Technical specification AF-CERVI-TROP1

System: Agroforestry - Live Fence
Variation: *Cedrela odorata*

Summary[1]

Live fences may be established by planting trees around the edge of arable fields or areas of pasture. The trees produce timber and other products and if correctly managed crop yields will not be significantly affected by competition for light or water. This a useful system where land is scarce as crops are not displace by tree planting as the trees are planted on the field boundary.

Ecology[2,3,4]

Cedrela odorata is a fast-growing, high-value timber tree that is native to large areas of Central and South America from southern Mexico to Bolivia, 28ºS–26ºN. It is found naturally at altitudes between 0 and 1500 masl, and where mean annual rainfall is between 1200-3000 mm per year, where the mean annual temperature is 20-32ºC. It will grow on light, medium or heavy soils but thrives on free draining, fertile soils. *Cedrela odorata* is a light demanding species that develops best in open spaces or large clearings in the highly diverse tropical broadleaved forests but in much of its native range the gene pool has been severely depleted due to the high demand for its valuable timber. *Cedrela odorata* is grown as a plantation tree throughout the tropics (see additional information).

Classification of climate and site productivity

Climate is classed as optimal and sub-optimal based on available ecological information and experiences within the project. The use of this system in areas classified as sub-optimal for climatic conditions is not recommended.

Optimal	Tropical, humid 300-1200 masl 1200 - 2250 mm/yr
Sub-optimal	Subtropical/temperate, subhumid <300 or >1200 masl <1200 mm/yr

Site productivity is classified by the locally reported yield of maize and soil conditions for the site[5]. (Exceptions occur on waterlogged soils where *C.odorata* will not grow well despite high maize yields).

	High	**Medium**	**Low**
Maize yield in a 'good' year without fertilizer	> 2000 kg/ha	1000-2000 kg/ha	< 1000 kg/ha
Soil type	Deep (>30cm) well drained, brown-black, few stones	20-30cm depth, heavy clays or sandy	Thin (<20cm) stoney, compacted soils or oxidised clays

Management objectives

The objective of this system is to provide additional products (including timber, poles and fuelwood) from what would otherwise be unproductive ground round the field edge. *C.odorata* produces very high quality, valuable timber for which there is a ready market. A live fence may provide increased protection form winds that can damage the maize crop (the fence must also retain its original function of protecting the field from stock). The inclusion of trees in agricultural areas can also provide soil erosion and biodiversity benefits.

Potential income – assuming a net value of timber of US$35 /m3 (accounting for harvesting and transportation costs) 150 m3 timber would produce a total net income of US$5,250 /ha at the end of the rotation. (Volume estimated from average reported yield).

Costs of implementation[6] - Estimated costs per ha over the rotation are: establishment US$58, maintenance US$31 and opportunity cost (lost production from land) US$0-75 depending site quality.

Management operations

Establishment

1. Although these techniques vary with location the following activities are carried out:

1.1 Clearing weeds

1.2 Making holes for seedlings – large holes 30cm diameter and depth produce better conditions for root development, the topsoil is more fertile and should be placed in the bottom of the hole for better rooting. In very compact soils holes may be dug after the start of the rains.

2. It is important to obtain good quality planting stock, which should be ready for planting at the beginning of the rainy season.

2.1 Planting spacing should be every 3m, representing 133 trees around a 1 ha field.

2.2 The roots of seedlings should be pruned just prior to planting to help root development

Maintenance

1. Weeding should be carried out at the same time as the crops in the field are maintained each year for at least the first 5 years.
2. Pruning is vital to maintain tree form where is there is evidence of *Hypsipyla* attack (see additional information below)

Thinning and harvest

1. No thinning.
2. The harvest should take place in year 25

Re-establishment

1. Re-establishment will involve re-planting after harvest.

Carbon sequestration potential[7,8,9,10,11]

Carbon sequestration potential over 100 years with a crop rotation of 25 years on an average quality site with optimal climatic conditions is 43 tonnes of carbon per ha above an initial soil and vegetation carbon baseline of 86 tC/ha. (For details of carbon storage see appendix 1).

Carbon sequestration potential is based on average net carbon storage in tree biomass and forest products. Carbon storage is calculated using the CO2FIX model (Mohren and Klein Goldewijk 1990, Mohren et al 1999). Details of the parameters used (basic wood carbon content; initial soil carbon content; timber production; total tree increment relative to timber production; turnover rate; humification factor; litter and humus residence time; product allocation for thinnings and expected lifetime of products) are given in de Jong et al (1996). The model uses an assumed annual timber production of 6m3/ha for planted trees; details of the productivity data are given in de Jong et al 1995. (For details of model inputs see appendix 2).

The soil baseline (75 tC/ha) is based on de Jong et al 1996. The vegetation baseline (11 tC/ha) is based on Ambio 2002. The baseline assumes that current land use would continue unchanged and that the long term average carbon storage would be the same as current carbon stock.

