

GTZ - TÖB
„TropenWaldForschung“

**Nutrition of
Organic Cacao For
Buffer - Zones**

J. Füssel / Gh Kassel
June 1997

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Abstract

A research proposal of 1997 for the GTZ – TÖB „TropenWaldForschung“ - Programme. Reviewing the literature it finds strong indicators, that farmers since ancient times (starting with historical paintings of the Mayans until first scientific research at the early 20th century) appreciate the ‘shade’ for Cacao in its much more complex ecological functions as an overstorey – nutrient pump. On the other hand they usually also know that Cacao is not a shade-plant (Alvim PT, 1958) and in fact does not need this function (shade) in itself, but its nutritional effect. Ensuring this on an optimal level, Cacao grows best under full sunlight (Botanical Bulletin, Trinidad, 1902-3). On this background a research is proposed (applying recent genetic materials, scientific results and methods), to find an optimum manuring regime for organic Cacao in Buffer Zones. The role of ‘shade’ in view of possible climate change will be redefined in [this recent research proposal](#).

Johannes Füssel, February 2010

Abstracto

Una propuesta de investigación de 1997 para el programa „TropenWaldForschung“ de la GTZ – TÖB. Revisando la literatura se encuentra fuertes indicadores de que los agricultores desde la antigüedad (a partir de pinturas históricas de los Mayas hasta primeras investigaciones científicas en los principios del siglo 20) apreciar la ‘sombra’ de cacao en sus funciones ecológicas mucho más complejo, como un piso superior - nutrientes de la bomba. Por otra parte, por lo general también saben que el cacao no es una planta de sombra (Alvim PT, 1958) y, de hecho, no necesita esta función (sombra) en sí, sino su efecto nutricional. Garantizar esta en un nivel óptimo, Cacao crece mejor bajo plena sol. (Botanical Bulletin, Trinidad, 1902-3). En este marco de referencia se propone una investigación (aplicando los últimos materiales genéticos, resultados científicos y métodos), para encontrar un régimen óptimo para el abono de cacao orgánico en zonas de amortiguamiento. El papel de la ‘sombra’ en vista de un posible cambio climático se redefinirán en [esta propuesta de investigación reciente](#).

Johannes Füssel, Febrero 2010

Abstrakt

Ein Forschungsvorschlag von 1997 für das Programm „TropenWaldForschung“ der GTZ-TÖB. Bei der Überprüfung der Literatur findet es starke Indikatoren, dass die Bauern, seit der Antike (beginnend mit historischen Gemälden der Mayas bis zu erster wissenschaftlicher Forschung am Anfang des 20. Jahrhunderts) den ‘Schatten’ für Kakao in seinen viel komplexeren ökologischen Funktionen als Überbau- Nährstoff- Pumpe schätzen. Auf der anderen Seite haben sie in der Regel auch Wissen, dass Kakao nicht ein Schatten-Pflanze ist (Alvim PT, 1958) und in der Tat braucht er nicht diese Funktion (Schatten) an sich, sondern dessen ernährungsphysiologische Wirkung. Wird diese auf einem optimalen Niveau gewährleistet, wächst Kakao am besten unter vollem Sonnenlicht (Botanical Bulletin, Trinidad, 1902-3). Vor diesem Hintergrund wird eine Forschung vorgeschlagen (bei Anwendung neueren genetischen Materials, wissenschaftlicher Ergebnisse und Methoden), eine optimale Düngung für ökologisch erzeugte Kakao in Pufferzonen zu finden. Die Rolle des ‘Schatten’ im Hinblick auf möglichen Klimawandel wird neu definiert werden, [in diesem jüngsten Forschungsvorschlag](#).

