**DFID Forestry Research Programme Project R7210**

**A species monograph on *Bombacopsis quinata***




**FINAL REPORT**

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## 1. Executive Summary


**Project Purpose**
*Multipurpose tree species with improved performance (e.g. drought/temperature tolerance) identified and their use in agroforestry systems promoted*

*Bombacopsis quinata* has been identified (including farmer participatory processes) throughout Central America, Colombia and Venezuela as a priority species for planting (fence lines and plantations), utilisation, conservation and tree improvement. Reforestation by resource poor farmers and by commercial companies increased demand for both quality seed and information, directly applicable to the management of *B. quinata*. A large body of research already existed, however application of results from problem driven research requires dissemination in the users' language; the focus of this project.

**Outputs**
The project worked with teams from CATIE (Costa Rica), CAMCORE (USA), and CONSEFORH (Honduras). CATIE revised growth/yield data from Central America in CATIE's database to check existing growth, yield and site quality equations for other climatic conditions in the region. CAMCORE collated and analysed data from existing provenance/progeny trials. CONSEFORH conducted pilot socio-economic surveys in Colombia, Costa Rica, Honduras and Nicaragua, which were published in the CONSEFORH Serie Miscelanea. The project produced and distributed; a) a monograph on *B. quinata*, b) an extension manual (validated through a users' workshop), c) a briefing paper summarising the current and potential value of *B. quinata* for resource poor farmers.

**Contribution of Outputs to Project Goal**
The outputs of the project have been achieved and are being widely distributed in the region. The policy review (summarised in the policy briefing note) shows *B. quinata* offers opportunities for improving small farmer livelihoods in the region, although a number of limitations restrict uptake. Greater dissemination of existing research results is required to increase the species incorporation within farming systems projects. Current incentives push producers towards short rotation exotics and are decisive in limiting *B. quinata*'s planting. Modifications should consider differential payments for native species (recognition of greater environmental service value) and for those of longer rotation. Policies are required that limit restrictions on harvesting of plantations and natural regeneration managed by farmers. Recent changes in plantation legislation to this effect require greater dissemination to field technicians and farmers. Overcoming a lack of markets for juvenile wood (thinnings, short rotations) and achieving greater added product value requires changes in preparation/implementation of forestry projects to look beyond plantation establishment and silviculture, to consider their management and integration within industry projects.

**Dissemination and Publications**
The project produced 1 book, 1 extension manual, 1 policy briefing note, 4 internal reports, 1 validation workshop. See pages 14-16 for details

**Follow-up Indicated/Planned**
The issues highlighted by the project are being pursued through R7588. Promotion of *B. quinata*, along with other native species, is continuing along with the promotion of the production of more extension materials on native species of user preference. The principlepal information from R7210 has been included in the species description sheet which uses a format of direct use to extension workers. This project targets extension workers throughout Central America who are in direct contact with large numbers of resource poor farmers.

**List of acronyms**

| | |
|---|---|
| AFE-COHDEFOR | Agencia Forestal Estatal - Corporación Hondureña de Desarrollo Forestal, Honduras |
| CAMCORE | The Central America and Mexico Coniferous Resources Cooperative, USA |
| CATIE | Centro Agronomico Tropical de Investigación y Enseñanza, Costa Rica |
| CIFOR | Centre for International Forestry Research |
| CITES | Convention on International Trade in Endangered Fauna and Flora |
| CMG & BSF | Centro de Mejoramiento Genetico y Banco de Semillas Forestales, Leon, Nicaragua. |
| CONIF | Corporación Nacional de Investigación y Fomento Forestal, Colombia. |
| CONSEFORH | Proyecto de Conservación y Silvicultura de Especies Forestales de Honduras, Honduras. |
| CUPROFOR | Centro de Utilización y Promoción de Productos Forestales, Honduras. |
| EARTH | Escuela de Agricultura para la Region Tropical Humeda, Costa Rica |
| ESNACIFOR | Escuela Nacional de Ciencias Forestales, Honduras |
| FAO | Food and Agriculture Organization |
| FRP | Forest Research Programme of DFID |
| INA | Instituto Nacional Agraria, Honduras |
| LABONAC | Laboratorio Nacional de Productos Forestales, Venezuela. |
| MINAE | Ministerio del Ambiente y Energia (formly MIRENEM), Costa Rica |
| NGO | Non-governmental organization |
| NHM | Natural History Museum, London, UK. |
| OFI | Oxford Forestry Institute, University of Oxford. |
| PMA | Proyecto Ordenación Forestal Participativa, COHDEFOR, Honduras |
| PMGF | Proyecto Mejoramiento Genético Forestal, CATIE, Costa Rica |
| PROCAFOR | Programa Regional Forestal para Centroamérica |
| PROSEFOR | Proyecto de Semillas Forestales, Central America. |
| REMSEFOR | Red Regional de Semillas Forestales de Centroamerica y el Caribe. |
| SETRO | Semillas Tropicales SA, Siguatepeque, Honduras |

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## 2 Background

**RESEARCH PROGRAMME PURPOSE:** New knowledge applied to problems in forest and tree resource management, the resolution of which benefits poor forest and tree - dependent people within the Forest/Agriculture Interface.
**RESEARCH PRODUCTION SYSTEM:** Forest Agriculture Interface
**COMMODITY BASE:** Timber
**BENEFICIARIES:** Direct beneficiaries: target institutions, extensionists. Ultimate beneficiaries: those planting, harvesting & collecting seed of *B. quinata* (resource poor farmers, contracted seed collectors, larger industrial scale planters).
**TARGET INSTITUTIONS:** National forestry organisations, seed banks, private reforesters, extension agencies in Central America, Colombia and Venezuela.
**GEOGRAPHIC FOCUS:** Colombia, Costa Rica, Honduras, Nicaragua, Panama, Venezuela

### 2.1 The importance of *Bombacopsis quinata*

Within its native range (Central and northern South America), *Bombacopsis quinata* is a highly valued timber, often used in living fence rows. In the period 1963-65 it was the second most important species in Venezuela in terms of volume produced (Finol and Melchior, 1970) and remains the most important timber species in the Llanos Occidentales region (FAO, 1986). At US$ 50 per board foot roundwood, in value it is second only to mahogany in the internal market of Panama (Moran, 1991). Principle uses of the fine, pale, stable timber, are for carving, interior panelling, windows and doors, while large stakes are used as living fence posts. Wood of *B. quinata* from natural stands is much in demand for the production of timber, plywood and veneer (Kane *et al*., 1993). In Colombia in 1991, some 40,000 $m^3$ of timber of *B. quinata* were exploited and by 1995 the value of the timber was at some $400 per $m^3$ (CONIF, 1996). Such timber qualities have made it the focus of extensive felling, both legal and illegal, throughout its range. This, coupled with general deforestation and negative agricultural practices, has led to a once common species becoming limited to isolated forest remnants (Hughes, 1989) and considered as endangered in some cases (Jimenez, 1993). *B. quinata* has attracted considerable investment, resulting in the establishment of thousands of hectares, both through reforestation by resource poor farmers and by commercial companies. *B. quinata* offers relatively easy plantation culture, moderate growth rates (10 - 20 $m^3$ $ha^{-1}$ $year^{-1}$ on most sites), and the production of a valuable and versatile wood of moderate density.

