COCOA GROWERS' BULLETIN

Number 1 August 1963

Contents

Cadbury Brothers Limited
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Introducing "Cocoa Growers' Bulletin"

The Directors of Cadbury Brothers Ltd. have always been aware of the dependence of those who manufacture and sell Chocolate products upon those who grow Cocoa.

This product of tropical agriculture, because of its unique qualities as an edible bean, is essential in our manufacturing process. Those who grow it know little of what happens in the market where it is sold, and while we, the buyers and processors, engrossed in our own job, do not give over much thought to the difficulties of the prime producer, we have many contacts with other manufacturers. The producer, however, is often isolated, not so much by geography as by the lack of facilities for contact with his fellows — particularly those in different continents.

This Bulletin is an endeavour to put the matter right. We hope to be able to let planters know at least something of what is going on in the cocoa world. We shall concentrate on agricultural matters, but we do hope also to deal with all aspects of our industry, in the belief that what will interest one section will also be valuable information to others.

John Cadbury

Editorial

Mr. John Cadbury has explained the purpose of this Bulletin in his preface. We shall concentrate on agricultural matters as we believe there is at present no ready means by which cocoa growers can learn the results of research or of developments in other cocoa-growing countries. We shall try to cover these subjects and to include practical information on subjects such as artificial driers, spraying machines and costs.

On the other side, that of the manufacturers and the market, we shall not attempt any forecasts of production, consumption or prices, nor shall we make any detailed record of market movements as such information is fairly generally available. We shall, however, review the production and consumption position and deal with any major changes in the market (such as a price stabilisation scheme). In addition we shall describe any other aspects of the manufacturing side that seem to be of interest.

The Bulletin will be published twice a year. We hope it will be useful, but we shall not know whether we are achieving our object unless we hear from our readers. We invite your comments and suggestions, therefore, on any aspect of this publication. Correspondence should be addressed to:

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Review of Cocoa Consumption, Production and Prices

S. L. Hale, Cadbury Brothers Limited

Consumption

The outlook for consumption of raw cocoa is very promising because it is confidently estimated that world use, which increased from 833,000 metric tons in 1958 to 1,109,000 metric tons in 1962, will go on increasing at the rate of about 4 per cent per annum.

There are several reasons behind this encouraging outlook. It has long been recognised that cocoa and chocolate are important foodstuffs, and in countries which already enjoy a high standard of living, consumption of beans tends to rise as the living standard goes even higher. In countries where the standard of living is not so high, there is a great potential expansion as incomes and spending power increase. Furthermore, world population is increasing so rapidly that it is expected to be double the present figure by the end of the century. The greater part of this increase may be in under-developed countries but may also be considerable in those countries which have a higher standard of living. This population factor alone argues an increasing cocoa consumption.

In looking at the use of cocoa, country by country, it is now customary to consider *grindings* of beans, i.e., the quantity of raw cocoa which is actually processed. The figures do not necessarily reflect *consumption* of cocoa products in the countries concerned, as they ignore imports and exports of cocoa butter and cocoa powder. For example, Holland's steady increase in grindings is mainly due to an increase in exports of butter and powder, while the U.K's increased grinding figure in 1962, compared with the three previous years, was due to U.K. manufacturers switching from buying butter to making it, an operation which depends upon the bean/butter price ratio.

Set out below are the grinding figures for the countries which are currently absorbing more than 20,000 tons of beans per year. The figures are in thousand metric tons.

GRINDINGS

	1958	1959	1960	1961	1962	1963 (forecast)
Brazil	55·05	65·0	62·0	46·0	52·9	50·0
Colombia ..	18·0	20·0	20·4	22·5	23·0	24·8
Dom. Rep. ..	10·1	12·0	14·8	25·0	20·0	20·0
France	53·8	49·8	52·5	60·5	65·0	70·0
German F. R. ..	90·0	95·0	109·0	116·0	125·0	130·0
Ghana	3·1	8·0	4·0	9·0	24·0	25·0
Holland	63·6	73·7	84·8	100·0	103·0	110·0
Italy	22·0	26·6	28·1	36·0	36·0	38·0
Japan	5·9	7·3	9·4	15·6	24·0	27·0
Spain	20·8	20·1	21·1	23·3	23·4	26·0
U.K.	96·0	74·1	75·2	81·5	95·4	101·0
U.S.A.	209·6	205·1	218·9	245·1	254·4	265·0
U.S.S.R. ..	20·0	26·9	30·0	40·0	45·0	50·0
World	833	854	921	1,026	1,109	1,168

Production

During the period for consumption we have reviewed there has also been an increase in cocoa production, but whereas the consumption figure has moved up every year, the production figures for the past two seasons show a decline of about 50,000 tons and, in fact, the production for 1962/63 is expected to be about 50,000 tons less than the estimated consumption in 1963.

The substantial increase in production since 1958 has been concentrated mainly in West Africa, especially in Ghana and Nigeria. On the other hand Brazilian production appears to be declining, the 1962/63 crop being 51,000 tons lower than that of 1957/58.

The increase in Ghana and Nigeria is due in large measure to the vigorous attempts to control losses by pests and diseases, notably capsids and black pod, but other factors such as good weather and the introduction of higher yielding varieties have also contributed.

We set out below, in thousand metric tons, production figures for the five largest countries concerned together with world totals, for crop years since 1957/58.

PRODUCTION

	1957/1958	1958/1959	1959/1960	1960/1961	1961/1962	1962/1963 (forecast)
Ghana ..	209·8	259·5	321·9	439·0	415·0	420·0
Nigeria ..	76·8	136·6	151·4	189·2	193·8	175·0
Brazil ..	162·0	174·0	199·0	122·0	118·0	103·0
Ivory Coast	45·4	55·7	61·8	93·6	81·0	98·0
Cameroon (inc. Brit.)	70·4	66·2	69·8	81·6	78·0	76·0
World ..	768	903	1,035	1,165	1,124	1,124

There are various reasons for the decline in world production during the past two years, weather conditions in Brazil have been unfavourable during these two seasons, and one disturbing feature of the Brazilian 1961/62 crop was the abnormally small beans. It is also possible that there has been less vigorous action against pests and diseases in other countries. It has been reported that on some farms in Ghana capsids have shown resistance to the insecticide which has been used for their control, and it also appears that farmers in some areas have not been as thorough in their spraying as they were initially.

