QUANTIFICATION OF CURRENT AGROFORESTRY PRACTICES AND CONTROLLED RESEARCH PLOTS IN COSTA RICA

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A paper submitted to the Consultative Meeting on Plant Research and Agroforestry, ICRAF, Nairobi, Kenya, April 1981.

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CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA, CATIE
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Quantification of traditional agroforestry practices has always been a difficult task because of their inherent complexity and the problems faced setting up an experimental design. Most of the studies in Latin America have concentrated in describing traditional systems or even in carrying out field trials that include economical analysis, but seldom to be carefully analyzed in conjunction with other alternative land use practices. A series of comparisons between some agro-forestry systems and monocultures involving one of the components of the system was recently attempted showing advantages and disadvantages as viewed from biological and physical aspects as well as from the economic and social angle (Budowski, 1981).

Such appreciations, derived mainly from the farmers' and researchers' own experiences are unavoidably teinted with subjective appreciations but they have the merit of leading to the formulation of hypothesis and their eventual validation through appropriate experimental designs.

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The present description of research carried out in Costa Rica attempts to describe the results achieved at CATIE* for the last 20 years and the link observed between traditional and relatively recent "promising" agroforestry practices and the experimentation carried out mostly by staff and graduate students at CATIE (until 1973, tne Inter American Institute for Agricultural Sciences).

Taungya

The practice to combine for a short period annual crops with more permanent tree planting has received much attention at CATIE where a series of M.S. thesis have been produced, varying crops and tree species, stocking of trees, methods of tree planting (seedlings, stumps), and cultural practices (amount of weeding, use of fertilizers). The descriptions found in literature from Asia and Africa and visits by staff to Kenya and Trinidad where pines, Mexican cypress and teak are planted in association with annual crops, led to the first experiment at CATIE in 1961. The purpose then was to find convenient and economic ways to replace secondary brush by valuable tree crops. One of the local most valuable timber trees, Cordia alliodora was used and planted at 3 x 3 m and associated with various crops (Cucumis sativum, Cucurbita maxima, Manihot utilissima, Phaseolus vulgaris and Zea mays) planted on 2 successive rotations, proved to be extremely worthwhile concerning survival, growth and form and the first year after establishment actually yielded an economic benefit of 1410 colones per hectare (1 US$ = 6.63 colones, in 1963) while the trees, measured 16 1/2 years later, had an average

*CATIE's research is carried out on a large estate of 1000 hectares situated at about 10° latitude North at 600 to 680 m. elevation with mean annual rainfall of 2600 mm and a mean annual temperature of 22.2°C. There is a short dry season lasting 1-3 months. Soils vary but are usually of good structure with mostly moderate fertility.

diameter of 19.6 cm, a basal area of 13.2 m^2/ha and an excellent form (Aguirre Corral, 1963). A further experiment was initiated in 1974 also with Cordia alliodora planted 2.5 x 2.5 meters and associated with maize, as cultivated traditionally using either stumps and seedlings, both 13 months old and applying to half of the plots 250 kg of fertilizer (15 - 30 - 8 -NPK- for the first application and 20-10-6-5 -NPK Mg- 22 days later). (Muñoz, 1975).

The results showed a better survival and growth rate for the stumps and no effect as to fertilization. The experiment indicated the desirability of associating maize with Cordia without fertilizer. Comparing costs, the establishment of Cordia through taungya was 5-8 times cheaper than Cordia alone. At 4.6 years of age the Cordia trees were thinned (two intensities: 24% and 40% of all trees) per ha showing the following measurements:

Table 1. Cordia alliodora, established by taungya after 4.6 years. CATIE, Turrialba, Costa Rica. Average measurements (taken from Muñoz, 1975).

Treatment	Before thinning				After thinning			
	Diameter cm	Height m	Number trees	Basal Area m^2/ha	Diameter cm	Height m	Number trees	Basal Area m^2/ha
No thinning	7.74	6.5	1477	7.86	7.24	6.5	1477	7.86
24% trees thinned	8.21	6.9	1397	8.03	9.15	9.0	1067	7.01
40% trees thinned	7.88	6.7	1520	8.52	9.37	9.1	960	6.59

These two initial experiments led to the desirability to investigate other tree species to be established by taungya, notably Eucalyptus deglupta, Gmelina arborea and Terminalia ivorensis.

