CIRAD CP
Rubber Programm

Applied Research Programme of the GREL Rubber Outgrower Plantations Project Agronomy Mission

From 3 to 14 June 2002

J.M. Eschbach

CP_SIC 1527

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Contents

Aim of the mission

This mission was part of the CIRAD appraisal missions providing support to the applied research component of the second phase of the outgrower project. The purpose of the mission was to take stock of on-farm agronomy studies covering the following subjects:

- planting
- fertilization
- intercrops

and make recommendations for continuing these studies.

Main persons met

Patrick Berny-Tarente	Directeur général of GREL
Emmanuel Akwesi Owusu	Project manager du ROU (Rubber Outgrower Unit)
A.A. Aikins	ATO (Agricultural Technical Office) Manager du ROU
Edouard de Rostolan	Applied research manager of ROU
C. Ayisi Larbi	Field manager of ROU
A.G. Abakah	Development manager of GREL
Charles Ntow Boahen	Production manager of GREL
Emmanuel Owusu Acquah	A.T.O. of GREL
Frederic Lefebvre,	Project advisor of CSDP (Coconut Sector Development Project)

Mission schedule

Monday 3/6	Departure from Montpellier, overnight in Abidjan
Tuesday 4	Travel Abidjan – Takoradi Introductory meeting, mission objectives.
Wednesday 5	Working meeting at ROU head office
Thursday 6	Tour of budwood gardens and nursery for outgrower planting material Working meeting at ROU head office
Friday 7	Tour of fertilization trials at Essamang (F01, F02), Kayankow (F25) et Asuogya (F26)
Saturday 8	Tour of smallholdings in Eastern Zone and trials at Morrison Junction (F17)
Sunday 9	Tour of planting sites at Animakrom
Monday 10	Meeting with outgrowers in the village of Yediyesele and tour of trials
Tuesday 11	Meeting with ROAA (Rubber Outgrowers and Agents Association) at Abura Participation in Workshop at Takoradi for the launching of CIRAD ATP : Stratégies patrimoniales, épargne et décisions d'investissement dans les cultures pérennes
Wednesday 12	Meeting with outgrowers in the village of Ewoku and tour of trials
Thursday 13	Working meeting with ROU Management and debriefing with GREL Management Travel Abura - Abidjan
Friday 14	Departure from Abidjan
Saturday 15	Arrival in Montpellier

Acknowledgements

We should like to thank GREL and ROU Management and staff, particularly Messrs Patrick Berny Tarente and Edouard de Rostolan for their hospitality and for the very good organization of the mission. Thanks also to the communitites and outgrowers met.

1 Rubber outgrower plantations project in Ghana

1.1 Background to smallholder rubber cultivation in Ghana

In 1960, the State set up agricultural development cooperatives with a view to introducing and developing crops such as citrus fruits, oil palm and rubber on smallholdings. In particular, it set up 3,500 hectares of cooperative plantings with seedlings, divided into units of 20 hectares.

Those areas were abandoned (1980) then rehabilitated between 1992 and 1995 by Ghana Rubber Estates Limited (GREL). They belong to independent farmers and are not supervised by GREL, though it does purchase their production. Those plantations are gradually being eliminated or replaced by new plantings under the 2 phases of the Rubber Outgrower Plantations Project (ROPP), with funding from Agence Française de Développement in Western Region.

Table 1. Development of GREL outgrower plantations

Phase	Period	Area planted (ha)	Number of farmers	Ha/farmer
I	1993 - 1999	1200	400	3.0
II	1999 – 2005	2800	500	5.6
Total	**1993 - 2005**	**4000**	**900**	**4.44**

1.2 Phase I

Apart from planting 1,200 ha for 400 farmers, the Rubber Outgrower Unit (ROU) has supervised the rehabilitation of old seedlings, the founding of a Rubber Outgrowers and Agents Association (ROAA), the construction of tracks and infrastructures, and rubber purchasing.

Table 2, below, shows that the average area was increased to 3.0 ha/farmer at the end of the phase

Year	Cumulated area (ha)	Cumulated number of farmers	ha/farmer
1993	2	2	
1994	14	8	1.8
1995	161	116	1.4
1996	402	203	2.0
1997	774	389	2.0
1998	1042	400	2.6
1999	1200	400	3.0

Table 3, below, shows growth, densities and disease incidence for the different planting years in 2001.

Year	Age (months) *	Circumference at 1 m	Density trees/ha	% diseased trees
1994	90	52	468	1.0
1995	78	44	444	1.2
1996	66	39	470	1.1
1997	54	29	436	0.5
1998	42	18	414	0.1
1999	30	12	419	0.0

* planting was carried out in May/June and the circumferences were measured from October to December

It can be seen that growth is a year behind that in Côte d'Ivoire, as the trees are opened at 7 full years (85 months). There are very few diseased trees and the densities are good. The first plantings are ready for tapping.

1.3 Phase II

This is intended to densify the 4 zones of phase I: Northern, Western, Eastern and Central (Annex 1), and provide upkeep on existing plantings until tapping starts. The areas planted to date are given in table 4 below:

Year	Cumulated area (ha)	Cumulated number of farmers	ha/farmer
1999-2000	171	54	3.2
2001	585	232	2.5

Over both phases, the Central zone now accounts for 48% of the areas, Western Zone for 27%.
Setting up the plantation involves the following operations carried out by:

The farmer	GREL
Plot clearing	Tree sawing
Burning	
Staking out and lining	Lining and row layout
Holing,	Planting,
Replacements	Provision of plants and inputs
Row and interrow upkeep	Fertilizer applications

The area planted under this phase will be extended to 2,800 ha for 500 farmers up to 2005. The organizational flowchart for the ROU, to which the applied research component belongs, is given in annex 2.

1.4 The Research component of the project

At the end of the first outgrower phase, it appeared necessary to launch an applied research programme to defiine the most appropriate techniques for the local smallholder context from physical, agronomic and socio–economic viewpoints.

The lines of research were as follows: planting techniques, fertilization, intercrops, disease control, tapping systems, rubber technology, and a socio-economic study.

This programme is being implemented with CIRAD-CP technical assistance. It was launched in April 1999, with GREL prefunding, and is due to end in March 2004, but it should be extended up to December 2005, when phase II comes to an end.

The person in charge of this component is assisted by an Extension Officer and an Assistant Extension Officer. The facilities provided are an office, a computer, a car and a motorbike. The budget is 1,842 million francs, 275,000 francs of which are for trials, 40,000 francs are for agricultural equipment and 50,000 francs for executive training.

2 Outgrower development applied research activities

Disease control, rubber technology, and the socio-economic studies are covered in other reports.

2.1 Trials

Agronomic trials are currently under way in 11 villages (Annex 3)

Location	Year of Planting					
	< 1998	1998	1999	2000	2001	Total
Agona		2				2
Animakrom				2		2
Asuogya			1	1		2
Essamang		2				2
Ewoku		4	5	2	3	14
Kayankow Road				1		1
Morrison Junction			4			4
Nsuaem	1		1			2
Simpa Dadwen				2		2
Yediyesele	4		2	2	3	11
Total	**5**	**8**	**13**	**10**	**6**	**42**

The following table shows how the different types of trials are distributed. Most are fertilizer trials, followed by intercropping trials and planting techniques.

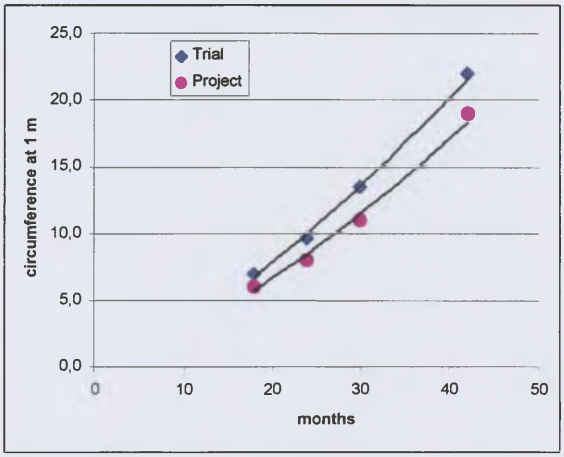
Location	Number of Trial				
	Planting	Fertilization	Intercrops	Tapping	Total
Agona		2			2
Animakrom			2		2
Asuogya	1	1			2
Essamang		2			2
Ewoku	2	9	3		14
Kayankow Road		1			1
Morrison Junction	1	3			4
Nsuaem	1			1	2
Simpa Dadwen			2		2
Yediyesele		4	3	4	7
Total	**5**	**22**	**10**	**5**	**42**

In 2002, emphasis will be placed on fertilization, clonal performance and tapping trials.

