa. MOHD IDRIS ZAINAL ABIDIN and AZMI BAKAR. Faculty of Agriculture, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia – *Planter 60* p. 111–112; March 1984.

This paper reports the results of experiments on cuttings in cocoa. Cuttings from softwood gave higher percentage rooting compared with semi hardwood. Single leaf cuttings gave a higher percentage rooting than two leafed cuttings. Cuttings which received wax treatment on their cut portion produced higher rooting ability than the control. Although cuttings treated with IBA had higher percentage rooting when compared with NAA, the difference was not significant.

(A study on the cause of die-back in coffee trees) YU, H. Agricultural Research Inst. Dehong, Yunnan, China – *Chinese Journal of Tropical Crops 5* (1) p. 93–104; March 1984.

The results of a study on the cause of die-back in coffee trees are presented. The main cause of die-back seems to lie in carbohydrate deficiency, arising from the depletion of this nutrient due to over-bearing. The root system of the seriously affected plant also displayed acute nutrient deficiency symptoms. The cause of die-back also lies in the coffee trees biological features.

Cocoa nutrition and manuring on inland soils in Peninsular Malaysia LING, A.H. Dunlop Research Centre, Batang Malaka, Negri Sembilan, Malaysia – *Planter* p. 12–24; January 1984.

On inland soils of inherently low fertility, adequate fertilizer applications to cocoa are essential for rapid growth and sustained high yields. N.P.K. and Ca are found to be important for rapid establishment and early production of cacao. In matured cocoa the requirement for K appears to decline, especially when recycling of pod husks is practised. As for N, the needs depend greatly on the environmental situation with rainfall and shade being the main determining factors. There are strong indications that P is continuously required for sustained growth and yield of mature cocoa. The requirement for Mg has not been fully established. An interim integrated approach towards manuring of cacao on inland soils is proposed. The approach takes into consideration factors such as soil type, nutrient uptake in relation to tree age, leaf nutrient level, yield level, type and level of shade and other related agronomic factors.

JUNE 1985

Chemical composition and potential uses of processing wastes from some Nigerian cash crops AWOLUMATE, E.O. Cocoa Research Inst. of Nigeria (CRIN), Ibadan, Nigeria – *Turrialba (IICA)* v. 33(4) p. 381–386; Oct 1983.

The proximate composition of crude protein, crude fibre, ash, sodium, potassium, phosphorus and other trace elements of coffee pulp and parchment, kola pod husk, kola nut testa, cashew-apple pulp, cocoa-bean testa and cocoa pod husk are reported. The samples are high in moisture and crude fibre hence they may be of limited use for direct animal feeding but ensiling could improve their feeding value. The ashes are poor sources of Mn, Cu and Zn but rich in Ca, N, K, Na, P, Fe and Mg. Therefore, they could be useful in the local soap industry or as sources of organic fertilizer. Possible uses as raw materials for the production of pectin, jam and food colours are suggested.

Pink disease of cocoa caused by Corticium salmonicolor Berk. and Br. in Western Samoa SCHNEIDER CHRISTIANS, J., FLIEGE, F.H. and SCHLOESSER, E. University of the South Pacific, Alafua, Western Samoa – *Alafua Agricultural Bulletin (Western Samoa)* v. 8(3) p. 9–19; Nov 1983.

This paper presents the results of 2 field surveys on the occurrence of pink disease in cacao due to Corticium salmonicolor conducted in Western Samoa. Sixty-four per cent of the cacao plantations were found to be infected. Spacing, elevation and shade plant species had no significant effect on infection rate. Infection rate on the south coast was far less than that on the North-western part of the island.

(Acid producing fungi isolated during the fermentation and drying of cacao) Fungos produtores de acidez isolados durante a fermentacao e secagem do cacau ALMEIDA RIBEIRO, N.C. DE and LOPEZ, A.S. Divisao de Tecnologia e Engenharia Agricolas, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Revista Theobroma (Brazil)* v. 13(4) p. 293–301; Oct 1983.

