unique land use

COMACO

With support from

Federal Ministry of Food and Agriculture

by decision of the German Bundestag

Agroforestry Extension Modules

Promotion of Agroforestry in Katete District, Eastern Province

Elaborated by unique land use GmbH, www.unique-landuse.de,
In partnership with Community Markets for Conservation (COMACO), www.itswild.org,

under the Bilateral Cooperation Program Agreement „Promotion of Agroforestry for the Production of Wood and Non-Timber Forest Products in Katete District, Eastern Province, Zambia" – between the Zambian Ministry of Agriculture, MOA, and the German Ministry for Food and Nutrition, BMEL.

April 2025

Table of Contents

List of abbreviations

BMEL	Bundesministerium für Ernährung und Landwirtschaft
COMACO	Community Markets for Conservation
DACO	District Agriculture Coordinating Officer
DVO	District Veterinary Officer
FI	Farm Institute
FTC	Farmer Training Center
GART	Golden Valley Agriculture Research Trust
GFA	GFA Consulting Group – General representative of BMEL for the Bi-lateral Cooperation Program
MFL	Ministry of Fisheries and Livestock
MoA	Ministry of Agriculture
PMU	Project Management Unit
SAO	Senior Agricultural Officer
SMS	Subject Matter Specialists
TOT	Training of Trainers
VA	Veterinary Assistant
ZARI	Zambian Agriculture Research Institute
ZMW	Zambian Kwacha

Introduction

The promotion of agroforestry project

In Zambia's Eastern province, the demand for agricultural land and firewood has taken its toll on the region's forests. To combat this trend, the Ministry of Agriculture (MoA) of Zambia and the German Bundesministerium für Ernährung und Landwirtschaft (BMEL) joined forces, launching the transformative "Promotion of Agroforestry for Production of Wood and Non-Timber-Forest-Products" project.

This project was run in Katete from September 2021 to June 2025 to promote agroforestry practices as a sustainable solution for smallholder farmers, enhancing both their agricultural productivity, economic opportunities and resilience to the effects of climate change. The key agroforestry activities promoted by the project, and covered in these modules, are:

Table 1: Summary of modules covering key building blocks for promoting agroforestry

Module Number	Key details
1	Forming and organizing farmer groups to ensure effective functioning and bottom-up planning for agroforestry activities
2	Centrally procuring seeds and planting bags before distributing them to nursery groups
3	Outlining the timeline of key activities from seed harvesting to seedling transplanting
4	Practical methods for producing Bokashi, an organic fertilizer which is a cost-effective alternative to synthetic chemical fertilizers.
5	Establishing tree nurseries managed by, and for the benefit of, smallholder farmers.
6	Introducing farmers to basic propagation techniques, focusing on budding lemons and grafting mangoes to enhance the economic value of fruit trees
7	Elaborating on a variety of options for combining trees with other agricultural activities, including: ‣ Alley cropping with 'fertilizer trees' in main crop fields ‣ Live fencing of fields, gardens and kraals to reduce deforestation ‣ Planting woodlots to provide a new and managed source of timber and non-timber products, that can also be combined with crops ‣ Planting orchards to diversify farm income
8	Engaging livestock farmers with agroforestry to: ‣ improve their land use through pasture planting ‣ improve the quantity and quality of livestock feed through, forage production and hay baling

Throughout these four years, the project has achieved numerous successes, while also facing several challenges to effective implementation. Both positive and negative experiences represent learning opportunities which have contributed to the guidelines and models presented in these modules. These insights were gained through 6 months of fieldwork and interviews focused on understanding and improving how the fundamental activities of the project work, encompassing both organizational and practical aspects. The modules are intended to support the preparation and delivery of training workshops (as part of the cascading "Training of Trainers" extension approach) at the district level, in order to improve the work of extension officers and veterinary assistants in the field.

Gliricidia alley cropping, a key agroforestry model promoted by the project.

Acknowledgements

- The senior staff (DACO, SAO, DVO) of the Ministry of Agriculture and Ministry of Fisheries and Livestock in Katete District, as well as the Subject Matter Specialists, Extension Officers and Veterinary Assistants.
- Key experts who have contributed to training workshops with both the MoA and MFL, including the Senior Livestock Production Officer for Eastern Province and the Programs Officer from the ZARI-Msekera.
- The Chief Technical Advisor, National Technical Advisor, Project Assistant, and Monitoring Support Staff of the Project Management Unit in Katete, as well as international colleagues from Unique Land Use.

- The many farmers throughout the district who are embracing the opportunities that come from agroforestry and were always eager to share lessons learned from their experiences.
- The German Bundesministerium für Ernährung und Landwirtschaft for their financial support of the project, in partnership with the Ministry of Agriculture of Zambia overseeing the implementation and GFA coordinating the on-site technical support.

Edward Tyler

Project Assistant, Unique land use

1. Nursery group formation and demand planning for small-scale farmers

1.1. Objectives

Good Practice:

- ✓ Large participation of farmers
- ✓ Sensitization at a site that demonstrates benefits of the trees

The selection of farmers, the formation of groups, and in particular the choice of lead farmer are key for determining the success or failure of agroforestry practices. It is particularly important:

- To bring together motivated and capable farmers who can successfully adopt agroforestry practices on their farms.
- To link farmers directly with the existing extension services (camp extension officers and veterinary assistants).
- To plan collaboratively for the next planting season, based on an understanding of each farmer's interest in different agroforestry species and its benefits.
- To increase the number of farmers adopting agroforestry practices as a more economically productive and resilient way of managing their fields.

1.2. Benefits

Well organized groups are the key for success. Rushed or ill-judged decisions during farmer group establishment and lead farmer selection might lead to social conflict and in the worst case to the group falling apart. All stakeholders benefit from well established, bottom-up farmer groups.

1.3. Sensitization meetings

When starting agroforestry promotion activities in new camps, sensitization meetings with the main local stakeholders are essential. Extension officers should invite village headmen, cooperative leaders, and interested farmers to a local stakeholder meeting to introduce the project and assess feasibility and local expectations. We recommend to:

1. Organize the sensitization meeting at one village within the camp,
2. Present and discuss the intervention approach and ideas,

3. Get feedback about the specific local demand and expectations for agroforestry,
4. Explain the organizational structure, including the formation of farmer groups,
5. Agree on the next steps to come,
6. End the meeting with a locally produced and prepared lunch.

1.4. Establishing farmer groups

Establishing groups with 20 farmers proved to be feasible and target oriented. Groups below 10 and above 30 members are not recommended. Social circumstances have a major influence on group formation and function. Nevertheless, we recommend encouraging mixed groups (men and women as well as old and young members). Avoid having too many members of the same family.

The general approach to forming **new** groups is to leave the decision-making process as much as possible to the farmers (bottom-up approach). This includes the selection of group members, their lead farmers, as well as the selection of trees that they will raise and introduce to their fields (species and numbers).

Where there are already existing and well-organized farmer groups (not cooperatives), extension officers should consider involving them in the project. Working with these groups can accelerate adoption since they might already have received training. However, it can also lead to the group being overstretched and reduce their performance in both projects. Extension officers should take care not to overload the groups and their leaders with additional tasks. As a rule of thumb, a lead farmer should only lead one group.

1.5. Selecting lead farmers

Good Practice: Farmers actively participating in meeting to discuss lead farmer selection.

Good results have been achieved by groups which chose their lead farmer themselves. Weaker results have been achieved in groups where the lead farmer was chosen by headmen, cooperatives, officers or other stakeholders who are not actually part of the group. The selection criteria for lead farmers should be explained by the camp officer, including:

- **Motivation and capacity**: Lead farmers must be self-motivated and be ready to invest time and labor. The main tasks of a lead farmer are:
- to attend training courses,
- to speak for the group and coordinate activities with the extension officer,
- to be responsible for the nursery and the survival rate at the nursery,

- to manage the distribution of seedlings.
- **Focus**: They should not hold the same role in another project or committee, so that they can give the leadership of the agroforestry group their full attention. Influential leaders in the community should still be encouraged to take part as follower farmers.
- **Respect**: Lead farmers must be respected by the group members, and they must be able to act as a representative for them.
- **Communication skills**: Lead farmers must be effective communicators for other farmers, able to facilitate and lead group activities, and be contactable by phone. They should also be able to keep written records of certain activities and be open to experiments.
- **Farm characteristics**: The lead farmer's farm is a key venue for holding group trainings, meetings and is often the site for the tree nursery. The farm should be easily accessible to other group members, have space for training demonstrations, and ultimately should act as an agroforestry showcase for the group.

The final selection of the lead farmers must be confirmed. Best results have been achieved by organizing a meeting to reach a consensus about each lead farmer with all main stakeholders (camp officers, block officers, Subject Matter Specialists (SMS), district Senior Agricultural Officer (SAO), District Agriculture Coordinating Officer (DACO), participating NGOs and partners) discussing, declining or confirming each lead farmer.

1.6. Group planning for each season

Prepare and hold meetings with the whole group in **May and June**. The agenda should include:

- Presenting the benefits of the available species to the farmers, as well as the requirements to grow them – in terms of water, space, time and effort. See module 7 for these details.
- Receiving feedback from each farmer group about which trees they are most interested in, and for what purpose.
- Comparing the demands with the capacity in terms of labor, knowledge (each species needs a different treatment) and space (nursery and transplanting sites).
- Identifying a realistic demand of each farmer and thus of the group. We recommend starting with only a limited number of different species (not more than 5).
- Reaching a consensus about what seeds to request and how many seeds

Good Practice: Existing agroforestry plot used to demonstrate benefits to farmers.

and planting bags will be needed. Record this information in a table (a template is provided below).

The outcome (concrete demand of each group in terms of numbers and species) must be communicated to the ESP, Extension Service Provider, to guarantee that the exact amount of planting bags (main cost factor) and seeds are procured. Demand identification template tables are provided in annex 2,1 and 2.2.

Note: After the first year, the agenda should include the results from the previous year, including survival rates – and the following questions need to be answered:

- How many seedlings are needed for gap-filling?
- How many planting bags are left over from the previous year?

Once the plan for each zone has been documented in written form, the camp officer compiles the demand for trees across the whole camp by **July** and submits the information to the Project Management Unit.

Before the transplanting phase begins, camp officers should review the plans and report about any changes observed. The zone-plans should also form the basis for seedling distribution between group members (sharing) prior to transplanting.

2. Seed procurement and input distribution

2.1. Objectives

The timely provision of sufficient seeds and planting bags to all farmer groups is a prerequisite for successful tree planting practices. It is particularly important:

- To identify sufficient seed sources of demanded species in time and organize the respective harvesting processes.
- To prioritize seeds from local, vital high-quality mother trees.
- To guarantee the timely distribution of planting bags to the farmer groups.
- To deliver the demanded number of seeds to the farmer groups in time.
- To inform farmer groups about storing the seeds securely to maintain their germination potential.