Use and planting of locally preferred indigenous species, such as *B. quinata*, in the seasonally dry Pacific regions of Central America is limited by a number of factors (*e.g.* seed production, unknown plantation/economic yields; Vasquez, 1996). *B. quinata* may have its greatest potential on low altitude sites of relatively low rainfall (800-1200 mm $annum^{-1}$) where other commercial species, producing similar quality timber, exhibit poor survival or slow growth (Kane *et al*., 1993). In a region where little original forest remains (<2%; Janzen, 1986), the project's outputs will promote the use of information in the efficient planting, growth and utilisation of the species, and the availability of high quality genetic material.

### 2.2 Demand and need for the research

*B. quinata* has been identified as a species under severe threat at the level of populations (FAO, 1986), and classified by the FAO Panel of Experts on Forest Genetic Resources, as maximum priority for genetic conservation, exploration and evaluation (FAO, 1993). Within its natural distribution *B. quinata* is listed by all national agencies and by CATIE, as a high priority species (*e.g.* Costa Rica, Nicaragua, CMG&BSF, 1995; Colombia, Motta, 1996, Pinto, 1997). *B. quinata* was identified by several bilateral project in the region as a priority species (*e.g.* ex DFID sponsored projects; CONSEFORH, Honduras; PMGF/CATIE, Costa Rica; DANIDA sponsored projects; PROSEFOR/CATIE Central America). Local recognition of the importance of the species is illustrated by the dedication of a whole issue of "Mejoramiento genético and semillas forestales para América Central" describing current and planned activities, related to the genetic resources of *B. quinata* (CATIE, 1991a). Similarly actual demand for seed of *B. quinata* was high and increasing: *e.g.* 65kg over the next five years in Nicaragua (CMG&BSF, 1995); the tree seed bank (ESNACIFOR, Honduras) distributed more than 25kg of *B. quinata* seed in 1994 compared to

almost nothing in 1993 (Barcenas pers. comm.); whilst a private seed bank's sales in 1997 in Honduras amounted to 150 kg (SETRO, pers comm.). The considerable investment in reafforestation using this species was also evidence of the level of interest. By 1997 some 9,000 ha had been planted in Colombia (Lugo, 1997); while in Costa Rica, by 1995, some 20,000 ha had been planted by a mixture of small and medium scale reforesters (MINAE, 1996).

A lack of both seed and information directly applicable to the planting and silvicultural management of *B. quinata* has, however, limited the extent and success of such investment (Vasquez, 1996). Considerable silvicultural research on *B. quinata* had been carried out, however, the results were, often unpublished, of variable quality and when published were not widely disseminated. Reliable growth models, and volume tables for *B. quinata* were limited to specific areas within a few countries (*e.g.* Vasquez and Ugalde, 1995). Recommendations for one ecological zone, may not be applicable to others, so that the application of blanket views, such as "Pochote (*B. quinata*) can grow on any site, particularly hill tops" had led to economic losses and disincentives to reafforestation (Vasquez, 1996). The comparative evaluation and collation of silvicultural research results from across the region into one monograph would provide more reliable growth and economic indicators of success, on different sites.

There have also been substantial problems with respect to seed quality and quantity. As a consequence of demand for *B. quinata* seed, seed orchards had been established in three countries within the natural distribution, but yields varied from 1kg to 55kg per ha. (Urueña, 1992; Sandiford, 1998). Results from FRP project ZF0017 indicated that various interventions are possible to alleviate problems associated with seed production; *e.g.* genetic variation in remnant stands and fence lines, implications of the breeding system/flowering synchrony, improvements in seed orchard design and management including the control of insect seed pests. Lack of quality seed puts in doubt the predictability and dependability of resulting planting stock, or of plantings to achieve expected yields, placing substantial investments, both in time and money, at risk. This in turn may act as a disincentive to future planting. Similarly, despite the potential of *B. quinata* and the extent of plantation initiatives, the level of development and use of the species varies considerably between countries in the region. To understand the social, economic and market factors that determine the domestication and use of *B. quinata* in the different countries of Central America, Colombia and Venezuela, there was a need to study the wide range of factors that influence the attractiveness of *B. quinata* to the potential growers who range from resource poor farmers to commercial companies in the forest industry.

### 2.3 Previous Research

By the very nature of this project, there was already a large body of both published and unpublished information on this species. Indeed the success of the project depended on the existence of this work. Some of these publications (*e.g.* CATIE 1991b; CONIF, 1996; Morales and Whitmore, 1978; Navarro and Martinez; 1989), are syntheses of the state of knowledge and practice for the species, although they are generally limited either in geographical scope, subject or age of the material (*e.g.* Hughell, 1991, Vasquez, 1996). As such there was no one publication that integrates all the subject material as in this monograph. In particular data on wood properties and utilisation (*e.g.* Moya and Cordaba, 1995) was either poorly reported or not easily available. Vegetative propagation had been extensively studied, using both macro (*e.g.* Melchior and Quijada, 1972) and micro techniques (*e.g.* Miranda, 1986, Newton *et al*., 1991), as has seed collection and storage (*e.g.* CATIE, 1997). In contrast information from genetic trials and on reproductive biology had not previously been widely reported, nor was it readily available, as it had only just been (*e.g.* Sandiford, 1998) or was still in the process of being generated (*e.g.* CAMCORE trials; Dvorak and Donahue, 1991; Paterson *et al*., 1996). Studies of a socio-economic nature had been mainly limited to young plantations or to Costa Rica (*e.g.* Alfaro, 1991; Navarro 1987, Navarro 1988). New research under this project aimed to fill such gaps in existing knowledge (socio-economic and yield models; older trees and greater geographic spread), provide the benefits of and make widely available key information to improve production of plantations, seed orchards, wood utilisation *etc*.

