Technical Specification: Reference: MOZ-TS-DIP var. gliricidia
Last modified: 8 May 2009

System: Dispersed interplanting	
Variation: Gliricidia	

Main tree species

Gliricidia sepium	Gliricidia	Gliricidia

Minor tree species

Calliandra calothyrsus	Calliandra	Calliandra
Sesbania sesbans	Sesbania	Sesbania

Summary

This system involves the planting of nitrogen fixing tree species (dominated by gliricidia) at a low stocking density throughout the mashamba. Crops can continue to be grown. Nitrogen fixing trees will increase and extend the expected productivity of the mashamba. These species increase soil nitrogen by actively manufacturing nitrogen compounds through symbiotic bacteria located in the roots. Any litter will act as a green manure (organic fertiliser) and the tree roots will also help to preserve the soil structure by retaining moisture and preventing erosion.

Planted trees should be pruned carefully every year to allow crops to continue to be grown throughout the mashamba. Many studies indicate that interplanting of nitrogen fixing trees with crops (e.g. sorghum, maize) will increase crop yields significantly (University of Queensland, 1998) as well as extending the productivity of the mashamba thereby reducing the pressure to clear new areas of forest.

It is also recommended to plant pigeon peas which will help to further improve soil quality whilst also producing a food / cash crop.

Ecology

Altitudinal range. Gliricidia will adapt to grow at low to medium altitudes (0 - 1200m). Sesbania can be grown at higher altitudes (up to 2300 m)
Climatic factors – Plant in areas of low to high rainfall (600 – 3500 mm/yr). All three species are capable of surviving a long dry spell. Mean temperatures from 15^{0}C to 30^{0}C. Gliricidia generally can coppice only in areas with light frost. Gliricidia tolerates fires well and trees quickly re-sprout with onset of the rains.
Habitat requirements. Few limiting factors. Will not tolerate very acidic soils.

Description

These are all small to medium sized trees which will not exceed 8-12 meters in height. Generally calliandra and sesbania are smaller than gliricidia and will not exceed 10 meters in height.
Sesbania will tolerate relatively cooler conditions (10^{0}C min) and higher altitudes (to 2300 m) and can withstand waterlogging.

Main timber products.

Fuel wood and fodder from thinnings and branches
Poles from thinning
Gliricidia will also produce a hard durable timber which is suitable for furniture, construction etc.
All species are suitable for apiculture
Gliricidia is used by farmers in some Latin American countries to repel insects. The leaves are ground up and combined with water. The animal is then bathed with the resulting paste, the bark and leaves of gliricidia are used to treat human skin diseases (though it is slightly toxic to eat). Leaves provide good forage for goats, and also for green manure.

Classification of climate/ 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	Description of climate Range - 0 - 1200masl Range - 700 – 3500 mm/yr
Sub-optimal	Description of climate Range - >1200 masl No. 500 – 4000 mm/yr

<u>Site productivity</u> is inferred from locally reported soil conditions for the site

	High	**Medium**	**Low**
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
Main management objectives. Plant nitrogen fixing trees to improve the soil. The whole area will continue to grow crops. The expected productivity of the site will be extended, which will remove the necessity to change mashamba every three to five years. Gliricidia can be managed as a source of fuel wood, fodder and timber.

Potential income
Poles may be sold but any additional income from this system is likely to be small.

Costs of implementation
Estimated costs per ha:
Establishment (year 1): 3,500 meticais ($145). Costs will be lower when planting cuttings.
Maintenance (year 2 – 5): 1,500 meticais ($62.5)
Opportunity cost (lost production from land): N/A

N.B. The above costs include values for the purchase of seedlings and for time that the farmer would spend on establishment and maintenance of the trees. However, in the first years of the project (during the Pilot Phase) seedlings are supplied at no cost to the farmer and most farmers will plant and maintain their own trees so this is not actually a cost that will be incurred.

Management operations

Establishment
The farmer must first remove any competing vegetation from the mashamba. All foliage and green waste should be spread on site to break down and enrich the soil. This will also help to retain moisture. The whole site must be turned to a low depth (5 – 10 cm). The farmer will then sow any crops (e.g. maize, sorghum), before planting the trees in small planting pits. Planting should establish 200 trees per hectare at a spacing of **10m x 5m**. The planting stock might be either seedlings or cuttings. Large sized cuttings (1 – 2.5m in length and 6 cm in diameter) are made from branches 1.5 to 2 years old. Small cuttings are 30 to 50 cm long and made from branches 6 to 12 months old. Branches used for cuttings should be straight and healthy without side branches. The top of the cutting should be cut at a slant to prevent water collection and subsequent rotting. The bark on the lower portion of the cutting should be scarred through to the cambium with a sharp knife to encourage rooting. One third of small cuttings should be buried in the ground. For large cuttings 50 cm is sufficient. Trees established from cuttings will have a shallow root system and a short bole. They are therefore susceptible to uprooting by heavy winds.

It is best to plant at the beginning of the wet season to minimize the requirement to water the seedlings. Mulch should be placed around the base of the seedlings to help retain soil moisture whilst also reducing the growth of competing vegetation and adding fertility to the soil.