2.2. Benefits

The key benefits of the timely provision of seeds and planting bags are:

- **Improved Nursery Productivity:** Providing adequate and high quality seeds allows nursery groups to maximize their seedling production capacity. It ensures optimal germination rates by sowing seeds at the ideal time.
- **Enhanced Agroforestry Implementation:** Timely availability of seeds means that seedlings can be ready for farmers to plant at the most suitable time in the agricultural calendar.
- **Local income opportunities:** Buying seeds from local farmers produces an extra incentive for farmers to develop woodlots and seed banks as a new source of income, while also reducing both transport and administrative costs for the Extension Service Provider (ESP).

2.3. Seed procurement

Based on the seed demand of farmers (see Module 1), the project staff can calculate the required quantity of seeds for the upcoming season. We recommend adding a buffer of 25% to the seed demand, to ensure that the project can react to unforeseen germination issues. 10% will be distributed to the nursery groups as an on-site reserve for prompt gap-filling, and 15% kept by the Extension Service Provider to respond to larger issues.

We consider it essential to identify and document reliable seed sources in the local area, as it reduces transport costs and promotes new market opportunities for farmers. The district forestry department, local agri-businesses, FTCs, FIs, individual farmers, NGOs and local

residents are all potential sources for suitable seeds. Alternatively, enquire about non-local sources in other districts, at provincial organizations, ZARI, or GART.

We recommend that the Extension Service Provider visits the seed sources, especially the high-volume sources, to assess the health and characteristics of the mother trees. The respective information must be documented (name and contact details of provider, number and age of seed trees, available seed quantity, seed quality, date availability of seeds). Templates for recording this information are available in Annex 2.

Table 2: Key procurement information for selected tree species

Tree species	Harvesting period	Seed price per kg (ZMW)	Number of seeds per kg
Gliricidia (Gliricidia sepium)	October – November	100.00	6,500
Khaya, Mubaba (Khaya nyasica)	September – November	75.00	2,500
Moringa (Moringa oleifera)	June – November *(available year round)*	75.00	5,000
Lukina (Leucaena leucocephala)	June – September	80.00	20,000
Senna spectabilis (Cassia spectabilis)	June - September	75.00	5,000
Senna Siamea (Cassia siamea)	June – September	75.00	5,000
Mango (Mangifera indica)	October – January	Farmers harvest fruits from local trees to get seeds	
Lemon (Citrus sinensis)	Year round *(with irrigation)*		
Papaya (Carica papaya)	June – August *(available year round)*	Purchase fruits from reliable source	30,000
Tamarind (Tamarindus indica)	June – October	230.00	1,500
Pigon pea (Cajanus cajan)	June – September	75.00	8,000
Tephrosia, Buba (Tephrosia vogelii)	June – September	80.00	20,000
Neem, Nimu (Azadirachta indica)	February – April	100.00	5,000

Note: prices given are a guide, based on prices between 2023-2024 in Eastern Province.

The later harvesting period for Gliricidia and Khaya means that the Extension Service Provider may have to procure seeds and then store them for the following year.

2.4. Planting bags procurement

The Extension Service Provider is responsible for procuring and distributing plastic planting bags alongside the seeds. We recommend using two types of plastic planting bags:

- **Small bags (4 x 6 inches),** which are used for species which spend less time in the nursery.
- **Medium size bags, (6 x 8 inches)** for fruit trees which will be budded or grafted. These species will spend longer periods in the nursery and therefore require more space for their roots to grow.

Planting bags are the main cost factor. For each new group we recommend providing 5,000 small planting bags and 500 medium-sized planting bags. Once the group has shown its commitment higher quantities can be supplied in the second year according to performance. Between 2022 and 2024 prices for planting bags in the Eastern Province were:

- Small bags (4x6 inches): 0,16 – 0,25 Kwacha per bag
- Medium sized bags (6x8 inches): 0,22 – 0,35 Kwacha per bag

The Extension Service Provider should procure planting bags according to the demand. We have experienced that not all farmer groups use all plastics in the first year. It is thus important that the camp extension officer annually documents the "leftover bags" from the previous season.

Planting bags should be handed out to extension officers for delivery to the nurseries at the same time as the seeds are.

2.5. Processing and distributing seeds

Once the seeds arrive at the office, first sort the seeds, removing any damaged seeds, before storing them in a cool, dry and dark place in durable bags to protect them from moisture and pests.

If seeds come from different sources, package these separately and document this, so that the quality of seeds from different sources can be tracked, monitored and assessed. This will help to make the right procurement decision the following year.

Some seeds require treatment before sowing (see Module 3 for details). It is important that all lead farmers and farmer groups receive training on the necessary treatment.

Best Practice:

- ✓ Weighing and packaging the seeds in secure plastic bags.
- ✓ Labelled with weight and species information, as well as the officer who will receive it.

The Extension Service staff are responsible for allocating and packaging the seeds. The allocation is determined by the demand of the farmer groups **plus a buffer of 10%**. To make distribution as efficient as possible, seeds should be packaged for each farmer group in small plastic bags (to keep moisture and pests out). These bags must be clearly labeled (species, quantity, camp and zone of farmer group). To package seeds, Extension Service Provider must know the weight of a given quantity of seeds. The weight of each allocation can then be calculated, and the seeds can be swiftly packaged according to weight. The seeds of each species are packed in separate bags and labeled. A larger bag containing all demanded seeds (species) in smaller bags is then packed for each farmer group. These "farmer group bags" are then handed over to the Camp Extension Officer to distribute them to each farmer group.

Best practices:

- Seeds should be handed to the extension officers at a TOT in September. The training content of this TOT should cover seed source identification, seed distribution and storage, and the setting up of a nursery.
- The delivery of seeds to farmer groups should be combined with farmer training (farmer field schools) dealing with how to store, treat and plant the seeds of each species. Each officer must invite all lead farmers of their camp to such a training session.
- The Extension Service staff should keep track of the seed source throughout the packaging and distribution process. In this way the origin of seed can be compared with the growth results.

2.6. Annual review of seed quality

Keeping comprehensive records of seed sources from procurement through the nursery phase and up to planting in the field enables Extension Service staff to assess the development of the seeds and thus their quality. Extension officers should be encouraged to give feedback about cases of poor germination, bad characteristics, or weak growth. This information contributes to the seed quality assessment.

Each year, before the procurement takes place, the Extension Service staff should demand feedback from the camp officers, review this feedback and use it to make a procurement decision for the following season. For example avoid seeds from providers of which seeds performed poorly.

The Extension Service Provider must keep up-to-date records at each stage. This allows informed decisions about adjustments to be made over time. The following information must be recorded:

Table 3: Important information to record at each stage of the logistics process

Stage of the process	Information to record
Demand identification	Species and number of seeds requested, per farmer group and camp. Number of leftover bags from previous year.
Seed identification	Name, location, price and contact details of potential seed providers of the demanded species.
Seed procurement	Name and contact details of provider, source (location), number and age of seed trees, available seed quantity, seed quality, price and harvesting date.
Seed storage and sorting	Sorting and cleaning conducted, percentage of seeds rejected during sorting, storage location, and storage duration.
Seed distribution	Species and number of seeds allocated per farmer group and camp, date of distribution to camp officers, date of distribution to farmer groups.

See Annex 2 for the template tables.

3. Detailed seed-to-field timeline for trees

This table offers an overview of the whole process from seed procurement to transplanting for each of the species promoted in Katete District.

- Timings represent the deadlines for each activity to be completed (i.e., by the end of the given month). This timeline gives all species enough time to germinate and develop in nurseries, so they are healthy and ready for transplanting at the beginning of the rainy season.
- Earlier potting also allows farmers and Camp Officers to identify cases of poor germination and procure replacement seeds with enough time for these new seeds to also germinate and grow in time for transplanting. It is better that seedlings are ready early, and topped, than they are ready too late and do not have enough time in the field before the rains are finished.
- Procurement should follow a general rule that "local is best", because buying seeds from local farmers reduces both transport and administrative costs and also produces an extra incentive for farmers to develop woodlots as a new source of income.
- For common species such as Gliricidia and Moringa, farmers should be developing their own seed sources, so that within 3-5 years they can procure seeds from their own or neighbors' woodlots, bringing the nurseries closer to being self-sustaining.

The Extension Service and MOA staff should use this table as a guide, adjusting and adding details where relevant to their district's activities (for example, adding local seed sources, or where specific local species are promoted).

Table 4 Guideline for Extension Service and MOA staff - to meet timeline of the seed-to-field process

Agroforestry Trees						
Species		Harvesting & Procurement	Distribution	Seed preparation	Nursery period	Transplanting
Gliricidia (Gliricidia sepium)	Timing	**October - November**	**September (early batch) and October**	**Before potting/sowing**	**Start: October** **Hardening off: late November** **Ready: December**	**December to January**
	Details	Source from COMACO and healthy local trees. Seeds can be stored from the previous year in a cool, dry place.	Early batches can use seed from the previous year, later batches can use freshly harvested seeds.	Soak overnight, plant in the morning. Discard any seeds that are floating. **Only soak if sowing the next day.**	7-14 days to germinate, and then 4-6 weeks until ready for transplanting	Transplant at the beginning of the rainy season. Also planted using direct seeding and cuttings.
Khaya, Muwawa (Khaya nyasica)	Timing	**September-November**	**September-November**	**Before potting**	**Start: October** **Ready: 12 months later**	**November-January**
	Details	Source from local healthy mother trees. Seeds can be stored in a dry place for planting early in following year	Immediately after seeds are harvested.	Soak overnight, plant in the morning. **Only soak if sowing the next day.**	14-21 days to germinate, and 12 months to reach 45-50cm tall and pencil diameter. Use large planting bags	Transplant once soil is moist. Add Bokashi to planting holes.

Agroforestry Trees						
Species		Harvesting & Procurement	Distribution	Seed preparation	Nursery period	Transplanting
Moringa (Moringa oleifera)	Timing	**June-November**	**September (early batch) and October**	**Before potting/sowing**	**Start: October** **Hardening off: late November** **Ready: December**	**December-January**
	Details	Source from local residents bringing seeds to FTC. Seeds are available year round, but it is best to plant fresh seeds in the nursery.	Early batches can use seed from the previous year, later batches can use freshly harvested seeds.	Soak overnight, plant in the morning. **Only soak if sowing the next day**	7-14 days to germinate, then 6-8 weeks months to 30-45cm, ready for transplanting.	Transplant at the beginning of the rainy season. Also planted using direct seeding and cuttings.
Lukina (Leucaena leucocephala)	Timing	**June-September**	**September-October**	**Before potting/sowing**	**Start: October** **Hardening off: Early December** **Ready: January**	**December-January**
	Details	Source from local farmers.		Soak in warm water for 30 minutes, or in boiling water for 3 minutes. Then sow. **Only soak if sowing immediately**	7-14 days to germinate (or 5-10 days with soaking). 2 months to 30-60cm.	Transplant at the beginning of the rainy season. Also planted using direct seeding.