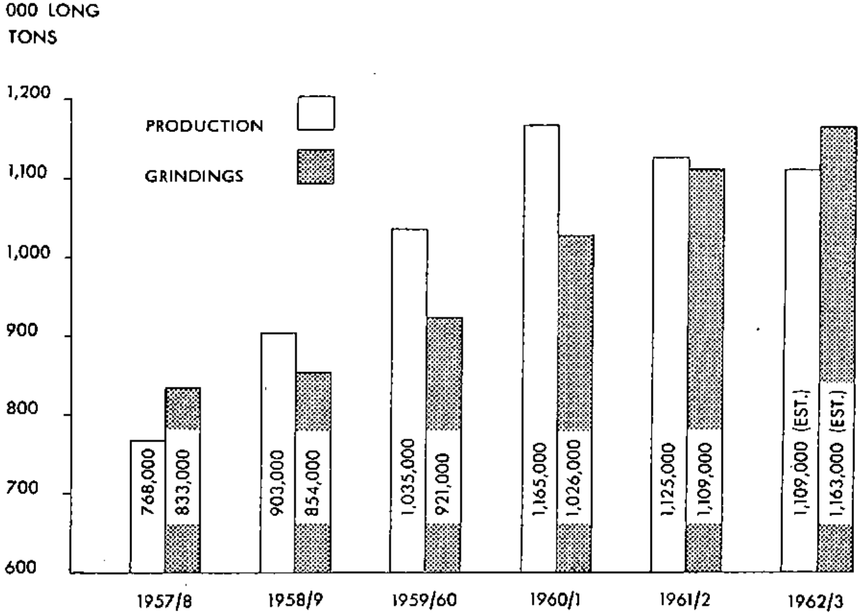
Prices

Violent fluctuations in cocoa prices are no good to either producers or consumers, and the possibility of levelling these has been under consideration at several meetings of the F.A.O. Cocoa Study Group at which representatives from producing and consuming countries have made known their respective Government's ideas.

At the end of the last meeting in Trinidad, in March 1963, the following resolution was adopted.

> "*Recognizing* the desirability of achieving, through the conclusion of a Cocoa Agreement, the objectives set out in Article 1 of the Draft International Cocoa Agreement;

WORLD PRODUCTION AND GRINDINGS OF RAW COCOA
1957/58 – 1962/63



> *Considering* that the scheme laid down in the Draft International Cocoa Agreement arrived at by the Group at its present Session constitutes a point of departure for negotiating an International Cocoa Agreement;
> Agrees that a United Nations Negotiating Conference on an International Cocoa Agreement should take place in the course of 1963;
> *Requests* the Director-General of the Food and Agriculture Organization to arrange with the Secretary-General of the United Nations for the convening of the Negotiating Conference".

The prices which are to be written into an agreement have not yet been discussed. Some producing countries, notably Ghana and Nigeria, look to cocoa earnings to provide money for large-scale development plans. On the other hand, consuming countries are concerned lest the price be so high that consumption is affected. What is really required, therefore, is a price range which will prevent the market falling to a level which is disastrous for the producer, and going so high that it will be harmful to both producer and consumer. We await with much interest the outcome of the Negotiating Conference which is expected to be held in Geneva in October.

Statistics

Reference is made above to the work of the F.A.O. Cocoa Study Group. In addition to considering a price stabilisation scheme the Group has from time to time issued cocoa statistics submitted by both producing and consuming countries. These statistics are published quarterly and the figures used in this review have been taken from this source.

Amazon Cocoa

G. A. R. Wood, Cadbury Brothers Limited

Origin

The Amazon varieties of cocoa form one of the most useful types for the grower and the plant breeder. For the grower they offer high yields and early bearing; to the plant breeder they are a source of parents for the next generation of improved planting material.

The Amazon varieties — also referred to as Upper Amazons or Amazonians — originate from the upper reaches of the Amazon and its tributaries. The story behind the introduction of the varieties goes back to the 'thirties when the cocoa estates of Trinidad were suffering from Witches' Broom disease. This disease, which is indigenous to the Amazon valley, spread to Trinidad in 1928. It was soon apparent that the best long-term method of combating this disease was to find resistant or immune varieties. So it was to the upper Amazon valley that Dr. Pound went in search of such trees. As a result of two expeditions a large amount of material was introduced to Trinidad, where two varieties, SCA6 and 12, were found to be virtually immune, and another, IMC 67, highly resistant to the disease. The introductions were, therefore, invaluable to Trinidad on this score alone, but they have proved to have other characteristics which have made them valuable to other countries as well, and in this article we are concerned with the use of Amazon cocoa by cocoa growers generally.

Introduction to West Africa

In 1944 Dr. Posnette, then botanist at the newly-formed West African Cocoa Research Institute at Tafo, went to Trinidad to gather planting material. There he made a collection which included many of Pound's introductions and in addition some Trinidad selections, a number of Criollo cocoas from Central America, and other types from the lower Amazon. All these were dispatched to West Africa as pods. Some of them had resulted from open-pollinations; i.e., the male parents were unknown. Others were the result of hand pollinations, deliberate crosses that Posnette made between various Amazon varieties. The letters SCA and IMC refer to two places, Scavina and Iquitos, at which Dr. Pound made selections. He also made selections along the rivers Nanay and Parinari, and most of Posnette's crosses were between trees originating from these two rivers and from Iquitos. Each pod introduced was given a number prefixed by the letter 'T', so that each type, e.g., the Amazon type T60, has arisen from the seeds of one pod.

After quarantine, the seedlings were planted at Tafo in a trial which included some Amelonado selections. It was soon apparent that the Amazons, particularly those that had resulted from hand pollinations, were more vigorous than the other types and nearly all the introductions gave higher yields than the Amelonado selections.

Yields in Ghana

The yields of the Amazon and Amelonado varieties during the early years were:—

	Yields in lb. per acre			
Year	4	5	6	7
Amelonado selection	0	137	262	287
9 Amazon types	156	470	795	992

Harvesting the crop from a three-year-old Amazon tree.

Three-year-old Amazon trees, Ikiliwindi, West Cameroon.

These yields are calculated from the yields of roughly 25 trees of each type planted at a spacing of 14′ × 14′.

The following figures of yields have been given by McKelvie and Glendinning (2):—

Total Number of Pods per Tree From Planting in 1945 *to End of* 1958–59 *Season*

AMAZON	T12	571 pods	T76	530 pods
	T60	684 pods	T79	578 pods
	T63	436 pods	T82	379 pods
	T65	301 pods	T85	367 pods
	T72	346 pods	T87	289 pods
	T73	303 pods		
AMELONADO		175 pods		

As a result of the early indications of vigour, the seed from these trees were distributed to the Departments of Agriculture in Ghana and Nigeria in order to form nurseries which could provide a supply of seed at a later date. The various Amazon types were tested for quality, particularly bean size and flavour and, as a result, ten of them — T60, 63, 65, 72, 73, 76, 79, 82, 85 and 87 — were approved for general distribution in 1954. A further type, T12, was approved in 1957.

The yield figures may not appear to be particularly high nor to indicate unusally early bearing, but this may be accounted for by the spacing and shade conditions used in these early trials. The spacing used in the introduction trial at Tafo was 14′ × 14′, and spacing trials at Tafo and elsewhere have shown that this is not the spacing at which yields are highest, particularly for Amelonado types. Furthermore, yields are slow to reach their maximum at this wide spacing owing to the small number of trees per acre.

