CSIR-FORESTRY RESEARCH
INSTITUTE OF GHANA

ANNUAL REPORT 2005

CSIR-FORIG

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INTRODUCTION

The 2005 Annual Report has been compiled based on the research and commercialisation activities undertaken by the Institute in the course of the year. The research activities included Ghana Government Funded Projects as well as Donor/Externally Funded Projects. The report is basically made up of three parts.

Part one provides a summary of research activities as well as the results achieved under three major research programmes of the Institute namely; Plantation Development, Processing and Utilisation and Non-Timber Forest Products. In addition, externally funded projects undertaken during the year have also been reported on. The concluding part is devoted to the commercialisation activities of the Institute.

The second part of the report provides information on administrative issues such as staff strength, new appointments, contract appointment, staff promotions, retirements, national service personnel recruitments, official visits, etc and financial matters including a summary of the financial statements of the year.

The concluding part is devoted to appendices that provide information on Senior Members and Senior Staff on divisional bases and list of publications including Journal Articles, Conference Papers, Technical Reports, Theses, Manuals and Guides produced by the Institute's scientists for the year under review. It also provides a list of Internal Seminars held during the year as well as list of Management Board Members.

PART 1: RESEARCH PROGRAMMES

1.0 PLANTATION DEVELOPMENT PROGRAMME

Main Project under the Programme

The main project under the Programme was 'Development of Technologies for Establishment and Management of Plantations of *Ceiba pentandra, Terminalia superba*, and *Nauclea diderichii*'.

Major Achievements

- Best seed source of *Ceiba pentandra, Terminalia superba,* and *Nauclea diderichii* identified.
- Prelimnary study identified Kocide, a fungicide as effective for control of dieback in seedlings.

1.1 DEVELOPMENT OF TECHNOLOGIES FOR ESTABLISHMENT AND MANAGEMENT OF PLANTATIONS OF *CEIBA PENTANDRA, TERMINALIA SUPERBA*, AND *NAUCLEA DIDERICHII*

Introduction

There is a predicted deficit in both wood and fuel-wood supply for Ghana by the turn of the present century. This is because the natural forest, which is the traditional sources of supply, can no longer meet the astronomical increase in demand for these items (Lowe 1984; Iyamabo 1990). Despite all these, timber export continues to play a leading role in the country's socio-economic development, being the third most important export commodity after cocoa and minerals.

The target of the National Forestry Development Master Plan 1996-2020, is to establish 200,000 ha of forest plantation of fast growing indigenous and exotic tree species over a period of 20 years (Ministry of Lands and

Forestry 1996). The five indigenous species selected are *Nauclea diderichii* (Kusia), *Terminalia superba* (Ofram), *Terminalia ivorensis* (Emire), *Ceiba pentandra* (Onyina) and *Triplochiton sclerexylon* (Wawa). Three of the selected species, (namely Kusia, Onyina and Emire) however have pest and disease problems that could negatively impact on their plantation establishment.

For successful plantation establishment of these species, adequate knowledge on the quality of seed sources (provenances) and application of appropriate establishment and management technologies would be required. There is presently lack of information on the required initial planting distance, thinning and pruning schedules, the most suitable ecological zone and site preparation requirements for any of the selected species. There is the urgent need to investigate these as well as the nutritional requirements for enhanced growth rates to reduce the long rotational periods. It will also be important to investigate specific influences and impacts of plantations of these species and their management operations on environmental parameters such as soil biogeochemistry, undergrowths, erosion, fire and rate of CO_2 uptake and release by different species. Analyses of the effect of various treatments and environmental factors on the photosynthetic properties of the foliage and the respiratory cost of growth and maintenance would enable models to be developed for predictions.

Objectives

1. To identify the best seed source and optimum planting site (ecological zone) for each species.
2. To develop the most appropriate method for producing sturdy planting materials in the nursery
3. To develop appropriate establishment techniques in terms of site preparation, planting distances and tending/weeding.

4. To evaluate the effects of different proportions of mixed planting on the growth performance of the species.
5. To develop management technologies required for optimum growth and yield of quality wood at each rotation for each species, i.e. thinning regimes, pruning schedules and appropriate rotation age.
6. To determine the costs and benefit of investment in plantation of selected timber species and develop guidelines for integrating in them alternative livelihood activities to provide sustained incomes for local people in target forest communities.

Methodology

Monitoring for fruiting and germplasm collection

For each of the tree species, three ecological zones where they occur naturally were selected as shown in Table 1 for seed collection. Monitoring for flowering and fruiting was undertaken during the second half of year 2005. Trees to be used as potential seed trees were marked.

Table 1. Species and their sampling areas

Species	Dry semi deciduous forest	Moist semi-deciduous forest	Moist/wet evergreen	Transition/ Savannah
Kusia	x	x	x	
Onyina	x	x		x
Emire	x	x	x	

Outcome

Potential seed trees were marked during the monitoring expedition so seeds will be harvested during the first quarter of year 2006. However fruiting of *Nauclea diderichii* has been poor.

2.0 PROCESSING AND UTILIZATION PROGRAMME

Objective

To determine the basic and technological properties of natural and plantation grown species and develop appropriate techniques for the efficient utilization of Ghana's wood resources.

Main Project under the Programme

The main project under the Programme was 'Utilization of Cocowood, Oil Palm wood and Rubber wood as timber resources in Ghana'.

Major Achievements

- A chemical capable of preventing fungal staining and borer infestation in Rubber wood has been identified as the best for prophylactic treatment
- Basic density values of Rubber wood and Cocowood indicate that they can be classified as medium and heavy density woods respectively
- Cocowood could be utilized for a wide range of end-uses, especially for heavy construction work
- Rubberwood could be utilized for furniture and light construction work
- Because of its compact nature, Cocowood would be very difficult to treat and maintain preservative retention
- Lumber recovery rate for the species is high when milled with a horizontal narrow saw band than with a vertical broad band saw.

2.1 UTILIZATION OF COCOWOOD, OIL PALM WOOD AND RUBBER WOOD AS TIMBER RESOURCES IN GHANA

Background

Timber from the natural forest in Ghana is dwindling at a rapid rate, thereby posing a threat to the raw material base of the timber industry. In order to ensure that timber harvesting in Ghana's natural forest is sustainable, the annual allowable cut (AAC) has been set at one million m^3 of round logs. However, the demand for wood is increasing at such an alarming rate that this AAC is insufficient. The current annual extraction of logs by the mills is estimated to be nearly 3.7 million $m^{3.}$ The supply of wood from commercial species has dwindled appreciably and that Ghana is faced with the prospect of a possible timber shortage. The utilization of other lesser-known species need to be looked at urgently as one of the possible solutions to address this unfortunate situation.

The coconut and oil palm trees are potential sources of raw material for housing construction, furniture, particleboard, and bridge timber and fence post. Ghana has considerable amount of these species particularly the coconut trees along the coast from Axim to Aflao. They are also well distributed in Ashanti, Brong- Ahafo and Eastern Regions of the country.

Rubber wood is also widely distributed in the Western Region of Ghana. Unfortunately, after extracting the latex, the rubber wood tree is not utilized. Studies in Malaysia have shown that it can be used as raw material for the timber industry.

Objectives

1. To determine the basic and technological properties of cocowood, oil palm wood and rubber wood;
2. To conduct socio- economic studies on the selected species in Ghana and

3. To develop prototype and other value-added products in accordance to their technological properties from the selected species.

Pretreatment study

A pretreatment study was carried out with rubberwood samples from Kwamo in the Ashanti region. The study was able to identify Xylophene ASI as the best available biocide that could offer protection from fungal and insect attacks to rubberwood samples between felling and drying. Results for antisapstain chemicals screened for the control of sapstain in rubberwood are shown in Table 2

Table 2: Effectiveness of antisapstain chemicals in controlling sapstain in Rubberwood

Antisapstain Chemical	Concentration %	% Effectiveness	
		2 wks exposure	6 wks exposure
Magnate	2	78.5	50.8
Folpan	5	62.3	38.2
Woodgard ES	3	75.5	52.8
Bumper	2	78.5	60.2
Protecta AB	5	58.2	45.3
Antiblue 3737	5	52.8	30.2
Fossilit	5	80.5	33.6
Cryptogil ASI	5	85.2	66.6
Cryptogli DC6	5	66.6	58.3
Xylophene ASI	5	96.3	86.6

Reconnaissance survey, extraction and processing

A reconnaissance study carried out provided species distribution and age class in selected localities in the Western region of Ghana. Extraction of the selected species from forests in the Western region was then carried out. Barked areas and log ends of species were applied with fungicides to retard log staining during extraction. During processing, lumber recovery and

production rates were calculated. Fleshly sawn lumber cut from a selected sawmill and from the wood mizer were then given prophylactic treatment with Xylophene ASI, a chemical that had proved to be effective in the pretreatment study. The lumber were stacked under a shed at FORIG for drying, collecting samples for green moisture content and basic density determinations

Visual examination of biological attack on samples was carried out to certify the effectiveness of Xylophene ASI in controlling biological attack under commercial conditions. The results of trees extracted, lumber recovery and production rates of the species are shown in Tables below.

Table 3: Number of trees and logs used for the test

	Cocowood		**Oil palm wood**		**Rubber wood**
	40 years	70 years	25 years	40 years	30 years
Trees felled	7	3	3	6	6
Logs	26	14	7	16	33

Table 4: Sawing characteristics of rubberwood

Parameter	Wood mizer	Sawmill
Lumber recovery (%)	75.0	41.2
Lumber production rate (m^3/hr)	0.91	3.98

Table 5: Sawing characteristics of coco wood

Age of wood (years)	Wood mizer		Sawmill	
	% Lumber recovery	Lumber production rate (m^3/hr)	% Lumber recovery	Lumber production rate (m^3/hr)
40	83.0	0.86	48.5	2.01
70	66.9	0.88	-	-

Table 6: Sawing characteristics of oil palm wood

Age of wood (years)	Wood mizer		Sawmill	
	% Lumber recovery	Lumber production rate (m^3/hr)	% Lumber recovery	Lumber production rate (m^3/hr)
25	53.2	1.50	-	-
40	72.7	1.58	59.2	3.66

The percentage lumber recovery was higher for all the species when milled with a wood-mizer (horizontal narrow band saw) than milling at the sawmill (vertical broad band saw). However, the rate of lumber production from the species was higher when milled at the sawmill than when milled with the wood-mizer as shown in Tables 3-5. But there were difficulties in their milling because facilities at the sawmill were not very convenient for the milling logs of such small diameter species. Hence wood-mizer is recommended for the milling of the species.

Physical properties determination

The basic density values, acting as a guide to the working properties of the species, give an indication of their possible end-uses. The mean basic densities for coconut wood and rubberwood can be classified as heavy and

medium density woods respectively. Coconut wood has the potential of being utilized for a wide range of end uses and especially for heavy construction work while rubberwood can be used for furniture making and light construction work.

Permeability trials

The porosity and absorption rates of rubberwood and cocowood have been determined and the provisional results are shown in Table 7 below.

Table 7: Porosity and absorption rates of Rubberwood and cocowood

Species	Porosity (%)	Max. absorption (lm^{-3})	Absorption at 12% mc (lm^{-3})
Rubberwood	25.5	588.5	514.4
Cocowood	9.2	425.0	321.6
Oil palm wood	42.8	756.1	714.7

The percentage space in the wood species (porosity) and the volume of water absorbed in litres per cubic metre of wood assessed, show a very compact nature for cocowood as compared to rubberwood and oil palm wood. This indicates a possibility of difficulty in treatment and preservative retention in cocowood, and palmwood absorbing excessive preservative chemicals making it uneconomical to treat.

Chemical properties

The test specimens consist of sawdust that has previously passed through a 40-mesh sieve and thoroughly air-dried. The methods employed were as described in the TAPPI

Test Methods (1996-1997). The results are indicated in Table 8 below

Table 8. Some chemical properties of selected species

Properties	**Coconut wood**	**Oil palm wood**	**Rubberwood**
pH	6.32	3.45	5.58
Cold H_2O solubility (%)	4.16	18.31	5.79
Hot H_2O solubility (%)	6.19	19.80	13.95
Acetone extraction (%)	4.63	3.70	4.16
Alcohol extraction (%)	3.17	2.21	3.04

The cold water solubility is a measure of the extent of the presence of compounds such as inorganic compounds, tannins, gums, sugars, and colouring matter in the wood species. The hot water solubility removes in addition to the compounds mentioned above, starches in the wood. The organic solvent extraction on the other hand removes fats and waxes

Status of Work

Extraction of logs was undertaken too late in the year hence some of the activities have been delayed. Work on pathological properties, drying schedules, mechanical properties, further chemical properties, durability and treatment techniques, machining characteristics and product development are on-going.