Trial	Year of setting up the experiments				Total
	1999	2000	2001	2002	
Planting	5				5
Fertilization	8	14		8	30
Intercrops		4	6		10
Tapping				6	6
Clones				8	8
Total	**13**	**18**	**6**	**22**	**59**

The graph opposite shows that the relative growth of the trial plots is better than that of the Project rubber trees.

It is often so in trials, with better field monitoring, and they are generally conducted on the farms of more motivated farmers.



2.2 Methodology

a. Protocol

The trial protocols will have to be updated and the checks modified.
Maps are drawn up each year indicating existing (x) and missing or dead trees (o) for each position.
Leaf flushing and mortality checks will be carried out twice, in November (at 6 months) and April (at 11 months).
The circumference will be measured on 50 trees located in 5 to 10 rows in a diagonal, at the collar in August of year 1 (at 15 months), then 1 m from the ground in November of each year (at 30, 42...months).

b. Measurement recording

All the data meaasured are entered in a spreadsheet file (annex 4), making it possible to extract dynamic two–way tables, which will be used for statistical analyses.

The ROU has developed a rating scale from 0 (very poor) to 4 (very good) to estimate the condition of the farm at the time of the 2 annual technical inspections, in the dry season and in the rainy season.
These scores (annex 5) relate to:
- intercrops,
- the appearance of the rubber trees (percentage of seedlings, growth compared to the norm, planting density per hectare, uniformity)
- the quality of plot upkeep (weeding, mulching, fire prevention)
- tree care (fertilization, pruning, control of disease and predators).

These planting density, growth and number of diseased trees results are also recorded on a map.
All the project plots are measured, hence also those involved in trials.

c. Statistical analysis

Statistical interpretation is carried out on the basis of an analysis of variance with 2 factors (treatment and farm) without replication, so that it is not possible to study treatment-farm interaction. An example of an analysis with Excel® is given in annex 6.

Jump® statistical software, a trial version of which was left at the ROU, enables a more detailed analysis.
The same example is given in annex 7.

2.3 Results and proposals

The results of measurements carried out on the trials can be found in the last report by Edouard de Rostolan (2001).

a. Planting techniques

The trials, which are comparing 20-month-old stumps and 10-month-old polybags, are in fact comparing stumps with polybags aged 7 or 8 months, which are still a little young (nursery in October/November and planting in May/June). Polybags are therefore no better than stumps, either for the flush rate, or for the percentage of living plants, or for growth at 30 months. It is also more difficult to transport them to the field and the soils are sometimes too sandy for the bag to sit well. One solution would be to bag the stumps in the field, for polybag planting at 20 months, but with the risk for the farmer of not being sure to plant them for an entirely different reason (health, unexpected expenses), which involves around 10% of farmers.

A second set of trials is comparing 24-month-old stumps and 12-month-old polybags for an October planting, in the short rainy season, before the main dry season starts. In this case, polybags very clearly show there superiority over stumps. In the latter case, over 50% of the plants have been killed by drought, as opposed to only 13% for the 12-month-old polybags, which is greatly appreciated by the farmers.

An economic calculation needs to be carried out, along with a survey of phase I where 20-month-old stumps and 12-month-old polybags were planted.

For the moment, 20-month-old stumps are preferable for the first planting period. 12-month-old polybags are recommended for late plantings.

b. Fertilization

Little is known about soil characteristics, but an initial estimation suggests that the soils of this region can be assimilated to those in southwestern Côte d'Ivoire, with a satisfactory N and K content, but particularly deficient in phosphorus. We therefore propose setting up the following series of trials:

F5: 3 farms (replicates) in june 2003 with:
. a control without P fertilizer
. a treatment with 600 g of rock phosphate mixed with planting hole soil and filling of the hole to prevent leaching.

The first applications are applied at 14 months, whereas the requirements of the young plants begin right from planting. We therefore propose setting up the following series of trials:

F3: 4 farms in October 2002 with:
. a control with 3 applications of 200 g of 15-15-15 at 14, 26 and 38 months
. a treatment with 3 applications of 200 g of 15-15-15 at 4, 14 and 26 months

Fertilization recommendations need to be adapted to the soil, but also to the previous plant cover, especially if the soils have been exhausted by intensive cassava crops. We therefore propose setting up the following series of trials after cassava:

F4: 4 farms in august 2002 with:
. an absolute control without fertilizers, with an application as soon as growth is retarded
. control with 3 applications of 200 g of 15-15-15 at 4, 14 and 26 months
. a treatment with 3 applications of 500 g of 15-15-15 at 4, 14 and 26 months

Growth observations could be completed with:
. observation of the soil profile using an auger, down to a depth of 1 metre.
. chemical analyses.

c. Intercrops

The intercropping trials set up with plantain banana, pineapple and maize, followed by vegetables, have not given the expected results, due to a lack of motivation on the part of the farmers selected. The rainy season was particularly wet and upkeep was neglected. The feasibility of intercropping with annual crops or multiannual crops is now well known and no longer calls for this type of trials.

However, better knowledge of the intercropping systems practised, and their profitability, is required and will form part of the planned socio-economic survey.

Likewise, in order to quantify the effect of such intercropping systems on rubber tree performance, after the event, an agronomy database initially containing all the plots involved in a trial (60 trials 120 plots, 40 farmers) will be compiled and interpreted (annex 8). It will then be extended to all the ROU farmers. In fact, although intercrops are generally seen to be beneficial, if they are badly managed they can compete with rubber, like maize at Asuogya, or oil palm and coconut at Essamang (see photos).

Lastly, a trial is to be set up in 2003, on Selormey's farm at Morrisson Junction to test permanent perennial intercrops, primarily fruit trees chosen with the farmer: citrus, cashew, avocado, etc. Coconut could also be tested in this region. The design adopted is a double row with one 18 m interrow, (3x2) x 18m, i.e. a rubber density identical to that in the project: 476 trees/ha. The aim is to ensure income for the farmer between 4 and 7 years, whilst maintaining the same productivity per hectare for rubber and reducing the cost of upkeep in the planting row (which closes up more quickly) and interrow, which can thus be cultivated with annual crops, from planting to 3 years.

Articles and off-prints on intercropping systems in Côte d'Ivoire, Gabon and Indonesia were left at the ROU. Given the flood of applicants, it is justified not to allow intercropping with cassava. Trials could be carried out jointly with the coconut smallholder project.

d. Tapping systems

The current system is ½S d/3 6d/7 11m/12, halted in March/April, with opening at 1.3 m and panel management based on a panel switching system described in annex 9. We recommend opening at 1.2 m, which makes it possible to tap the bottom panel for 10 years, and ensures suffiicient bark for more productive upward tapping. We also recommend only switching panels once production begins to decline.

Four trials are under way (TA0) comparing opening at 1.1 m compared to standard opening at 1.3 m, in 1995 plantings. These trials are to be continued. The trees are not yet stimulated for the time being. We therefore propose setting up the following trial on GT1 tapped in d/3:

TA1: 3 farms (replicates) in 2003 with:
. a control without stimulation
. trees stimulated 1/y in August in year 1 then 3/y in January, August and October in years 2 and 3.
. trees stimulated 3/y in July, September and November in year 1 then 5/y in January, May, July, September and November in years 2 and 3.

All stimulations will be carried out on the panel with 0.7 g/tree at 2.5% a..i..

e. Density and designs

The planting density is 476 trees/ha with a 6 x 3.5 m design. For smallholdings favouring productivity per unit area, it is preferable to plant at 555 trees/ha with a 6 x 3m design. This also leads to faster closure of the row, facilitating upkeep.

