A COCOA RESEARCH SCHEME FOR THE ICA PROGRAMA DE CACAO

REPORT OF THE 2nd TECHNICAL ADVISORY MISSION TO STRENGTHEN THE ICA PROGRAMA DE CACAO, IN PARTICULAR ITS BREEDING AND GENETIC RESOURCES EFFORT

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HILDE TOXOPEUS*

Plant breeder and cocoa production specialist

* Foundation for Agricultural Plant Breeding, SVP
   PO Box 117, 6700 AC, Wageningen, The Netherlands.
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1. INTRODUCTION AND NEXT MISSION

This is the report of the second Technical Advisory Mission (TAM) in support of the Programa de Cacao (P de C) of the Division Cultivos Industriales of the ICA.

The mission is the second out of three. The first mission was carried out from 12 July - 11 September 1986, the first 6 weeks of which were spent visiting the main cocoa producing areas in Colombia.

Problems of cocoa production were identified and defined, and approaches towards solutions were proposed. The history of cocoa production was set out and a working hypothesis was put forward regarding the evolution of populations and their present approximate location in terms of Cocoa Map of Colombia (chapter 4.4.4).

The present mission provides a view of the role of the ICA P de C in the whole process of cocoa research and development as well as a masterplan for cocoa research, and practical details of its implementation. The research scheme is directed towards solving the main problems of cocoa
cultivation in Colombia. As in the report of the first TAM, special attention is paid to the breeding programme. The new plan for research is likely to take off soon.

Considering that about 2 years will be required before the first results will come, it is suggested that the 3rd and last mission should be carried out two years from now: end of 1989. Progress of research will be reviewed and adjustments will be suggested. The further planning of the breeding programme on the basic of accumulated evaluation records will receive special attention.

The organization of the mission was in the hands of Dr. P Buriticá C Director of the ICA Division Cultivos Industriales and mr Bejarano of the IICA office in Bogota.

I am specially indebted to Ing G Rondon M Sc (Birmingham) who was with me during the whole mission as organisor, guide, interpreter, for his good company, moral support and otherwise whilst I was hospitalized in Palmira for treatment of a violent attach of malaria.
The Cocoa Map of Colombia and the drawing of the Model of the mature cocoa plantation are his. He is the editor of this report, and has prepared translations in Spanish of the Appendices.

HILLE TOXOPEUS

Bogotá

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2. SUMMARY OF OBSERVATIONS AND RECOMMENDATION

2.1 The main problem of cocoa cultivation in Colombia is the lack of understanding if the role of the cocoa canopy in relation to permanent overhead shade and fertilizer use.

2.2 The ICA P de C should therefore concentrate its research activities towards mastering the "Shade and fertilizer interaction" taking due care of the cocoa canopy and providing solid evidence of the response of production to shade manipulation and fertilizer use in field trials.

2.3 The two species of insect Monalonion must be brought under control as a matter of urgency.

2.4 The quality of cocoa beans is largely determined by the variety. The issue of quality has not received attention by cocoa research and development institutions in Colombia. The issue can only be properly investigated in cooperation with the users of the cocoa bean: the chocolate manufacturing industry.

2.5 The breeding programme of the ICA P de C should aim to produce a variety with a very considerably higher
potential yield level than the present hybrid-mix and produce a much improved quality bean. It should venture out of the narrow confines of the parentage of the present hybrid-mix.

2.6 If the new research programme of the P de C is succeed an adequate traveling budget should be made available for meetings between the researchers involved to meet and exchange experiences and discuss technical issues. An absolute minimum requirement is an annual meeting of research staff.

3. MASTERPLAN FOR A COCOA R AND D SCHEME FOR COLOMBIA

The objective of cocoa cultivation in the prolific and profitable production of cocoa beans of acceptable quality.

Cocoa production is an economic activity that must result in a substantial rate of return.

Considerable capital investment is required for planting since it takes the trees 2 to 3 years after planting to produce the firsts economic crop. In the following 3 to 4 years the per ha production increases sharply to a maximum level of
production depending on shade, soil fertility and inputs.

Quite obviously it is of crucial importance to be able to make plantations reach a high level of production for many years.

Considerable research and experimentation is required to arrive at optimum management systems and level of inputs. This issue is therefore central in the following consideration.

3.1 The cocoa world's experience (W Africa, Brasil, Malaysia) has learned that the mature productive cocoa plantation is characterized by a well developed integrated canopy, at about 2m above ground level. The canopy is born on a framework of firm secondary and primary branches issuing from trunks of individual trees at a density of between 1,500-1,000 trees per ha. Interspersed between the cocoa trees are shade trees at about 10% of the cocoa stand. The shade trees should intercept not more than approximately 25% of incoming radiation. Cocoa has a high energy requirement since its basic product, the bean consists for more than 55% of its oven-dried weight of fat.
Scientific and practical aspects of this type of plantation are discussed in detail in Appendix 1, which also includes a graph showing a projection of average per ha production over 20 years.

The functions of the canopy of cocoa and the role of overhead shade are apparently ill understood in Colombia. Either the shade is heavy or there is no shade at all. In many cases the canopy of the cocoa (the photosynthesis factory!) is heavily pruned, or opened up for a variety of reasons, the main one a fear for the increase of pod rots such as caused by Monilia wich, however, can only be effectively controlled by phitosanitary removal.

Well argued and carefully planned field trials are required to gain insight in this most important area; details are presented in chapter 4.1.

3.2 Establishment. The agronomy of rapidly growing seedlings into a mature plantation is of obvious importance.

Spacing and temporary shade are the important issues here.

The cocoa plant in this early phase is tender and susceptible of desiccation especially by vind during a dry season. It is recommended to experiment with hedgerows of either natural vegetation or local suitable annual crops.
Spacing is usually a controversial issue. A dense spacing like 2x2 m sq; (2.500 plants per ha) results in very rapid establishment and high early production (at a high cost of planting material). However, soon after closure of the canopy the field runs into problems of an over luxurious canopy and competition for light between trees and a need for thinning out usually resulting in a messy situation. Spacing trials are valuable and most instructive. Detail suggestions are presented in Appendix 4 and some aspects of implementation are discussed in chapter 4.2.

Pruning consists of guiding the developing trees along their natural growth pattern making sure that the jorquett joint is quickly (self) shaded, so that compact, well balanced trees grow up eventually to merge their individual canopies into one integrated canopy. Pruning is discussed in Appendix 2.

3.3 The plantation and the crops have to be defended against the onslaught of pests and diseases. Two major ones. Witches' Broom disease and Monilia pod rot can economically and entirely satisfactorily be controlled by phytosanitary removal of early infections, respectively vegetative brooms and pods.
A damaging pest is the insect Monalonion that occurs in two closely related species, the one feeding mainly on pods and the other on young shoots. The latter is dangerous because it damages the canopy by killing all or many of a new flush.

The former causes direct losses by damaging pods. Monalonion is a pest of cocoa all over Colombia but there is no satisfactory economic method of control.

For recommendations regarding research see chapter 4.3.

3.4 To a large extent the quality of cocoa beans is determined by the variety grown. The chocolate manufacture needs a uniform bean of an average weight of 1.1 - 1.2 g, with a plain chocolate flavour. The present variety, the so-called hybrid-mix, probably produces a bean that is too variable and has too weak a chocolate flavour. There is, however, an almost complete lack of information about its quality aspects. This gap has to be filled.