Agroforestry Trees						
Species		Harvesting & Procurement	Distribution	Seed preparation	Nursery period	Transplanting
Senna Siamea (Cassia siamea)	Timing	**June-September**	**September**	**Before potting**	**Start: October** **Hardening off: early December** **Ready: January**	**December-January**
	Details	Source from local farmers		Soak in hot water and allow it to cool in the water overnight. **Only soak if sowing the next day.**	7-14 days to germinate, 2 months to 30-50cm height, ready to transplant	Transplant at the beginning of the rainy season.
Senna spectabilis (Cassia spectabilis)	Timing	**June-September**	**September**	**Before potting**	**Start: October** **Hardening off: early December** **Ready: January**	**December-January**
	Details	Source from local farmers		Soak in hot water and allow it to cool in the water overnight. **Only soak if sowing the next day.**	7-14 days to germinate, 2 months to 30-50cm height, ready to transplant	Transplant at the beginning of the rainy season.

Direct seeding						
Species		Harvesting & Procurement	Distribution	Seed preparation	Nursery period	Transplanting
Neem (Azadirachta indica)	Timing	**Late February-April**	**Immediate**	**Before sowing**	**Direct Planting**	**February-April**
	Details	Flowers after rains begin, then around 2 months until seeds can be harvested	Avoid storage longer than 2 weeks	Germination is improved if the outer shell is removed.		**Must plant fresh seed, within 14 days of harvesting.** Germination occurs in 7-12 days. Plant around homesteads (as shade tree)
Tephrosia (Tephrosia vogelii)	Timing	**June-September**	**September-October**	**Before sowing**	**Direct Planting**	**December-January**
	Details	Source from local farmers	Distribute as early as possible for farmers to store until direct planting. Cool, dry place.	Soak the seeds in warm water overnight. **Only soak if sowing the next day**		Transplant at the beginning of the rainy season. Germination should occur after 8-10 days
Pigeon Pea (Cajanus cajan)	Timing:	**June-September**	**September-October**	**Before sowing**	**Direct Planting**	**December-January**
	Details:	Source from local farmers.	Farmers should store in secure, cool, dry place (away from rodents).	Old seeds should be soaked in cold water for 24 hours, fresh seeds no treatment.		Transplant at the beginning of the rainy season. Germination should occur after 7-14 days

Fruit Trees						
Species		Harvesting & Procurement	Distribution	Seed preparation	Nursery period	Nursery period
Papaya, Pawpaw (Carica papaya)	Timing	**June-August**	**September-October**	**Before potting**	**Start: October** **Ready: January**	**January**
	Details	Seeds are available year round.		Soak overnight, plant in the morning	1-4 weeks to germinate. Weeding is key as Papaya is sensitive to root damage	Transplant at the beginning of the rainy season.
Mango (Mangifera indica)	Timing	**October-January**		**Before potting**	**Start: October-November** **Ready: following year**	**1 year after planting**
	Details	Farmers must harvest fruits from local mangoes.	Farmers must harvest fruits from local mangoes.	Cut seed slightly with a knife, soak for 3 to 4 days and peel off the seed coat.	2-4 weeks to germinate. 8 months in nursery until ready for grafting.	6-8 months healing after propagation before seedling is ready for transplanting.
Tamarind (Tamarindus indica)	Timing	**June-October**	**October**	**Before potting**	**Start: October** **Ready: January**	**January-February**
	Details	Tamarind seed remains viable for up to 2 years, when kept cool and dry		Soak in hot water and cool for 24-48 hours	2-4 weeks germination	Transplant at the beginning of the rainy season.

Fruit Trees						
Species		Harvesting & Procurement	Distribution	Seed preparation	Nursery period	Nursery period
Lemon (Citrus sinensis)	Timing	**Year round**		**Before potting**	**Start: October-November** **Ready: following year**	**1 year after planting**
	Details	Farmers must harvest fruits from local/purchased lemons.	Farmers must harvest fruits from local/purchased lemons.	Soak overnight and peel off the coat in the morning before planting.	2-4 weeks to germinate. 8 months in nursery until ready for grafting.	6-8 months healing after propagation before seedling is ready for transplanting.

Note on seed coat removal

Although for several species, coat removal can hasten germination, experience shows that unless farmers are given training, they can damage the seeds when trying this (especially with more fragile coats). Therefore, generally a soaking is enough treatment, and if seeds are planted on time, then germination speed is not an issue anyway.

4. Preparing, making and applying Bokashi

4.1. Objectives

Producing a nutrient-rich organic fertilizer by fermenting easily accessible inputs within two weeks. In comparison, common composting techniques need between 8-16 weeks.

4.2. Benefits

Bokashi offers several key benefits for small-scale farmers in Zambia:

- **Low-cost fertilizer:** Bokashi can be produced using locally sourced materials, making it an affordable alternative to expensive mineral fertilizers.
- **Improved soil health:** It enhances soil fertility, improves soil texture, and increases organic carbon content.
- **Increased crop productivity:** Bokashi boosts crop yields and overall productivity.
- **Improved moisture and nutrient retention:** It helps retain both moisture and nutrients in the soil, reducing the need for frequent watering even in dry conditions.
- **Additional income source:** Farmers can sell excess bokashi to other farmers, creating a new revenue stream.
- **Adaptability to climate change:** By improving soil health and water retention, Bokashi can help farmers adapt to changing climate conditions.

4.3. Preparing to make Bokashi

Site selection: Choose a site that is protected from rain, wind and direct sunlight. A place with tree cover is usually suitable in the dry season. During the rainy season, the Bokashi must be under waterproof cover.

- **Best practice**: Make the Bokashi close to where it will be used – at the nursery, or in the garden. This should be a site with available labor nearby.

Labor organization: Most labor is needed on day 1, followed by 1 or 2 people each day to do the monitoring and heap-turning over the next 14 days.

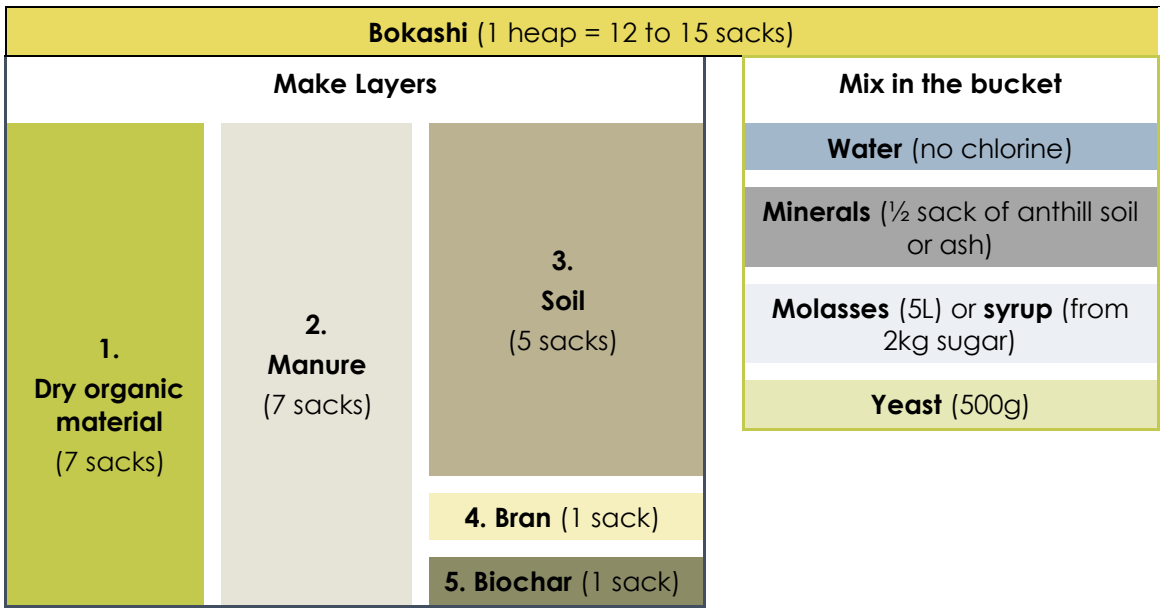
Material inputs: The following recipe refers to 1 Bokashi heap, which yields 12-15 sacks in volume (50kg-size sacks). Focus on the ratio of 50 kg-size sacks used. The actual weight of each sack cannot be indicated as it varies according to the dryness of the input/output.

Table 5: Detail on material inputs and quantities required for making Bokashi

Input	Quantity *	Purpose and description
Manure	7 x 50 kg sacks	Manure provides nutrients. A mix of dry manures is best (cattle, sheep, pigs, goats, chicken, etc.).
Dry organic material	7 x 50 kg sacks	A mixture is best (leaves, maize stover, rice husk, dry leaves, sawdust, etc.). The mix should be cut into small pieces so the heap can be turned easily. Note: Gliricidia leaves are an excellent source of additional nutrients.
Soil	5 x 50 kg sacks	Clay or native soil are the best sources of microbes for the bokashi.
Bran (rice, wheat or maize)	1 x 50 kg sack	This is a food for the microbes.
Molasses or sugar syrup	5 Litres (or 2 kg sugar dissolved in water)	A source of energy for microbes. Molasses is better and usually cheaper.
Yeast	500 g	Yeast speeds up the fermentation process.
Minerals (if available)	*20-25kg (half sack)*	The most common minerals used are anthill soil and ash. Use a half sack if available.
Water (no chlorine)	Plenty	If only chlorinated water is available, leave it in the sun for a day to remove the chlorine.
Biochar (optional)	1 x 50 kg sack	Biochar provides the best environment for the microbes.

4.4. Making Bokashi

Figure 1: Inputs required for making Bokashi



Day 1:

1. Make layers (in this order) of: dry material, manure, soil, bran, biochar and minerals. For consistency, make each layer a couple of centimeters.

