STRENGTHENING AGRICULTURAL RESEARCH IN BRAZIL

(IICA-EMBRAPA-WORLD BANK PROJECT No.11.S.B.1)

EPIDEMIOLOGY AND CONTROL OF RUBBER DISEASES

(ACTIVITY No.02. SB .1.11)

REPORT OF THE CONSULTANT IN PATHOLOGY

1 SEPTEMBER 1983 - 31 AUGUST 1985

NATIONAL RUBBER AND OIL PALM RESEARCH
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IICA/EMBRAPA CONSULTANCY REPORT ON 1984-85 PROJECT ON "LEAF DISEASE EPIDEMIOLOGY AND CONTROL" OF RUBBER AT CNPSD, MANAUS IN BRAZIL

1. NAME OF CONSULTANT:

   Dr. Tow Ming Lim, Plant Pathology Specialist.

2. PERIOD:

   01 September 1983-31 August 1985

3. TITLE OF PROJECT:

   Agricultural Research in Brazil: Project No II. SB.1. (Epidemiology and Control of Rubber Diseases).

4. NAME OF ACTIVITY:

   Technical co-operation to strengthen the research progress of the CNPSD: Activity No. K.02.SBB.1.11.

5. TYPE OF ACTIVITY:

   Research and Supporting

6. LOCALITY:

   CNPSD, Manaus, Amazonas and its co-operating units in other States of Brazil.

7. PROBLEM IDENTIFICATION AND JUSTIFICATION FOR THE RESEARCH PROJECTS.

Introduction

In line with the duties and responsibilities specified under my "job description" under the 2-year IICA/EMBRAPA contract (please see IICA "Terms of Reference"), relevant activities designed to fulfil these are elaborated hereunder.

These activities are described by first fully identifying the existing and new main diseases and the problems caused in producers' fields. The appropriate on-going and new research projects that are considered necessary to try to resolve these problems are then defined and formulated. At the same time, all projects are rated for priority for execution, then followed by planning and extensive discussion, their lab and field implementation, monitoring of their progress and reporting of the relevant results. All these activities were done in consultation with my local counter-parts, Head of CNPSD, Manaus and Heads of all co-operating units, including where necessary useful suggestions from local extensionists and planters.

To help achieve as much as possible the planned objectives by the end of the 2-year contract period, attendant essential activities pertaining to research co-ordination, training of counterparts and their associated local staff, and interactions with other researchers and rubber extensionists and development officers are also provided for.

The main Term of Reference of work having been defined by IICA/EMBRAPA as "Epidemiology and Control of *Hevea* Diseases", this was for practical convenience treated in 4 phases, viz. (a) detection of new diseases and their evaluation, (b) studies on disease epidemiology and effects of the host, environment and soils, (c) evaluation for clonal field resistance and (d) improving or developing effective disease control systems against leaf diseases.

To prepare for the work, two initial important activities were undertaken following my arrival in Manaus in September 1983. The first was participating in the CNPSD's annual presentation and discussion on its 1984 research programme held from 12-16 September, 1983 at IAC, Campinas. Attendance at this annual meeting and the ensuing discussions provided a timely insight into the recent and on-going work of the CNPSD and all its co-operating units. The second activity was familiarisation visits to some of the major rubber growing areas in which are also located the important Centre's co-operating units such as UEPAE-Rio Branco, Acre, UEPAE in Rondonia, Convênios CEPLAC/EMBRAPA, south Bahia, FCAP/EMBRAPA, Belém in Pará and Convênios IB & IAC/EMBRAPA. These visits, always accompanied by a pathologist from CNPSD and the local pathologist (s) and stretched into February of 1984, allowed first-hand survey of the actual disease situation, the problems being faced by planters and the state of research being executed. An assessment of the research personnel and the facilities available for the projected programme implementation was conveniently made at the same time.

Rubber Leaf Disease Problem and Rubber Cultivation

The world's entire supply of natural rubber (NR) comes from *Hevea brasiliensis*, a tree native to the Amazon Basin but now widely cultivated elsewhere. Introduced into South-east Asia and successfully grown as a plantation and smallholding cash crop at the turn of century, some 90% of the current world's total NR produced comes from this small region.

Until 1912, Brazil was actually the principal supplier of NR to the world, the elastomer then or, is being still to-day, collected from the self-grown trees growing in the Amazonian forests. Over-taken since then by the rapidly expanding NR industry in South-east Asia and subsequently also those in India, Africa and China, Brazil turned into a net importer of NR from 1951 in order to meet her increasing national needs. Currently, she has to import some 50% of her annual (1983 total requirement of NR with 73.9% (Souza *et al*, 1984) still coming from the native jungle trees. Like several of her neigbouring countries around the Amazon Basin, she did attempt to augment her supply of NR at the start of this century by cultivating *H. brasiliensis* outside the the forests. However, even with the financial and technical aids then made available from the U.S.A., the early attempts during the 1920-40S at rubber cultivation all ended in failure. Because of this, South America does not, up to now, has a viable NR industry, in contrast to the one now flourishing in the East.

SALB and Other Diseases in Brazil

Leaf diseases: As is well-documented, the failure to grow *H. brasiliensis* on a plantation scale in Brazil or the few neighbouring countries has been attributed to a serious fungal disease, namely the well-known and destructive leaf disease, South American Leaf Blight (SALB) caused by *Microcyclus ulei* (Tollenaar, 1959). Long evolved with the *Hevea* tree host, this most devastating leaf disease is endemic within the tropical and sub-tropical America. While of no consequence on widely-spaced self-grown seedling trees in the forests, SALB quickly assumed epidemic form in its attacks on closely cultivated stands of clonal rubber. The failure of a 1,200 ha plantation in Surinam in 1916, followed by those of Ford Motor Company (Lopes, 1972), the first at Fordlandia (4,000 ha in 1928) and the second at Belterra (800 ha in 1934), provided some classic examples of the devastating nature of SALB. In south Bahia and around Belém in Pará, subsequent American and other local plantations established during the 1950-60s with locally bred, more resistant materials were also severely infected by the blight. Most on the verge of collapse, it was only following the introduction from the 1970s of regular fungicidal treatments then becoming available with active government participation that these renewed plantings were saved from the same dreadful fate.

Of the States planted with rubber, south Bahia now has the single, biggest area of some 25,000 ha (Rocha, 1972), with much of it currently in production. Being located in one of the so-called traditional rubber areas with a cool, humid climate, SALB has long been endemically severe, worsened in recent years by shoot dieback and leaf wither caused by several *Phytophthora* spp. on several of the widely planted clones, eg Fx 2261 and Fx 3864 (Medeiros *et al*, 1965). Existing clones there therefore tend to be either SALB - or *Phytophthora*-prone (Medeiros *et al*, 1967), with the oldest popular clone Fx 25 having lost its resistance to SALB. Also, several clones derived from *H. benthamiana* tend to winter and refoliate slowly or late, thus encouraging prolonged infection by SALB. Being pre-disposed by the clonal and environmental factors, the leaf diseases became such a constraint that mean annual yield at the end of 1960s stood at less than 300 kg/ha, the planters having little incentive to manure or weed the fields.

To counteract the serious decline in productivity, the government, following the establishment of SUDHEVEA in 1967, intervened by sponsoring the large-scale aerial spraying of the 2 leaf diseases under the PROMASE project (Bezerra *et al*, 1980). After some 10 years of continuous annual spraying, recent evidence suggested that economical treatment of the leaf diseases was viable, with the affected rubber plantations sufficiently rehabilitated and showing signs of gradual yield improvement (Souza *et al*, 1980). Currently, PROMASE is still being implemented yearly, 4,220 ha were fogged from the ground and another 1,050 ha aerially sprayed in 1982. Planters participating in this large-scale treatment need to carry out the protective treatment in view of the continuing debilitating effects of the 2 leaf diseases. Likewise, the 2 motor tyre company plantations established in Para near Belem also annually has to fog all their rubber against SALB.

Having shown that SALB in south Bahia and Para was not uncontrollable, the government decided to go into large-scale new rubber planting under PROBOR which was launched by SUDHEVEA from 1972. This was essentially aimed at meeting the country's own need for NR, a target date for self-sufficiency being set for 1992. This assumed that the new rubber would develop normally under the 3 successive 5-year planting projects, under PROBOR I from 1972-77 for 18,000 ha, PROBOR II from 1977-82 for 120,000 ha and PROBOR III from 1982-87 for 250,000 ha (Barros *et al*, 1983). Under PROBOR I and II, much of the new planting was located in the traditional rubber areas such as the Amazonia (Rondonia, north Mato Grosso, Acre, Amazonas and Para) and south Bahia where SALB and *Phytophthora* or *Thanatephorus* are endemically severe. There was some new rubber planted also in the non-traditional SALB-escape States like Espirito Santo and south Mato Grosso under this scheme. On her own, São Paulo started rubber cultivation from the 1950/60S, very successfully even with SALB-susceptible Asiatic clones in the virtual absence of the leaf blight.

By the end of PROBOR I and II in 1982, some 75,000 ha of new rubber, comprising mainly the 3 clones IAN 717, IAN 873 and Fx 3899, were planted out in the leaf-disease infested Amazonia alone. Because of the prevalence of SALB and the other leaf diseases yet fully identified, the rubber in the Amazonia is adversely affected in growth. The continuous ravages by leaf diseases cause poor canopy growth for most of the year, resulting in poor girthing and some dieback of the weakened trees. In the more remote regions of the Amazonia where manuring and weed control are seldom practised, the adverse affects of leaf diseases are accentuated as a result. Moreover, except for the 2 large plantations near Belem and another near Rio Branco, no regular fungicidal treatments of any leaf diseases are in use. Many fields of 6-9 years old rubber are so backward that they are still below the minimum tappable girth while others so overtaken by diseases and neglect that they are in danger of being abandoned. Not unlike the case of south Bahia during the mid - 1960s, the badly diseased rubber areas in the Amazonia obviously need to be rehabilitated, the trees to be correctly protected from attacks by SALB and other leaf diseases. This will help ensure the success, or in some cases, even the survival of the PROBOR I and II plantings. Efficient and economic systems of leaf disease treatment in the SALB - endemic traditional areas of rubber growing, therefore, are immediately required for the existing large rubber areas.

The speed and ease with which this technology may be developed for use by planters would depend on scale-up research into areas of work such as identifying and assessment of the kind and damage inflicted by SALB and other major known and unidentified leaf diseases, and getting the best fungicides and leaf defoliants and formulations to treat each of the diseases with the most appropriate applicators. Their use must be combined with the optimising of the timing and frequency of the protective treatment rounds, by means of short-range disease forecasting. Only long-term epidemiology and disease/weather relationship studies will allow the latter to be worked out (Lim, 1972 & 1983).

For future planting, clones recommended must be those having been bred or selected and thoroughly evaluated for field resistance. This is to avoid the costly routine disease treatment or the eventual loss of the clonal resistance. Research to select and assess critically the long-lasting resistance in such clones which are preferably also high yielding, should be intensified.