The role of the fungi in the fermentation and drying of cacao with emphasis on acid producing fungi was studied. Fungi were found in relatively small numbers during the entire period of fermentation. Acid producing strains appeared after 24 hours and increased to 5 per cent of the fungal population at the end of fermentation. The growth characteristics of Aspergillus niger in relation to fermentation conditions were examined and the importance of the fungi in relation to preservation of quality is discussed.

("Pinhalense" rotary drier utilization as a new option for cacao drying) Utilizacao do secador rotativo "Pinhalense" como nova opcao na secagem de cacau CUNHA, J., MCDONALD, C.R. and FREIRE, E.S. Divisao de Tecnologia e Engenharia Agricolas, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Revista Theobroma (Brazil)* v. 13(4) p. 303–313; Oct 1983.

A rotary dryer, type S.T.R. 2700, originally used for coffee, was modified and used for cacao drying. The dryer has a static capacity of 2700 kg of freshly fermented cacao

beans and can produce 1350 kg of dry beans in 38–42 hours at a temperature of about 60°C. The heat source is the wood that is burned in a furnace and heats the drying air indirectly, eliminating smoke contamination – consuming 0.88 kg of wood per kg of dry beans. Construction, operation and cost details are given and limitations of use relative to the southern Bahia cacao farms are also mentioned.

Metodologia para avaliar resistencia de cultivares a progenies hibridas de cacau a Phytophthora spp. que causam podridao-parda na Bahia LAWRENCE, J.S. Divisao de Fitopatologia, Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Revista Theobroma (Brazil)* v. 13(4) p. 349–359; Oct 1983.

On the basis of experience gained from recent work at the Cacao Research Center (CEPEC), Ilheus, Bahia, Brazil, methods are recommended for evaluating resistance of cacao cultivars and hybrid progenies to Phytophthora spp. both in routine screening for resistance and in studies on the inheritance of resistance. Detailed descriptions of these techniques are provided as a practical guide for other workers.

(The role of Phytophthora palmivora in the cacao cultivation in the North Sumatra) Peranan jamur Phytophthora palmivora pada budidadya tanaman coklat di Sumatera Utara PARNATA, Y. – *Buletin Balai Penelition Perkebunan Medan (Indonesia)* v. 14(2) p. 53–57; Jun 1983.

Phytophthora palmivora exhibits more or less the same phenomena in rubber as in cacao in North Sumatra, in that certain plantings do escape specific appearances of a Phytophthora disease. New Phytophthora strains may have been formed, which could affect the tolerance characteristics of the plantings. The control of the Phytophthora disease has so far been based on the life characteristics of the fungus and on integrated approach such as by integrated sanitary and agronomic measures.

(A method for the evaluation of the production of fresh beans applicable to completely randomized trials) Une methode d'evaluation de la production de feves fraiches applicable aux essais entierement randomises LAUCHENAUD, P. Station Centrale, Institut de Recherches du Cafe et du Cacao, Divo, Ivory Coast – *Cafe, Cacao, The (France)* v. 28(2) p. 83–88; Apr 1984.

After a brief description of the two methods used at present for the evaluation of production, one based on a count of pods, the other on the weight of fresh beans, the author presents a new method based on the weight of pods. This method, in which it is proved that the production of fresh beans can be modelised, enables the labour needs on completely randomized plots to be reduced considerably and valuable information to be used in cacao breeding to be obtained.

(Variations in the abundance of Pseudococcines, vectors of the swollen shoot disease in Togo) Variations d'abondance de pseudococcines vectrices de la maladie du swollen-shoot au Togo NGUYEN BAN, J. Institut de Recherches du Cafe et du Cacao, Yaounde, Cameroon – *Cafe, Cacao, The (France)* v. 28(2) p. 103–110; Apr 1984.