The rows are currently aligned North-South, irrespective of slope. It is preferable to align perpendicular to the slope, to prevent erosion and facilitate movements during tapping and collection. On flat land, an East-West alignment provides more light for intercrops.

f. Clones

"The plants are budded with clones recommended by CIRAD according to the ecological conditions of Ghana. At present, the recommendations are GT 1, IRCA 18 and PB 217 " (page 39, para 2143 of the 1998 appraisal report). The clones recommended for Côte d'Ivoire in 2000-2001 for smallholdings are in fact: GT 1, IRCA 18, IRCA 41, IRCA 331, PB 217, PB 254, RRIC 100. It is therefore important to diversify plantings with these clones. The characteristics and performance of the following clones in Côte d'Ivoire have been sent to the ROU : GT 1, PB 217, PB 235, PB 254, PB 260, IRCA 18, IRCA 41, RRIM 600, RRIC 100, PR 107.

However, an interaction is seen between the performance of a clone and its environment. For example, PB 217 displays poorer growth than GT 1 if upkeep is not satisfactory. By setting up clonal plantings on smallholdings, it will be possible to more effectively assess the performance of these clones under Ghanaian conditions, and make appropriate recommendations.

We propose setting up 10 trials with 2 or 3 clones from the following: GT 1, PB 217, IRCA 18, RRIC 100, PB 254, IRCA 41. All these clones are in the GREL budwood garden and were certified true-to-type in 1997 (A. Leconte). Priority should be given to the first 4 clones.

It would be worthwhile recording the production of clones in the 1993 GREL planting (6 rows of 4 clones), and adapting stimulation accordingly.

g. Disease control

Termites are the main problem and can cause up to 50% mortality in a planting. Wounds on stumps are the main access and pruning of the stump root seems too severe (photo). Plants in dry sandy zones seem to be attacked more. Such attacks are also encouraged by dead wood left from manual clearance, and the bamboo support rod should be removed once the stump is planted. Farmers use naphthalene or extract from neem tree bark. Fipronil-based products are also effective: Regent 50SC (50g/l) at 0.2% - 1 litre/stump or Regent 5GR (5g/kg) at 15g/stump on planting. Names of commercial brands have been passed on to GREL.

Young plants are also quite often damaged by rodents and dears.

Fomes is still rare. Table 4 shows that its incidence on the oldest phase I plantings is only 1% at 8 years.. A simple technical note and information for farmers need to be developed. In fact, without recommendations, some farmers such as Armoo John at Essamang take the wrong initiatives by cutting the lateral roots of infected rubber trees.

Loranthus has been seen in the 1999 plantings and it is extremely urgent to proceed with a survey and eradication.

h. Upkeep

If there are no intercrops, *Pueraria* is recommended. The opinions of farmers are divided on its use, which is often controversial: it requires more frequent upkeep than *Eupatorium*. When poorly controlled, it climbs the rubber trees, damages young plants, attracts snakes and labourers do not like removing creepers.

Farmers are rather in favour of planting this cover crop from 3 years onwards, when it becomes less aggressive for rubber trees, in the absence of intercrops, or after the last intercrop cycle. Indeed, from that age onwards, umbrella trees or Eupatorium compete much more with rubber trees than *Pueraria*.

As for intercrops, interpretation of the database will make it possible to quantify the effect of the vegetation on rubber tree performance.

i. Database.

The statistical analyses do not reveal any treatment effect on rubber tree growth. However, in all cases the farms making up the replicates have a very significant effect. Multivariate analyses are therefore necessary. Plot data will be recorded in a database grouping the main agronomic characteristics for growth and production in relation to environmental characteristics and crop management sequences. This database could be used for:

- collecting, standardizing and grouping field records
- carrying out multivariate analyses (PCA, FCA…)
- possibly spatializing data (GIS)

2.4 Other aspects

a. Training

It would be useful to arrange training for the executives of the project's applied research component in data processing using spreadsheets and databases.
Likewise, a visit to an experimental station, such as HEVEGO in Côte d'Ivoire, would be most instructive for these executives.

b. Missions

The next priority mission for 2002 is a plant pathology mission (Tran Van Canh)
For 2003, an Agronomy mission, a Technology mission (Jérôme Sainte-Beuve) and a Socio-economics mission (Bénédicte Chambon) for an overview of the surveys and of the project can be planned.
For 2004, a final mission will take place for a general overview of the research component (Jean-Marie Eschbach)

Conclusion

Despite the halt in CIRAD technical support in 2000, 2001 and the beginning of 2002, the activities of the ROU applied research component have proceeded satisfactorily and have given results, particularly with regard to planting techniques. The trials are being properly conducted. It is now important to reconsider data gathering, recording and processing, given the large number of trials to be set up. In fact, the field visits and observations made it possible to modify and complete the topics to be studied: fertilization and intercrops, but also tapping systems and clonal performance plots.