## 3 Project Purpose

*Multipurpose tree species with improved performance (e.g. drought/temperature tolerance) identified and their use in agroforestry systems promoted*

*Bombacopsis quinata* has been identified (including farmer participatory processes; *e.g.* Colindres *et al*., 1995) throughout Central America, Colombia and Venezuela as a priority species for planting (fence lines and plantations), utilisation, conservation and tree improvement. Reforestation by resource poor farmers and by commercial companies increased demand for both quality seed and information, directly applicable to the management of *B. quinata*. A large body of research already existed, however application of results from problem driven research requires dissemination in the users' language; the focus of this project.

## 4 Research activities

The main project activity was the writing, publication and distribution of a monograph (in the OFI Tropical Forestry Paper series) on *B. quinata*, and a sample extension manual. Through collaboration with key organisations in Central and South America that are most active in *B. quinata* research (i.e. CATIE, CONSEFORH, CAMCORE), the project used both published research, existing research projects nearing completion and where necessary some new research (related to provenance/progeny trials, growth models, socio-economic factors). Only issues relating to new research or analysis are detailed in sections 4.1-4.3.

### 4.1 Provenance and progeny trials

Provenance/progeny tests had been previoulsy established in randomized complete block designs replicated nine times with six-tree family row plots. Spacing was 3x3m at all locations. Tests were planted over several years with provenance composition varying from year to year. Therefore, provenances were not equally represented across tests or years. Seeds from the Atlántico, Colombia provenance were included in 8 of 10 trials as a control.

Of the 272 open-pollinated families distributed only 155 produced enough seedlings to be included in the tests. Tests were assessed at one year for survival, three years for height and diameter at breast height (dbh), and five and eight years for both growth and quality traits. An individual tree volume index (over bark) was calculated using the formula:
**$V=0.00003d^2h$** where V is individual tree volume in $m^3$, d is diameter at breast height in cm, and h is total tree height in m. The quality traits of stem straightness and branch diameter were scored on a 1 to 3 scale with 1 being the most crooked stem or largest diameter branch, and 3 being the straightest stem or smallest branch diameter. A relative score for number of spines on the trees was also recorded for test 01A at Zambrano using a 1 to 3 scale. A score of 1 indicates many spines and 3, few or no spines.

Pizano/Monterrey also established two full-sib progeny trials at Zambrano derived from a partial diallel mating design from clones in its first generation orchard. The origin of the material in the clonal orchard were plus tree selections which came predominantly from the Atlántico department in Colombia, and a few selections from the Bolivar department.

The two full-sib tests were established in a randomized complete block design on different sites near Zambrano with a total of 112 families and 105 families common to both sites. Crosses among 52 parent trees generated the 112 full-sib families. Each test was divided into three sets, with six replications and six tree family row plots and planted at 3x3m spacing. The full-sib trials were measured at four years of age for height, dbh, stem straightness, branch diameter, and spininess using the same assessment criteria as described above.

**STATISTICAL ANALYSES**
Single-site analyses were conducted for each open-pollinated provenance/progeny tests. The linear model was:

$$y_{ijklm} = \mu_i + B_j + P_k + F(P)_{kl} + B*f(P)_{jkl} + e_{ijklm}$$

where $y_{ijklm}$ = phenotypic observation for the ijklm$^{th}$ tree,
$\mu_i$ = mean in the i$^{th}$ test,
$B_j$ = fixed effect of the j$^{th}$ block,
$P_k$ = fixed effect of the k$^{th}$ provenance,
$F(P)_{kl}$ = random effect of the l$^{th}$ family in the k$^{th}$ provenance,
$E[f(P)_{kl}] = 0$, $Var[f(P)_{kl}] = \sigma^2_F$,
$r_{jkl}$ = random effect of the jkl$^{th}$ row-plot, specifically the interaction of the j$^{th}$ block and the l$^{th}$ family of the k$^{th}$ provenance, $E[r_{ikl}] = 0$, $Var[r_{ikl}] = \sigma^2_r$,
$e_{ijklm}$ = random error associated with the ijklm$^{th}$ tree, $E[e_{ijklm}] = 0$, $Var[_{eijklm}] = \sigma^2_e$,

Variance components for all traits were estimated using PROC VARCOMP METHOD=REML (SAS 1989). Phenotypic variance within-provenance ($\sigma^2_T$) was calculated as:

$$\sigma^2_T = \sigma^2_F + \sigma^2_r + \sigma^2_e.$$

Single-site (or biased) heritability estimates within provenance ($h^2_B$) were estimated for all traits using the formula: $h^2_B = 3\,\sigma^2_F / \sigma^2_T$.

The covariance among offspring of true half-sib families is ¼ of additive genetic variance (i.e. the coefficient of relationship is 0.25). The coefficient of relationship of open-pollinated families will often be higher than 0.25; this could result from inbreeding and/or a small number of effective male pollinators leading to the presence of some percentage of full-sibs within the OP family. Thus, a coefficient of 3 instead of 4 was multiplied by the family variance in the calculation of heritability. The "B" subscript indicates that the family variance was calculated on a single-site basis, and may be biased upward by the presence of family x environment interaction. Specifically, $\sigma^2_F = \sigma^2_f + \sigma^2_{fe}$, where $\sigma^2_f$ and $\sigma^2_{fe}$ are the family and family x environment variances in a multiple site model (Comstock and Moll 1963, Hodge and White 1992).

A parameter measuring the genetic coefficient of variation (GCV) was also calculated as
$GCV = \sigma_A / \bar{y}$ where $\sigma_A$ = additive variance = $3\sigma_F$, and $\bar{y}$ = trait mean.

Parameter means and empirical standard errors were calculated treating each test site as an independent estimate.

Genetic Correlations: Age-age genetic correlations (the same trait at different ages), and correlations among different traits were estimated from single site analyses. Covariance components were calculated using a dummy variable approach (Searle 1992). The approach is illustrated below for an age-age correlation:

$r_g = \sigma_{F1,F2} / (\sigma_{F1}\,\sigma_{F2})$
where $\sigma_{F1,F2}$ = family covariance between the trait measured at the first and second age,
$\sigma_{F1}$ = family variance at the first age,
$\sigma_{F2}$ = family variance at the second age.