The variety also provides for the potential of production. The present hybrid-mix probably has a potential of 2,000 kg/ha at maturity, given optimal management and inputs. This is a very acceptable level and it will require a carefully designed long term breeding programme to produce a variety with a substantially higher yield potential.
The basis and the perspective of any breeding programme is the degree of genetic variation to its disposal. The available germplasm should be evaluated for the important economic characters (such as quality).

Thus, first the objectives of the breeding programme should be clearly defined, and analysed in relevant detail. This must result in a clear view of the characters required. Evaluation methods should be defined with which the germplasm is screened so as to identify which clones or trees possess these characters. This will provide for the crossing programme which must lead to the desired recombination of characters into one cultivar. Practical details of a plan of operation for the first few years are stated in chapter 4.4.

4. IMPLEMENTATION

4.1 The shade and fertilizer interaction
It is essential that the agronomists of the Programa de Cacao (P de C) gain experience with the shade and fertilizer interaction. The model is explained in Appendix 1.
4.4.1 The first main issues is control over shade trees as they grown up in a newly planted cocoa field.

Basically this is easy by lopping off excess branches every other year or so. The Glyricidia (Mataraton) is one of the best trees from this point of view. Many of the roadsides in tropical Colombia are planted with Mataraton trees that are pruned regularly and have an ideal shape for shade in a cocoa plantation.

The fact that Mataraton trees may become defoliated by caterpillars occasionally is not important to the cocoa, because it is only temporary.

The defoliation will retard the growth of the Mataraton.

The clonal trial and the progeny trial in the CRI Caribia, about 2 years old after planting, are planted with a mixture of permanent shade trees. These trials offer an excellent opportunity to optimise shade production by regulating the shade and test levels of and formulations of fertilizers.

Apart from the experimental plot records, the production of the whole field be carefully recorded for its production including the losses to diseases. Pods harvested in the peak of production should be separately fermented and dried, bean counts should be recorded (nr of cured beans in 1 kg).
A similar trial should be carried out on part of the neighbouring 2 years old commercial planting. It should be possible to work out a sensible plan with the management of the CRI Caribia.

4.1.2 The second major issue is the reduction of shade in older more or less heavily overshadowed fields. It is customary to plant fast growing trees for permanent shade such as the Carbonero and the Saman tree.

As from about the fourth year of planting these trees will have grown into major trees that oversnade the cocoa completely in the following years, to the effect that yields of the cocoa start to decline. The shade trees have a major liability because cutting down major branches or whole trees will wreak havoc to the cocoa canopy.

The shade trees have to be gradually reduced by ringbarking major branches, possibly applying chemical tree killers to be pointed on the exposed wood. The process should be spread over two to four years depending on the size of the trees.
Unless the shade trees were planted densely, they should not be hilled.

Ringbarking has the effect that the branch gradually dries out. Since the water content is about 80% and water is heavy, the weight of the branch is much reduced before it falls off, and it will drop in pieces, first the top part, the remainder later. Nevertheless damage to the cocoa canopy will be the result.

Technical assistants and labour will have to develop skill in reducing shade and guiding the regeneration process of the affected cocoa trees. Appendix 2 provides information as to how to repair gaps in the cocoa canopy.

The progeny trial at the ICA Palmira, 6 years old and declining as a result of rapidly growing shade trees increasingly overshading the cocoa, also provides an excellent opportunity to gain experience with shade reduction.

Also near Palmira the cocoa plantation of the finca El Porvenir will provide plenty of opportunity to develop skill

* ref Appendix 5 Summaries of farm visits farm nr 1
with shade reduction (and the response to fertilizers).

At the CRI Caribia the 6 ha. of 12 years old commercial cocoa, heavily overshaded and yielding only about 600 Kg/ha., provides for an excellent opportunity too. At this moment occasional shade trees are killed off. This is not the right way of doing it, because the distribution of shade becomes very erratic. A well conceived plan should be worked out with the CRI management to reduce shade gradually over the next 2-3 years, over an area of some 4 ha. including a fertilizer trial, with the objective to double the per ha. production.

In both cases the fertilizer aspects have to be worked out with Dr. Garcia. The objective is to reach a production level of 1500 Kg/ha at maturity; The graph of figure 2 in Appendix 1 is the guideline.

4.1.3 The third case is that of the no shade cocoa of Caldas and Caribia. It is not recommended that the P de C plants field trials without shade. There is plenty of unshade cocoa around. It would seem unlikely that owners would agree that a part of their 2-4 years old cocoa is interplanted with,
say., Mataratog. However, it is worth a try, but the field should be at last 1 ha in size.

It is not recommended to plant shade in older fields because by the time that the shade becomes effective 2-3 years latter if successful at all, the cocoa trees are likely to star to decline. The cocoa of Las Mercedes in the Manizales area will probably turn out to be a tropical case. Appendix 5 case nr 3 provides more details the graph gives the projection of production of no-shade plantings over time.

It is strongly recommended that "case histories" are built up of the (no-shade) cocoa of a number of farms: date of planting, spacing, temporary shade (date of cutting out plantains) fertilizer use, irrigation cultural practices, pruning, and, most important: annual production. Theses cases should be regularly reviews, and discussed.

It will be most interesting to see as to wheter the fertilizer trial in La Papirusa (no shade) will eventually provide a formulation that will present the probable decline in the 8th-10th year after planting as predicted in the projection of fig. 1.
FIGURE 1. PROJECTED AVERAGE PRODUCTION OF CURED COCOA BEANS PER HA AS A RESULT OF 2 DIFFERENT SYSTEMS OF MANAGEMENT

- close spacing, no shade, maximum inputs
- wider spacing, 25% shade, optimum inputs
It is strongly recommended that the unit plot size of a fertilizer trial is appr. 20x20 m.

The comparison of the projected average production of cured cocoa per ha as a result of the 2 system of management, as drawn in figure 1 is particularly illustrative.

4.2 Establishment: The term "establishment" indicates the growth phase of the cocoa plantation from the date of planting in the field, to the time that the canopies of the individual trees close into an integrated canopy. This is also approximately the time that commercial production starts.

The main issues are spacing, and the use of temporary shade. Theses issues are discussed in Appendix 1.

It is recommended to plant a number of spacing trials. Details of a standard spacing trial are provided in Appendix 4. A most important detail is that the different spacings are planted on approximately the same unit area, 20x20 m.

Apart from the research value, spacing trials are most
instructive demonstration plots, particularly in the longer term.

Do plan permanent overhead of shade (Mataraton).

If a spacing trial has to be planted on a slope, make sure that the spacing between trees is measured horizontally and not along the slope.

4.3 Control of pest and Diseases

4.3.1 Witches'Brom disease and Monilia podrot

Intensive research by the P de C and other agencies in Colombia during the past two decades has conclusively shown that phytosanitary harvesting of respectively vegetative brooms and early pod infection give complete, and economic control of both diseases.

It is recommended that the evidence accumulated over the years is summarized in one or several semi popular articles (in spanish) in a revelant journal or issued as ICA publications. The purpose is to indoctrinate farmes and extension workes that theses cultural practices are an essential part or successful cocoa cultivation in Colombia.
Only in the Tumaco area Witches' Broom disease seems out of control as a result of a heavy "background" inoculum. The possible solution to the problem here will eventually be provided as a result of the efforts of the Witches' Broom International Programme, in which the ICA is actively involved.