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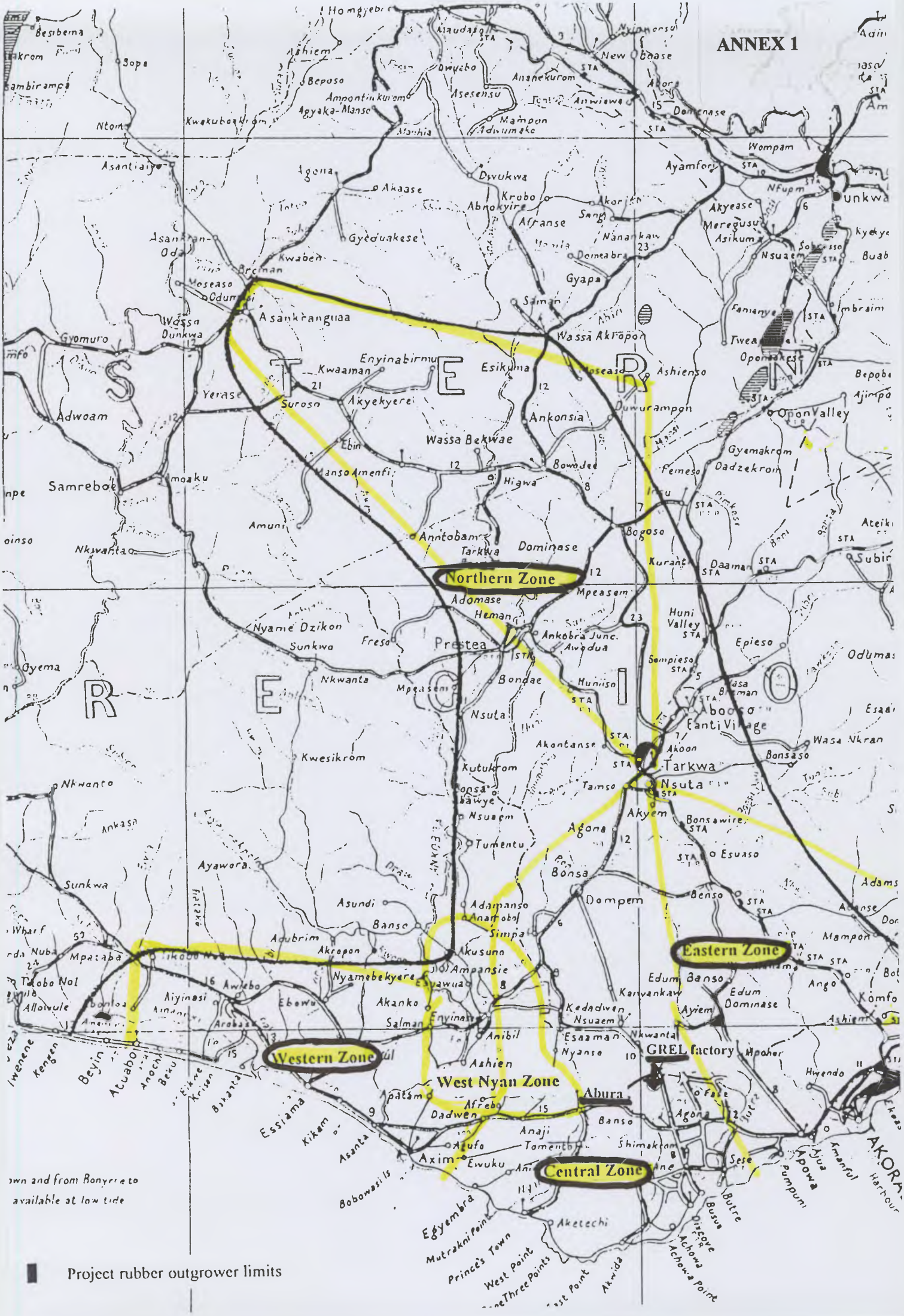
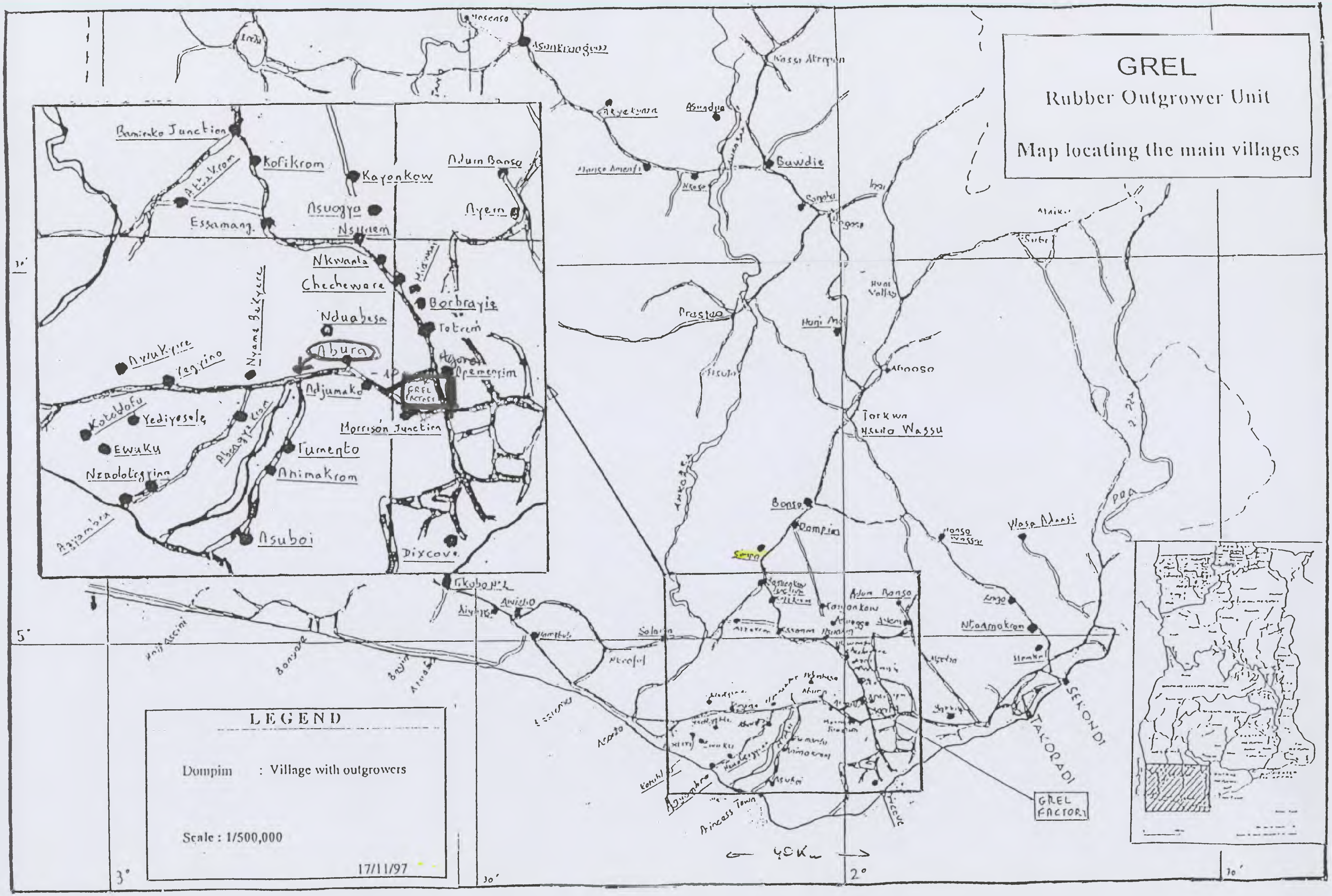
ANNEX 1

Maps

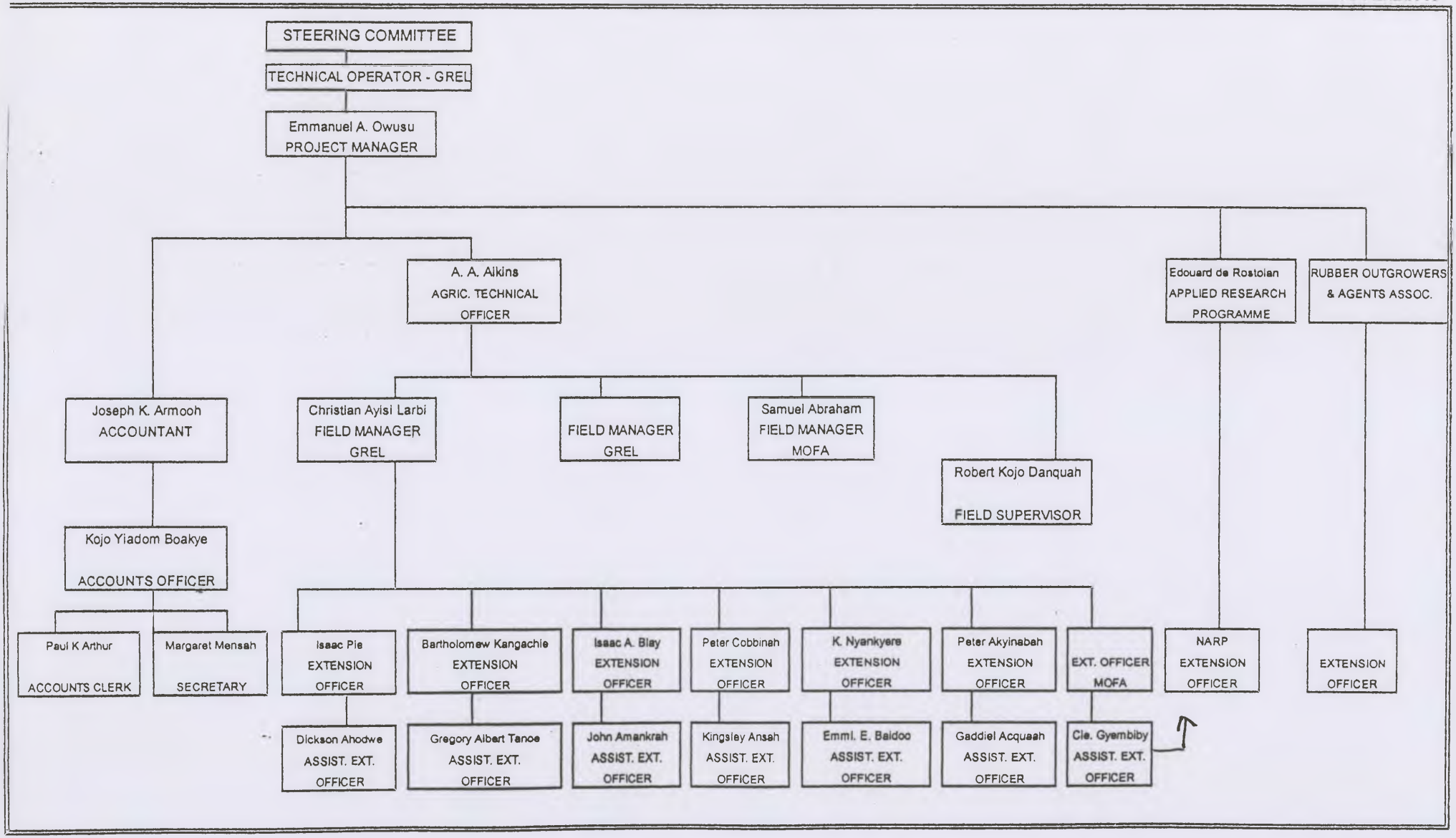

ANNEX 1
Northern Zone
Eastern Zone
Western Zone
West Nyan Zone
Central Zone
GREL factory
Project rubber outgrower limits