2. Mix 5L of molasses and 500g of yeast with water and sprinkle it on the heap after each set of layers.
    - **Best practice**: A watering can will sprinkle most effectively. Alternatively, use a bucket and sprinkle by hand or a small cup.
3. Repeat steps 1 and 2, until all materials are used up. **Do not** make the heap more than 1.5 m tall.
4. Mix the layers together by turning the heap. Turn the heap **using a large shovel** 3 or 4 times, and make sure to sprinkle additional water as you are turning the heap.
5. **Moisture test**: Squeeze a handful of the mix in your fingers, making a sausage shape.
    - If water comes out, it is too wet. Turn the heap again and add more soil.
    - If the mixture crumbles or can't form a sausage, it is too dry. Turn the heap again and add more water.

- **Note**: After the first day, you cannot add more water, so make sure that the heap passes the squeeze and sausage tests.

Good Practice:

✓ Strong group involvement in turning the heap

✓ Bokashi being made under shade from trees

Poor Practice:

× Too little shade for Bokashi making

× Poor group involvement

Days 2-5:

1. Turn the heap **twice per day**, in the morning and evening. The heap should not smell unpleasant or attract flies.
2. **Heat test**: Insert your hand fully into the Bokashi heap. If you can keep it there for 10 seconds without burning your hand, then the heap is at the right temperature (around 55°C). If you must remove your hand quickly, the heap is too hot and must be cooled down. To do so, turn the heap with a shovel and let each slab slowly trickle through the air.

- **Note**: Failing to turn the heap causes overheating that destroys the microbes and the Bokashi itself. Not turning can lead to the product becoming infected.

Days 6-15:

1. Continue with the **heat test** and turn the heap **once per day** until the temperature becomes the same as the surroundings. At this point, the Bokashi is ready.

4.5. Using the Bokashi

Once the Bokashi is ready, use it as soon as possible, to maximize its effects. If necessary, you can keep the Bokashi for 2-3 months. It should be stored in a shaded and dry area.

Many farmer groups make only 1 heap, which limits the amount of Bokashi available for different applications. Once a group is familiar with the process, farmers must be encouraged to make more Bokashi each year, so that they can also apply it to field crops and vegetable gardens, reducing the costs of buying synthetic fertilizers.

Good Practice:

✓ Bokashi under well-constructed shade

✓ Bokashi adjacent to nursery site (fenced in background) and planting site

Poor Practice:

× Bokashi heap exposed to sunlight

Good Practice:

✓ Bokashi adjacent to nursery site

Bokashi Application Options

Bokashi can be used in tree nurseries, for transplanting tree seedlings and it is an effective fertilizer alternative for field crops (maize, soya, groundnut, etc.) or vegetables (horticulture). Whatever the use, always make sure to:

- Bury or mix the Bokashi into the soil, because the microbes cannot survive direct sunlight.

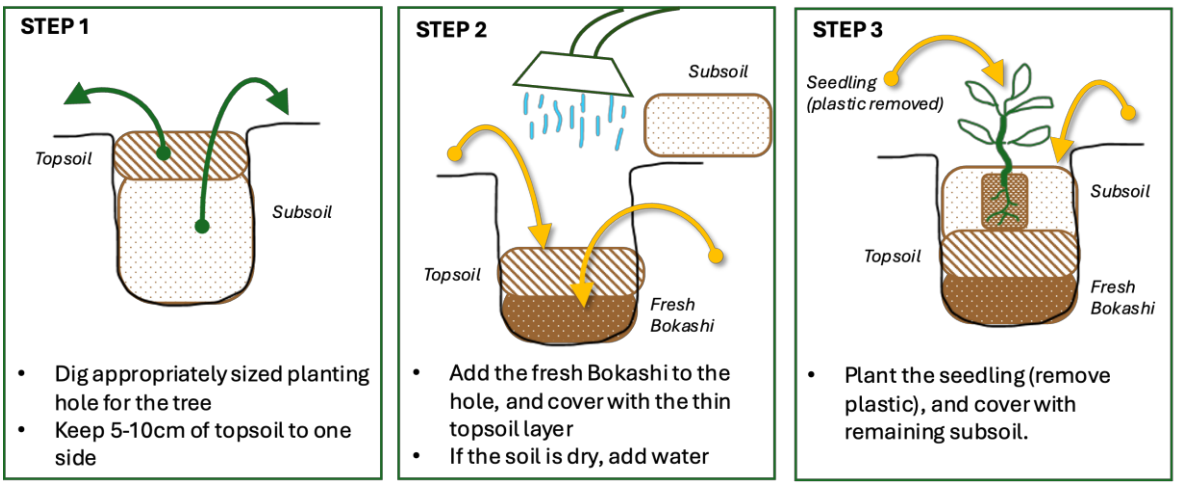
- Young plant stems and roots are vulnerable if they come into direct contact with some microbes in the Bokashi. Therefore, leave a layer of soil between the Bokashi and the plant, or wait before planting – 7 days if the Bokashi is mixed with topsoil, or 14 days if not mixed.

- **Nurseries:** Make sure clumps are removed (with a sieve) before mixing the Bokashi with soil. Clumps might affect newly grown roots.

Transplanting tree seedlings:

- **For fruit trees,** dig a large hole, 60cm x 60cm x 60cm, and mix around 5kg of Bokashi with the same amount of topsoil, then add to the bottom of the hole under a thin layer of topsoil. Water the hole and then plant the seedling with the remaining subsoil.
- **For soil-fertility trees (Gliricidia) and woodlot trees (Moringa, Khaya**), dig a medium-sized hole, 30cm x 30cm x 30cm, and mix a handful of Bokashi with the top 10cm of topsoil. Bury the mix in the hole, under a thin layer of topsoil. If there is no rain, manually add water, and then plant.
- **For boosting the growth of already planted trees**, dig a shallow trench (10cm deep) or widen the basin around the tree, add several handfuls of Bokashi (as much Bokashi as you need to half fill the trench) and then cover with soil. This can be done each year.

Figure 2: How to prepare planting holes using Bokashi



Vegetables: Bury the given amount of Bokashi in the soil next to the vegetables.

- Leaf crops (such as rape, kales, lettuce): 1 handful.
- Crops with a head (such as cabbage, cauliflower): 2 handfuls.
- Crops with ongoing harvests (such as tomatoes or aubergine): 3 handfuls. The Bokashi can be repeatedly applied, waiting 2 weeks in between applications.

Field crops:

- Bokashi can also be used for field crops. Bury one handful of Bokashi next to each plant station (avoiding direct contact of unmixed bokashi with the seeds or young plants).

Better maize yield and quality is achieved when burying a second handful of Bokashi after 4 weeks. Farmers and camp officers should test different doses.

5. Establishing and managing a tree nursery

5.1. Objectives

Tree nurseries help to ensure that there is a sufficient supply of tree seedlings to meet the demands of farmers and to integrate trees into their farming activities. The purpose of agroforestry nurseries is:

- to increase the household income of farmers,
- to diversify production and to make farmer fields more resilient against the consequences of climate change.

Best Practice: Sheltered group nursery in a fenced garden with a water supply.

5.2. Benefits

The main benefits of engaging farmers in nursery management and decentralizing nurseries are:

- **Reduced seedling transport costs**: Minimizes expenses, time, and physical effort required for transporting seedlings.
- **Increased farmer engagement**: Encourages long-term involvement in agroforestry activities before planting in their fields.
- **Focal point for agroforestry activities**: the nursery site is also suitable for making Bokashi and plant propagation.
- **Additional income opportunities**: Surplus seedlings can be sold for profit. When farmers run their own tree nurseries, they can also be trained in plant propagation techniques and sell the budded and grafted seedlings at a premium price.

5.3. Organizational steps

Group preparation

The establishment of a nursery needs time, labor and a clear commitment of the participating farmers. Additionally, the group must clearly define the species that they want, and the number of trees that each farmer will plant. Group organization and demand planning for the seed and input supply is explained in Module 1. Nursery-specific considerations for the seed and input supply are noted in the Table 6 below.

Table 6: Key recommendations for preparing to plant a nursery

Key considerations for seed and input supply

✓ **Focus on quality not quantity** to maximize survival rates, not just planting numbers. ✓ **Keep 10% of seeds in reserve** for a quick gap-filling response where germination fails. The Extension Service Provider will keep a further spare supply. ✓ **Save spare plastics** for next year and give the camp officer the numbers. ✓ **Apply leftover bokashi** to field crops or gardens.	✗ **Do not plant more seeds than can be:** (a) cared for in the nursery, and (b) transplanted into fields or gardens. ✗ **Do not start with too many different species** at a new nursery, as the farmer group must learn the specifics of growing each species. Not more than 4 species at a new group.

Timing and planning

Seedlings must reach an optimum size before they are transplanted at the start of the rainy season. However, the time for gemination and reaching an optimal seedling size depends on the species and varies between species. Camp officers must distribute seeds at the right time of the year, and regularly follow-up to support farmers. While most species can be raised within some month before the rainy season, farmers must understand that Khaya, Citrus and Mango seedlings will require between 8-12 months in the nursery before they can be transplanted, budded or grafted.

Batch planting for Gliricidia and Moringa

The inconsistent onset of rains is a challenge for nursery group planning, and although the uncertainty cannot be entirely removed, farmers can increase their adaptability to early or late rains by raising some seedlings in different batches. Specifically, we recommend that nursery groups raise their Gliricidia and Moringa seedlings in 2 or 3 different batches, each sown 1 month apart. This increases the chance that a portion of the seedlings will reach their optimum size (2:1 shoots to roots ratio) at the right time, which reduces waste in the nurseries.

Gliricidia and Moringa are both fast-growing and so even the later batches will have time to establish in the later months of the rainy season. Batch planting also means that seedlings from different batches can serve different purposes:

- For Gliricidia, it means that farmers can spread out the transplanting in different fields: early batches which have grown taller can be planted at the same time as faster-growing crops like maize, while later batches can still be planted with shorter crops like soybean, where they face less initial competition.

- For Moringa, early batches can be planted for live fence posts which will grow quickly over the course of the whole rainy season, while later batches are still suited to planting in woodlots and around homesteads.

Table 7: Time planning for nursery species.