Monitoring[10]

Monitoring targets for the first 3 years are based on establishment; all the trees must be planted by the third year with at least 85% survival. Thereafter monitoring targets are based on DBH, the expected DBH at the time of monitoring is based on a predicted mean annual diameter increment on which carbon sequestration estimates are based.

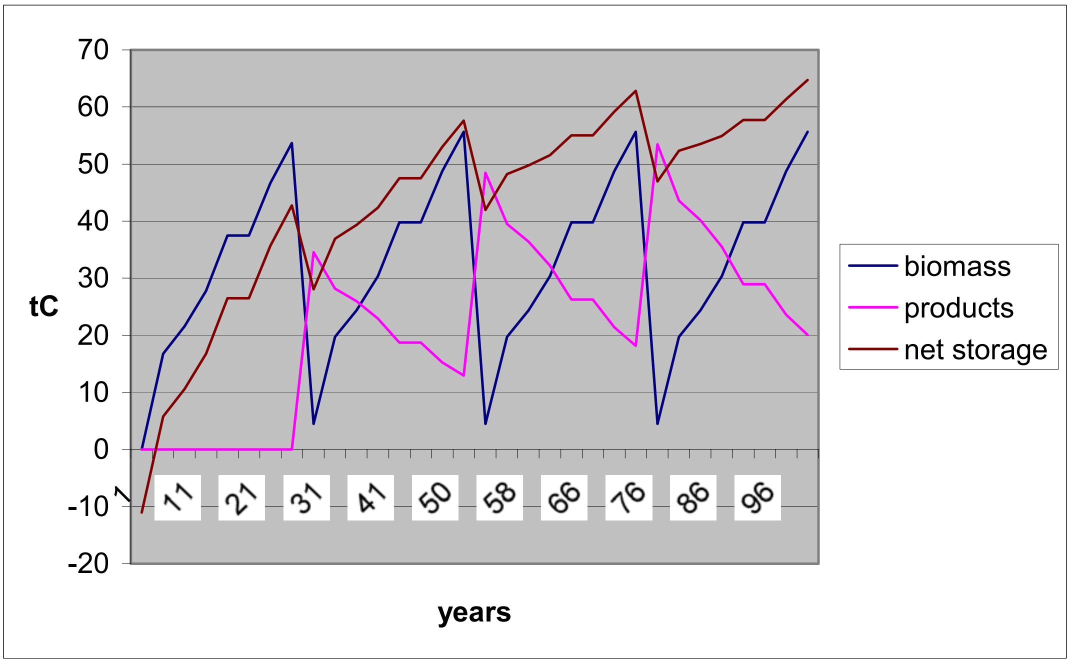
Year	Indicator
1	At least 33% trees planted
2	At least 66% trees planted
3	All trees planted (at least 133 stems /ha) At least 85% survival
5	Average DBH not less than 9cm
10	Average DBH not less than 18cm
15	Average DBH not less than 26.5cm

Additional information[4,12]

The most important pest on plantation of Cedrela odorata and one of the most important factors in establishment is the shoot borer *Hypsipyla grandela*. The larvae of the moth develop in the apical bud of young mahogany trees causing the shoot to die. This does not kill the tree but this leads to the growth of several subsidiary shoots. If not pruned this will lead to forking of the main stem and drastically reduce the value of the timber. However if damaged shoots are removed the tree will continue to grow with good form and the length of saleable timber much increased. Pruning of subsidiary shoots must take place within one or two years of *Hypsipyla* attack as the removal of older branches will put the tree at risk of disease. One means of reducing the occurrence of the shoot borer is to use a mixture of species. Although not conclusively proven, planting fast growing species with the *Cedrela* may help prevent infestation through reducing the chances host location. Chemical and biological means of control do exist but at high the cost. The advantage in small scale plantations of mahogany is that the farmer can quickly spot damaged trees and prune the shoots where necessary during routine maintenance. After approximately 5 years the trees become less susceptible to the shoot borer. It is extremely important that farmers are given training in pruning trees if they are to realise the full value of this species.