Much investment has been made in sizeable areas on rubber planting before and during the PROBOR I to III projects. It is vital that where in existance, the serious problems of SALB and other undescribed leaf diseases be quickly researched on, to halt their continuing ravages with protective chemicals. More simply or cheaply, of course, their partial or total avoidance may be effected by the use of stable resistent clones in the case of new planting yet to be carried out.

Outside the SALB - endemic Amazonia and south Bahia, Espirito Santo, south Mato Grosso and São Paulo (planalto paulista) encounter little of no SALB. Here, rubber planted under PROBOR I and II grow well, to reach tapping within 6-7 years. Apparently such a "SALB-escape" area is currently defined only in terms of an annual moisture deficit of 200-350 mm, distributed over a 4-6 months period, with the wintering of trees occuring in the 3 intermediate months within this period. Within this general weather criterion more data from disease/weather studies are obviously needed, to more precisely describe such a disease escape zone, in terms of the exact temperature regime or moisture availability inimical to SALB development. It is generally felt that the real potential for rapid new rubber planting lies in such an area, PROBOR III as a result is going more into it.

Other diseases: In Brazil, diseases of major economic importance are confined up to now to only those of the leaf. The only disease of the roots, red root disease caused by *Ganoderma phillipii* (Trinidade *et al*, 1981), has been recorded occasionally in immature rubber. Being only the first generation rubber planted in jungle cleared land where disease inoculum is normally low, epidemic of the root disease is not expected. Red root disease, moreover, is slow growing in soil and will not pose an obstacle to rubber growing for many years. For the same reasons, stem problem like pink disease caused by *Corticium salmonicolor* is rarely encountered. In mature rubber, panel diseases like mouldy rot caused by *Ceratoscystis fimbriata* and black stripe caused by *Phytophthora* spp are common but these are easily and economically controlled with fungicides. Research into these diseases, therefore, will not be given priority as accorded to leaf diseases in Brazil for the moment.

8. RESEARCH AREAS AND PRIORITY

Improving Leaf Disease Control

In Brazil, SALB has thus been historically linked with the success or failure of the early rubber plantations. To-day, this would still apply in much of the new rubber areas outside the "SALB escape zones". Unless all the leaf diseases are properly identified, their treatment with fungicides most efficiently made, or their avoidance in future planting rationally effected through use of crown clones or clones of long-lasting resistance, or the use of areas truly can be considered as "disease escape", costly rehabilitation started earlier in south Bahia may never be ended, or prove necessary for an increasing number of rubber areas. In terms of existing knowlege or areas in need of more information to improve disease control, the followings are elaborated in a descending order of priority for research:

Disease identification and assessment: In the Amazonia, in particular, SALB is not the only serious leaf fall pathogen. Recent observations pointed to a similar role increasingly being assumed by *Thanatephorus* and at times, *Colletotrichum*, on some of the new clones widely grown. Black crust caused by *Catacauma huberi* could be another suspect, besides the others yet fully identified. Obviously, each of these leaf diseases must be quickly identified so that it may be assessed for the extent of damage caused. Efficient treatment against SALB alone, for example, will not lead to the formation of a full tree canopy, as the other leaf fungi have long been implicated along with SALB, either within or outside the main annual refoliation season. Collectively, they cause the currently observed year - round premature defoliations, resulting in the trees in a virtual leafless state most of the year.

Protective treatment with chemicals: Several fungicides were available early for spraying against SALB but non-availability then of suitable equipment that could reach the increasing height of maturing rubber trees (15-35m), or effect rapid coverage over large areas, hindered efficient control of SALB. In south Bahia, most of the plantations were on hilly to steep terrains inaccessible to wheel-drawn conventional power sprayers. It was for this reason that from the early 1970s, fix-winged aircrafts were initially used, followed in 1974 by helicopters found to be better suited to the rubber plantation conditions (Bezerra *et al*, 1980). Although very costly and lacking flexibility during use, only aerial spraying can give the desired and speedy coverage of mature rubber (Rogers and Peterson, 1975; Rocha *et al*, 1975). Thus, under the special, heavily government - subsidised annual project for SALB control in south Bahia (PROMASE), some 6,000 ha were aerially sprayed in 1980. Although generally satisfactory in most years, aerial spraying is expensive and still presents some problems such as the most appropriate fungicide formulation and droplet size, and the control of even spread over the target. In terms of practicability, the majority of small-and medium-sized plantations could not hire helicopter individually or outside the limited contracted period for the spraying (Rao *et al*, 1980) For rubber areas outside Bahia, eg the Amazonia, aircraft availability and specialised agricultural aviation services are currently non-existant, being too far from its normal operating base in São Paulo.

Spraying: Ground-based spraying machinery was available since the early days. However, their evaluation and appropriate adaptation for use under the often difficult rubber plantation conditions were not undertaken with vigour. The main obstacles to their possible general application long recognised were the great height and canopy of mature trees, often planted on stiff to hilly terrains. Following a recent field evaluation with a few of the portable and tractor-mounted mechanised sprayers (Gasparotto *et al*, 1982), some small modifications were effected to improve their performance. Because these machines remain *basically* unchanged in the main mechanical moving parts and all employed water-borne fungicides with a limited spray swath and vertical throw, their use can still only be recommended on trees not exceeding more than 15m high, or under the continuously SALB-infested conditions in Brazil, 6-9 years old. Characteristically, the spray droplets tend to be large and highly variable in size, necessitating use of medium to high volume of spray formulation to ensure an efficient coverage. With a limited coverage range, the rate of working with these tractor-mounted or portable machines is relatively slow, besides a tendency to incur considerable wastage of the chemical during spraying.

Thermal fogging: Fogging with a ground-based machine, Tifa, was first used in 1976 to supplement existing methods on several foreign commercial plantations to apply fungicides in a water-oil carrier to control SALB (Wastie, 1978). Not having previously researched on, this technique initially did not give good results. However, following the successful development of an oil-based fungical formulation (Lim, 1979) specially suited to application with a fogger that was correctly calibrated for use on rubber, the technique was successfully applied in Malaysia to control *Oidium* SLF and *Phytophthora* leaf fall (Lim *et al*, 1978; Lim *et al*, 1980). In Brazil, the first and only field evaluation of fogging using a Tifa "TART" and a Dyna-fog was made on rubber plantation in Para. Conduru Neto *et al* (1980) suggested that the first-mentioned fogger gave a satisfactory SALB control.

Based on these experimental results (Lim *et al*, 1980), combined with its long commercial usage within the country, thermal fogging with Leco 120-D, a machine similar to Tifa but costing less, was introduced on a large scale into the PROMASE project in south Bahia in 1981 alongside aerial spraying. The rationale behind this was cost-saving, as aerial spraying was 40.0% costlier than fogging, besides being less flexible. Subsequently, to improve machine performance and field handling, several modifications to the imported Leco 120-D (Corrêa *et al*, 1984) eg changing the formulation pump and feeding system of the combustion chamber, were made. By 1983, most of the plantations treated under PROMASE were by thermal fogging. However, this method of treatment was found not to give the expected good results. Factors associated with this reported poor effect against SALB and *Phytophothora* have yet to be identified. However, what has become apparent was that unlike aerial spraying, fogging was introduced into the PROMASE programme on plantations without the benefit of adequate local research in adapting its use to the difficult Bahain weather conditions. South Bahia has a frequent and high rainfall, with a persistent mist over-hanging the low-lying plantations. Leaves often remain moist most of the time. Application of protective fungicides to such leaves, if at all possible, is quite difficult. Fungicidal residual effect will also be low, due to the constant rain-washing. In fact, inconsistency in the results of aerial spraying under PROMASE has been ascribed to some of these factors, or a combination of them. Up to 1983, no field evaluation of fogging in commercial practice or on experimental scale, in the meantime, was ever undertaken.

In support of the costly on-going PROMASE programme in south Bahia in which fogging was already included, it became a matter of urgency that this technique be critically evaluated and the necessary modifications made through immediate research to overcome its short-comings so far revealed. This is particularly important before fogging is continued for routine use or be extended to more rubber areas. Because of the highly variable weather and plantation conditions existing in Brazil, the evaluation should preferably by made in several selected representative regions, even within the Amazonia. The work should cover areas such as the potent fungicides and their comparative field performance, the optimum dosages, the best mineral or vegetable oil carriers or their appropriate mixtures, fungicidal residual effects and the critical field evaluation and calibration of existing and new foggers. At the same time, work should continue with the adaptation of both the tractor-mounted or portable power sprayers, to further improve their cost efficiency. Aerial spraying with helicoptes, where readily available and not too costly, may be further defined by limited research in collaboration with aerial spraying firms.

<u>Disease epidemiology and effects of host and environment</u>: In Brazil, 2 features not encountered anywhere else are the growing of *Hevea* of a higly mixed parentage over an extremely variable condition of climate and soil. Thus, cultivated rubber is now found from the extreme northen Para/Maranhão States to São Paulo in the south, and from the most eastern Altlantic coastal Bahia to Amazonas/Acre in the west. The commercial clones used, moreover, have not solely been derived from

H. brasiliensis, in sharp contrast with that of the entire cultivated rubber in the Orient.

Because of these, the leaf diseases the Brazilian rubber carries vary greatly in type and incidence. A destructive fungal pathogen typically long evolved with the *Hevea* tree in the Amazonia, *M. ulei* has followed the host wherever and whenever it was cultivated, except where, like on the plateau (planalto) of São Paulo and in Espirito Santo, the prevailing local climate proves unfavourable for the pathogen's development and spread, forming the so-called "SALB escape zones". Contrasted with this is the SALB-endemic traditional rubber areas in the humid tropical States in the Amazonia or Bahia. Here, the blight proves particularly virulent and its damage to rubber is made worse by the other additional fungi like *Phytophthora* in Bahia and *Thanatephorus* and *Colletotrichum* in the several Amazonia States. Apart from the variation in local climate which determines the different levels of disease incidence, the wide use of clones derived from *H. benthamiana*, with their slow wintering and refoliation habit, can modify their field susceptibility by generally worsening it.

For reasons of a highly variable environment and clone used, further studies on epidemiology of SALB and other leaf diseases from those already started in Brazil (Langford, 1945; Camargo *et al*, 1967; Rocha *et al*, 1978) should now be related to the definable or measurable features of local climate or soils and the clonal tree host. Such long-term, 3-factor interaction studies are necessary in order to understand what has caused, or continues to cause leaf diseases to remain or worsen, as the major constraint to the development of existing or new rubber. The findings so derived will help identify or even predict cases of different disease behaviours among regions, climatic zones and cultivars. One of their immediate applications is the use of weather/disease relationship data to formulate short-range disease forecasting system to enhance the effectiveness of the fungicidal treatments, as was done against *Oidium* and *Phytophthora* leaf diseases in Malaysia (Lim, 1972; Lim, 1980). Up to now, such a forecasting system is not available for SALB or *Phytophthora*, although a large area of rubber in south Bahia has annually been treated since 1974. Against SALB and *Thanatephorus* in the Amazonia which obviously will soon need to be similarly treated, such a study in advance is most timely. It will also become useful for the Litoral of São Paulo or the northern parts of Mato Grosso where SALB may, with increased use of some the susceptible clones, pose a real problem. The same data may, at the same time, be used to more precisely define a so-called "SALB escape zone", using simple meteorological parameters more pertinent to

SALB activity than the annual water moisture deficit currently used.

