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Editorial

The importance of extension work

In the last issue we reviewed the possibilities of increased production and concluded that extra production must come from higher yields. This involves effective control of pests and diseases, the reduction of shade and use of fertilisers. In most cocoa growing countries, farmers are accustomed to the practice of spraying, usually against capsids or black pod, and will carry out this operation provided they can obtain the pesticides and a spraying machine. This is not always so and some of the decline in cocoa production in West Africa is due to lack of pesticide and the use of ineffective machines. This could be put right if Governments took the necessary decisions.

While farmers are willing, or even anxious, to spray their cocoa farms they need guidance as to the most effective time to spray and the best method. These points become most important when resistance makes it necessary to change from one pesticide to another. The extension service has to be well informed on these aspects so as to pass the message on to farmers.

When it comes to the reduction of shade and the application of fertilisers the extension service has a more difficult task because any general recommendations have to be interpreted in the light of conditions on individual farms. To undertake this extension officers have to be well trained and provided with suitable guidance. In addition they need the right materials – leaflets, posters, film strips – to help them pass on the messages which arise from research work.

Thus an extension service needs not only sound basic training but must be given regular refresher courses to bring them up to date. They must also be given effective means for passing on information to farmers.

A seminar on extension methods is being arranged during the first half of 1977 and it is expected to deal with these two aspects of extension work. It should provide a good opportunity to instil new ideas into the extension services of many countries.

G. A. R. Wood

Review of Production and Consumption

November 1976

A. B. Cook, Cadbury Schweppes Limited

Production

Production in the crop year ended 30 September 1976 is now estimated at 1,507,000 tonnes, a decrease of 37,000 tonnes on the previous year.

In West Africa production increased in Ghana and Nigeria but there was a larger decrease in Ivory Coast and Cameroon. In Brazil production decreased after the remarkably large crop in 1974/75.

Consumption

The forecast of world consumption in 1976 by Gill & Duffus has been raised to 1,518,000 tonnes. This would be an increase of 72,000 tonnes or 5·0% over 1975. Nearly half this increase was in grindings in producing countries which now amount to 26% of world grindings.

Stocks

Gill & Duffus estimate stocks at the end of 1975/76 season to be 424,000 tonnes or 3·4 months usage. This figure is the same as that estimated for the previous year but is less in terms of months usage as consumption is rising.

This figure of stocks includes the Brazilian Temporao crop of about 2 m bags or 120,000 tons, most of which will not have been shipped at the end of the season.

Prices

Month end prices for nearby Ghana shipment cocoa have been:

1976	January	£790/tonne
	February	£760/tonne
	March	£835/tonne
	April	£1105/tonne
	May	£1325/tonne
	June	£1350/tonne
	July	£1325/tonne
	August	£1590/tonne
	September	£1720/tonne
	October	£1900/tonne

Even with the benefit of hindsight it is hard to find the reasons for the sharp rise in prices in April and May, although, as we suggested in our last issue, the decline in the value of sterling against other currencies, world wide inflation and the increased buying of commodities by speculative interests as a long term hedge against inflation were all contributing factors.

The rapid increase in prices since the end of July has undoubtedly been due to the pessimistic forecasts for the coming West African main crops which have been circulating the market. As time has gone on most observers have been reducing their forecasts even further.

Prospects

The consensus of opinion on this year's West African crops is that production will decrease appreciably. Thus the relatively small deficit in 1976 is likely to increase in 1977. Current prices reflect this forecast but the extent to which these prices, when they reach the public, will affect consumption remains to be seen.

WORLD COCOA PRODUCTION AND GRINDING DATA

Reproduced from Gill & Duffus Market Report
Dated 25th October 1976

(Thousand Metric Tons)

Production

	1973/74	1974/75 (Estimate)	1975/76 (Forecast)
Africa	954	1,007	994
America	397	439	409
West Indies	43	41	42
Asia and Oceania	53	57	62
World Total	1,447	1,544	1,507
Principal Countries			
Ghana	350	377	397
Nigeria	215	214	216
Ivory Coast	209	242	228
Cameroon	110	118	96
Equatorial Guinea	12	12	10
Brazil	246	273	258
Ecuador	72	78	65
Dominican Republic	30	27	30
Venezuela	17	19	15
Colombia	23	25	26
Mexico	28	32	33
New Guinea	31	33	34
Malaysia	10	13	16

Grindings

	1974	1975 (Estimate)	1976 (Forecast)
Western Europe	539	507	518
Eastern Europe and U.S.S.R. ...	260	276	275
North America	209	211	229
Central and South America ...	246	217	242
Australia and New Zealand ...	20	18	19
Asia	58	61	64
Africa	146	156	165
World Total	1,478	1,446	1,518
Principal Countries			
United States	230	206	230
Germany (Federal Republic) ...	138	139	138
Netherlands	115	119	124
United Kingdom	93	73	80
U.S.S.R.	143	152	150
France	37	34	34

A Framework for the Physiology of Cocoa

Part 2

W. V. Hutcheon

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NUTRIENT STORAGE

The yielding potential of a tree at a given point of time depends not only on current production of carbohydrates and minerals but also on the amount of stored nutrients. All trees contain large quantities of mobilisable nutrients in the storage cells of the stem and elsewhere which form a buffer stock to enable normal metabolism and growth to proceed during short periods when the immediate requirements for assimilates exceeds the current supply. Reserve nutrients may be in a storage form (e.g. starch as opposed to soluble sugars) and may not be so readily available as currently produced substances.

The demand for raw materials for growth exceeds the supply when conditions are unfavourable for photosynthesis (e.g. during the night, dull days etc.) and when the nutrient requirement is relatively high (e.g. during a phase of active leaf or fruit growth). Production of carbohydrates may exceed the demand during periods very favourable for photosynthesis (e.g. during the sunny wet season when the LAI is high) and the surplus may be stored for future use.

The nutrient status of the tree therefore fluctuates in both the short and long term about a normal basal level due to imbalances in the production and consumption of nutrients. There are internal controls which limit the extent of these fluctuations and the nutrient status of most trees will tend to return to the baseline over the long term. The nutrient status is not easy to define as for some nutrients there is no clear distinction between that which has been assimilated and that which appears to be available for respiration and use in further growth. For most nutrients it is not clear what part of the substances which are chemically extractable from the plant tissue skeleton forms the reserve and what part is necessary for the functioning of that tissue.

Little is known about nutrient storage in the cocoa tree and the extent to which the reserves fluctuate, but it is clear that changes occur mainly as a result of periodic leaf flushing and seasonal cropping. Leaf growth following the initiation of a flush consumes large quantities of nutrients, lowering the nutrient status for some time until photosynthesis by the new leaves restores the carbohydrates used for their growth. The well known effect of flushing on cherelle wilt may be due to the temporary depletion of reserves by leaf growth. In most cocoa growing areas there is a peak in the demand for nutrients by the crop of pods which may cause a marked decline in the reserves (9).

The extent of year-to-year changes in the nutrient reserves of cocoa has not been adequately studied but there is indirect evidence that considerable changes may occur under some situations. Reserve nutrients accumulate when trees are undercropped – e.g. due to inadequate setting – and the future cropping

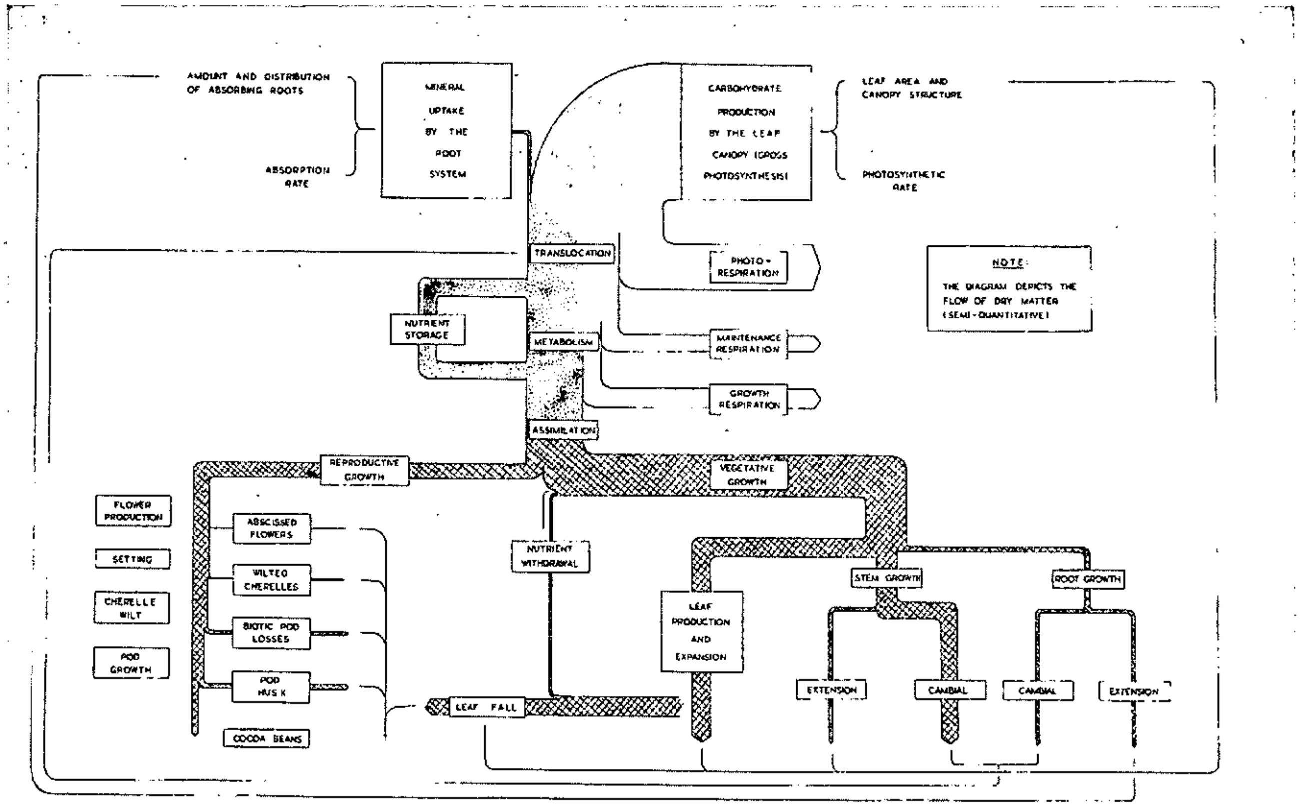

Fig. 1. A dry matter balance sheet for cocoa, showing the gross physiological processes affecting yield.