At the time this trial was undertaken, it was the usual practice to shade cocoa heavily. Recent experiments have shown that less shade during development and no shade when the canopy is complete can, under suitable conditions, result in far quicker growth and higher yields.

With a closer spacing and different shade conditions growth would have been more rapid and yields higher, but this would not have invalidated the conclusions drawn from the first trial. One would still expect the Amazon to develop more quickly, and yield earlier. Under really favourable conditions the difference in ultimate yield of the two types may well be small, but under less favourable conditions the vigour of the Amazons shows up in comparison with other types.

Yields in other Countries

At Ikiliwindi in the Cameroons, the local planting material — a Trinitario type — has been found to be much less vigorous than Amazon material, as the following figures show:—

	Local Trinitario	*Amazons*
	(Potential yields, lb. per acre)	
4 year old	25	260
5 year old	190	350

In Malaya, too, Amazons have proved to be superior to Amelonado. Haddon (1) has published the following figures:—

YIELD OF CACAO ON A TRENGGANU ESTATE
(lb./acre dry cocoa)

Variety	Date of Planting	Age from planting — years				
		3rd	4th	5th	6th	7th
Amelonado	1953/54 (55 acres)	0	0	20	184	408
	1954/55 (79 acres)	0	4	75	205	—
	1955/56 (288 acres)	0	5	40	—	—
	1956/57 (43 acres)	5	—	—	—	—
Upper Amazon	1955/56 (5 acres)	13	224	591	—	—
	1956/57 (21 acres)	26	272	—	—	—
	1957/58 (18 acres)	52	—	—	—	—

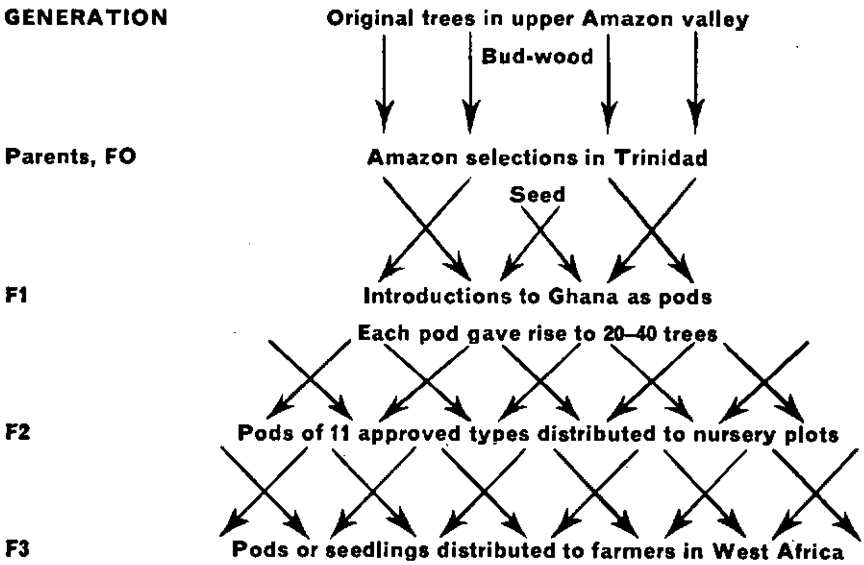
The data that has now been collected show that Amazon types are more vigorous than Amelonado and some local Trinitario types, coming into bearing earlier and yielding more heavily. The value of this to the farmer needs no emphasis.

Distribution of Amazon Types

Since 1954, when approval of certain Amazon types was given by manufacturers, several million pods and seedlings have been distributed to farmers in

Ghana and Nigeria, and the Amazon varieties have been introduced to other countries in East Africa and the Far East. The pods distributed to farmers are the grandchildren or, more commonly, the great-grandchildren of the original parents in Trinidad and are referred to as belonging to the F2 or F3 generations. The following diagram may make the relationship clearer.

GENERATIONS OF AMAZON VARIETIES



Quality

The quality of Amazon types has sometimes been questioned; this aspect has been fully investigated and it is possible to summarise the present position.

Bean Size. Some of the Amazon types produce beans smaller than the minimum standard of 1 gram dry weight recommended by manufacturers. The smallest beans were found among some of the Nanay and Parinari types; these were not recommended for distribution. The Scavina type T12 was also rejected in the first place because of small bean size, but further studies revealed an improvement and the type was subsequently accepted.

Several shipments of Amazon cocoa have been examined at Bournville and have given the following figures of bean size:—

1958/59	..	0·88 gm.
1959/60	..	1·09 gm.
1960/61	..	1·11 gm.

The figure for 1958/59 was well below 1 gram, but it was found that Amelonado cocoa beans produced in Ghana at the same time were of small size.

Fat Content. This factor varies considerably within the full range of Amazon types. Bulk samples have given the following data:—

1958/59 crop	..	59·5%
1959/60 crop	..	57·4%

This indicates a rather higher fat content than for Amelonado — 56·1 per cent is a typical figure for Ghana cocoa — but this advantage is offset to some extent by a higher shell percentage. (In these figures fat content is expressed as a percentage of the dry weight of the cotyledon.)

Flavour. Bulk samples of Amazon cocoa have given a chocolate which is fully acceptable, and Amazon beans are considered equal to normal West African beans. This is not intended to disguise the fact that differences in flavour do occur, but these differences are small and not consistent.

Such then are the main characteristics of Amazon cocoa. These varieties have proved an invaluable introduction to West Africa and are the first stage in the improvement of planting material. They might be criticised for their variability, but it is this very factor which makes Amazons as a whole so valuable to the plant breeder in producing even better planting material for a second stage. Having analysed the Amazon population, he can select the types which have the required characteristics and attempt to combine them by cross-breeding. When Amazons are crossed with other types of cocoa, the progeny frequently exhibit hybrid vigour, being more vigorous than either parent.

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1. Haddon, A. V. *Malayan Agricultural Journal* 43.3.1961. 'Variety Trials of Serdang Cacao in Malaya'.
2. McKelvie, A. D. and Glendinning, D. R. *Agriculture and Land Use in Ghana* 262.

What Shade and Fertilisers are Needed for Good Cocoa Production?

R. K. Cunningham, Rothamsted Experimental Station, Harpenden, Herts.

EDITORIAL NOTE
Mr. Cunningham worked on cocoa in Ghana and he describes the results of experiments conducted there. It should be emphasised that these results and the recommendations based on them are restricted to West Africa.

Cocoa growers are showing an increasing interest in the manipulation of shade and the use of fertilisers. As a result, agronomists and soil chemists have been asked to provide information about the best shade and the most efficient manuring for cocoa. Both questions are difficult to answer until future methods of cultivation have been decided by the cocoa-growing countries. It may be decided to continue with the present system of growing small-yielding cocoa trees under heavy shade, adopting new ideas only when they interfere little with current methods. Alternatively it may be profitable to change to growing larger-yielding unshaded trees on clear-felled land, using fertiliser and so producing the same amount of cocoa as at present on less land and with fewer workers.