Johannes Füssel, Februar 2010

1 PROJECT SUMMARY

- Project Title:** Optimal Nutrition of Organic Cacao in Traditional and Improved, Low External Input Agroforestry Systems, to Contribute to the Stabilization of the Buffer Zones of the 'Biosphere Río Plátano', Honduras.
- Project Short Title:** Nutrition of Organic Cacao for Buffer - Zones
- Project Country:** Honduras
- Type of Project:** Dissertation (PhD)
- Applicant:** J. Füssel (MSc. Forestry / MSc. Agronomy / Dipl. Ecology; Gh Kassel)
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- Local Institutions (1):** Universidad Nacional Autónoma de Honduras, La Ceiba, Honduras (UNAH-CURLA) Tel: +504- 41- 0630, Fax: +504- 41- 0537
- (2):** Asociación de Productores de Cacao de Honduras (APROCACAHO)
PO Box 1235, San Pedro Sula, Honduras.
Tel: +504- 69- 3912, Fax: +504- 69- 3829
- (3):** GTZ / KFW / GFA Project: 'Conservación de la Biosfera Río Plátano'
Harald Erichsen, Asesor Técnico Principal, Casilla 3739 Tegucigalpa.
Tel. and Fax: +504- 328 334
- Period of Promotion:** 3 Years (01/11/1997 - 31/10/2000)
- Total Budget, TÖB:** US \$ 250,000.00

Summary of Background and Justification:

Since the 'Conference of Rio', 1992, the protection of tropical forests is a top priority of German development politics. In this context, the research proposed, intends to intensify a permanent sustainable agroforestry system with Cacao, by improving its nutrition with on-farm manure. This is an alternative to slash and burn agriculture, which is considered to be destructive, mainly due to the pressure on land. Cacao is an ancient agroforestry crop in the region of the 'Biosphere Río Plátano' project, and its form of cultivation makes it an ideal crop for the management of its buffer zone. Since APROCACAHO is already working on a program for 'Organic Cocoa', the Río Plátano project may use the research results later on, to promote the cultivation of organic Cacao and commercialize it by established channels.

An urgent need has been identified, to fill the gap of knowledge on the nutrition of organic Cacao with on-farm manure, which normally is wasted in the project area. Improved manuring practices are a necessity for a management package, to combat the potential devastating *Monilia* disease, which threatens the Cacao- agroforests in the buffer zones. To ensure the success of the Río Plátano project, this gap should be closed by the presented research proposal. Research should start at the nursery level, as there is a very close relationship between proper nursery management and the development of healthy and high yielding mature trees.

No work has been done by the 'Biosphere Río Plátano' project on agroforestry systems with (organic) Cacao. The candidate's background of expertise on organic Cacao is his 9th year of work experience in (organic / low external input) tropical agroforestry of which 2 years were in organic Cacao. He set up the 'Organic Cacao' program for APROCACAHO on behalf of BID and at present is elaborating the draft for the 'El Cacaotero Orgánico' manual.

Objectives and Intentions:

1. *Evaluation of the effects of on-farm manure at nursery-, establishment-, and early production level on physiological- and yield parameters of the cocoa tree, to ensure adequate nutrition and optimum production of the adult plant in agroforestry plantations, in the buffer zones of the Río Plátano project.*
2. *Elaboration of a practical guidebook on organic Cocoa, to facilitate successive training of farmer groups by the staff for the Río Plátano project.*

Expected Results and Outputs:

1. On-farm manure are evaluated for optimal nutrition of Cacao in nurseries (08/1998).
2. Optimum levels of on-farm manures for Cacao establishment are known (10/1999).
3. The effect of on-farm manure on early Cacao yield are known (10/2000).
4. A practical guidebook is elaborated at the conclusion of the research project (10/2000)

Serviceability and Context of Utilization:

1. Generally, the result of the proposed research will help the 'Biosphere Río Plátano' project to manage its buffer zones in a productive, sustainable and environmental sound manner. It will aid the project to implement the production of certified organic Cacao, which has a significant higher market price. At a community and individual farmer level, this will serve to improve the productivity of Cacao- agroforests, and guarantee a significant higher price for their product, with positive social effects.
2. Specifically, the research results will enable the project extension staff to introduce a better nutrition regime for Cacao at a nursery- and plantation level. This will also be an essential part of a package to improve management of Cacao plantations for increasing yields and combating the potential very destructive *Monilia* disease.
3. The results of the proposed research may be used for other agroforestry crops, convincing farmers of the high value of organic manure, which is wasted. Farmers may be reinforced in their knowledge and appreciation of the ecological (nutritional) functions of the overstorey.