potential is increased. The rate of vegetative growth under these circumstances may increase but vegetative growth alone does not seem to be capable of using all the available nutrients, and some are stored. Conversely, the nutrient reserves of cocoa may be depleted when trees are overcropped – e.g. by repeated heavy concentrated hand pollination, and the yielding potential in the following year is reduced. Under these rather extreme conditions marked long term changes in the nutrient status apparently occur. Under more normal plantation conditions changes are less noticeable but probably take place. The considerable year-to-year variations in the yield of individual trees may be a result of changes in the reserves caused by inaccurate balancing of crop and assimilate supply in a particular season.

Fluctuations in the amount of reserve material need not concern us if we are dealing with long term yield, but they are important in several respects: processes such as flowering, cherelle wilt, and pod growth appear to be related to the nutrient status of the tree; storage is of obvious importance in crop forecasting and in explaining effects which carry over from one season to the next.

THE PARTITIONING OF DRY MATTER

We may now consider the way in which the tree utilises the available raw materials for growth. The tree may be regarded as a self-expanding factory, minerals, light, CO_2, etc. being the raw materials, the plant body the machinery, and beans the final product. Most plant organs and tissues – leaves for photosynthesis, roots for nutrient absorption, phloem for nutrient transportation etc. – have a limited efficient life and to maintain long term production part of the assets has to be expended in renewing these parts. Excessive expenditure on new vegetative tissue is wasteful, while inadequate expenditure reduces the long-term output so an appropriate balance should be maintained. Any imbalance which develops – overbearing or underbearing – affects future pod production both by influencing the machinery and by affecting the nutrient reserve.

Few data are available for partitioning between vegetative and reproductive growth in cocoa and even less is known about partitioning among the vegetative growing points on the tree – leaf growth, primary and secondary stem and root growth. Little is understood about how plants control partitioning but there seem to be complex feedback control mechanisms which maintain a balance between growth of the various organs. The balance established between vegetative and reproductive growth in cocoa appears to vary with the growing conditions and management, and different cocoa genotypes establish different balances, some having a strong tendency to grow vegetatively, others tending to flower and crop heavily and grow more slowly.

Though little can be said about internal control of partitioning, some of the factors which affect vegetative and reproductive growth may be mentioned:

Vegetative growth

Most attention has been given to leaf production – especially the seasonal periodicity of flushing. Some information is available on flushing in relation to changes in weather but little is understood about the internal mechanism controlling the alternating phases of growth and dormancy of the buds. Flushing of cocoa is basically an endogenous rhythm in that normal growth cycles proceed in a constant environment. It is probably not a true endogenous rhythm by the usual definition (10) and physiologically may be quite different from a circadian rhythm. Borchert (8) proposed that rhythmic shoot growth may be the result of an internal feedback control mechanism based on the maintenance of a constant root/shoot ratio, and this hypothesis fits most of the observations, though the details have still to be worked out.

In the field some flushes appear to be the result of the rhythm and others the result of an environmental change. The basic rhythm normally has a period of 4–10 weeks depending on conditions, and proceeds whenever conditions for bud growth are favourable. Water stress and low temperature/radiation tend to inhibit bud development and some flushes are clearly related to release from these conditions – e.g. rain following a period of moisture stress, or sunny warm conditions after a cool dull spell. The latter type of flush is highly synchronous over an area and may set the pattern for the following flushes.

Less is understood about the intensity of flushing but there is evidence that leaf production is partly related to the existing LAI. Thus trees with a low LAI as a result of drought, pruning, insect damage etc. tend to flush more vigorously than trees with a good canopy. This observation may support Borchert's hypothesis of a feedback mechanism which matches leaf production to some other process in the tree.

Leaf expansion is most strongly controlled by the available nutrient supply, light intensity, leaf water status and temperature. The availability of both minerals and carbohydrates strongly affects leaf growth, and competition within the plant – especially between leaves expanding at the same time – reduces the size of individual leaves. Low light intensity promotes leaf expansion and the beneficial effect of shade on the early growth of cocoa seems largely attributable to the resulting increased rate of leaf area expansion. It is well known that leaves expanding under drought conditions grow to only a small proportion of the normal size. Under conditions of stress, many leaf initials abort.

Of the various ways in which dry matter is used for growth, leaf production consumes most, followed by secondary stem growth. Secondary growth of both stem and root seem mainly controlled by the availability of nutrients, water stress and temperature. Stem growth is most active when canopy photosynthesis is maximal and is relatively inactive during drought or when there is internal competition from pods.

In most species, roots are low on the priority list for nutrients and when strain is put on the tree by a heavy crop, root growth suffers most of all, and the tree is thus weakened. Extension growth of roots is important for nutrient absorption but little is known about root growth in cocoa as it is not easy to study.

The feedback effects of vegetative growth on further growth are shown in the diagram, especially the effects of leaf and root growth on photosynthesis and nutrient absorption. Translocation has not been studied in cocoa and it is not clear if it can be a limiting process under normal conditions.

Reproductive growth

Reproductive growth consists of flower initiation and development, fertilisation, setting, survival from cherelle wilt, and growth of the pod to maturity. The extent of dry matter expenditure on pod production can be controlled by the tree at several points in the above sequence.

A general hypothesis about reproductive growth in cocoa which we are now testing is that pod production is fundamentally determined by the available nutrients in the tree, and that internal controls at various points regulate pod production with reference to nutrient availability. Reproductive growth is controlled through the intensity of flowering, cherelle wilt and pod growth. The intensity of flowering of a given genotype seems to be related to nutrient availability, though several other factors are also involved. As the extent of setting cannot be readily controlled by the tree, a further control is necessary, and hence a cherelle thinning mechanism evolved to match the pod load to the nutrient supplying capacity of the tree. Both flowering and cherelle wilt are probably controlled by hormones, but nutrients may be the primary controlling factors which regulate hormone production.

It is not possible for the tree to accurately regulate the pod number to the nutrient supply over short periods of several months. This is due to uncertainty about the supply of nutrients which will be available for the later stages of pod growth, and to variable seasonal setting patterns which complicate the control of cropping very considerably. A control mechanism of the type outlined above would be most effective over longer periods, as errors in one season would be corrected in the next. Some control of cropping is exercised at the pod growth stage, pods being reduced in size when the number exceeds the bearing capacity of the tree, probably through a straightforward nutritional control.

According to the above hypothesis, the tendency for cocoa to flower and fruit is strongest when there are surplus nutrients to support reproductive growth. In addition to the fundamental internal controls hypothesised above, most aspects of reproductive growth are affected by environmental factors in a more direct manner. Flowering is depressed by low temperature/radiation and by water stress, and is stimulated by relief from water stress ("crazy" flowering) or by a rise in temperature after a cool spell. Likewise cherelle wilt occurs not only as a result of internal competition but also due to unfavourable conditions such as moisture stress, low temperature etc.; pod growth can also be adversely affected by these conditions. It seems that at least some of the above factors have a relatively "direct" effect on flowering, cherelle wilt, and pod growth, rather than an indirect effect through controlling the nutrient availability.

Much has still to be learned about the control of reproductive growth in cocoa and the above is merely a statement of an hypothesis which seems to fit most of the observations. Very little is known about the control of the balance between vegetative and reproductive growth, e.g. to what extent does excessive vegetative growth occur when there are inadequate pods present to utilise the nutrients which may have been available for reproductive growth?

SENESCENCE, ABSCISSION AND NUTRIENT CYCLING

Most plant organs which have become senescent and have lost much of their original physiological efficiency are shed by the tree and renewed. Most obvious for cocoa are the leaves which are normally completely renewed yearly or more frequently. Some branches are likewise shed when they become old and are heavily shaded by the canopy above. Fine roots normally have a very short life and are then shed. The abscission of flowers and the eventual fall of wilted cherelles also cause some recycling of nutrients through the plant/soil. In the case of leaves there is internal cycling of nutrients within the plant as some nutrients are mobilised and withdrawn prior to leaf abscission.

Abscission itself should not be regarded as being wasteful, as organs are generally shed after they are useless to the plant. The processes of senescence which lead to abscission, however, are important in that they can to some extent be controlled. Senescence is a natural process but is accelerated by adverse conditions such as water stress, low temperature, flooding, low light, etc. Leaf fall in cocoa occurs in phase with flushing and is induced by water stress, low temperature, flooding, etc. These factors adversely affect many processes in cocoa, including senescence. Premature abscission of leaves, roots, etc. and a high rate of turnover of these organs are likely to depress pod production because of the extra photosynthates required for replacement. Minerals, of course, are not lost from the system though a high rate of turnover will decrease the availability due to the extra amount present in litter.