On the effect of some soils on leaf disease severity, this may be related to their nutritional influence. In the remote Amazonia, in particular, soil protection and manuring are generally inadequate. This factor, if not more clearly defined and an appropriate remedial measure taken and integrated with use of fungicides, will not achieve the fullest control of SALB.

Evaluation for field clonal resistance: In areas where SALB and other leaf diseases are endemic, the long-term solution is the planting, in a discriminate manner as advocated under the Enviromax scheme (Ho *et al*, 1974), of clones with long-last field resistance. Or, where newly planted rubber is still not too old, it can be crown-budded with a SALB-resistant clone like PA 31 (Lion *et al*, 1982). Several clones, eg Fx 25, bred and widely planted out earlier in the country, saw their resistance gradually eroded over the years with the emergence of new *Microcyclus* races (Langdon, 1965; Miller, 1966). Better hope lies therefore in the continuous search and evaluation for materials with horizontal resistance. Such observed resistance should preferably be made in different localities over a sufficient long period of time. Apart from resistance to SALB, it should be observed for reaction to *Thanatephorus* or other leaf diseases as soon as these are identified. Thus, a good starting point in a long-term, systematic evaluation for this resistance is in the national or regional, small or large scale clonal trials, using some appropriate and reliable criteria to be evolved during this contract period.

9. OBJECTIVE OF RESEARCH PROJECTS

Genaral

To detect and assess the effects of new diseases besides SALB on rubber, and to initiate studies on their epidemiology and interactions with the host, climatic and soil factors, aimed at forecasting their outbreaks or avoidance while improving their control with protectant chemicals, integrated with other agronomic inputs.

Specific

To assess the effects of SALB and other new leaf diseases on growth and productivity of rubber, including their general distribution within the Amazonia or outside it.

To identify and define the factors of the host, climate and soil affecting the development of SALB and the major leaf diseases (*Phytophthora* and *Thanatephorus*) and establishing their relationships, if any, for disease forecasting based on simple weather rule, and for avoiding the diseases.

To devise and improve on chemical disease treatment systems, through the employment of more potent fungicidal formulations and the most appropriate equipment, integrated with the use of leaf defoliants, improved field nutrition and weed control practices.

To identify and determine the extent of field resistance in clones so as to formulate the first stage of the Enviromax clonal recommendation scheme for Brazil.

10A. RESEARCH PROJECTS

5.11 Disease Detection and New Outbreaks

To detect and assess new disease outbreaks which adversely affect the host in the major rubber growing areas.

5.12 Disease Epidemiology and Effects of Host, Climate and Environment

To identify and define the main climatic factors associated with host phenological changes and disease development, and establish their relationships with a view to forecast disease outbreaks or their avoidance (*Microcyclus* and *Phytophthora*).

5.13 Disease Control with Chemicals

To evaluate new machinery, fungicides and defoliants and their formulations to enhance disease control in an integrated manner (all the major leaf diseases).

5.14 Field Disease Resistance Evaluation

To assess field clonal resistance to leaf diseases with a view to formulate the first part of Enviromax planting recommendations (all major leaf diseases).

10B. OTHER SUPPORTIVE RESEARCH ACTIVITES

5.21 Research Co-ordination and Monitoring

To discuss, plan and help implementing projects on the above research areas at CNPSD and its co-operating units and monitoring their progress.

5.22 Training and Seminars

To discuss and train staff in methodologies of research, including methods of analysis and reporting, supplementing by personal visits and seminar sessions.

5.23 Technology Transfer and Advisory

Along with local staff, interact with extensionists, other related researchers and planters to assess and accelerate field adoption of research results.

5.24 Reporting and Result Presentation

To prepare technical/advisory reports related to the above activities and their results.

5.23 Supply of Planting Materials

To advise CNPSD on available sources for procuring improved rubber and oil palm genetic materials.

11. ANNUAL SCHEDULE OF ACTIVITIES

See Table on p.15 please.

SCHEDULE OF ANNUAL ACTIVITIES 1984 & 85

ACTIVITY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
5.11	x	x	x	x	x	x	x	x	x	x	x	x
5.12			x	x	x	x	x	x	x	x	x	x
5.13	x	x	x	x	x	x	x	x	x	x	x	x
5.14						x	x	x	x	x	x	x
5.21	x	x	x	x	x	x	x	x	x	x	x	x
5.22	x	x	x	x	x	x	x	x	x	x	x	x
5.23	x	x	x	x	x	x	x	x	x	x	x	x
5.24	x	x	x	x	x	x	x	x	x	x	x	x
5.25	x	x	x									

12. IMPLEMENTATION STRATEGY

In all, there are 4 main areas of research which are interrelated that need to be planned, implemented and monitored over the 2-year contract period while based at CNPSD, Manaus. Because producers are currently facing grave problems of leaf diseases, particularly in south Bahia where control of SALB and *Phytophthora* by fogging urgently requires improvement, priority during 1984-85 will be given to its evaluation, and improving its use, where possible.

At the same time, long-term experiments on plantations to measure and collect weather and disease data with a view to establisch their relationships, if any, for disease forecasting against SALB & *Phytophthora* are to be initiated. Any fungicidal treatment system lacking a reliable forecasting method to accurately time the application rounds will not give the best results. Similar lines of work will also be started in parts of the Amazonia where there are sufficient large areas of rubber already under or intended for fungicidal treatment eg. Para, Amazonas and Rondonia.

An area of urgent work for CNPSD in the Amazonia is the detection and identification of all the major leaf diseases other than SALB which are directly associated with the backwardness or extended period of immaturity of rubber planted under the PROBOR projects in the region.

For the planned formulation of a Enviromax clonal planting recommendations for Brazil, suitable methods to assess field resistance in clonal trials at CNPSD will be initiated from the first year. If found reliable, the assessment methods may be applied to the clone trials in the other States subsequently.

Other important work includes the development of a disease integrated control system that takes into account the peculiar situation of the Amazonia where inputs other than protective fungicides may be needed.

CNPSD being located in Manaus, Amazonas, distant from practically all of its 6 co-operating units currently staffed with pahologists, a considerable travelling is required for me to meet with them and discuss project planning and implementation, especially during the first year. Thereafter, only occasional visits to these units, or meetings with collaborating pathologists to be invited to CNPSD, are necessary to monitor the progress of work and discuss the results obtained for publication.

Apart from the research activity described above, time will be allocated at CNPSD, and during the visits to other rubber growing States, for interactions and discussions with local planters, extensionists and rubber project implementors. This will help pinpoint current or new problem areas requiring the attention of researchers. At the same time, opportunity will be used to put across to these people, for rapid adoption and use, some of the results of the successfully completed projects.

13 DESCRIPTION OF R & D ACTIVITIES AND RESULTS

(A) RESEARCH ACTIVITIES

The various activities planned for the 1984 and 1985 under the 4 areas of research identified and established for the 2-year IICA-EMBRAPA Contract's assigned project entitled, "Epidemiology and Control of Leaf Diseases" (IICA,1983), have been given separately under "Plans of Activities for 1984 and 1985" (Lim 1984a and 1985a). The research and development (R & D) activities executed during 1984 (including last quarter of 1983), along with the results obtained, have been reported (Lim, 1985b , "Annu Report for 1984"). In June 1985, a 12-month progress report, to cover the most recent R and D work for the period June 1984 to June 1985, was also submitted, in complaince with the request of the newly appointed President of EMBRAPA (Lim, 1985c). This report is now presented to cover the whole 2-year contract consultancy period that started at CNPSD on 2 September 1983. As my contract terminated in 1985, annual report for the yea: was incorporated into this final report.

Activiy 5.11: Disease detection and new outbreaks

The project was aimed at ascertaining more exactly the number and relative importance of most, if not all, the rubber leaf-defoliating parasites, besides the 3 already recognised (*Microcyclus*, *Thanatephorus* & *Colletotrichum*), responsible for the virtual year-round "leafless" state of clones like IAN 717, IAN 873 and Fx 3899 widely planted under the PROBOR I and II Project in many parts of the Amazonia. This appears a pre-requisite, in order to first clearly or fully defining the problem, before testing and securing the appropriate chemical protectants and treatment systems to protect the estimated 75,000 ha of clonal rubber implanted under PROBOR in the region.

For the new planting, disease avoidance through the use of clones with the desired resistance in the traditional "leaf-disease endemic" areas is only workable if the screening or evaluation process for lasting field resistance takes not only SALB into account, but also the other major leaf fall parasites, already known or in the process of discovery through intensified research. This comprised symptom identification, isolation of the pathogens and evaluation for the unknown disease on pre-maturely fallen leaves. This study involved fields at CNPSD, Manaus and those encountered during the many field visits made to the various parts of the Amazonia.

Results provided new evidence to enable the reporting, for the first time, another 3 fungal leaf fall pathogens, and one also of the leaf which was caused by a bacterium. The first fungus found in 1984 to be associated with pre-mature yellowing and fall of fully mature leaves is *Catacauma huberi*, previously recognised only as a minor leaf spot disease (Gasparotto *et al*, 1984). The second is *Corynespora cassiicola* which also causes premature leaf fall, now discovered in Brazil besides known earlier in India and Malaysia. Continuing the search, *Periconia manihoticola* and a new Ascomycete fungus causing leaf spotting and fall in clonal gardens and nurseries, were found at CNPSD during the first half of 1985.

During the same period, repeated tests of the pathogenicity of the bacterium isolated from *Hevea*, identified as a *Pseudomonas* sp. by collaborating bacterialogists at Viçosa University, MG., was conclusively established. This new bacterial disease, with grave implications to *Hevea* health, is thus confirmed by Brazilian researchers for the first time in the world. Its discovery in Amazonas poses new challenges to effective control of leaf diseases that up to now, are known to be caused exclusively by fungi. Clones so far affected included IAN 873 and Fx 3864.

With no less serious implications to the overall well-being of *Hevea* in the Amazonia and elsewhere, continued search during early 1985 in rubber fields at CNPSD yielded definite virus symptoms on leaves on trees of several clones. Collaborating virologists at CENARGEN and University of Brasília, DF, confirmed the presence of virus particles in samples of such malformed, undersized or variegated leaves collected from the systemically affected stunted trees with drooping foliage or pre-mature flowering. Clones in the fields with virus symptoms included IAN 6158 (SALB resistant) and F4512.