Taungya with Eucalyptus deglupta

Several provenances of Eucalyptus deglupta have been introduced in years before and apparently some cross fertilization took place, producing a vigorous tree locally known as "Turrialba Eucalyptus hybrid". The tree is in demand for banana props and posts and growth has shown to be spectacular, some trees reaching a diamter of over 50 cm in less than 10 years. For the experimental plantation, initiated in January 1976, 5 randomized blocks were used. Half of the plots had Eucalyptus deglupta associated with corn and again half of the plots were fertilized and two planting distances were selected: 2.5 x 2.5 m and 3.0 x 3.0 m. The results here are summarized 11 months after planting. (After Aguirre Castillo, 1977).

a) there was no significant difference between both spacings;

b) best growth was achieved with taungya and fertilization but it was estimated that the high cost of fertilizer does not warrant its use;

c) even non fertilized Eucalyptus associated with corn grew well;

d) economically it was best to establish E. deglupta with corn and without fertilizer in comparison to any other combination. In relation to Eucalyptus without corn, it proved 56 to 66% cheaper.

The trees were monitored for a further 2 years but without any fertilizer aplication and gave the following data.

Table 2. Eucalyptus deglupta performance, established through taungya in 1976, with and without associated crops at two planting distances and with and without fertilizer (after Combe and Gewald, 1979)

Year after establishment	2nd.		3rd.			
Period of observation	Jan to Dec. 1977		Jan. 78 to Jan. 1979			
Thinnings	without		without		with	
Increments in:	diameter cm/year	height m/year	diameter cm/year	height m/year	diameter cm/year	height m/year
Treatments*						
2.5 x 2.5 m						
1A	3.4	4.1	2.2	2.5	3.2	3.1
1B	3.3	4.0	2.3	3.5	3.1	3.1
1C	3.5	4.3	2.5	3.2	3.7	3.5
Treatments*						
3.0 x 3.0 m						
2A	4.1	4.4	2.9	3.3	3.3	3.7
2B	3.6	3.7	3.0	4.9	3.6	4.9
2C	4.1	4.2	3.0	2.6	3.6	3.5

* A = Eucalyptus deglupta alone

B = E. deglupta associated with maize (only for one year)

C = E. deglupta associated with maize and fertilized (only for one year).

Taungya with Gmelina arborea

The experiment was initiated in 1977 and used traditional cropping systems of maize (Zea mays) and beans (Phaseolus vulgaris), either separately, or planted together . The first crop of beans was harvested early for string beans; it corresponded to the wetter part of the year. The second crop of beans was led to mature (total time: 10 months). Distances for Gmelina was 2 x 1 and 2 x 3 m and no fertilizer was used. Half of the trees planted were by stumps, the other by seedlings.

The treatment of 2 x 3 m. associated with 2 crops of maize and beans was the most productive and gave a net benefit of 9190 colones* per ha (Fernández, 1978). The Gmelina trees were measured after 10 months , 5 months after the last harvest of beans.

Table 3. Gmelina arborea planted alone or under taungya 15 months old, 5 months after harvesting annual crops. CATIE, Turrialba, Costa Rica (Combe and Gewald, 1979).

Treatment		diameter cm	height m
Plantation alone	1 x 2 m	5.41	6.04
" and maize (twice)		5.30	5.74
" and beans (twice)		5.55	5.84
" and maize and bean		5.70	6.03
Plantation alone	2 x 3 m	8.80	6.12
" and maize (twice)		7.52	5.55
" and beans (twice)		7.31	5.34
" maize and beans (twice)		7.27	5.38

There is clearly a relation between spacing and diameter of Gmelina but no significance could be detected when the effect of associated crops on Gmelina was analyzed.

* 1US$ = 8.54 colones

Taungya with Terminalia ivorensis

Terminalia ivorensis a valuable African timber tree, had been tested in CATIE over 10 years in various plots, showing a remarkable growth, good form and a striking similarity in branch architecture with Cordia alliodora including light shade and decidiousness in time of water stress. This lead to testing it as a component of agroforestry systems, first to be established through taungya and at a later stage to be combined with perennial crops (coffee, cocoa, citrus trees) for permanent combinations. All Terminalia trees were planted in June 1978 at a distance of 3x3 m, half of them as stumps, the rest as seedlings. The wide spacing was intended to allow intercropping for more than a year. No fertilizer was used. The plots included: Terminalia ivorensis alone; T. ivorensis associated with maize followed by beans; T. ivorensis associated with cowpeas (Vigna unguiculata) followed by maize T. ivorensis associated with maize and cowpeas together, followed by maize and string beans.