3.0 NON-TIMBER FOREST PRODUCTS PROGRAMME

Objective

To determine technological quality indicators for selection of bamboo culms for handicrafts and industrial products.

Main Projects under the Programme

During the year, the main project undertaken was:
'Development of suitable techniques for Bamboo propagation and establishment of Bambusetum at Bobiri Forest Research Centre'

Major Achievements

- Culm morphology and Anatomy studied.
- Moisture content, density, shrinkage properties determined.
- Two species of bamboo; *Bambusa vulgaris* and *Oxytenanthera abyssinica* identitied for construction and weaving purposes respectively.
- Stumps and culm cuttings have been found to be the best propagating materials for *B. vulgaris*.

3.1 DEVELOPMENT OF SUITABLE TECHNIQUES FOR BAMBOO PROPAGATION AND ESTABLISHMENT OF BAMBUSETUM AT BOBIRI FOREST RESEARCH CENTRE

Project Team: A. A. Oteng-Amoako, E. Ebanyenle, F.A Awuku and R. E. Awunyo

Background

Variations in morphological, anatomical and physical properties within and between bamboo culms have implications on their properties and utilization. Almost all morphological, anatomical and physical properties

investigations on bamboo have been focused on bamboo species grown in Asia. However, research has revealed that variation in bamboo culm morphology, anatomy and physical properties could be attributed to species, geographic sources (provenances) and their genotypic constitution. Therefore results of studies on Asia bamboo species cannot apply for bamboos grown in Ghana even when they are of the same species. Knowledge on morphology, anatomy and physical properties of bamboo species grown in Ghana is therefore urgently needed to aid in selection and diversification of end-uses for their efficient utilization.

Project objective

To determine technological quality indicators for selection of bamboo culms for handicrafts and industrial products.

Work done during 2005

More samples of *Bambusa vulgaris* were further collected from the Wet evergreen and Moist semideciduous forest types of Ghana. All sampling procedures followed ISO 22157-1:2004 -requirements for determination of physical and mechanical properties of bamboo. Density, initial moisture content and shrinkage properties of *Bambusa vulgaris* from the two sampling sites were determined following ISO 22157-2:2004 –laboratory manual for the determination of physical and mechanical properties of bamboo.

Preliminary Results

The mean culm length; culm diameter; internode length; culm wall thickness; moisture content and shrinkage values for *Bambusa vulgaris* from wet evergreen were observed to be higher than those from Moist semid-deciduous (Table 9). However, *Bambusa vulgaris* growing in Moist semi-deciduous forest type exhibited higher

mean density values than those growing in the Wet evergreen forest type (Table 9)

Table 9: Preliminary mean values of selected physical properties of *Bambusa vulgaris* sampled from Wet evergreen and Moist semideciduous forests of Ghana

	Vegetation Type	
Properties	*Wet evergreen*	*Moist semi-deciduous*
Culm Length (m)	21 (19.5-24.5)	17 (15-20)
Outer Diameter of Culm (mm)	75 (49-97)	63 (39-79)
Internode length (cm)	37 (32.5-42.5)	35 (31-37.5)
Culm wall thickness (mm)	9.2 (7-11.9)	8.6 (5.9-11)
Basic density (Kg/m^3)	600 (493-681)	680 (617-747)
Moisture content %	102 (78.8-126)	69 (54.6-81.7)
Shrinkage:-		
Length	0.2 (0.05-0.3)	0.1 (0.06-0.1)
Diameter	8.7 (6.6-9.8)	6.4 (4.6-7.4)
Thickness	12 (6.1-16)	6.8 (3.5-8.3)

Key Results and Further Work

The preliminary results indicate that the Wet evergreen forest type is more favourable for the optimal growth of *Bambusa vulgaris* than the Moist Semi-deciduous.

Anatomical investigations into *Bambusa vulgaris, Bambusa vitata, Bambusa arundinaceae, Oxytenanthera abyssinica* and *Dendrocalamus strictus* shall be carried out to aid in the development of identification key and understanding of their physical and mechanical properties in 2006.

4.0 EXTERNALLY FUNDED PROJECTS

4.1 ALTERNATIVE PEST MANAGEMENT STRATEGIES FOR DEVELOPMENT OF INDIGENOUS SPECIES PLANTATIONS IN GHANA

Project Leader: P. P. Bosu

Forest plantation development efforts in Ghana are unacceptably skewed towards the planting of exotic monoculture teak plantations. This is in spite of the high diversity of indigenous species available for plantation development. The preference for teak can be attributed to its fast growing, pest resilience, and fire tolerance characteristics compared to many indigenous species. Teak plantations, however, do not provide for the multitude of other non-timber products that can be provided by natural forests or indigenous species plantations capable of sustaining ecological diversity as well as providing communities with sustainable livelihoods.

The goal of this study is to identify prospects of mixed-species planting as alternative more sustainable plantation strategy to support the development of indigenous species plantations in Ghana.

Objectives

1. To minimize pest damage to 'at risk' high value indigenous timber species and enhance their success in plantations using mixed-species planting approach.
2. To demonstrate the ecological advantages of indigenous mixed-species plantations over exotic monoculture plantations

3. To promote the establishment of indigenous mixed-species plantations as viable alternative forest plantation enterprise.

Work done in 2005

Approximately 21,000 indigenous tree seedlings were produced for plantation activities. By the end of the year some 6 ha of experimental mixed-species plantations had been established. This included 4 ha of 'production' type plantations and 2 ha of 'restoration' type plantations. Production plantations comprise mixtures of only timber species established at once whereas restoration plantations comprise mixtures of timber and multi-purpose tree species inter-planted with agricultural crops and established in phases to simulate natural succession.

Production type plantations

The design of the Production plantation consist of five treatments (plots) replicated two times each at the South Fumangsu Forest Reserve (Moist Semi-Deciduous Forest zone) and the Afram Headwaters Forest Reserve (Dry Semi-Deciduous Forest zone) sites. The treatments are as follows:

1. Six-species mixture which includes the three 'at risk species each at 5% density
2. Ten-species mixture which includes the three 'at risk species each at 5% density
3. Ten-species mixture which includes the three 'at risk' species each at 10% density
4. 100% Mahogany (indigenous monoculture plantation)
5. 100% teak (exotic monoculture plantation)

Each plot consists of 400 seedlings planted at 2m spacing between rows and columns with a spacing of 5m between adjacent plots. The three at risk species are Odum (*Milicia excelsa*), Mahogany (*Khaya ivorensis*) and Kokrodua (*Pericopsis elata*). The other species include onyina

(*Ceiba pentandra*), Ofram (*Terminalia superba*), Oprono (*Mansonia altissima*), *Tieghemella heckellii*, *Antiaris toxicaria*, *Piptadeniastrum*, *Albizia* and *Tetrapleura tetraptera*. The companion species were always planted at equal proportions in the mixture.

Restoration plantations

Restoration plantations were set up at Bia-Shelter belt Forest Reserve and Mesewam forest nursery area and were essentially for demonstration purposes:
At Bia-Shelterbelt near Mim (Goaso Forest District) a one-hectare restoration plantation was set up. 20 plots each covering an area of 10m x 10m (36 trees/ plot, 2m x 2m spacing) was demarcated, with 3m spacing between adjacent plots. Five treatments made up of three mixed-species plantings, of between two and four species combinations, and two monoculture plantings of Kusia (a moderately at risk species) were planted. The three nurse species were *Albizia adianthifolia* (Albizia) *Terminalia superba* (Ofram), *Tetrapleura tetraptera* (Prekesse). Each of the five treatments was replicated four times using a randomized complete block design. In addition, plantain suckers were planted at 6m x 6m spacing in the matrix of the timber species.

At Mesewam, a half-hectare plantation was set up. Chewsticks, *Sokodua* and *Tweapea* were planted at 5 m intervals in alternate rows. In addition, black pepper was planted and staked with the N-fixing *Gliricidia sepium* at 10 m spacing in the matrix of the chewsticks. The entire plantation area was then inter-cropped with maize during the major planting season.

Farmers' field trials

Five farmers from the village of Kubease, near the Bobiri Forest Reserve volunteered to plant indigenous timber species on their own farmlands. Approximately 5 acres of farm plantations were thus established with technical and logistical support from the Project team. The species

planted were ofram, mahogany, tweapea, sokodua and prekesse.

Development of Protocols for biodiversity assessment

In order to demonstrate the ecological advantages of indigenous mixed-species plantations over exotic monocultures we have proposed to evaluate biodiversity in the production and restoration plots using ants and ground beetles as bioindicators. Since our plantations are at a very young age, we carried out preliminary assessment in 8-10 old plantations and in other land use systems, 1) non-forested, 2) teak (exotic species) plantation, 3) mixed native species plantation, and 4) natural forest. Ground dwelling arthropods were collected using a standard pit-fall trapping method.

Key Results

IRS trials: As at the time of this report, no shoot borer attack on Mahogany had been recorded in the plots – neither in the treatments nor in the control plots. This is not unexpected as shoot borer attack to mahogany may occur within the period of few months to as long as several years.

Pruning trials: After almost 15 months following establishment of the plots the first shoot borer attack on mahogany was finally recorded in the Mesewam plots (September 2005). But at least 50% of the plants should be attacked before the pruning treatments can be applied.

Production plantation trials

Mortality of seedlings was very high (30-60%) in all the plots during the first six weeks following establishment. As at the time of this report, pest damage to the three at risk species was insignificant in the SFFR and AHWFR plantations.

Restoration plantation trials

Bia-Shelterbelt: In spite of the unusually low rainfall during the major season, the plots are in good condition. Survival and overall condition of Kokrodua (*P. elata*) is higher than that of Kusia (*N. diderrichii*). Overall survival of kokrodua in the plots was between 80-95% as against 40-65% for kusia. However, the arrival of *L. lateritialis* defoliator in the plantation may lead to a reduction in the survival and growth of kokrodua should the pest population increase over time. The lower survival and growth of kusia is the direct result of dieback incidence recorded on the seedlings. The etiology of this dieback is unknown to this investigator, and would therefore require further search in the literature to determine the status of existing knowledge as well as identify any gap for future investigation.

Mesewam: The restoration plantation at Mesewam is still in the early stages and so no data has been collected. Survival and growth was encouraging.

Biodiversity assessment

Initial results showed that biodiversity of ground foraging ants in mixed species plantations was higher than in teak plantations or intensively cultivated agricultural lands. Ant biodiversity was, however, comparable to that in intact natural forest. Assessment of new trap catches is currently in progress.

Farmers' field trials

Five volunteer farmers from the village of Kubease established a total of 2.5ha of farm plantations. All the plantations were planted with indigenous trees namely, ofram (*Terminalia superba*), mahogany (*Khaya ivorensis*). Farmers also planted non-timber trees species, which included *Garcina cola* (tweapea) and *Tretrapleura tetraptera* (prekesse).

Further work for the coming year (2006):

The activities planned for 2006 include:

1) Maintenance and monitoring and of established plantations,
2) Establishment of additional restoration plantations
3) Collection of data on growth and analyses of tree responses to treatment effects in the plantations
4) Expansion of farmer's field trials to include other farmers
5) Evaluation of biodiversity in experimental plantations
6) Initiation of restoration treatments in declining gaps within Bobiri Forest Reserve using a combination of mechanical clearing, release of biocontrol agents of *Chromolaena odorata* and enrichment planting.