The populations of the two most common vectors of swollen shoot disease of cacao in Togo, i.e. Planococcoides njalensis and Pseudococcus kenyae were studied at two sites. On young plantations, P. kenyae was found to be the dominant species, and P. njalensis on adult plantations. P. njalensis is rife in the dry season while P. kenyae populations increase in the wet season. The distribution of P. njalensis is, because of its mode of life, in aggregates while the more mobile P. kenyae has a random distribution.

(Factors determining the localization of black pod disease lesions of the cocao tree (Theobroma cacao) 2. Determinisms involved) Facteurs determinant la localisation des lesions de pourriture brune des cabosses du cacaoyer (Theobroma cacao). 2. Determinismes impliques BABACAUH, K.D. Ecole Nationale Superieure Agronomique, Abidjan, Ivory Coast – *Cafe, Cacao, The (France)* v. 28(2) p. 111–122; Apr 1984.

Anatomical, morphological and physiological changes in space and in time largely explain why black pod disease (Phytophthora spp.) invades more readily the distal parts of young cacao pods, and the flanks of older pods.

Cushion galls of cocoa in India CHANDRA MOHANAN, R., SUBRAMONIAN, N. and BALASIMHA, D. Regional Station, Central Plantation Crops Research Inst., Vittal, Karnataka, India – *Journal of Plantation Crops (India)* v. 12(1) p. 23–29; Jun 1984.

During a survey of cacao gardens in South India, cushion galls were observed in the Trichur District (Kerala State). Based on symptomatology they were identified as fan galls and knob galls. The etiology of these galls is yet to be established. Attempts to transmit these disorders were unsuccessful. In a pod collected from a normal cushion of a fan gall affected tree, only 50 per cent of the beans were normal and healthy. The abnormal beans failed to germinate. Anatomical peculiarities of knob galls and biochemical basis of hyperauxinity in gall tissue were investigated.

JULY 1985

Phytophthora associated with cocoa (Theobroma cacao L.) in South Kanara District, Karnataka, India SREENIVASAN, T.N. and MOHANAN, R.C. Cocoa Research Unit, University of the West Indies, St. Augustine, Trinidad and Tobago – *Tropical Agriculture (Trinidad and Tobago)* v. 61(3) p. 186–187; Jul 1984.

Studies to identify the Phytophthora associated with cacao in the south Kanara District, Karnataka, India, showed the presence of only one species of Phytophthora. From the sporangial morphology of the various isolates it is concluded that P. palmivora is the pathogen associated with cacao in south Kanara.

Cocoa drying: a review MCDONALD, C.R., LASS, R.A. and LOPEZ, A.S.F. Centro de Pesquisas do Cacau (CEPEC), Itabuna, Bahia, Brazil – *Planter (Malaysia)* v. 59(693) p. 557–593; Dec 1983.

This review attempts to provide a complete picture of cocoa drying theory and equipment and to reconcile the often divergent views of the biochemist and the engineer. The theoretical aspect of drying and end-product quality are covered first, followed by a discussion on the advantages and disadvantages of each drier type with reference whenever necessary, to the appropriate theoretical aspects. Some illustrations of the various types of driers are included.

Effects of pruning on Amelonado cocoa in Fiji MARTIN, M.P.L.D. and PRASAD, G. Research Div., Department of Agriculture, Suva, Fiji – *Fiji Agricultural Journal (Fiji)* v. 45(1) p. 7–12; June 1983.

A pruning experiment commenced in 1968 on hitherto strictly pruned 10-year-old Amelonado cacao at Waimaro, in eastern Viti Levu, Fiji was continued from 1974 to 1982. Throughout this 9-year-period discretionary pruning, where 2–3 basal chupons were allowed to grow in addition to the main stem, gave appreciably greater potential and actual yields than strict pruning, no pruning and continued vertical growth from the first jorquette. No pruning gave a higher potential yield than strict pruning, though there was no difference in actual yield. Unpruned cacao had the highest % black pod loss, and strictly pruned cacao the least. Discretionary pruned and unpruned cacao were more susceptible to hurricane damage, but recovered earlier and better than the more strictly pruned cacao. The possible reasons for these differences and the advantages of discretionary pruning over the other methods of pruning are discussed.