Paired- and Multiple-site Analyses: There were five pairs of provenance/progeny tests which contained a sufficient number of common families to conduct a paired site analysis. There was only one of the five pairs where the two tests were planted in the same country: 02A and 02D in Venezuela. The other four pairs had one test planted in Colombia and one in Venezuela. Paired site analyses were conducted in order to examine the amount of genotype x environment interaction among families within provenances. Phenotypic observations from each block in each test were first standardized prior to paired site analysis. This was done to eliminate bias of the genotype x environment interaction variances due to heterogeneous variances (scale effects) (Hill 1984). The linear model was

$$y_{ijklm} = \mu + E_i + B(E)_{ij} + P_k + PE_{ik} + f(P)_{kl} + f(P)E_{ikl} + r_{ijkl} + e_{ijklm}$$

where $y_{ijklm}$ = phenotypic observation for the ijklm$^{th}$ tree,
$\mu$ = overall mean,
$E_i$ = effect of the i$^{th}$ test,
$B(E)_{ij}$ = fixed effect of the j$^{th}$ block nested in the i$^{th}$ test,
$P_k$ = fixed effect of the k$^{th}$ provenance,

$PE_{ik}$ = fixed interaction of the $k^{th}$ provenance and the $i^{th}$ test,
$f(P)_{kl}$ = random effect of the $l^{th}$ family in the $k^{th}$ provenance,
$E[f(P)_{kl}] = 0$, $Var[f(P)_{kl}] = \sigma^2_f$,
$f(P)E_{ikl}$ = random interaction of the $l^{th}$ family in the $k^{th}$ provenance and the $i^{th}$ test,
$E[f(P)E_{ikl}] = 0$, $Var[f(P)E_{ikl}] = \sigma^2_{fe}$
$r_{ijkl}$ = random effect of the ijkl$^{th}$ row-plot, specifically the interaction of the $j^{th}$ block of the $i^{th}$ test and the $l^{th}$ family of the $k^{th}$ provenance, $E[r_{ikl}] = 0$, $Var[r_{ijkl}] = \sigma^2_r$,
$e_{ijklm}$ = random error term associated with the ijklm$^{th}$ tree, $E[e_{ijklm}] = 0$, $Var[_{eijklm}] = \sigma^2_e$,
and all other terms defined as in the single-site model with blocks nested with tests.

For each pair of tests, estimates of Type B genetic correlations ($r_{Bg}$) were calculated:
$r_{Bg} = \sigma^2_f / (\sigma^2_f + \sigma^2_{fe})$

Type B correlations measure the genetic correlation between the same trait expressed on two different sites (Burdon 1977). Type B correlations range between 0 and 1; an $r_{Bg} \approx 1$ indicates a near perfect correlation between performance in different environments, or in other words, an absence of genotype x environment interaction. Type B correlations were only calculated if $h^2_B$ exceeded 0.05 in both tests of a pair. Use of tests with extremely low $h^2_B$ can result in seemingly very imprecise estimates well out of the theoretical range. Parameter means and empirical standard errors were calculated using each pair of tests as an independent observation.

Provenance Effects: A combined analysis across sites in Venezuela and Colombia was done to examine if provenances performed consistently in the two countries. Provenance effects were estimated for percent gain for all growth traits using SAS PROC MIXED (Littell et al. 1996) to calculate the generalized least squares estimates. Separate analyses for Venezuela and Colombia were conducted using the linear model described above for paired site analyses.

Diallel Analysis: The two full-sib tests established at Zambrano were analyzed in a combined site analysis using GAREML (Huber 1993). The linear model was

$$y_{ijklm} = \mu + E_i + S_j + B(SE)_{ijk} + gca_l + gca_m + sca_{lm} + gcaE_{il} + gcaE_{im} + scaE_{ilm} + r_{ijklm} + e_{ijklmn}$$

where $y_{ijklm}$ = phenotypic observation for the ijklm$^{th}$ tree,
$\mu$ = overall mean,
$E_i$ = effect of the $i^{th}$ test,
$S(E)_{ij}$ = fixed effect of the $j^{th}$ set,
$B(SE)_{ijk}$ = fixed effect of the $k^{th}$ block nested within the $j^{th}$ set at the $l^{th}$ test.
$gca_l$ = random effect of the $l^{th}$ parent,
$E[gca_l] = E[gca_m] = 0$, $Var[gca_l] = Var[gca_m] = \sigma^2_f$,
$sca_{lm}$ = random interaction of the $l^{th}$ and $m^{th}$ parents, $E[sca_{lm}] = 0$, $Var[sca_{lm}] = \sigma^2_s$,
$gcaE_{il}$ = random interaction of the $l^{th}$ parent and the $i^{th}$ test,
$E[gcaE_{il}] = E[gcaE_{im}] = 0$, $Var[gcaE_{il}] = Var[gcaE_{im}] = \sigma^2_{fe}$,
$scaE_{ilm}$ = random interaction of the $l^{th}$ and $m^{th}$ parents and the $i^{th}$ test,
$E[scaE_{ilm}] = 0$, $Var[scaE_{ilm}] = \sigma^2_{se}$,
$r_{ijkl}$ = random effect of the ijklm$^{th}$ row-plot, $E[r_{ijklm}] = 0$, $Var[r_{ijklm}] = \sigma^2_r$,
$e_{ijklmn}$ = random error term associated with the ijklmn$^{th}$ tree,
$E[e_{ijklmn}] = 0$, $Var[_{eijklmn}] = \sigma^2_e$,

From these analyses, the following genetic parameter estimates were calculated:

phenotypic variance: $\sigma^2_T = 2\sigma^2_f + \sigma^2_s + 2\sigma^2_{fe} + \sigma^2_{se} + \sigma^2_r + \sigma^2_e$.
heritability (unbiased, across sites): $h^2 = 4\,\sigma^2_f / \sigma^2_{T.}$
dominance proportion: $d^2 = 4\,\sigma^2_s / \sigma^2_{T.}$
Type B genetic correlation: $r_{Bg} = \sigma^2_f / (\sigma^2_f + \sigma^2_{fe})$
Type B dominance correlation: $r_{Bd} = \sigma^2_s / (\sigma^2_s + \sigma^2_{se})$
Genetic coefficient of variation: $GCV = \sigma_A / \bar{y}$

Theoretical standard errors of $h^2$, $d^2$, and Type B correlations were calculated according to Dickerson (1962) and Namkoong (1979).

### 4.2 Plantation establishment and management

This chapter (chapter 8) was prepared by the CATIE yield modelling team under Dr Markku Kanninen (Director, Research Program, CATIE). This required some new field and office work to extend provisional yield models for Costa Rica to the rest of the region, and finish on-going studies on pruning. The CATIE team revised the growth and yield data from Central America in CATIE's data base to check existing growth, yield and site quality equations, and to determine the need for more information to cover different climatic conditions in Central America. The team also collected data from trials at the Tree Improvement Programme of Precious Woods-Costa Rica, on pruning systems and planting stock material.