The results after 10 months here summarized show that: 1) again planting Terminalia as stump produced much higher survival and slightly better growth than striplings, and is therefore the desirable choice because of lower handling and planting cost; 2) the best economic combination was the association with maize followed by beans, 3) when maize and cowpeas were cultivated jointly in two periods, labor costs were excessive in comparison to the market valuable of these two food crops; 4) all interplanted trees showed greater height than trees planted alone (but regularly weeded) (Magne, 1979).

This same Terminalia plantation when 15 months old was then underplanted with coffee (Coffea arabica), cocoa (Theobroma cacao) and oranges (Citrus sinensis) themselves associated in rotations with beans (Phaseolus vulgaris) green beans (P. vulgaris var. Harvester) for half of the plots and mung beans (Vigna radiata) followed by cowpea (V. unguiculata) for the other. The initial Terminalia trees

were thinned from 1111 per ha to 694, six months after initiation (Castañeda 1981).

After one year observation the results here summarized showed that: 1) all Terminalia trees associated with crops were growing markedly better than in unassociated plantations; 2) the growth of the perennial crops was poor when compared to those grown in the open. Measurements of the root systems in Terminalia showed it to be extensive and superficial; 3) the best net benefits derived from the sale of crops were obtained with beans followed by green beans.

In this combination it was possible to obtain a net benefit of ₡2325.00* per ha.

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*The colon was fluctuating between 8.54 and 16.00 per U.S. dollar during the period

The carefully planned sequence leading from annual to complex perennial associations

Since 1977 and over a period of eight years an elaborate experiment is carried out, covering several hectares and involving the following 18 treatments each with four replications: (Enríquez, 1979).

Maize followed by maize with beans

Maize followed by beans and sweet potato (Ipomea batatas)

Maize and sweet potato followed by bean and sweet potato plantain (Musa sp.) associated with Cassava (Manihot esculenta) and maize (Zea mays)

Sugar cane (Saccharum offinalis) followed by sugar cane with maize

Giant star pasture (Cynodon plectostachyus) and laurel (Cordia alliodora)

Giant star pasture and poró, Erythrina poeppigiana

Giant star pasture

Coffee (Coffea arabica) associated with laurel, plantain and beans

Coffee associated with poró and beans

Cocoa (Theobroma cacao) associated with laurel, plantain, pigeon pea (Cajanus cajan) and maize

Cocoa associated with poró, plantain, pigeon pea and maize

Cassava followed by cassava with maize

Laurel associated with corn and beans

Maize followed by maize (with two tillages for each crop)

Maize followed by maize (no tillage but herbicides)

Maize followed by maize (mulching, no tillage)

Natural vegetation (control, free growth).

The first seven crops are considered as representatives of the basic component of the rural diet while coffee and cocoa are major export crops. The trees used, laurel and poró have totally different functions. Laurel provides a valuable timber; poró is used as a nurse tree, for shade and to improve the soil,

by fixing N from the air and apporting large amounts of organic matter and mulch through periodic prunings. Fertilizers are used for annual and perennial crops but not for the trees (which nevertheless benefit from it). No conclusive data are yet available for this 8 years experiment (while yields, soils and pests are monitored but random diameter and yield measurement after 3 years show extremely promising results: cocoa is fruiting after only 3 years) and laurel in some combinations averages over 8 cm in diameter.

Erythrina poeppigiana as a multiple purpose nurse tree

This extremely fast growing legume is widely used for "shade" in coffee and cocoa (see above for reasons). It is also widely planted between various annual and perennial crops as well as in pastures. The leaves are relished by cattle and lopping is often practiced. The wood has recently been purchased by a local paper factory as a substitute for pine. Propagation is usually by large cuttings 2 m long, that start immediately to produce shoots. Distances vary but in coffee it is usually 6 - 10 m apart. Techniques to prepare cuttings and planting have been analyzed by Lozano (1962) while the amount of biomass derived from Erythrina pruning realized every 6 months within coffee plantations, was investigated by Molleapaza (1979). The latter also calculated the amount of N that is apported to the soil by this tree, planted in coffee plantations by measuring leaf fall and the biomass of prunings. This amounted to 80 kgs of N/ha over a period of 6 months. The N. concentration in leaves fluctuated between 4.2 and 4.6% dry weight.

The multiple strata coffee (Coffea arabica), poró (Erythrina poeppigiana) and laurel (Cordia alliodora) association.

This perennial combination involving three strata is very frequently used by coffee growers in the Turrialba region and elsewhere in Costa Rica, usually below 800 m elevation. The poró crown is kept at a height varying between 2.5 and 4 m.

and regular pruning takes place every 6 months, when the crown has reached an average diameter of 5-6 m. The pruning is very fast and it takes usually less than 2 minutes to cut down the branches with a machete and another 4-5 minutes to hack and spread them over the floor.