These activities will be implemented by the agricultural- and forestry extension service for the 'Biosphera Río Plátano' project by Mid 1998, when the first research results will be available on the nutrition of Cacao in nursery.

4. In an analogous manner, other projects may directly use the output of the research, in similar agroecological zones. Generally, the valuation of on-farm manure for this zone and specifically in (organic Cacao) agroforestry systems.
5. The 'El Cacaotero Orgánico' guidebook will be a very handy tool for extension work. An English version could be produced by the author upon request.

2**BACKGROUND AND JUSTIFICATION****2.1.****Context between Development Challenges, Projects and Identified Research Issues**

In official development politics, the protection of tropical forests only recently has become an important question. The 'United Nations Conference on Environment and Development', (held in Río de Janeiro, 1992) was a milestone for the up-growth of projects, targeting sustainable and ecological land use strategies. Although native slash and burn agriculture may be the most sustainable form of land use of tropical dense-forest regions [29, 48], social-economically it is not sustainable for societies, where land has become scarce. Immigrants, unfamiliar with proper native slash and burn techniques, may permanently destroy forests by unsustainable exploitation. This is the case in North-eastern Honduras, a region of native Indians, to which official politics paid little attention, but during the last decade several national parks and biosphere reserves were declared in this region and others are planned or at the point of official pronouncement. One of these is the 'Río Plátano Biosphere Zone', a project being executed by the GFA / GTZ, for which the research is proposed, would serve. While the project policies for the land use of the buffer zone of this bio reserve will imply certain limitations, which to the local population may appear to be a drawback to their freedom, it centres on sustainable land use. In the long run this should be an economic advantage and a prerequisite for ecological sound management, which in exchange may make them suitable for enhanced use, such as eco-tourism and production of 'organic' (forest-) products for external markets.

Cacao in Northern Honduras, traditionally has been cultivated in agroforestry systems¹ since very ancient times [125; 132], by the Mayans and related groups for as long as 12 – 17 centuries [proper investigations at the Copán Ruins] and at least for 7 centuries by the Aztecs [24; 50; 76]. The crop is planted in virgin or secondary forests, thinned out selectively or the overstorey is established on purpose, historically using *Gliricidia sepium*: 'Mother Cacao'. Farmers refer to the overstorey as 'shade', but the majority of them are still reasonably conscious of the multiple functions and ecological effects of Cacao-overstorey (also obviously implied, in the historical name of *G. sepium*, given by the Indians). This makes this 'plantation crop' an ideal candidate for the stabilization of buffer-zones. Additionally, the traditional way of cultivation, recently has encouraged the largest cacao producer – and processor of Central America (APROCACAHO) to start a program for organic cacao. This will further encourage farmers to establish more land with this environmentally sound cultivation system, even though APROCACAHO did not establish any type of advisory service to date and still acts only as a purchaser, in the project area.

By early 1997 the most potentially devastating disease, 'Monilia' fungus, has been detected in the North-eastern coast of Honduras, threatening the entire cacao production. The clearing of existing agroforestry- cacao plantations for this reason, would be shattering for the 'Río Plátano' project to fulfil its objective, as this system is environmentally sound for the region, farmers are already quite familiar with it and alternatives are scarce. The only solution to this problem is to intensify the cropping system, in other words, to control the fungus by improving the cultural care. This includes pruning and organic nutrition of the crop, which finally would lead to better yields, consequently motivating farmers to adopt these improved techniques, staying with their organic cacao-forests or even extending them. This will effectively support the objectives to manage economical and environmental sound buffer zones of the 'Río Plátano' project area. More agroforests will be established and conserved, giving them much higher value than before by the inclusion of the commercialization of organic cocoa. It will be a starting point par excellence for the project, to put into value even more, agro- forests of the target group, by encompassing more products of organic and sustainable production, like timber, honey and other agro- forest by- products.