4.2 CASSAVA AS AN INDUSTRIAL COMMODITY – IMPROVING ACCESS TO KNOWLEDGE ON APPROACHES AND OPTIONS FOR EXPANDING MARKETS FOR CASSAVA (DFID PROJECT)

Project team: Dr. D Sekyere, J. Degraft Yartey & N S A Derkyi

Background

Research in Ghana has shown that conversion of cassava into products for food, plywood, paperboard, textile and pharmaceutical industries contributes significantly to rural livelihood. Innovative public-private sector partnerships were used to establish a market chain from producer to end-user, and an institutional framework to support market development and manage uptake of knowledge. This project supports integration of these concepts into the national system so as to ensure sustainable support for market development, and to influence institutional thinking on the future agro-industrial initiatives.

Objective

To generate knowledge and promote national innovation systems to mobilize a sustainable uptake and adoption of cassava post harvest (CPH) knowledge for the benefit of the poor.

Work Done

During the year under review a visit was made to seven timber and plywood companies to collect information on their activities. The information collected is shown in Table 10 on the next page.

Table 10: Data on timber firms visited

Parameter	**Timber/plywood company**						
	Topp	Farres	Hanmax	Habitat	Pledgetex	Wood Pillar	C. Korsah
Production capacity (m^3)	-	1200	-	-	1600	1700	1800
Staff strength	135	275	310	155	45	196	54
Quality Control Unit	No	yes	Yes	No	Yes	No	yes
Ownership	Private	Private	Private	Private	Private	Private	private
Scale	Medium	Medium	Medium	Medium	Small	Medium	small
Daily Flour consumption(kg)	300	400	200	200	150	200	150
Product	Veneer & plywood	Veneer & plywood	Veneer, lumber & plywood	Plywood & veneer	Plywood	Veneer, lumber & plywood	Plywood
Export	none	Yes	Yes	Yes	Yes	Yes	Yes
Local consumption	Yes	yes	Yes	Yes	Yes	Yes	Yes
Species used	Mainly Ceiba	Ceiba & Antiaris	Mainly Ceiba	Mainly Ceiba	Available veneer	Mainly Ceiba	Available veneer

Plywood manufacturing trials

The selected plywood mills were visited to introduce high quality cassava flour and to monitor their quality systems and offer technical support. Two to three visits were made to each plywood mill. At each mill, two formulations were made and applied; 100% substitution of wheat flour with cassava flour and 80% substitution, using the particular formulation concentration of each mill. In all cases, the bond strengths estimated by the knife test proved the adhesives to be good. The formulations for the individual plywood mills are shown in table below.

Table 11: Glue formulations and their performance at individual plymills

Formulation	Company													
	Topp		Farres		Hanmax		Habitat		Pledgetex		Wood pillar		C. Korsah	
	F1*	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Glue (kg)	12.5	12.5	100	100	25	25	25	25	25	25	75	75	25	-
Cassava (kg)	25	20	50	40	10	5	15	12	16	13	25	20	5	-
Water(kg)	36	36	140	140	60	60	42	42	39	39	70	80	5	-
Hardener (kg)	1.5	1.5	2	2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	-
Viscosity (secs)	55	55	-	-	-	-	-	-	16	10.9	16	10.9		-
Wheat (kg)	-	5	-	10	-	5	-	3	-	3	-	5	-	-
Quantity(boards)	150	153	170	-	80	84	70	-	70	-	50	-	28	-
Normal Production Quantity/ pot	150		180	-	144		90-100		60-70		40 -50		45	

* F1 – Formulation with 100% substitution of wheat flour and
F2 - Formulation with 80% or 50% substitution of wheat flour

Technical support
Technical support was provided to 5 mills in terms of the following.

- Dry matter of cassava flour/amount of water in the glue mix
- Guidance on appropriate mixing of ingredients
- How to check glue spread
- Use of FORIG's Instron machine for a more precise testing of glue bonds

There were no problems associated with the use of cassava flour compared to wheat flour. Some mills however experienced defective bonding in some of their 4mm plywoods. The problem persisted when cassava flour was used to replace the wheat flour.

Comments
Management was very happy with the outcome of the trials, and enthusiastic to replace wheat flour with the cassava flour. They however wanted a guaranteed source of high quality cassava flour.

4.3 DOMESTICATION OF *ALLANBLACKIA* SPECIES IN GHANA

Project Team: D. A. Ofori, D.E.K.A. Siaw, T. Peprah and J.R. Cobbinah

Introduction

Unilever is exploring the possibility of building a sustainable production, a sizeable tonnage of *Allanblackia* oil per annum, with fair returns to collectors and local processors. The oil from the *Allanblackia* nuts is attractive to Unilever since it can be used for margarine production with less chemical processing and refraction than palm oil. They are committed to helping conserve natural forest areas where it occurs and stimulating a small-holder production supply chain. Unilever have asked ICRAF to assist in the domestication of the species. Of particular concern is that material entering cultivation is of sufficient genetic diversity to provide an adaptive capacity to potential changes in environment and user requirements. Genetically diverse populations within farming landscapes will prevent inbreeding depression.

For this to be sustainable, knowledge on the intra-specific genetic variation for development of core collection (gene bank) is a prerequisite. One major bottleneck in the domestication programme of *Allanblackia* is the development of methods for propagation and enhancement of phase change from juvenile to mature phase.

Unilever in collaboration with World Agroforestry Centre/ICRAF identified institutions in Tanzania, Cameroon and Ghana of which the Forestry Research Institute of Ghana is included to assist in the domestication of the species.

Objectives

1. To develop methods for seed germination of *Allanblackia* sp.

2. To develop methods for vegetative propagation of *Allan*blackia sp.
3. To establish *Allanblackia* gene bank in Ghana.

The *Allanblackia* Nursery

Establishment of *Allanblackia* nursery at FORIG began in January 2005. Currently, the nursery covers 60m x 60m land area. One half of the nursery is screened by 50% shade netting supported by treated teak posts. The other half is under natural shade provided by the existing trees on the land to mimic what occurs in nature. A one-thousand capacity water storage tank has been installed at the nursery and connected to a pump that draws water from a nearby dam. One hundred and thirty-five germination beds of size 1.2m x 3m were constructed.

Germplasm Collection

Germplasm collection was undertaken between January and March 2005. Seven zones ranging from Wet evergreen to Moist semi-deciduous forest zones where the species occurs were selected. The target was to identify 21 fruiting trees in each zone and collect at least 30 fruits from each tree. Each tree was marked and given identification number. Records on each tree such as GPS, height, dbh etc were recorded on a passport data sheet. Each tree was visited at least two times for collection of adequate number of fruits that fall on their own. Table 12 shows the seven zones and the number of trees from which fruits were collected. Leaf samples were also collected for DNA analysis.

Table 12 *Allanblackia* germplasm collection zones and number of accessions collected

Name	**Ecological zone**	**No. of trees**
Gwira Banso	Wet Evergreen	28
Samreboi	Moist Evergreen	34

Benso	Moist Evergreen	28
Daboase	Moist Evergreen	21
Sefwi Wiawso	Moist Evergreen	6
Mankranso	Moist Semi-deciduous N/W	27
Atewa Range	Moist Semi-deciduous S/E	6
TOTAL		150

Processing

All fruits collected were sent to FORIG's seed processing shed. Before seed extraction from the fruits, the following records were taken; Fruit size (weight, length and circumference), fruit shape (straight, curved) grooves (shallow, deep, very deep) and nipple size. After seed extraction, the number of seeds per fruit and seed weight per 100 seeds were recorded.

Seed germination in green house

Seeds from 21 accessions are being tested in germination bowls in a green house that maintains 50% of the incident sun light. A standard number of 200 seeds per accession was used except for only three accessions that ranged between 182 and 196 seeds. The treatments being evaluated are:

1. Sowing with testa removed
2. Sowing with testa on
3. Removal of testa + soaking for 24 hours before sowing
4. Testa not removed + soaking for 24 hours before sowing

So far germination has been obtained from 15 accessions with an average germination percentage of 2.1% and 0.05% respectively for seeds with testa removed and intact seeds respectively.

Germination on nursery bed

The seeds were sowed following the protocol obtained from ICRAF. Permanent metal labels were provided for each accession. In addition the layout of the germination beds was drawn to avoid loss of accessions in case a label is accidentally removed. The beds were heavily mulched with dry leaves after sowing the seeds. Watering is done once everyday.

A total of 63,393 seeds were sowed (Table 13). Monitoring for germination is done weekly. As at 31st December 2005, germination had been recorded in 27 accessions. The germination percentages ranges from 0.2 – 8.0 % with a mean of 1.5 %. The total number of seedlings obtained from both nursery bed and germination bowls in green house is 122 from 36 half sib families.

Table 13. Number of seeds sowed per zone

Name	Ecological zone	No. of seeds
Gwira Banso	WE	13,576
Samereboi	ME	13,158
Benso	ME	11,685
Daboase	ME	2,238
Sefwi Wiawso	ME	1,343
Mankranso	MSNW	14,025
Atewa Range	MSSE	2,932
TOTAL		63,393

Vegetative propagation

Cuttings

Vegetative propagation by cuttings started during the year. Sixteen trees were felled to produce coppiced shoots for cutting propagation. Rooting success obtained as 31st

December 2005 was 12%. The vegetative propagation unit is being improved to enhance rooting of cuttings.

Air layering

Possibility of propagating *Allanblackia* by air layering was investigated during the year. This was done by removal of 5 cm width of the bark from small branches (about 5-10 cm diameter) and a ball of soil tied round the wounded portion. A total of 40 layers were made from six trees. So far only one of the layers has produced roots.

DNA analysis

Protocol for DNA analysis is being developed. Extraction of DNA with Quiagen DNA extraction kit did not yield any good quality DNA. DNA extraction buffer is being prepared following the basic CTAB protocol with minor modifications . With this protocol high quality DNA has been obtained from fresh leaves of seedling at the nursery.

Discussion and Way forward

The behaviour of *Allanblackia* was unknown at the beginning of the project. It has been found to be a difficult species in terms of germination of seeds, vegetative propagation and DNA extraction from the leaves. Our experience however shows that seed germination takes a long time, starting at about 7 months after sowing but could be reduced by removal of testa before sowing. Seeds with testa removed and sowed in bowls in green house had higher germination than seeds sowed on nursery beds with intact testa. At nine months after sowing, germination in green house ranged between 0 and 8% with and average of 2.1% for seeds with testa removed while seeds sowed with intact testa, only one accession had germinated (1% germination). Pre-sowing treatments such as removal of testa, acid and hormone treatments need to be evaluated.

For vegetative propagation, 12% rooting success of cuttings and only 2.5% success for air layering have been obtained. Structures for propagation by leafy stem cuttings

are being improved following the protocol from ICRAF, Cameroon to enhance rooting.

Analysis of genetic diversity at DNA level is in progress. Difficulty in obtaining good quality DNA for the analysis has been a major problem. Our experience shows that DNA extraction from dry leaves of mature trees is very difficult compared to DNA extraction from young leaves from seedlings. Hence DNA would be extracted from leaves of the seedlings in the nursery to complement with extractions from leaves from mature trees.

4.4 MASS PRODUCTION OF PLANTING STOCKS OF ODUM (*MILICIA* SP) THROUGH IN-VITRO TISSUE CULTURE

Project Leader: **D.A. Ofori**

Introduction

Iroko (*Milicia* spp.) is the most important timber species in the family Moraceae. The economic importance of Iroko wood is partly due to its natural resistance to decay-causing organisms, timber borers, termites and acquatic worms as well as its good working properties. Based on the current rate of extraction in Ghana (172,983 m3/yr) and the annual growth rate (28,650 m3/yr), this valuable species is seriously threatened (Alder, 1989). Attempts at establishing plantations have been a complete failure because of damage caused by a pest, *Phytolyma lata*. This study aimed at mass propagation of *Phytolyma* resistant genotypes of *Milicia* through in-vitro tissue culture.

Development objective

The development objective of the study was to restore *Milicia species* as a plantation species.

Specific objective

The specific objective of the project was to develop a suitable protocol for in-vitro micro-propagation of resistant lines of *Milicia species* using locally prepared media.

Materials and methods

Comparison of lab prepared with pre-mix

Two half strength MS media were prepared:

Media was prepared in the laboratory of CSIR-FORIG following the protpcol of Murashige and Skoog (1962)

Medium was prepared using ready-use premix MS media (SIGMA):

The media were supplemented with 0.7% agar, 3% sucrose, 0.08 mg/l IBA and 0.6 mg/l BAP.

