A financial analysis of a small scale *Gmelina arborea* Roxb. improvement programme in Costa Rica

C. HAMILTON[1,2], L. CHANDLER[1,2], A. BRODIE[1,2] AND J.P. CORNELIUS[1,3]

[1]*Tree Improvement Project, Tropical Agronomic Research and Higher Education Centre (CATIE), Turrialba 7170, Costa Rica*

[2]*Oxford Forestry Institute, South Parks Road, Oxford, England*

[3]*Overseas Development Administration, 94 Victoria Street, London, England*

Corresponding author: J.P. Cornelius, CATIE, Turrialba, Costa Rica. Fax: 506 556 1533.

Email: jcorneli@computo.catie.ac.cr

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Application. Tree improvement activities for and by smallholder farmers, particularly in Central America, have largely been limited to low-intensity activities such as seed stand establishment. The main reason for this appears to have been the common view that higher-level tree improvement is not economically justifiable for relatively small-scale planting programmes. We describe a financial analysis which suggests that seed orchard programmes are often economically justifiable at annual planting rates of 125 ha or less. On this basis, we recommend that tree improvement above the seed stand intensity be more widely adopted in support of smallholder tree planting. The main application of the study would therefore be to justify such policies and, thereby, to improve the quality and productivity of smallholder plantations.

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Key-words: Central America, smallholder forestry

Abstract. A financial analysis of a small-scale *Gmelina arborea* improvement programme in Hojancha, Guanacaste Province, Costa Rica is described. The programme consisted of a clonal seed orchard, made up of ramets of plus-trees, and three progeny tests / seedling seed orchards. A 5% discount rate was used. The total discounted / compounded cost of the programme was US$25423. The analysis demonstrated that this outlay would be justified at annual planting rates of from 31ha / year (at 20% genetic gain) to 125ha / year (at 5% genetic gain) over the 20-year life of the orchard. It was concluded that the implementation of such small-scale, locally-based programmes by community-based or locally-orientated organizations may often be justifiable.

Resumen. El documento presenta los resultados de un análisis financiero de un programa de mejoramiento genético de escala pequeña de *Gmelina arborea* en Hojancha, provincia de Guanacaste, Costa Rica. El programa consistió en el establecimiento de un huerto semillero clonal, conformado por ramets de árboles "plus", y tres ensayos de progenies / huertos semilleros de plántulas. Se empleó una tasa de descuento de 5%. El costo compuesto total del programa fue de US$25423. El análisis demostró que tal inversión sería rentable con tasas anuales de plantación de 31 a 125 ha / año, a 20% y 5% ganancia genética, respectivamente, durante la vida útil del huerto (20 años). Se concluye que, en términos financieros, se puede justificar la implementación de tales programas por organizaciones comunitarias.

Introduction

In recent years there has been increasing interest in strategies for smallholder tree improvement (Barnes, Simons and MacQueen, 1992; Burley, 1980; Chuntanaparb and MacDicken, 1991; MacDicken and Bhumibhamon, 1990; MacDicken and Mehl, 1990; Mesén, Boshier and Cornelius, 1994; Raintree and Taylor, 1992; Simons, 1992; Simons, MacQueen and Stewart, 1994; Sinclair, Verinumbe and Hall, 1994; Venkatesh, 1988). Small-scale, locally-based approaches to tree improvement by or for smallholders would appear to have advantages over large-scale, centralized programmes, e.g. it is easier to take into account local differences in species preferences, environment and ideotypes; farmers can be involved or take charge of the process more easily; overall genetic diversity may be enhanced; costs are likely to be lower because of short distances from base to field sites. At least in Costa Rica, various community-based or community-orientated organizations are interested in, or already implementing, such programmes (Haggar, 1995; Hamilton and Baeza, 1995). Many studies demonstrate that industrial tree improvement tends to be profitable (e.g. Willan, 1988; Zobel and Talbert, 1984). However, such studies have not been reported for small-scale, locally-based programmes in support of small to modest planting programmes. The present article seeks to fill this gap, taking as an example a *Gmelina arborea* improvement programme for the Hojancha Canton Agricultural Centre (CACH), in Guanacaste Province, Costa Rica. The Costa Rican Cantonal Agricultural Centres are cooperative-like organizations, originally established by the government, but now practically autonomous and self-financing. A part of their income is derived from affiliation fees paid by farmers.