To ascertain the relative importance of the new pathogens, comparative epidemiological studies on these leaf-defoliating agents have been included at CNPSD. The 2 newly found fungi now recognised along with *Microcyclus*, *Thanatephorus* and *Colletotrichum* already known, have been published as detailed below (i - iii). Another paper describing this new multi-agent serious "leaf disease complex" was presented at the 15th Congress of Brazilian Phytopathology in July, 1985 at Fortaleza (iv).

(i) Lim, T.M.; Gasparotto, L. & Silva, H.M. e (1984). Black crust - a post - refoliation leaf fall problem on rubber. In: 4th NAT. RUBB. SEMINAR, 1984 Salvador, BA. Anais. Brasília: SUDHEVEA (in press).

(ii) Silva, H.M. e & Lim, T.M. (1984). Leaf diseases other than SALB in the Amazonia. In: INTERNATIONAL WORKSHOP ON SALB, Itabuna, BA, 1984. Anais. Brasília: SUDHEVEA (in press).

(iii) Gasparotto, L.; Elainy, P. & Lim, T.M. (1984). An outbreak of Corynespora leaf fall on rubber in Amazonas. Comunicado Técnico, No 39. CNPSD/EMBRAPA, Manaus, 1985, 2p.

(iv) Junqueira, N.T.V.; Gasparotto, L.; Silva, H.M. e & Lim, T.M. Complexo de doenças foliares em seringais de cultivo no Estado do Amazonas. In: CONGRESSO BRASILEIRO DE FITOPATOLOGIA, 15, Julho, 1985, Fortaleza-CE. Resume.

(v) Lim, T.M.; Gasparotto, L.; Silva, H.M. e; Trindade, D.R.; Castro, A.M.G. de. & Souza, A.R. de. (1984). Diseases in relation to rubber cultivation. In: 4th NATIONAL RUBBER SEMINAR, Salvador, BA, 1984. Anais. Brasília: SUDHEVEA (in press).

The publication under (iv) was presented to some 500 rubber planters, researchers and extensionists attending the 4th National Rubber Seminar. It critically assessed the existing type and nature of diseases for their past and current impact on rubber growing in Brazil, as compared with SALB-free Malaysia. This review would serve as a good starting point with which to formulate, through research, a proper management strategy particularly of SALB and the othe leaf diseases that still pose a severe constraint to rubber cultivation in the American tropics.

Also proposed for publication before the end of 1985 year are 2 important papers reporting the first discovery or the occurence on *Hevea* of a virus and a bacterial leaf diseases. The first joint paper will be with collaborators from CENARGEN and University of Brasília, and the second with that from the University of Viçosa, MG.

On oil palm, a *Fusarium solani* pathogenic to clonal young tissue - cultured plants received from England was detected. Its quick control was achieved by spraying benomyl and reducing the humidity of the growth chamber. Interestingly, clones of palm differed greatly in their susceptibility even at this early age.

Activity 5.12: Disease Epidemiology and Effects of Host, Climate and Soil

In support of the current protective scheme of chemical treatment against *Microcyclus* and *Phytophthora* leaf diseases, a long-term study to assess the relationships, if any, between the principal parameters of local prevailing weather, along with the relevant host clonal phenological features, and disease incidence/severity, was initiated on a national scale. From this, it was hoped eventually to formulate short-range

Microcyclus and *Phytophthora* disease forecasting methods. Each will help optimise the timing and frequency of protective fungicidal application thereby improving treatment efficacy.

Secondly, such a 3-factor relationship study will provide more definite meteorological criteria,besides the annual moisture deficit parameter,with which to more reliably define what, well in advance of any rubber planting, constitutes a permanent "SALB-escape area".

To collect the necessary data to formulate a short-range disease forecasting system for SALB and, possibly also for *Phytophthora,* suitable sites on representative zones of the country were selected to set up the long-term weather/host/disease observation stations on the disease susceptible rubber. At each of the observation stations, the main meteorological parameters being continuously monitored with simple but robust clock-work instruments are temperature, humidity, rainfall, wetness period and wind (if available only). These instruments were set up among trees within rubber fields, to provide the more realistic in-crop weather data. At the same time, changes in host's phenology relating to leafy growth were measured by weekly or daily leaf fall counts and % changes in canopy density. On the progress of leaf disease and severity, weekly or daily counts were made of the infected leaves which pre-maturely drop in marked areas or nylon cages of fixed dimensions under a selected number of trees, accompanied by leaf infection identification and scoring. Randomly selected trees around the leaf count areas were also marked out for periodic assessment of canopy susceptibility stage and density. All these data were being accumulated and filed properly . Later,correlation studies will be carried out to see if relationships exist among the relevant parameters taken continuously over a sufficient period of time for in-crop weather, disease severity and detectable change in the host's susceptibility stage.

Thus, in accordance with my recommendations (Lim, 1983) such a 3-factor observation station was successfully established in a clonal rubber field at (i) CNPSD, Manaus, AM (Mar, 1984) (ii) P.V. in Rondônia by UEPAE/P.V. (iii) FCAP/EMBRAPA,Belém, PA and (iv) Fazenda Três Pancadas, Itubera, BA (April, 1984) by CEPLAC/EMBRAPA. The last station included observation on *Phytophthora* besides SALB. Due to poor road accessibility and lack of man-power stationed on site, the station set up in early 1984 on Fazenda Bonal, Rio Branco, AC stopped functioning after 3 months. The 3 other observation stations set up by CNPSD on its own (1981-82) earlier at Boca do Acre, Aramanai and Belterra did not supply the desired data for the same reasons, and were recommended for closure as a result.

Data on local climate and disease incidence collected during the first SALB season during June-August 1984 were analysed for relationships on IAN 717, IAN 873 and Fx 3899 in Amazonas and for the same on IAN 717 in Para. In the first State, SALB severity was shown to be correlated negatively with the daily maximum temperature or positively with RH > 90% or daily rainfall (Lim, 1985b). In Para, during the month of July when maximum leaf fall took place due to *Microcyclus*, there was a minimum of 5 days with temperature 24º - 28ºC, accompanied by 14 days with RH > 95% persisting for more than 10 hours, conditions optimal for a SALB epidemic outbreak (Stein & Nunes, 1985). Similar data from Rondonia and south Bahia have yet to be received at CNPSD or analysed by the respective collaborating counterparts.

At the time of this reporting, the 1985 *Microcyclus* or *Phytophthora* season has yet to arrive. The required data on weather, host and disease incidence for 1985 are being awaited.

All these observation stations for long-term studies will be continuously monitored, as planned, for at least 2-4 years. There appears a possibility that a similar station might be set up in São Paulo during 1985, based on a recommendation made and accepted by the Convênio IB/EMBRAPA during my recent re-visit to the State in July 1985.

Significance of Results and Recommendations

This is a long-term fundamental study now initiated on a national scale, adopting for the first time a uniform methodology so that the results may be usefully compared. They will reveal the expected differences in local climate and clonal phenology which largely account for the great variation in disease incidence among the different rubber growing regions.

In south Bahia, where SALB and *Phytophthora* are serious and annually treated, it is envisaged that the forecasting schemes to be worked out based on this study will be a great help to rationalise the timing and frequency of fungicidal applications. In the Amazonia where SALB and several other different diseases are endemic, comparative epidemiological studies to include those newly found diseases caused by the 3 fungi, a bacterium and virus should be initiated. By the time PROMASE NORTH is launched, the close relationships already demonstrated by initial results in Amazonas and Para between SALB commencement and incidence may provide the basis for evolving an annual blight prediction scheme. For defining a "SALB escape area", such a study must include observation stations in States such as Espirito Santo and the São Paulo plateau, to explain the absence of SALB in terms of meteorological factors.

Activity 5.13: Disease Control with Chemicals

As elaborated in the 1984 and 1985 Work Plans, (Lim 1984a & 1985a), studies on leaf disease control took on a high priority. This was especially in respect of the evaluation of thermal fogging widely used in south Bahia since 1981, without apparently an adequate prior adaptive research into it (Lim, 1983). In view of this, and under the directive by EMBRAPA in response to SUDHEVEA and Bahian planters' requests, a major part of the 1984 activities for the 9 pathologists and 2 application technologists under CNPSD and its co-operating units at FCAP/EMBRAPA, PA, CEPLAC/EMBRAPA, BA, UEPAE-Rio Branco and UEPAE-Rondonia, were devoted to this work.

In fact, leaf diseases being currently such a vexing problem faced by planters in the Amazonia and south Bahia, trials on fogging and spraying of fungicides were recommended and planned on a national scale (Lim, 1983). This was partly also to expose most of the inexperienced researchers to the vital art of disease control.

In line with this broad objective, a total of 6 plantation-scale spraying/fogging trials and 1 observation on commercial scale fogging, were carried out during 1984. The results are summarised by States and participating research units as follows:

(1) South Bahia (Ituberá), trials by CNPSD and Convênio CEPLAC/EMBRAPA

In relation to fungicidal treatment of SALB or *Phytophthora*, south Bahia's frequent rainy, cool and misty atmosphere plus the steep or hilly terrains make any spray or fog application difficult while frequently reducing its efficacy. Aerial spraying, although costly and less flexible in usage, has long been in use and is generally satisfactory in most years. However, the same cannot be said for thermal fogging. Fazenda Três Pancadas, Ituberá, is one of the first to use this technique and since been making claims on its good results against SALB. In view of this, this particular plantation offers an excellent site for determining the effectiveness or otherwise of thermal fogging (on clones Fx 3864 and Fx 4098), as practised on a commercial scale under PROMASE.

At the same time, a properly laid out fogging trial against Phytophthora leaf fall with 2 fungicides, employing a modified Leco 120-D was put down (on the susceptible Fx 3864) on another plantation, Fazenda Cultrosa, Camamu. Details pertaining to treatments, disease assessment methods and the results in terms of periodic leaf counts or & canopy retention, were given fully in the 2 separate progress reports by Pereira *et al* (1984). The main points are as follow:

Against SALB: On Fazenda Três Pancadas, practically all the fogging rounds suffered rain wash-out either during or immediately after the day of application. The frequent rains during the treatment month of August (137.8 mm in 19 days), accompanied by a low temperature caused a predominant leaf fall due to *Phytophthora* with only negligible SALB. Although greatly increased dosages of benomyl (Benlate), mancozeb, triforine (Saprol) and thiophanate methyl, or appropriate mixtures of some of them were applied, no consistent good effect was shown for the above reasons. Pereira *et al* in their report (1984) rightly concluded therefore that no valid inference could be drawn from this 1984 commercial-scale fogging. A follow-up evaluation in 1985, under a normal weather and heavier blight conditions, should therefore be more meaningful. However, this observation did reveal some of the practical problems associated with fogging, in terms of poor control of machine specifications, rain interference and the resultant non-standard treatment frequency. From these, in fact, useful lines of research aimed at resolving some of these main problems had been formulated for implementation in 1985 (Albuquerque *et al*, 1984).