1 Cultivation of perennials in farming – or annuals in forestry systems

2.2. Present-Day Deficits

2.2.1 Specifically on Project Level

Farmers in the project area usually throw away organic manure of highest value, also as a consequence of one-sided agricultural advice on chemicals, although these chemicals are not normally used either, due to their high costs. This means a very significant loss in productivity, not only in the Cacao agroforests, but also for other agricultural crops and the lack of soil fertility maintenance usually leads to soil degradation. World-wide, hardly any research is being done on organic manure for Cacao in a nutrient cycling context of an agroforestry system. A deficit of high priority for the buffer zones of the project. Improved nutrition of the Cacao crop is an important step towards improved management practices.

There is a very close relationship between proper nursery management and the development of high yielding mature trees [45; 110]. Ergo experimental organic manuring from the nursery stage onward, merely is a logical consequence and prerequisite, to facilitate promotion of new Cacao plantations in agroforestry systems, at later stage in the project. The high value of on-farm manure, has been proven for conditions in Honduras in low external input systems [61], but world-wide there is an absolute lack on confidential data for Cacao organic manuring. Its response at the nursery level is essentially unknown and only some uncompleted historical data is available for organic manuring and management of Cacao in sustainable agroforestry systems.

Frequently, the ecological effects of the overstorey are misinterpreted by the farmers in the project area (only appreciated as shade, and also misunderstood by researchers [133]) and could lead to accelerated overstorey removal. Research should be done, to evaluate the nutritional effects of the overstorey on the Cacao crop without – or with little - shading effects, for example an overstorey with a heavy pruning regime, much like an alley cropping system, against a system with more pronounced shading, but similar rooting system and organic matter input.

Cocoa in the project area is managed like a semi-wild plant with very little cultural or material inputs, giving little yield. The upcoming *Monilia* fungus, however, cannot be controlled by other means than improved cultural management (see 2.1). Normally this implies a heavy thinning of the overstorey and the Cacao trees themselves, which in return needs the input of manure, as plants under higher radiation yield more, but also have higher nutritional requirements. Thus the cultural practice necessary to control *Monilia*, needs improved nutrition of the crop to prevent severe soil degradation (see full discussion in 2.2.2).

For the project this is a new problem, since *Monilia* has not been identified as a matter of concern during program formulation, nor explicitly Cacao cultivation as one important, and potentially environmental sound, cropping system.

One major focus of the 'Río Plátano Programme' should be on the cultivation of Cacao in agroforestry systems of the buffer zones and there are marketing facilities developing for the commercialization of high valued organic Cacao. While an important gap in knowledge of organic Cacao nutrition has been identified, there is an urgent need to fill this gap for this programme to be a success.

2.2.2 Literature Review on Cacao Nutrition

2.2.2.1 Nutritional Requirements

The true nutritional requirements of Cacao in agroforestry systems, is still not completely understood. Standard recommendations on its management [132] converge on the demand of supplementary mineral nutrition [129]. In contrast, researchers on nutrient cycling in agroforestry systems with cacao conclude, that apart from natural inputs from an efficient under-overstorey (nutrient pump), rain and dust, very little, or no external inputs are required [7; 9; 12; 40; 62; 74; 82; 86; 96; 114; 115; 117].