Measurements in a farm, close to Turrialba involved coffee production in this system, compared with an adjacent plot where only coffee and poró were found but no replications could be made. The coffee yield from the plot containing laurel was considerably higher during 1979 but the reverse ocurred in 1980 (Beer, 1981).

From the agronomic viewpoint Gonzalez (1980) investigated the net economic production between 4 treatments commonly encountered in the Turrialba region: 1) coffee with poró and a high density (270 to 410 trees per ha) of laurel; 2) coffee with poró and a moderate density of laurel (120 - 180 trees per ha); in both treatments the average diameter of laurel varied from 28 to 33 m at initiation; all trees were established through natural regeneration; 3) coffee with poró the latter at distances of 8-10 m apart in this and former treatments; 4) coffee with no shade (exposed to direct sunlight). Three different sites, widely separated and under diferent soil conditions were used. The coffee harvest of 1978 and 1979 were measured as well as the diameter increment of laurel. The conclusions showed that 1) the highest coffee yields were obtained by non shaded coffee but the difference was rather small; 2) the highest economic yields (adding coffee to wood production) were found in those treatments were laurel was associated with coffee (either at a high or moderate density) and this gave a 10-30% economic increase depending on plots, over non shaded coffee; 3) there was great variation between plots concerning laurel volume increment as summarized in the following table.

Table 4. Annual volume increment of laurel, Cordia alliodora, associated with coffee and its economic value in three sites of the Turrialba area (according to González, 1980).

	Laurel density ha	Volume increment m^3/ha/year	Value of timber increment $ /ha/year
Site 1	410	5.5	351.64
	120	5.6	358.03
Site 2	270	20.1	1285.08
	180	17.8	1138.03
Site 3	340	13.4	856.72
	180	11.4	728.85

Other measurements of laurel yields in coffee show the following increments.

Table 5. . Growth of a naturally established stand of Cordia alliodora over coffee shaded by Erythrina poeppigiana, the latter planted by large cuttings every 6 m and heavily pruned twice a year (after Combe and Gewald, 1979).

	1977	1979
Estimated age	15 years	17 years
Number of trees per ha.	288	228
Average dhb (cm)	28.9	30.7
Average height (m)	22.5	22.9
Total volume with bark (m3/ha	162.3	189.0
Mean annual increment with bark (m^3/ha/year)	10.82	11.12

Logging trials showed that Cordia trees can be felled easily between the rows and hauled to the road by oxen. Logging is best practiced before the pruning of coffee and Erythrina.

Some interesting additional information was obtained such as the delaying of poró pruning by some of the small farmers so as to delay the coffee harvest. Coffee harvesting in a reduced period over the year creates competition for labor (coffee pickers). By delaying the harvest, through manipulation of poró shade, small coffee growers were able to mitigate or solve the critical labor shortage (Beer, 1981).

Laurel, Cordia alliodora associated with cocoa (Theobroma cacao)

The management of naturally established laurel trees in cocoa plantations is a relatively recent phenomenon in Costa Rica since it was barely observed 20 years ago at that time a mixture of former rain forest trees, considerably opened to provide admission of light, was the rule. The steep increases of lumber values have undoubtedly triggered the increasing presence of Cordia trees,

Research by CATIE staff and graduate students as well as by UNU fellows has been undertaken since 1977.

One measurement over 2 years in the lowlands close to the coast gave the following results.

Table 6. Growth of a naturally established stand of Cordia alliodora over cocoa (and a few other low shade trees), Home Creek, Costa Rica, (after unpublished data, Natural Renewable Resources, CATIE, Turrialba, Costa Rica, 1979). Rainfall is around 3000 mm and mean annual temperature around 24.5°C.

	15 April 1977	16 March 1979	Current annual increment**
Estimated age in years	20-25	22-27	
Trees per ha.	120	100*	
Average dbh in cm**	41.1	43.1	1.0
Average height in m**	34.0	35.2	0.6
Total volume in m^3/ha with bark	271.1	257.0*	14.8

* The figure decreased because many trees were harvested in the 2 year period.

** Based on the same trees measured in 1977 and 1979.

Beer (1981) has summarized all measurements in the following table.