Against *Phytophthora*: On Fazenda Cultrosa, fogging, machine specifications and all its field operations were better controlled by researchers. *Phytophthora* being also severe here, the effect of fungicidal fogging was more clearly shown. In terms of canopy retention, fogging showed a beneficial effect. That given by Cursate-M (60.8% canopy) was the best, followed by copper oxychloride (Cuprantol) (46.4%) and the control (29.5%). These results suggest that fogging is of promise against *Phytophthora*, despite the frequent rains which adversely affected aerial spraying on other plantations.

Other trials made are as follows:

SALB fogging and bioassay tests: At CEPLAC, a field fogging trial under mature rubber with Leco 120-D was made just before the SALB season. Increasing dosages of benomyl, chlorothalonil (Bravonil) and triforine were applied and susceptible rubber leaves exposed to chemical fog collected and bioassayed in the lab for conidial germination. The results suggested that fogging with the higher fungicide concentrations but not low concentrations, gave adequate fungicidal deposition to the abaxial leaf surface for protection against SALB. The effect, however, was not consistent, even with benomyl at 500g/ha or chlorothalonil at 750g/ha (Pereira *et al*, 1984). This observed inconsistency was not unexpected. It may be easily attributed to the characteristic nature of a chemical fog. It being dependent on the existence of a temperature inversion and wind movement in air for effective dispersal, any rapid changes in the atmosphere will affect deposition of the chemical fog. Being also a form of drift application, such an inconsistency obtained in small-scale test run is not unusual.

Copper deposition on leaves upon fogging. In south Bahia, fogging of copper oxychloride in palm oil with a modified Leco 120-D was made in a mature 21 years old Fx 2261 on Fazenda Três Pancadas to determine if deposition of the heavy metal occurs on leaves at increasing distances from the machine. The leaves on trees were sampled before and after fogging and their copper contents determined in the lab. The results showed effective deposition of copper on leaves at 15m height in a field with closed canopy for up to 50-70m away (Corrêa *et al*, 1984). This confirmed similar results reported earlier from Malaysia (Lim, 1982).

(2) Pará (Belém), trial by Convênio FCAP/EMBRAPA

In the State, Fazenda Granja Marathon was also one of the first plantations to adopt fogging in controlling SALB. Each field on this plantation is planted with several clones, one clone along a row. This being the case, each year up to 14 weekly rounds of fogging with a mixture of different fungicides were used, apparently to cover an extended refoliation period in the mixed clonal fields.

The fogging trial put down was designed to compare Saprol at 3 concentrations (600, 1,000 & 1,500 ml/ha) and its mixture (at 1,000 ml/ha) with 450g/ha Bayleton against the standard plantation treatment using a mixture of Cercobin, Calixin (tridemorph) Dithane M-45, Saprol, Bayleton (triadimephon) and Benlate. The carrier oil was 80% diesel + 20% palm oil, each treatment comprising 6 weekly rounds made on a 20-ha block. The severity of SALB was assessed based on weekly counts of fallen diseased leaves and % canopy retention.

The results suggested that fogging generally reduced leaf fall and enhanced canopy retention in comparison with the control. Because the experimental area suffered from a severe attack by *E. ello* which also damaged the new canopy soon after refoliation, the effect of different fungicide concentrations was not apparent. However, Saprol at 600 ml/ha or above, applied in 6 weekly rounds, appears of promise in controlling SALB. This treatment seems to be distinctly superior to the costlier existing plantation system requiring 14 rounds of fogging with 6 different fungicides (Stein *et al*, 1984).

(3) Rondonia (Ouro Preto do Oeste), trials by UEPAE/Rondonia & CNPSD

Generally in the more remote parts of the Amazonia such as Rondonia, many areas of rubber planted under PROBOR I and II are not well managed. The adverse effect of yearly repeated attacks by SALB and other leaf diseases or pests is made worse by the lack of adequate manuring and weed control. Due to these, some of these rubber areas are on the verge of being abandoned. Three trials were designed in Rondonia in 1984 to rehabilitate the badly diseased rubber, combining or integrating fungicidal teatment by spraying or fogging with proper manuring and weed control. In 1 of the trials, fogging was compared with spraying with a modified Leco 120-D. Mixed in mineral spray oil and diesel (5:2), 4 weekly rounds of macozeb (Dithane M-45) at 2Kg/ha combined with 2 rounds of Bayleton at 1Kg/ha against target leaf spot, or 6 rounds of Cercobin at 0.75 and 1.5Kg/ha were applied along every 6 rows, normally after 5.30 pm. Fogging was effective against SALB with only Dithane M-45 which gave a low leaf fall count and good canopy retention. With Cercobin(thiophanate methyl) however, the result was not as good, attributed to an inefficient coverage in a more open canopy. Spraying of the 2 fungicide however, was effective, with either Hatsuta or Jacto sprayers, as expected. The results have been published (Gasparotto *et al*, 1984; Gasparotto *et al*, 1985).

(4) <u>Amazonas (Manaus), trials by CNPSD</u>

Typical of much of the rubber planted under PROBOR I & II in the Amazonia, trees of IAN 717, IAN 873 and Fx 3899 are generally so badly affected by leaf diseases that although 6-9 years old, they have yet to reach the minimum tappable girth. They are normally therefore low enough in height for spraying or fogging with a small-sized portable sprayer of fogger. Moreover, most of the planted rubber is made up of widely dispersed smallholdings, averaging 20-100ha in size. This situation therefore does not permit practical use of large tractor-mounted sprayer or fogger.

The effect of fogging Saprol, a promising new fungicide (Gasparotto *et al*,198 and Bayleton, using the shoulder-mounted Puls-fog K20/0, was put down on Fazenda Viçosa near Manaus. Each of the fungicides was used at 4 concentrations on a 7 years old mixed clonal field, the fog directed from the ground to cover the tree canopy (delivering 0.1 l/ha in 0.6 min.). A total of 4 weekly rounds were made, the treatment effect expressed in terms of total leaf fall and % canopy retention. The results showed that fungicidal fogging with Puls-fog K20/0 was effective against SALB and *Thanatephorus* (Albuquerque *et al*, 1984 ; Lim, 1985e).

(5) <u>Acre (Rio Branco) trial by UEPAE/Rio Branco & CNPSD</u>

In this State, target leaf spot is prevalent and together with SALB, can cause severe pre-mature defoliation on susceptible clones. A fogging trial with Leco 120-D was therefore planned with Bayleton on a 7 years old Fx 3864 on Fazenda Bonal near Rio Branco However, owing to its remote situation and non-accessibility by road from June-December, the fungicide needed for the experimental fogging was not received until the 3rd week of July, well past the optimum time for treatment initiation. Apart from this problem, *E. ello* also attacked the new canopy soon after refoliation and interfered with the experiment. No conclusion could therefore be made from this trial.

Significance of Results and Recommendations

Thus, following the only field fungicidal fogging trial carried out in 1979 by Conduru *et al.* against SALB in Pará, and a subsequent one with a defoliant to induce defoliation by Romano *et al*, 1982, effects of fogging were assessed under the different environmental and tree conditions in 1984 in south Bahia, Pará, Amazonas, Acre and Rondonia. The results in south Bahia showed success of fogging to be depended on the adequate control of machine specifications and field operational aspects, besides the important environmental factor of climate. While no valid inference could be drawn from this assessement of commercial-scale fogging of SALB on Fazenda Três Pancadas on account of the above-mentioned adverse factors, that of a properly controlled fogging against *Phytophthora*, on the other hand, appeared to be of promise. In Pará, fogging of Saprol against SALB also seemed promising on Fazenda Granja Marathon. In Rondonia, the effect of fogging was shown to be depending on the fungicide used and tree canopy stage during applications. In Acre, the effect of fogging was not demonstrable owing to a very late start in the application. This underlies the importance of correct time of application. In Amazonas, where it would be more practical to use a portable Puls-fog K20/0, efficacy was obtained with fogging Saprol or Bayleton against SALB and chlorothalonil against *Colletotrichum* (Lim, 1982).

Effectiveness of fogging was shown to be dependent on an increased dosage of fungicides as compared with those normally used in aerial spraying. Of equal importance were a correct timing and frequency of application, a proper control and specification of fogging machine, little or no rain interference and an ideal receptive stage of canopy during fogging. For the fogging, the widely-used modified Leco 120-D proved adequate in upward dispersal of fungicides to the leaves, and of promise in controlling SALB and *Phytophthora*. For trees less than 8-10 m (or 6-9 years old) in height, fogging may be effectively made from the ground with a portable Puls-fog K20/0, treating the trees individually, as was shown in trials in Amazonas (Albuquerque *et al*, 1984). The trials had not included use of the new Jacto fogging machine because it was then undergoing modification at CEPLAC workshop at Itabuna.

In ground spraying with modified portable or tractor-mounted sprayers in Rondonia and Amazonas, using the standard fungicides thiophanate methyl (Cercobin), mancozeb or triademephon (Bayleton), or the new chemical triforine, good control of SALB was achieved (Gasparotto *et al*, 1985).

On the new approach to develop a novel and more effective leaf disease control or management system, based on integrating fungicide/inseticide treatment by spraying or fogging with manuring and weed control, this was successfully tried out on 3 holdings badly diseased in Rondonia which required rehabilitation. Significance of the results (Gasparotto *et al*, 1985) lies in the fact that, where the rubber has been severely affected by SALB and pest attacks, protectant chemical treatment is enhanced by prior corrective manuring and weed control. In fact, this useful finding was quickly adopted by SUDHEVEA as a basis for drawing up a special rubber rehabilitation project entitled "PROMASE NORTH" for Acre, Rondonia and Amazonas. It is now scheduled for implementation in 1985/86 (SUDHEVEA, 1984). In further support of this important project and refining this new "integrated approach" to leaf disease management or control for the Amazonia, follow-up trials at CNPSD were carried out. These incorporated the use of chemical leaf defoliants eg. DROPP (Schering, Germany), so as to advance and uniformise wintering, and, in an on-going 1985 trial, also pruning of terminals to encourage uniform refoliation, aimed at reducing the number of expensive fungicidal treatment rounds while enhancing treatment effect (Moraes, V.H.F., 1985, personal communication).

The above results of the 1984 treatment evaluation were only preliminary. Similar follow-up trials were therefore planned in 1985 (Lim, 1985d) so as to put fogging on a firmer basis for continuing or increasing use in Brazil. However, due to fund shortage for this field experimentation for 1985, coupled with curtailing in travelling, almost all the proposed experiments outside CNPSD were cancelled during the year. Against the 3 new additional leaf fall pathogens, *Catacauma*, *Corynespora* and *Periconia*, new potent fungicides obviously need to be found for their treatment soon, by spraying or fogging. Against the new bacterial and viral diseases, urgent remedial or treatment meaures are to be researched on.