2.2.2.2 A century of Research on Cacao Nutrition

During the early part of the 20th century, cultivation and nutrition of Cacao has been seen with surprising frequency, in a holistic context of its agroforestry system. In 1904, strong warnings were given to undertake a cultivation without it. When chemical fertilizer would be applied, it would need additional on-farm manure and the best manure would be compost [75]. By 1902, the first scientific research results on the beneficial effects of mulch on a cacao crop were published [16 in: 53; 50]. Advantages of overstorey 'shade' and well managed 'weeds' over chemical fertilizers were known and therefore vigorously recommended, specifically for the humid tropics [50], even considering chemical fertilizers harmful for the Cacao tree [53]. Later, in the 30's [64], more detailed investigation was carried out, resulting with similar conclusions, and analogous results in the 50's, mainly for mulch [57; 58; 127], recognizing its beneficial effects, also on diminishing soil erosion [58]. This was the time of the first environmentalists, also advocating agroforestry systems for Cacao [63]. Even early strong advocates of chemical fertilizers of this time also admit the importance of maintaining organic matter by mulch or 'shade', which may partially replace external input [101; 99] and would be a prerequisite of the management of tropical soils [31]. Twenty years later, other authors changed their opinion from favouring chemical fertilizers, recognizing mulch for conserving moisture only [34], to a more integrated approach [35]. From the 60's onward, fertilising with NPK is seen as the only economical option [17; 26; 33], with few exceptions [130], even advocating an overstorey for commercial plantations (see also references in 2.2.2.9 -'Sustainability'). This, although the importance of organic manure in maintaining soil fertility is acknowledged [26, 113] and first ideas of a multistored understorey were introduced [65]. In 1995/96 organic Cocoa products had a spectacular commercial success [46; 67], but only a more updated handbook, looks at organic manure (provided by overstorey and imports) as essential for a healthy Cacao and for maintaining sustainable high yield [60]. A standpoint, outlined 90 years before [16 in: 53, p. 58].

2.2.2.3 Experimental Research with Synthetic Fertilizers

Experimental research with synthetic fertilizers may use sophisticated methodology, the 'soil diagnostic method', specifically developed for Cacao [69; 121; 126]. Generally fertilizer experiments, including (the removal of) an overstorey, however, do not give details on its management. Important data is omitted or incomplete [87], and the 'shade' frequently is not seen in the complexity of the overstorey functions, e.g. *G. sepium* 'shade' for a 120 km² plantation in Indonesia [116]. Sometimes overstorey species are used, now known to have adverse effects on Cacao, e.g. *Terminalia ivorensis* [3; 5; 15; 35]. Cacao, although naturally occurring only under dense overstorey, is not a typical shade plant [6] and this fact led to the removal of the overstorey and the input of artificial fertilizers. Working with artificial shade, it was observed, that the yield of NPK fertilized Cacao was higher in function of increasing radiation over 3 years [100], while unfertilized Cacao increased its yield only until 50% sunlight. Proving only, that NPK was better than nothing at all. In overstorey 'shade', however, important quantities of organic matter and nutrients are stored. When removed [131] they are returned to the soil in large quantities, and therefore it is not surprising, that an additional input of NPK, generally increased yield dramatically [3; 20; 28; 38; 66]. However, rapid deterioration of the

Cacao crop was associated; e.g. 50% loss of organic carbon over 15 years [3], or 44.5 t/hm² equivalent to a organic carbon decomposition rate of 3.44% /a to 3.73% /a [5]. These facts lead to the conclusion, that even with 'optimum' (high fertilizer dosage) agronomic practice, this cropping system is not economic for more than 20 years [5], because the period of high yield, is commonly followed by a rapid decline of the plantations soil fertility [80; 87].

2.2.2.4 *NPK Effects*

The effects of NPK, and especially N, are very heterogeneous [124]. Different levels of N [19; 104] or NPK application had no effects at all [70], in fully matured Cacao [85, in: 86] or only at one out of 7 locations [93], while P had positive effects [104]. The minor dosage of NPK gave the best yield [90; 98; 109]. N application frequently had negative effects on yield [81] in association with *Erythrina poeppigiana* [57]. N application had negative, K neutral and P positive effects on yield [4; 5]. N application had negative effects, but in combination with PK positive effects [84]. On nutrient rich alluvial soil, N had positive, while P y K neutral effect [79]. Yield in association with legume 'shade' + NPK gave highest yields [72 (who claims the contrary without 'shade')]. Clearly positive and significant effects of NPK on yield was demonstrated in 1988, particularly of P [95], but there was no effective overstorey established, nor managed. Generally the soil must be in good condition, before a response to (chemical) fertilizers can be expected [71], e.g. on cleared forest soils: An exploiting form of cultivation. Synthetic fertilizers have toxic effects on young Cacao plants, especially when they are applied into the planting hole [128], and particularly lead to high mortality (appr. 50%, relative to control [77], or do not have clear, significant effect [91, although the contrary was claimed by the author, not giving the mortality rate].