Table 7. Growth of Cordia alliodora in association with Theobroma cacao and pasture (after Beer, 1981)

Site	Density (trees/ha) 1977 (3)	1979	1980	Diameter breast height (m) 1977 (3)	1979 (2)	1980 (2)	Heights "h" (m) 1977 (3)	1979 (2)	1980 (2)	Basal area G (m^2/ha) (1) 1977 (3)	1979	1980	Commercial Volume V (m^3/ha) (1) 1977 (3)	1979	1980	ΔG (2) (m^2/ha/yr) 1979-80	ΔV (2) (m^3/ha/yr) 1979-80
Madre de Dios (cacao)	180	167	166	34.5	36.0	36.6	35.8 (4)	35.9	35.8	17.6	17.8	17.7	160	168.5	168.7	0.6	5.8
Latino (cacao)			78			39.6			32.0			9.9			85.0		
Home Creek (3),(5) (cacao)	120	100	-	41.1	43.1	-	34.0	35.2	-	16.0	14.6	-	141	134			
Cahuita Plot 1 (pasture)		150	150		30.4	31.3		26.6	26.5		11.4	12.1		81.9	86.1	0.65	4.23
Cahuita Plot 2 (pasture)		208	208		36.7	37.5		33.0	33.8		22.5	23.5		195.6	206.4	0.94	10.8

(1) Values affected by exploitatic and natural mortality.

(2) Calculations based only on measurements of trees still standing in 1980.

(3) Rosero, P. y Gewald, N. Growth of Laurel (Cordia alliodora) in coffee and cacao plantations, and pastures, in the Atlantic region of Costa Rica. In De las Salas, G., ed. Proceedings of the Workshop Agro-forestry Systems in Latin America. Turrialba, Costa Rica, CATIE. 1979. pp. 205-208.

(4) Based on a diameter-height regression curve obtained from the 1979 measurements.

(5) Remeasurements not taken as, after exploitation, only 6 C. alliodora remain in 1980.

Recently a devasting fungal disease, a pod rot (Monilia roreri) has appeared in the area and this will undoubtedly complicate future research. Lack of income from cocoa has prompted farmers to harvest their laurel trees. This is a good demonstration of need for diversification. The resulting widespread harvesting of laurel has allowed to determine the yields (see table 7) and gross income under present harvesting techniques and to initiate monitoring studies on the many sprouts that grow from the stumps.

Laurel (Cordia alliodora) and Cedro (Cedrela odorata) in pastures

The practice of leaving valuable seedlings to grow into timber trees, is well known in Costa Rica and elsewhere. Laurel has been investigated. In the early fifties, Pérez (1954) showed that 40 years old laurel trees were reaching an average diameter of 79 cm and at age 50, 89 cm. The measurements were taken on good soils in the lowlands with close to 4000 mm of annual rainfall and 25°C temperature. He reccommended an economic rotation of 25 years when trees average between 40 and 45 cm dbh.

Detailed measurements on one plot gave the following results:

Table 8. Growth of naturally established Cordia alliodora trees in man-made pastures. Cahuita (sea level), 3000 m rainfall, mean annual temperature of 25°C. (after unpublished data, National Renewable Resources, CATIE, Turrialba, Costa Rica).

	Date		Current annual increment**
	15 April 1977	16 March 1979	
Number of trees per hectare	200	190*	-
Estimate age	25-20	17-32	-
Average dbh in cm	37.5	38.6	0.55
Average height in m	34.5	35.0	0.25
Total volume in m3/ha (with bark)	380.4	389.1*	13.5

*Some trees were harvested in the two year period.
**Based on measurements of the same trees.

Cedrela odorata when grown in coffee and receiving benefits through weeding, grows very fast and is able to withstand the attacks of Hypsipyla grandella a destructive shootborer. It was calculated that trees can be harvested on a 15-20 year rotation (Ford, 1979).

Alder in pastures in the dairy region of Costa Rica

Between 1400 and 2500 m elevation Alnus acuminata, a local alder is widely planted in Costa Rica, either with pastures that are grazed, mostly "kikuyo" (Pennisetum clandestinum) or cut for fodder (Pennisetum purpureum and Axonopus scoparius). Most of the farms are small 3-10 ha but income is relatively high in comparison with other regions of the country. The pastures are usually fertilized and fenced forming small enclosures to allow rotations. The spacing of the alder varies from 8 x 8 m to 12 x 12 m and a few times even wider. Sometimes the lower branches are pruned to allow more light. Striplings from exposed roadsides or riverbanks are used and are usually protected for a few years by meshed wire, until free from harmful effects by cattle. Alder fixes N from the air through the activity of an actinomycete (Frankia sp.) that produces large nodules, sometimes over 1 cm thick and of irregular size.

Table 9 shows the growth of the alder.