ACKNOWLEDGEMENT

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Establishment and Maintenance of Cocoa Seedling Nurseries

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Experiences in trials and in estate practice in Malaysia have confirmed important economic advantages in raising hybrid cocoa seedlings to an advanced stage in the nursery before field planting. The main benefits, in comparison with seed-at-stake planting, are listed below:

- More economical use of high quality planting materials.
- Weak seedlings and off-types may be rejected in the nursery.
- Seedling survival rate after field planting is higher.
- The established stand vigour is more uniform.
- Time to bearing is reduced and early yields are greater.
- The financial return on the nursery investment is high.

The necessity for using the best possible nursery practices cannot be over-emphasised, especially since vigorous nursery-raised seedlings are less prone to transplanting shock and come to bearing earlier than less well developed seedlings. Moreover, for a given nursery area, throughput is greater if conditions are conducive to vigorous seedling growth. Whilst there is scope for variation according to individual preference and practical experience, the following recommendations are based on well-tested techniques which are expected to be suitable in most situations.

SEED REQUIREMENT

To allow for germination failures, adequate nursery selection and other contingencies, 30% in excess of field requirements should be ordered from the seed supplier.

SEED GERMINATION

Cocoa seeds germinate readily and it is quite normal for germination success to exceed 90% within 15 days of placement of fresh seeds in a favourable environment. The rate and uniformity of germination may be improved if adhering mucilage is removed beforehand. This is normally done by the seed supplier, by repeating rubbing of seeds in dry sawdust or fine sand, washing seeds at intervals in a strong water jet to remove loosened mucilage.

Planting of ungerminated seeds directly into the seedling nursery container soil is not recommended as a proportion of the seeds will not germinate and seedlings which develop from early-germinating seeds compete with seedlings from late-germinating seeds, resulting in irregular nursery development. In such circumstances it is not possible to do truly objective thinning of seedlings on the basis of their inherent growth capacities.

The germination technique is not critical provided that seeds are adequately aerated and not exposed to extremes of temperature or subjected to drying conditions. Although satisfactory germination is obtained when seeds are planted in shaded sand beds, consistently high germination is also possible if seeds are germinated indoors in polythene bags (with occasional mist spray to maintain the seed surface moist) or in shallow heaps under wet sacking.

Where seeds are to be germinated outdoors in sand beds they should be planted with their long axis in a horizontal plane or with their hilum pointing downwards, with their upper surface no more than 1 cm below the sand surface. Planting of seeds with the hilum pointing upwards must be avoided because the hypocotyl and radicle are liable to be severely distorted and as a result seedling growth may be weak and recovery slow. Germinated seeds should be "pricked out" from sand beds for transplanting in the nursery when their cotyledons have been raised a fraction above the sand surface, before the plumule or shoot emerges.

Seeds germinated indoors should be sorted at intervals not exceeding two days, extracting germinated seeds before their germs are 1 cm long. As late-germinating seeds are normally less vigorous, seeds which do not germinate within 15 days ought to be discarded.

NURSERY PREPARATION AND MAINTENANCE

1. Nursery location

Whilst distance from the nursery to the area for planting will affect transport costs to a small extent, the main consideration in site selection should be obtaining the best possible nursery development. To this end, nurseries should ideally be located in a secure area where adequate supervision is assured and sufficient water is available.

2. Containers

Polythene bags (polybags) have superseded woven split cane and other forms of containers for raising cocoa seedlings. According to the duration seedlings will be raised in the nursery, bag specifications should be approximately as follows:

Months in Nursery	*Layflat Dimensions Length*	*Width*	*Gauge*	*Perforations*	*Colour*	*Filled Weight*
3–4	25 cm	18 cm	150	20	Clear	2·7 kg
4–5	30 cm	20 cm	200	30	Black	4·5 kg
5–6	35 cm	23 cm	250	40	Black	6·8 kg
over 6	40 cm	25 cm	250	50	Black	9·0 kg

3. Filling of bags

Bags should be filled to capacity shortly before seeds are scheduled to be received for germination. The best available topsoil of good stable structure must be chosen. The soil should have a satisfactory organic matter content, reasonable nutrient reserves and pH not less than 4·5 (preferably within range 5·5–6·5). A sandy clay loam texture is favourable to cocoa seedling growth. If soils are of too heavy texture and/or their organic matter content is comparatively low, up to 20% coarse river sand and/or well rotted cow dung may be incorporated before filling the bags. Unless soils are very fertile, good responses can be expected to incorporation of 10–15 g limestone dust and 10 g compound fertiliser (12:12:17:2 or similar composition) in soil used for filling the topmost 10 cm of each bag.

4. Arrangement of bags

After filling, the bags should be arranged in beds of about 80–100 cm width with 45 cm wide access paths. To enhance growth rate and prevent excessive etiolation, seedlings must be spaced further apart when they are 2–3 months old. The spacing chosen may range between 20 cm and 35 cm between bag centres, the distance increasing with the period of seedling retention in the nursery. The importance of generous spacing is emphasised as the growth vigour of well-spaced seedlings is far superior to that of closely spaced seedlings which may require considerable staking after transfer to the field.

5. Nursery shade

The shade provided should intercept 70–80% sunlight during the initial two months that seedlings are held in the nursery. Excessive shading causes retarded and spindly seedling development while over-exposure may also reduce plant vigour, especially if the nursery soil is of sub-optimal quality and difficulties are experienced in providing sufficient water to prevent moisture stress.

The initial shade may be of palm fronds (not woven) held on a suitable framework at about 175 cm height. Sacking or fronds should be secured to the peripheral fence to provide protection against drying winds. Alternatively, the nursery may be located under trees (e.g. Gliricidia, rubber or oil palm) which provide the desired level of protection.

Progressive thinning of the frond or tree shades should be carried out after two months or earlier if the seedlings display symptoms of etiolation. Final nursery shade density ideally must match that in the field where seedlings will be planted. Sun scorch is liable to occur if nursery shade when seedlings are transplanted is significantly denser than that in the field.

6. Planting of germinated seeds

After making a small hole in the soil to accommodate the radicle and lower hypocotyl region, germinated seeds extracted from sand beds should be planted carefully in the centre of each bag. Soil should be tamped carefully to ensure firm contact between the radicle and soil.

Seeds germinated indoors should have germs not exceeding 1 cm length. These must be planted with their radicle pointing vertically downward and the top of the seed should be just visible above the soil surface. Particular care must be taken to prevent damage to the delicate germ and the soil should not be tamped too firmly against the seed which in due course is elevated above the soil by elongation of hypocotyl tissues.

7. Watering

Seedlings must be watered regularly, early morning and late evening, to maintain the soil in a moist but not saturated state. Good quality water should be used as there is risk of damage to seedlings if the water contains a high concentration of salts. If the soil surface structure deteriorates to the extent that water penetration is poor, the soil should be raked very lightly before topping up the bags with coarse sand or organic mulch.

8. Pest control

A peripheral fine mesh wire fence must be provided if there is risk of damage by domestic animals or rodent pests. Rat and snail baits should be distributed throughout the nursery area prior to planting the germinated seeds. Thereafter, a close check must be maintained for evidence of these pests, repeating baiting as necessary.

As cocoa is attractive to a wide variety of insect pests, close attention is necessary to ensure timely application of insecticides for control of pests which inflict economic damage. Recommended insecticides and dosage rates for control of the most commonly occurring insect pests are listed below.

Insect Pest	*Insecticide*	*Active Ingredient*	*Spray % a.i.*	*Frequency*
Caterpillars and	Lead arsenate		·50	10 days
Beetles	Dipterex 80 SP	Trichlorphon	·25	10 days
	Orthene 75 SP	Acephate	·125	10 days
Thrips/mites	Thiodan 35E	Endosulphan	·10	5 days
	Rogor 40	Dimethoate	·10	5 days
Mealy Bugs	Albolineum	White oil	1·0	7 days
	Rogor 40	Dimethoate	·10	7 days

Note. Insecticides with γ BHC active ingredient (e.g. Lindane, Agrocide) must not be applied to very young cocoa seedlings, on account of their acute sensitivity to the chemical.

9. Disease control

Gloeosporium is the only disease of consequence in cocoa seedling nurseries in Malaysia. Outbreaks of economic significance are comparatively rare and are readily controlled by application of Difolatan 4F or Daconil 2787 fungicides at 0·1% a.i. concentration at weekly intervals.

10. Fertiliser applications

In nurseries where good quality topsoil is used and cow dung or compound fertiliser are incorporated in the soil used for filling bags, it may not be necessary to apply fertilisers until seedlings are at least two months old.

Where mild deficiencies are suspected, either urea (if only nitrogen is implicated) or complete foliar nutrient fertilisers (e.g. a formulation supplying 11% N, 8% P_2O_5, 6% K_2O, trace elements, chelates, buffering substances and growth promoting hormones) may be applied as foliar sprays at 0·5–1·0% and 0·2% concentrations respectively, at weekly intervals. However, in situations where more severe deficiencies occur and foliage is under-sized and/or pale, more rapid responses have been obtained in Malaysia to urea or compound fertiliser (composition 15:15:6:4 or 12:12:17:2 with soluble phosphate) applied at 14 day intervals.

Recommended fertiliser application rates per plant are indicated below.

Seedling Age	*Urea*	*Compound Fertiliser*
2–3 months	0·5 g	1·0 g
3–4 months	1·0 g	1·5 g
4–5 months	1·5 g	2·0 g
over 6 months	2·0 g	3·0 g

The above fertilisers should be applied uniformly over the soil surface, avoiding application within 3 cm of the seedling stem.

Occasionally, especially if limestone has been incorporated in the soil at excessive rates, manganese or iron deficiency symptoms develop on the cocoa foliage. Such deficiencies may be corrected by application of 1% solutions of manganese sulphate or ferrous sulphate at 14 day intervals.