### 4.3 Socio-economic factors relating to the use of *B. quinata*

This chapter (chapter 10) was prepared by CONSEFORH in conjunction with Manuel Gomez (CATIE). Given the lack of information it was decided to conduct pilot studies that would help in identifying socio-economic issues relating to the use of *B. quinata*. Owing to the limited resources available these studies aimed to provide starting points from which future studies might be conducted, rather than providing definitive information. The team prepared questionnaires and guidelines for carrying out pilot surveys in Colombia, Costa Rica, Honduras and Nicaragua (see pages 148-149 of the TFP). The results were synthesised, along with information from previous studies, into a chapter on the socio-economic factors that affect planting, management and use of *B. quinata*. The four pilot studies were published in the CONSEFORH Serie Miscelanea.

The studies used two approaches to collecting information. The first was to collate, by country, general information on: i) the species and its use; ii) current extent of plantations; iii) tree establishment costs and product prices; iv) the national legal and institutional framework for plantations; v) the existence of incentives; vi) the market for plantation products. The second approach employed pilot studies in specific communities in Honduras (Zona Sur), Nicaragua (Departaments of León, Chinandega) and Costa Rica (province of Puntarenas), selected to examine issues related to the sustainable management or neglect of *B. quinata*. The studies employed semi-structured interviews, during visits to the communities, where a total of 10 farms (4 in each of Costa Rica and Honduras, 2 in Nicaragua) and a large company in Colombia (Departament of Zambrano) were visited. Local carpenters were also interviewed (4 in Honduras, 2 in Nicaragua, 1 in Costa Rica) as were other stakeholders in the forest/agriculture interface related to *B. quinata* (see page 147 of the TFP for a detailed breakdown). Offices of 9 government institutions and NGOs were visited (4 in Honduras, 2 in Nicaragua and 3 in Costa Rica), interviewing 10 technical staff/extension workers (2 in each of Colombia, Honduras and Nicaragua, 4 in Costa Rica). Interviews were also conducted with a total of 23 experts/decision makers (6 in Honduras, 8 in Nicaragua, 5 in Costa Rica, 4 in Colombia) in 12 national institutions (2 in Honduras, 3 in Nicaragua, 5 in Costa Rica, 2 in Colombia).

In all cases interviews were carried out through an open dialogue, using the guide prepared for each interviewee category. Each topic was discussed with the different categories of stakeholders to improve the reliability of the information and broaden the coverage of the study. This allowed verification of the consistency of information from different groups and the integration of information at local, regional and national levels to complement the field data which was limited to a specific area of each country. Given the varied knowledge base, questions were only asked of those with some experience of that topic. Thus the number and scope of replies varied for each topic.

Interviews with farmers were conducted during a tour of the farm, allowing direct observations of the species. This produced additional information on landuse options, establishment and management techniques, trade and local use of products, limiting factors at each site, farm and surrounding area. Interviews with experts/decision makers were conducted in the central offices of the institution, providing the majority of the information on aspects related to markets,

economics, institutions and forest policy, plus technical aspects related to the species at a national level.

The studies principal limitations relate to; geographic coverage, number of interviewees/farms visited (due to time/resource limitations), lack of quantitative information on socioeconomic aspects. The latter was due to: the lack of species specific documentation on socioeconomic and financial aspects, the difficulty in obtaining, in a short time, reliable quantitative information on the range of socioeconomic factors considered in the study. Given these limitations only very simple analyses were conducted which considered:

1. The analysis of factors in two phases: i) for each country, ii) at a regional level. This allows the separation of factors peculiar to a country, to avoid distorsions of the regional results and conclusions.
2. Stratification of farms as small or large, to focus the effect of factors influential at each level and reduce the variability of data from the farms.
3. The use of broad ranges in the data, which give a high probability of correct values for the majority of situations. Data sets, presentation were kept simple, in line with the ability to draw conclusions.
4. Comparison of the results and conclusions of the study (principally financial analysis), with results from other studies in the region.

The analysis generated results and conclusions that form a knowledge base of socioeconomic factors relating to the species use within the range of the study. The restrictions detailed above explain the principal limitations, namely the low capacity to explain in depth cause-effect relationships of the different factors that influence the species use.

## 5 Outputs

The outputs of the project have been achieved and are being widely distributed in the region through the project's collaborators.

### 5.1 Tropical Forestry Paper

The main project output was a monograph (in the OFI Tropical Forestry Paper series) on *B. quinata.* Owing to the particular geographical interest in this species publication was only in Spanish (670 copies). The emphasis was on the presentation of existing research results in a clear, concise manner, drawing out the implications and applications of the research in the day to day management and use of the species. The chapters covered in the TFP are as follows.

1. Introduction
2. Species description and natural distribution
3. Reproductive biology
   - including phenology of flowering and fruiting, incompatibility and controlled pollinations.
4. Mating system, population structure and gene flow
   - in a) natural forest, b) fragmented forest, c) fence rows and d) seed orchards
5. Genetic variation
   - including data from provenance, progeny and clonal trials
6. Seed production and collection
   - including management of seed orchards
7. Vegetative propagation
   - including establishment and management of living fence rows and propagation by cuttings
8. Plantation establishment and management
   - including nursery techniques; site selection, preparation, spacing and weed control; site indices, volume and yield tables; silvicultural guidelines, pruning, thinning, rotations.
9. Wood properties
   - including characteristics of fast grown plantation material in contrast to mature natural regeneration
10. Socio-economic factors in the use and conservation of *B. quinata*

## 5.2 Development of a sample extension manual for *B. quinata*

As a follow up to an extension manual on *B. quinata* previously produced by CONSEFORH (1998), a further extension manual was produced containing new information from the monograph on:

- Productivity and yield of *B. quinata* under different site conditions and management regimes;
- The institutional, social and land tenure factors that are likely to make plantations of *B. quinata* a viable option;
- Profitability of plantations of *B. quinata*.

The manual was validated by sending draft versions to the principal rural development agencies working in the dry forest regions of Honduras. Representatives of these agencies (30 people from: AFE-COHDEFOR, INA, Municipalities (UMA), CARE, World Vision, individual producers, extension workers) attended a one-day workshop in CONSEFORH during which the technical recommendations were presented and feedback sought on the content and style of the draft extension manual. The manual was then revised, prior to its printing (1500 copies) and distribution to organisations in Honduras. Distribution was to individual producers, farmer organizations, technicians, extension workers, NGOs, the state forest authority, libraries in universities and other education institutes within the country.