Preliminary investigations into the chemical control of the cocoa moth podborer Acrocercops cramerella Snellen., in Sabah SIDHU, M. Hap Seng Plantation Sdn Bhd., Tawau, Sabah, Malaysia – *Planter (Malaysia)* v. 60(699) p. 228–242; Jun 1984.

Deltamethrin, cypermethrin, fenvalerate, propoxur and 8-BHC, when applied to the resting and ovipositing sites of the adult moth, reduced podborer infestation and yield losses. Particularly deltamethrin and propoxur, applied in 4 or 5 consecutive sprays at intervals of 10–14 days were highly consistent in performance. Cost effectiveness of the treatments at various yield levels and preliminary recommendations on the use of the technique are presented.

Coppicing experiments on the spread and control of cocoa swollen shoot virus in Ghana LEGG, J.T., LOVI, N.K. and OLLENNU, L.A.A. Cocoa Research Inst., New Tafo-Akim, Ghana – *Crop Protection (UK)* v. 3(3) p. 289–304; Sep 1984.

In Ghana, a coppicing technique was used in cacao to determine the incidence and distribution of latent and missed infection with swollen shoot virus in and around naturally occurring outbreaks. When apparently healthy trees were coppiced within at least 27 m of trees found infested, some failed to regenerate. Many of the regenerating shoots developed stem and/or leaf symptoms of swollen shoot disease within 3 years of coppicing. These and other results reported emphasize the limitations of routine inspections and will influence the eradication measures adopted in Ghana.

AUGUST 1985

(Contribution to the development of the chemical control of cocoa black pod disease in Togo: studies on the possibilities of using metalaxyl) Contribution a la mise au point de la lutte chimique contre la pourriture brune des cabosses du

cacaoyer au Togo: etude des possibilites d'emploi du metalaxyl DAVOUS, M.P., DJIEKPOR, E.K. and CILAS, C. Institut de Recherches du Cafe et du Cacao (IRCC), Montpellier, France – *Cafe, Cacao, The (France)* v. 28(3) p. 191–202; Jul 1984.

Fungicide trials carried out in Togo have demonstrated the efficacy of metalaxyl (Ridomil 25) against Phytophthora palmivora and P. megakarya. The risk of the development of resistant strains of the two diseases is smaller for P. megakarya than for P. palmivora. Copper in combination with metalaxyl prevents the appearance of resistant strains. Metalaxyl at 0.4 g/l combined with copper at 2 g/l applied every 21 days provided protection equivalent to that offered by 0.5 g/l, also applied at 21-day-intervals.

(Eleven years of cacao renovation at the Cacao Research Centre of Bahia) Renovacao de cacaueis; onze anos de observacao de fazenda unitaria do Centro de Pesquisas do Cacau, Bahia FERREIRA, H.I.S., TREVIZAN, S.O.P. and SOUZA, J.P. DE Divisao de Ciencias Sociais e Estatistica, Comissao Executiva do Plano da Lavoura Cacaueira (CEPLAC), Itabuna, Bahia, Brazil – *Boletim Tecnico – Centro de Pesquisas do Cacau (Brazil)* no. 119, 86 p. 1983.

The economic and social aspects of renovation of cacao plantations was examined. The economic evaluation consisted of 2 types of methods: the first used the typical year (break-even point) and, the second considered the evolution of capital in time, with present (discounted) value, benefit-cost ratio and internal rate of return as criteria. Two different methods of renewal were studied for 11 years in 5 renovated areas. The outcome in each area reflects the contribution of the three major factors of agricultural production – genetics, environment and management. The results of the area were analysed according to the criteria; neither method was indicated as superior. The social analysis was based on the use of manpower as well as the maintenance of the areas. From these bases useful coefficients were calculated for the planning and administration of the production in a cacao plantation.

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