11. Thinning out

The uniformity of seedling growth depends to a large extent on the standard of nursery practices and on the identities of progenies included in the nursery. Although 10% culling may suffice in well managed nurseries with progenies which are comparatively uniform in growth vigour, it is recommended that sufficient material be planted to allow for rejection of up to 20% of the seedlings. Rejected seedlings should be destroyed.

12. Transplanting

To minimise transplanting shock, it is necessary to turn polybags a few degrees at least one week before the scheduled date of field planting if there is evidence of roots having penetrated the soil beneath. This operation should be done only if the terminal flush is reasonably well hardened. Fairly liberal watering may be necessary for a few days thereafter.

Field planting should not be attempted during very dry spells. Seedlings should ideally be transferred to the field at the beginning of rains. However, even if favourable weather prevails, field planting should not be considered while terminal leaf flushes on seedlings are immature. Only seedlings with fully matured foliage should be planted out.

ACKNOWLEDGEMENTS

The writer acknowledges with gratitude the nursery experimentation undertaken by colleagues at Prang Besar Research Station and is indebted to Harrisons & Crosfield (M) Sdn. Berhad for permission to publish this article.

Fig. 2. Nursery beds showing wide access paths to allow for wider spacing of bags at a later stage.

The Work of the International Cocoa Black Pod Research Project at Gambari

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Background

In 1968 the Cocoa, Chocolate and Confectionery Alliance of the United Kingdom commissioned a report on the problem of black pod disease. After a review of research in progress in various cocoa-producing countries it was apparent that, although many potential sources were known in the environment from which infection could reach the pods, the relative importance of these sources was unknown. Research was needed on epidemiology and ecology of the fungus pathogen (*Phytophthora palmivora*) in order to make it possible to apply control measures more effectively and economically in the future. This would involve using new techniques and devising new experimental systems of a kind that would not fit easily into research at national institutes. It was realised that results of a localized project would apply mainly to the one place, but it was hoped to develop methodology applicable elsewhere.

The I.O.C.C. Project

The International Office of Cocoa and Chocolate agreed to fund a scheme of research, with an additional grant from the American Cocoa Research Institute. The plantations and new laboratories of the Cocoa Research Institute of Nigeria at Gambari were seen to have excellent facilities for the work, coupled with a moderate incidence of black pod that would not swamp experimental treatments. Dr. L. K. Opeke, then Director, agreed to the suggestion that a research team for epidemiological work should be based at Gambari and offered full facilities. The U.K. Alliance undertook to administer the scheme with the detailed work being carried out by The Nestle Co. Ltd. which also gave local support through its subsidiary, Food Specialities (Nigeria) Ltd. The scheme was launched under the direction of a Scientific Co-Ordinating Committee consisting of Monsieur R. Coste, Dr. R. A. Muller (I.F.C C.), Professor G. A. Zentmyer (University of California, Riverside) and Dr. P. H. Gregory (Convener). C.R.I.N. contributed laboratory accommodation and field plots, and paid for junior staff and local supplies. Senior staff and capital equipment were funded by I.O.C.C.

The project started in the spring of 1973 with the arrival of Dr. A. C. Maddison, who had been trained in epidemiology at Southampton University, and Dr. M. J. Griffin, a specialist in diseases caused by *Phytophthora*, who was seconded for 3 years from the British Agricultural Development and Advisory Service. In 1974 Dr. Brian Taylor, an entomologist who had worked in the British Solomon Islands, was attached to the team by the U.K. Alliance to study insect vectors of the black pod fungus.

The First Three Year Phase

Besides numerous field and laboratory experiments designed to identify potential sources, the first three years of the project were occupied mainly with two intensive field experiments to analyse in great detail the course of the epidemic.

In Dr. Maddison's "3-D Mapping Experiment", a steel scaffolding framework was erected giving access to all parts of 9 Amelonado trees (and their surrounding 16 trees) including the top of the canopy. The three dimensional position and history of every pod set was recorded by inspection every three days throughout 1974 and 1975 – a physically exacting task enthusiastically performed by junior and senior staff alike. Infected pods were left in position in this experiment. to let the epidemic run its course. This experiment has yielded unique data. The voluminous records are being analysed using a computer retrieval programme written for the experiment by Mr. Keith Bicknell of Rothamsted Experimental Station, U.K., who was seconded to the U.K. Alliance for two short visits to Gambari in 1975 and 1976. Preliminary results give a novel picture of the course of the annual epidemic in Nigeria. Primary pod infections ("initiators") occur here and there at random throughout the year. By action of rain splash and drip, spores from the primaries give rise to strictly localised "sequences" of secondary pod infections clustered around the "initiators".

In Dr. Griffin's "Ultimate Hygiene Experiment" the main treatment involved examining every pod daily through 1975 and 1976 (another exacting task), and, in contrast to the previous experiment, removing every *Phytophthora*-infected pod before it could sporulate and set up secondary infection "sequences". The records obtained from this plot of upwards of 550 trees therefore give information solely about the "initiators" and the sources from which they arise, because secondary sequences are prevented by the strict hygiene imposed. Results to date suggest that the soil accounts for approximately two thirds of "initiators", by inoculum which reaches the pods either by rain-splash of soil particles or in "soil-tents" constructed by certain species of ants to protect mealy bugs or scale insects which they put to "pasture" on developing cocoa pods. Of the remaining one third of initiators only 2 or 3% arise from cushion infections or sporulating trunk cankers – the remainder coming from flying insects, rodents, lateral drift of splash droplets, etc. (While there is evidence that in Ghana a larger proportion of diseased pods arise from infected cushions than in Nigeria, the team has achieved one aim – that of developing a methodology that can be used elsewhere.)

The Forms of Phytophthora

Meanwhile laboratory and field studies by Dr. Griffin showed that two morphologically distinct forms of *Phytophthora* exist side by side on cocoa in Nigeria, differing in ecology and infectivity. Co-operation with the cytologist, Dr. Eva Sansome (formerly of the University of Ibadan and Ahmadu Bello University, Zaria), and with Dr. C. M. Brasier of the British Forestry Commission Research Laboratory, showed that the predominant Nigerian form also differed in having fewer and larger chromosomes than the usual type of *P. palmivora* on cocoa. In consequence of this discovery Dr. P. de T. Alvim suggested holding a "Workshop" type meeting so that, for the first time, workers from different countries concerned with cocoa black pod could meet under strict quarantine conditions in a non-cocoa-producing area, to compare their local isolates of the fungus. This meeting was sponsored by the I.O.C.C. and was held at Rothamsted Experimental Station, Harpenden, England in May 1976. At the Workshop the existence of four morphological forms was recognized within "*Phytophthora palmivora*": MF1 (and MF2) with small chromosomes is widely distributed geographically; MF3 with large chromosomes is characteristic of Nigeria and also occurs in Cameroon; and MF4, a new type, was recognized as characteristic of Brazil, and occurs elsewhere in South America. Obviously cocoa which has been bred for black pod resistance, if moved to another region, will have to be tested extensively against local strains of the fungus.

The Second Phase

The project completed its initial term of three years early in 1976, and by agreement with Mr. S. A. O. Adeyemi, now Director of C.R.I.N., the research is being continued for a further three years. Dr. M. J. Griffin has returned to his post in the U.K. and has been replaced by Dr. Martin Ward from Hull University. Because the results to date (agreeing with earlier work at C.R.I.N. by Dr. E. K. Okaisabor) emphasise the importance of the soil as the ultimate source of *P. palmivora* infection, Dr. Ward will develop methods of assessing the activity of the fungus in the soil.

Dr. Taylor, who has also returned to England, has prepared illustrated guides to identifying ants inhabiting cocoa and other trees in Nigerian forest. These guides are now being published by C.R.I.N. and will supplement his field work on the "ant mosaics" of cocoa plantations in relation to black pod infection. Dr. Idowu on the C.R.I.N. staff has replaced Dr. Taylor as Entomologist to the team.

For the second and final term of three years, Dr. Alan Maddison remains as team leader, with Dr. A. A. Adebayo, mycologist in the C.R.I.N. Plant Pathology Division, as Co-Leader.

The future research programme will continue the "Ultimate Hygiene Experiment", and develop new experiments to measure the contribution from those sources which make up the 30% of primary sequence "initiators" which still remain of unidentified origin, with special emphasis on flying insects. The project is now in a position to make a start in applying knowledge already achieved to control of the disease, using field experiments in which tree bases are sprayed with insecticides and fungicides as a tentative approach.

Fourth Conference of West African Cocoa Entomologists, University of Ghana, December 1974

The conference was organised in seven scientific sessions. A total of 27 papers were presented covering the whole spectrum of cocoa entomology in West Africa; over 60 delegates were present, and each session was terminated by a lively discussion. The Proceedings were edited for publication by the convener, Professor R. Kumar.

SESSION 1 – Biology and Population Dynamics of *Bathycoelia thalassina* (H – S) Heteroptera: Pentatomidae

The biology, ecology, distribution and economic damage of this pest were discussed in papers by E. Owusu Manu and W. E. Eguagie for Ghana and Nigeria respectively. This pest, of comparatively recent importance appears to be most damaging in well managed cocoa with a history of consistent spraying against cocoa capsids. The increased incidence of *Bathycoelia* was considered to be in part due to the direct lethal effects of insecticides on egg and larval parasites and general predators and in part due to the increased use of continuous cropping cocoa varieties and the effect of general forest clearance reducing alternative host plants.