Producers commented that publications of this type provide a good incentive to invest in planting trees. Sergio Salinas, the largest planter of *B. quinata* in Honduras, said the information was useful as a guide and proves that his investment will not be wasted. It's a shame that there often isn't enough seed and he has to buy it from Nicaragua. The director of PMA in COHDEFOR made a presentation about the manual and its information to business groups in the capital and commented on a favourable impact with some of investors realising that forestry is also a feasible investment opportunity. One technician described it as a valuable tool that should be available for other such species of user preference.

## 5.3 Policy briefing note

The socio-economic review (summarised in a policy briefing note) shows *B. quinata* offers opportunities for improving small farmer livelihoods in the region, although a number of limitations restrict uptake.

- Greater dissemination of existing research results is required to increase the species incorporation within farming systems projects.
- Current incentives push producers towards short rotation exotics and are decisive in limiting *B. quinata*'s planting. Modifications should consider differential payments for native species (recognition of greater environmental service value) and for those of longer rotation.
- Policies are required that limit restrictions on harvesting of plantations and natural regeneration managed by farmers. Recent changes in plantation legislation to this effect require greater dissemination to field technicians and farmers.
- Overcoming a lack of markets for juvenile wood (thinnings, short rotations) and achieving greater added product value requires changes in preparation/implementation of forestry projects to look beyond plantation establishment and silviculture, to consider their management and integration within industry projects.

## 6 Contribution of Outputs

### 6.1 Contribution of Outputs towards DFID's developmental goals

*Livelihoods of poor people improved through sustainably enhanced production and productivity of forest resource systems*

The production of monographs and extension manuals on species valued by poor farmers forms part of FRP's strategy to provide '*Knowledge relating to land-use and forest decision making promoted for the benefit of small-scale poor farmers*'. The project's socio-economic review showed the need for greater dissemination of existing research results to increase the species incorporation within farming systems. Production of this and other such monographs continue to form the sound technical basis required for the preparation of simpler materials by project collaborators (*e.g.* CONSEFORH) and others. The feedback from those validating the associated extension manual (section 5.2) illustrates the demand for such information on this and other preferred species. Project R7588 provides the context under which distribution and uptake of information on a far greater range of farmer preferred species will be achieved more directly to a greater range of collaborators (section 6.3).

### 6.2 Feedback

Although it is early days, given the recent publication and distribution of the TFP, below are some feedback quotes.

*Buenos dias!!! Felicitaciones Dr. Boshier por el Tropical Forestry Paper # 39 sobre la especie llamada POCHOTE. Es una excelente publicacion, de enorme utilidad y esperamos dar la mejor importancia a tan valioso trabajo.*
Atte, Carlos Luis Sandi, Encargado Forestal Academico
Universidad EARTH, Costa Rica

*I want to thank you the shipment of the book "Bombacopsis quinata" and also to congratulate you because this effort is a great contribution to the knowledge of tropical species.*
*Regards,*
Luis F. Osorio A., Jefe of Investigacion Forestal,
Smurfit Carton of Colombia

*The book arrived today and it is very well done- looking at the cover I'd say people should start planting these before the blasted teak and African mahogany.*
Dr David Roubik
Smithsonian Tropical Research Institute, Panama

### 6.3 Follow up action and research

The issues highlighted in 5.2 and 5.3 are being pursued through R7588. Promotion of *B. quinata*, along with other native species, is continuing along with the promotion of the production of more extension materials on native species of user preference. The principle information from R7210 has been included in the species description sheet which uses a format of direct use to extension workers (see appendix 2). This project targets extension workers throughout Central America who are in direct contact with large numbers of resource poor farmers.

### 6.4 List of publications, reports, workshops, training courses and oral presentations

A full list of the project's research outputs is given on the following pages. A summary of the TFP's distribution by country is given in appendix 1.

| Categories | Book - Formal Publication |
|---|---|
| **project code** | R7210 |
| **author, institution, editors** | CORDERO, J. and BOSHIER, D.H. |
| **Year** | 2003 |
| **reference title** | *Bombacopsis quinata*: un arbol maderable para reforestar |
| **Volume** | Tropical Forestry Papers. No. 39. |
| **Institute** | Oxford Forestry Institute (OFI) |
| **location of institute** | Oxford, UK |
| **Publisher** | Oxford Forestry Institute (OFI) |
| **location of publisher** | Oxford, UK |
| **no of pages** | 192 pp |
| **ISBN/ISSN** | ISBN: 0 85074 151 3 |
| **associated web address** | |
| **medium type** | Book Formal publication |
| **language available in** | Spanish |
| **target audience** | University faculties/research institutes - researchers/lecturers. |
| | |
| **previously reported? Yes/No** | Yes |
| **Categories** | **Informal Publications** |
| **project code** | R7210 |
| **author, institution, editors** | CONSERVACION Y SILVICULTURA DE ESPECIES FORESTALES DE HONDURAS |
| **Year** | 2000 |
| **reference title** | El Cedro Espino: una inversión forestal rentable. |
| **series/report no.** | |
| **Institute** | Conservación y Silvicultura de Especies Forestales de Honduras |
| **location of institute** | Comayagua, Honduras |
| **Publisher** | CONSEFORH |
| **location of publisher** | |
| **no of pages** | 26 pp |
| **associated web address** | |
| **medium type** | Booklet Informal publication |
| **language available in** | Spanish |
| **target audience** | Extension services: NGOs or government |
| | |
| **previously reported? Yes/No** | Yes |

| Categories | Briefing Notes |
|---|---|
| **project code** | R7210 |
| **author, institution, editors** | GOMEZ, M. and ZELAYA, Y. |
| **Year** | 2003 |
| **reference title** | *Bombacopsis quinata* para pequeños productores: beneficios actuales, potenciales y limitaciones politicas forestales. |
| **series/report no** | |
| **no. of copies** | 1000 copies |
| **Institute** | Centro Agronomico Tropical de Investigación y Enseñanza, Conservación y Silvicultura de Especies Forestales de Honduras, Oxford Forestry Institute |
| **location of Institute** | Turrialba, Costa Rica; Comayagua, Honduras; Oxford, UK |
| **no. of pages** | 2 pp |
| **associated web address** | |
| **medium type** | Briefing notes |
| **language available in** | Spanish |
| **target audience** | Policy makers, Government organisations |
| **previously reported? Yes/No** | Yes |
| | |
| **Categories** | **Workshop – the whole actual event** |
| **project code** | R7210 |
| **author, institution, editors, leaders or speakers** | CONSERVACION Y SILVICULTURA DE ESPECIES FORESTALES DE HONDURAS |
| **Year** | 1999 |
| **reference title** | El Cedro Espino: una inversión forestal rentable. |
| **Institution** | CONSEFORH |
| **location of institution** | Comayagua, Honduras |
| **date of conference** | July 1999 |
| **number of participants** | 30 |
| **type of participants** | Extensionists |
| **language of presentation** | Spanish |
| **web address** | |
| **medium type** | Workshop, The whole actual event |
| **Language** | Spanish |
| **Target audience** | Local stakeholders in general |
| **previously reported? Yes/No** | Yes |