GREL
Rubber Outgrower Unit
Map locating the main villages
LEGEND
Dompim : Village with outgrowers
Scale : 1/500,000
17/11/97
SEKONDI
TAKORADI
GREL FACTORY
Princess Town
Dixcove
Abura
Adjumako
Morrison Junction
Nkwanta
Chechewere
Borbrayie
Totrem
Nduabesa
Nyame Bekyere
Awukyire
Tegyino
Kotokofu
Yediyesele
Ewuku
Nzadoletgyina
Asuboi
Animakrom
Tumento
Essamang
Kofikrom
Kayonkow
Asuogya
Nsuiem
Adum Banso
Ayem
Bamianko Junction
Akyekyere
Asuogya
Bawdie
Prestea
Huni Valley
Tarkwa
Nsuta Wassu
Bonsa
Dompim
Wasa Akropong
Ntoamokrom
Agona
Asankragwa
Kassi Atropon
Abooso
5°
3°
2°
30´
1°

ANNEX 2
ROU organisational flowchart

ORGANIZATION CHART



ANNEX 2

ANNEX 3

List of ROU trials

Liste des essais ROU

ANNEX 3

Location	Planting	Experiment	Ref	Farmer
Essamang	mai-98	Fertilizer	F01	Armoo John
Essamang	mai-98	Fertilizer	F02	Ackah Francis
Ewoku	mai-98	Fertilizer	F03	Armoo Ishaq
Ewoku	mai-98	Fertilizer	F04	Annan Abdulai
Ewoku	mai-98	Fertilizer	F05	Dentu Koffi
Ewoku	mai-98	Fertilizer	F06	Assana Ibrahim
Agona	mai-98	Fertilizer	F07	Ogoe Isaac
Agona	mai-98	Fertilizer	F08	Baakoh Charles
Ewoku	mai-99	Fertilizer	F11	Annan Abdulai
Ewoku	mai-99	Fertilizer	F12	Dentu Koffi
Ewoku	mai-99	Fertilizer	F13	Armoo Ishaq
Yediyesele	mai-99	Fertilizer	F14	Cobbinah Alhassa
Yediyesele	mai-99	Fertilizer	F15	Nkrumah George
Morrison Junction	mai-99	Fertilizer	F16	Baidoo Albert
Morrison Junction	mai-99	Fertilizer	F17	Selormey C.K.
Morrison Junction	mai-99	Fertilizer	F18	Appaffram E.K.
Ewoku	juin-00	Fertilizer	F21	Korneh Ibrahim
Ewoku	juin-00	Fertilizer	F22	Annan Abdulai
Yediyesele	juin-00	Fertilizer	F23	Nana Kwame Ess
Yediyesele	juin-00	Fertilizer	F24	Ababie Haruna
Kayankok Road	juin-00	Fertilizer	F25	Nkrumah Helena
Asuogya	juin-00	Fertilizer	F26	Ahorsowu Kobina
Animakrom	juin-00	Intercropping	I01	Appiah Benjamin
Simpa Dadwen	juin-00	Intercropping	I02	Cobbinah Isaac
Animakrom	juin-00	Intercropping	I11	Appiah Paul
Simpa Dadwen	juin-00	Intercropping	I12	Cobbinah Emmar
Ewoku	mai-01	Intercropping	I21	Ibrahim Hannetr
Ewoku	mai-01	Intercropping	I22	Ibrahim Lubiana
Ewoku	mai-01	Intercropping	I23	Ibrahim Mariana
Yediyesele	mai-01	Intercropping	I24	Yacoub Nuhu
Yediyesele	mai-01	Intercropping	I25	Cobbinah Alhassa
Yediyesele	mai-01	Intercropping	I26	Yacoub Ibrahim
Morrison Junction	mai-99	Planting	TP01	Archer Kwesi
Asuogya	mai-99	Planting	TP02	Nchonah John
Ewoku	juin-99	Planting	TP03	Zakariah Adamu
Ewoku	juin-99	Planting	TP04	Zakariah Shaibu
Nsuaem	oct-99	Planting	TP11	Borden Emmanue
Nsuaem		Tapping	TA01	Borden Stephen
Simpa		Tapping	TA02	Nana Agyefi Kwa

ANNEX 4

Trial data recording

ANNEX 4

Zone	Location	Planting	Ref	Farmer	Soil	Treatment	C18	C24	C30	C36	C42
Central	Morrison Junction	mai-99	TP01	Archer Kwesi	G	Stump 20 month	8,0		16,2		
Central	Morrison Junction	mai-99	TP01	Archer Kwesi	G	Polybag 10 month	8,1		15,6		
Central	Asuogya	mai-99	TP02	Nchonah John	SL	Stump 20 month	6,4		10,5		
Central	Asuogya	mai-99	TP02	Nchonah John	SL	Polybag 10 month	5,5		10,5		
Western	Ewoku	juin-99	TP03	Zakariah Adamu	SL	Stump 20 month	6,7		11,7		
Western	Ewoku	juin-99	TP03	Zakariah Adamu	SL	Polybag 10 month	6,6		10,1		
Western	Ewoku	juin-99	TP04	Zakariah Shaibu	SL	Stump 20 month					
Western	Ewoku	juin-99	TP04	Zakariah Shaibu	SL	Polybag 10 month	7,5		15,0		
Central	Nsuaem	oct-99	TP11	Borden Emmanuel	G	Stump 24 month	6,3	9,0			
Central	Nsuaem	oct-99	TP11	Borden Emmanuel	G	Polybag 12 month	5,4	7,5			
Central	Essamang	mai-98	F01	Armoo John	G	200/200/200 g/an		9,0	14,3		23,4
Central	Essamang	mai-98	F01	Armoo John	G	100/200/300 g/an		6,9	10,6		17,3
Central	Essamang	mai-98	F02	Ackah Francis	G	200/200/200 g/an		8,9	13,6		21,9
Central	Essamang	mai-98	F02	Ackah Francis	G	100/200/300 g/an		8,8	14,4		23,5
Western	Ewoku	mai-98	F03	Armoo Ishaq	G	200/200/200 g/an		9,0	13,3		18,7
Western	Ewoku	mai-98	F03	Armoo Ishaq	G	100/200/300 g/an		8,8	14,5		20,3
Western	Ewoku	mai-98	F04	Annan Abdulai	SL	200/200/200 g/an		12,2	17,0		27,6
Western	Ewoku	mai-98	F04	Annan Abdulai	SL	100/200/300 g/an		12,5	17,0		27,8
Western	Ewoku	mai-98	F05	Dentu Koffi	SL	200/200/200 g/an		12,2	18,4		29,2
Western	Ewoku	mai-98	F05	Dentu Koffi	SL	100/200/300 g/an		12,3	16,5		27,2
Western	Ewoku	mai-98	F06	Assana Ibrahim	G	200/200/200 g/an		9,3	13,3		17,1
Western	Ewoku	mai-98	F06	Assana Ibrahim	G	100/200/300 g/an		10,2	13,5		17,4
Central	Agona	mai-98	F07	Ogoe Isaac	SL	200/200/200 g/an		9,3	12,6		22,1
Central	Agona	mai-98	F07	Ogoe Isaac	SL	100/200/300 g/an		9,2	13,2		22,7
Central	Agona	mai-98	F08	Baakoh Charles	SL	200/200/200 g/an		9,1	11,2		16,7
Central	Agona	mai-98	F08	Baakoh Charles	SL	100/200/300 g/an		8,3	11,1		17,6
Western	Ewoku	mai-99	F11	Annan Abdulai	SL	200 g/an	6,7		11,9		
Western	Ewoku	mai-99	F11	Annan Abdulai	SL	100+100 g/an	7,6		14,7		
Western	Ewoku	mai-99	F12	Dentu Koffi	SL	200 g/an	6,9		13,1		
Western	Ewoku	mai-99	F12	Dentu Koffi	SL	100+100 g/an	6,0		11,6		
Western	Ewoku	mai-99	F13	Armoo Ishaq	G	200 g/an	6,8		12,4		
Western	Ewoku	mai-99	F13	Armoo Ishaq	G	100+100 g/an	7,7		13,6		
Western	Yediyesele	mai-99	F14	Cobbinah Alhassan	SL	200 g/an	12,1		19,8		
Western	Yediyesele	mai-99	F14	Cobbinah Alhassan	SL	100+100 g/an	12,6		19,8		
Western	Yediyesele	mai-99	F15	Nkrumah George	SL	200 g/an	7,8		12,2		
Western	Yediyesele	mai-99	F15	Nkrumah George	SL	100+100 g/an	10,6		17,1		
Central	Morrison Junction	mai-99	F16	Baidoo Albert	G	200 g/an	4,6		7,2		
Central	Morrison Junction	mai-99	F16	Baidoo Albert	G	100+100 g/an	5,2		9,2		
Central	Morrison Junction	mai-99	F17	Selormey C.K.	G	200 g/an	5,8		11,5		
Central	Morrison Junction	mai-99	F17	Selormey C.K.	G	100+100 g/an	6,4		11,6		
Central	Morrison Junction	mai-99	F18	Appaffram E.K.	G	200 g/an	7,4		13,3		
Central	Morrison Junction	mai-99	F18	Appaffram E.K.	G	100+100 g/an	5,8		11,3		
Western	Ewoku	juin-00	F21	Korneh Ibrahim	GS	Control	5,2				
Western	Ewoku	juin-00	F21	Korneh Ibrahim	GS	200 g RP	5,4				
Western	Ewoku	juin-00	F22	Annan Abdulai	SL	Control	6,4				
Western	Ewoku	juin-00	F22	Annan Abdulai	SL	200 g RP	5,4				
Western	Yediyesele	juin-00	F23	Nana Kwame Essua	SL	Control	11,0				
Western	Yediyesele	juin-00	F23	Nana Kwame Essua	SL	200 g RP	10,1				
Western	Yediyesele	juin-00	F24	Ababie Haruna	SL	Control	6,7				
Western	Yediyesele	juin-00	F24	Ababie Haruna	SL	200 g RP	7,7				
Central	Kayankok Road	juin-00	F25	Nkrumah Helena	G	Control	6,6				
Central	Kayankok Road	juin-00	F25	Nkrumah Helena	G	200 g RP	7,6				
Central	Asuogya	juin-00	F26	Ahorsowu Kobina	G	Control	6,4				
Central	Asuogya	juin-00	F26	Ahorsowu Kobina	G	200 g RP	6,8				
Central	Animakrom	juin-00	I01	Appiah Benjamin	SL	Pueraria	4,5				
Central	Animakrom	juin-00	I01	Appiah Benjamin	SL	Plantain	5,4				
Central	Simpa Dadwen	juin-00	I02	Cobbinah Isaac	G	Pueraria	*				
Central	Simpa Dadwen	juin-00	I02	Cobbinah Isaac	G	Plantain	*				
Central	Animakrom	juin-00	I11	Appiah Paul	SL	Pueraria	4,5				
Central	Animakrom	juin-00	I11	Appiah Paul	SL	Pineapple	4,5				
Central	Simpa Dadwen	juin-00	I12	Cobbinah Emmanue	G	Pueraria	*				
Central	Simpa Dadwen	juin-00	I12	Cobbinah Emmanue	G	Pineapple	*				