4.3.2 Monalonion

The Monalonion insects (M. anulipes, M. dissimulatum) are the main pests of cocoa in Colombia. The first species feeds on pods mainly and the second prefers the young shoots, but in the absence of the preferred substantial the other alternative is attached.

The one species causes losses of pods and losses of pod content through malformation of pods and the other, although not present in all cocoa growing areas, causes the death of flushes and damages the canopy. The latter damage is the most serious because by the reduction of the canopy the yield level is affected.

Despite all kinds of treatments, Monalonion is out of control.
For a more detailed analysis of the problem and possible solutions reference is made to the report of the first TAM chapter 3.2, p 17-20.

Developing economic methods of control of the Monalonion pest should be one of the main research issues for the P de C. Expert advice from entomologists has to be sought.

The objective is to develop a census and management system. The census element consists of a method of detecting fresh feeding lesions caused by adults and a threshold level of lesions beyond which the affected trees should be sprayed. The adults are actively flying and can only be effectively killed by using motorblow spraying apparatus in combination with a persistent insecticide like lindane.

Three successive sprays with intervals of 10 to 14 days will be necessary to kill adults and emerging nymphs depending on the growth rate from eggs to larvae, a process that is temperature dependent.
4.3.3 Phytophthora pod rot and bark canker

This disease category is dangerous and potentially very damaging, particularly the pod rot. Phytophthora pod rot cannot be controlled by phytosanitary harvesting such as the rot caused by Monilia. Protective chemicals have to be used.

It is recommended that a pathologist is identified who should accumulate the (considerable) world literature on this disease, as well as bark canker. In the latter case there may be some promise in the use of the Phosphorus bases systemic fungicides such as Aliette.

4.3.4 Other pathogens such as the root disease (Rosellinia) the pajarito, and Ceratocystis appear to be of local, or of minor significance.

The root rot and Ceratocystis appear to be parasites of weakened trees. The best protection is to grow healthy vigorous trees. Cocoa trees growing without shade altogether are continuously under stress because of the overdose of radiation. This makes the trees most affected by this stress condition vulnerable to attack by these parasites.
4.4 Breeding and Genetic Resources

4.4.1 The quality issue

This issue has been dealt with in detail in the report of the first TAM in chapter 3.1 in pages 14-17. For a variety of reasons the average quality of the Colombian cocoa bean is poor.

The main cause of this unfortunate situation is the government regulation that all cocoa beans must be bought by the national chocolate manufacturers at a fixed price (close to the world market price) providing samples meet three criteria:
- The moisture content should not be more than 8%
- The proportion of flat beans should not exceed 1%
- The proportion of insect damaged beans should not exceed 3%

Since the price for the product is fixed there is no incentive for the farmer to invest in adequate fermentation facilities and an adequate fermentation period.
A grading system based on international cut test of samples, coupled with a higher price for first grade beans would go a long way to solve this problem.

However, there are also inherent qualities of the varieties that play a role. Varieties such as the old "Comun" types (ref. chapter 4.4.5 Cocoa map of Colombia) produce a large plump bean with a tight break (of the cured beans). The old hybrid-mix, dominated by the clone Sca 6, which was planted on a large scale, presently in full production, produces a very variable bean which on average is small. The variability of the bean size is a big problem for the manufacturer.

The bean size and the variability are determined by genetic factors and so is the flavour.

The user of the bean is the chocolate manufacturer who should be consulted and involved in the considerations as to the criteria for good quality cocoa beans. This will provide the necessary objectives for the breeding programme.
A regular communication with Colombia's chocolate manufacturing industry is therefore essential and moreover the active cooperation with the quality control laboratories is required for the evaluation of specially prepared samples of cured cocoa beans.

The visit to the quality laboratory of the factory of La Nacional in Rionegro near Medellin during the 1st TAM taught us that what manufacturers want is:
- Average weight of the cured bean (moisture content 7\%)
  1.07 gm or 93 beans in 100 gm.
- Uniform bean (not specified)
- Fat content high (\geq 55\% of oven-dried weight of nibs)
- Plain chocolate flavour.

These characters are determined by the variety, they are under genetic control. Therefore they should feature high in the objectives of the breeding programme.

4.4.2 Improvement of the present hybrid mix and prospects for further improvement

a. According to an agreement reached in 1981 the hybrid mix issued to farmers in Colombia consists of the following crosses:
TSH 565 x IMC 67  
P 7 x ICS 39  
ICS 1 x SCA 12  
EET 400 x ICS 1  
ICA 6 x IMC 67  
EET 400 x ICS 6  
ICS 6 x TSA 654  
ICS 95 x IMC 67  
ICS 60 x SCA 12  
ICS 8 x IMC 67  
P 7 x ICS 6  
ICS 60 x IMC 67  
ICS 6 x P 7  
EET 400 x IMC 67  
ICS 39 x P 7  
P 7 x ICS 60  
ICS 1 x P 7  
ICS 1 x IMC 67  
IMC 67 x EET 62  
P 7 x IMC 67  
EET 62 x IMC 67  
EET 400 x ICS 39  
IMC 67 x ICS 6  
EET 96 x SCA 12  
TSH 792 x IMC 67  
P 7 x ICS 1  
ICS 40 x IMC 67  
EET 400 x ICS 60  

The hybrid-mix has a very broad genetic basis which explains its wide ecological tolerance. Since most of the crosses are wide, its plants are vigorous and the potential yield level will be somewhere around the 2.000 kg/ha.

One of the disadvantages of this genetic diversity is variation in plant growth and productivity of individual trees. These phenomena can be largely offset by superior agronomy.
Another (probable) disadvantage is a great variability in individual bean weight which is a bad quality character. There is an unfortunate and serious lack of information on the quality characters of the product of the hybrid-mix.

This gap should be filled as soon as possible, urgently. Quality evaluation must be carried out by the quality laboratories of the big chocolate manufacturers (see also chapter 4.4.1. The quality issue). Quality evaluation should include the analysis of fat content. Moreover, so as to gain insight in the inherited aspects of quality, 2 kg samples of cured beans should be prepared of each of the 17 parents of the hybrid-mix.

ICS 1  SC 95  TSH 792
ICS 6  IMC 67  TSH 812
ICS 8  SCA 12  EET 62
ICS 39  P 7  EET 96
ICS 40  PA 46  EET 400
ICS 60  TSA 654  (SCA 6)

For this purpose open pollinated pods should be used, about 70 pods are required, the beans can be fermented in basket lined with banana leaves, fermentation period 6 days, beans should be turned every day.
Whenever possible more clones should be included in the evaluation. In the course of this research, very important information should be generated on pod value (how many pods are required to produce 1 kg of cured beans).

If it so happens that some of the parent clones have clearly unwanted quality properties they might be deleted as parents. However, only in the case that the character is linked to a weakness in the product of the hybrid-mix.

b. The prospect of significant improvement in productivity by testing series of hybrids within the same parental background is limited.

Improvement of uniformity of growth pattern is definitely possible. However, it will always be necessary to make a hybrid mix because the productivity of single hybrids may suffer from cross incompatibility as a result of the occurrence of only one or a few incompatibility alleles in the cross. Moreover single hybrids usually make a product with soft-flavours.