| Categories | Internal Report | Internal Report | Internal Report | Internal Report |
|---|---|---|---|---|
| **Project code** | R7210 | R7210 | R7210 | R7210 |
| **author, institution, editors** | CONSERVACION Y SILVICULTURA DE ESPECIES FORESTALES DE HONDURAS | CONSERVACION Y SILVICULTURA DE ESPECIES FORESTALES DE HONDURAS | CONSERVACION Y SILVICULTURA DE ESPECIES FORESTALES DE HONDURAS | CONSERVACION Y SILVICULTURA DE ESPECIES FORESTALES DE HONDURAS |
| **Year** | 2000 | 2000 | 2000 | 2000 |
| **reference title** | Cedro Espino: *Bombacopsis quinata* uso y conservación en Honduras | El Pochote: *Bombacopsis quinata* uso y conservación en Nicaragua | El Pochote: *Bombacopsis quinata uso* y conservación en Costa Rica | Ceiba Rojo: *Bombacopsis quinata* uso y conservación en Colombia |
| **series/report no.** | | | | |
| **Institution** | Conservación y Silvicultura de Especies Forestales de Honduras | Conservación y Silvicultura de Especies Forestales de Honduras | Conservación y Silvicultura de Especies Forestales de Honduras | Conservación y Silvicultura de Especies Forestales de Honduras |
| **location of institution** | Comayagua, Honduras | Comayagua, Honduras | Comayagua, Honduras | Comayagua, Honduras |
| **no. of pages** | 32 pp | 27 pp | 31 pp | 23 pp |
| **associated web address** | | | | |
| **medium type** | Internal report | Internal report | Internal report | Internal report |
| **language available in** | Spanish | Spanish | Spanish | Spanish |
| **target audience** | Project collaborators | Project collaborators | Project collaborators | Project collaborators |
| | | | | |
| **previously reported? Yes/No** | Yes | Yes | Yes | Yes |

## 7 References


Alfaro, M. 1991. Evaluación financiera de la inversión en plantaciones forestales. *Silvoenergia* no 48. CATIE, Turrialba, Costa Rica. 4pp.

Burdon, RD. 1977. Genetic correlation as a concept for ctudying genotype-environment interaction in forest tree breeding. *Silvae Genetica* 26: 168-175.

CATIE 1991a. Mejoramiento genético y semillas forestales para America Central. no. 6. 25 pp.

CATIE, 1991b. Pochote (*Bombacopsis quinatum* (Jacq.) Dugand) especie de árbol de uso múltiple en América Central. Coleccíon de guías silviculturales no 13. Serie Técnica, Informe Técnico no 172, CATIE, Turrialba, Costa Rica. 44pp

CATIE, 1997. *Bombacopsis quinata* (Jacq) Dugand. Nota Técnica sobre Manejo de Semillas Forestales. no. 17. CATIE, Turrialba, Costa Rica. 2pp.

CMG&BSF, 1995. Estrategia integrada para el suministro de semillas forestales, mejoramiento genético y conservación. MARENA/DANIDA, Leon, Nicaragua. 35pp.

Colindres, I., Allison, G., Belaunde, L.E. 1995. Estudio participativo: uso de especies forestales por los pobladores del bosque seco de la zona sur (Choluteca, Valle, El Paraiso) de Honduras. CONSEFORH/COHDEFOR/ESNACIFOR/ODA, Honduras. 142 pp.

Comstock R.E., Moll, R.H. 1963. Genotype-environment interactions. In: Statistical Genetics and Plant Breeding. Hanson, R.E., Robinson, H.F., eds. NAS-NRC Pub. 982, Washington DC. pp. 169-194.

CONIF, 1996. Latifoliados zona baja. CONIF, Bogata, Colombia. pp. 39-51

CONSEFORH, 1998. Cedro espino. Manual de extensión. CONSEFORH, Comayagua, Honduras.

Dickerson GE. 1962. Implications of genetic-environmental interaction in animal breeding. *Animal Production* 4:47-64.

Dvorak, W.S., Donahue, J.K. 1991. Status of gene conservation efforts for *Bombacopsis quinata* in Central and South America by the CAMCORE Cooperative. In: Mejoramiento genético and semillas forestales para America Central 6: 22-25.

FAO, 1986. Databook on endangered tree and shrub species and provenances. FAO, Rome, Italy. pp. 155-162.

FAO, 1993. Report of eighth meeting of the FAO Panel of Experts on Forest Genetic Resources. FAO, Rome, Italy.

Finol, U.H., Melchior, G.H. 1970. Unos apuntes sobre la conservacion de reservarios de genes especies forestales indigenas de actual valor comercial en Venezuela. *Revista Forestal Venezolana* 19/20: 73-81.

Hill WG. 1984. On selection among groups with heterogeneous variance. *Animal Production* 39:473-477.

Hodge, G.R., White, T.L. 1992. Genetic parameter estimates for growth traits at different ages in slash pine and some implications for breeding. *Silvae Genetica* 41: 252-262.

Huber, D.A. 1993. Optimal mating designs and optimal techniques for analysis of quantitative traits in forest genetics. PhD dissertation, School For. Res. Conserv., Univ. of Florida, Gainesville, FL. 151pp.

Hughell, D. 1991. Modelo preliminar de rendimiento para pochote (*Bombacopsis quinata* (Jacq) Dugand) en Costa Rica y Panama. *Silvoenergia* no 39. CATIE, Turrialba, Costa Rica. 4pp.

Hughes, C.E. 1989. The status of dry forest genetic resources and options for genetic conservation in the Republic of Honduras. ODA/MCS unpublished report to CONSEFORH project. 31pp.

Janzen, D.H. 1986. Guanacaste National Park: tropical ecological and cultural restoration. UNED, San José, Costa Rica. 103pp.

Jimenez, Q. 1993. Arboles maderables en peligro de extinción en Costa Rica. INCAFO, San José, Costa Rica. 121pp.

Kane, M., Urueña, H., Dvorak, W., Atehortua, C. 1993. The potential of *Bombacopsis quinata* as a commercial plantation species. Forest Ecology and Management 56: 99-112.

Littell, R.C., Milliken, G.A., Stroup, W.W., Wolfinger, R.D. 1996. SAS System for Mixed Models. Cary, NC. 633 pp.