Shoots were harvested from greenhouse grown stockplants. They were sterilised using 30% of commercial bleach (containing 30% sodium hypochlorite) for 20 minutes and then 70% ethanol. Axillary bud explants were excised and inoculated unto the two types of media and observed for growth. The cultures were maintained in a growth room fitted with 40W florescence bulbs, 16 hrs photoperiod, minimum and maximum temperatures of 22 and 26 ^{o}C respectively. Weekly assessments were undertaken and the cumulative number of explants that could pass through bud break, bud elongation and shoot growth were recorded.

Organogenesis (shoots and root differentiation from the induced calli)

Half strength MS working media was prepared and supplemented with 0.7% agar, 3% sucrose and various concentrations of hormones as shown in Table 14.

Table 14. Treatments Used To Induce Organogenesis Of The Stem Calli

Treatment	1	2	3	4	5	6	7	8
IBA mg/l	0	0	0	0	0.1	0.1	0.1	0.1
BAP mg/l	1	2	3	4	1	2	3	4

Young and succulent stem pieces were sterilised as described above and explants (about 3mm square) prepared from them. They 20 explants were grown in each of the media. They were maintained in the growth room without light to induce callusing. Callus growth was at its peak in the third week. Explants were transferred into media supplemented with the various hormone treatments shown in Table 2. The cultures were then kept in a growth room under 16 hours photoperiod.

Results

Results showed that the performance (bud break, elongation and shoot development) of explants grown in the medium prepared in the laboratory of CSIR-FORIG was not significantly different from the MS pre-mix medium even though the ready-to-use has better performance than the former (Fig. 1).

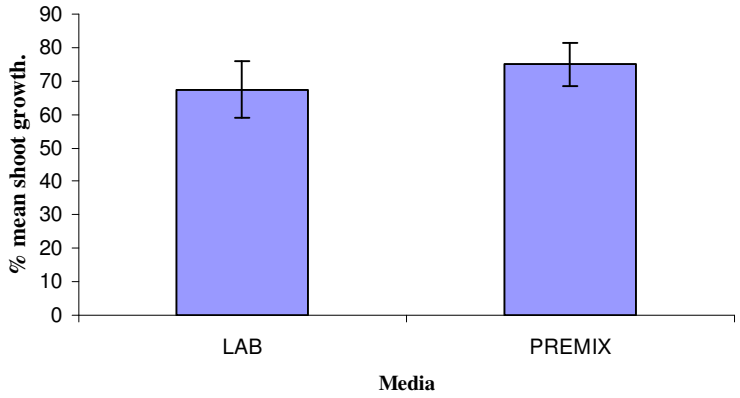

Fig. 1. Comparison of lab prepared and pre-mix MS media in terms of shoot growth

Discussion and Conclusions

Preparation of MS medium locally has been successful to alleviate the ordeal of importation if tissue culture media from Europe. Organogenesis for induction of multiple shoots and probably a diversity of genotypes from a piece of plant tissue is very promising. Work on this is in progress for development of a suitable protocol.

4.5 DARWIN INITIATIVE EXERCISE ON COMMUNITY TREE SEEDS (DIRECTS) PROJECT

4.5.1 Effect of storage conditions and desiccation on the viability of *Terminalia superba* seeds

Project Leader: **T. Peprah**

Introduction

The Government through the Forestry Services Division, Non-Governmental Organisations, communities, private entrepreneurs and individuals is undertaking tree-planting activities all over the country. Generally, trees are propagated from seeds. Seed handling and genetic quality have a significant effect on the success of the plantations raised from them. This therefore calls for a good knowledge of the seed handling and proper planning of activities so as to be able to reap the best out of plantation investments.

Tropical forest seeds loose viability gradually under open storage without temperature and moisture control. A dry atmosphere and a temperature of 3-5^{o}C are reported to ensure much higher germination after storage periods beyond two weeks (Lamb 1968). Tabi-Gyansah (1994) established an ideal condition for short-term storage of S*terculia rhinopetala* (Wawabima).

Terminalia superba, a member of the Combretaceae family is classified as a Red Star species. Even though the species is currently common, current rates of exploitation presents a significant danger to the economic potential of the species within the next few years (Amoah, 1999).

The initial germination of freshly collected seeds of the species can be as high as 90% but this high germination capacity is drastically reduced few weeks after seed harvesting if stored under ambient (room) conditions.

The study reported here was undertaken to determine the tolerance to drying and optimum storage conditions for this species.

Materials and methods

Initial moisture content and seed viability tests

Moisture content of the seeds was determined prior to germination. The moisture content of 5g of seeds in four replicates was determined. The initial germination percentage of the seeds (as an initial test of viability) was also determined. Twenty-five seeds per replicate for four replications were set, making a total of 100 seeds. The medium used, which was coarse river sand, was placed in germination bowls. They were put in a shade house with about 50%, irradiation. The germination bowls were watered daily in the morning. Temperatures of germination media as well as the room were recorded three times in a week.

Desiccation experiment

One hundred and twenty five seeds in four replicates were randomly selected for tolerance to drying studies using silica gel. This was done following a protocol on desiccation studies. Equal weights of 65 and 60 seeds to equal weights of silica gel were used. This was done for six hours and after every two hours seeds were sampled for germination and moisture content determination. Another set of one hundred and twenty five seeds was used for the control using sawdust instead of silica gel. At every two hours a set of 65 and 60 seeds from the four replicates were sampled for moisture content and germination. 15 seeds from the 65 and 10 seed from the 60 seeds were taken for the moisture content and the 100 seeds were used for germination. At the sixth hour the seeds were hydrated overnight before sowing.

Seed Storage experiment

Seeds were stored at three different storage conditions: room temperature, freezer and refrigerator and in three different containers (jute sacks, plain plastic bags and

glass bottles). Twelve (12) containers each of polythene bag, jute sack and glass bottles were used. Each of the twelve container types had hundred and fifty (150) *T. superba* seeds. Four (4) of each container-type was kept in Deep freezer at a temperature of -10 to -15^{o}C, refrigerator at a temperature range of 0-2^{o}C and room temperature ranging between 28 to 30^{o}C.

At four weeks interval, a container of each type was taken for moisture content and germination tests. Hundred (100) seeds from each container were selected randomly for germination and 5g for moisture content. Completely randomised factorial design was used. Data was collected on the moisture content of the seeds as well as on germination. Data was collected every three days.

Results

The initial moisture content and germination percentage of the seeds were 14.08% and 50% respectively. The moisture content of the seeds reduced significantly after the six hours of desiccation from 14.08% to 5.80%. For the control treatment, the moisture content remained at 15.02%. The results suggest that desiccation has significant influence on the viability of the seeds. The germination percentage of the seeds increased from 50% initial to 84% after six hours of desiccation an increase of about 40%. A marked increase in germination was recorded after only 2 hours of desiccation (50% to 76%). Thereafter the increase was less dramatic peaking at 84% after 6 hours.

After four months of storage of the seeds, the moisture content and germination percentage of the seeds stored under different conditions shows some variation. The initial moisture content and germination percentage of the seeds were 14.08% and 50% respectively.

The viability (germination percentage) of *Terminalia superba* seeds with initial moisture content of 14.08% was (positively) influenced significantly by decreasing moisture content as a result of desiccation. The seeds were able to tolerate drying to almost 40% of the initial

moisture of the seeds. However the Critical Moisture Content could not be established and therefore the time needs to be extended beyond the six hour period in order to obtain the Critical Moisture Content.

4.5.2 Effect of desiccation on germination of *Garcinia afzelii* and *G. kola* seeds

Project Leader: T. Peprah

Introduction

Garcinia kola and *G. afzelii* are Non- Timber Forest Product (NTFP) mainly used as chewsticks. The extensive exploitation of these species has led to their gradual disappearance from the forest. Falconer (1992) describes the species as being rare. The most recent inventory revealed that the species are close to commercial extinction in Ghana (Wong, 1999) and currently patches of population can be found only in Western Region. In terms of star rating (Hawthorne and Abu- Juam 1993) based on species, *G. kola* is rarer than *G. afzelii*. Both species have been included in the IUCN red species list.

Attempt by farmers to cultivate the species has been unsuccessful due to insufficient knowledge about the seed handling techniques. Reforestation efforts have been hindered by problems of seed availability. Therefore for successful propagation of the species, knowledge of optimal and critical moisture content at which germination occurs is crucial. This study was undertaken to find out the moisture contents for maintaining viability and high germination capacity of *G. kola* and *G. afzelii*.

Species

Garcinia afzelii and *G. kola* belong to the family Guttiferea. *G. kola* and *G. afzelii* are shade bearers and natural regeneration of the species is rare while the artificial regeneration is slow and irregular (Taylor, 1960; Abbiw, 1990)

In general, *G. afzelii* and *G. kola* have many different uses. They were known for their oral hygiene properties as chewsticks and medicinal applications also. Economically, for many years, chew stick have been commercialized in the major towns and cities in Ghana especially in Kumasi where the chew stick industry is well developed, creating employment for many women. *G. afzelii* and *G. kola* were identified by Falconer (1992) as the two main species of chew stick in the Ghanaian market. She reported that, between 2000-6500 trees may be harvested in a month for Kumasi traders. She also identified two main chew stick market centres in Ghana as Accra and Kumasi.

G. afzelii

G. afzelii locally known as 'Nsorkor' is a large spreading tree, which grows up to 60 feet high (Irvine, 1961). G. afzelii bears fruits which are spherical and resembles an orange consisting of seeds ranging from one to four. The seeds are smaller as compared to G. kola. *G. afzelii* is found in Evergreen Forest often in damp situation and a small or medium under storey tree in dry forest.

The acid pulp of the fruit is edible. The wood is also used for constructional purposes. It is known to be good for carpentry work. The dried, pulverized root and bark is used as species or condiments and known to cure serious forms of diarrhoea and dysentery. The root, bark and fruits are eaten in Sierra Leone as an aphrodisiac.

G. kola

G. kola, locally known as, 'Tweapea' is also a spreading forest tree which grows to 90 feet in height. *G. kola* bears fruits which are green when not ripened but change to orange and yellow when ripened. The fruits consist of seeds ranging from one to four, which are bigger in size than those of *G. afzelii*. *G. kola* is found in moist situation in closed forest especially Moist Semi-Deciduous Forest.

The acid red aril-like fruit-pulp is edible and of fine flavour. The twigs produced are used as tapers and the roots yield the favourite bitter chew sticks sold in small

bundles in local markets. The seeds, the bark and the other parts of the species have been used effectively for treating several diseases.

Materials and methods

Seed Source

Mature fruits of *G. afzelii* were collected from the Volta Region in May 2004 and those of *G. kola* from the Ashanti Region in August 2004. Fruits were temporarily stored in the sack for a period of two weeks. This is to soften the fleshy pulp to allow easy extraction of the seeds.

Fleshy part of both *G. kola* and *G. afzelii* fruits were removed and seeds were then cleaned. Desiccation test were carried out immediately after extraction at the seed lab. The desiccant used is silica gel and sawdust as the control. These experiments were done following the protocol for dessication. *G. afzelii* seeds were desiccated for six hours to different levels of moisture content to assess germination. G. kola seeds were desiccated for eight days to different levels of moisture content and germination assessed weekly for the first one month thereafter it was done every three days. Watering was done once a day.

G. afzelii

Five grams of seeds in four replicates were sampled for initial moisture content determination. Three different containers; air-tight bottles, plastic bottles and plain polythene sac were used for desiccation trials. One thousand one hundred and twenty-five seeds were weighed and further divided into 60 and 65 seeds into each container in three replications. Each seed lot was weighed and corresponding weight of silica gel was placed on it. Another set of 65 seeds in 3 replicates and 60 seeds also in 3 replicates were weighed into similar containers and an equal amount of sawdust was placed on them. The containers were labelled. In both cases the

seeds were removed and weighed at an hour interval for six hours. However when the silica gel turned pale, it was substituted with fresh silica gel. After the six hours of desiccation, 3 replications of 5 seeds each for the 65 seeds and 2 replications of 5 seeds each for the 60 seeds were sampled for moisture content determination. The moisture content was then calculated

Germination test was then performed by sowing 100 seeds (4 replications of 25 seeds each per bowl) in river sand in each germination bowl for the three replications per each container. The seeds in the sawdust were sown immediately after the six hours whereas seeds in the silica gel were hydrated over water in closed containers for 24hrs before they were sown.