It should be realised that a consistently higher production of at least 20% in more than one site will be required to
persuade cocoa development agencies to establish the necessary new seed gardens. This, after all, is a major investment.

c. The conclusion is, that, cocoa breeding has to take a fresh view of the position. On the basis of a clearly defined goal, objectives have to be formulated and analysed, to be translated into a breeding programme. This is worked out in some detail in the next chapter.

4.4.3 The long term breeding programme

- The goal of this programme should be to breed a particularly productive variety producing a good quality bean.

- Regarding productivity, the increase of the yield potential can only be realized by a considerable increase of the pod value so that instead of the present 30-35 pods required for 1 kg of cured beans, only half the number is required. This increased pod value will have to be realized mainly by increasing the average nr of beans per pod to 50 or more. An increase of the average bean weight may not be acceptable to the industry; this is to be checked out.
The fact that fewer pods are required to produce 1 kg of cured beans also means a considerable increase of labour productivity.

If the pod husk were thin and could be slit open by a hand knife, or broken on a stone, pods could be opened upon harvesting. This would be another increase of labour productivity.

- Regarding quality, the variety has to produce a uniform bean of an average weight of 1.07 gm (93 beans in 100 gm) with a low shell content, and with a good chocolate flavour, and a high fat content.

- These quality characters should be combined with: A very high pod value, i.e., pods should contain an average nr of beans of 50 or more, which probably means that the ovaries of flowers should contain 60 or more ovules.

The pod husk should be thin and/or soft so that they are easily broken.

The cv should produce quick growing robust plants, easy to establish and very precocious.
The cv should not be particularly susceptible to any of the main diseases.

There is no case for breeding for resistance as yet:
- The main diseases Witches' Broom disease and Monilia podrot are easily controlled by phytosanitary harvesting.
- Stable resistance factors, absolutely necessary in tree crops, have not been identified and well tested screening methods are not available.
- The research capacity of the ICA P de C is inadequate for major resistance breeding programmes.

However, active participation in interregional research programmes such as the International Witches Broom disease Project is to be encouraged. The collective effort would provide for the necessary research capacity.

- At this very early stage of the breeding programme the phase is evaluation for the above characters with the purpose of identifying clones, populations or trees with the desired characters.
- As to quality, clones, populations and varieties should be evaluated by chocolate manufacturers on the basis of samples of 2 kgs of cured beans (ref chapt 4.4.1 The quality issue). Determination of fat content is also necessary.

- As to pod value information on the average nr of beans of normally developed pods is required. The potential nr of beans of a pod is the number of ovules in the ovary of the flower. An "ovule-count" can be made quickly and will give valuable back up information.

- Regarding the softness of the pod husk, a practical qualitative assessment will have to be worked out.

The evaluation work will identify which plant material (clones, populations, varieties) harbours specific characters. Since it is unlikely that one plant material will combine all desired characters, crossings will have to be made, and these have to be planted in a field trial for further careful observation.

Some general considerations on categories of parent material that should be crossed are as follows.
The strong chocolate flavour (not necessarily "plain") is found in parents that produce dark purple beans. They are clones like PA 46, IMC 67, P 7, Sca 6 and 12, and related clones, combining this with, on the whole, a high pod index (30-40 pods/kg cured beans). A local population worth attention is the Pajarito! The fat content of beans may well be high.

A low pod index (15-20 pods/kg dry beans) is probably found in the TSA and TSH clones from Trinidad, however combining it with a large bean with a weak flavour and possibly a low fat content.

A soft pod, and indeed a very thin one is found in the Pentagona clones and local Comun, combining with a plump bean probably with a weak flavour and possibly a low fat content.

Crosses should be made between the first and the last two categories. Considering the wide nature of the crosses there is a good prospect that the F1 trees show transgression in essential characters, and lots of hybrid vigour.
4.4.4 Cocoa Genetic Resources and the Cocoa map of Colombia

a. Material collected in the past year

The following plant material was collected and planted in the past year (1986/1987).

The material was collected following recommendations formulated during the first TAM. Unfortunately the precise recommendations as written in the report were not available for some considerable time later. Appendix 3 is an improved version of these recommendations.

Cacao Vegetal

In November 1987 the Cacao Vegetal was collected by the local technical assistant. Apparently pods were collected from the original Cacao Vegetal trees we visited in 1985 (last year). Unfortunately details regarding the sample size are lacking: how many pods were collected from how many trees in how many different farms which were the farms, the location of the farms, the names of the farmers.
The beans from the pods collected were mixed and three samples of 200 seeds each were prepared and sent to CNI Palmira, CRI Caribia, CRI Tulenapa. The last batch failed to germinate, 72 seedlings were planted in the CNI Palmira and 144 were planted in the CRI Caribia.

This population was not adequately sampled

Cacao del Pais

This population was collected by Ing M Pinto from the finca Lolita Wall. Budwood was taken from ancient trees and seeds with white cotelydons were selected from open pollinated pods from these trees. The material was planted in the CRI Caribia.

We revisited the trees in the finca Lolita Wall, and those in the finca La Envidia on the rio Cordoba, and came to the conclusion that the trees clearly belong to the same population. During the first mission we came across the same population in Cerro Azul (report of the first TAM p 91 farm report nr 31). This population is characterized by small warty pods with a slightly bent point basically without bottleneck, blanco, often pigmented, small plump beans with
white cotyledons. The leaves are small and broad, the leaves of the young flush are of delicate pale green. Leaves and twigs of the young flush and the hardened of flush are covered with small hairs, velvety to the touch, quite unlike all other cocoa population.

This population in adequately collected and growing well under considerable shade in the CRI Caribia, from where it may be propagated (hand pollinated seed) to other centres.

The impression is that, to all intents and purposes, the old Criollo trees in Lolita Wall have died, have been cut out, or are so poor that they are beyond reproduction.

Huila Comun

This population was sampled in December 1986 by Dr Luis Lopez and Ing Alvaro Caicedo. Quantitative details of the sample were not available during the mission. Only a sample of 72 seedlings was successfully planted in the ICA Palmira.

In addition bud wood was taken from 49 trees with strong "Criollo" characters amongst which seeds with white cotyledons. From 23 of these trees an equal nr of pods were
taken to ICA Palmira, all seeds were planted in the nursery. It is recommended to plant the successful buddings together with as many of the seedling in one plot. This sample is strongly biased towards "Criollo characters". A representative sample of the Huila Comun was not obtained.

Tolima

Dr Luis Lopez collected bud wood from 19 "Criollo" trees as well as one pod from each tree from plantings around the town Chaparral. Buddings were made and all seeds were planted in the nursery at ICA Palmira. It is recommended that the plants are planted out together is one plot next to the Huila material. A representative sample of the Tolima population was not obtained.

Sierra Nevada de Santa Marta (Granada)

Dr Lopez collected budwood from 13 trees, as well as one pod from each of 3 trees from an isolated cocoa planting in the montaña of the Sierra Nevada de Santa Marta (Granada).
The material was budded and planted in the CRI Caribia.
The population was not adequately collected. However, the area is inaccessible for lack of infrastructure, and dangerous.

b. Future collection activities

The objective is to collect representative samples of cocoa genetic variation in Colombia.