ANNEX 5

Immature plot evaluation format

ANNEX 5

Ghana Rubber Estates Limited
Rubber Outgrowers Unit

N°. 0001111

Date: / /

IMMATURE RUBBER EVALUATION FORM

Farm Number		Farmer's Name	
Zone		Type of Visit	
Year of Plant.		Farmer's Presence	

INTERCROP

INTERCROP	

TREE CONDITION — MEAN MARK

Clone		Tree per Ha.		Growth		Homogenity		

FIELD MAINTENANCE

Weeding		Basin/Mulching		Soil Conservat		Fire Control		

TRRE - UPKEEP

Fertilizer		Pruning		Disease Control		Pest Control		

COMMENTS:

EXTENSION OFFICER

ROU MANAGER

ANNEX 6

Analysis of variance with Excel

ANNEX 6

Moyenne circonf 18 mois	Traitement		
Ref	200 g RP	Contrôle	Moyenne
F21	5,4	5,2	5,3
F22	5,4	6,4	5,9
F23	10,1	11	10,55
F24	7,7	6,7	7,2
F25	7,6	6,6	7,1
F26	6,8	6,4	6,6
Moyenne	7,2	7,1	7,1

Analyse de variance: deux facteurs sans répétition d'expérience

RAPPORT DETAILLE	Nombre d'échantillons	Somme	Moyenne	Variance
Ligne 1	2	10,6	5,3	0,02
Ligne 2	2	11,8	5,9	0,5
Ligne 3	2	21,1	10,55	0,405
Ligne 4	2	14,4	7,2	0,5
Ligne 5	2	14,2	7,1	0,5
Ligne 6	2	13,2	6,6	0,08
Colonne 1	6	43	7,17	3,09
Colonne 2	6	42,3	7,05	4,04

ANALYSE DE VARIANCE						
Source des variations	Somme des carrés	Degré de liberté	Moyenne des carrés	F	Probabilité	Valeur critique pour F
Lignes	33,68416667	5	6,736833333	17,14934238	0,003645143	5,050338814
Colonnes	0,040833333	1	0,040833333	0,103945694	0,760189757	6,607876912
Erreur	1,964166667	5	0,392833333			
Total	35,68916667	11				

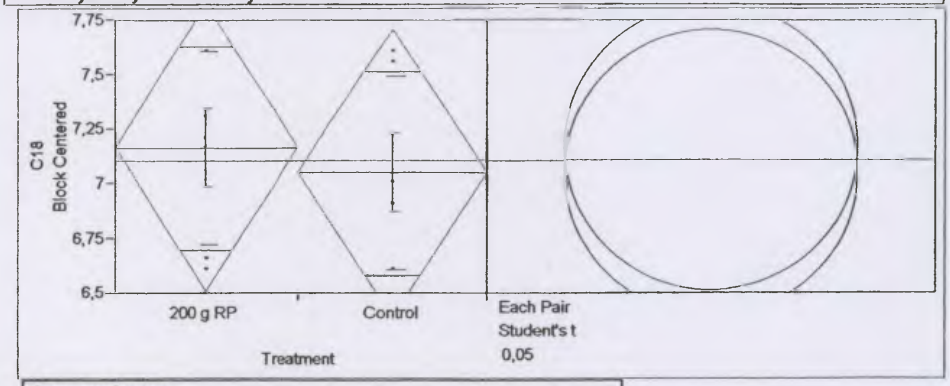
ANNEX 7

Analysis of variance with Jump

ANNEX 7a

Untitled 1- Fit Y by X

Oneway Analysis of C18 By Treatment



Oneway Anova

Summary of Fit

Rsquare	0,944965
Adj Rsquare	0,878922
Root Mean Square Error	0,626764
Mean of Response	7,108333
Observations (or Sum Wgts)	12

t-Test

	Difference	t-Test	DF	Prob > |t|
Estimate	0,1167	0,322	5	0,7602
Std Error	0,3619			
Lower 95%	-0,8135			
Upper 95%	1,0469			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Treatment	1	0,040833	0,04083	0,1039	0,7602
Farm	5	33,684167	6,73683	17,1493	0,0036
Error	5	1,964167	0,39283		
C. Total	11	35,689167			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
200 g RP	6	7,16667	0,25588	6,5089	7,8244
Control	6	7,05000	0,25588	6,3923	7,7077

Std Error uses a pooled estimate of error variance

Block Means

Farm	Mean	Number
F21	5,3000	2
F22	5,9000	2
F23	10,5500	2
F24	7,2000	2
F25	7,1000	2
F26	6,6000	2

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
200 g RP	6	7,16667	0,443189	0,18093	6,7016	7,6318
Control	6	7,05000	0,443189	0,18093	6,5849	7,5151

Means Comparisons

Dif=Mean[i]-Mean[j]

	200 g RP	Control
200 g RP	0,00000	0,11667
Control	-0,11667	0,00000

Alpha= 0,05

Comparisons for each pair using Student's t

t

2,57058

Abs(Dif)-LSD

	200 g RP	Control
200 g RP	-0,93020	-0,81353
Control	-0,81353	-0,93020

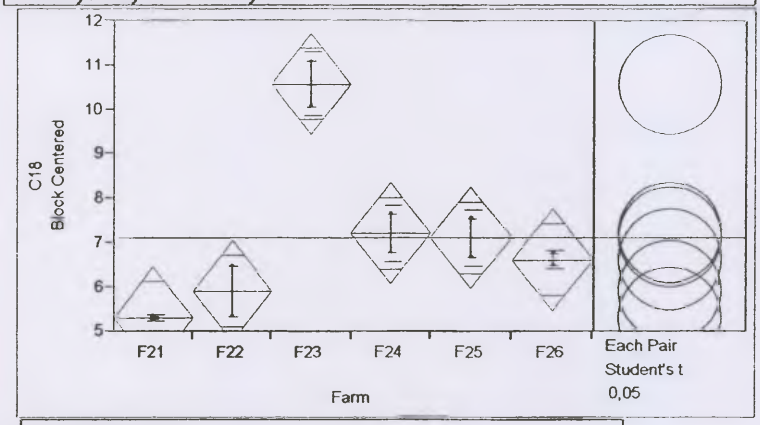
Positive values show pairs of means that are significantly different.