Despite this set-back, the extensive activities developed on leaf disease control during the this consultancy are duly reflected by the following 6 publications made on the topic, the significance of each being also given:

(a) Consultancy report by Lim, T.M. (1983). on "Fogging for controlling leaf diseases in south Bahia". Prepared in early 1984, it contained recommendations for trials on epidemiology and disease control by fogging for the Amazonian States (PA, AM, RO & AC) and Bahia for 1984.

(b) Consultancy report by Lim, T.M. (1984e) on "A preliminary evaluation on thermal fogging for leaf disease control in Brazil". Prepared towards the end of 1984, it reported the promising good results of 1984 spraying/fogging trials suggested under (a) above.

(c) Technical paper by Albuquerque, P.E.P.; Gasparotto, L.; Lim, T.M. & Corrêa, H.G. (1984) Recent progress in fungicide application technology for rubber leaf control. A review containing the 1984 fogging spraying results plus the recently completed work in Brazil, it was read at the INTERNATIONAL WORKSHOP on SALB held at CEPLAC, Ilhéus, BA, 1984. This review is timely, to serve as a basis for current and future research.

(d) Technical paper by Gasparotto, L.; Albuquerque, P.E.P.; D'Antona, O.J.G.; Ribeiro, I.A.; Rodrigues, F.M. & Lim, T.M. (1985) A suggested integrated approach to SALB disease control in the Amazonia. Boletim de Pesquisa, NO 01, 1985. EMBRAPA/CNPSD, Manaus-AM. Based on the 1984 SALB season's results of 3 spraying/fogging trials in Rondonia, it was shown that application of fungicides, combined with prior proper manuring and weed control, gave the best canopy growth and the least disease attack. Significantly, SUDHEVEA has adopted these results as the basis for the proposed "PROMASE NORTH" rubber rehabilitation programme for Acre, Rondonia and Amazonas to be implemented in 1985/86 (SUDHEVEA, 1984).

(e) Technical paper by Lim, T.M. (1984b) The epidemiology and control of *Phytophthora botryosa* on rubber. An invitation paper read at the 17th BRAZILIAN PHYTOPATHOLOGY CONGRESS, September, 1984, São Paulo, Abstr. The methodology and approach used in Malaysia to bring about the satisfactory control of *Phytophthora* (also a serious problem on rubber in south Bahia) were presented for open discussions and possible adoption by local pathologists.

(f) Technical paper by Gasparotto, L. & Lim, T.M. Research on SALB (*Microcyclus ulei*) in Brazil - recent progress. In: INTERNATIONAL WORKSHOP ON SALB, Itabuna, BA, August, 1984. Anais. Brasília, SUDHEVEA (no prelo). A timely review of recent and current work on SALB.

In addition, 4 other progress reports prepared by local counterparts on the same topic of disease control during the consultancy are as listed below:

(i) PEREIRA, J.C.R.; ALBUQUERQUE, P.E.P.; SANTOS, A.F. & AZEVEDO, A.C. Projeto especial de termonebulização na Fazenda Cultrosa, Camamu-Ba. Relatório. Manaus, EMBRAPA-CNPSD, November, 1984. 3p.

(ii) PEREIRA, J.C.R.; ALBUQUERQUE, P.E.P. & SANTOS, A.F. Projeto especial de termonebulização na Fazenda Três Pancadas, Camamu-BA. Relatório. Manaus, EMBRAPA-CNPSD, November, 1984. 19p.

(iii) GASPAROTTO, L.; ALBUQUERQUE, P.E.P.; D'ANTONA, O.J.G.; RIBEIRO, I.A. & RODRIGUES, F.M. Recuperação de seringais em Ouro Preto do Oeste - Rondonia. Relatório. Manaus, EMBRAPA-CNPSD, October, 1984. 15p.

(iv) ALBUQUERQUE, P.E.P.; PEREIRA, J.C.R. & SANTOS, A.V. dos. Programa de pesquisa de pulverização e termonebulização para controle de doenças da seringueira no sul da Bahia para 1985. Relatório. Manaus, EMBRAPA-CNPSD, December, 1984. 4p.

Significantly, the publication under (iv) was prepared based on problems revealed from commercial-scale fogging under (ii) that required prompt research. Towards this end, lines of new work were proposed and duly implemented without delay by local counterparts in south Bahia from mid-1985.

Activity 5.14: Field Clonal Disease Resistance Evaluation

Evaluation for clonal field resistance in breeders' trials forms an important initial part of work that will lead to a rational, discriminative use of long-lasting resistance under the Enviromax (Ho *et al*, 1974) or Zonation recommendation scheme.

In Brazil, a standardised method to evaluate the incidence or severity of above-ground diseases (Lim & Rao, 1973) is lacking. Because SALB is not the only leaf disease attacking the developing canopy, it becomes essential that the criteria used to denote leaf infection scores, number of diseased fallen leaves and the resultant canopy retention must be sought separately for each of them. The assessment is to be made also at the correct time of the year.

A study was therefore initiated during the consultancy to work out suitable leaf disease assessment methods that best describe the clonal field susceptibility or resistance (as influenced by tree wintering/refoliation behaviour which is not the case with vertical resistance) towards *Microcyclus*, *Thanatephorus*, *Catacauma*, *Corynespora* and *Colletotrichum*, commencing at CNPSD.

Significance of Results and Recommendations

This is a long-term project to run for 2-3 disease seasons. Initial results from a trial assessment made on clone trials a CNPSD suggested that suitable parameters are: (a) periodic counts of fallen, diseased leaves in marked areas of fixed dimensions, (b) infection score of leaves in marked areas of fixed dimensions, (c) infection score of leaves using a standard disease key to be evolved and (d) estimation of periodic % canopy retention. These are being employed to assess the 3 clone trials at CNPSD. The promising criteria were, at the time of reporting, critically tested out during the 1985 leaf disease season from July to September.

(B) RESEARCH SUPPORTING ACTIVITIES

Activity 5.21: Research Co-ordination and Monitoring

Being based at CNPSD, Manaus, frequent and close interactions with its Chief and his technical and administrative heads were facilitated. These were in respect of research project planning, its implementation, co-ordination and progress monitoring. CNPSD being separated far from its co-operating units in the other States, frequent visits to hold discussions with counterparts outside Manaus were necessary, especially during the first year.

These activities, aimed at enhancing co-ordination and monitoring of work undertaken within CNPSD and outside Manaus, took the form of formal and informal meetings. At CNPSD, a total of 20 meetings, chaired either by Dr. Valois or his technical chief, were held. Outside Manaus 15 recorded, with counterparts and their Chiefs at the other co-operating units during the consultancy period (see Annual Report for 1984 and Progress Report June 1984-June 1985, for details).

In an effort to promote co-operative research between CNPSD and some well-known local specialist researchers who show interest on *Hevea*, discussions were made on the named tropics with the following:

Local Contacts

(a) Prof. A. Bergamin and Dr. J.O. Menten of University of São Paulo at Piracicaba (epidemiology and host/parasite relations).

(b) Dr. A.A. Ortolani and Maria J.P. of IAC, São Paulo (zonation scheme for rubber planting and meteorological equipment).

(c) Profs. Chaves, G.M., and Dr. Kushalappa, A.C., of University of Viçosa(rubber diseases and epidemiology)

(d) Profs. Katajima, E.E., and Lin, M.T., of University of Brasília (virus diseas of rubber, follow-up studies)

(e) Dr. H.M. Rocha of CENARGEN, Brasília (epidemiology of rubber diseases)

(f) Drs. Stephen, A. Rudgard and Teklu, A of CEPLAC, Belém and Rondonia (epidemiology and control of diseases for cocoa and rubber)

(g) Dr. Bezerra, J.L. of CEPLAC, Itabuna (rubber diseases and fungus identificat

(h) Bastos, T.X. of CPATU, PA(microclimate and rubber diseases)

International Contacts

Similary, contacts through correspondence were established with specialist researchers or persons outside Brazil on the named topics below:

(a) Director of Commonwealth Mycological Institute, Kew, England, Dr..Hawkesworth D., its Chief Mycologist, Dr. Sutton, B.C. and bacteriologist, Dr. Bradbury J (identification of new fungi and bacteria for CNPSD)

(b) Dr. Stahl, K.H., of Puls-fog machinery Co., West Germany (supply on loan of machines for testing by CNPSD)

(c) Dr. Blencowe, J.W., Oxford, England, FAO/UN Consultant for rubber

(d) Dr. Yee, Y.L., of Australian Agricultural Consulting and Management, Adelaide Australia (supply of planting materials).

(e) Mr. Hew, C.K., of PLANTEX Plantation Agric. Services, Kuala Lumpur, Malaysia (private consultancy services to plantations)

(f) Dr. Abdul Aziz, S.A.K., Deputy Director, (Res) RRIM (disease control in gener and Mr. Teoh, C.H., Deputy Director, Prang Besar Research Station, Kajang (Pr Besar clones), all of Malaysia.

Significance of Results and Recommendations

Lacking an officially appointed Chief at CNPSD, the current large number of pathologists spread out in co-operating units in distant States sorely need a better co-ordination and closer discussions. This is to ensure the approved projects are exec smoothly and their objectives achieved. Standardisation in the methodologies used, supp of research materials and timely financing are areas constantly needing attention.

To ensure that practical problems faced by producers are quickly attended to, unlike the unsatisfactory state experienced in south Bahia during 1983/84, researchers in disease control must spend more time in producers' fields, evaluate the acute problems and put down plantation-scale trials to resolve these. For this, constant orientation and on-the-spot discussions between the co-ordinator and pathologists are essential. As the Brazilian NR industry is expanding so rapidly into traditional leaf disease endemic areas, problems of diseases surface time and again, needing an effective co-ordinator or Chief, to deal with not only the extensionists and project implementors but the many new producers as well.

Activity 5:22: Training & Seminars

In the course of planning and executing the various research projects in the lab and field at CNPSD and its other units outisde Manaus, the local counterparts and their associated staff were shown and trained in some proven methodologies developed in Malaysia and elsewhere in the formulation and conduct of experiments, including data collection, their storage, treatment and analysis. These exercises were held in the labs, fields or during meeting and seminar sessions with the local counterparts.

The training initiated is a continuous process, particularly that pertaining to treatment and analysis of field data which await collection and success of trials. Briefly, demonstration and training relating to the following subjects were given:

(a) Methods for leaf disease evaluation in the lab and field in terms of severity and incidence (for *Microcyclus*, *Thanatephorus*, *Phytophthora* and *Catacauma*)

(b) Improved techniques in conducting thermal fogging trials for leaf disease control with Leco and Puls-fog machines, including disease assessment, leaf disease score and leaf fall counts, canopy density evaluation and yield recording of trees.

(c) Methods in leaf disease assessment (including new or modified disease keys) for differentiating clonal susceptibility in nursery and field screening trials.

(d) Methods in data collection in field, preliminary treatment and analysis to establish micro-climate/disease relationships for disease forecasting in weather/host/disease studies (SALB and *Phytophthora*).