The cocoa populations existing in Colombia, as we see them at the time of the mission, are listed out in Appendix 3 and their approximate location in figure 1, the Cocoa Map of Colombia of this Appendix.

Representative samples should be collected of each population except the Cacao del Pais which has been successfully collected.

Apart from the rather obvious importance of growing conserving and evaluating this collection a most important aspect is in its value to exchange genetic variation with other countries.
5. Notes on the organization, coordination and manpower development of the ICA Programa de Cacao

There are 4 or 5 main areas of cocoa cultivation in Colombia. The ecologies differ in terms of rainfall, and temperature, soils topography and elevation. The agronomy of cocoa production therefor has to be adapted, especially from the point of view of fertilizers, in relation to shade. Leadership will be required to coordinate this effort. There should be an adequate traveling budget to make sure that the scientists and technical staff can meet regularly to present and discuss their research effort and results and discuss problems and exchange ideas and observation.

An annual meeting of ICA P de C research staff, centring around one or two themes could be the backbone for effective coordination.

The main issues for the next 5 years are: Shade and fertilizers of mature cocoa. Monaloniion control, evaluation of germplasm and breeding material.
The requirements for manpower development are in the fields of:

Breeding and Genetics
Soils and nutrition
Crop physiology
Agroforestry may well be useful
6. ITINERARY AND PEOPLE MET

NOVEMBER

Tuesday 3  14:00 hrs departure from home, via Frankfurt with AV 0011
Wednesday 4  11:00 hrs arrival Bogotá
Thursday 5  09:00 hrs dr Bejarano in the IICA Office
            14:00 hrs dr Buritica at ICA Tibaitata Office
Friday 6  09:00 discussion dr L Lopez of ICA Genetic Resources Unit
            14:00 hrs dr Buritica and Ing Rondon M Sc
to draw up the programme
Saturday 7  10:00 hrs visited the Gold Museum
Sunday 8  Free
Monday 9  Travel to Cali and Palmira, ing F Ocampo and
         Ing R Saavedra
Tuesday 10 Discussions
Wednesday 11 Discussions dr A Garcia, soil scientist,
to monday 16 afternoon hospitalized for treatment of a
         malaria attack
Tuesday 17 Work on research programme
Wednesday 18 Work on research programme
Thursday 19 Work on research programme
Friday 20 Work on research programme
Saturday 21 Visit finca El Porvenir, Ginebra
Sunday 22 Travel to Manizales
Monday 23 ICA, Manizales: work on report organise
            programme
            Afternoon: visit Granja Luker
Tuesday 24 Morning: flat tyre; afternoon: progeny
            trial at La Papirusa and fertilizer trial,
            visit finca La Argentina
Wednesday 25  Morning, early afternoon car brank down, discussion on the road, late afternoon discussion with Director and ICA staff

Thursday 26  Morning visit Las Mercedes, final discussions travel to Medellin

Friday 27  Travel to Santa Marta meet Ing M Pinto, discussion

Saturday 28  Visit farms and cocoa trials CRI Caribia

Sunday 29  Travel to Bogota

Monday 30  ICA Tibaitata, discussion and report visiting

DECEMBER

Tuesday 1  ICA Tibaitata: discussions and report visiting

Wednesday 2  ICA Tibaitata: discussions and report visiting

Thursday 3  Final visit to IICA, final discussions at ICA hand over of final draft of the report 14:00 hrs departure to airport

Friday 4  Arrival home

32 dagen uit en thuins.
APPENDIX I

MODEL OF THE MATURE, PRODUCTIVE COCOA PLANTATION

1. The model presented in figure 1, it is based on principles of crop physiology but also on general practices of cocoa growing.

2. Like any other cultivated higher plant, cocoa depends, for growth and production, on energy in the form of radiation from the sun, which is absorbed into the leaves.

   For the complete absorption of the light, a layer of leaves is required.

   A complete, integrated canopy has a LAI* of 3-4. At this density more than 95% of the incoming radiation from the sun is absorbed. This radiation provides the energy that

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*Leaf Area Index: The total surface of all the leaves over 1m² of soil surface.

LAI 4 indicates that the leaf area covering 1m² of soil is 4m².
activates and fuels the photosynthesis process in the leaves, \( \text{CO}_2 \) from the air and \( \text{H}_2\text{O} \) from the soil are combined into basic carbohydrates. Part of the energy from the radiation is fixed chemically so that it can be transported throughout the tree and made available wherever it is required.

The larger part of the carbohydrates produced by the factory (the canopy), also referred to as the source, are transported downwards, to the main branches and trunk and temporarily stored. The carbohydrate "reserve" can be used for growth of the tree, and for the growth of pods and seeds. At maturity the demand for carbohydrates by pods of various ages is very strong, the reserve is drained, the growing pods act as a sink.

A special aspect of the cocoa bean is that more than 50% of its dry matter is fat. The transformation from carbohydrates to fat requires much (chemical) energy.

Apart from carbohydrates, small but significant amounts of a range of nutrients are required for the production of the scala of enzyme systems and tissues in the trees. The nutrients are derived from the soil and are taken up and transported by the rootsystem.
The more radiation is absorbed by the canopy (by reducing shade) the higher the production of carbohydrates, but there is also a higher demand for nutrients. Soils do not normally contain the necessary reserves of nutrients. Fertilizers have to be applied.

Cocoa, like any other crop has its own specific demands for nutrients, in relation to soil fertility and nutrient status. However, in most of the world's cocoa production centres, the experience shows that for optimal productivity over many years (such as shown in fig. 2) some overhead shade is required intercepting appr. only 20% of incoming radiation.

In the model Glyricidia shade trees are planted at about 12 m sq spacing. The shade should be kept under control! The more shade, the more light interception and a lower level of cocoa production but also lower fertilizer requirement! Details about shade management are stated in Appendix 2.

3. The root system consists of two parts: The lateral, feeder root system grows in the top 30 cm of the soil. The tap root, as big as the trunk, grows down to depths of 150-200 cms,
it provides the tree with a firm anchor. For good performance cocoa needs a deep, well drained soil.

The closed canopy completely shades the soil, covering it with a layer of decomposing leaf litter. The top soil has a high content of organic matter. There are no weeds. Considering the dense, integrated, feeder root system, fertilizers should be applied broadcast, just before the onset of the rains.

The lower part of the canopy should be about 2 m above ground level so as to allow workers free movement for the various jobs on hand field supervisors have an uninterrupted view. After establishment some pruning of the lower branches may be required to "lift" the canopy to this height. Otherwise the canopy should be left untouched because the cocoa tree can take care of itself. Only where gaps occur the regeneration process of damaged trees should be guided by (minimal) pruning.

A gap in the canopy is a loss of productive capacity. A gap is a danger spot because the trees surrounding the gap will grow out into it, unbalancing themselves in the process. Eventually the trees will fall into the gap, enlarging it.
Gaps in the canopy are an extra cost factor because of the weed growth. Moreover they usually become breeding places for insects amongst which pests such as species of the Miridae (Monalonion), which can cause great damage to the canopy. Gap management is an important element in the agronomy of the mature cocoa plantation.

4. One of the most important aspects of the art of cocoa production is "playing the shade and fertilizer interaction". This requires a closed canopy and good control of pest and diseases.