G. kola

Initial Moisture Content Determination and Germination test

Forty- nine seeds were sampled, out of which 40 seeds (2 replications of 20 seeds each) were used for the initial germination test and 9 seeds (3 replications of 3 seeds each) were also used for initial moisture content determination.

Two hundred and fifty seeds (5 replications of 50 seeds each) were taken for desiccation experiment. 50 seeds in four replications were weighed and placed in equal amount of silica gel and 50 in moist sawdust into an air-tight glass bottles. Seeds were drawn at two days intervals to assess moisture content and germination up to ten days. The silica gel was replaced whenever it turns pale. For each replicate of 50 seeds, 40 seeds (2 replications of 20 seeds each) were used for germination test and 9 seeds (3 replications of 3 seeds each) were used for moisture content determination. Seeds desiccated were hydrated for 24hrs and the testa removed before sowing. Seeds in the sawdust were sown at the end of the tenth day by taking 20 seeds in two replications and 9 seeds (3 replications of

3 seeds each) for moisture content. The remaining one seed for each of the replicate was thrown away.
Assessment on seed germination was done weekly, and when germination started it was done every three days.

Results

Response of *G. afzelii* seeds to drying within six hours in the various containers

There was a gradual loss in weight with time. The seeds in the various containers responded to the drying differently. During desiccation of seeds from the 0hr to the 6^{th} hr, the moisture loss for the glass bottle, plastic and plain polythene bag were 5.17g, 5.42g and 5.60g respectively. The higher moisture loss was recorded on the polythene bag followed by the plastic and then the bottle. The difference in moisture loss between the plastic and polythene bags were less pronounced than with the bottle. Seed weight, decreased with increasing time. The moisture losses within the three hours were 0.85g, 0.53g and 0.79g for glass bottle, plastic and plain polythene bag respectively. These differences were not as high as the desiccated seeds.

Germination percentages at different levels of moisture content with respect to the various containers

The germination of *G. afzelii* was very low for the desiccated seeds and the control, with 7.35%, 12% and 7.3% germination for desiccated seeds and 5%, 6.5% and 8.5% germination for the control in different containers.
The plastic container recorded the highest germination percentage with moisture content of 32.29% followed by the bottle and the polythene bag. Statistically the treatment effect of the three containers on both moisture content ($F= 3.56$; $df = 2.6$ $p>0.05$) and germination ($F=1.37$, $df = 2.6$ $P>0.05$) was not significant. Germination period was relatively long with the first germination recorded after 60 days.

G. kola

G. kola had initial moisture content of 53.33% with an initial germination percentage of 82%. Moisture content of 53.33%, 45.75%, 39.53%, 38.30%, 37.84% and 53.29% resulted in 82%, 95%, 80%, 62.5%, 57.5 and 55% germination respectively. Pearson chi-square analysis showed that moisture content significantly affects germination of seeds at $P<0.05$. Level of significance was tested using Pearson chi-square and it was observed that there was no significance difference between moisture content and germination of seeds from day 0 to day 4 at $P<0.05$. However as moisture content decreases to below 39%, germination is significantly affected.

The results of this study confirm that the seeds of both *G. afzelii* and *G. kola* are recalcitrants. The germination percentage was very low for *G. afzelii* seeds but very high for *G. kola seeds*. Moisture contents below 34% were not optimal for the germination of *G. afzelii* seeds since seed germination was low at these levels of moisture content. The containers had no effect on both moisture content and germination hence any of them can be used for further desiccation experiment. For the *G. kola*, germination reduced below, a critical moisture content of 38.30%.

4.6 INCREASING PRODUCTIVITY AND QUALITY OF WEST AFRICAN TEAK PLANTATIONS USING GENETIC DIVERSITY AND SUSTAINABLE MANAGEMENT

4.6.1 Capturing genetic gain through Vegetative Propagation (WP 4)

Project Leader: **T. Peprah**

Objectives

- To assess teak cutting potential at the between and within clone level for efficient deployment.

- To develop efficient propagation techniques adapted to mass cloning of mature selected trees.
- To produce clones for advanced field test with WP2
- To set up clonal banks for genetic conservation and future deployment

Materials and Methods

Nursery Facility

Installation of pipes and pumping machine to the mist system has been completed. A new controlling system has also been fixed.

Marking and re-marking of plus trees

Initially, one plus tree per provenance was selected from 12 provenances in the International Provenance Trial of Teak at Tain II and Pra Anum, respectively. The collections were one tree per provenance per plot. These were potted and the coppiced shoots were collected and set on a propagation bed using the mist propagation system. Individual provenances and their ramets were labelled. The number of sprouts produced per provenance, were also recorded. Initial assessment of rooting was carried out six weeks after setting and thereafter at two weeks intervals. The rooted cuttings were labelled and then potted (Table 1). Some of the rooted cuttings have been cut and set on the mist system.

Another set of plus trees were selected based on the results of WP2. A total of sixty trees were therefore selected based on their growth performance. The identification number is uniform for WP2 and WP4.

Collection of Branches

Branches were collected from the selected plus trees from the provenance trial plots. The objective is to produce sufficient number of mother plants for each provenance in other to be able to start rejuvenation process and to obtain materials for clonal testing. Sticks from sixty plus trees were collected for vegetative propagation from Tain II

forest Reserve at Berekum. These branches were labelled and then brought to the nursery, waxed and then potted.

Vegetative Propagation

Coppiced shoots were collected at monthly intervals and set on a propagation bed using the mist propagation system. The number of sprouts produced per provenance was recorded. The first assessment was done six weeks after setting to observe rooting, and thereafter the assessment was done at two weeks intervals. The rooted cuttings have been potted (Table 2). These are going to be intensively managed for serial process in other to increase the rooting ability of the cuttings. Another set of sticks have been collected from Tain II and potted. The sticks have started sprouting. The coppiced shoots would be ready soon for cutting.

Stock plant Management

The few rooted cuttings obtained are being intensively managed for mass production to obtain clones for the establishment of clonal tests. Some of the few rooted cuttings had been cut back and set on the mist system.

Results

Rooting of Cuttings

The experiment aims at rejuvenating mature branches of selected plus trees in order to mass propagate the materials produced.

Table15. The number of rooted cuttings per provenance per site.

Provenance	**Number of rooted cutting/Site**	
	Pra-Anum	Tain II
3047	1	4
3021	2	-
3049	3	3
3056	1	-

3044	1	9
3050	3	9
G4	1	4
G1	1	3
G3	-	3
3059	-	3

Tain II had provenance 3044 and 3050 rooting more than the other provenances whiles the others had as low as one cutting rooting out of at least thirty cuttings set per each provenance. The provenances from Tain II had the higher rooted cuttings than those of Pra Anum. These rooted cuttings have been potted. Some of the potted rooted cuttings have been cut and set.

The result on the re-labelling however shows that rooting has been very low (Table 16). The low rooting might be due to the age of the materials used. And also the boiling water generated by the pump, which was being used to water the cuttings unknowingly due to the other poly tanks, which were connected to the pump. This however has caused the high mortality rate of the cuttings.

Table 16. Number of rooted cuttings

Plus Tree Number	**No. of cuttings set**	**No. of rooted cuttings**
15T48	30	3
26T56	41	1
11T48	13	1
20T50	32	2
7T21	9	1

50T55	96	1
40T47	86	4
54 T56	101	2
19 T50	29	1
10 T48	30	2
43 T47	43	1
13 T48	56	1
42 T47	63	3
2 T21	16	1

Multiplication of rooted cuttings
Few rooted cuttings have been obtained from the serial propagation (Table 17).

Table 17. Rooted cuttings obtained from managed stockplants.

Provenance	**Number of rooted cutting/Site**	
	Pra-Anum	Tain II
3047	-	2
3049	-	1

3050	1	2
T G1	-	1
T G4	-	1

Constraints

Initially the mist control system that was installed did not work properly due to problems with the programming of the controller. Hence, watering could not be done at the required specific intervals. A pump has been installed and therefore water can be sprinkled regularly but because it has to be on for 24 hours the water therefore becomes boiling water. This had turned to kill all the cuttings when set. The problem was however discovered recently. This however had brought about the low rooting of cuttings. The pump needs an electric Booster to cool the water being drawn for watering of the cuttings.

Field visit in 2004 and 2005

In 2004 and 2005 six two-days field visits were made with one researcher, two technicians, a tree climber, a driver and two forest rangers. Four visits at Tain II for collection of branches. This activity formed 20% of the work done in 2004 and 20% 2005.

Activity for 2006

Re-marking of trees at Pra Anum forest Reserve will be done. New collections will be made from the International Provenance Trial of Teak at Tain II and Pra Anum Forest Reserves. This will be based on the selected plus trees result of WP2.

A total of thirty to sixty plus trees would be collected for vegetative propagation one-third in Pra Anum and two-thirds in Tain II. This would need ten two-day field visits. The objective is to produce sufficient number of mother plants for each clone in other to be able to start

rejuvenation process and to obtain materials for clonal testing (two hundred and fifty cuttings per clone).
The problem with the boiling water from the pump will be solved. Multiplication of the potted rooted cuttings will begin.

4.6.2 Technological wood characteristics assessment

Project Team: **F.W. Owusu, J. Ofori & A.A. Oteng-Amoako**

Introduction

Plantations of species including teak have been developed to take care of the reducing primary species in the natural forest. In removing pressure from the over-exploited primary species, these plantations are a means to encourage the forest products industry to utilize forest resources in the country for the development of the Ghanaian society.
Processed teak is very attractive, that is, it exhibits high quality sawn wood and veneer.
Teak industry profitability is related to stem form and variability in wood properties. Thus, the shape of a teak log is very important when considering the yield of the sawing process.

With the advent of near infrared spectroscopy for rapidly determining both qualitatively and quantitatively properties of organic molecules-containing products, possibilities of rapidly predicting wood properties have been established. WP5 therefore seeks to rapidly determine the quality of teak wood in different ecological zones of Ghana using near infrared spectroscopy by calibrating the classical laboratory reference methods. The results will then be used by tree breeders in silviculture and progeny trials in order to obtain high quality teak for planting. After calibration, the NIRS system will be used for measuring these properties on cores originating from hand-held motor-driven drill.

Measurement of the quality of teak boards would provide information for the selection of best silvicultural practices as well as the best provenances to improve on the quality of teak wood. The quality parameters of teak being considered are; natural durability, extractives content, shrinkage, density, colour and modulus of elasticity.

Objectives

i. To evaluate wood characteristics of Teak through classical destructive techniques and innovative non-destructive methods.

ii. To provide data on technological characteristics of Teak to assess the effects of site and silvicultural practices on wood characteristics.

Outputs

- Wood properties for silvicultural trials assessed.
- Quality of sawn timber assessed.

Activity 1: Processing of Teak from six different localities in Ghana

Work Done

1. Wood properties for silvicultural trials were assessed through:
   - Extraction of 5 (five) Teak trees each from 6 different localities in Ghana, (namely: Abofour, Wa, Kintampo, Dormaa Ahenkro, Somanya and Obuasi).
   - Cutting of three 5cm thickness discs from the butt end of each sample log for distribution to IVaLSA in Italy, CIRAD in France and FORIG for growth ring analysis tests; stem form, heartwood extension tests and Near Infra Red Spectroscopy studies and for storage respectively.

2. Sawing of diametrical boards from each log to:

- Determine angles between cutting direction and the north-south direction.
- Prepare 70cm and 40cm length pieces for further processing into strips for the determination of physical and mechanical properties as well as natural durability.

3. Assessment of quality of sawn timber for all thirty (30) logs extracted from the 6 different localities. From each log, yield (recovery) of boards was determined while visual grading of the boards was done for each board, taking into consideration defects like the shape, splits/shakes, sapwood proportion, knots, rotten heart/pith etc.

Status

- Moisture content of the mechanical test (BING) samples is being monitored and the samples are undergoing conditioning to a final mc of about 12%.
- The natural durability test boards and shrinkage samples are under storage.
- Assessment of dimensional quality of boards is still on-going.