Table 9. Growth of alder, Alnus acuminata in two plots in the highlands of Costa Rica, associated with pastures and cutgrass. (After Combe, 1979). Rainfall is around 3500 mm and mean annual temperature between 16 and 18°C, according to elevation.

	Las Nubes	San Rafael
Elevation above sea level	1700	1450
Pasture associated with alder	Pennisetum clandestinum (grazed)	P. purpureum (cutgrass)
Age in years	15	6
Spacing of trees in m	8x12 and up to 10x14	7x9 and 7x11
Density per ha initial	132 approx.	---
present	78	159 and 130
Height in m (26 trees)	22.0	10.0
Mean annual height increment in m	1.47	1.67
dbh in cm (25 trees)	44.8	17.0
Mean annual dbh increment in cm	2.29	2.83

As can be seen, growth is outstanding although on good volcanic soil. Milk production is also high, whether alder is part of the pasture or not and cows are given supplementary concentrates.

The wide spacing of alder allows an excellent development of grass and there is presently an effort by various governmental institutions to plant more alder; a popular manual based on the research work by Poschen (1980) is presently been written. The trees are harvested on a 15 - 20 year rotation when they reach 40 - 50 cm diameter. The medium soft wood is in demand for construction in the highland, for boxes, crates, coffins, firewood and, lately, for orthopedic shoes.

It has been calculated that about 6000 ha of land could be devoted to such combination (Combe, 1979).

Live fence posts

The practice of planting large cuttings that take roots and serve as fences is extremely old throughout tropical America (and for that matter also in Africa and Asia). In Costa Rica they constitute a typical feature of the landscape where they serve to attach barbed wire. There is remarkable little literature on planting techniques and uses, although many of the species are known to produce food (fruits and flowers that are eaten) feed for cattle and rabbits, medicinal products, firewood, posts and of course, more fence posts from the branches. There is much empirical knowledge concerning choice of species, planting techniques, management practices (pruning, renovation, etc.) and techniques to attach barbed wires. Yet there are regions within the country where there are few or no fence posts, even if climate and soils would make it perfectly feasable. An initial inquiry showed that live fence posts are usually associated with poverty and that the rather sophisticated technology to plant and tend live fences may not have reached these areas. It points out that socio-cultural factors play a most important role in the adaption of live fence post establishment. Some of these ideas are expressed in the following table based on a series of inquiries and discussions with people knowledgeable about the subject.

Table 10. Comparison between live fence posts and wooden fence posts (the latter either naturally durable or treated with preservatives). Both posts are being used to attach barbed wires and to prevent trespass principally by cattle (Budowski 1981).

Factor	Live fence	Wooden (dead) fence
Choice of species	Depends of ecological conditions	Many possibilities: depends on availability
Cost	Relatively low or free	Relatively high
Handling of post before placing	Needs careful preparation, transport and storage	No special care required
Placing in soil	Needs care, adequate soils	Soil not limiting
Placing of barbed wire	Special techniques in some species	Some skills required
Initial maintenance	Necessary, requires protection against some animals	None, in some cases needs fire protection
Survival	Losses possible	100%
When to place wire	Usually when well anchored	Immediately
Increase of post density along fence	Easy and cheap	Easy but expensive
Durability	Usually very long	Variable, limited according to treatment and species
Organic matter production	Varies with species	None
N fixation	Possible in some species	None
Effect on soil fertility	Beneficial, specially when branches are pruned and some roots die off (aeration)	None
Erosion control	Can be effectively used as barrier	None
Competition for water and nutrients and light with nearby crop	Does exist but varies according to system; organic matter production compensates	None

Protection of crops and/or animals against wind	Effective but varies according to species, height, density	None
"Horizontal" rain (fog drip) from moisture ladden winds	Possible	None
Toxic effects	Possible (allelopathy)	None, (except when some preservatives are used)
Toxic fauna	Can be sheltered	None (except termites in some cases)
Beneficial fauna	Provides shelter and food (e.g. birds, honey bees)	Little
Additional economic products	Many, such as food, feed, medicinal products; also firewood, posts and more live fence posts	None
In case removal if necessary	Difficult and costly	Relatively easy
Labour for management	Periodical pruning is necessary; skills required	Skills also required to place posts and wires and replace them
Acceptation by farmer	Very popular among poorer farmers	Depends of income. More affluent farmers tend to avoid live fence posts
Special limitations	Disliked by fumigation pilots	Firebreaks must be kept clean during fire season
Aesthetics appreciation	Depends on management and cultural background	Depends on investment possibilities and cultural background

Conclusions

The former descriptions point to quantitative data and additional observations could provide the basis for hypothesis leading to scientific experiments. Many of the data were based on common practices carried out within the country but scarcely appraised or investigated or otherwise registered by the scientific literature -in opposition to a wealth of documentation on agronomic practices not involving trees. Admittedly research in agroforestry is a complex task and experimental designs are not easily set up; there are few scientists trained in the multidisciplinary aspects that concern agroforestry; moreover the socio-cultural dimension of agro-forestry appears to complicate the picture even more, at least from the researcher's viewpoint.