Shade reduction allows more light to fall on the cocoa canopy which thus reaches a higher level of energy (and potential for production).

This in turn causes a greater demand for specific nutrients, part of which have to be supplied by fertilizers. The game is to be able to supply the right formulation in the right amounts at the right time.

The graph in figure 2 shows the projection of the average productivity of such cocoa, over time.

5. A major aspect is the establishment of the plantation i.e. growing the plants into the required trees.
Growing nursery plants is an important phase but will not be discussed here. The seedlings are planted in the field at a certain spacing, which may be anything from about 2 m square (2,500 plants/ha) to 4 m square (625 trees/ha). Between these limits, cocoa trees can grow a plantation with a closed canopy.

When mature, the production will be the same, irrespective of the spacing and the number of trees per ha. Spacing trials in different parts of the cocoa world have shown this quite clearly. However, this presumes that there are no gaps in the canopy.

At a 4 m sq. spacing the loss of even one tree will result in a gap which the surrounding trees cannot cover. This is one of the serious disadvantages of planting at this spacing. Another disadvantage is that, compared with the closer spacings, it takes much longer for the canopy to close. The farmer therefore has to cope with the problem of weeds for a longer time. Early production is low because there are only 625 trees on a ha.

At a spacing of 2 m sq. the loss of some trees is of little consequence provided they do not die in the same place.
The surrounding trees will easily cover the gap(s). The canopy will close very quickly and consequently weeding is only a matter of a year or so. Early production is high because there are so many trees (2,500) per ha.

In most ecologies, however, as they grow up, the trees start to compete for light and in the process become tall and eventually, uneconomic!

Another important disadvantage is that many nursery plants are required to plant one ha (2,500). The cost of the input "plant material" often becomes too high. After all, with 2,500 plants 4 ha at 4 m sq spacing can be planted.

The above are the main reasons why, in other cocoa growing countries, 3 m sq spacing has been adopted as the best compromise.

6. Pruning: As concerns growing young plants in the field, the rule is that **any removal of foliage slows down growth.**

The natural growth habit of the cocoa seedling is exactly what we want: first an upring growing, single stem with branches out sideways at a height of 100-150 cm. In the following 2 years or so the plant grows gradually into a balanced, self shading tree with a compact canopy.
This growth phase requires the guidance (pruning) by a minimum input of skilled labour (re: statement on pruning).

The goal of the closed, integrated canopy is now reached. Some more pruning may be required to "lift" the canopy to the required 2 m height. Otherwise the mature cocoa canopy should be left untouched! This part of the plantation is also self-regulatory. For more details, Appendix 2 "pruning and canopy gap management", should be consulted.
Figure 1. Model of the mature cocoa plantation.

SHADE

SUN

CANCOPY

2 m

ROOT SYSTEM
FIGURE 2. PROJECTED AVERAGE PRODUCTION OF CURED BEANS PER HA OF WELL-MANAGED COCOA WITH 25% OVERHEAD SHADE, OPTIMUM INPUTS.
APPENDIX 2

PRUNING AND CANOPY "GAP" MANAGEMENT

The most serious problem of the cultivation of cocoa in Colombia is the traditional practice of pruning. This consists of the removal of all vegetative growth on the primary branches from the joint of the jorquette over a length of up to 150 cm.

This practice is started after the young tree has jorquetted, in the second year after planting, and it is continued indefinitely.

The consequences of this practice are very serious indeed:

a. The growth of the branches is forced outwards, opening the centre of trees and causing undue mechanical stress on the jorquette joint, making the trees weak and vulnerable. The canopy remains too low for free access.

b. Direct sunshine on the jorquette joint, and primary branches leads to irreversible deterioration and cracking of the bark. In time this creates cracks and crevices for a multitude of insects, ants and termites to breed and feed.
Phytophthora bark canker usually also comes in to make things worse.

As the years go by, the main frame of the trees becomes completely undermined. The economic life time of the plantation is considerably reduced.

c. The thus opened canopy fosters increased populations of Monalonion.

d. Any mechanical force, like a plantain tree coming down (first three years of the planting), or a branch of a shade tree or indeed an entire shade tree, will break off primary branches of the cocoa tree, often at the jorquete joint, splitting the trunk.

Trees are often damaged beyond repair.

e. The pruning and the subsequent entry of sunlight triggers off the light response and causes the tree to produce new flushes all the time which have to be pruned off again. This means continued pruning activities at great additional cost and to the detriment of the trees!

The increased flowering does not cause and increase of fruit setting.
In conclusion: it really is a very counter productive process at a substantial labour cost.

The solution is extremely simple: the objective is to grow a balanced tree, initially with a compact canopy that is later on to merge with the others into a closed, an integrated canopy.

The natural growth pattern of the cocoa plant is exactly as desired, it only requires some guidance especially after jorquettting. One or a few of the developing primary branches sometimes have a tendency to keep growing on the terminal bud. This usually brings the plant out of balance causing unwanted effects.

A proportion of the plants of the hybrid mix produce a so called flat jorquette with the consequent danger of exposure later.

What needs to be done is to nip off or prune off the apical bud or the tip of branches that appear to continue to grow outwards. This action forces the branch to grow secondary side shoots which invariably grow up wards (this is where the light is). Thus the young tree becomes self shading, the
effect which, amongst other things, is that the jorquette and primary branches cease to grow flushes in the centre since this is now shaded.

CANOPY GAP MANAGEMENT

The reduction of shade over the heavily overshadowed mature cocoa, in conjunction with fertilizer use, will be a major issue in the next decade. There appears to be a general lack of interest and motivation to regenerate damaged cocoa trees. This is a disturbing observation because, for their income, farmers depended on their trees. Cocoa trees have a great capacity for regeneration. Cocoa trees always grow flushes at the place of damage and in the direction of the light. This is referred to as the light response. Often, however, the tree produces too many shoots at the place of damage. The only thing pruners have to do is to reduce the number of shoots to, say, three. These will grow out vigorously into the gap, where the light is, guided by the light impulse.
The new shoots will grow out most vigorously with the broken branches on the trees. Don't remove broken branches until the time (like a year after the event) that the new shoots have grown out to close the gap.

This principle applies also to trees that have fallen over, or trees the jorquette of which has split and are beyond repair.

Invariably chupons will start to grow out from the tree base, as often as not very many. The number should be reduced to 3, growing from a good vantage point. The chupons grow up most vigorously with the original tree still there (and podding). The first chupon to grow a jorquette should be selected to become the new tree. To give it the best opportunity to grow a good canopy, the branches of surrounding trees should be pruned so as to make a gap for the new tree to grow into.

The objective is a closed canopy born by strong well balanced trees.
APPENDIX 3

NOTES ON THE COLLECTION AND PRESERVATION
OF COCOA GERMOPHISM AND THE COCOA
MAP OF COLOMBIA

- The objective is to collect representative samples of cocoa genetic variation in Colombia.

- As at the time of this report it is considered that cocoa genetic variation is made up of the following populations, each of which should be sampled. From north to south:

  - Cacao del País (has been sampled)
  - Criollo Azúcar Bueno
  - Criollo Granada de Sierra Nevada de Santa Marta
  - Común Norte de Santander (Trinitario)
  - Común de Santander (Trinitario)
  - Común de Santa Fé de Antioquia (Trinitario)
  - Común de Cauca
  - Común de Huila, including that of Tolima
  - Pajarito de Urabá (Amelonado, Matina, blanco calabacillo)
Cacao Vegetal de Tumaco (Amelonado, large blanco Amelonado)
The Amazonica populations are not yet in danger of genetic erosion.