2.2.2.5 *Destructive Cacao Cultivation*

Cacao cultivation has rather destructive effects on the soil after clearing tropical forests, without the establishment of a suitable overstorey [18]. Remaining forests in the hot humid tropics can be permanently destroyed [25; 134; a process described, but not reflected by the authors], although a high NPK- dosage may be applied [41]. Soil erosion processes, also have to be considered, particularly when a soil cover is not maintained [56].

2.2.2.6 *P- Supply*

P- supply for Cacao frequently is a limiting factor, but for the production of organic Cacao an effective source of P may be delivered by rock phosphate [87]. This natural mineral performs similar to triple- super- phosphate (TSP) [94], on certain soils even better [51], and economically may replace it [52]. Native effective micro-organisms, capable of dissolving the inorganic P [102] and Cu, Zn [27] usually are present. When not present, inoculation of the soil by efficient strains may improve P uptake [21].

2.2.2.7 *Nutrient Uptake*

For the nutrient uptake, Cacao has a considerable efficient root system. First results show, that 70 % [92: 80 %] are in the first 30 cm and only around 3 % among 90 cm – 120 cm [23]. More recent research found 90 % of the roots (around 1 kg weight, 1200 m extension, 1 m² surface / m³) in the upper 10 cm of the soil [78]. N application has a stunning effect on the 1 mm – 5 mm root fraction [39]. The roots develop best with 50 % shade of the overstorey [92].

2.2.2.8 *Intercropping Cacao*

Cacao is an ideal intercrop, due to its shade tolerance and root pattern [42; 103; 107]. For Oil palm [2; 8; 35], multiple crops [7; 103; 107], Arecanut [14], Kola [35], finding synergistic effects between the two crops [36, 106], Areca- and Coconut [118], Rubber [65] having severe root competition [89], but usually giving higher net returns than each sole crop, calculating its Land Equation Ratio, e.g. 1.75 [106]. This is also due to efficient space utilisation of the root- understory, suggested in 1969 [65] and verified later, finding that nutrient loss with suitable over / understory is significant less, similar to natural forests, leading to a sustainable cropping system [68].

2.2.2.9 *Sustainability*

The sustainability of a Cacao cropping system obviously can be insured, only by an effective overstorey. A comprehensive list of its potential advantages and disadvantages [10], of mulch in relation to micro-climate [123], organic material in general [44] and the principles of nutrient cycling [73] is available. Early research on overstorey species in Cacao [6], verified their positive effects on physical and chemical characteristics, e.g. of the *Erythrina fusca*, *sin. Glauca* [22]. Sustainable multiple mixed Cacao cropping systems were reported from Brazil [7]. Detailed studies in Venezuela found effectively nutrient cycling agroforestry systems, maintaining soil fertility in mixed overstorey systems [9]. Similar results were obtained in Costa Rica with *Cordia alliodora* / *Erythrina poeppigiana* [11; 12; 40; 62], also with respect on its economical sustainability [96]. Multi-storey homestead farming systems in Nigeria [74], generally is considered to be sustainable, and self-sufficient in terms of nutrient requirements. Something similar was concluded in Brazil [82], including nutrient inputs by rain in an agroforestry system with *Erythrina fusca*, and *Gliricidia sepium* in Malaysia [86] and with focus on N-cycles and leaching in Brazil [114; 115]. In Costa Rica [117] contrasting high losses in monocrops (maize) versus perennial multicrop (*C. alliodora* / *T. cacao* / *Musa spp.*) were found. In Venezuela the quantities of nutrients exported by the Cacao crop, were found to be very small compared to those recycled in the system [59].

2.2.2.10 *Organic Management*

Cacao seems to be an ideal crop for organic management, due to its low nutrient requirements of external origin. Sustainable medium level yields are feasible by its management in nutrient cycling agroforestry systems, which fundamentally have to supply adequate quantities of organic matter, to keep up the cycling process efficiently. Major deficits in P, may be corrected by supplying rock phosphate.