Taungya has shown to be relatively successful at CATIE yet it is little applied in Costa Rica presumably because there is scarcely any extension foreseen to transfer technologies.

Regardless of the research carried out at CATIE (or elsewhere) the practice of adding Cordia alliodora to coffee, cocoa or other crops is widely practiced in the country and the area under this multistrata system is actually increasing. So is the planting of Alnus in pastures.

It appears that research under controlled conditions may possibly be best directed to current practices already in use rather than transferring new technologies (as in the case of taungya, that is little known in the country). Wheter this is so or not, this rather superficial analysis raises an important question to decision makers that deal with the promotion of agroforestry.

LITERATURE CITED

AGUIRRE CASTILLO, C. 1977. Comportamiento inicial de Eucalyptus deglupta Blume, asociado con maíz (sistema "Taungya") en dos espaciamientos con y sin fertilización. Tesis Mag. Sc. Turrialba, Costa Rica, UCR/CATIE. 130 p. 122 refs.

AGUIRRE CORRAL, A. 1963. Estudio silvicultural y económico del sistema Taungya en condiciones de Turrialba. Tesis Mag. Agr. Turrialba, Costa Rica, IICA, 103 p. 67 refs.

ALVAREZ VALLE, H. 1956. Estudio forestal del "jaúl" (Alnus jorullensis H.B.K.) en Costa Rica. Tesis Mag. Agr. Turrialba, Costa Rica, IICA. 87 p. 58 refs.

BEER, J. 1980. Alnus acuminata con pasto. Turrialba, Costa Rica, CATIE. 6 p. 10 refs. (mimeogr.)

_____. 1981. CATIE-UNU Convenio. Annual Report 1980. s.n.t. 17 p. 17 refs. (mimeogr.) (unpublished).

_____. 1980. Cordia alliodora with Theobroma cacao: a traditional agro-forestry combination in the humid tropics. Turrialba, Costa Rica, CATIE. 4 p.

_____. 1980. La Suiza study area agroforestry project. Operational plan October 1980 December 1981. Turrialba, Costa Rica, CATIE. 32 p. 13 refs. (mimeogr.)

BUDOWSKI, G. 1980. The place of agro-forestry in managing tropical forests. Turrialba, Costa Rica, CATIE. 19 p. 20 refs.
(Presented at the "International Symposium on Tropical Forests: Utilization and Conservation", New Haven, USA, 1980).

_____. 1981. The socio-economic effects of forest management on lives of people living in the area. The case of Central America and some Caribbean countries. Turrialba, Costa Rica, CATIE. 27 p. 19 refs.
(Presented at the Workshop on "Socio-economic Effects and Constraints in Forest Management. IFIAS and Forest Research Institute, Debra Dun, India, January 11-18, 1981).

CADIMA ZEVALLOS, A. y ALVIM, P. DE T. 1967. Influencia del árbol de sombra Erythrina glauca sobre algunos factores edafológicos relacionados con la producción del cacaotero. Turrialba (Costa Rica) 17(3):330-336. 2 refs.

CASTAÑEDA, L. A. 1981. Comportamiento de Terminalia ivorensis A. Chev. asociada con cultivos anuales y perennes en su segundo año de crecimiento. Tesis Mag. Sc. Turrrialba, Costa Rica, UCR/CATIE. 116 p. 81 refs.

COMBE, J. y GEWALD, N., eds. Guía de campo de los ensayos forestales del CATIE en Turrialba, Costa Rica. Turrialba, Costa Rica, CATIE, 1979. 378 p.

COMBE, J. y BUDOWSKI, G. 1979. Classification of agro-forestry techniques. In Workshop Agro-Forestry Systems in Latin America, Turrialba, Costa Rica, 1979. Proceedings. Ed. by G. de Las Salas. Turrialba, Costa Rica, CATIE. pp. 17-47. 50 refs.

_____. 1979. Conceptos sobre la investigación de técnicas agroforestales en el CATIE. In Taller Sistemas Agroforestales en América Latina, Turrialba, Costa Rica, 1979. Actas. Editado por G. De Las Salas. Turrialba, Costa Rica, CATIE, pp. 49-57.