Lugo, A. 1997. Saqui-saqui: a promising new plantation species? IUFRO working party 4.04.06 Newsletter 21.

Melchior, G.H., Quijada, M. 1972. Results of nine year trials on vegetative propagation of *Bombacopsis quinata* (Jacq.) Dugand by branch sets. *Silvae Genetica* 21: 164-166.

MINAE. 1996. Información estadistica relevante sobre el sector forestal 1972-1995. San José, Costa Rica.

Miranda, C.R. 1986. Enraizamiento de estacas de pochote (*Bombacopsis quinata* (Jacq.) Dugand) en diferentes épocas del año. Tesis Lic. en Ciencias Forestales. UNA, Heredia, Costa Rica. 135 pp.

Morales, R., Whitmore, L.J. 1978. Apuntes ecologicos y silviculturales de *Bombacopsis quinata* (Jacq.) Dugand; Revision bibliografica. CATIE, Turrialba, Costa Rica. 21pp.

Moran, B. 1991. Programa de mejoramiento genético de *Bombacopsis quinata* (Jacq.) Dugand, en Panama. *Mejoramiento genético and semillas forestales para America Central* 6: 19-21.

Motta, M.T. 1996. Importancia económica de la investigación en mejoramiento genético. Identificación, selección y manejo de fuentes semilleros. Serie Técnica, no 32. CONIF, Bogata, Colombia. p3-9.

Moya, R., Cordaba, R. 1995. Evaluación de aserrio y trabajabilidad de la madera de pochote (*Bombacopsis quinatum*) de ocho años de edad. *Revista Forestal Centroamericana* 12: 19-24.

Namkoong, G. 1979. Introduction to quantitative genetics in forestry. USDA-FS Technical Bulletin No.1588.

Navarro, C.M. 1987. Evaluación del crecimiento y rendimiento de *Bombacopsis quinata* en 14 sitios en Costa Rica; indices en sitio y algunos aspectos financieros de la especie. Tesis Mag. Sc. CATIE, Turrialba, Costa Rica. 136 pp.

Navarro, C.M. 1988. Relación factores de sitio y crecimiento de *Bombacopsis quinata* en Costa Rica. *Silvoenergia* no 26. CATIE, Turrialba, Costa Rica. 4pp.

Navarro, C.M., Martinez, H.H. 1989. El pochote (*Bombacopsis quinatum*) en Costa Rica: guía silvicultural para el establecimiento en plantaciones. Serie Técnica, Informe Técnico no 142, CATIE, Turrialba, Costa Rica. 44pp.

Newton, A.C., Mesen, J.F., Leakey, R.R.B. 1991. ITE/CATIE link: interim report to ODA. ITE, Penicuik, Scotland. 84 pp.

Paterson, R., Cornelius, J., Baeza, O. 1996. Comportamiento de procedencias de *Albizia guachapele* y *Bombacopsis quinata* en Costa Rica. Mejoramiento Genético y Semillas Forestales, no. 13. CATIE, Turrialba, Costa Rica. p18-21.

Pinto, G. 1997. Situación del mercado de semillas forestales en Colombia. En: *Avances en la producción de semillas forestales en América Latina*. ed. Salazar, R. CATIE, Turrialba, Costa Rica. pp. 347-353.

Sandiford, M. 1998. A study of the reproductive biology of *Bombacopsis quinata*. Unpublished D.Phil thesis. University of Oxford, England. 200 pp.

SAS 1989. SAS Institute Inc. SAS/STAT User's Guide Fourth Ed., Volume 2. SAS Institute, Cary, North Carolina, 846 pp.

Searle, S.R., Casella, G., McCulloch, C.E. 1992. Variance Components. John Wiley and Sons, Inc. New York. 501 pp.

Urueña, H. 1992. Production and management of *Bombacopsis quinata* (Red Ceiba) seed. In: Lambeth, C., Dvorak, W. eds., Breeding tropical trees, IUFRO conference, Cartagena-Cali, Colombia, 9-18th October, 1992. p. 43-47.

Vasquez, W., 1996. Clasificación y selección de sitios para reforestar en la región Chorotega, Guanacaste, Costa Rica. Coleccíon de materiales de extensión no7. Serie Técnica, Informe Técnico no 283, CATIE, Turrialba, Costa Rica. 58pp

Vasquez, W., Ugalde, L. 1995. Rendimiento y calidad de sitio para *Gmelina arborea*, *Tectona grandis*, *Bombacopsis quinatum* y *Pinus caribaea* en Guanacaste, Costa Rica. Serie Técnica, Informe Técnico no 256, CATIE, Turrialba, Costa Rica. 33pp.

**Appendix 1 Distribution of *B. quinata* TFP as of 10/6/2003 (addresses available; 360 copies remain to be distributed)**

***N.B.* Distribution within countries denoted in bold italics was by collaborators (CAMCORE, CATIE, CONSEFORH).**

| Country | Collaborators/ Training course participants | Current/ex DFID projects | Research incl CGs | Education | GO/NGO | total |
|---|---|---|---|---|---|---|
| Australia | | | 1 | 1 | | 2 |
| Bolivia | | | | 1 | | 1 |
| Brazil | | 1 | 4 | 4 | | 9 |
| Chile | | | | 1 | | 1 |
| ***Colombia*** | ***4*** | | ***5*** | ***12*** | | ***21*** |
| ***Costa Rica*** | ***3*** | | ***38*** | ***24*** | ***4*** | ***69*** |
| Cuba | | | 1 | | | 1 |
| El Salvador | 1 | | 1 | | | 2 |
| Guatemala | 1 | | | | | 1 |
| ***Honduras*** | ***8*** | | ***11*** | ***15*** | ***36*** | ***70*** |
| Italy | | | 2 | | | 2 |
| Indonesia | | | 5 | | | 5 |
| Kenya | | | 1 | | | 1 |
| Mexico | | | 7 | 3 | | 10 |
| ***Nicaragua*** | | | ***1*** | ***10*** | ***5*** | ***16*** |
| ***Panama*** | ***4*** | | ***1*** | ***6*** | ***5*** | ***16*** |
| Philippines | | | 5 | | | 5 |
| Portugal | | | 5 | | | 5 |
| UK | | 3 | 6 | 3 | | 12 |
| ***USA**** | | | 51 | 1 | | 52 |
| ***Venezuela*** | | | 10 | 1 | | 11 |
| Totals | 21 | 4 | 155 | 82 | 50 | 312 |

*N.B.* * Distribution is by CAMCORE to collaborators/researchers within a range of developing countries – breakdown by country currently not available.

## Appendix 2 Species description of *Bombcopsis quinata* from R7588