The context: forestry and tree improvement in Hojancha

The canton of Hojancha is located in the seasonally dry, Pacific northwest of Costa Rica. The canton's 230 km^2 are dedicated almost entirely to agriculture. Since the late 1970s, this activity, which historically consisted of cattle farming and, to a lesser extent, production of basic grains (Campos, Rodríguez and Ugalde, 1992) has been increasingly supplemented by plantation forestry. By 1995, more than 1700ha of plantations, around 50% of them of gmelina (José Miguel Valverde, CACH, pers. comm.), had been established, mostly as 2-3 ha blocks on small- and medium-sized holdings. Initially, farmers' interest in tree planting appears to have been largely a result of declining productivity and profitability of traditional activities, promotion of forestry activities by agencies such as CATIE and, particularly, CACH, and government reforestation incentives. More recently, however, farmers increasingly appear to be accepting tree planting as a 'mainstream' productive activity, undertaken in expectation of income from the final product rather than from government incentives. The installation by CACH of a small-diameter sawmill, which is now working at full capacity (José Miguel Valverde, CACH, pers. comm.), and provides a ready local market, is presumably partially responsible for this trend.

In the mid-1980s, CACH and CATIE initiated tree improvement activities in Hojancha. Currently, the programme concentrates on gmelina, and consists of three main components: seed stands, two progeny tests of plus-tree material, one of which is under conversion to a seedling seed orchard, and a pilot programme of vegetative propagation and clonal testing. Selected germplasm (at present available only from seed stands) will be supplied by CACH to smallholder farmers through the existing seed and plant distribution system. At the request of CACH, a long-term breeding strategy is being prepared by CATIE's Tree Improvement Project.

Methods

General approach

The aim of the study was not to financially analyze the activities carried out to date by CACH, but rather to use CACH as a model in the formulation of a simple programme of activities whose analysis would permit some conclusions of general application to be drawn. For this reason, the programme analyzed is based on the traditional configuration of clonal seed orchard plus progeny tests / seedling seed orchards. Some, but not all, of this programme has already been implemented by CACH/CATIE. The rest may be implemented by CACH as part of the long-term strategy currently being drawn up. After defining what activities the programme would consist of and when they would be carried out, costs were estimated, mostly from actual cost data collected over many years by the CATIE Tree Improvement Project. Gross returns were then estimated for various genetic gain scenarios. Both costs and returns were discounted or compounded to the base year using standard formulae. Following this, the break-even annual planting area was calculated, i.e. the annual area of improved plantations that must be planted in each year of orchard life in order to produce enough gain to justify the costs of the programme (i.e. to give internal rates of return equal to the discount rate or net present value of zero). A real interest rate of 5 per cent was used throughout. As real interest rates from alternative long-term investments are unlikely to move above 1-2% (von Platen, 1995), this is considered to be a conservative assumption. The year of trial establishment was taken as the base year for compounding and discounting purposes. All calculations were made using a spreadsheet file, copies of which are available from the senior author.

Description Of The Programme: The Base Scenario

The programme begins with the selection, on stem straightness and growth criteria, of 70 plus-trees within local gmelina plantations. The following year, 3 progeny trials, each with the same 50 families, are established. The remaining 20 families are assumed to be unavailable for planting because of seed collection or germination problems. Each trial has 15 randomized complete blocks, three trees per plot, 3mx3m spacing, and a two-tree border around the entire trial. The trials are maintained according to local practice, and measured in year three before thinning. At year three, a consultant is employed to analyze the the trial data. On the basis of the analysis, the best families are identified and ramets collected from the plus trees for the establishment of a clonal seed orchard, while the progeny trials are converted to seed orchards through a single heavy thinning. Seed production is assumed to start in year 7 in both seedling and clonal seed orchards. The first improved plantations are established in year 8, and harvested in year 18 . The orchards are assumed to have a productive life of 20 years. With the exception of the consultant contracted to analyze the trial data, the programme is implemented wholly by CACH, through a team consisting of the CACH Head Forester, a field assistant, and casual labourers.

Costs of the programme

All activities that, in the absence of a tree improvement programme, would be unnecessary to secure (unimproved) seed supplies were costed (table 1). An overhead of 15% was allowed to cover administrative costs and maintenance / depreciation of infrastructure. Total present value costs of the programme were estimated at US$25423 (table 1).