The success of either decision will depend on how profitable the method is to the grower. Unfortunately there is less information about production costs and levels, times and frequency of fertiliser applications for cocoa than for any other tropical perennial crop. In this article the price of cocoa paid to the grower is assumed to be 1s. 0d. per lb. dry cocoa, and the profits to be expected by the grower in three different systems of cultivation are assessed by using the most recent published estimates of fertiliser, harvesting and processing costs in West Africa, where more than half the world's supply of cocoa is produced (Table 1). Although the assessments are approximate they do show which methods are worth while.

1. Shaded, very low-yielding cocoa

This category of cocoa is usually grown on a smallholding of five acres with standard capsid spraying and routine inspection for swollen shoot and cutting out of infected trees. The average yield on such farms in Ghana is 250 lb. dry cocoa per acre (8) and the profit per acre (£7 12s. 0d.) to be expected without using fertiliser is shown in Table 2.

Shade

Little is known about the effects of removing some or all of the shade trees from cocoa cultivated like this. However, damage by falling trees, invasion by weeds, soil degradation by exposure to sun and rain, introduction of new pests and the possibility of a prolonged dry season are all very serious dangers when shade is removed from randomly planted cocoa growing under irregularly spaced forest trees. Unless growers of this category of cocoa give more attention than now to husbandry, thus increasing their production costs, they would be well advised to leave their shade unchanged.

TABLE 1

PRODUCTION COSTS

	Operation.	Cost. £ s. d.	Ref.
1.	Establishment on clear-felled land (from felling forest to planting cocoa)/acre	100 0 0	1
2.	Production* (maintenance, harvesting, processing) ..	0 0 3½	14
	Production of 1-lb. dry cocoa — average smallholder ..	0 0 5½	est.
	Production of 1-lb. dry cocoa — good smallholder ..	0 0 7	est.
	Production of 1-lb. dry cocoa — clear-felled land		
3.	Estimated cost of thinning shade by poisoning/acre/annum	2 0 0	est.
4.	Standard spraying against capsids/acre/annum	1 5 0	7
5.	Intensive spraying against capsids and *Earias* on clear-felled land/acre/annum	6 19 0	2
6.	Fertilisers:		
	Urea (46 per cent N) cwt. landed	1 12 6	
	Triple superphosphate (47 per cent P_2O_5)/cwt. in	1 7 0	11
	Potassium sulphate (48 per cent K_2O)/cwt. Ghana	1 2 0	
	Internal transportation, distribution, application/cwt./acre	0 8 0	

*Additional maintenance, harvesting and processing costs caused by responses to removing shade or applying fertilisers are estimated at 25 per cent of these costs.

Fertilisers

Only recently has it been shown in Ghana that fertilisers can improve yields when cocoa is grown under shade (4, 5). The initial increases in yield of 20–30 per cent under shade resulted from applying 60–100 lb. P_2O_5/acre/annum broadcast in April-May at the beginning of the main rains, but more recent results show that the same responses can be obtained from 40 lb. P_2O_5/acre/annum (13). As yet there have been no responses to nitrogen, potassium, magnesium or calcium under shade. If it is assumed that a yearly application of 1 cwt. triple superphosphate (47 per cent P_2O_5)/acre can produce a response of 25 per cent, the profit from fertiliser, calculated from Table 2, would be £1 2s. 0d. per acre. This small profit is probably not attractive enough to encourage growers to use fertilisers, and emphasises that fertilisers are not a substitute for good care and maintenance, and should not be expected to convert a badly run farm yielding little into one that is productive. When fertilisers are not used on farms with small yields, there is little danger of the soil being drained of nutrients, because small cocoa crops remove few nutrients, which probably accounts for the absence of obvious nutritional problems in the past.

2. Shaded, good-yielding cocoa

Cocoa farms in this class are in regions where the dry season is short and not too severe and are on better soils than those already mentioned; the cocoa trees are still randomly planted and grow under forest trees, but production costs are higher because the cocoa is given more care and maintenance, including regular weeding and harvesting. Good farms produce 500 to 1,000 lb. dry cocoa/acre and, with a yield of 750 lb. dry cocoa/acre, under full shade and without fertilisers a profit of £19 1s. 0d. per acre is possible (Table 2).

TABLE 2

Profits per acre on three types of cocoa farm or plantation

Type of farm or plantation		Expenditure: Production costs: Normal	Expenditure: Production costs: Extra	Expenditure: Spraying	Expenditure: Fertiliser including application, etc.	Expenditure: Thinning shade	Income: Normal yield	Income: Yield increase	Profit per acre
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Average small-holding, heavy shade (normal yield 250 lb. dry cocoa/acre)	no fertiliser	3 13 0	—	1 5 0	—	—	12 10 0 (250 lb.)	—	7 12 0
	fertiliser	3 13 0	5 0†	1 5 0	1 15 0	—	12 10 0	3 2 0 (62 lb.)†	8 14 0
Good small-holding (normal yield 750 lb. dry cocoa/acre)	heavy shade, no fertiliser	17 4 0	—	1 5 0	—	—	37 10 0 (750 lb.)	—	19 1 0
	shade thinned by one-third, no fertiliser	17 4 0	1 9 0‡	1 5 0	—	2 0 0	37 10 0	12 10 0 (250 lb.)‡	28 2 0
	heavy shade, fertiliser	17 4 0	1 2 0*	1 5 0	1 15 0	—	37 10 0	9 8 0 (188 lb.)*	25 12 0
	shade thinned by one-third, fertiliser	17 4 0	1 9 0‡ (thinning shade) 1 9 0§ (fertiliser)	1 5 0	1 15 0	2 0 0	37 10 0	12 10 0 (250 lb.)‡ (thinning shade) 12 10 0 (250 lb.)§ (fertiliser)	37 8 0
Clear-felled land¶ (normal yield 1,500 lb. dry cocoa/acre)	no shade, no fertiliser	43 15 0	—	6 19 0	—	—	75 0 0 (1,500 lb.)	—	24 6 0
	no shade, fertiliser	43 15 0	3 17 0§§	6 19 0	11 16 0	—	75 0 0	26 5 0 (525 lb.)§§	34 18 0

†Response to fertiliser under heavy shade: 25 per cent of 250 lb. = 62 lb.

‡Response to thinning shade by one third: 33⅓ per cent of 750 lb. = 250 lb.

*Response to fertiliser under heavy shade: 25 per cent of 750 lb. = 188 lb.

§Response to fertiliser under thinned shade: 25 per cent of 1,000 lb. = 250 lb.