2.3. *The Applicants' Expertise*

This chapter has been deleted for this edition (February 2010) since it is out-dated and all important topics are reflected in the actual CV. Please contact the author for a CV in English or Spanish and visit his home-page:

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3 PROJECT DESCRIPTION

3.1. Objectives and Intentions

- 3.1.1 *Evaluation of the effects of on-farm manure at nursery-, establishment-, and early production level on physiological- and yield parameters of the Cacao tree, to ensure adequate nutrition and optimum production of the adult plant in agroforests plantations, in the buffer zones of the Río Plátano project.*
- 3.1.2 *Elaboration of a practical guidebook on organic Cocoa, to facilitate successive training of farmer groups by the Río Plátano staff.*

3.2. Expected Results and Outputs

- 3.2.1 On-farm manure are evaluated for optimal Cacao in nurseries (08/1998).
- 3.2.2 Optimum levels of on-farm manure for Cacao establishment are known (10/1999).
- 3.2.3 The effect of on-farm manure on early Cacao yield are known (10/2000).
- 3.2.4 A practical guidebook is elaborated at the conclusion of the research project (10/2000).

3.3. Necessary Activities

- 3.3.1 Research on the nutrition of Cacao at nursery level.
- 3.3.2 Research on the nutrition of Cacao at establishment level.
- 3.3.3 Research on the nutrition of Cacao in improved agroforestry systems.
- 3.3.4 Elaboration of a guidebook with previous back-stopping of selected farmers.

3.4. Methodology

- 3.4.1 (For 3.3.1) The Cacao seedlings will be nursed under optimal conditions, regarding management [54]: Shading regimes with standard artificial shade nets, according to recommendations from Ghana [105] and Malaysia [55]. Due to the high grade of heterogeneity [32; 37; 88; 119] the genetic material will be obtained by leaf cuttings [111; 122; 125] of one mother tree of a common variety to be selected. The only variation will be in nutrition. NPK requirements will be calculated by the 'soil diagnosis method' [69; 121; 126] and 6 levels of concentrations (1) 0 %, (2) 25 %, (3) 50 %, (4) 100 %, (5) 150 % and (6) 200 % of 6 different manure will be applied, where the organic manure concentration will be calculated on the basis of P - requirements:

- (1) an optimised mix of NPK and trace elements [69; 121; 126];
- (2) fresh cattle manure (the most common on-farm manure);
- (3) dried cattle manure;
- (4) *Gliricidia sepium* mulch (the most common overstorey species);
- (5) *G. sepium* mulch + fresh cattle manure (imitating surface composting in practice);
- (6) a compost, produced according to standard recommendations [30; 47].

A standard split plot design and -analysis will be employed [43; 112], the 6 manure types being the main- and the manure concentrations the sub- treatments with 6 repetitions for each sub- treatment and 36 plants / repetition.

Physiological growth parameters to be measured are: (1) Calculated leaf area [1; 108] (2) stem diameter, (3) height, (4) leaf nutrient content, and (destructive measuring of root development, after 1, 2, 3, 4 and 5 month.

- 3.4.2 Methodology for 3.3.2, according to point 3.4.1, with proposed modifications [97; 119]. Only 25 plants per plot (5 x 5) can be planted, due to the destructive root measurements at the nursery phase (with 5 repetitions). Only 5 manure types will be studied, the use of compost at plantation level being considered in-practical and not advantageous for mature trees. All treatments will be provided with *G. sepium* 'shade', to be established by direct seeding [44] in double rows, but prunings will not be returned to the soil for treatment (1), instead exported to treatments (4) and (5).
- 3.4.3 Methodology for 3.3.3, according to point 3.4.2 for 2 years (1 year already yielding). Repetition of soil analysis and adjustment of fertilizer requirements every 6 month.
- 3.4.4 Methodology for 3.3.4: Standard free computer publishing program (Linux - [Scribus](#)) and local press techniques being used.