Results

Table 18: Preliminary results of green moisture content and basic density of Teak from 6 different localities in Ghana

Locality	Number of samples	Green moisture content			Basic density		
		Mean	SD	Range	Mean	SD	Range
Wa	50	64.9	9.51	37.5 – 86.3	636	65	540.3 – 940.1
Somanya	90	60.6	15.28	36.1 – 105.7	633	50	508.5 – 743.6
Dormaa	70	70.6	7.19	49.8 – 87.2	593	34	530.8 – 721.3
Obuasi	70	105.6	13.20	80.8 – 135.5	560	47	479.0 – 691.6
Abofour	74	64.8	20.11	33.0 – 105.2	616	75	445.6 – 783.9
Kintampo	42	76.4	8.84	59.4 – 93.3	590	46	421.6 – 668.6

Table 19: Lumber yield of teak from six different localities in Ghana

Locality	Diameter range (m)	Log volume m^3	Volume of heartwood in lumber m^3	Volume of heartwood in log m^3	Lumber recovery (%)	Volumes of lumber and heartwood ratio
Abofour	0.155 - 0.278	0.6821	0.4786	0.5201	70.2 (0.1)*	0.920
Dormaa	0.151 - 0.290	0.5683	0.3396	0.3935	59.8 (0.06)	0.860
Kintampo	0.161 - 0.224	0.7792	0.4865	0.5083	62.4 (0.08)	0.957
Obuasi	0.230 - 0.260	0.7000	0.3595	0.3750	51.4 (0.06)	0.959
Somanya	0.199 - 0.282	0.6894	0.4652	0.5317	67.5 (0.08)	0.875
Wa	0.128 - 0.202	0.5474	0.2898	0.4000	52.9 (0.09)	0.724

* Standard deviation in brackets

The average diameters of the logs from the various localities were between 0.165m (Wa) and 0.245m (Obuasi).

The percentage lumber recovery of the teak from the six localities ranged between 51.4% (standard deviation = 0.06) and 70.2% (standard deviation = 0.1) and these were from Obuasi and Abofour respectively. The minimum and maximum ratios of the volume of heartwood in lumber to the volume of heartwood in log were 0.724 (Wa) and 0.959 (Obuasi). This is an indication that the heartwood that was lost as residues from the lumber recovered was lower with the Obuasi materials than with that of Wa.

The visual grading of the teak boards from both faces before drying was done by taking into consideration the sapwood proportion and defects like shape, splits/shakes, knots and rotten heart/pith.

Activity 2: Use of near Infra-Red spectroscopy for rapid prediction of wood quality

Teak samples collected from different ecological zones of Ghana were cut into boards and sent to CIRAD, France for wood quality assessment.

Table 20: Sample Collection

Ecological zone / Area	Number of trees	Age of stand
DSDF (Abofour)	11	28
Savanah (Wa)	5	31
Savanah (Kintampo)	5	43
DSDF (Dormaa Ahenkro)	5	23

2.2 Dimensions of test samples (Radial X Tangential X Longitudinal)

Shrinkage Sample : 30 x 25 x 40mm
Moisture Content (1) Sample : 30 x 25 x 20mm

Modulus of Elasticity Sample : 25 x 15 x 320mm
Natural Durability/Colour Sample : 25 x 15 x 50mm
Moisture Content (2) Sample : 25 x 15 x 50mm
NIRS Sample : 25 x 15 x 20mm
Chemical Extractives Sample : 25 x 15 x 100mm

2.3 Parameters determined included the following:

i. Shrinkage ii. Modulus of elasticity iii. Natural durability iv. Extractives content v. Colour and vi. Near infrared spectroscopy

Preliminary Results

i. Shrinkage

The preliminary results are shown in Tables 21 and 22.

Table 21. Radial, tangential and longitudinal shrinkage values from green to 6% moisture content.

Area	**Radial**	**Tangential**	**Longitudinal**
	(%)	**(%)**	**(%)**
Abofour	1.780	2.991	0.05
Wa	1.982	2.996	0.09
Kintampo	2.052	3.445	0.06
Dormaa Ahenkro	1.764	3.112	0.06

Table 22. Radial, tangential and longitudinal shrinkage values from green to 0% (oven dry) moisture content.

Area	**Radial**	**Tangential**	**Longitudinal**
	(%)	**(%)**	**(%)**

Abofour	2.564	4.106	0.1
Wa	3.204	4.218	0.4
Kintampo	2.889	4.789	0.1
Dormaa Ahenkro	2.668	4.624	0.6

ii. Modulus of elasticity

The preliminary results of the BING analyses are shown in Table 23.

Table 23. Average modulus of elasticity values from different ecological zones**.**

Area	**Average MOE (MPa)**
Abofour	15000
Wa	10000
Kintampo	16000
Dormaa Ahenkro	18000

iii. Near infrared spectroscopy

800 of NIR spectra have been generated ready for chemometric calibration models for rapid prediction of wood properties.

Work to be done

- Completion of natural durability tests.
- Determination of extractives content.
- Measurements of quality characteristics on samples from 1 ecological zone in Ghana and 1 ecological zone in Cote d'Ivoire.
- Chemometric modelling of the wood properties.
- Re-calibrations for properties that may have lower correlation coefficients of calibration.
- Relationship between the wood properties.

5.0 COMMERCIALISATION AND INFORMATION DIVISION (CID)

The Commercialisation and Information Division is made up of Information and Publication section, Computer section, Public Relations section and the Business Development section.

5.1 COMMERCIALISATION ACTIVITIES

The Commercialisation and Information Division is responsible for the coordination of all commercial activities of the institute. FORIG's commercial activities for the year under review centred mainly on the following:

1. Sale of Seeds
2. Sale of Seedlings
3. Sale of Wood
4. Consultancy Services

During the year, some of the commercial activities registered increase in sales while others registered reduction in revenue generation.

Sale of Seeds

Seed collection for the year 2005 started in November 2004 and closed in March 2005. During the period various species of tree seeds were collected. Based on seed request from our clientele, the seeds of various tree species were collected for sale namely, Ofram, Emire, Cedrela, Mahogany, Wawa, Edinam, Kusia and Teak. In all a total of over 800 Kg of seeds were sold out. The seeds were sold mainly to nursery and plantation developers. However, a substantial amount of seeds that were collected remained unsold because many of our clients preferred to collect their own seeds without recourse to the seed quality. It is our candid opinion that FORIG should be designated as the forest seed supply centre for Ghana to ensure that plantations that are being developed will continue to be of high quality and form.

Sale of Seedlings
Seedling sales were down this year with a lot of them unsold. No single reason could be assigned to this poor showing but many plantation developers produced their own seedlings so this could account for thee lack of patronage.

Sale of Wood
FORIG continued to sell thinnings of wood from its research plots at Amantia and Afram Headwaters at Abofour. It is evident that the sale of wood is not a sustainable source of income for FORIG because it is an activity that occurs periodically.

Training Activities
A numbers of training courses in Mushroom cultivation and snail rearing were organised in 2004 for church groups, school children and individuals. However, no training was organised for 2005 due to the tight schedule of the resource persons.

Sale of Spawns
Spawns for mushroom cultivation were however prepared and sold to various clients who had previously gone through the training and have established their own mushroom farms. They rely on FORIG to provide them with the spawns.

Contract Research
Few consultancy services and contract research activities were undertaken during the year.
The general revenue generated through commercialisation activities is shown in the table below.

Table 24: Internally generated fund (IGF) for the year 2005

DETAILS	INCOME (¢)	EXPENDITURE (¢)	NET REVENUE (¢)
1. Sale of Seeds	47,125,000.00	100,530,604.00	- 53.405,604.00
2. Sale of	2,825,000.00	5,020,000.00	-2,195,000.00

Spawn			
3. Sale of Seedlings	37,660,700.00	52,945,200.00	- 15,284,500.00
4. Sale of Wood	138,700,000.00	47,794,600.00	90,905,400.00
5. Consultancy Fees	48,134,263.00	28,186,205.00	19,948,058.00
Total	**274,444,963.00**	**234,476,609.00**	**39,968,354.00**

5.2 THE LIBRARY SECTION

The library provides essential information services to support research activities at the institute and to cater for the general information needs of the entire forestry stakeholders. The library has a book stock of approximately 6,500 books and subscribes to over 20 journal titles. The library also has in stock an extensive collection of bulletins, reports and annual reports.

In this era of advanced information storage and retrieval, it has become necessary for the library to facilitate access to information technology and provides the means and techniques by which researchers and other clientele could acquire advanced skills for literature searches.

The library is equipped with a few desktop computers, which provide access to a number of databases including PROSPECT, WOODS of the WORLD, FOREST COMPANIUM and FOREST SCIENCE.

The library is connected to the internet and provides access to many subscribed online journal titles such as those provided by AGORA, HINARI, EPSCO, PERI, etc. The library also provides access to internal and international databases such as Forestry Information Network (FIN), Environmental Information Network (EIN) and Global Forestry Information Service (GFIS).

The library continues to provide proactive services such as Selective Dissemination of Information (SDI) and the distribution of Journal Content List to scientists. During the year under

review, CD-ROM and internet services increased considerably. Over 500 literature and internet searches were conducted for users.

PART I1: GENERAL MATTERS

1.0 ADMINISTRATIVE MATTERS

1.1 STAFF STRENGTH

There is currently total staff strength of 266 made up of 49 senior members; 63 senior staff and 154 junior staff and daily rated workers. However, the approved 2005 manpower ceiling is 296.

1.2 NEW APPOINTMENTS

Mr. Francis K. Dwomoh was appointed Assistant Research Scientist effective 1st May, 2004.

1.3 CONTRACT APPOINTMENTS

Mrs. Augustina Gyimah, a retired Principal Research Scientist was given a two year contract appointment effective 1st November 2005

1.4 PROMOTIONS

- Dr. Joseph Ofori Principal Research Scientist was promoted Chief Research Scientist effective 01/01/2002.
- Dr. Daniel Sekyere was promoted from Senior Research Scientist to Principal Research scientist effective 1st July 2002.
- Messers John Agbozo and Michael Mensah both Senior Technical Officers promoted to Principal Technical Offices effective 1st January, 2003
- Mr. A. Yeboah-Konadu Senior Administrative Assistant promoted to Principal Administrative Assistant effective 1st January, 2004.
- Messers Jonathan Dabo and Samuel Sarpong were promoted from Senior Technical Assistant to Technical Officer effective from 1st January 2005.

1.4 RETIREMENTS

The following staff retired compulsorily during the year 2005.

- Messers Freeman Adu-Awuku and Ayim Boakye both Chief Technical Officers.
- Mr. Emmanuel Opoku, Senior Assistant Transport Officer (Traffic).

1.5 OFFICIAL VISITS

The following personalities paid an Official Visit to the Institute during the year under review:

- M.D. Swaine, University of Aberdeen, April 8, 2004.
- D. Wijewardana, Ministry of Agriculture and Forestry, New Zealand, May 4, 2004.
- E. Pekan and Robinet, O., French Embassy, July 5, 2004.
- J. Carret, World Bank, July 5, 2004.
- E. Labo, University of Aberdeen, July 21, 2004.
- M. Veeken, Amsterdam School of Business, July 21, 2004.
- Prof. A. A. Oteng-Yeboah, CSIR, July 21, 2004.
- Allard, G., FAO, Rome- Italy, July 21, 2004.
- P. Tweneboah, Ministry of Lands and Forestry, July 21, 2004.
- B. Steed, USDA Forest Service, July 21, 2004.
- Poff, B., H. Stockwell, M. Schaffer, B. Zebrowski and G. Seymour, Forestry School of Northern Arizona University July 21, 2004.
- Prof. S.E. Ayensu, Chairman, CSIR, August 25, 2004.

1.6 NATIONAL SERVICE PERSONNEL 2005/2006

Eleven (11) Service Personnel from the Kwame Nkrumah University of Science and Technology, K.N.U.S.T, University of Cape-Coast, U.C.C. and Kumasi Polytechnic started their service for the 2005/2006 at the Divisions/Sections mentioned.