§§Response to fertiliser without shade: 35 per cent of 1,500 lb. = 525 lb.

¶The initial outlay of £100 per acre to establish young cocoa on clear-felled land is not included in the table.

Shade

Experiments at WACRI showed that when forest shade, which was till then accepted as the best for cocoa in Ghana, was diminished, yields increased in approximately the same proportion as the shade was reduced. Forest shade could be lessened by one third without exposing the cocoa and the soil too much to the bad effects already described. Although maintenance and production costs were more, the increase in income (£9 1s. 0d. per acre) from the cocoa crop, which was approximately one third greater, made thinning of shade profitable (Table 2).

Fertilisers

There is no evidence in West Africa that shaded cocoa, yielding around 750 lb. dry cocoa per acre, requires any fertiliser except the superphosphate already mentioned. The profits per acre to be expected from broadcasting 1.0 cwt. triple superphosphate over entire cocoa plots under deep shade (£6 11s. 0d.) and thinned shade (£9 6s. 0d.) have been calculated from Table 2 and are good enough to make the use of fertiliser, particularly under thinned shade, attractive to growers.

3. Smallholding co-operatives or plantations

Shade

Very spectular increases in yield, two-fold or more, were obtained in Ghana when cocoa was grown without shade (3) and unshaded cocoa also yielded better in Trinidad (9). Therefore it may be tempting for a large co-operative group of smallholdings or for a plantation to grow cocoa in full daylight. However, injudicious removal of shade on a large scale would probably lessen rather than increase yields because it would probably lead to more weeds, soil degradation, new pests and defoliation during the dry season. If growers do decide to grow unshaded cocoa, they would be well advised to replant on clear-felled land in straight lines at a spacing which ensures a complete cocoa canopy, rather than remove the shade from old, randomly planted cocoa growing under large forest trees.

Some of the techniques of clearing and planting have been successfully tested (1, 2) and the initial outlay per acre for the period from clearing to planting of young cocoa is approximately £100. Until more is known about clearing techniques and about growing unshaded cocoa, it may be wise to split the co-operative or plantation up into a chessboard pattern containing plots of 5 to 10 acres with unshaded cocoa plots alternating with plots having thinned shade. The profit (£24 6s. 0d. per acre) from unshaded cocoa on clear-felled land without fertiliser, assuming a yield of 1,500 lb. dry cocoa/acre, is less than that (£28 2s. 0d. per acre) from cocoa growing under thinned shade (Table 2) mainly because of the large increases in production costs. These additional production costs may be over-estimated in this article but, apart from this, growers may consider that the return is not enough to justify the extra outlay and effort.

One benefit of growing unshaded cocoa that may help to offset these disadvantages is that it starts bearing in 2 to 4 years after planting (6), compared with 5 to 10 years for heavily shaded cocoa.

Fertilisers

Removing shade as well as giving greater yields also increases and changes the nutrient requirements of the cocoa tree. The tree needs more nitrogen in full daylight than under shade (10) and the larger crop without shade removes so much nitrogen, phosphorus, potassium and magnesium that fertilisers must be used to return these nutrients to the soil (4). In Ghana, cocoa grown after removing shade showed a nutrient deficiency previously unsuspected; experiments under shade on soils representative of the cocoa-growing regions showed no response to potassium (5), but within two years of removing shade from cocoa growing on a soil at WACRI, regarded as a very fertile cocoa soil, potassium deficiency had appeared unless potassium fertiliser, or mulch rich in potassium, had been used (12). This suggests that unshaded cocoa should be restricted to the more fertile, slightly acid to neutral soils (pH 6.0P7.2), for although these will require fertilisers the amount will be less than on the poorer, more acid soils, where chemical and physical problems may make the growing of cocoa both difficult and unprofitable. So far unshaded cocoa has responded to nitrogen, phosphorous and potassium, but not to calcium, magnesium or micro-nutrients.

Preliminary results in Ghana have suggested that responses to fertilisers without shade are greater than those under shade, 35 per cent compared with 25 per cent and that yields of unshaded cocoa can be maintained at approximately 1 ton dry cocoa/acre where trees are on a good soil with fertilisers broadcast in April-May at the following levels: 2.0 cwt. urea (46 per cent N)/acre, 1.0 cwt. triple superphosphate (47 per cent P_2O_5)/acre and 4.0 cwt. potassium sulphate (48 per cent K_2O)/acre.

Table 2 shows that when a 35 per cent response to this NPK fertiliser is assumed, the profit, £10 12s. 0d. per acre, from the fertiliser is satisfactory. The total profit of £34 18s. 0d. per acre which can be expected when cocoa is grown without shade and with fertiliser on clear-felled land (Table 2) would ensure that the initial outlay of £100 per acre, needed for clearing and planting, would be returned to growers after three years of full production. Although this would probably be achieved in the eighth year after planting, when cocoa under shade would still not be in full bearing, it is unlikely that growers would accept the extra expenditure and work which are needed to get profits which in this article are estimated to be less than those obtained with fertiliser under thinned shade, £34 19s. 0d. per acre compared with £37 8s. 0d. (Table 2).

Future trends

In the preceding discussion of the best shade and fertilisers for cocoa growing no account has been taken of the large yields, 3,500 lb. dry cocoa/acre and more, obtained in Ghana with Amelonado cocoa grown without shade and with fertilisers (4) or of the yields of more than 2 tons dry cocoa/acre which are possible with vigorous hybrids grown in this way. Clear-felling and growing generously-manured, unshaded cocoa would be very profitable with such yields. However, the profits mentioned here have been those of the cocoa growers and not those of the cocoa-producing countries and, if these countries start to use fertilisers in bulk, this may cheapen the fertilisers so that profits from fertilising may be attractive enough for governments to introduce fertiliser subsidies.

Recommendations

1. The average grower producing around 250 lb. dry cocoa/acre should not remove shade trees. Shade on the best farms, producing 500 lb. dry cocoa/acre and above, should be brought to two-thirds of what is normally considered best for cocoa.

2. When cocoa is grown under full shade, or thinned shade on soils such as those in West Africa using present husbandry methods, only the best farmers would profit from using 1.0 cwt./acre/annum triple superphosphate broadcast at the beginning of the main rains.

3. Co-operatives of smallholdings, or plantations of 500 acres or more, wishing to grow unshaded cocoa, should be divided into 5- to 10-acre pltos of shaded and unshaded cocoa trees arranged in a chessboard pattern. These co-operatives or plantations should be on the best soils where there is a dry season of not more than three months.

4. Fertiliser must be applied to all unshaded, vigorous, high-yielding cocoa, and preliminary results in Ghana show that each year 2.0 cwt. urea/acre, 1.0 cwt. triple superphosphate/acre and 4.0 cwt. potassium sulphate/acre broadcast at the beginning of the main rains can maintain yields around 2,000 lb. dry cocoa/acre.