Returns from the programme

The forecasting of yield increases due to genetic improvement is perhaps the most problematic element in the financial analysis of tree improvement (Cornelius and Morgenstern, 1986; Fins and Moore, 1984; Friedman, 1992; Ledig and Porterfield, 1982). In the CACH programme, as in most other programmes that have been analyzed, data on realized genetic gain are not yet available. In addition, there is little reliable data on which to base estimates of current productivity, and in any case such historical data would be of dubious relevance as, due to inexperience, many plantations have been established on unsuitable sites and have received poor management, particularly as regards thinning. Rather than attempt to forecast gain, it was decided to make calculations for genetic gains from 5-20%, applied to a plantation programme with the following mean characteristics: rotation length 10 years, with MAI of $20m^3$/ha/year and half of the total cumulative volume removed in thinnings. It is considered that these assumed parameters are justified; there is little doubt that, due to accumulated experience, future plantation management and site selection will improve substantially with respect to past practice. Timber prices were based on current gmelina prices of around \$15 / m^3 delivered to mill (José Miguel Valverde, CACH, pers comm.), halved to allow for costs of harvesting and transport. All thinnings are assumed to be non-commercial. On these assumptions, improved stock with 20% and 5% gain produce gross discounted revenues (i.e. discounted to the beginning of the 10 year rotation) of US\$553/ha and US\$483/ha respectively, whilst the unimproved stock yields US\$460/ha i.e. marginal gross discounted revenue varies from US\$23/ha to US\$93/ha. These increases accrue as a series of 20 returns, beginning 10 years after establishment of the first improved plantations, and ending 10 years after the abandonment of the orchards in year 27.

Break-even financial analysis

The annual planting programme necessary to cover programme costs was calculated using the following formulae:

$$A = PVC / GDR \qquad (1)$$

where:

A = required annual planting programme (ha)

PVC = total present value of costs of the programme ($US)

GDR = the present value ($US/ha) of the series of 20 marginal discounted returns.

GDR was calculated as:

$$GDR = \Sigma MDR_i / 1.05^t \qquad (2)$$

where:

MDR_i = marginal revenue per ha due to tree improvement accrued in plantations established in year t, discounted to year t;

t = year of planting (relative to programme base year) of the plantations derived from each of the 20 annual seed harvests.

The analysis method assumes that improved growth rate will be used to produce more timber over the same rotation, rather than to reduce rotation length. It is also assumed that there will be no real changes in costs or stumpage values over time.

A sensitivity analysis was carried out by examining the effects of the following modifications: assumption of higher ($25m^3$/ha/year) and lower ($15m^3$/ha/year) site index; planting of just one trial, on the assumption that other trials exist in the region that have been paid for by other organizations; variations in timber price (±25%); a 4-year delay in the onset of seed production; variations in the productive periods (10 and 25 years) of the orchards..

Results and discussion

The break-even annual planting programme required under the base scenario is from 31ha (at 20% improvement) to 125ha (at 5% improvement) (table 4). Evidently, an effective (i.e. one capable of achieving genetic gains of at least around 10%) gmelina improvement programme in Hojancha of the type analyzed would be amply justified by the current planting programme of around 100 ha. Of the factors considered in the sensitivity analysis, at least acting in isolation, only the reduction in orchard life to 10 years might alter this conclusion. It is, in any case, probable that programme returns have been underestimated: neither returns from decreased cleaning costs (due to faster early growth), the incorporation of first generation gains in the genotype of future germplasm production populations or possible income from second (commercial) thinnings have been considered. It is also worth stressing that the apparently high cost of the programme is made up in large measure of the cost of using existing personnel and infrastructure (i.e. existing, not additional, budget) for this specific purpose. This is important because an additional cost of more than $25,000 would be beyond the resources of most community organizations.

The results have important implications for smallholder tree improvement in Costa Rica and elsewhere. Data held on the CATIE Tree Improvement Project Users' Network database indicates that in Costa Rica, farmers' organizations involved in tree planting are establishing 60-350 ha per year. Although these figures are combined data for several species, usually one or two species predominate. In any case, assuming moderate to high levels of heritability and additive genetic variation, as found in on-farm progeny tests to date in Costa Rica (Cornelius, Corea and Mesén, 1995; Cornelius and Hernández, 1995; Cornelius and Masís, 1994), genetic gains of 20% or higher should be feasible (Cornelius, 1993). Under such conditions, small-scale programmes of the sort described here would be justifiable even for minor species, providing that the costs incurred are likely to be broadly similar to the case described here. In cases where programme costs can be shared between various organizations, each of which would establish one trial, the situation would be still more favourable (table 4).