Untitled 1

Rows	Treatment	Farm	C18
1	200 g RP	F21	5,4
2	200 g RP	F22	5,4
3	200 g RP	F23	10,1
4	200 g RP	F24	7,7
5	200 g RP	F25	7,6
6	200 g RP	F26	6,8
7	Control	F21	5,2
8	Control	F22	6,4
9	Control	F23	11
10	Control	F24	6,7
11	Control	F25	6,6
12	Control	F26	6,4

ANNEX 7b

Oneway Analysis of C18 By Farm



Oneway Anova

Summary of Fit

Rsquare	0,944965
Adj Rsquare	0,878922
Root Mean Square Error	0,626764
Mean of Response	7,108333
Observations (or Sum Wgts)	12

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Farm	5	33,684167	6,73683	17,1493	0,0036
Treatment	1	0,040833	0,04083	0,1039	0,7602
Error	5	1,964167	0,39283		
C. Total	11	35,689167			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
F21	2	5,3000	0,44319	4,1607	6,439
F22	2	5,9000	0,44319	4,7607	7,039
F23	2	10,5500	0,44319	9,4107	11,689
F24	2	7,2000	0,44319	6,0607	8,339
F25	2	7,1000	0,44319	5,9607	8,239
F26	2	6,6000	0,44319	5,4607	7,739

Std Error uses a pooled estimate of error variance

Block Means

Treatment	Mean	Number
200 g RP	7,16667	6
Control	7,05000	6

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
F21	2	5,3000	0,058926	0,04167	4,771	5,829
F22	2	5,9000	0,789603	0,55833	-1,194	12,994
F23	2	10,5500	0,718892	0,50833	4,091	17,009
F24	2	7,2000	0,624611	0,44167	1,588	12,812
F25	2	7,1000	0,624611	0,44167	1,488	12,712
F26	2	6,6000	0,200347	0,14167	4,800	8,400

Means Comparisons

Dif=Mean[i]-Mean[j]

	F23	F24	F25	F26	F22	F21
F23	0,0000	3,3500	3,4500	3,9500	4,6500	5,2500
F24	-3,3500	0,0000	0,1000	0,6000	1,3000	1,9000
F25	-3,4500	-0,1000	0,0000	0,5000	1,2000	1,8000
F26	-3,9500	-0,6000	-0,5000	0,0000	0,7000	1,3000
F22	-4,6500	-1,3000	-1,2000	-0,7000	0,0000	0,6000
F21	-5,2500	-1,9000	-1,8000	-1,3000	-0,6000	0,0000

Alpha= 0,05

Comparisons for each pair using Student's t

t

2,57058

Abs(Dif)-LSD

	F23	F24	F25	F26	F22	F21
F23	-1,6111	1,7389	1,8389	2,3389	3,0389	3,6389
F24	1,7389	-1,6111	-1,5111	-1,0111	-0,3111	0,2889
F25	1,8389	-1,5111	-1,6111	-1,1111	-0,4111	0,1889
F26	2,3389	-1,0111	-1,1111	-1,6111	-0,9111	-0,3111
F22	3,0389	-0,3111	-0,4111	-0,9111	-1,6111	-1,0111
F21	3,6389	0,2889	0,1889	-0,3111	-1,0111	-1,6111

Positive values show pairs of means that are significantly different.

Untitled 1

Rows	Treatment	Farm	C18
1	200 g RP	F21	5,4
2	200 g RP	F22	5,4
3	200 g RP	F23	10,1
4	200 g RP	F24	7,7
5	200 g RP	F25	7,6
6	200 g RP	F26	6,8
7	Control	F21	5,2
8	Control	F22	6,4
9	Control	F23	11
10	Control	F24	6,7
11	Control	F25	6,6
12	Control	F26	6,4

ANNEX 7c

JUMP

Once the table is drawn up, the operations are as follows:
Analyze, Fit Y by X,
Y response: measured value
X factor: treatment or farm
Block: farm or treatment
OK
One way analysis, Anova, Means, Compare means, Each pair