5. The extra expenditure and work associated with clear-felling and growing unshaded cocoa with large amounts of fertilisers would probably be justified only when yields of 3,000 lb. dry cocoa/acre and over are obtained.

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Swollen Shoot Disease of Cocoa

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What is swollen shoot disease, and where is it found?

Swollen shoot disease of cocoa is caused by a virus, and derives its name from the swellings found on the branches. It has been known in Ghana since 1938, and since then many millions of infected trees have been destroyed in Ghana and Nigeria in efforts to eradicate the disease, and many more were killed by the unrestricted spread of swollen shoot disease before control measures started. There are different forms of swollen shoot disease. They differ in their effect on the cocoa tree and in the symptoms they cause, but all are transmitted from tree to tree by mealybugs.

Virus infections of cocoa have also been found in the Ivory Coast, Trinidad and Ceylon.

What are the symptoms of swollen shoot?

The swellings caused by virus infection develop on fan or chupon branches (Fig. 1) and tend to appear most frequently on rapidly growing shoots.

Cocoa plants show characteristic symptoms on leaves produced after infection with virus. The first symptoms appear on the young flush leaves as a network of red vein-banding. This symptom is a temporary one and the permanent leaf symptoms take the form of clearings or chlorosis on or alongside the veins (Figs. 2a and 2b).

The form of the vein-banding may differ with the form of swollen shoot disease. Usually there is a definite acute phase of infection in which conspicuous symptoms are produced and this is followed by a chronic or recovery phase, with limited symptoms.

The effects of swollen shoot disease on growth and yield

Virulent forms from both Ghana and Nigeria can kill young seedlings, and in Ghana particularly severe forms like those from New Juaben can kill mature trees within two years. In Nigeria the viruses appear to be less severe in their effects, and infected trees may only suffer a relatively low reduction in yield.

Infected trees grow at a reduced rate and infection may cause extensive leaf fall; those leaves which persist may not show symptoms but they are often chlorotic and unusually small.

Virus-infected trees are in a delicate balance with the environment and are not able to withstand periods of drought, insect attack and poor growing conditions as well as healthy trees. Where growing conditions are unsatisfactory and diseased trees are attacked by capsids they usually deteriorate quickly and die. In Nigeria the presence of capsids appears to be a critical factor; with good growing conditions and capsid control infected trees may continue to give an acceptable yield. With continued capsid attack the canopy is destroyed, weeds invade the farm and compete with the weakened trees, which eventually die.

How cocoa viruses are transmitted

Cocoa viruses are usually spread by the movement of the mealybug vectors; they are not carried through the soil, nor in the seeds. The adults of these insects are usually grouped in colonies on different parts of the cocoa tree and are often attended by ants (Fig. 3); they rarely move from these feeding sites. The immature forms are more mobile. When these migrate from an infected tree across the canopy onto a healthy tree and feed there, a new infection develops. They inject into the healthy tree when feeding some of the infected sap from the infected tree on which they had previously fed. This type of spread, where most of the new infections arise close to trees already showing symptoms, is the most common. Less frequently, new infections arise when mealybugs are blown from infected trees to healthy ones some distance away. This is the so-called 'jump'-spread. The slow and localised mode of spread makes control of the disease in limited areas relatively easy. The rate of spread of infection is influenced by many factors. The mealybug vectors are distributed irregularly; many trees in any one plot may not have any mealybugs whereas others may support large populations. Some mealybug species are not able to transmit swollen shoot virus and some species may transmit some forms but not others. Also the different types of mealybug may vary in their ability to transmit a certain form of swollen shoot. So virus spread can be influenced by the distribution of the mealybug population and the species present.

The spacing of the farm affects the rate of spread; at close spacings more trees are in contact and there is a greater chance of mealybugs moving to adjacent trees.

Different forms of swollen shoot may spread at different rates, and the difference appears to depend on the rapidity with which they multiply and become distributed throughout the tree. Dispersal of mealybugs by wind currents appears to be greatest during the dry season and most new outbreaks of virus are possibly started at this time. Movement of mealybugs between trees is greatest at the beginning and the end of the wet season; thus spread of existing outbreaks is probably greatest at these times.

The control of swollen shoot disease

It has not been found possible to cure infected plants, and control measures against swollen shoot disease are restricted to methods of reducing the spread of infection.

At present the only method of controlling the disease is to remove all the infected trees as they are discovered and this method has been adopted by the Ministries of Agriculture in Nigeria and Ghana. In the former country inspection for infected trees and their destruction is carried out by Government staff. This used to be the case in Ghana, but much of the responsibility now lies with the farmer.

The magnitude of the task of controlling the disease was enormous and difficulties confronted the Government survey teams, which were greatly hampered by the poor access roads and inadequate maps. Further, it is not always easy to find symptoms on infected trees, for example, symptoms are less conspicuous in the dry season when leaves with symptoms may fall and shoots with swellings may be destroyed by drought dieback. Symptoms are not easy to spot in the cool cloudy weather when the trees are not flushing. When outbreaks are detected by the survey parties, it is not sufficient for them to cut out only those trees showing symptoms, as trees around them may have been recently infected and not showing symptoms. With small outbreaks of only a few infected trees, only a small number of trees around the outbreak will be infected and not showing symptoms. Around larger outbreaks of fifty or more

Fig. 1. Swellings on chupons caused by swollen shoot infection.

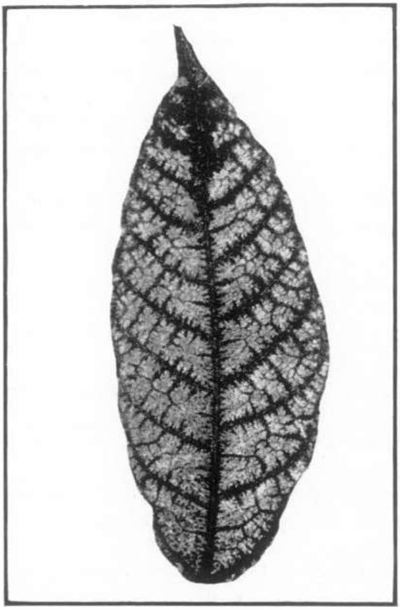

Fig. 2a. Severe chlorosis symptoms of swollen shoot.

Fig. 2b. Vein banding infection on cocoa leaves.

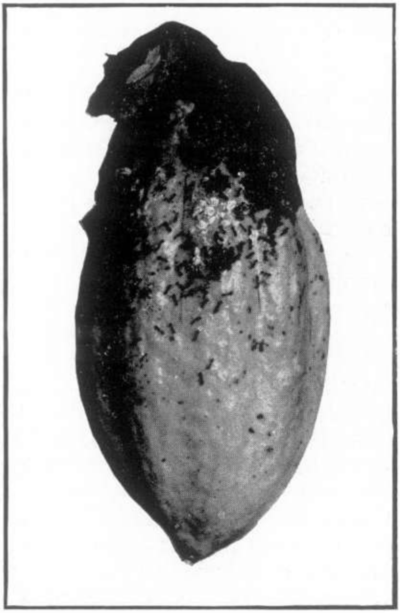

Fig. 3 A colony of mealybugs on a cocoa pod, attended by ants.