Tree species	Seed harvesting period	Sowing deadline (end of month)	Time to germination	Total nursery duration
Gliricidia (Gliricidia sepium)	October – November	Early Batch: September Middle Batch: early October Late Batch: November	7-14 days	6-8 weeks
Khaya, Mubaba (Khaya nyasica)	September – November	October	14-21 days	12 months
Moringa (Moringa oleifera)	June – November *(available year round)*	Early Batch: early September Middle Batch: early October Late Batch: early November	7-14 days	6-8 weeks
Mango (Mangifera indica)	October – January	October	2-4 weeks	6-8 months before grafting, 6 months further recovery
Lemon (Citrus sinensis)	Year round *(with irrigation)*	October	2-4 weeks	6-8 months before grafting, 6 months further recovery
Papaya (Carica papaya)	June – August *(available year round)*	September-October	1-4 weeks	3-4 months
Tamarind (Tamarindus indica)	June – October	September	2-4 weeks	4 months
Lukina (Leucaena leucocephala)	June – September	October	7-14 days	8 weeks
Senna spectabilis (Cassia spectabilis)	June - September	October	7-14 days	8 weeks
Senna Siamea (Cassia siamea)	June – September	October	7-14 days	8 weeks

Role of camp officers in nursery organization

We recommend that camp officers support the planning of each nursery group by moderating farmer discussions and providing knowledge about timing considerations. Camp officers should teach farmers about the role of nurseries and most importantly, how they

will benefit from each agroforestry tree. Agroforestry is only attractive to the farmers if they know how to benefit from each species.

Table 8: Summary of key uses of the different species available

Species	Common name	Benefits	Notes
Gliricidia sepium	Gliricidia	Fuelwood, poles, live fence, N-fixing, soil mulch	The key species for alley cropping, with maize, soya etc.
Leucana leuco-cephala	Lukina	N-fixing, fodder, green manure	Invasive concern but naturalized in region. Farmers should avoid planting in main fields.
Moringa oleifera	Drumstick or miracle tree	Traditional medicine, water purification (seeds), cooking oil, fodder, food supplements	Faces a pest problem in the nursery – red spider mite, *Tetranychus* spp.
Khaya nyasica (anthotheca)	Mubaba, Red Mahogany	Quality timber, poles, shade, ornamental	Stays in nursery for 12 months Shoot borer problem in field, distorts form.
Senna spectabilis	Senna/Golden cassia	Firewood, poles, ornamental, boundary marker	Easy to raise and the wood is termite resistant.
Senna siamea	Senna/Yellow cassia	Poles, firewood, furniture wood, windbreaks, fodder, ornamental	Foliage can be used as fodder for ruminants, but is toxic to non-ruminants.
Citrus sinensis	Lemon or orange	Fruit production, quality timber	Needs 6-8 months in nursery before budding, and 6-8 months after
Mangifera indica	Mango	Fruit production	Needs 6-8 months in nursery before budding, and 6-8 months after
Carica papaya	Pawpaw, Papaya	Fruit production	Trees do well for 3-4 years, so farmers should frequently re-plant to maintain production.
Tamarindus indica	Tamarind	Fruit production for food and medicine	Slow growth: >5 years to fruiting
Cajanus cajan	Pigeon pea	N-fixing, green manure, live fencing, fodder	Direct sowing. Relatively short-lived (dies after 5 years)

Species	Common name	Benefits	Notes
Tephrosia vogelii	Tephrosia, Fish-poison bean	Pest control, live fences, firewood, green manure	Direct sowing. Leaves and seeds are poisonous to fish, humans and domestic animals. Using Tephrosia in this way is banned.
Azadirachta indica	Neem	Medicine, pest repellents, firewood, ornamental	Direct sowing. Leaves, bark and roots all used in traditional medicine.
Sesbania sesban	Sesbania, river bean	Live fencing, N-fixing, fodder, green manure.	Direct sowing. Short-lived shrub commonly used also in improved fallows.

More information on the benefits and uses of each species is available in Annex 1.

5.4. Site preparation

Camp officers and lead farmers must ensure that all following conditions are met:

Table 9: Checklist for site preparation

Site conditions needed	Yes/No
Having a reliable and accessible water source (even during dry periods)	
Secure fencing to protect from animal disturbances and act as wind shield	
Space for the planned seedling quantity	
Bare soil (no shrubs, grasses or termites) and good drainage (a gentle slope helps)	
Shelter (natural shade or constructed shade). *Best practice = 50% shade for germination, that can be adjusted for hardening-off later*	
Space for making bokashi on site or nearby	
Easily accessibility for transporting seedlings to fields and gardens	
Clear structure - Raised and/or separated 'beds' of pots (see images below)	

Several further lessons have been learned in Katete district about the specifics of setting up the nursery site:

- Living fences offer a combination of shelter, shade, and leaves for Bokashi. However, they must be actively pruned to reduce shade during hardening-off.
- **Best practice for shade** is around 50% shade for sowing and germination, reduced to around 30% after early growth and further reduced for 2-3 weeks of hardening-off.
- Raised and separated beds are helpful for management. We also recommend **not laying** a plastic sheet underneath the beds, since this can cause root spiraling or deformation, and is not a substitute for good root pruning.

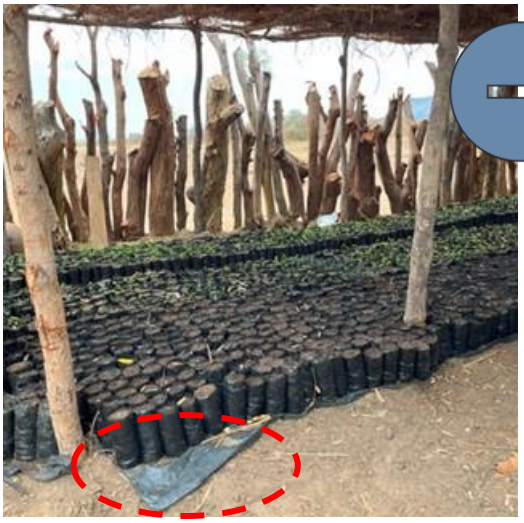
Ultimately, the **minimum requirements** for a successful nursery site are reliable water, security, and shade.

Best Practice:

- ✓ Separated beds,
- ✓ Seedlings organized by species and germination stage,
- ✓ Easy access to all seedlings,
- ✓ Constructed shelter.

Poor Practice:

- × No separation of beds,
- × No organization and uneven germination,
- × Poor access to seedlings,
- × Inconsistent shelter/shade.



Poor Practice:

- × Difficult to access all beds
- × Plastic sheet under the pots is not a good substitute for regular root pruning

Good Practice:

- ✓ Constructed shelter
- ✓ Robust protective fence

Poor Practice:

- × No water source nearby
- × Thorny fence is weak and temporary
- × Poor control of sunlight levels and dried grass mulch is not a substitute for a proper shade
- × Beds are poorly separated, and no management is taking place.

5.5. Input preparation

Equipment

The set-up of a nursery does not require much specialist equipment, and groups should organize their own watering equipment. The best practice is a watering can with a 'shower' style head, so the flow is low-pressure and does not spill from the pots. Punching holes in an old tin can or bucket can also re-create this effect, even if it is more effort to use. Large 200L drums are also useful for conveniently storing water at the nursery site.

Camp officers are responsible for delivering the plastic planting bags to the nursery groups. These are either 6 x 4-inch or 8 x 6-inch bags, with the larger bags to be used for seedlings that stay longer in the nursery (Khaya, Mango or Lemon). The group is responsible for storing and re-using planting bags from the previous year. For more details, see Module Seed procurement and input distribution.

Seeds

Camp officers are responsible for distributing the seeds at the time of planting of the first batch and once the nursery groups receive the seeds, they should store the seeds which are not immediately needed in a cool, dry and secure place. To boost germination of some species, camp officers should inform the group on the appropriate treatment.

Table 10: Pre-sowing treatment for different tree species

Tree species	Number of seeds per kg	Pre-sowing treatment*
Gliricidia (Gliricidia sepium)	6,500	Soak overnight, plant in the morning.
Khaya, Mubaba (Khaya nyasica)	2,500	Soak overnight, plant in the morning.
Moringa (Moringa oleifera)	5,000	Soak overnight, plant in the morning.
Mango (Mangifera indica)	Farmers harvest fruits from local trees to get seeds	Cut seed slightly with a knife, soak for 3 to 4 days and peel off the seed coat.
Lemon (Citrus sinensis)		Soak overnight and peel off the coat in the morning before planting.
Papaya (Carica papaya)	30,000	Soak overnight, plant in the morning.
Tamarind (Tamarindus indica)	1,500	Soak in hot water and cool for 24-48 hours
Lukina (Leucaena leucocephala)	20,000	Soak in warm water for 30 minutes, or in boiling water for 3 minutes. Then immediately sow.
Senna spectabilis (Cassia spectabilis)	5,000	Soak in hot water and allow it to cool in the water overnight.
Senna Siamea (Cassia siamea)	5,000	Soak in hot water and allow it to cool in the water overnight.

Tree species	Number of seeds per kg	Pre-sowing treatment*
Pigon pea (Cajanus cajan)	8,000	Old seeds should be soaked in cold water for 24 hours, fresh seeds no treatment.
Tephrosia, Buba (Tephrosia vogelii)	20,000	Soak the seeds in warm water overnight.
Neem, Nimu (Azadirachta indica)	5,000	Germination is improved if the outer shell is removed.
Sesbania (Sesbania sesban)	85,000	

*Only treat seeds when they will definitely be planted the following morning (or immediately after). Treatment boosts germination and is optional. In general, germination rates for fresh seed that has been properly stored and handled are very high without treatment.

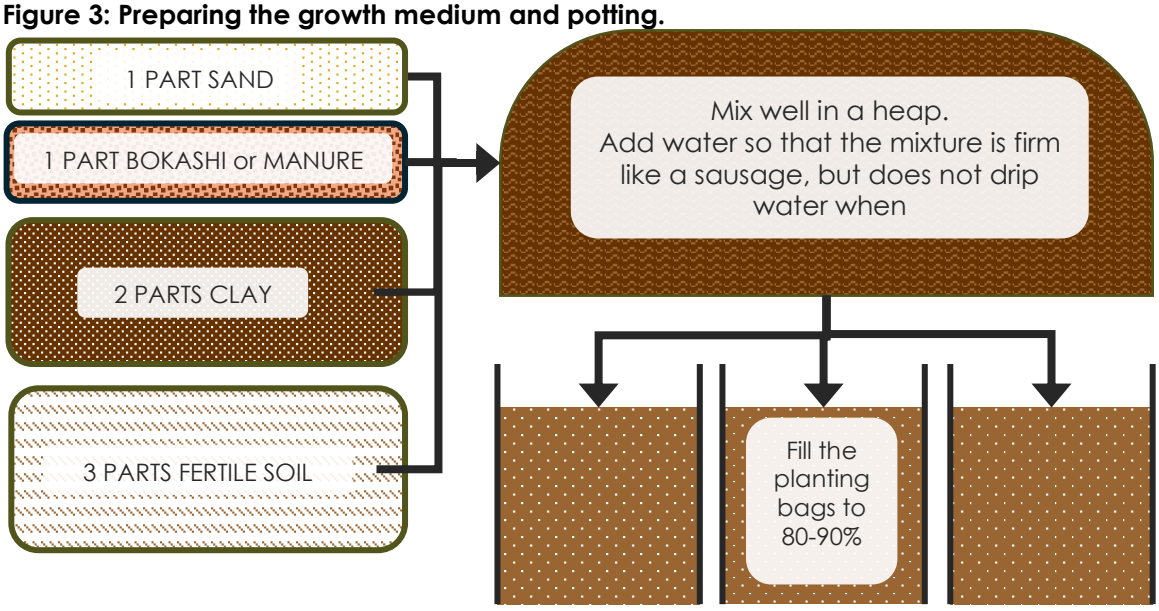
Growth medium and potting

The group should agree a time to all come together to fill the planting bags with the growth medium. The planting bags should be filled 3-5 days before sowing. For Papaya, Tamarind and the early batches of Gliricidia and Moringa, this is the **beginning of September**. For most other species and batches, this is the **beginning of October.**

In a large heap, mix together 3 parts fertile soil, 2 parts clay, 1 part Bokashi or manure, and 1 part river sand. Wet the mixture lightly while mixing, before testing the consistency by hand, and then putting it into planting bags. It should have the consistency of a sausage and not drip when squeezed.