Broadly speaking, the findings of the present study are likely to be applicable to other countries. Indeed, given the relatively high labour costs in Costa Rica, in other developing countries small-scale tree improvement may constitute an even more attractive way of improving yield and quality of smallholder forestry plantations. To date, tree improvement for smallholders in Central America has been characterized by the establishment of seed stands as 'interim' seed sources. Due, in part, to a general perception that higher level activities are only justifiable when annual planting rates are in the thousands of hectares, rather than tens or hundreds, there has been a reluctance to enter into higher-level activities, even of the simple sort reported here. The results of the present study suggest that this reluctance is unjustified. At the same time, however, it should be emphasized that the present analysis establishes only the financial feasibility of programmes of this type. Their wider feasibility will depend on, among other factors, the degree of commitment, training and awareness of local personnel, and the presence of organizations able to fulfil the catalytic and supporting functions carried out by CATIE in the case of Hojancha.

Conclusions

The results of the study indicate that small-scale, locally-based tree improvement programmes of the type described here are financially justified for annual planting programmes of the scale being undertaken by many farmers' organizations and other community-based groups in Costa Rica. Providing that programmes can be designed and implemented so as to allow gains of around 20%, these should be justifiable even for planting programmes as low as 31 ha per year. However, even tree improvement programmes producing gains in the order of 5% are readily justifiable for modest (around

125ha) annual planting programmes of even medium-value species. We therefore recommend that tree improvement activities beyond the seed stand level be implemented as a routine element of such planting programmes.

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Table 1. Present value costs at 5% discount rate of one progeny trial / seedling seed orchard in a Gmelina arborea improvement programme in Hojancha, Costa Rica

activity	year	total actual cost[1] ($US)	present value ($US)	source	Notes / assumptions
plus-tree selection @ $22/ tree	-1	523	556	2	two trees selected/day; note that total cost is per each of 3 trials
seed collection @ $20/tree	-1	466	496	3	five trees/day, two visits/tree note that total cost is per each of 3 trials
nursery costs	-1	194	199	2,3,4,5	
establishment @ $702/ha	0-1	1404	1416	2,3	includes soil sampling, site clearance, planting, replanting
maintenance @ $433/ha (average of first two years)	0-4	2098	1976	2,3	includes fertilization, spot and general cleaning, stump pruning, firebreak
measurement, analysis	3	936	808	2	includes consultant time (2 days @ $300 p.d.)
conversion to seed orchard (genetic thinning) at $232/ha	3-4	394	332	2	
subtotal			5783		
15% overhead			867.45		
total			6650.45		

[1]wage rates: technician (B.Sc.) $16000 p.a., field assistant $8000 p.a., labourers $3500 p.a.; [2]CATIE Tree Improvement Project records; [3]MIRA data base (Ugalde, 1989) database records; [4]Murillo and Valerio, 1991; [5]Latin American Forest Tree Seed Bank (BLSF), CATIE

Table 2. Present value costs at 5% discount rate for one clonal seed orchard in a *Gmelina arborea* improvement programme in Hojancha, Costa Rica

activity	year	total actual cost ($US)[1]	present value ($US)	source	notes/assumptions
collection of ramets	3	500	416	2	
grafting	3	640	533	2	
nursery costs	3 to 4	780	642	2	
establishment	3 to 4	1404	1165	2	includes soil sampling, site clearance, planting, replanting
maintenance	4 to 7	2588	2002	2	includes fertilization, spot and general cleaning, rootstock pruning, firebreak
present value subtotal			4758		
15% overhead			713.7		
total present value			5472		

[1]wage rates: technician (B.Sc.) $16000 p.a., field assistant $8000 p.a., labourers $3500 p.a.;

[2]CATIE Tree Improvement Project records;

Table 3. Total present value costs at 5% discount rate of a *Gmelina arborea* improvement programme in Hojancha, Costa Rica.

Component	Present value cost (US$[1])
three progeny tests / seedling seed orchards	19951
one clonal seed orchard	5472
total	25423

Table 4. Results of a break-even financial analysis of a *Gmelina arborea* improvement programme in Hojancha, Costa Rica (base scenario and sensitivity analysis)[1].

assumptions	marginal yield increase due to programme (%)			
	5	10	15	20
	break-even annual planting requirement (ha)[2]			
base scenario	125	62	41	31
orchard life of 10 years	201	101	67	50
orchard life of 25 years	110	55	37	28
25% increase in stumpage or in unimproved MAI	100	50	33	25
25% decrease in stumpage or in unimproved MAI	166	83	55	42
4 year seed production delay	152	76	51	38
only one trial planted	60	30	20	15

[1]at 5% discount rate; [2]i.e. the annual planting rate at which internal rate of return = the discount rate and net present value = zero