When planting nursery grown stock:
- Care should be taken handling plants not to cause damage to shoots, buds or bark
- Only remove plastic from around root-ball at the time of planting. Care should be taken to remove all the plastic
- Prune back roots (especially any circular roots) at the time of planting to stimulate new root growth once in the ground
- Plant to depth of root collar (i.e., for bagged plants, to level of existing soil). Never plant deeper than in nursery leaving no roots exposed
- Ensure that soil is replaced firmly around trees (i.e., well heeled in). Put top soil back in planting hole first

It is recommended that this system is combined with pigeon pea planting. This will help to improve soil fertility whilst at the same time producing a food crop.

Mycorrhizal inoculation

The following simple mycorrhizal inoculation process is recommended as a way of promoting an association between soil borne fungus and the leguminous trees being planted in the mashamba.
1. Collect soil (only top 15 – 20 cm) from under an area of undisturbed vegetation (including non burning in recent years). Either place this soil in a large container or in a ground pit lined with plastic.
2. Plant a mixture of food crops (maize) and leguminous plants (pigeon peas) into this soil. Maintain with regular watering.
3. After 3 months cut both the food and leguminous crops at ground level. Stop watering.
4. After a further week (with no watering) pull up the roots of the food and leguminous crops and cut into 1 cm sections. Mix the soil and cuttings together. This is the inoculum.
5. The inoculum should be placed around the root ball of the plant when planting out. Alternatively the inoculum is placed in the container in which the seed is sown, a few centimeters below the seed.

Maintenance
Any weeding should be done as required particularly in the first year after planting to ensure successful establishment. It is assumed that extensive weeding will be associated with crop maintenance.
Side branches can be removed to assist access and reduce shade. No more than 30% of the stem should be pruned at any one time.

For the first two years after planting any dead trees should be replaced at the beginning of the following wet season.
Crops will continue to be grown throughout the mashamba.
There should be **no** burning at any time. Any foliage and green waste should be left on site and worked into the ground. Woody material from pruning / thinning can either be used as fuel wood or for poles etc.

Thinning and harvest

Thinning may be done according to the following schedule:

Year	% removal	No. of trees remaining on site per hectare (minimum)	No. of trees that may be felled per hectare(maximum)
5	25	150	50
10	25	100	50
30	100	200 (at this stage 200 new trees will be planted).	100

Re-establishment

The whole site will require replanting at year 30. Gliricidia might live for longer up to 50 years in which case replanting should be done as required. The life span for calliandra is likely to be 15 – 20 years. Sesbania will only live for up to 5 years. The thinning and harvest cycle will continue on this basis.

Carbon sequestration potential
Carbon sequestration potential over ***100*** years with a crop rotation of ***30*** years on an average quality site with optimal climatic conditions is ***10*** tC/ha above an initial vegetation carbon baseline which is assumed to be zero. The Nhambita carbon calculator (ECCM, 2005) should be used to calculate the number of saleable carbon credits based on the land use system and area planted.

Carbon sequestration potential is based on average net carbon storage in above and below ground biomass and forest products. Carbon storage is calculated using the CO2FIX-V3 model (Mohren et al 2004). Details of the parameters used (basic wood carbon content; timber production; total tree increment relative to timber production; product allocation for thinnings and expected lifetime of products) are given below. The model uses an assumed annual timber production of 1.59 m^3/ha for planted trees. For details of model inputs see appendix 2.

N.B. Timber production (MAI & CAI) was calculated on the basis of trees measured within the project area. All the trees measured were young (<7 yrs). This is likely to result in a conservative forecast of timber production (MAI). As the project expands and more data becomes available these calculations should be revised and updated.

N.B.B **10 tonnes of carbon** is equivalent to **36.6 tonnes of carbon dioxide**.

Monitoring
Monitoring targets for the first 4 years are based on establishment; the whole plot must be established by the first year with at least 85% survival of seedlings. 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.