- An area to be collected should be surveyed prior to actual collection, in the course of a preparatory visit.

- The preparatory visit should involve local sources of information and assistance such as: cocoa technical officers, cocoa buying agents, cocoa farmers.

- The main objective of the preparatory visit is to obtain a good idea of the extent of old populations, the limits of variation, their location in cocoa planting, and time of maximum pod production in the year. This last point fixes the time for collection!

- Moreover, information regarding location the history of these plantings local names of the variety, cultural practices, possible uses other than the production of cured cocoa, and information regarding the ecology (rainfall, soils, main pests and diseases), should be collected.
- By far the most effective and economic method of collecting the genetic variation is in the form of seeds.

- Representative samples of seeds should be collected considering that cocoa is basically an outbreeding species. Open pollinated pods should be collected. Therefore, the actual collecting trip should be made in the season of the main crop.

- The following example shows the procedure of collecting a population.

- Several, say three, pure stands, considered representative for the population, and previously identified, should be collected as follows: In a field of 1 ha (at 4 m spacing 625 trees) one open pollinated healthy ripe pod is taken of each of at least 30 trees chosen at random. If the field is surrounded by plantings with hybrid-mix trees, the pods should be taken from trees in the centre of the field. This process repeated in three plantings would result in 90 pods. The pods can be kept for 14 days in a good condition when stored in a shaded, dry and cool place.
- At the end of the collecting trip the pods are opened and the seeds extracted. In the case of the example this would yield a total of about 2,700 seeds which are to be thoroughly mixed in a bucket. This provides for adequate samples of 300 seeds each, for distribution and planting in specially prepared gene bank fields.

- The seeds should be planted in a nursery so as to have spare seedlings for gapping up in case of death of plants in the field during the first 6 or so months.

- It is proposed to plant 215 good seedlings of each population in a square of 15x15 plants in a 3 or 4 m square spacing depending on ecological conditions.

- The plants should grow slowly so that the resulting trees will survive for at least 50 years, in a low energy condition under fairly heavy shade that, however, must be kept under control.

- The space required to contain the collections of the 10 main populations in there for (at a 3 m sq spacing) 10 x
(45x45 m), 10 × 2.025 m² = 20.250 m² = 2 ha. Each collection requires 2.025 m² of space.

- When collecting there may be complications such as the case of the Finca La Japonecita which contains a considerable number of very old trees that belong to what is referred to as the Común de Cauca on the Cocoa Map. However these trees are mixed up with more recently planted mixed-hybrid trees and other types (ref report of the first TAM p 79 nr 6).

In this case open pollinated pods cannot be taken from the old trees since part of the seeds will have originated from pollen of surrounding hybrid-mix-trees.

During the preparatory visit the possibility of making hand pollinations should be investigated. A simple design of making pair crosses between neighbouring (old) trees involving at least 50 of them, could possibly be carried out within a fortnight. Reciprocal crosses are not necessary. This should yield at least 100 pods to be harvested within the same week, appr. 3,000 seeds, out of which the standard sample of 300 seeds can be taken.

- At all times budwood may be taken of special trees.
- The main advantages of this system of collection are the following:

a. Populations and their genetic variation are collected in terms of representative samples, without bias to any special character such as white beans, Criollo trees or the like.

b. The samples represent the still existing populations, which are defined in terms of a coherent "cocoa map" of Colombia (fig. 1).

c. The accessions grow up as seedlings, jorqueting and growing out as normal cocoa trees. The evaluation will be much more meaningful than of budded plants (on rootstock) or cuttings, both of which show the plagiotropic, fan, growth habit.

d. The accessions may be reproduced simply by taking one open pollinated pod from each of the core 25 trees of the plot.

The size of the plot is such that the frequency of cross fertilization with pollen from a neighbouring accessions is practically nil.
FIGURE 1. COCOA MAP OF COLOMBIA
APPENDIX 4

LAY OUT OF A STANDARD SPACING TRIAL

Explanatory note

There are 5 square spacing arrangements worth testing: 2x2, 2x3, 3x3, 3x4, 4x4 m sq.

Trees at spacing of less than 2 m sq grow up the same way as trees at 2 m sq but in a more extreme way.

Trees at spacings wider than 4x4 will not be able to grow a closed integrated canopy, there will be large gaps and the production per unit area will be poor.

It is recommended to include an extra 2x2 m sq spacing treatment for thinning out of trees in alternate diagonal lines during the establishment phase.

This gives 6 treatments: 2x2 m sq, 2x2 m sq to be thinned, 2x3 m sq, 3x3 m sq, 3x4 m sq, 4x4 m sq.
The temporary shade should be plantains. The permanent shade should be the Mataraton Glyricidia.

Core plots of each spacing should have approximately the same surface area.

The following diagrams provide logistical details of spacings and the proposed standard lay out.
Lay out of trees in different spacings

Trees at 2 m sq spacing
nr of trees 100 (10x10)
a) core plot: 64 (8x8) = 16x16 m² = 256 m²
  1 guardrow 36 trees
b) core plot: 36 (6x6) = 12x12 m² = 144 m²
  2 guardrows 64 trees

Trees at 3 m sq spacing
nr of trees 49 (7x7)
core plot: 25 (5x5) = 15x15 = 225 m²
  1 guardrow 24 trees

Trees at 3x2 m sq spacing
nr of trees 70 (7x10)
core plot: 40 (8x5) trees: 16x15 m² = 240 m²
  1 guardrow 30 trees

basic plot size
20x20 m = 400 m²

plot size 21 x 21 m
441 m²

plot size 21 x 20 m
420 m²

scale
1 m
Lay out of trees in plots with different spacings

Trees at 4 m sq spacing
- nr of trees: 36 (6x6)
- core plot: 16 (4x4 trees = 16x16 m = 256 m²)
- 1 guardrow: 20 trees

Trees at 4x3 m sq spacing
- nr of trees: 42 (6x7)
- core plot: 20 (4x5 trees = 16x15 m = 240 m²)
- 1 guardrow: 22 trees

Trees at 5x5 m sq spacing
- nr of trees: 25
- core plot: 9 (3x3) trees = 15x15 m = 225 m²
- 1 guardrow: 16 trees
Proposed lay out of standard spacing trial

38x4 = 152 m

guard row all around

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Total surface, including 4 m guardrow all around

152 x 80 m = 12,160 m² ≈ 1.25 ha

Proposed pattern of thinning 2x2 m sq spacing

- original trees at 2 m sq spacing: □
- trees cut out (alternate diagonals)

spacing: \[ /: 2 \sqrt{2} m \]

\[ \approx 2.8 m \]
APPENDIX 5

SUMMARIES OF FARM VISITS

1. Valle del Cauca

Saturday 21 November. El Porvenir, Ginebra, 20 ha, 4, 5, 6 years old cocoa, hybrid-mix. Visit with owner Mr Tascon.

Ref farm report nr 3 p 78 of report of the first TAM

Characteristic

- The shade trees are growing fast, the cocoa plantings are becoming increasingly overshaed.