SESSION 2 – Capsid Pests of Cocoa in West Africa

A resumé of the problem in Nigeria was given by A. Youdeowei. The area of *Sahlbergella singularis* resistant to lindane has spread considerably in the last few years and no satisfactory alternative insecticide has yet been recommended. The biology of *Boxiopsis madagascariensis* in Madagascar cocoa was given by B. Decazy. Damage is, in every respect similar to that caused by *Distantiella theobroma* and *S. singularis* in West Africa. Seasonal population cycles are similar to those of the West African species and synchronised with the cycle of pod production, but are not apparently dependent on pod production, nor on seasonal weather since there is no dry season in Madagascar. Further work on parasitism of *S. singularis* by *Euphorus* in Ghana was described by N. Kumah. General parasitism ranged between 20 and 43%.

SESSION 3 – Cocoa Diseases Transmitted by Insect Vectors

A general paper on fungal disease transmission was given by J. T. Dakwa who showed that some fungi were structurally well adapted to insect transmission. B. Taylor gave an account of preliminary work on possible insect vectors of black pod disease. J. T. Legg discussed aspects of swollen shoot disease, concluding that the ultimate satisfactory solution was the development and use of cocoa types resistant to virus infection. M. Bigger outlined work on population dynamics including ant relationships of mealy bug vectors of swollen shoot and described methods of computer simulation technique based on known reproductive and mortality rates. It was noted that *Oecophylla,* a supposedly beneficial predator, was present at eight out of 14 sites of swollen shoot outbreaks. C. A. M. Campbell demonstrated that the commonest mealybug species included *Planococcus citri, Planococcoides njalensis* and *Phenacoccus hargreavesi.* Over 95% of colonies of these three species are found in the tree canopy; their distribution changes with time and is associated with leaf flushing.

SECTION 4 – Cocoa Pollination, Systematics of Cocoa Farm Insects and Problems of Cocoa Storage

A review paper by T. Kaufman indicated that Halictid bees, ceratopogonid and cecidomyid midges and psyllids were the main pollinators to cocoa in Ghana. Ceratopogonid midges were probably the most important, but the eight pollinating species observed only accounted for 27% of effective pollination. Favoured breeding sites included cocoa husk heaps, buttress niches of tall shade trees and decomposing logs and stumps. A paper on arthropods associated with mistletoe on cocoa by P. M. Room showed that of over 1,000 species collected, a very large proportion could not be named to species level and some 3% could not be identified even to genus. A similar list was presented by J. D. Majer of arthropods associated with cocoa collected over 15 months at Kade, where 40% of species could not be named. E. W. Kisiedu and S. E. A. Ntifo discussed problems of cocoa storage and shipment in relation to insect infestation, insecticidal resistance and residues. Methyl bromide fumigation and pyrethrum fogging are the main methods used. I. Van der Puije and P. K. Awuah described similar problems associated with long term silo storage which was feasible provided right conditions were maintained and necessary fumigations carried out.

SESSION 5 – Control of Cocoa Pests by Chemicals

E. Owusu Manu discussed effects on non target organisms of lindane/arprocarb mixtures, Orthobux and promecarb as effective lindane substitutes for capsid control. None had adverse effects on minor pests with the exception of *Bathycoelia* which built up on all treated plots compared with untreated. An initial depressing effect on *Oecophylla* ants was followed by complete population recovery within three weeks after spraying; no other predators were affected. B. Adjei outlined methods for studying long term effects of insecticides on a cocoa plot layout at Tafo.

D. Adomako described a study on methyl bromide residues in fumigated cocoa; 70% in the form of decomposition products occurred in the shells but this was considerably decreased after roasting.

E. Owusu Manu and R. Kumar gave a paper on control of cocoa capsids in Ghana; arprocarb, lindane/arprocarb mixtures and Orthobux continue to be the most effective alternatives to lindane, but two other materials, Elocron and Landrin, show promise. S. A. O. Adeyemi briefly discussed cocoa capsid control work in Nigeria. Lindane was still the only pesticide officially recommended but promising substitutes for use in resistant areas include arprocarb and Orthobux as in Ghana.

Session 6 – Potential Pests of Cocoa in West Africa

S. K. Firempong gave an account of the bioecology of the black citrus aphid. Ant species having a facultative association with these aphids did not prevent normal predation and parasitism so that despite large reproductive potential. aphid populations were kept in check. The biology of *Characoma* pod borers was described by M. A. K. Akotoye. Populations are checked by rain and by syrphid predators, fungal pathogens, nematodes and tachinid parasites.

J. Nguyen Ban outlined methods of mass laboratory rearing of *Trichogramma* parasites of *Earias*, an important pest in the Ivory Coast.

Session 7 – Alternative Control Methods of Cocoa Pests

M. Bigger introduced a review of a varietal susceptibility to insect pests. Variety screening work showed that there was differential susceptibility to attack by a range of sucking insects, but data subjected to multi-variate analyses gave rather conflicting results. P. Bruneau de Miré showed that damage by Homoptera on cocoa varieties differed according to shade, but that some hybrids were resistant to psyllid attack. J. D. Majer outlined suggestions for ant manipulation methods as a means of integrated control.

Session 8 – Cocoa Entomology – A Prospect

In a concluding paper, C. A. Collingwood took up various points that had arisen in discussion. Various workers had suggested the use of common recording methods for varietal and other trials concerned with pest and disease incidence. Taxonomic training, services and resources should be intensified to enable identification of species present in any field of cocoa study. A stage had been reached when research on detoxification systems in cocoa capsids was not only desirable, but practicable as a step towards planned use of insecticides to avoid resistance problems.

In the concluding phases of the Conference, resolutions were formulated and a permanent committee was formed to maintain liaison between cocoa entomologists in West Africa including interchange of literature and to arrange for future conferences on a regular basis. E. Owusu Manu (Ghana), J. Nguyen Ban (Ivory Coast) and A. Youdeowei (Nigeria) were elected as a standing committee. A further resolution was passed to the effect that there was an urgent need to establish taxonomic centres in West Africa.

C. A. Collingwood,
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The proceedings of this conference have been published by the Zoology Department, University of Ghana, Legon, Ghana.

Notes on Contributors

Shepherd, R.

Born Scotland 1934. B.Sc. (Hons) Aberdeen 1956. Dip. Ag. Sci. (Cantab) 1957. Joined Harrisons & Crosfield as a research officer in 1957 working on rubber initially. Has since been concerned with cocoa plantings by H. & C. in West Malaysia and is now Director of Research.

Tropical Abstracts

December 1975

Toxopeus, H.; Hutomo, T. Bulk cocoa in Indonesia and the production of improved planting material. (Working Paper – Strengthening Research on Rubber and Oil Palm in North Sumatra.) FAO Medan (Indonesia). No. 35, 26 p.; January 1975 (En) tables, 6 refs.

This report contains the findings of a FAO consultant plantbreeder who visited Indonesia from March 26 to April 24, 1975. Recommendations are presented which include that Indonesia must organise its own seed supply and build up the required expertise and also that Indonesia should adopt the long-term policy objective of producing 25,000–50,000 tons of good-quality bulk cocoa in the 1990s because the manufacturers' absorption capacity for "Edelcacao" is unknown and would quite possibly be reached already at supplies of 5,000–10,000 tons.

Partiot, M. (Institut Français du Cafe et du Cacao (IFCC), Bingerville, Abidjan, Ivory Coast). **La résistance horizontale du cacaoyer au Phytophthora sp. Méthodes d'évaluation précoce.** (Horizontal resistance of the cocoa tree to Phytophthora sp. Methods of early evaluation). Café, Cacao, Thé (France) v. 19(2), pp. 123–136; April 1975 (Fr) graph, photos, tables, 31 refs; summaries.

Laboratory work conducted in the Ivory Coast to develop methods for early evaluation of horizontal resistance to Phytophthora sp. of cacao is reported. Two direct methods to be used with pods and two indirect methods to be used with young roots of plagiotropic cuttings, beans, and plantlets are described. The tests would allow: (1) the constitution of a differential range of pathodemas and pathotypes; (2) acceleration of programmes for resistance breeding; and (3) a better understanding of the pod rot horizontal resistance phenomenon.

Boulard, M. (Ecole Pratique des Hautes Etudes, Paris, France). **Un nouvel homoptère jessidomorphe des cacaoyères camerounaises.** (A new jessidomorphic Homoptera of the Cameroon cocoa plantations). Café, Cacao, Thé (France) v. 19(2), pp. 137–138; April 1975 (Fr) figs, photos, 6 refs.

Morphology of the sucking insect Wolfella benjamini occurring in cacao in the Republic of Cameroon is described.

Prem Kumar T. (Central Plantation Crops Research Inst., Vittal, Karnataka, India). **Effects of some antifeedants on the caterpillars of Pericallia ricini F. (Arctiidae, Lepidoptera). A pest of cacao.** Journal of Plantation Crops (India) v. 2(2), pp. 21–22; December 1974 (En) tables, 9 refs; summary.

A laboratory experiment in India studying the effectiveness of three antifeeding agents against the caterpillars, showed that triphenyl tin acetate (fentin acetate) at concentrations of 0·2% and 0·1% and triphenyl tin chloride (fentin chloride) at 0·2% were most effective in protecting the leaves and causing maximum mortality of the caterpillars. The chemical AC 24055 was least effective.

Rezende, A. M.; Aad Neto, A.; Sousa, A. F.; Barroco, H. E.; Brandt, S. A. (Escola Superior de Agricultura, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brazil). **Características da comercialização de cacau na Bahia.** (Characteristics of the marketing of cocoa in Bahia). Revista Ceres (Brazil) v. 22(120), pp. 116–140; March 1975 (Pt) tables, 20 refs; summaries.