If using Bokashi in the growth medium, remove clumps of organic material before mixing – use a sieve to filter out clumps – this will ensure that the roots are not impeded during early stages of growth.

Figure 3: Preparing the growth medium and potting.



5.6. Sowing

For the 3-5 days after filling the planting bags, they should be lightly watered. *Aside from the last batches of Gliricidia and Moringa,* **all sowing should be completed by the end of October at the latest**.

When sowing, the seeds should be pushed around 1-2cm into the moist soil. The rule of thumb is that the sowing depth should be about 1-2 times the width of the seed. We recommend sowing only 1 seed per planting bag. Where germination fails, it is much more resource-efficient to gap-fill, than to use several seeds in each bag from the beginning.

Good Practice: Sowing Khaya seeds that have been soaked in water to boost germination

Once seeds are sown, the bags must be organized into beds with straight columns and rows for easy counting and management. Different species should be raised in different beds, or dividers should be used within each bed. As the **site preparation** section states, the beds should be secured by bricks or wooden planks, and there must be small paths in between for access so that farmers can water, weed, and monitor.

5.7. Management

Good management is vital to ensuring that the seedlings are healthy and ready at the right time for transplanting. It also needs group members to commit to completing daily management practices. The key management practices are outlined in the next table.

Table 11: Key nursery management practices

Management practice	Details
Watering	**Water when the seedlings need it**. During hot and dry periods, this means twice per day. Water in the early morning and/or late afternoon, so less moisture is lost to evaporation. **Use a low water pressure** (e.g., a watering can with a shower-style head) and ensure water is draining well, not waterlogging the pots. A 300-seedling bed needs around 20L of water per day in hot periods.
Weeding	Remove weeds whenever they appear, or at least once a week.
Root pruning	**Monitor the emergence of roots and prune when necessary**. We recommend regularly re-arranging the seedlings every 1 or 2 weeks to prevent roots developing into the nursery ground. **Allow 1 week after root pruning before transplanting seedlings**, to allow them to recover from the shock.
Pest control	**Keep the nursery clear and tidy** to reduce the threat of pests. **Monitor for signs of pests** (e.g., leaf destruction, discolouration) **and isolate affected seedlings.** Prioritize natural control measures, including manually removing visible pests.
Gap-filling	**Sort seedlings according to germination success** a week after the first germination. Record the rate of germination at this point. Monitor the pots without germination for another week, and then re-sow in those pots.

Nursery management practical examples

Good Practice: Placing seedlings on a table with small air gaps underneath which will 'air prune' the roots.

Good Practice: Several weeks after sowing, seedlings are 'graded' by size, and pots with no germination are re-sown.

Poor Practice:

- × Nursery completely overrun with weeds, very few seedlings still alive.
- × Nursery is not fenced off from the rest of the farm

Good Practice:

- ✓ Using a watering can with a shower-style head that reduces the water pressure and avoids spilling soil.
- ✓ Nursery is well-fenced

Pesticide use

Although good management can help prevent many pest outbreaks, nurseries will sometimes require pesticides, for sudden fungal and/or insect attacks. However, their use raises important health and safety issues which must be addressed. We recommend using botanical pesticides only, as promoted by ZARI. Chemical pesticides should only be considered as last option – and only be used if:

- Alternative control measures to chemicals have already been tried, **and**
- They are legally approved for use in Zambia, for a specific application, **and**
- The person(s) using them understand the dosage, the precautions to be taken with mixing and handling the product, the correct application method, the safe storage of

the product (away from food and children) and the safe disposal of the empty containers.

Monitoring and record-keeping

- **Recording nursery activities enables farmers to learn and improve their practices**. For each species, lead farmers should record species name, date of planting, number of seeds planted, germination date, and germination rate after the expected germination period. They should also record the date for gap-filling in the nursery. With good records, nursery groups can experiment with different growing conditions/nursery practices and adjust to what works best in their nursery and for their seedlings.

Best Practice:

- ✓ Removable shade
- ✓ Beds are separated and basic information is recorded on the signs for each bed.
- ✓ Using a watering can with a shower-style head.

5.8. Preparation for transplanting

Hardening off

Over the last 2-3 weeks before transplanting, nursery operators must gradually expose the seedlings to field conditions to improve their chance of survival after transplanting. The key changes are:

- Gradually reduce the water supply so that seedlings can better tolerate dryer periods during the rainy season.
- Increase exposure to sunlight, giving the seedlings full sunlight for at least the final week before transplanting.
- Stop root pruning at least 1 week (ideally 2 weeks) before transplanting to give the seedlings a chance to recover.

Poor Practice:

- × Seedlings beds are becoming overgrown and inaccessible.
- × Shade has not been removed for hardening-off of mature seedlings.

Best Practice:

- ✓ Shade removed for hardening-off 2 weeks before transplanting.
- ✓ Seedlings are not too tall, and fit the 2:1 ratio.

Seedling size and topping

After the hardening-off period of 2-3 weeks, the shoots should be 2-3 times the height of the roots. To check, simply hold up the seedling and compare shoot height to the planting bag (containing the roots).

Poor Practice:

- × Overgrown shoots reduce chance of survival in the field.
- × Roots have not been pruned

- If the shoots are 3 or more times the height of the roots, the root system won't be able to support the shoot biomass. Thus, the shoot of the seedling must be 'topped'. Cut the main stem cleanly with scissors or secateurs at a height of 2 times the height of the roots.
- Topped seedlings need time to recover and should only be planted after new shoots appear below the cut stem (usually 1-2 weeks after topping).

Before transporting seedlings to the field, farmers should check that the roots are well-developed enough. A simple test is to remove the plastic from a seedling and see if the roots hold the soil in place – if it all crumbles away, the roots are probably not ready.

6. Plant Propagation: Budding and Grafting

6.1. Objectives

Fruit production is a high-value agroforestry activity that is highly appealing to farmers. To improve fruit production and income opportunities, farmers should practice plant propagation:

- To combine desirable traits of different plants into a single plant, by fusing the scion of a preferred variety onto a suitable seedling from the tree nursery (the rootstock).
- To produce higher-value or more functional hybrid fruit trees in the nursery, improving income generation from selling these seedlings or increasing future fruit production from them.

Benefits: Budded citrus trees can start producing fruits within 3 years, and at a more accessible height.

6.2. Benefits

The main benefits of plant propagation are:

- **Earlier fruiting and income generation:** Shortening the time a seedling must spend in the nursery and reducing the time to fruiting, which means fruit production and income can be made earlier.
  - For example, a grafted Mango can start fruiting in 3-5 years, compared to 5-8 years for seed-grown trees. A budded citrus can start fruiting in 3 years, compared to 4-5 years without propagation.
- **Improved tree quality and yield**: Produces trees that combine desirable characteristics of the scion's mother tree and the rootstock. Using scions from proven varieties improves fruit yields, quality and taste. Higher production and consistency increase income opportunities from fruit production for farmers.
- **Easier harvesting**: Harvesting fruit is easier because the trees do not grow as tall and the branches are not as wide, increasing the possible density of fruit trees.
- **Direct income from fruits**: Farmers can earn money by selling the fruits produced.
- **Direct income from seedlings**: Farmers can earn money by selling the budded or grafted seedlings, without having to transplant and nurture them in an orchard over a longer period.
  - In Katete, budded orange seedlings sell for 75 Kwacha, compared to just 45 Kwacha for unbudded lemon seedlings at local markets. Grafted mango seedlings can be sold for twice as much as non-grafted mango seedlings.

- **Disease resistance**: combining local rootstocks that are well-adapted to local conditions with scions from high-quality mother trees can improve plant health and reduce the need for pesticides.
- **Improved nutrition**: increased yields allow farmers to add nutritious fruits to their diets.

Table 12: Key recommendations for budding and grafting

Key recommendations for budding and grafting	
✓ Only use fresh genetic material (scions, buds) from healthy, productive mother trees. ✓ **Use only healthy rootstock seedlings,** which are mature enough to withstand the shock of propagation. ✓ Use sterile and sharp tools to reduce disease risks ✓ Keep records of propagation activities.	✗ Do not allow dirt (or disease) to affect the bud or graft site ✗ Do not allow the seedling to dry out after budding or grafting. ✗ Do not plant the seedling until it has fully recovered from the propagation.

6.3. Preparing for propagation

Identifying and nurturing healthy mother trees is the foundation for propagation activities, as the genetic material and characteristics of these trees will be transferred to the seedlings. Mother trees should be mature trees that are pest- and disease-free, have shown good productivity, and have proven their resilience to climate and water-related pressures in the local area.

Regarding mother tree identification and location, the FTC or FI in the district is well-suited to growing mother tree plots, under the supervision of trained district staff. **We recommend that every FTC grows a mother block**. Additionally, farmers in the district who already have orchards should also be surveyed to identify alternative sources of high-quality genetic material. Other stakeholders such as ZARI can often provide further information about suitable mother tree locations.

The genetic material is transferred from **mother tree** to the seedling – the **rootstock** – via a healthy shoot from the previous season – the **scion**. In both budding and grafting methods, the quality and handling of the scion is vital to successful propagation.

- Scions should be carefully selected from the healthiest parts of the mother tree. The shoots should be from the previous season, and have buds that are active (swollen), but not open yet.
- Scions should also be the same diameter as the target rootstock, to better align the cambium and improve the union.
- Scions should be cut cleanly with a sterile knife or secateurs.
- **Best practice**: only harvest the scion on the same day as the budding or grafting.