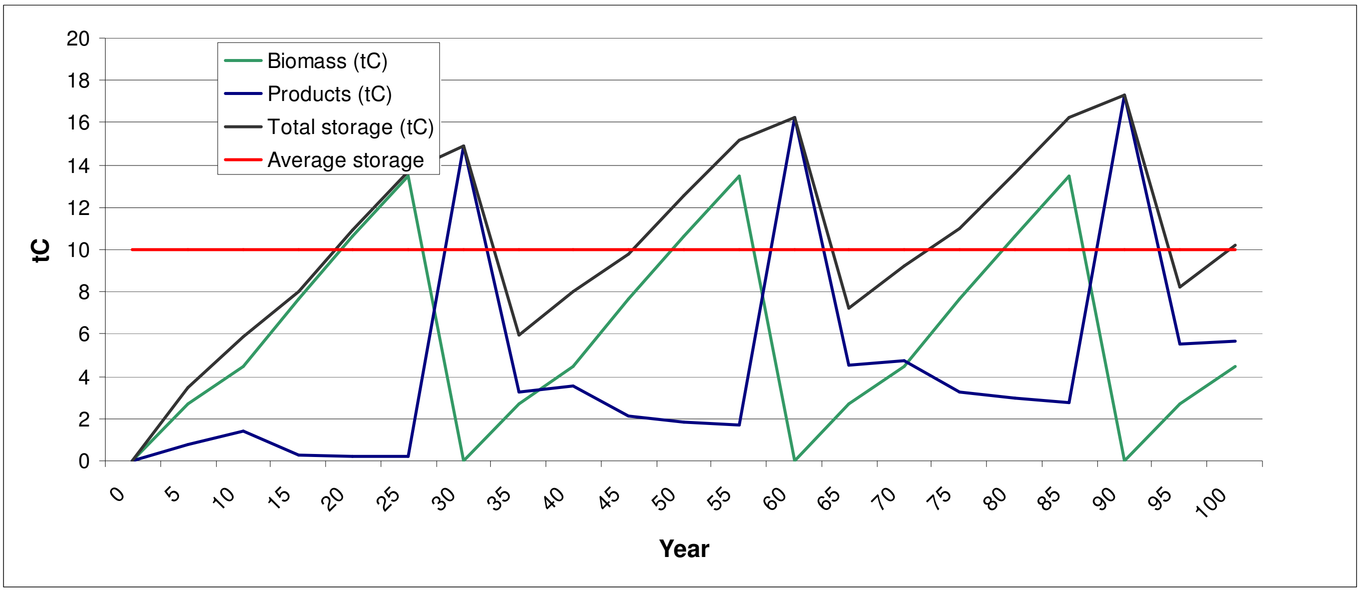
Year	Indicator
1	100% plot established. 85% survival.
2	100% plot established
3	100% plot established
4	100% plot established
5	Average DBH not less than 7cm
6	Average DBH not less than 8.5cm
7	Average DBH not less than 10cm
10	Average DBH not less than 16cm

Information about pests
Sesbania is attacked by nematodes, insects, fungi and viruses. The leaf-eating beetle *Mesoplatys ochroptera* can completely defoliate sesbania, leading to mortality. Caterpillars, Hymenoptera, and stem borers are normally associated with sesbania (World Agroforestry Centre, 2004).

Pachnoda ephippiata (a coleopteran), feeds on the fruits, flowers and foliage of calliandra, causing floral abortion and failure of seed production. The degree of infestation seems to be aggravated by prolonged dry spells when insect populations on the plants are high (World Agroforestry Centre, 2004).

Appendix 1 Carbon storage figures

Year	Biomass (tC)	Products (tC)	Total storage (tC)
0	0	0	0
5	2.71	0.77	3.48
10	4.5	1.41	5.91
15	7.69	0.29	7.98
20	10.65	0.24	10.89
25	13.48	0.21	13.69
30	0	14.91	14.91
35	2.71	3.26	5.97
40	4.5	3.52	8.02
45	7.69	2.12	9.81
50	10.65	1.87	12.52
55	13.48	1.69	15.17
60	0	16.27	16.27
65	2.71	4.54	7.25
70	4.5	4.73	9.23
75	7.69	3.27	10.96
80	10.65	2.98	13.63
85	13.48	2.76	16.24
90	0	17.31	17.31
95	2.71	5.54	8.25
100	4.5	5.7	10.2



Appendix 2 - CO2Fix Inputs

Stand parameters		
Rotation length (yr)		30
Number of rotations		3
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
	Branches	0
	Stems	0
	Deadwood	0

Tree Growth Table				
Age (yr)	Stem increment MAI (m3/yr)	Dry weight increment relative to stem		
		foliage	branches	roots
0 - 100	1.59	0.35	0.2	0.25

Tree species Parameters		
Basic density of stemwood (kg/m3)		620
Carbon content of dry matter		0.5
Turnover of various biomass components (1/yr)	Foliage	1
	Branches	0.05
	Roots	0.07
Mortality as a fraction of trees per year (1/yr)		0.0
Average residence time of carbon in wood products (1/yr)	Dead wood	10
	Energy	1
	Packing	5
	Construction	25

Thinning and harvest table					
Thinning age	Fraction stem removed	Dead wood	Energy	Packing	Construction
5	0.25	0	0.5	0	0.5
10	0.25	0	0.5	0	0.5
Final harvest		0	0.5	0	0.5

References

ECCM (2005). Nhambita carbon calculator

Mohren, F., van Esch, P., Vodde, F., Knippers, T., Schelhaas, M., Nabuurs, G., Masera, O., de Jong, B., Pedroni, L., Vallejo, A.., Kanninen, M., Lindner, M., Karjalainen, T., Liski, J., Vilen, T., Palosuo, T. (2004). CO2FIX-V3

Sambane, E (2005). Above ground biomass accumulation in fallow fields at the Nhambita Community, Mozambique. A dissertation presented for the degree of Master of Science, University of Edinburgh, 2005.

University of Queensland (1998). Forage Tree Legumes in Tropical Agriculture. Published by the Tropical Grassland Society of Autralia Inc.

World Agroforestry Centre (2004). Agroforestry tree database.

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