(e) Orientation towards a leaf disease fungicidal control system integrated with use of extra manuring and better weed control for the Amazonia.

Significance of Results and Recommendations

Apart from imparting the above proven methodologies to local counterparts to improve their research, the overall philosophy of my 2-year consultancy in Brazil is to evolve a better leaf disease control or management system. This system could be formulated only basing on an appropriate research programme that work towards it. In fact, lack of this has let SALB had its free reign for so long, thereby delaying for nearly a century the satisfactory domestication of *H.brasiliensis* in the Amazonas,Brazil (Lim *et al*, 1984; Albuquerque *et al*, 1984).

Because SALB still presents a serious problem, and newer and potentially serious leaf diseases are appearing at the same time, it becomes imperative that the relatively young team of local pathologists be trained in a rapid evaluation of field situations and fully apreciate their existing and future disease problems. Projects are then formulated and the established and new techniques from elsewhere applied, wherever possible, to speed up research in resolving the same. In an applied research centre like CNPSD, researchers should preferably be problem-orientated and pragmatic in approach to their research programme. While pursuing different specialised areas of work, they should be led to see problems and the proposed solutions in an overall context.

Two good examples of this promising new approach realised during 1984 is the work reported by Gasparotto *et al*, 1984 on an integrated approach towards SALB control in the Amazonia and that of Albuquerque *et al*, 1984, all involving a multi-disciplinary team-work. The first tapped the essential services of the State EMATER extensionists and an economist while the second, the expertise of an experienced agriculture engineer from IAC, São Paulo.

By necessity, most of my local counterparts are spread out in the other States (Appendix 1). Currently, 2 in Acre and Rondonia are working without a satisfactory lab and staff, in a rather remote or isolated situation, 3 in south Bahia not fully orientated to the State's grave leaf disease problem on account of the local Head of their pathology unit while the 1 most experienced in São Paulo just about to build a team dedicated to work in full unison with CNPSD.

On staff qualifications, almost all have been trained at post-graduate M.Sc level, and are generally competent and receptive. The CNPSD and EMBRAPA had since 1980 worked out a sound scheme for staff specialist training at Ph.D. level, with the first one completing his course and assuming duties at CNPSD in early 1985 while 2 are currently reading the course.

It is gratifying to place on record the excellent efforts and positive responses in work shown during this consultancy by Gasparotto, L. & Albuquerque, P.E.P., & Junqueira, N. AM, Stein, R. at Convênio FCAP/EMBRAPA, PA, Moreira, M.I.P. of UEPAE/P.V., RO, Pereira, J.C. and Santos, A. at Convênio CEPLAC/EMBRAPA, BA, and Rosa Maria C. of IB São Paulo, in our efforts to construct a cohesive and pragmatic team of plant pathologists, to serve the rapidly growing new Brazilian NR industry.

Activity. 5.23: Transfer of Technology and Extension

In response to periodic requests by rubber implementation or advisory agencies, plantation owners or EMBRAPA researchers, several visits or meetings to identify, evaluate and recommend remedial measures against diseases were made during the period.

The subject invariably touched on disease control research and its latest findings and how all these could be best adopted for use by extensionists, implementors of planting projects and planters. The following details were recorded:

(1) With SUDHEVEA

(a) 30 May 1984, discussing leaf disease control strategies for Amazonia with A.R. Souza of SUDHEVEA, Olinto G. & Gasparotto, L. at CNPSD.

(b) 2 June 1984, field visit to Viçosa plantation, Manaus, to evaluate experiment on fogging, with A.M. Souza of SUDHEVEA and 3 French IRCA scientists.

(c) 19 July 1984, to review results of thermal fogging projects 1984 in Manaus and Rondonia, with Orivaldo A.A. (Chief) & A.R. Souza of Agricultural Production Department, SUDHEVEA, Brasília.

(d) 20 July 1984, with Souza, A.R. and Subramanian, S. of SUDHEVEA, Drs. Abreu of CEPLAC, Chee, K.H. of RRIM and Gasparotto, L.; as members of Organizing Committee, to plan the proposed International SALB Workshop to be held at CEPLAC in late August, 1984.

(e) 24 July 1984, discussing leaf disease control in general, with A.M.G. Castro, Chief of Planning Dept., Souza, A.R., & Subramanian, IICA/SUDHEVEA Consultant, & a World Bank rubber loan Consultant, in Manaus.

(f) 29 & 30 June 1985, discussing the proposed "PROMASE NORTH" rubber rehabilitation projects with Dr. Orivaldo, A.A. (Chief), Dr. Bernado, B. & Dr. Cyro, P.R. of Agricultural Production Dept. of SUDHEVEA, Brasîlia.

(2) Visits to Plantations

(a) Eirunepé, AM, 30 Jan to 3 Feb 1984, to evaluate leaf disease problems and clone trials, with Dr. Paiva, J.R. and Francisco, L. of EMATER, meeting Mustafa Said, Edy Monte Conrado & Maria Said.

(b) South Bahia, BA, April, 1984, to evaluate effects of fogging and aerial spraying of SALB and *Phytophthora* under PROMASE. With Gasparotto, Hermes Corrêa of IAC, A.M.G. Castro of SUDHEVEA, Pereira, J.C.R. and Santos, A.F. of CEPLAC/EMBRAPA and meeting planters Fabia, Z. Mais, Vandenschvick, P.A.V.G., Robert J, Dunham, Mário I.T. Souza, Jivi Hlavnicka, John Jarold & Julio C. Gerk.

(c) Belém, Pará, June 1984, to evaluate leaf disease problems. With Silva, H.M. e, Pinheiro, E.; Ruth B.; and Nunes M.A.L., meeting planters B. Avery Jones, Lion, A., and Francisco A.Chagas.

(d) Rio Branco, Acre, Feb 1984, to evaluate SALB and *Thanatephorus* problems. With Silva, H.M.; Pereira, L. and Gasparotto, L. & meeting planters Constantino, E., and Guy, L.

(e) São Paulo, July 1984, to assess leaf disease problems. With Rosa Maria, C., Domingo, A.Z.; Marly, S., and Edson, F. of IB & met planters Carlos A. Ostenblad, Niggo, R., Ussaki Jorge and Maximo, Y.

(f) Agricultural District (SUFRAMA) Manaus, AM (a) 13,20 & 22 November & 1 December, to assess disease problems on Fazenda Viçosa, Montebor, Triangulo & Agrocin with Gasparotto, L. & Jomar, P., (b) 17-20 December, to assess all aspects of problems on the State PROBOR III 40 planting projects, as a member of a multi-disciplinary team from CNPSD and representatives of SUDHEVEA and EMATER, Amazonas.

(g) Fazenda Triangulo, Mato Grosso, 7-11 July 1985, to evaluate the serious problem of plant die-back due to *Botryodiplodia* and cold, and recommending leaf disease control measures, with Silva, H.M. e & Bernardo B. and meeting Soares, P.H.B., Brito, O.C. de & Yokoyama, R.

(3) Seminars to Planters/Extensionists/Researchers

(a) Manaus, 18 December, 1984 giving a talk on "Leaf disease problems on PROBOR I-III plantings in Amazonia and their control" to members of Planters' Association and officers of SUDHEVEA and EMATER in Manaus.

(b) University of São Paulo at Piracicaba, 3 June 1985. "A suggested leaf disease control or management system against leaf diseases on *Hevea*", to professors and 25 post-graduate students on phytopathology.

(4) Other Advisory Contacts

Discussions were held on general disease problems and advices given to the following rubber extension people:

Marcelo, D.A.G. of EMBRATER, Brasília, Dr. Cyro, P.R., and Dr. Bernardo, B. of SUDHEVEA, Brasília, Jordão, F.O., of R. Gerson S. EMATER, Itacoatiara, Ézio, B. & Yara of SUDHEVEA, Manaus & Conduru, J.M.H., of SUDHEVEA, Belém.

Significance of Results and Recommendations

In the transfer of technology, the remoteness of Amazonia and its great distance from conventional sources of supply of protectant chemicals and equipment in São Paulo pose a severe constraint. Although tentatively recommended, the fungicides Saprol and Bravonil are difficult to buy or are prohibitively costly in most parts of Amazonia for use against SALB and *Colletotrichum*. The same applies to equipment especially routine services and spares, eg Puls-fog K20/0 now recommended for use based on 1984 results, besides the portable mist-blower.

Even in area of research, few technical or project personnel of agrochemical or equipment firms visit Amazonia often to fully appreciate the serious problems of leaf diseases. They are therefore unable to be on-the-spot regularly to assist researchers in the supply of new chemicals or loan of equipment for testing or their field development for rapid use by planters. This has to be improved somehow and CNPSD captures their attention, as is the case enjoyed by researchers in the central or southern parts of Brazil. Where CNPSD is located, few extensionists or planters outside Amazonas visit it to seek advice or discuss problems. Hence, the need to decentralise research, to facilitate greater contact and technology transfer.

Activity 5.24: Reporting and Result Presentation

Early data tabulation and analysis, followed by timely publication of results of research, ensure their speedy disemination and adoption by the planters. Thus, local counterparts were encouraged to do this during this consultancy.

This has resulted in the compilation of reviews (Lim *et al*, 1984; Albuquerque *et al*, 1984; Gasparotto & Lim, 1983) essential for enhancing research directions, progress reports on a specific trial or project to facilitate evaluation (Lim, 1984e; Pereira *et al*,1984), technical papers on an important R & D topic and advisory articles (Gasparotto *et al*,1984) to speed up,finally, technology transfer.

Thus, including those already cited in this report, with me as author or co-author, the following numbers of different publications useful to research and extension were produced in the area only of leaf diseases and their control:

(a) Technical reports

9

(b) Technical papers

27 of which 14 are full-length papers published or submitted for printing, and the rest as abstracts presented at a seminar & congress & outside Brazil.

(c) Extension articles

One submitted for publication, and 3 as extension reports after plantation visits.

Compared with previous years, the above represents a record number of publications on leaf diseases compiled by the pathologists and 2 application technologists currently serving CNPSD and its co-operating units. With some of the projects already initiated terminating later on,more advisory leaflets on specific topics should be compiled, for use by the planters,extensionists or policy makers connected with the growing Brazilian NR industry.

14 GENERAL CONCLUSIONS AND RECOMMENDATIONS

Brazil, a country with plenty of unused land, has a great potential for the growth of several tree perennial crops, including the *Hevea* rubber. Since the turn of this century, she led all other countries of the tropical America in a determined effort to domesticate *H. brasiliensis*, as Malaysia did so successfully in the Orient. This was, and still is to-day, aimed at augmenting her production of NR which traditionally comes largely (74.0% of national NR production in 1983) from tapping the native wild trees.