- To transport the scions, they should be kept moist and clean in a plastic bag, or with damp tissue paper. Survival rates are higher when the scions are also soaked in clean water for an hour before the budding or grafting.

The health and characteristics of the rootstock are also important factors in propagation, since it must be strong enough to survive the cutting and the insertion of the bud/scion. The rule of thumb is that the rootstock stem should be the width of a pencil (about 1cm) and between 30-45cm tall. Typically, this would be a seedling that has been between 6-8 months in the nursery, although this varies depending on the growing conditions: water supply, soil fertility, and the presence of pests or diseases.

The tools for propagation must be kept as sterile as possible to protect the plants. Farmers will need:

- A clean grafting knife (preferably a surgical blade) and V-cut secateurs,
- A sterilizing solution (e.g., alcohol or methylated spirit) for the cutting tools
- Grafting tape or clean plastic wrapper.
- A long, thin clear plastic bag to use as a cover over the graft to prevent rotting.

The hygiene of the tools and the propagation is vital to survival rates. Tools must be sterile and sharp, and cuts should be made as cleanly and precisely as possible.

Good Practice:

✓ (bottom left) Keeping scions in clean water during transport and budding.

✓ (top left) Preparing strips of clear plastic to protect the bud site.

✓ (top right) Protectively wrapping the bud site with clear plastic

6.4. Budding lemons

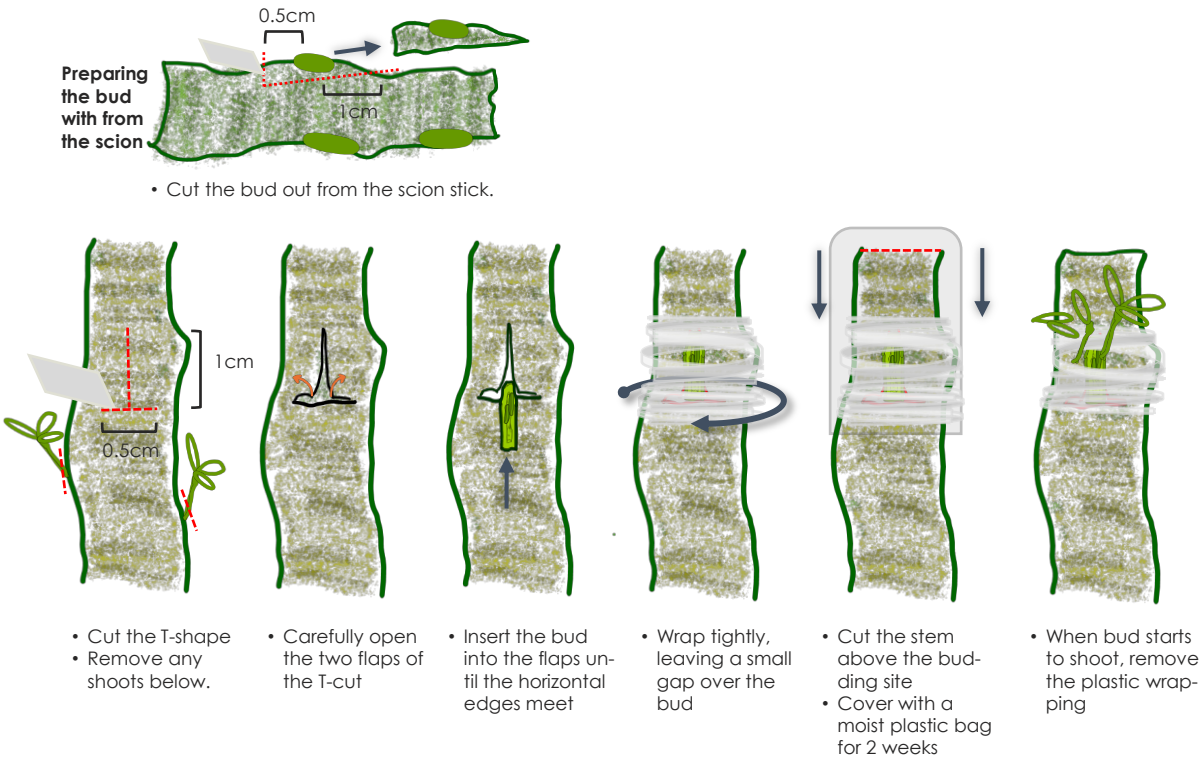
Budding involves inserting a bud into the stem of the rootstock seedling, to form a new tree with a root system belonging to the rootstock plant, and shoots from the scion bud. Lemon rootstock can be budded to grow into either an orange tree or a more productive lemon variety. To grow the rootstock seedlings, farmers should procure their own lemon seeds from local varieties and then be provided with scions from orange varieties or more productive lemon varieties.

The preferred varieties for budding are Citrus sinensis *Valencia* or *Washington Navel*. The Extension Service Provider must identify a reliable source of scions for these varieties, and if possible, support the FTC or FI in establishing their own 'mother block' orchard which can provide scions.

A common and proven method for citrus is **inverted-T budding**, which can take a couple of minutes for each plant, using the following steps:

1. **Prepare the rootstock stem**: identify a straight section of the stem that is wide enough for budding (the width of a pencil, about 1cm). Remove any buds and leaves on the stem below this section.
2. **Making the T-Cut**: Make a very shallow and 0.5cm wide horizontal cut into the stem, only cutting the bark/surface. Then make a vertical cut above it, around 1cm long, meeting the middle of the horizontal cut to make an upside-down "T" shape. Use the blade to slightly open the two flaps of bark.
3. **Prepare the bud**: make a horizontal cut into the scion stick 0.5cm below the selected bud, and then a cut from 1cm above the bud that slices underneath until it reaches the first cut, and the bud is removed.
4. **Insert the bud**: push the bud upwards into the flaps of bark, until the horizontal cut on the bud is level with the horizonal cut on the stem.
5. **Protective wrapping**: firmly wrap grafting tape or clear plastic wrapping around the stem and the bud, with a very small opening by the bud itself. This gap is vital to allow the bud to shoot.
6. **Cut and protect the stem**: cut the stem 5cm above the budded site and then cover with a moistened clear plastic bag for up to 2 weeks to prevent rotting when the seedling is watered. Cut away any buds below the budding site.
7. **Record information**: label the seedlings which have been budded, or the bed they are in, with the date of budding, as well as the scion source and variety name.

Figure 4: Visual representation of key steps to bud lemons





Good Practice: *Budding*
- ✓ **Left**: The bud is inserted into the small T-shaped cut made on the rootstock stem.
- ✓ **Middle:** The bud should hold itself in place. Then, the farmer can wrap the bud site with grafting tape, taking care to leave a very small opening at the bud itself, to allow it to easily shoot.
- ✓ **Right**: The tape should be wrapped tightly and securely, so that it stays on without being held.



Good Practice: *Budding*
- ✓ **Left**: A very small opening is left at the bud site to allow it to shoot.
- ✓ **Middle:** We recommend that farmers come together as a group to bud or graft their seedlings. This is important for sharing skills and improves cost effectiveness since scions only need to be transported to the location once.
- ✓ **Right**: Once the seedlings have been budded, and the stem above the bud site is cut, covering the 'bare' stem with a plastic bag will prevent rotting during watering.

6.5. Grafting mangoes

Grafting combines parts of two different plants so that they grow together. Farmers can source their own seeds for the rootstock from healthy local mango trees, which have shown resilience to local environmental conditions. Scions should be from a more productive and better quality variety, such as *Kent* or *Tommy atkins* varieties, or from local big

mangoes. A grafted mango will begin fruiting within 3-5 years, compared to 5-8 years for seed-grown trees.

The cleft or wedge grafting technique is simple and widely used, and involves the following steps:

1. **Prepare the scions**: cut the scion to 15cm long, and then using V-cut secateurs, make a V shaped cut in the scion, so that it is as long as one hand-width.
   - If the V-cut secateurs are not available, use a sharp sterile knife to make two sloping cuts 2-3 cm long at the bottom to form a wedge shape.
2. **Prepare the rootstock**: using the V-cut secateurs, cut the rootstock 15-20cm above the soil, where it is pencil width (around 1cm diameter).
   - If V-cut secateurs are not available, use a sharp sterile knife to cut the rootstock. Then, make a straight cut about 3cm into the top of the rootstock.
3. **Insert the scion**: push the scion firmly into the cut at the top of the rootstock, leaving just ½ cm of the scion 'wedge' showing. Using V-cut secateurs guarantees that the scion will fit perfectly into the rootstock.
4. **Wrapping**: firmly wrap clear plastic grafting tap or plastic wrapping around the graft, although it should not be so thick that new shoots cannot emerge. Only remove this once the scion begins to grow (indicating a successful graft).
5. **Protect the graft:** For the first 2 weeks, the graft should be further protected with a moistened and clear plastic bag covering the stem to prevent rotting when the seedling is watered. Cut away any buds that grow below the graft.
6. **Record information**: label the seedlings which have been grafted, or the bed they are in, with the date of grafting, as well as the scion source and variety name.

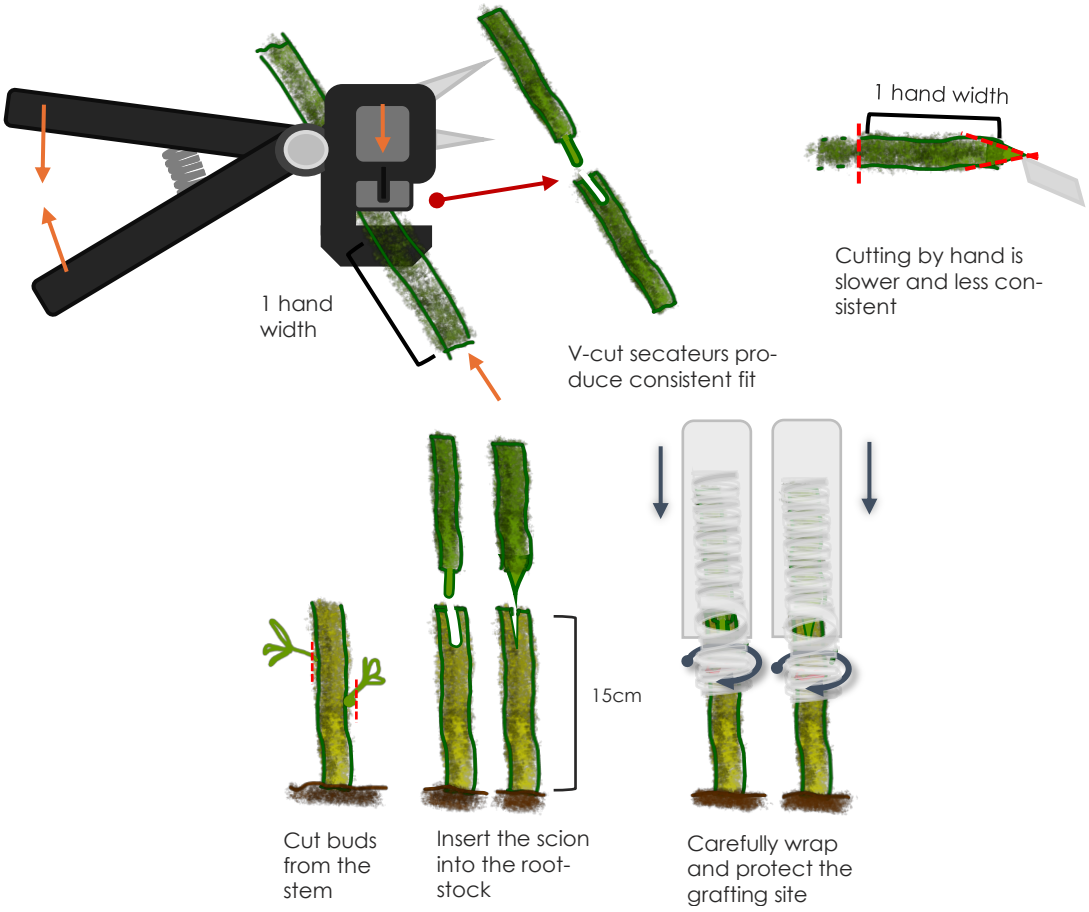
Good Practice:

✓ Grafted mango firmly wrapped, with thinner layer at the top to allow shoots to emerge.