	Name	Qualification	Institute	Section
1.	Awurama Andoh	HND. Sec. & Mgt.	K-Poly	Administration

2.	Daniel Addo Danso Shallom	B.Sc. Natural Res. Mgt.	KNUST	Seed Technology & Tree Improvement
3.	William Kwadwo Dumenu	B.Sc. Natural Res. Mgt.	KNUST	Biotechnology
4.	Abraham Kusi Obeng	B.Sc. Agric	UCC	Seed Technology & Tree Improvement
5.	Wilberforce Kwaku Asare	B.Sc. Natural Res. Mgt.	KNUST	Biology & Forest Health
6.	Kofi Nkansah Jnr.	B.Sc. Natural Res. Mgt.	KNUST	Biology & Forest Health
7.	William Kwame Bandoh	B.Sc. Biochem	KNUST	Biotechnology
8.	Lawrencia Gyamfi	B.A. Arts	KNUST	Commercialization & Information
9.	Kwadwo Opoku-Mensah	B.Sc. Natural Res. Mgt.	KNUST	Natural Forest Mgt.
10.	Josephine Bema Antwi	B.Sc. Natural Res. Mgt.	KNUST	Biology & Forest Health
11.	Jemima Lartey	HND Chem. Eng.	K-Poly	Chemistry & Chemical Technology

2.0 FINANCIAL MATTERS

2.1 OBJECTIVES OF THE FINANCE DIVISION

1. The Finance Division seeks to provide machinery for recording financial transactions in such a manner as to comply with legal and other requirements governing the operations of the Institute.

2. Provide suitable financial information to management for day-to-day management of the units of the Institute.

3. Assist in planning, both for short term and long term.
4. Establish internal control measures to safeguard assets of the Institute and ensure the completeness, accuracy and reliability of financial records.

2.2 GOG AND DONOR SUPPORT FOR RESEARCH

INFLOWS	**¢**
GOG Recurrent Grant	8,485,880,978.00
Service Grant (Research)	68,325,926.00
Other incomes	760,979,583.00
Total Inflows	9,315,186,487.00

OUTFLOWS	
Salaries and Wages	9,523,678,654.00
Administrative Costs	1,065,792,789.80
Service Activity Expenses	251,854,126.00
Total Outflows	**10,841,325,569.80**
Inflows less Outflows	**-1,526,139,082.80**

Negative sign shows that Outflows were more than Inflows. In 2005 Service Grant (Research) formed only 0.73 % of the GOG Subvention to the Institute, the remaining 99.27% was meant for Salaries and Wages and Administrative Costs.

APPENDIX I

LIST OF STAFF AS AT 31ST DECEMBER 2005

1. SENIOR MEMBERS

NAME		QUALIFICATIONS	DESIGNATION
1.	Joseph R. Cobbinah	BSc, Ph.D (Entomology)	Chief Research Scientist/ **Director**
		1.1 Administration Division	
2.	K. Adjei-Kusi	BA. (Hons.) Geography	Snr. Adm. Officer
3.	N. Obiri-Yeboah Darko	BSc (Hons.) Civil Eng.	Maintenance Engineer
4.	F. Osei-Amofah	BA. (Secretaryship), Dip.Ed.	Asst. Adm. Officer
5.	Comfort D. Konto (Ms)	BA. (Hons) Economics, Dip.Ed.	Asst. Adm. Officer
		1.2 Finance Division	
6.	Osei Yaw Adjei*	BA. (Hons.) Accounting Option	Assistant Accountant
		1.3 Natural Forest Management Division	
7.	Dominic Blay Jr.	BSc, MSc, PhD.	Snr. Research Scientist
8.	Victor K. Agyeman	BSc, MSc, PhD	Snr. Research Scientist
9.	Kwasi A. Adam	BSc, MSc, PhD.	Research Scientist
10.	K. Owusu-Afriyie *	BSc, MSc.	Research Scientist
11.	Francis K. Dwomoh	BSc. (Nat. Res. Mgt.)	Asst. Research Scientist
12.	Lucy Amissah (Mrs)	BSc M.Phil. (Nat. Res. Mgt)	Research Scientist

13.	Akwasi Dua Gyamfi	BSc. (Nat. Res. Mgt.)	Asst. Research Scientist
1.4 Seed Technology & Tree Improvement Division			
14.	Daniel A. Ofori	BSc, MPhil, PhD	Snr. Research Scientist
15.	Theresa Peprah (Mrs.)	BSc, MSc, (Tree Improvement)	Research Scientist
16.	Joseph M. Asomaning	BSc (Agric.), MSc (Seed Tech.)	Research Scientist
17.	Gloria D. Djagbletey (Mrs.)	BSc. M.Phil. (Natural Resources Mgt.)	Asst. Research Scientist
1.5 Plantation Production Division			
18.	Daniel E.K.A. Siaw	BSc, MSc., PhD. (Plantations)	Research Scientist
19.	S. Adu-Bredu	BSc. B.Sc. (Nat. Res. Mgt.), MSc., PhD (Agric. Science).	Research Scientist
20.	Luke C.N. Anglaaere	BSc, MSc. (Nat. Res. Mgt.) PhD	Research Scientist
21.	Ernest G. Foli	BSc, MPhil PhD (Forest Mensuration)	Snr. Research Scientist
22.	E. Owusu-Sekyere	BSc, MSc. (Agroforestry)	Research Scientist
23.	Isaac K. Abebrese	BSc., Mphil (Nat. Res. Mgt.)	Research Scientist
1.6 Biology and Forest Health Division			
24.	A. Oteng-Amoako	BSc, MSc, PhD. (Wood Products Engineering)	Prin. Research Scientist
25.	Mary M. Apetorgbor (Mrs.)	BSc, PhD. (Plant Mycology)	Research Scientist

26.	Evelyn Ahulu (Ms) *	BSc, MSc (Microbiology)	Research Scientist
27.	N. Gyimah-Boadi	BSc (Nat. Res. Mgt.), MPhil.	Research Scientist
28.	Bright O. Kankam	BSc (Natural Resources), MPhil	Research Scientist
29.	Paul P. Bosu	BSc (Bio. Science), Ph.D Forest Entomology	Research Scientist
30.	Emmanuel Opuni-Frimpong*	BSc, M.Phil. (Nat. Res. Mgt)	Research Scientist
31.	Emmanuel Ebanyenle	BSc., M.Phil (Natural Resources)	Research Scientist
	1.7 Engineering and Mechanical Processing Division		
32.	Joseph Ofori	BSc, MSc. & D.I.C., PhD. (Wood Tech.)	Prin. Research Scientist **/ Deputy Director**
33.	John de Graft Yartey	BSc, MSc. (Wood Science & Tech.)	Research Scientist
34.	Joseph K. Appiah	Dip. (Lab. Tech.), BSc (Wood Tech.), MPhil	Research Scientist
35.	Francis W. Owusu	BSc, MSc. (Wood Tech.)	Research Scientist
	1.8 Chemistry and Chemical Technology Division		
36.	Daniel Sekyere	BSc. PhD (Chemistry)	Prin. Research Scientist
37.	Sarfo A. Derkyi	BSc., MSc. (Chemistry)	Research Scientist
38.	Kofi Sarpong	B.Sc, MSc. (Chemistry)	Research Scientist
	1.9 Economics, Marketing and Policy Section		
39.	F. Ohene-Coffie	BSc, MSc, PhD (For. Economics)	Research Scientist

40.	B. Obiri-Darko (Mrs)	BSc, MSc. PhD	Research Scientist
41.	Emmanuel Marfo	BSc, MSc (Forestry Policy)	Research Scientist
42.	Eric E. Nutakor	BA (Social Science)	Asst. Research Scientist
43.	Lawrence Damnyang	BA, MA. Economics	Research Scientist
1.10 Commercialisation & Information Division			
44.	M. Sraku-Lartey (Mrs.)	BA, Post-Grad. Dip. (Lib. Studies), MA (Ind. Mgt.)	Snr. Asst. Librarian
45.	Kennedy K. Asamoah	BA. (Geog.), Post Grad. Dip. (Lib. Studies)	Asst. Librarian
46.	Stella Britwum* (Ms)	BSc. (Computer Science)	Asst. Comp. Programmer
47.	Naomi Appiah (Mrs.)	B. A. Publishing Studies	Junior Assistant Librarian (Publications)
48.	Samuel Owusu Yeboah	BSc. (Bio. Science), M.Sc. (Food Security & Nat. Res. Mgt.)	Scientific Secretary

* Study Leave ** Sabbatical Leave

2.0 SENIOR STAFF

NAME		QUALIFICATIONS	DESIGNATION
2.1 Administration Division			
1.	Kate C. Djokoto (Mrs.)	Dip. (Stenography)	Chief Adm. Asst.
2.	Asiamah Konadu Yeboah	GCE 'O' Level, MDPI Cert.	Prin. Adm. Asst.
3.	Georgina Atta (Mrs.)	City & Guilds 706/1 & 706/2	Principal Catering Officer (Administration)
4.	Samuel Larbi	GCE 'O' & 'A' Levels	Snr. Adm. Asst.
5.	Benevolio K. Stephens	MSLC, MDPI Cert.	Adm. Asst.
6.	John Sackey	City & Guilds Builders II	Prin.Works Supt.
7.	Francis Sagoe-Paintsil	Testimonial in Draughtsmanship	Draughtsman Gd. I
8.	K. Mensah-Nyantakyi	GCE 'O' & 'A' Levels	Snr. Security Officer
9.	Paul Adusei	NVTI Cert. II & I,	Tech. Officer
10.	Samuel K. Appiah	KTI Cert.	Snr. Asst. Transport Officer
11.	John Eshun	HND Secretaryship and Business Mgt.	Snr. Adm. Asst.
2.2 Finance Division			
13.	N. Agyeman-Prempeh	ICA (Inter), ICA (Part II)	Chief Accounting Asst.
14.	E.Y.B. Imouro	RSA Stage III	Prin. Accounting Asst.
15.	C.C. Acheampong	RSA State III	Snr. Accounting Asst.
16.	E. Owusu-Agyeman (Mrs)	RSA State III	Prin. Accounting Asst.

17.	I. Mensah Bonsu	RSA Stage III, AIA Part A	Snr. Accounting Asst.
18.	K. Mankoe	RSA Stage III	Snr. Accounting Asst.
19.	Victoria Erskine (Ms)	RSA Stage III, GCE ('O' & 'A' Levels) Dip. (Accounting & Mgt.)	Snr. Accounting Asst.
20.	Mavis Kwarteng (Ms)	RSA Stage III	Snr. Accounting Asst.
21.	J. J. Mensah	RSA Stage III	Snr. Accounting Asst.
22.	Asamoah Dickson	RSA Stage II	Accounting Asst.
2.3 Natural Forest Management Division			
23.	Augustina Addai (Ms.)	Forestry School Cert.	Chief. Tech. Officer
24.	Thomas Alhassan Idrissu	Dip. Forestry	Chief. Tech. Officer
25.	Alfred Boakye	Forestry School Cert.	Prin. Tech. Officer
	Jonathan Dabo		Tech. Officer
	Samuel Sarpong		Tech. Officer
2.4 Seed Technology and Tree Improvement Division			
26.	Miss Jacqueline Twinto	Forestry School Cert.	Tech. Officer
27.	Letitia A. Asamoah (Ms)	Forestry School Diploma	Prin. Tech. Officer
28.	S. Ackom Okyere	Farming Institute Cert.	Tech. Officer
29.	Eric Amankwah	Dip. Lab. Tech.	Tech. Officer

2.5 Plantation Production Division			
30.	B.K. Addei	BSc (Natural Resource Mgt.)	Chief Tech. Officer
31.	Oppong Y. Duah	Diploma in Forestry	Chief Tech. Officer
32.	Kingsley Sarfo	Forestry School Cert., Dip. (For.)	Prin. Tech. Officer
33.	M. Agyeman-Prempeh (Mrs)	Forestry School Cert.	Snr. Tech. Officer
34.	Yamoah Kyei	Dip. Forestry	Snr. Tech. Officer
35.	Elizabeth Ampah (Ms)	Forestry School Cert.	Snr. Tech. Officer
2.6 Biology and Forest Health Division			
37.	J. Appiah-Kwarteng	Dip. (Forestry)	Chief Tech. Officer
38.	Freeman A. Awuku	Dip. (Forestry)	Chief Tech. Officer
39.	R. Boamah-Tawiah	Forestry School Certificate	Chief Tech. Officer
2.7 Engineering and Mechanical Processing Division			
40.	A.I. Mohammed	Dip. (Forestry)	Chief Tech. Officer
41.	Bridgette Brentuo (Mrs)	Dip. (Lab. Tech.), BSc.	Prin. Tech. Officer
42.	G. K. Zorve	Adv. City & Guilds (Carpentry & Joinery)	Snr. Tech. Officer
43.	Michael Mensah	Dip. (Forestry)	Prin. Tech. Officer
2.8 Chemistry & Chemical Technology Division			
44.	Samuel Adu-Poku	City & Guilds Science Lab. Tech. Cert. Part I	Prin. Tech. Officer
45.	Maxwell O. Bekoe	Lab. Technician Diploma	Tech. Officer

46.	Kwabena Prempeh Bandoh	Lab. Technician Diploma	Tech. Officer
2.9 Commercialisation & Information Division			
47.	Godfrey Mensah	Cert. in Library Studies	Prin. Library Asst.
48.	Emmanuel Asiedu Opoku	HND. Statistics	Tech. Officer (Stats)
49.	P.H.K. Amuah	Cert. in Forestry	Chief Tech. Officer
50.	John K. Agbozo	Dip. (Computer Science)	Prin. Tech. Officer
51.	Dramani Bukari	Cert.in Photography, Cert. 'A', B.A Publishing Studies	Snr. Tech. Officer
52.	A.K. Nyaha	City & Guilds Cert. (Cabinet Making)	Tech. Officer
53.	Peter Loving Arthur	City & Guilds Cert.	Tech. Officer
54.	Eric K. Frimpong	City & Guilds Cert. (Cabinet Making)	Tech. Officer

* Study Leave

APPENDIX II

LIST OF PUBLICATIONS

The following Refereed Journal Papers, Technical Reports, Manuals and Conference Papers were produced during the year under review.