_____. 1979. Concepts of agro-forestry research techniques. In Workshop Agro-Forestry Systems in Latin America, Turrialba, Costa Rica, 1979. Proceedings. Ed. by G. De Las Salas. Turrialba, Costa Rica, CATIE. pp. 48-55.

_____. 1979. Combinaciones silvo-pastoriles en zonas altas de producción de leche en Costa Rica. In Proceedings, Simposio Internacional sobre las Ciencias Forestales y su Contribución al Desarrollo de la América Tropical. 11-17 October, 1979. Notes for field trip No. 3. 4 p. (In press)

DACCARET, M. 1967. La influencia de árboles leguminosos y no leguminosos sobre el forraje que crece bajo ellos. Tesis Mag. Sc. Turrialba, Costa, Rica, IICA. 34 p. 22 refs.

ENRIQUEZ, G. 1979. Central trial of perennial crops as compared with some annuals. In Workshop Agro-Forestry Systems in Latin America, Turrialba, Costa Rica, 1979. Proceedings. Ed. by G. De Las Salas. Turrialba, Costa Rica, CATIE, pp. 193-196.

ENSAYO CENTRAL de cultivos perennes. 1979. In Combe, J. y Gewald, N., eds. Guía de campo de los ensayos forestales del CATIE en Turrialba, Costa Rica. Turrialba, Costa Rica, CATIE. pp. 263-267.

FERNANDEZ, S. 1978. Comportamiento de Gmelina arborea asociado con maíz (Zea mayz L.) y frijol (Phaseolus vulgaris L.) en dos espaciamientos. Tesis Mag. Sc. Turrialba, Costa Rica, UCR/CATIE. 125 p. 86 p.

FIERROS, A. M. 1980. Raleos iniciales en plantaciones de Gmelina arborea Roxb en Turrialba, Costa Rica. Tesis Mag. Sc. Turrialba, Costa Rica, UCR/CATIE. 92 p. 52 refs.

FORD, L. 1979. An estimate of the yield of Cedrella odorata L. (Syn. C. mexicana Roem.) grown in association with coffee. In Workshop Agro-Forestry Systems in Latin America, Turrialba, Costa Rica, 1979. Proceedings. Ed. by G. De Las Salas. Turrialba, Costa Rica, CATIE. pp. 177-183.

GONZALEZ, L. E. 1980. Efecto de la asociación de laurel (Cordia alliodora (Ruiz y Pav.) Oken sobre la producción de café (Coffea arabiga L.) con y sin sombra de poró (Erythrina poeppigiana (Walpers) O.F. Cook). Tesis Mag. Sc. Turrialba, Costa Rica, UCR/CATIE. 110 p. 66 refs.

LOZANO, O. R. 1962. Postes vivos para cercas. Tesis Mag. Agr. Turrialba, Costa Rica, IICA, 75 p. 24 refs.

MAGNE, J. 1979. Comportamiento de Terminalia ivorensis A. Chev. en su fase de establecimiento, asociado con maíz, caupí y frijol, utilizando pseudo-estacas y planton en el trasplante. Tesis Mag. Sc. Turrialba, Costa Rica, UCR/CATIE. 90 p. 62 refs.

MOLLEAPAZA A., J.E. 1979. Producción de biomasa de poró Erythrina poeppigiana (Walpers) O.F. Cook y del laurel (Cordia alliodora (Ruiz y Pavon) Oken asociado con café. Tesis Mag. Sc. Turrialba, Costa Rica, UCR/CATIE. (In press)

MUÑOZ, M. 1975. Comportamiento inicial del laurel Cordia alliodora (Ruiz y Pav.) Oken plantado en asocio con maíz (Zea mayz) bajo dos niveles de fertilización. Tesis Mag. Sc. Turrialba, Costa Rica, UCR/CATIE. 78 p. 68 refs.

POSCHEN, P. 1980. El jaúl con pasto; la práctica de un sistema silvo-pastoril en Costa Rica. Turrialba, Costa Rica, CATIE. 6 p. 6 refs. (Presentado en el Curso sobre Técnicas Agroforestales para el Trópico Húmedo, Turrialba, Costa Rica, 1980)

ZAFFARONI, E. y ENRIQUEZ, G. A. 1979. Asociación de cultivos perennes; una alternativa de diversificación en áreas tropicales para pequeños agricultores. Turrialba, Costa Rica, CATIE. 17 p. 39 refs. (mimeogr.)