To-day, almost a century later, after much effort and several attempts, Brazil at least is nuturing a small but growing NR industry. In 1984, the country needs only to import about 50.0% of her total need of NR, with 26.0% of the balance derived from her own cultivated rubber (Souza *et al*, 1984). Under the PROBOR planting project started in 1972, she envisages an increase in the area of cultivated rubber from about 160,000 ha in 1984 to 388,000 ha by 1994, when she hopes to be self-sufficient in NR production. In this planning, it was assumed that growth of the existing and new rubber would he normal, capable of producing from 6-7 years of age and thereon sustaining a reasonable level of productivity.

That this goal in self-sufficiency is not going to be attained with ease may be inferred from the fact that, of the total of 106,000 ha planted under PROBOR up to the end of 1983, some 87.0% is concentrated in the SALB-endemic, tropical States of Amazonia. Outside the Amazonia, south Bahia has the biggest single piece of about 25,000 ha of rubber in production, but this needs annual spraying and fogging under PROMASE against severe SALB and *Phytophthora* to maintain yield. The SALB-escape States like Espirito Santo and São Paulo have, respectively, only 0.5% and 0.1% of the share of PROBOR planting.

In the Amazonia, SALB although now controllable, is still a serious problem. Moreover, a leaf disease survey (Dinaldo & Lim, 1980) conducted during my earlier consultancy revealed that more than just SALB were associated with the poor canopy and growth of the PROBOR rubber. Hence, on my return to take up the present consultancy, a systematic search and identification of the other major diseases became a priority task. Unless this disease problem is precisely defined, research into any control strategy will not be fruitful, or the inadequecy of chemical treatments to-date explanable (Lim, 1980).

As expected, and helped by collaborative efforts successfully forged during this consultancy with local research specialists from 2 universities and CENARGEN, and international researchers from Commonwealth Mycological Institute, England, this study proved rewarding. In Amazonas alone it was shown that leaf damage and its premature fall are caused not only by another 3 new fungi but, with grave implications to cultivated rubber world-wide (Junqueira *et al*, 1985), by a leaf virus and a bacterium as well. Long evolved and adapted to the tree host, these new pathogens of diverse kinds, along with *Microcyclus*, *Thanatephorus*, *Catacauma* and *Colletotrichum*, now form a serious "leaf disease complex" that needs careful studying and a radical new approach in devising control measures. Besides that caused by SALB, the role each of these new pathogens plays in bringing about the virtual leafless state of susceptible rubber in the region may be assessed. Outside Amazonas, a survey of the occurence on rubber of these important new pathogens should be mounted without delay. At the same time, proper preventive or phytosanitary treatments of planting or new germplasm materials beyond the state or national boundary would help minimise risks of spread of the dangerous new bacterial and viral diseases (Junqueira *et al*, 1985).

It is recommended that the current team of pathologists be immediately strengthened by the employment of a well-qualified bacteriologist and a virologist. Work should continue in detecting and identifying new diseases, or to monitor closely the increase in the virulence of some of the existing ones. On the latter, we noted *Phytophthora* flare-up in Bahia and Para, and there was also the case of a serious *Botrydiplodia* trunk dieback and tree loss in Fx 3899 ($1^1/2$- 4 years old) on plantations in Mato Grosso, predisposed by lower bark injuries caused by extreme day heating alternated with night freezing cold. With a rapid increase in the area of cultivated rubber going into new or unknown regions, and the commonly planted clones subjected to a wider range of environmental and disease stresses, new problems are not unexpected and they should not be left unattended.

On the screening of clones for stable field resistance, the method of assessment once perfected, will provide a good basis for a long-term study to be undertaken jointly with the breeders. While already initiated with the new clones at CNPSD, Manaus, it should be extended to all clonal trials on a national-wide basis, to eventually cater for the need under the Enviromax planting scheme. So far, this work revealed that the first lot of 3-4 clones widely used under PROBOR I-II are not without defects, some gravely so. In Amazonas, IAN 717 is highly prone to leaf fall caused by *Microcyclus*, *Thanatephorus*, *Catacauma* and *Colletotrichum*, IAN 873 susceptible to the same fungi besides the new bacterium and Fx 3899 moderately so to these but highly to *Botrydiplodia* trunk dieback. Somewhat tolerant to most leaf diseases, Fx 3864 is unfortunately quite susceptible to the new Corynespora leaf fall and the bacterial leaf disease. Of the new clones, IAN 6158, with an outstanding resistance to all existing leaf diseases, is found to be habouring the new virus. Similarly, PA 31, the popular SALB-resistant crown clone (*H.spruciflora*), is liable to attack by the leaf bacterium. It is clear that no popular clones so far cited can escape attack by at least one of this diverse group of leaf disease causal agents. The work of rubber breeders or selectionists, therefore, would seem doubly difficult in the light of this feature of Brazilian existing materials, or the special adaptive ability displayed by their leaf defoliating parasites in the region.

Concerning the fundamental, long-term study on the effects of environmental, host and soil factors initiated on *Microcyclus* and *Phytophthora*, on a national scale for the first time, this would later provide a basis for disease forecasting urgently needed to improve the annual fungicidal treatment of the 2 diseases in south Bahia. In the Amazonia, one for *Thanatephorus* should also be aimed at. Now that a serious "leaf disease complex" (Nilton *et al*,1985) is recognised in the region, comparative epidemiology to assess the relative role of each and its requirement for remedial measure should commence without delay. Lacking money and the necessary essential lab and field equipment, a proposal entitled "Studies on epidemiology and control of rubber leaf diseases" was prepared and submitted for external funding by EEC R & D Programme for Science & Technology, Europe. Also, to better describe the "leaf disease escape area",specifically valuable for new or future planting eg. under PROBOR III, the current 3-factor observation stations should also be extended to "non-leaf-disease " States like Espirito Santo and São Paulo. The climatic data derivable are essential guide-lines with which, when compared with those from the Amazonia and Bahia,to help define the limits under or beyond which no SALB or *Phytophthora* would occur. In São Paulo where such a study first originated (Camargo *et al*,1967), excellent facilities exist at IB and IAC to undertake this jointly.

On disease control with chemicals, new or more potent fungicides (and defoliants) are required immediately to treat the new leaf fall agents like *Catacauma*, *Corynespora*, *Periconia* as well as the bacterium. Proper screening and heat treatment of planting materials to limit the spread of the newly discovered virus within and beyond Amazonas are of urgent importance. In view of the unique problem of tree height and large size of rubber plantations, an important but often neglected part of disease control work is that to do with application technology and use of suitable machinery (Corrêa *et al*,1984). While to-day leading all the rubber research institutes in research in this area, including the successful assembly of a local fogger (Jacto), Brazil needs this kind of intensified work, as demonstrated during 1984 by CNPSD on a national scale. This is because the existing leaf diseases like SALB,*Phytophthora* and *Thanatephorus* are inadequately being treated, not to mention the several additional ones discovered during this consultancy.

In the Amazonia, long years of unchecked attacks of the PROBOR I and II rubber by these leaf diseases, worsened by lack of other essential agronomic inputs, have meant that efficient control of SALB cannot be achieved solely by means of the best fungicides alone even with the best applicator used. This underlies the vital importance of a multi-proned approach to tackling this special disease situation in the region.

Specifically to show this, the 1984 rehabilitation trial in Rondonia suggested what an appropriate integrated scheme of SALB control, with adequate manuring and weed control prior to spraying of fogging of fungicides and insecticides, ensured a better success. It is recommended that similar trials now be made to demonstrate this concept in all the States of Amazonia. In respect of fogging, results of a national scale evaluation on plantations obtained in the first year (1984) showed this technique to be effective, under suitable conditions of weather and tree refoliation stage. Unfortunately similar trials were not realised in 1985 (due to fund shortage) to confirm the promising results. Fogging, of course, is now recommended for routine use in Malaysia while tests in India against *Phytophthora* and *Oidium* confirmed its efficacy (Edathil *et al*, 1984; RRIM, 1985).

Also, the wide use of a mixture of clones (IAN 717, IAN 873 and Fx 3899) in Amazonia, worsened by many subsequent failures and consequent supplying or re-supplying, cause non-uniformty in tree growth and leaf flushing. An efficient coverage by spray or fog application at any one time is difficult. To counter this, promising results of trials made at CNPSD with thidiazuron (DROPP, Shering, Germany) as a defoliating agent to induce a uniform refoliation for more effective fungicidal deposition, should be followed up. Where the infected trees are too badly attacked, with terminals dying back and too weak to sustain the new flushing, terminal branch pruning to healthy wood just prior to the annual refoliation, offers another promising alertnative to uniformising or inducing flushing for improved fungicidal treatment. In fact, all the integrated treatment measures adopted so far in trials progressing at CNPSD at the time of this reporting, represents the most comprehensive or promising approach there is, for eventual use under the Amazonian situation. Here, the several clones used being invariably susceptible to either one or the other or more of the leaf disease complex, provisions for mechanised routine spraying or fogging, with a mixture or cocktail of several fungicides plus insecticides, will be a permanent essential feature of plantation practice that ensures normal growth or produtivity of *Hevea* in the Amazônia. This need can only be dispensed with when all susceptible rubber, at the suitable young age, is crown-budded with stable resistant clones, or Enviromax planting is effected with newer, more resistant clones.

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APPENDIX 1

List of Pathologist Counterparts with Details on Location and Project, 1984-85

Name	Research Unit/Location	Research Activity Code
1) Gasparotto, L. M.Sc. (3 years)		5.11, 5.13,5.14
2) Silva, H.M. e. M.Sc. (>10 years)	CNPSD, Manaus-AM	5.11, 5.12,5.14
3) Albuquerque, P.E.P. M.Sc.* (2 years)		5.13
4) Stein, R.L.B. B.Sc. (2 years)	Convênio FCAP/EMBRAPA,PA	5.12, 5.13
Nunes, M.A.L. M.Sc. (< 1 year) **	FCAP, PA	5.13
5) Santos, A.F. dos. M.Sc. (2 years)	Convênio CEPLAC/EMBRAPA,BA	5.13
6) Pereira, J.C.R. M.Sc. (2 years) **	Convênio CEPLAC/EMBRAPA,BA	5.13
7) Almeida, L.C.C. de. M.Sc. (2 years)	CEPLAC, BA	5.12
8) Pereira, L. M.Sc. (< 1 year)	UEPAE-Rio Branco, AC	5.13
9) Moreira, M.I.P. M.Sc. (2 years)	UEPAE-Porto Velho, RO	5.12
10) Rosa Maria, C. M.Sc. (> 10 years) **	IB, São Paulo	5.12
11) Corrêa, H.G. M.Sc.* (agri.engineer on secondment to EMBRAPA (1984 only)	IAC, São Paulo	5.13
12) Junqueira, N.T.V. Ph.D. (3 years)***	CNPSD, Manaus, AM	5.11, 5.13, 5.14

(- years): Years of research experience on *Hevea* diseases.

* : Agriculture engineer.

** : Part-time only

*** : Since Feb., 1985 only