This marketing study deals specifically with the various channels of the commercialisation of cocoa and quantifies the respective contributions by the participants in the market. Results show that the wholesale exporters are mainly responsible for the marketing in the study area, i.e. the municipality of Ilheus, Bahia (Brazil). Information is presented on the forward selling of cocoa, credit, length of storage of the produce, and the relation between size of enterprise and level of technology in the method of transport.

Wood, G. A. R. Cocoa. (Tropical Agriculture Series) Longman Group Ltd., London (UK) 3rd., 304 pp. 1975 (En) figs, graphs, photos, tables, refs.

This handbook deals with the botany, environmental requirements and cultivation of the cacao tree and with the processing, quality and marketing of its product. The 1st edition of 1955 and the 2nd edition of 1961 were written by D. H. Urquhart. This 3rd edition is an entirely new book. Mr. Wood is responsible for most of the text but the chapters on botany and on shade and nutrition were contributed by D. B. Murray, that on soils by A. J. Smyth, and that on insect pests by P. F. Entwistle. The metric system of units has been used throughout but British equivalents are still added in many places. Appendices describe international quality standards for cocoa beans and visual symptoms of mineral deficiencies (in key form).

Bigger, M. (Cocoa Research Institute, Tafo, Ghana). **Susceptibility of two cocoa progenies to attack by insect species. I. Proportion of trees infested.** Experimental Agriculture (UK) v. 11(3), pp. 187–192; July 1975 (En) fig, table, 13 refs; summary.

In Ghana, two cocoa progenies, T85/799 × T17/359 and E1:C43/291 × T63/967 (Series IIB hybrid), were compared for degree of infestation by 17 insect species comprising a coccid, an aphid, a mirid and six ants. A significantly greater proportion of trees of the second variety was infested by the mealybugs Planococcus citri Risso and Pseudococcus hargreavesi Laing, by the Lecaniid scale Gascardia sp. nr. zonatus Newst., by the aphid Toxoptera aurantii Boys, by attendant ants Camponotus spp., and Crematogaster spp., and by the ant Polyrhachis laboriosa F. Smith. Because of differences in habitat requirement between the four Hemiptera, it is postulated that it is more likely that the response is due to a physiological difference between the two progenies than to a purely environmental difference. Author's summary.

Bigger, M. (Cocoa Research Institute, Tafo, Ghana). **Susceptibility of two cocoa progenies to attack by insect species. II. Effects of canopy size on numbers of mealybugs.** Experimental Agriculture (UK) v. 11(3), pp. 193–199; July 1975 (En) fig, 6 refs; summary.

The two progenies T85/799 × T17/359 and E1:C43/291 × T63/967, studied in Ghana differed in canopy size, the latter having larger canopies. It was indicated that for a given canopy size, the mealybugs were 2·3 times more prevalent in the latter progeny than in the former. A similar analysis with the combined numbers per tree of seven mealybug species showed that they were 1·9 times more prevalent in trees of the same size of the latter progeny than those of the former one.

Annual Report 1971–72. (Cocoa Research Institute, Tafo, Ghana). Annual Report – Cocoa Research Institute (Ghana), Cocoa Research Institute, Tafo (Ghana), 1971–72, 237 pp. 1973 (En) figs, graphs, map, photos, tables.

A review is presented of the activities during the year consisting of the necessary general information and the reports of the divisions: Plantation management, Agronomy, Plant pathology, Entomology, Plant breeding and selection, Plant physiology and Chemistry. A list of 12 publications issued during the year, together with short summaries, is added.

Dakwa, J. T. (Cocoa Research Institute, Tafo, Ghana). **The effect of Phytophthora palmivora (Butl.) on the development of cocoa seedlings infected with cocoa viruses.** Ghana Journal of Agricultural Science (Ghana) v. 7(3), pp. 179–184; December 1974 (En) tables, 15 refs; summaries.

The effect of viruses on the tolerance of plants to fungi is known. Isolates of the cocoa swollen shoot virus and cocoa mottle leaf virus were used It could be shown that with plants infected with both viruses, attack of the fungus caused them to have significantly fewer leaves with smaller leaf areas and also shorter stems and less weight as compared with plants not infected by the fungus.

Atanda, O. A.; Jacob, V. J. (Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria. **Assessment of WACRI Series I and II varieties of cocoa in Nigeria. I. Establishment and yield.** Ghana Journal of Agricultural Science (Ghana) v. 7(3), pp. 215–220; December 1974 (En) tables, 16 refs; summaries.

Trials with the West African Cocoa Research Institute Series I and II progenies showed that none of them was significantly inferior, and many superior to F_3 Amazon in establishment ability. Over the first six years of bearing, series II progenies outyielded F_3 Amazon by an average of 165·2 kg/ha per year. Series I progenies were inferior to those of series II; the reason for this is discussed. It is concluded that mixed series II progenies constitute a more promising general purpose variety than F_3 Amazon, which, up to the 1960s, was the best available in Nigeria and Ghana.

January 1976

Adegbola, A. A.; Omole, T. A. (Department of Animal Science, University of Ife, Ife, Nigeria. **A simple technique for preparing discarded cocoa bean-meal for use as livestock feed.** Nigerian Agricultural Journal (Nigeria) v. 10(1), pp. 72–81; April 1973 (En) graph, tables, 24 refs; summary.

Every year substantial quantities of cocoa beans are discarded as unfit for export. To make them suitable for feed, the theobromine has to be removed by simple and cheap means. Sodium hydroxide and hot water were tried. A method involving hot water treatment of the ground meal at 100° C for 1 hour 15 minutes was used to prepare the meal in bulk for incorporation into livestock feed. The nutritional quality of the meal and a possible use in swine grower-fattener rations in West Africa are discussed.

Adegboye, R. O. (University of Ibadan, Ibadan, Nigeria). **Land tenure problems and improved practices.** Ghana Farmer (Ghana) v. 17(2), pp. 49–52; December 1973 (En) photo, 4 refs.

The introduction of perennial crops such as cacao, rubber and oil palm caused a reappraisal as to land tenure. Among the problems are the land rent charged, extended duration of land use, changes in customary tenure, and competition for land between food and cash crops. The latter even leads to migration. Landlords are increasingly reluctant to approve tree crop cultivation by their tenant farmers in view of ownership disputes when redeeming the land.

Boaten, K. (Department of Geography, University of Ghana, Legon, Ghana). **Some farming problems in the old cocoa growing area of Ashanti: a case study of Mampong cocoa district.** Ghana Farmer (Ghana) v. 17(2), pp. 53–61; December 1973 (En) fig, photos, tables, 14 refs.

Socio-economic problems in cacao farming in Ghana consist of fluctuating prices, food shortages, labour shortage and land tenure systems. Physical problems are low yield, diseases and old age. Food production has decreased due to shortening bush fallow periods (1940: 15 years, 1972: 5 years), resulting in high food prices. The cacao farmer had no interest in food crops in the past, planted most land to cacao and consequently has to purchase food crops. Swollen shoot disease may result in 20–30% yield decreases. The farmer is not particularly willing to fell diseased trees. Capsids may reduce yield by 30–40%. Control with Gammalin 20 has become popular as trees are not felled. Replant of old areas is difficult because farmers spend most of the time in new plantings. Conversion of old cacao land to food crops may solve many problems. However, the literate youth does not consider farming a profitable profession.

Buxton, T. K. The cash income of cocoa farmers in Ghana. Ghana Farmer (Ghana) v. 17.2), pp. 68–70: December 1973 (En) tables, 4 refs.

As part of a wider investigation, an analysis is presented on the farmers' net cash earnings on cacao, other crops and non-farm sources. It is observed that 33·4% of the farmers produce 77·3% of the cocoa crop and top 7·7% farmers produce 40·3%. Many small cacao farmers depend on outside sources of income. The small farmer retains 79·7% of his gross cocoa income decreasing to 65·8% for the big farmer. This decrease is due to cost for hired labour and chemicals. In cash terms 27·4% of the farmers earn less than US $0·87 per day. Only 6·8% of the farmers earn US $1,392 per year, the minimum wage of a graduate worker in Ghana.

Manu, J. E. A. Cocoa in the Ghana economy. Cocoa Marketing Board Newsletter (Ghana), No. 59, pp. 17–23; April 1975 (En) tables.

The enormous importance of cacao for the Ghana economy is discussed.

Actual earnings from the crop since 1960 have been lower than potential earnings because increases in the area under cacao and the yield per ha have been small. The low rate of increase in production is mainly due to the impact of the swollen shoot eradication campaign, high export duties, and the reduction of government expenditure on behalf of the industry. Ghana should stimulate cocoa production by raising prices paid to farmers and by subsidising new plantings.

Annual report of the Cocoa Research Institute of Nigeria 1971–72. Cocoa Research Institute of Nigeria, Ibadan, Nigeria. Annual Report – Cocoa Research Institute (Nigeria), Cocoa Research Institute of Nigeria, Ibadan (Nigeria), 165 p. 1973; graphs, tables.

This report contains details of the activities of various divisions, including soil aspects of cacao rehabilitation, plant breeding, agronomy, soils and chemistry as well as entomology and plant pathology. The Institute has undertaken studies on kola (Cola nitida), coffee and cashew as well. It is stated, that in case of cacao rehabilitation, growing young cacao under old cacao trees is an economic proposition, provided the old cacao farm is virus free and the rainfall adequate.

February 1976

Cruz L, J. de la; Soria V, S. (Facultad de Ciencias Agropecuarias, Universidad Nacional Palmira, Palmira, Colombia). **Estudio de fluctuaciones de polinización del cacao por las mosquitas Forcipomyia spp. (Díptera, Ceratopogonidae), en Palmira, Valle, Colombia.** (A study of fluctuations in the pollination of cacao by the midges Forcipomyia spp. (Diptera, Ceratopogonidar) in Palmira, Valle, Colombia. Acta Agronomica (Colombia) v. 23(3–4), pp. 1–17; 1973 (Es) graphs, tables, 26 refs.