ANNEX 8

Agronomy database

ANNEX 8

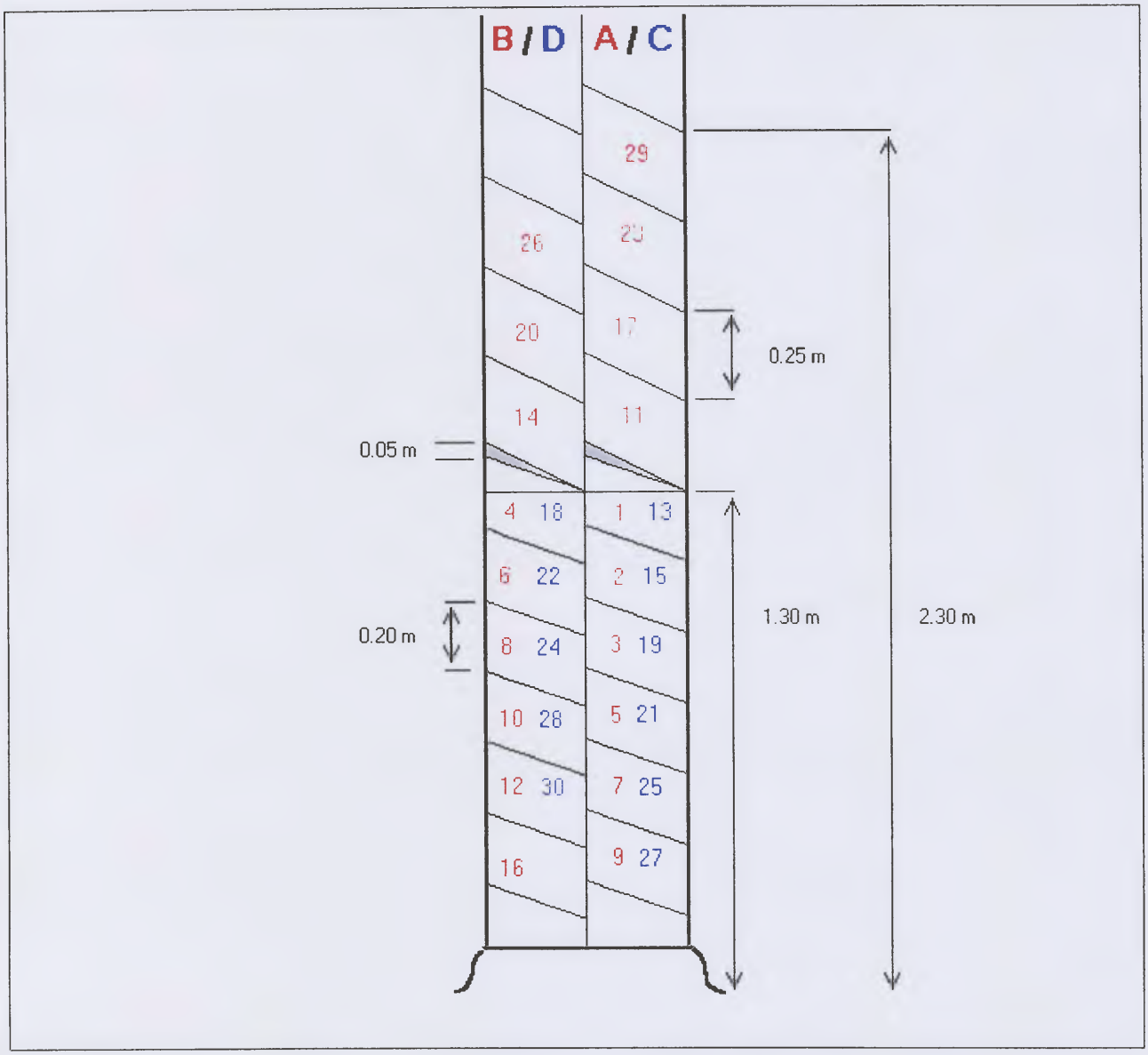
ONE	*Zone*	C	W	E	N	WN
CTOFFICER	*Rou Extention Officer for the farm*					
LLAGE	*Name of village*					
RIAL	*Type of trial*	TP0	TP1	F0	I	TA
BRTRIAL	*Trial Number*	TP01	TP02			
REATMENT	*Name of treatment*	S20 Stump 20 mo	Polybag 10 month			
LOT	*Name of plot*	C	T1	T2		
ARMNB	*Farm number except zone and year of planting*					
OTIVATION	*Motivation*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
CPERIENCE	*Experience of the farmer*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
NVIRONMENT	*Main environment*	1 Dense forest	2 Secondary forest	3 Perennial crop	4 Old rubber	5 young rubber
REA	*Area of plot (ha)*	=C15/476		6 Annual crop	7 Cassava	8 Open land/Fallow
ENSITY	*Density (tree/ha)*	1 476a/ha	2			
REE	*Number of rubber tree planted*					
LONE	*Clone*	1 GT 1	2 PB 217	3		
EAR	*Year of planting*	1998	1999	2000	2001	2002
ONTH	*Month of planting*	5	6	7	9	10
LANTMAT	*Planting material*	1 Polybag 10m	2 Polybag 12m	3 Stump 20m	4 Stump 24m	3 Other
REVIOUS	*Previous vegetation*	1 Dense forest	2 Secondary forest	3 Perennial crop	4 Old rubber	5 young rubber
OIL	*Type of soil*			6 Annual crop	7 Cassava	8 Open land/Fallow
OILTEXTURE	*Texture of soil*	1 Gravely	2 Sandy Loam			
PROOTING	*Quality of uprooting*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
URNING	*Quality of burning*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
OLING	*Quality of holing*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
EGROW1	*Vegetation on rubber row year 1*	1 Regrowth	2 Intercrop	3 Eupatorium	4 Pueraria	5 Others
EGROW2	*Vegetation on rubber row year 2*					
EGROW3	*Vegetation on rubber row year 3*					
EGROW4	*Vegetation on rubber row year 4*					
AINTROW1	*Maintenance of the rows year 1*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
AINTROW2	*Maintenance of the rows year 2*					
AINTROW3	*Maintenance of the rows year 3*					
AINTROW4	*Maintenance of the rows year 4*					
OEINGROW1	*Number of weeding hoeing Year 1*					
OEINGROW2	*Number of weeding hoeing Year 2*					
OEINGROW3	*Number of weeding hoeing Year 3*					
OEINGROW4	*Number of weeding hoeing Year 4*					
INECLEANING1	*Number of line cleaning Year 1*					
INECLEANING2	*Number of line cleaning Year 2*					
INECLEANING3	*Number of line cleaning Year 3*					
INECLEANING4	*Number of line cleaning Year 4*					
EGINTER1	*Main vegetation on interrow year 1*	1 Regrowth	2 Intercrop	3 Eupatorium	4 Pueraria	5 Others
EGINTER2	*Main vegetation on interrow year 2*					
EGINTER3	*Main vegetation on interrow year 3*					
EGINTER4	*Main vegetation on interrow year 4*					
AINTINTER1	*Maintenance of the interrow year 1*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
AINTINTER2	*Maintenance of the interrow year 2*					
AINTINTER3	*Maintenance of the interrow year 3*					
AINTINTER4	*Maintenance of the interrow year 4*					
IGHINTER1	*Vegetation average High (m) year 1*	1 0 to 1 meter	2 1 to 2 meter	3 More than 2 meter		
IGHINTER2	*Vegetation average High (m) year 2*					
IGHINTER3	*Vegetation average High (m) year 3*					
IGHINTER4	*Vegetation average High (m) year 4*					
LASHINTER1	*Number of slashing year 1*					
LASHINTER2	*Number of slashing year 2*					
LASHINTER3	*Number of slashing year 3*					
LASHINTER4	*Number of slashing year 4*					
RUNING1	*Quality of the pruning year 1*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
RUNING2	*Quality of the pruning year 2*					
RUNING3	*Quality of the pruning year 3*					
RUNING4	*Quality of the pruning year 4*					
AGREPLAC1	*Number of replacement bags Year 1*					
AGREPLAC2	*Number of replacement bags Year 2*					
ONTING1	*Number of contingency stumps Year 1*					
ONTING2	*Number of contingency stumps Year 2*					
EPLACEMENT1	*Total number of replacements done year 1*	=C50+C52				
EPLACEMENT2	*Total number of replacements done year 2*	=C51+C53				
ASING	*Presence of basin*	1 Yes	2 No			
HOOTEDTREE6	*Number of shooted trees 6 month*					
HOOTEDTREE12	*Number of shooted trees 12 month*					
HOOTEDTREE18	*Number of shooted trees 18 month*					
IVING30	*Number of living trees 30 month*					
IVING42	*Number of living trees 42 month*					
AMAGE1	*Main damage Year 1*	1 No damage	2 Cows	3 Fire	4 Termite	5 Antelope/Grass cutte
ECDAMAGE1	*Secondary damage year 1*			6 Other	7 Lorenthus	8 Wind
ITDAMAGE1	*Intensity of main damage year 1*	1 Low	2 Medium	3 High		
AMAGE2	*Main damage Year 2*					
ECDAMAGE2	*Secondary damage year 2*	1 No damage	2 Cows	3 Fire	4 Termite	5 Antelope/Grass cutte
ITDAMAGE2	*Intensity of main damage year 2*			6 Other	7 Lorenthus	8 Wind

)MESDEAD3	*Number of trees dead by fomes year 3*					
)MESINFECTED3	*Number of trees infected by fomes year 3*					
)MESCONTAM3	*Number of trees contaminated by fomes year 3*					
:RTILIZER4	*Quantity of 15-15-15 4 month g/tree*	100	200	300		
:RTILIZER14	*Quantity of 15-15-15 14 month g/tree*	100	200	300		
:RTILIZER26	*Quantity of 15-15-15 26 month g/tree*					
:RTILIZER38	*Quantity of 15-15-15 38 month g/tree*					
TERCROP11	*First cycle of intercrop year 1*	1 Yam	2 Tomato	3 Vegetable	4 Peanut	5 Maize
TERCROP12	*Second cycle of intercrop year 1*	6 Rice	7 Cassava	8 Sweet potato	9 Pepper	10 Pineapple
TERCROP1	*Intercrop year 1*	11Banana	12	13	14	15 Other
REAINTER1	*% of area intercroped year 1 (cycle 1+2)*	0 No intercropping				
TERCROP21	*First cycle of intercrop year 2*					
TERCROP22	*Second cycle of intercrop year 2*					
TERCROP2	*Intercrop year 2*					
REAINTER2	*% of area intercroped year 2*					
TERCROP31	*First cycle of intercrop year 3*					
TERCROP32	*Second cycle of intercrop year 3*					
TERCROP3	*Intercrop year 3*					
REAINTER3	*% of area intercroped year 3*					
REECOND1	*Tree condition year 1*	0 Poor	1 Below average	2 Average	3 Good	4 Very good
REECOND2	*Tree condition year 2*					
REECOND3	*Tree condition year 3*					
REECOND4	*Tree condition year 4*					
18	*Girth of rubber at 18 months*					
30	*Girth of rubber at 30 months*					
42	*Girth of rubber at 42 months*					
54	*Girth of rubber at 54 months*					
66	*Girth of rubber at 66 months*					
em	*Limiting factor or other*					

ANNEX 9

Tapping panels management

PROPOSED PANEL CARD FOR RUBBER OUTGROWER PLANTATIONS PROJECT



ANNEX 10

Photos

ANNEX 10

carence minerale visuelle

concurrence cocotier-hevea

degat de biche

eupatorium

eradication du loranthus

concurrence du maïs

concurrence palmier-hévéa

parasolier

orientation N-S

pueraria non maitrisé

degat du pueraria sur jeune hévéa

Essai de saignée TA01

legume en intercalaire