Cutting out of infected trees is the only method of control. A photograph taken in Ghana.

diseased trees a larger number of trees around the outbreak will have latent infections. Consequently outbreaks are treated according to size, the larger the outbreak, the greater the number of apparently healthy trees which must be cut out. Even this treatment may not remove the subsidiary outbreaks arising from 'jump'-spread, and one or more re-inspections of the area are necessary to detect these.

These eradication methods have succeeded in removing virus from areas in Nigeria which were not heavily infected, but the task of keeping the virus contained in the 'abandoned areas', where no control measures are practised, is more difficult and these areas remain dangerous foci of infection.

Prospects for the future

The abandoned areas in Nigeria, the 'Areas of Mass Infection', comprise one-sixth of the cocoa-growing area in the Western Region and contain some of the best cocoa soils. They are planted almost entirely with Amelonado cocoa which is susceptible to swollen shoot disease. A large proportion of this cocoa is old, and much of it is infected. One method of dealing with the swollen shoot problem here, and possibly elsewhere, may be to replace this susceptible population with one resistant or tolerant to the disease.

The Amazon cocoas are usually more difficult to infect than Amelonado, but unfortunately this resistance to infection is not sufficiently high to justify a programme of breeding for resistance to the disease.

However, certain of the Amazon types, once they become infected, are tolerant of infection, that is they only show slight symptoms which are often temporary and their growth is little reduced. Attention is now centred on the production of tolerant, high-yielding Amazon hybrids, and early tests suggest that this approach may have considerable promise. We know that hybrids between Amazon and either Amelonado or Trinitario cocoas are more vigorous than either parent, so we are producing hybrids between tolerant Amazons and tolerant Trinitario parents. These hybrids should have high vigour and outstanding tolerance. Unfortunately Amelonado cocoa may not be suitable as a parent, as its susceptibility to swollen shoot dominates the tolerance of the Amazon parent.

These tolerant hybrids are at present only intended for use in the abandoned areas. For other areas where eradication control measures are practised it is obviously unwise to introduce cocoa types which only show slight, possibly temporary symptoms, as this would render the task of the survey parties more difficult.

In the meantime, how can new plantings be kept free from virus infection? There is no certain method, but our knowledge of the mealybug vectors is of great help. Virus only persists in the mealybugs for a relatively short time. If a crop like coffee, plantains or bananas were planted round new cocoa plantings, infective mealybugs entering the area from outside would have to cross this barrier and the virus they carry would be removed or exhausted by the time they reached the new planting. In this way cocoa plantings could be kept free from virus for many years.

The Fermentation of Cocoa in Trays

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Introduction

The preparation of raw cocoa for the market involves processes which are carried out in the country of origin. The so-called fermentation is possibly the most important of these, and without it the product is unfit for chocolate manufacture. After fermentation, the cocoa is dried and bagged for shipment. Modifications to the traditional methods of fermenting cocoa have been many, but the peasant farmer or small planter cannot afford to introduce exotic techniques for curing his cocoa, especially when these call for near-scientific control. There is, nevertheless, a need for improvement in this haphazard process, not only on small farms and plantations but also on large plantations. The tray method of fermentation, described in this article, is a new technique which lends itself to both large and small production units. It was developed as a result of a study of heap fermentation, and is no more than a synthesis of the best features of heap fermentation and box fermentation.

Development of the tray method of fermentation

In a study of the fermentation of cocoa in heaps, Rohan (6) observed a lack of uniformity in the appearance of large heaps (one ton wet cocoa) when these were cut open after 48 hours. The beans in the top four inch layer were quite brown and had the appearance of fermented cocoa in contrast to those at the centre of the mass which were still quite unchanged. The temperature in the surface layer rose much more rapidly than that of the beans at the centre of the heap, and subsequent chemical and physical investigations confirmed this lack of uniformity. In short, fermentation appeared to be taking place more rapidly at the surface of the heap than at the centre. This was finally confirmed in unpublished work by Lipscomb and Rohan, the results of which are summarised in Table 1.

TABLE 1

FLAVOUR DEVELOPMENT DURING HEAP FERMENTATION

Fermented hours	Position in heap	Germination %	Temp. °C.	Flavour assessment
22	Top	25	43	Bitter; astringent; weak chocolate flavour
26	Top	0	44	Slightly bitter; fair chocolate flavour; nutty
30	Top	0	45	Slightly bitter; fairly good chocolate flavour
44	Top	0	47	Good chocolate flavour
22	Centre	96	41	Very bitter; astringent; no chocolate flavour
46	Centre	0	45	Slightly bitter; fairly good chocolate flavour

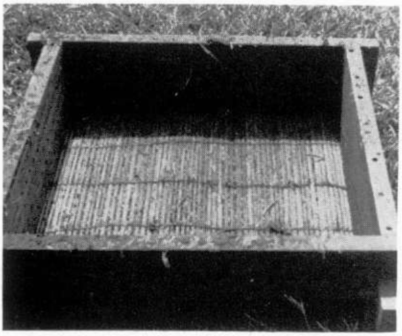

Fig. 1. Protype fermentation tray.

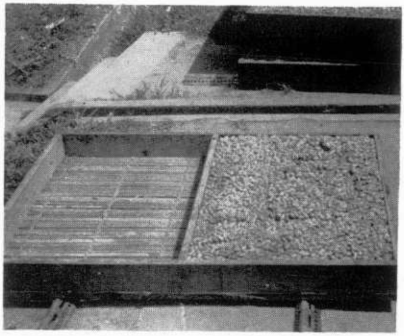

Fig. 2. Fermentation tray showing dividing strip.

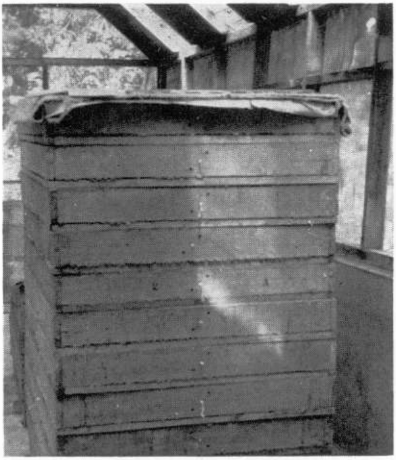

Fig. 3. Stack of fermentation trays during first phase of process.

Fig. 4. Second phase of tray fermentation process showing close-fitting cover.