In a study in Colombia, the number of Forcipomyia midges was found to be one midge to 1,038 cacao flowers. A midge pollinated 0 to 4 flowers per tree per day. Pollination fluctuated throughout the year in direct dependence on flowering and rainfall.

Wood, G. A. R. Cocoa pests, diseases, and weeds and their control. World Crops (UK) v. 27(5), pp. 200–203; September 1975 (En) figs, photos.

Tables are presented, dealing with: (1) symptoms, country of occurrence, insect species and control of insects infesting shoots, leaves, stems and pods of cacao; (2) class of weeds, herbicides, rate per unit area and notes on herbicide use in cacao; and (3) symptoms, country of occurrence, causal agent and control of diseases infecting whole tree, shoot, leaves, branches and trunk, and pods and flower cushions of cacao.

Opeke, L. K.; Jacob, V. J. Mutation breeding in Theobroma cacao, L. I. Radiosensitivity of cacao seeds and buds. Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria. Nigerian Agricultural Journal (Nigeria) v. 10(2), pp. 139–144; October 1973 (En) graphs, 12 refs; summary.

The objective of mutation breeding in Nigeria is to produce cultivars with satisfactory levels of resistance to Phytophthora pod rot disease caused by the fungus Phytophthora palmivora. Healthy viable seed and buds of cultivars were exposed to various dosages of gamma rays from a Co^{60} source. The 50% lethal dose was found to be between 1 and 2 hr (for buds) and 2 and 3 hr (for seeds). The Nigerian selection N38 was found to be more vulnerable than the F_3 Amazon seeds. Physical damage due to irradiation was manifested mainly in the leaves. Abnormalities in the leaves included crinkled leaf, partial variegation, forked leaf and leaves with wavy margins. The optimum dosage required to produce the desired mutants has still to be found.

Quesnel, V. C.; Lopez, A. (Cocoa Research Unit, University of the West Indies, St. Augustine, Trinidad and Tobago). **A sweat-box for fermenting small samples of cacao.** Tropical Agriculture (Trinidad and Tobago) v. 52(4), pp. 309–316; October 1975 (En) figs, graphs, 12 refs; summary.

A sweat-box for the small scale (10 to 20 kg) fermentation of cacao is described. Insulation is such that no external sources of heat are required to supplement the heat of fermentation. Chemical analysis of fermenting cacao has shown that the changes occurring in this box are very similar to those in a normal Trinidad sweat-box, though on the whole the cacao tends to be slightly more aerated. The quality of the product is good enough to allow quality assessments on new varieties developed by plant breeders. Authors' summary.

Leach, B. J.; Friend, D.; Chase, I. D. G. (Ministry of Agriculture and Rural Economy, Honiara, British Solomon Islands). **Deficiency of sulphur and nitrogen in seedling cocoa on an alluvial grassland of Guadalcanal, Solomon Islands.** Tropical Agriculture (Trinidad and Tobago) v. 52(4), pp. 317–323; October 1975 (En) photos, tables, 19 refs; summary.

Three months after planting cocoa under Leucaena leucocephala shade trees established on a Themeda australis grassland alluvial plain, some cocoa seedlings had died, others were stunted, and their leaves were chlorotic with marginal necrosis. Deficiencies of nitrogen and possibly sulphur were suspected. A field trial compared effects of ammonium sulphate with equivalent amounts of S and N as gypsum and urea, separately and together. Nitrogen alone aggravated the condition and responses to sulphur alone were small. Good responses were obtained on plants receiving either formulation providing both N and S. Authors' summary.

March 1976

Doreste S, E.; Capriles de Reyes, L.; Aponte L. O.; Mijares, J. (Facultad de Agronomia, Universidad Central de Venezuela (UCV), Maracay, Venezuela). **Nueva información sobre la "engurruñadera" del cacao en Venezuela.** (New information on "engurruñadera" of cacao in Venezuela). Revista de la Facultad de Agronomia (Venezuela) v. 8(3), pp. 119–127; July 1975 (Es) figs, photos, 3 refs; summaries.

Investigations showed that eriophyd insects (Floracarus theobromae and Eriophyes reyesi) can be held responsible for the growth disorder "engurruñadera" occurring in cacao trees. Symptoms consisting of shedding of leaves and dieback of the branch ends and distributions of the pest and intensity and variability of attack over the year are described and susceptible varieties are indicated. Long periods of dry weather appear to promote heavy attacks.

Schwartz, P. B. Observations on quality and sale of Malaysian cocoa beans. Planter (Malaysia) v. 51(591), pp. 258–261; June 1975 (En) tables.

Problems related with quality requirements and sale on the world market of cocoa beans are identified. Malaysian growers often have to sell their produce for lower prices than Ghanaian or Nigerian growers. The solution obviously lies in striving for good quality of the beans and it is therefore recommended that Malaysian producers should pay more attention to: (1) reappraising selection of planting materials; (2) conducting research more intensively into all aspects of bean processing and the agronomy of the crop; and (3) aiming for quantity only in as far as it is compatible with quality.

April 1976

Williams, J. A. (Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria). **The role of flavonoids, phenolic acids and purine alkaloids in Theobroma cacao, L.** West African Journal of Biological and Applied Chemistry (Nigeria) v. 14(1), pp. 10–19; 1971 (En) fig, table, 27 refs.

Purpose of this paper is to bring together and up to date the widely dispersed information about the occurrence and the role of these compounds in cacao and its products. This information may be useful in breeding programmes.

Maravalhas, N. (Divisao de Bioengenharia, Centro de Pesquisas do Cacau (CEPEC), Ilheus, Bahia, Brazil) **Combato aos ratos nos armazéns de cacau.** (Rat control in cocoa stores). Cacau Atualidades (Brazil) v. 12(1), pp. 22–23; January 1975.

A description of the use of Warfarin containing baits for rat control is given. The use of arsenical or other toxic products containing baits are not recommended for rats since the latter can, when urinating, provoke an off-flavour.

Tan, G. S. (Tun Razak Agricultural Research Centre, Sungai Tekam, Pahang, Malaysia). **Helopeltis theivora theobromae on cocoa in Malaysia. II. Damage and control.** Malaysian Agricultural Research (Malaysia) v. 3(3), pp. 204–212; December 1974 (En) graphs, photos, tables, 16 refs; summaries.

Descriptions are given of the types of damage on cocoa caused by Helopeltis theivora subsp. theobromae. Results of exploratory field trials indicate that lindane at 0·2% a.i. (224 g a.i./ha) will give good control for up to 20 days after application in the field.

Emechebe, A. M. (Department of Crop Science, Makerere University, Kampala, Uganda). **Some pathogen factors affecting inoculation of cacao seedlings with Verticillium dahliae.** East African Agricultural and Forestry Journal (Kenya) v. 40(2), pp. 168–176; October 1974 (En) graphs, tables, 20 refs.; summary.

In experiments conducted in Uganda, the incidence of Verticillium infection increased with a concentration of conidia inoculum beginning at a threshold value of $\pm 5 \times 10^4$/ml. A 60% incidence was obtained from conidia obtained from cultures 1–2 weeks old, whereas this was only 10% for conidia from 12-week-old cultures. Amount of N in the culture medium increased incidence, but carbohydrates had no such effect. Isolates of Verticillium from cacao, cotton and okra were equally pathogenic to cacao.

Willey, R. W. (Department of Agriculture and Horticulture, University of Reading, Reading, Berkshire, UK). **The use of shade in coffee, cocoa and tea.** Horticultural Abstracts (UK) v. 45(12), pp. 791–798; December 1975 (En) graph, tables, 54 refs.

Recent research is reviewed and it is attempted to assess fundamental relationships in the very complex effects of shading. Traditional shading is a technique which is rapidly declining in many areas. However, this review suggests that in some situations there can be sound arguments for its retention.

May 1976

Pereira, C. P. (Centro de Pesquisas do Cacao (CEPEC), Ilheus, Bahia, Brazil). **Porque é baixo o rendimento do cacaual no Sul da Bahia.** (Why cocoa yields have diminished in South Bahia). Cacau Atualidades (Brazil) v. 12(1), pp. 6–8; January 1975.

The development and quality of pods were investigated during various production cycles. The developing pods of 350 cocoa trees of 15–26 years old were monthly inspected and abortive pods were classified per causal agent, such as physiological pod fall or pods attacked by blights. Pod rot accounted for a 14% loss, whereas physiological pod fall amounted to an average of 50%. Only 3% of the trees were without physiological pod fall. Only 25% of the pods present and collected, which explains the low yields. Various recommendations to increase yield are given, including blight control and fertilising.

Cunha, J.; Ghosh, B. N. (Divisao de Geociencias, Centro de Pesquisas do Cacau (CEPEC), Ilheus, Bahia, Brazil). **Estudo do clima na secagem natural do cacau em baraças.** (A climate study with respect to natural drying of cocoa beans on platform dryers). Cacau Atualidades (Brazil) v. 12(1), pp. 14–17; January 1975 (Pt) graphs, photos, tables.

The aim of this study in Brazil was to investigate the different factors on drying, including temperature, rain, relative humidity and wind velocity. The wet beans entered the natural drying process with an average moisture content of 48·3% (39·6–53·7%) to leave it with an average water content of 8·6% (7·12–10·4%). The drying period varied between 5 and 12 days. Seventy-four percent of the initial water content was evaporated during the first 5–6 days and only 12% during the 5–6 final days. It is concluded that during peak periods, the final drying on platform dryers can be better taken over by artificial dryers, which need only 8–10 hours.