3.5. Serviceability and Context of Utilisation

- 3.5.1 Generally, the results of the proposed research will help the 'Biosphere Río Plátano' project to manage its buffer zones in a productive, sustainable and environmental sound manner. It will aid the project to implement the production of certified organic Cacao, which has a significant higher market price. At a community and individual farmer level, this will serve to improve the productivity of Cacao- agroforests, and guarantee a significant higher price for their product, with positive social effects.
- 3.5.2 Specifically, the research results will enable the project extension staff to introduce a better nutritional regime for Cacao at a nursery- and plantation level. This will also be an essential part of a package to improve management of Cacao plantations for increasing yields and combating the potentially very destructive *Monilia* disease.
- 3.5.3 The results of the proposed research may be used for other agroforestry crops, convincing farmers of the high value of organic manure, which usually is wasted. Farmers may be reinforced in their knowledge and appreciation of the ecological (nutritional) functions of the overstorey.
- These activities will be implemented by the agricultural- and forestry extension service for the 'Biosphera Río Plátano' project by Mid 1998, when the first research results will be available on the nutrition of Cacao in nursery.
- 3.5.4 In an analogous manner, other projects may directly use the output of the research, in similar agroecological zones. Generally, the valuation of on-farm manure for this zone and specifically in (organic Cacao) agroforestry systems.
- 3.5.5 The 'El Cacaotero Orgánico' guidebook will be a very handy tool for extension work. An English version could be produced by the author upon request.

4 EXECUTION

4.1. Organisational Integration with the Consociate Country

To ensure an efficient collaboration with the 'Biosphere Río Plátano' project, the applicant will participate, upon request of the team leader, in project meetings. He will present preliminary results of his research, insuring a professional back-stopping by the team and smooth integration of his work into the project. This will start on regular basis in October 1998, since the applicant will be quite occupied due to the establishment of the trials.

The research programme will be integrated into the research- and lecturing activities of the National Autonomic University of Honduras (UNAH), which runs a special programme for the Atlantic Coast (CURLA). The trials will be established on its campus. It manages a diversified farm with an integrated Cacao clone garden in San Juan Pueblo, near La Ceiba, where some additional practical oriented trials on Cacao nutrition may be executed by MSc. - students.

4.2. Transfer of Know-how & Training of Local Counterparts

The applicant's counterpart is a permanent member of the UNAH lecturing staff. Thus, he will ensure stable supervision of the proposed trials, since the trials will be set up on the UNAH campus, where he concurrently supervises various undertakings. Furthermore his counterpart will direct the field work, while the applicant will do this under his supervision only.

All the scientific field work will be done jointly, but under the responsibility of the applicant. There will be an exchange of on-the-job training between the applicant, who has a more theoretical background, and his counterpart, who has pronounced practical knowledge of appropriate local technologies and applied science. Furthermore, two or three students will be integrated into the scientific field-, analytical- and office work and / or with proper trials on Cacao, e.g. the influence of the phases of the moon on growth parameters.

Scientific knowledge will be transferred at University level by the applicants' counterpart, directly to the students in his concurrent lecturer duties and in special seminars. Technicians of APROCACAO, and local NGO's working with Cacao, will be asked to participate.

4.3. Logistical and Technical Accoutrements

An agroclimatological station and a computer are needed to calculate accurate water balance on hourly basis. The same computer will be used for statistical analysis and the elaboration of the 'El Cacaotero Orgánico' guidebook in its 2nd edition. Minor field equipment is required, and there is a separate budget for soil, and tissue- analysis to be carried out by the applicant in the laboratories of the UNAH-CURLA. For the applicant and his counterpart, a pick-up truck and a local manufactured trailer for field transportation (manure, etc.) is requested. This transport will also be used to assist students with their field work in the clone garden in San Juan Pueblo (80 km distance) and it is necessary for the back-stopping with selected farmers and the project staff in the remote project area.

The plantation trial will have an extension of 1 hm². This area and all necessary field preparations will be provided by the UNAH.

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