Attempts were then made to isolate the surface effect in order to obtain a more uniform product in a shorter time. This was accomplished in a wooden tray (Fig. 1) three feet square and eight inches deep with a slatted bottom. Wet beans were placed in this to a depth of four inches and covered with plantain leaves. The system was sufficiently successful (7) to warrant further investigations, and after much experimental work a technique was devised which allowed of the fermentation of cocoa in trays (1). The method is described below in detail.

Fermentation of cocoa in trays

Wooden trays, four feet by three feet and four inches deep with slatted split-cane bottoms were made from *Chlorophora excelsa* timber. Each tray was divided into two equal sections by means of a sliding wooden partition, and half was filled to a depth of four inches with 100 lb. wet cocoa (Fig. 2). Twelve such trays were stacked so that the filled sections were directly above each other (Fig. 3), and the stack supported on one empty tray to improve aeration. The top tray only was covered with plantain leaves and sacking. After 24 hours a close-fitting sacking cover was slipped over the whole stack (Fig. 4) and no further handling was required until the stack was dismantled for drying. At the end of fermentation, the stack was broken, the dividing pieces removed from the trays and the beans spread to a uniform depth of 2 inches. The trays were then exposed to the sun. The object of the dividing piece in each was to facilitate drying. Experience showed that while cocoa fermented readily in four-inch layers it dried more quickly in two-inch layers.

Production Costs: The data given in Table 2 include the following operations:—

Weighing the raw cocoa
Loading the fermenting vessel
Mixing during fermentation
Discharging the fermenting vessel
Covering and uncovering during drying
Bagging.

TABLE 2

COMPARATIVE COSTING ANALYSES FOR DIFFERENT METHODS OF FERMENTATION

Method	Cost of preparing 1 ton dry cocoa man hours
Sweat boxes in tiers. Fermented 6 days mixed after 48 and 96 hours	66
Sweat boxes on level. Fermented 6 days mixed after 48 and 96 hours	67
Heap fermentation. Fermented 6 days mixed after 48 and 96 hours	58
Tray fermentation. Fermented 3 days not mixed	50

After Allison and Rohan (1).

Quality: Assessments were made in England and Switzerland and the results showed that West African Amelonado cocoa fermented by this technique was superior in appearance, uniformity and bean size to the same type of cocoa produced by conventional methods. Tasting tests showed it to be within the range of acceptability.

Extension work

Ghana: Since the first published account of this method in 1958 Allison and Kenten (2) have fermented 400 tons of West African Amelonado cocoa in trays and have obtained valuable information from some 800 fermentations. Twelve bulk samples, for factory processing, and eleven small samples, for laboratory processing, were sent to manufacturers in Britain, Switzerland and the United States. The results of tasting tests confirmed that four days fermentation gave a product superior to that obtained by the traditional heap method. The technique was applied to Amazonian cocoa and the same conditions were found to apply. The results of this extension confirmed that the product of tray fermentation was more uniform than that of box fermentation.

Economy of floor space and materials of construction resulted from the use of the tray method. 2,000 lb. wet cocoa in sweat boxes occupied a floor area of 32 sq. ft. while the same quantity of cocoa in trays covered only 24 sq. ft. When artificial driers were used the trays were completely filled for the fermentation stage and the floor area occupied by a 2,000 lb. charge was then 12 sq. ft. Trays for this amount of cocoa cost less than half as much to make as sweat boxes.

Cameroons: Messrs. Cadbury Brothers Ltd. have made a number of trials with the tray system at Ikiliwindi, using fresh cocoa purchased from the Colonial Development Corporation, at Tombel, and also from a local farm (Mukete). The cocoa bought was of the Trinitario type. No significant labour saving was observed and the advantage of the method over the traditional system was found to be in its increased convenience and flexibility. A saving in floor area of 40 per cent was recorded. No improvement in uniformity or appearance of the fermented beans was observed when compared with beans fermented in boxes. More recently, experiments have been made with Amazonian cocoa at Ikiliwindi and the products subjected to tasting tests. The results of these tests showed that four-day fermentation in trays gave a product indistinguishable in quality from a six-day box fermentation.

Dutch New Guinea: Ruinard (8) recorded the results of trials made in New Guinea, and concluded that the method of fermenting in trays was 'quite efficient'. He found no saving in time nor in labour costs. No improvement in quality, as compared with box fermentation, was observed. The minimum time required for the fermentation of New Guinea cocoa by this method was six days.

Costa Rica: A considerable amount of planned research on the tray method of fermentation has been carried out at the Inter-American Cocoa Center at Turrialba by Helfenberger. Samples were sent for assessment to manufacturers in the United States. The results of tasting tests showed that when Costa Rican cocoa was fermented in trays it gave a product superior to that produced by box fermentation. Maximum flavour development was realised in much shorter times. Helfenberger modified the method to accommodate the fermentation of very small samples (the contents of between 6 and 30 pods) for assessing the results of plant breeding trials. Onc tray was divided into small subdivisions ($10 \times 6 \times 4$ inches deep) and placed in the centre of a stack of trays. Desrosiers and Molina (3), at the experimental station of Los Diamentes, fermented cocoa in trays and published results which showed that a product of very much improved quality was obtained. Costa Rican farmers have now begun to adopt the tray method to their own and their customers' satisfaction.

Resumé

The fermentation of cocoa in trays owes its success to the increased and more uniform aeration of the mass. This results in a more rapid and uniform temperature rise and a more rapid and uniform rate of loss of viability of the beans throughout the fermenting mass. There is recent evidence which supports the initial claim that fermentation time could be reduced, and four days appears to be the optimum for both West African Amelonado and Amazonian cocoas. Costa Rican cocoa is fully fermented in four days, but there is some evidence that fermentation may be reduced to three days with no ill effect. This shorter fermentation time, together with the saving in floor space and cheapness of construction of trays, makes the tray method particularly attractive

to the larger plantation. The flexibility of the method is however demonstrated in that it would be equally suited to small farms with a maximum yield, at one picking, of about 2,000 pods. The improvement in quality, claimed by Allison and Rohan, appears to depend on the quality of the cocoa already being produced by conventional methods in the area concerned. There is, however, no doubt that good quality cocoa is obtained by the use of the tray system. The reduced fermentation time which the method allows must result in an increased recovery of dry cocoa and there should be little tendency for the production of the characteristic putrid smells associated with long fermentation in heaps or boxes. In Costa Rica, where the tray method of fermentation has achieved rapid popularity with farmers, improved quality has been rated as the prime advantage.

By eliminating the necessity for mixing the bean mass during fermentation, the new technique requires less supervision, an important point when unskilled labour is used, and there is some evidence that its use is accompanied by reduced labour costs. The fermented cocoa may be sun-dried on the trays in which it was fermented or mechanically dried either in the trays or in other vessels.

In conclusion, the fermentation of cocoa in trays is now established as an alternative to box or heap fermentation, but this is a notoriously conservative field in which new ideas are usually confined to the country or area of their origin.

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