Soria, S. de J. (Divisao de Fitoparasitologia, Centro de Pesquisas do Cacau (CEPEC), Ilheus, Bahia, Brazil). **Uso de atomizador para induzir produçao do caucaueiro.** (Use of an atomiser to induce production of the cacao tree). Cacau Atualidades (Brazil) v. 12(1), pp. 18–21; January 1975 (Pt) graphs, tables.

Cacao is harvested during two periods, the first is called early (temporão), the second safra (harvest). As pollinating insects are scarce during the period of November–January, the early harvest is always small. A trial was carried out to induce artificial pollination, using an atomiser. The flowers were treated six times at alternating days in the early morning hours during January. The results obtained showed that the early harvest was tripled but that the total annual harvest was not increased.

Gregory, P. H. (ed). (Cocoa, Chocolate and Confectionery Alliance, London, U.K.). **Phytophthora disease of cocoa.** Longman London (U.K.), 360 p. 1974 (En) figs, graphs, maps, photos, tables; bibliography (27 pp).

This collective work, mainly on the black pod disease (Phytophthora palmivora) of cacao, was written by a team of 29 international experts. The book deals, among other things, with aspects of history, taxonomy, physiology, symptoms, damage to various parts of the cacao tree, influence of meteorological factors, research methods, breeding, chemical control, and integrated control. There are also chapters on mealy pod disease (Trachysphaera fructigena), Monilia pod rot, Witches' broom disease (Crinipellis perniciosa = Marasmius perniciosus), vascular-streak dieback (Oncobasidium theobromae), and allied pathogens (Phytophthora spp.) of other crops. A concluding chapter discusses prospects for overcoming attack by Phytophthora palmivora.

Vogel, M. (ORSTOM, Yaounde, Cameroon). **Recherche du déterminisme du rythme de croissance du cacaoyer.** (Research on the determinism of the growth rhythm of the cocoa tree). Café, Cacao, Thé (France) v. 19(4), pp. 265–290; October 1975 (Fr) figs, graphs, photos, tables, 178 refs; summaries.

From a review of the literature it appears that the growth rhythm of leafy cacao shoots is of endogenous origin for plagiotropic axes. In view of the regular and "automatic" character of the growth rhythm of both arthotropic and plagiotropic axes, and the fact that the overall root elongation rhythm has the same period as the rhythm of the aerial plant parts, the idea of overall endogenous rhythm is suggested. Experiments showed that the growth rhythm of the shoots is essentially due to internal correlations between the shoot apex and the nearest by half-developed leaves. The nature of these internal correlations is discussed, viz. transfer of inhibiting substance, membrane message from cell to cell, and competition for nutrients. Practical applications are suggested.

Babacauh, K. D. (Laboratoire de Phytopathologie, Ecole nationale supérieure agronomique, Abidjan, Ivory Coast). **Evolution de la pourriture brune dans les conditions naturelles de la cacaoyère ivoirienne.** (Evolution of black pod disease under natural conditions of the Ivory Coast cocoa plantations). Café, Cacao, Thé (France) v. 19(4), pp. 293–302; October 1975 (Fr) graphs, tables, 14 refs; summaries.

Phytophthora palmivora strains were systematically gathered in seven cacao plantations. Greatest damage was caused by P. palmivora, except for one plantation where Trachysphaera fructigena (mealy pod disease) was the most damaging agent. Progression of the disease varies from one area to another. A correlation was established between rainfall and the development of rot between July and September. It is estimated that two to four fungicidal treatments should be sufficient during this short period of rains.

Decazy, B.; Lotodé, R. (Laboratoire d'entomologie, Institut Français du Café et du Cacao (IFCC), Nkoemvone, Cameroon). **Comportement de familles hybrides de cacaoyers soumis aux attaques de Helopeltis Sign.** (Behaviour of hybrid families of cocoa trees subjected to Helopeltis Sign. attacks). Café, Cacao, Thé (France) v. 19(4), pp. 303–306; October 1975 (Fr) tables, 5 refs; summaries.

Ten hybrid families of cocoa trees in ten randomised repetitions of 20 trees each under shading were studied. Analysis of multiple regression leads to the conclusion that the development of the canopy has a positive and significant attracting influence; the attracting character is not a function of the number of cherelles (or very young pods) per tree but increases with the number of pods/tree. It should be noted that this increase varies from one hybrid to the next and represents the intrinsic attracting character of these hybrids with respect to Helopeltis sp. The resisting nature to psyllids (Tyora tessmani) and the non-attracting character with respect to Helopeltis sp. are in all likelihood carried by the same genes. Authors' summary.

Alvim, R.; Alvim, P. de T.; Lorenzi, R.; Saunders, P. F. (Divisao de Fitologia, Centro de Pesquisas do Cacau (CEPEC), Ilheus, Brazil). **The possible role of abscisic acid and cytokinins in growth rhythms of Theobroma cacao L.** Revista Theobroma (Brazil) v. 4(3); pp. 3–12; July 1974 (En) graphs, 19 refs.

The possible relations between abscisic acid and cytokinins are described in some detail. In particular, the effect of soil moisture stress on ABA levels is discussed.

Soria, S. de J.; Abreu, J. M. (Divisao de Fitoparasitologia, Centro de Pesquisas do Cacau (CEPEC), Ilheus, Brazil). **Mortalidade dos polinizadores Forcipomyia spp. (Diptera, Ceratopogonidae) causada pela aplicação de inseticidas nos cacauais baianos.** (Mortality of Forcipomyia spp. midges (Diptera, Ceratopogonidae) following insecticide applications in Bahian cocoa plantations). Revista Theobroma (Brazil) v. 4(3), pp. 13–25; July 1974 (Pt) graphs, tables, 14 refs; summaries.

Field trials with application of BHC, parathion-methyl and carbaryl at 0·24, 0·24 and 1·2 kg a.i./ha showed that population of Euforcipomyia and Forcipomyia midges were equally affected by each insecticide. Mortality was 89% for parathion-methyl, 79% for BHC and 68% for carbaryl. Maximum mortality was found two hours after application.

Singh, A.; Sundaram, S.; Vernon, A. J. (Research Division, Department of Agriculture, Suva, Fiji). **Fertiliser trials on young cocoa.** Fiji Agricultural Journal (Fiji) v. 36(1), pp. 7–11; January 1974 (En) tables, 12 refs; summary.

In fertiliser trials on young cacao in Wainibuka and Cakaudrove, Fiji, neither trunk growth nor yields during the 3rd and 4th year responded to P or K. This was in accord with relatively high values of P and K content of soil (72 ppm and 0·40 m.e.%, respectively) and foliage (0·22 and 1·7% dry matter, respectively). There were slight but statistically significant, responses of both trunk growth and yield to N, in Cakaudrove Province (where all the trial cacao was growing under unfertilised coconuts). This was in accord with the somewhat marginal average soil and leaf content of N (0·20% and 1·98% dry matter, respectively, in Cakaudrove) but the responses varied appreciably and inexplicably between sites. Authors' summary.

June 1976

Hicks, P. G. (Lowlands Agricultural Experiment Station, Keravat, Papua, New Guinea). **Phytophthora palmivora pod rot of cacao in Papua, New Guinea; investigations 1962–1971.** Papua, New Guinea Agricultural Journal (Papua, New Guinea) v. 26(1), pp. 10–16; May 1975 (En) fig, graphs, tables, 7 refs; summary.

Disease incidence was over 20% in 1955–56, but less than 3% in 1962–65 and between 10% and 20% in 1969–71. Average annual rainfall for these three periods were 246, 277 and 289 mm, respectively. On three occasions in 1963–65 long distance (beyond 20 m) dispersal was evident, contrasting with the usual short distance (less than 4 m) spread. Control may therefore be directed more economically at individual trees. Some obviously susceptible clones have been recorded in the field, but it is not clear whether the remainder are escapes or resistant ones.

Ashiru, G. A. (Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria). **Vegetative propagation of tropical tree crops with emphasis on cacao (Theobroma cacao L.) and kola (Cola nitida, (Vent.) (Schott and Endlicher).** Acta Horticulturae (Netherlands) v. 49, pp. 67–73; July 1975 (En) 34 refs.

The subject is reviewed. Attention is paid to the choice of mother trees, methods of vegetative propagation (treatments of cuttings with rooting hormones, the propagator, media for propagation, grafting, budding, budwood selection, marcotting) and prospects of vegetative propagation with particular reference to cacao and kola.

Amponsah, J. D. (Cocoa Research Institute, Tafo, Ghana). **Studies in natural pollination of cocoa in Ghana.** Acta Horticulturae (Netherlands) v. 49, pp. 223–229; July 1975 (En) tables, 9 refs; summary.

Field observations indicated, that six rows of cacao spaced 2·4 × 2·4 m could not prevent the transfer of pollen across that distance by pollinating insects. In an area of 31·7 × 31·7 m, 24% of all pods harvested over three crop seasons were found to be the result of transfer of pollen from outside the plot, while 58% could be traced to pollen within the plot alone. Only 7% of the pods arose from mixed pollinations.

Bonaparte, E. E. N. A. (Cocoa Research Institute, Tafo, Ghana). **Yield gradients in cocoa (Theobroma cacao L.) – shade and fertiliser experiments.** Acta Horticulturae (Netherlands) v. 49, pp. 251–257; July 1975 (En) graphs, tables, 9 refs; summary.

In a study of Amelonado cacao conducted at Tafo, Ghana, yield was not significantly affected either by species of shade tree or by the distance of the cacao tree from the shade tree. Fertilisers produced highly significant yield increases, irrespective of distance of the cacao trees from the shade trees. The results are discussed in the light of apparently conflicting results obtained in other studies. Author's summary.

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