Refereed Journal Papers

1. **Apetorgbor,** M. M., Gyimah-Buadi, N., Darkwa, N. A. & Kyereh, B. (2005): Chemical control of blue stain and insect borers in *Pterygota macrocarpa* logs at a logging site. Ghana Journal of Forestry (Accepted).
2. **Apetorgbor,** M. M., Apetorgbor, A. K. & Obodai, M. (2005): Indigenous knowledge and utilization of edible mushrooms in Southern Ghana. Ghana Journal of Forestry (In press)
3. **Ebanyenle,** E. & Oteng-Amoako, A. A., (2005): Variation in some Anatomical and Physical Properties of Stems of five Rattan Palm Species of Ghana, *International Journal for Bamboo and Rattan*, 4 (2), 125-142.
4. **Ebanyenle,** E., Oteng-Amoako, A., Sunderland, T.C.H., Beligné V., Bonnéhin, L. & Zouzou, E. J. (2005): Taxonomy, Population Dynamics and Utilisation of the Rattan Palms of Upper Guinea Forests of West Africa, (In): *Forest Climbing Plants of West Africa – Diversity Ecology and Management*, F Bongers, M. P. E. Parren, D. Traoré (Eds), pp 145-164, CABI Publishing.
5. **Ofori,** D.A, Verhaegen, D. Fofana, I., Poitel, M. & Vaillant, A. (2005). Development and characterisation of microsatellite markers in *Tectona grandis* (Linn, f). *Molecular Ecology Notes* 5, 945-947.
6. **Ofori,** D. A., Afreh, K. A., Oteng-Amoako, A.A. & Dzogbefia, V. (2005). Genetic structure of *Bambusa vulgaris* in Ghana using RAPD and its implications for sampling and conservation. Submitted to *Journal of Bamboo and Rattan*.
7. **Ofori,** D.A. & Cobbinah, J. R. (2005). Forest biodiversity conservation - The role of molecular markers in seed orchard establishment. BIOTECH.GHANA, 3:1, 3-4.

8. **Ofori,** J & Brentuo, B. (2005): Green moisture content, basic density, shrinkage and drying characteristics of the wood of C*edrela odorata* grown in Ghana. *Journal of Tropical Forest Science* ***17****(2):211-223(2005).*
9. **Owusu-Sekyere,** E., J. Cobbina & T. Wakatsuki. Distribution Characteristics of Mineral Elements in Tree Species from Two Contrasting Secondary Forests in Ghana. 2005, *West African Journal of Applied Ecology.*
10. **Owusu-Sekyere,** E., Cobbina J., Annan-Afful E. & Wakatsuki. T. Distribution. Nutrient Cycling in Primary, Secondary Forests and Cocoa Plantation in Ashanti Region, Ghana. 2005, *West African Journal of Applied Ecology*.

Technical Reports

1. **Bosu,** P.P., Cobbinah, J.R. & Obiri, B.D. (2005). Alternative Mixed Plantation Systems and Restoration Strategies for Conservation and Sustainable Production of Native Timber Species in Ghana. Progress Report No. 2 Submitted to ITTO, August 2005.
2. **Bosu,** P.P., Cobbinah, J.R., Obiri & B.D. (2005). Alternative Mixed Plantation Systems and Restoration Strategies for Conservation and Sustainable Production of Native Timber Species in Ghana. Progress Report No. 1 Submitted to ITTO, February 2005.
3. **Bosu,** P. P. (2005). Restoration, Conservation and Sustainable Production of Indigenous Timber Species in the Goaso District of Ghana. Report submitted to Tropenbos Ghana Programme, December 2005.
4. **Ofori,** D.A., Siaw D.E.K.A., Peprah, T. & Cobbinah, J.R. (2005). Domestication of Allanblackia in Ghana. Progress report submitted to ICRAF, Nairobi, Kenya. Pp18.
5. **Ofori, J.** (2005): Assessment of the bending strength (fibre stress) and related properties of Caribbean pine (*Pinus caribaea)* poles grown in Congo. Prepared for Cachecorp Procurement (Pty) Ltd; Greyville, South Africa. (August 2005). 16pp.

6. **Ofori,** D. A., Cobbinah, J.R. & Djagbletey, G. (2005). Genetic improvement, productivity and biodiversity conservation of

Triplochiton scleroxylon K. Schum in West Africa. Progress report submitted to AFORNET.

Manuals

1. **Derkyi,** S. A., Sekyere, D., Yartey, J. G. & Darkwa N. A. (2005) Training Manual for the Production of Plywood with Cassava Flour as Extender .
2. **Derkyi,** S. A., Sekyere, D., Yartey, J. G. & Darkwa N. A. (2005) Quality Assurance Manual for Plywood Production with Cassava Flour as Extender.

Workshop/Conference Papers

1. **Apetorgbor,** M. M., Apetorgbor, A. K. & Nutakor, E. Utilization and cultivation of edible mushrooms for rural livelihood in Southern Ghana. 17th Commonwealth Forestry Conference on Forestry's contribution to poverty reduction. Colombo, Sri Lanka. 28th February - 05 March, 2005.
2. **Ofori,** D.A.. Siaw D.E.K.A., Perpah, T. and Cobbinah, J.R. (2005). Domestication of *Allanblackia* in Ghana. Achievements at Forestry Research Institute of Ghana. Oral Presentation, *Allanblackia* Planning Meeting, 29th November-1st December 2005, ICRAF, Nairobi, Kenya.
3. **Sraku-Lartey**, M., Developing the professional skills of information managers in the forestry sector in Africa, paper presented at the IAALD World Congress in Kentucky USA, May 14-19, 2005.
4. **Sraku-Lartey**, M., Enhancing access to forestry information in Africa to ensure sustainable forest management, Paper presented at the IUFRO World Congress 8-14 August 2006, Brisbane, Australia.
5. **Ofori, J.** (2005): 'Utilisation of wood in the handicrafts industry'. Sensitization workshop on the Handicraft Industry in the Ashanti Region. Organised by the National Association of Handicrafts Exporters & Manhyia Development Unit / Promoting Partnership with Traditional Authorities. At the Wood Industries Training Centre, Akyawkrom. 25th February 2005. 14pp.

APPENDIX 111

SCHEDULE FOR INTERNAL COLLOQUIA FOR 2005

During the year 2005, twenty-four (24) internal colloquia were held as presented in the table below:

Date	Speaker	Topic
10/02/05	Eric Nutarkor	The Socioeconomics of indigenous fruits in Northern Ghana
17/02/05	S. A. Derkyi	
22/02/05	S.K. Osei	Ghana Agricultural Information Network System : An Update
03/03/05	Lawrence Damnyag & E. Nutarkor	Policies and pathways out of Poverty in high forest zone: the role of forest resources in Ghana
14/04/05	Emmanuel Ebanyenle	Scientific Data Management Training Course –*An overview*
24/05/05	Mr. Emmanuel Opuni-Frimpong	Towards Sustainable Timber Production in Ghana: Improving Shoot Borer resistance and developing Silvicultural Systems to maximize Mahogany Plantation success
09/06/05	Lawrence Damnyag	Using environmental values to communicate values of Bobiri forest: A multicriteria decision analysis
23/06/05	Kennedy Owusu-Afriyie	Fire damage to forest structure and the road to restoration: the convalescence option
30/06/05	Afia Konadu (M.Sc.	Characterization of genetic

	Student, KNUST)	diversity in *Bambusa vulgaris* in Ghana and its implications in for domestication and conservation
08/07/05	Prof. Heiner Schanz (Inst. of Forest Policy and Politics, Freiburg University)	Connecting the links : Forest governance, sustainable forest management and Scientific Research
14/07/05	Dr. F. Ohene-Coffie	Cost of producing seedlings of forest tree species in a nursery: a case study of the FORIG nursery
26/07/05	Presentations by National Service Personnel	
28/07/05	Dr. Andrew J. Storer (Michigan Technological University, USA)	The use of behavioral Chemicals in forest pest management
04/08/05	Mr. Ebenezer Owusu-Sekyere	Impact of changing Land cover on the production & ecological functions of vegetation in Inland Valleys in Ghana, West Africa (VINVAL)
25/08/05	Mr. Emmanuel Marfo	Does the Law matter ? Researching Legal Pluralism in Forest Governance
08/09/05	Dr. Luke C.N. Anglaaere	Leaf phenology and crown characteristics of some indigenous forest tree species in relation to shade provision for cocoa cultivation in Ghana
14/09/05	Dr. Victor Agyeman	Biodiversity Conservation

		under Cocoa Cultivation
17/10/05	Ms. Katherine Secoy (Desk Officer, Global Canopy Programme)	Whole Forest Observatory Project in Ghana
20/10/05	Ms. Claudine Ethier	Improving forest Nursery technique in Ghana
25/10/05	Mrs. Lucy Ammissah	Biodiversity Assessment and Monitoring: Methods and Techniques
01/11/05	Dr. K. Asamoah Adam	Tree species abundance and regeneration under traditional farming systems: Implication for mamagement of Farm Woodlands for Timber
10/11/05	Dr. Daniel A. Ofori	Genetic diversity in *Tectona grandis* (teak) and its implications for improvement and conservation
24.11.05	Mr. S. A Derkyi	Rapid prediction of Teak wood properties using Near Infrared Spectroscopy
06.12.05	Mr. A. D. Gyamfi	Seedling dynamics after Selective Logging in the moist tropical forest in Ghana

APPENDIX 1V

COMPOSITION OF FORIG MANAGEMENT BOARD

1.	Prof. A. Oteng-Yeboah Dep. Director General, CSIR	Chairman
2.	Dr. J.R. Cobbinah Director, FORIG	Member
3.	Dr. S.O. Bennet-Lartey Director, PGRC	Member
4.	Dr. Wahab Alhassan Rep. Ministry of Finace	Member
5.	Mr. A.S.K. Boachie-Dapaah Chief Executive, Forestry Commission	Member
6.	Mr. J.K. Otoo Executive Director, Forestry Services Division	Member
7.	Dr. William Oduro Director, IRNR-KNUST	Member
8.	Nana Dwomoh Sarpong G.T.M.O	Member
9.	Mr. K. Awuah Agyeman Rep. of FAWAG	Member
10.	Peter Osei-Wusu Rep. of Tree Growers	Member
11.	Mr. J.A. Armah Rep. of G.T.A	Member
12.	Mr. K. Adjei-Kusi Snr. Adm. Officer, FORIG	Secretary