Appendix 1 – carbon storage

YEAR	CCBIOM	CPRODW	B&P storage	net storage	accum tCyr
1	0	0	0	-11	-11
6	16.77	0	16.77	5.77	-24.075
8	21.59	0	21.59	10.59	-7.715
11	27.8	0	27.8	16.8	33.37
16	37.49	0	37.49	26.49	141.595
21	46.68	0	46.68	35.68	297.02
25	53.71	0	53.72	42.72	453.82
26	4.5	34.56	39.06	28.06	489.21
31	19.73	28.18	47.91	36.91	651.635
33	24.36	25.97	50.32	39.32	727.865
36	30.35	22.98	53.33	42.33	850.34
41	39.76	18.73	58.5	47.5	1074.915
46	48.75	15.28	64.02	53.02	1326.215
50	55.66	12.97	68.63	57.63	1547.515
51	4.5	48.46	52.95	41.95	1597.305
56	19.73	39.51	59.25	48.25	1822.805
58	24.36	36.41	60.77	49.77	1920.825
61	30.35	32.21	62.56	51.56	2072.82
66	39.76	26.27	66.03	55.03	2339.295
71	48.75	21.42	70.16	59.16	2624.77
75	55.66	18.19	73.85	62.85	2868.79
76	4.5	53.46	57.96	46.96	2923.695
81	19.73	43.59	63.32	52.32	3171.895
83	24.36	40.17	64.53	53.53	3277.745
86	30.35	35.54	65.9	54.9	3440.39
91	39.76	28.98	68.74	57.74	3721.99
96	48.75	23.63	72.37	61.37	4019.765
100	55.66	20.07	75.73	64.73	4271.965



Appendix 2 - CO2Fix Inputs

Stand parameters		
Rotation length (yr)		25
Number of rotations		4
Adjustment of assimilate to account for non-optimal site conditions	Foliage	1
	Branches	1
	roots	1
Initial biomass (Mg/ha)	Foliage	0
	Roots	0
	Litter	0
	Soil humus	150
	Branches	0
	Stems	0
	Deadwood	0

Tree Growth Table				
Age (yr)	Stem increment (m3/yr)	Dry weight increment relative to stem		
		needles	Branch	roots
0	6	0.7	0.6	0.7
10	6	0.4	0.4	0.4
15	6			
20	6	0.4	0.4	0.4
25	6			

Tree species Parameters		
Basic density of stemwood (kg/m3)		500
Carbon content of dry matter (kg/kg)		0.5
Turnover of various biomass components (1/yr)	Needles	0.5
	Branches	0.05
	Roots	0.07
Mortality as a fraction of trees per year (1/yr)		0.02
Average residence time of carbon in wood products (1/yr)	Dead wood	10
	Energy	1
	Packing	5
	Construction	25
Humification and decomposition coefficients (yr)	Humification	0.1
	Litter decomposition	1
	Humus decomposition	100
Carbon content of stable soil humus (kg/kg)		0.5

Thinning and harvest table					
Thinning age	Fraction stem removed	Dead wood	Energy	Packing	Construction
8	0.25	0.4	0.6	0.4	0
16	0.25	0.2	0.4	0.4	0
Final harvest		0	0	0	1

References

[1] This specification is based on a system used in Chiapas, Mexico.
[2] Webb D.B., Wood P.J., Smith J.P. and Henman G.S. (1984) *A Guide to Species Selection for Tropical and Subtropical Plantations*. Tropical Forestry Paper 15, Oxford, UK
[3] CABI Forestry Compendium
[4] Mayhew J.E. and Newton A.C. 1998 The Silviculture of Mahogany. CABI Publishing, UK
[5] Site class characteristics are based on surveys conducted with farmers in the region.
[6] Data adapted from Tipper R., de Jong B., Ochoa-Gaona S., Soto-Pinto M., Castillo-Santiago M., Montoya-Gomez G. and March-Mifsut I. (1999) Assessment of the cost of large scale forestry for CO2 sequestration: evidence from Chiapas, Mexico. IEA Greenhouse Gas R&D Programme.
[7] Mohren G. and Klein Goldewijk C. 1990. CO2FIX: A dynamic model of the CO2-fixation in forest stands. De Dorschkamp Resrach Institute for Forestry and Urban Ecology. Report 624. 35p + app. Wageningen, The Netherlands.
[8] Mohren G., Garza Caligaris J, Masera O., Kanninen M., Karjalainen T. and Nabuurs G. 1999. CO2FIX for Windows: a dynamic model of the CO2 fixation in forest stands. Institute for Forestry and Nature Research, Instituto de Ecologia, UNAM, Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE), European Forest Institute. Wageningen The Netherlands, Morelia Mexico, Turrialba Costa Rica, Joensuu Finland. 27p.
[9] de Jong B., Soto-Pinto L., Montoya-Gomez G., Nelson K., Taylor J. and Tipper R. 1996. Forestry and agroforestry alternatives for carbon sequestration: a study from Chiapas, Mexico. In: W. Adger, D. Pettenella and W. Whitby (eds) *Climate Change Mitigation and European Land Use Polices*. CAB International pp.269-284
[10] de Jong B., Montoya-Gomez G., Nelson K., Soto-Pinto L., Taylor J. and Tipper R. (1995) Community forest management and carbon sequestration: a feasibility study from Chiapas, Mexico. *Interciencia* 20(6):409-416
[11] de Jong per comm
[12] Newton A., Baker P., Ramnarine S., Mesen J. and Leakey R. 1993. The mahogany shoot borer: prospects for control. *Forest Ecology and Management* 57: 301-328