- The yields per ha are going down.

- The leaves on many flushes are small, brittle, dark green.
  At times showing tip burn. Occasionally typically shaped small seedless cherelles are observed. The syndrome is probably caused by Boron deficiency. This is a serious constraint.
- The stand of cocoa trees is being thinned; trees are ok.

- The monalonion insect is a serious problem.

- The cocoa is irrigated and has received considerable inputs of a range of fertilizers in past years.

Observations

Thinning the cocoa stand is completed in most of the area, to satisfaction; the cocoa tree density has probably been halved from the original 2,500 trees/ha to 1,200-1,500 trees/ha. The thinning follows an irregular pattern because, as much as possible, small and poorly growing trees are cut out as well as large but improductive ones. The cocoa canopy should now be left to recover; only branches that obstruct workers and supervisory staff should be pruned so as to lift the canopy to a height of about 2 m above the ground.

Since last year during the first mission the shade trees have grown up vigorously. The plantation is rapidly becoming grossly overshaded. This is why the production is going down!
The production pattern of the 6 years old planting has apparently been approximately as follows; 3rd year after planting 400 kg/ha, 4th year 1,000 kg/ha, 5th year 800, this year's expectation is 500-600 kg/ha. Attention must be focussed on getting control over the growth of the shade trees: shade should be gradually reduced.

Plan of operation

If the owner is agreeable to cooperate with ICA, the following action is proposed.

1. The growth of new shoots with very poorly developed leaves, caused by a nutrient deficiency (Bn?) is the most urgent problem. The advice of dr A Garcia must be sought. He should be given ample opportunity to analyse soil nutrient status, and to field-test a number of treatments (replicated) to attempt to cure the deficiency.

2. Pruning activities should be directed towards getting control over the growth of the shade trees. This must be done by ringbarking major side branches of the shade trees. This will cause a gradual reduction of the shade over a few years. The branches ringbarked will gradually dry up.
and will lose most of their original weight before falling on the cocoa canopy. Workers should develop skill in repairing the cocoa canopy (ref Appendix 2 pruning, this report).

Major reduction of overhead shade should begin after the deficiency syndrome problem has been solved.

3. Pruning of the cocoa trees should be stopped, only branches that obstruct normal operations should be removed.

4. As concerns inputs, application of fertilizers should be discontinued pending recommendations by Dr. Garcia.

However irrigation must be continued so as not to cause undue moisture stress.

5. Control of Monalonion must, unfortunately, await results of entomological research at ICA.

6. Details should be obtained of the history of each field, such as: exact date of planting, method of establishment, number of shade trees, times and amounts of irrigation, applications of fertilizers and insecticides, frequency and type of pruning. All this should be written up into a report.
2. Granja Luker

Monday 23 November, afternoon, we were taken round by Mr H Salazar.

The leaves of the last flush are small, brittle, dark green, at times showing tip burn. This syndrome is probably caused by Boron deficiency. It is very similar to what we observed in the finca El Porvenir in Ginebra (see above), Bo deficient cherryels were not observed. Mr Salazar mentioned that this phenomenon was normal for the time of the year. It seems that the syndrome has a transient nature.

The cocoa is growing under light shade of scattered big, old, shade trees. It appears that the shade is thinning out over the years as shade trees die of natural causes.

The productivity of the old plantings remains at a high level of approx. 1,500 kg/ha. Fertilizers are regularly applied, soils are deep draining and basically very fertile.

The insect Monalonion causes little damage, the populations are low because emerging nymhs are killed off by hand at a very early stage so only very few adults develop. This is
a labour intensive effort, but there appears to be no lack of labour. Moreover the cocoa in the Granja is completely isolated from any other.

A substantial area of old cocoa (4 m sq spacing) has been under planted with young seedlings, which are growing well under the severely thinned-out canopy of the old trees. The old trees are still yielding quite well. Our estimate was that on average the old trees would yield in the order of 30-35 pods per annum, i.e. appr. 1 kg of cured cocoa. This would add up to about 600 kg/ha since the tree density per ha at 4x4 m sq is 625.

Originally the field was probably yielding 1,200-1,500 kg/ha.

Recently new permanent shade trees were planted in the farm of Hevea rubber trees. This harbours the danger of overshading in the next decade. Rubber trees are amongst the most vigorous growing trees, specially if not tapped.

Pruning of the young trees was minimal, the trees were allowed to grow out naturally into well balanced trees with a compact canopy - with a well shaded centre of the tree, well protected against direct sun shine.
Cocoa, mature and young, at the Granja Luker in grown under carefully controlled permanent shade, in contrast with the apparent recommendation to farmers to grow cocoa without permanent, overhead shade.

3. Brief visits were paid on 24 and 26 November to cocoa plantations on the fincas La Papirusa (2-3 yrs old), La Argentina (4-6 yrs old), La Mercedes (7-9 yrs old). All cocoa unshaded.

At La Papirusa the young trees are developing well. Apparently the (very damaging) traditional pruning method is not applied. There still are many plantain trees, which will hopefully be removed soon. Some of the 2x2 m sq spacing was observed, 3 yrs old and yielding, there was little evidence of the Bn deficiency syndrome.

At La Argentina, the spacing experiment was visited. At about 6 yrs of age the trees at 4 m sq spacing had not been able to close canopy.

Monaloniion damage, especially to young shoots was bad.

Even at a 3 m sq spacing the trees had not always been able to close canopy. Yet the 2 m sq spacing seems to be
too close with a very dense canopy. Individual trees were suffering from sudden violent attack of pink disease and Phytophthora bark canker.

The cocoa field we visited at the finca La Mercedes was in decline (at 8 or 9 years old), dieback of twigs on the outside of the canopy was widespread. Trees were dying, many were in a bad shape, suffering from the after effects of pink disease and/or Phytophthora bark canker with the bark flaking off large parts of the trunk. Occasional trees had died of Ceratozostis. Monilia pod rot was widespread.

Planting the hybrid-mix at a close spacing (2x2 m sq) in a fertile soil with maximum fertilizer inputs, and just plantains as a temporary shade crop, results in a very high early production, a high production peak from year 6 to about 8 and an equally early decline. The average projection of production is shown in figure 1.

4. In the Santa Marta area the finca La Lucy was visited with a technical officer of the Fedecacao Mr Ernesto Rodriguez.
The same finca was visited last year during the first TAM and reported to be a typical example of the no shade maximum input (both fertilizers and irrigation) cocoa planting. The cocoa is now 5, 6 years old, the production was reported to be on the decline but it apparently was not quite; yields in
1984 were 550 kg/ha and promising
1985 were 670 kg/ha a little bit below expectation
1986 were 700 kg/ha no real increase
1987 were 850 kg/ha (expected)

Considering the apparently very good soils this is in fact a disappointing performance (ref figure 1). Presently the canopy is drastically reduced in an effort to gain complete control over it especially to prevent the trees from growing taller. There is an almost total disregard for the foliage and apparently a complete lack of understanding of the function of the canopy.

The Cu deficiency syndrome of leaves was not encountered here, a few flushes with mild Mn and/or Fe deficiency symptoms were seen.
FIGURE 1. PROJECTED AVERAGE PRODUCTION OF CURED BEANS PER HA OF MAXIMUM INPUT NO SHADE COCOA 2x2 m sq SPACING