Timber species for shade in new and old cocoa fields

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Key words: *Theobroma cacao*, *Cordia alliodora*, *Terminalia ivorensis*, *Tabebuia rosea*, *Inga edulis*, Costa Rica, Panamá, financial analysis, timber growth

Introduction

Since late 1980's agroforestry research was carried out in Talamanca, Costa Rica and Bocas del Toro, Panama, together with local farmers and governmental and non-governmental organizations. The objectives were to improve cacao production technology, to diversify crops and promote reforestation (Somarriba et al 1996a). Timber and leguminous tree species were evaluated as shade in old and new cocoa (*Theobroma cacao* L.) plantations. In this paper, information on timber growth, cocoa production and financial results are presented.

Materials and methods

Three timber (*Cordia alliodora, Terminalia ivorensis* and *Tabebuia rosea*), and one leguminous species (*Inga edulis*) were tested in private farms. In old cocoa fields trees were introduced to replace existing, non-regulated, unproductive shade (Somarriba y Calvo, 1998). Trials were established in five private farms, one or two blocks per farm, each block with four treatments (shade species) in a complete block design. Farms were selected in bottom valley and hills (three blocks each) (Somarriba et al, 1994). The variables evaluated were: tree survival, growth (diameter at breast height (dbh), total height, crown diameter), stem form, tree management costs, and the percentage of trees with crowns above the cocoa canopy at 2.5 years after planting. Trees were planted at 7x7 m (204 trees ha^{-1}).

In new cocoa fields, trials were established in two farms, one in the coastal plains of Puerto Viejo, Talamanca, and one in the hills of fila Almirante, Bocas del Toro. In Puerto Viejo, three species (*T. rosea* not included) in a complete block design with three replicates. In Bocas del Toro, four treatments and four replicates were evaluated. The variables evaluated were: tree survival, tree growth (same variables as in old cocoa fields), cocoa production, and management costs (Somarriba *et al*., 1995 and Somarriba *et al*., 1996). Trees were planted at 6x6 m (278 trees ha^{-1}).

Results

C. alliodora and *I. edulis* showed high mortality rates when introduced into existing cocoa fields; *T. rosea* had only a 3% mortality after 4.3 years (Table 1). Heavy shade accounts for mortality in *I. edulis* whereas poor drainage and flooding may explain high mortality in *C. alliodora*. Leaf cutting ants were a severe problem for *T. ivorensis*. Timber volumes were higher for *T. ivorensis* and lower for *T. rosea*. No volume figures are available for *I. edulis*.

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Table 1. Survival and growth at 4.3 years of age

Species	Mortality (%)	Exit from canopy (%)	dbh (cm)	h (m)	Total volume ($m^3 ha^{-1}$)
C. alliodora	36	35	15.9	13.5	21.2
T. ivorensis	24	54	19.0	16.6	34.6
T. rosea	3	36	16.3	9.8	18.5
I. edulis	38	16	14.0	10.5	-

Source: Somarriba *et al.*, 1994

In new cocoa fields, mortality rates were high for both *T. ivorensis* and *C. alliodora*, and very low for *T. rosea* (Tables 2-3). Wind damage (Bocas del Toro), leaf cutting ants and soil fungus (both sites) reduced *T. ivorensis* survival. *T. ivorensis* produce high volumes in short rotations, but caution must be taken due to high mortality. *C. alliodora* grows better than *T. rosea* (Tables 2-3). Cocoa production did not differed among shade species due to differential management (thinnings of timber species and pruning of *I. edulis*) to fulfill cocoa needs for shade. Cocoa production differed between sites; low production in Puerto Viejo was due to increased losses to pathogens (*Moniliophthora roreri*).

Table 2. Tree growth and cocoa production at 6 yr of age. Bocas del Toro.

Species	Cocoa ($kg\ ha^{-1}\ yr^{-1}$)	Mortality (%)	dbh (cm)	h (m)	Total volume ($m^3 ha^{-1}$)
C. alliodora	762	41	25.4	19.1	80.1
T. ivorensis	726	68	27.5	19.7	91.5
T. rosea	863	11	22.7	12.3	40.0
I. edulis	772	22	20.2	-	-

Source: Somarriba *et al.*, 1995

Table 3. Tree growth and cocoa production at 4.3 yr of age. Puerto Viejo.

Species	Cocoa ($kg\ ha^{-1}\ yr^{-1}$)	Mortality (%)	dbh (cm)	h (m)	Total volume ($m^3 ha^{-1}$)
C. alliodora	360	9	20	18	70
T. ivorensis	359	34	22	17	73
I. edulis	368	15	18	-	-

Source: Somarriba *et al.*, 1996b

C. alliadora had the best financial performance in both old and new cocoa fields; *I. edulis* is the worst financial alternative over a 15 yr planning horizon and 5% discount rate (Table 4).

Table 4. Financial indices for old and new cocoa fields with timber and leguminous shade species. Gross margin figures apply only to new cocoa fields in Bocas del Toro.

Species	Benefit / cost ratio		Gross margin ($US\ \$\ ha^{-1}$)
	New fields	Old fields	
C. alliodora	1.8	5.2	395
T. ivorensis	1.5	4.7	239
T. rosea	1.6	4.5	278
I. edulis	0.9	-	-23

Source: Hernandez *et al.*, 1995 and Trejos *et al.*, 1995

Discussion

Timber trees in cocoa plantations provide both shade and income in medium and long term. Diferential management resulted in negligible differences in cocoa production between shade species; this favors the use of timber species over the traditional, service only, leguminous species. Among timber species, volume growth is higher with T. ivorensis, but high mortality rates due to soil fungus, susceptibility to wind damage and severe ant attacks prevent us from recommending it. *T. rosea* on the other hand, showed modest volume growth, but it is a rustic species, with very low mortality rates, and tolerant to poor drainage and floodings (common in many cocoa production areas). This species can be recommended for extensive areas with variable soil conditions. *C. alliadora* grew well, showed a moderate mortality rate, is well appreciated in the regional markets for timber, but is very demanding in terms of soil fertility and does not tolerate poor drainage and flooding.

The costs of replacing current shade trees with timber species or leguminous species amount to between US$750 and US$950 ha^{-1} in the first four years. After 15 years, this change in shade trees can generate an economic benefit of between US$4,500 and US$5,500/ha through the sale of timber. Replacing shade trees with timber species in mature cacao fields is economically productive under the trial conditions.

Conclusions

1. Using timber species as shade trees is an investment with high economic returns. Therefore it is preferable to us timber trees and not leguminous trees to provide shade for cacao. The selection of the timber species depends on factors such as: site conditions farmer's preference, and expected timber prices for each species.
2. Differential management resulted in negligible effects on cocoa production.
3. *I. edulis* was the worst species to use as a shade substitute in established cacao fields. Its growth and survival were poor in dense cacao fields.
4. The cacao-*C. alliodora* association is the most viable economic alternativ. *C. alliodora* should be planted in soils with good drainage and no flooding risks. *T. rosea* can be planted in soils with drainage problems. *C. alliodora* should be spaced at distances of 9 x 9 m. planting two to four seedlings per site and thinning to one plant at 6 to 12 months.

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