Good Practice:

✓ New shoots emerging from a grafted mango. At this point, the protective wrapping can be removed.

Figure 5: Visual representation of key steps to graft mangoes



Success will be clear once the first green shoots appear growing from the graft. Failure is visible when the scion turns brown.

6.6. Post-propagation management

- Labelling and record keeping is vital to monitoring the success of the propagation. Improving practices through experimenting relies on farmers keeping good records. Keep a record of:
- **Timing**: seedling age when budded or grafted, time before new bud shoots.
- **Scions**: source(s) of scions, scion soaking or handling, quantity (and cost if applicable) of scions.
- **Outcomes**: success rate / survival rate.
- The seedlings are vulnerable immediately after propagation, and the key causes of death are dirt and disease affecting the cut, or too much exposure to sunlight. Covering the budded or grafted section with a clear plastic bag can help to keep moisture in and pests out. **Seedlings must be shaded** and kept out of direct sunlight until they are growing again consistently. To keep the seedlings healthy, they should also be watered every day.

6.7. Local capacity building – nursery operators

Building local capacity for propagation helps to spread good practices in a bottom-up manner and rewards local farmers who have expertise and commit to training their fellow farmers.

In Katete, 34 lead and follower farmers from across the district were identified as having existing skills, or considerable interest, in budding and grafting. These individuals received specific training in introducing propagation to their fellow farmers, in order to supplement the interventions of camp extension officers. The training included a ZARI certificate as budding and grafting nursery operator. Ideally nursery operators are farmers who have their own orchards with mother trees that can provide scions. This gives groups more independence in choosing when to do budding or grafting, since the scions do not always need to be sourced from the FTC or FI.

Good Practice:

✓ A nursery operator demonstrates to a farmer group (from another zone in the camp) how to bud lemons and provides scions.

7. Transplanting trees for agroforestry

7.1. Objectives

Agroforestry succeeds when trees can survive and fulfil their functions in fields, woodlots, fences, and orchards. These guidelines are particularly important:

- To ensure that seedlings are transplanted correctly - following established good practices to maximize the survival rates.
- To guide on the spacing and tree combinations that work best together.
- To guide on maintaining or expanding existing agroforestry plots.

7.2. General guidelines

7.2.1. Locations for transplanting

Planting in a suitable location is essential to the survival of agroforestry trees. This should be considered as early as the group planning meetings in May and June. Plots should be accessible for the farmer to manage and harvest products effectively, as well as secure them from livestock and other disturbances.

The main locations are:

- Open fields – usually unfenced open areas relatively far from villages or houses where the main crop production takes place. The most relevant agroforestry activities are **alley cropping** and **live fences**.
- Gardens - fenced or semi-fenced plots outside of villages and mostly found in lower-lying valley bottoms where water lasts longer. The most relevant agroforestry activities are **live fences**, **woodlots**, and **orchards**.
- Homestead - Around the home, particularly for fruit trees to reduce the risk of fruit theft)

We recommend the use of gardens as focal points for agroforestry, since they are generally already fenced, have a water supply, and are accessible to the farmer. Farmers should be encouraged to:

- Establish a nursery in their garden,
- Plant woodlots or fruit trees within garden boundaries,
- Expand these 'green islands' in the landscape by integrating new fields with living fences with the existing garden.

Additionally, we recommend that each year, farmers gap-fill existing agroforestry plots as a priority before expanding to new plots.

7.2.2. Final steps in the nursery

To achieve successful growth in the field, seedlings should be pest- and disease-free and comply with the 2:1 shoots to roots ratio. Generally, farmers should consider the following timings:

- **2 weeks of hardening off:** During the last 2 weeks in the nursery, seedlings must be exposed to direct sunlight and reduced watering to prepare them for conditions in the field.
- **1 week since root pruning:** Do not plant seedlings with roots which have extended beyond the planting bag. Roots that have grown deep into the ground at the nursery must be undercut at least one week before transplanting to allow the seedling recover from the shock of root cutting.
- **2 weeks since topping:** If the seedling was topped to conform to the 2:1 shoots to roots ratio, then it should remain in the nursery for at least 2 weeks to allow it to recover from the shock.

Best Practice:

- ✓ Seedling has recovered and re-grown after being topped to fit the 2:1 shoots to roots ratio.
- ✓ No roots extending beyond the planting bag
- ✓ Planting hole was prepared in advance

Poor Practice:

- × Seedling is severely overgrown and will be distressed by field conditions.
- × Leaf development high up the stem cannot be supported by the thin stem and small roots.

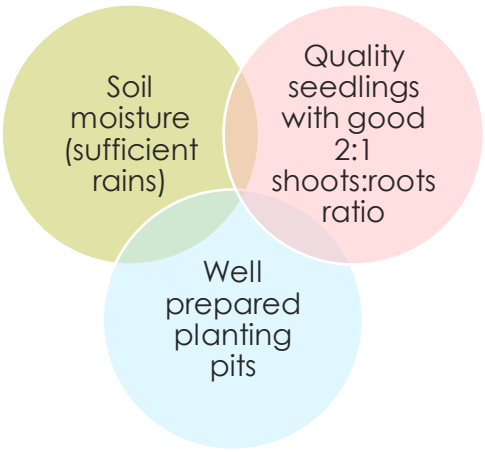
7.2.3. Timing of transplanting

Successful transplanting relies on timing, so that the farmer, field conditions and seedlings are prepared and ready at the right moment.

The right moment has come, when:

1. The location has been defined,
2. Weeds have been cleared,
3. Soils are moist and the onset of consistent rain is imminent,
4. Planting pits are prepared and Bokashi has been added to the pits,
5. Farmers have organized themselves to transport and transplant the seedlings, ideally as a group.

Figure 6: three key considerations for improving survival rates in the field



7.2.4. Transporting seedlings

Farmers usually transport seedlings by motorbike, bicycle, ox cart, or on foot. We recommend that farmer groups work collaboratively to plant seedlings in each other's fields as a group. Farmers must make sure that the seedlings and planting bags are not damaged during transport.

Good Practice: Bulk transport of seedlings using an ox-drawn cart

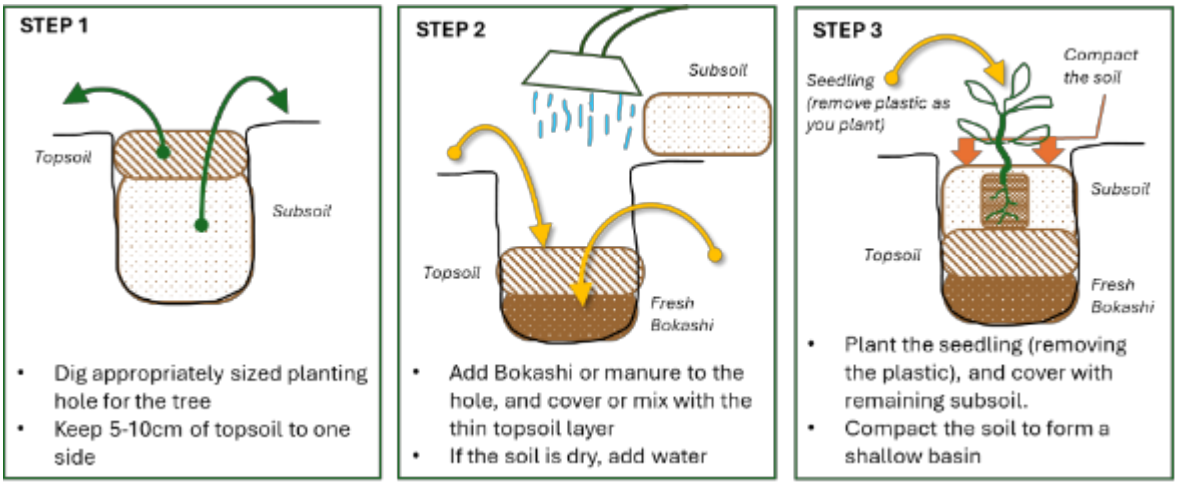
7.2.5. Planting seedlings

To ensure the best possible survival rate of transplanted tree seedlings, we recommend the following:

- Mark out the grid or rows of planting holes, using sticks or strings to ensure consistency.
- Dig planting holes, following the specific sizing for the given tree species. Use a hoe or shovel to dig the hole, keeping the nutrient-rich topsoil to one side, and the subsoil to the other side.
- **Best practice**: Planting holes should be dug in advance, and farmers should add Bokashi to each hole.

- Follow the recommended spacing guidelines for the given species and purpose.
- Remove the plastic planting bag (either by ripping it, or if the soil mix is moist, pulling it off).
- Place the seedling in the planting hole, then cover it first with the topsoil and then with the remaining sub-soil from the hole.
- Compact the soil by hand or foot, to make a shallow basin around the seedling that can help retain rainwater.
- Either bury the plastic bag in the planting hole or collect all plastic planting bags and bury them at a single site.
- **Best practice**: Remove the plastic bag carefully in a way that it can be reused the following season.

Figure 7: Key steps in planting a seedling in the field.



Good Practice: Measuring out the required spacing (for a Khaya woodlot) and digging the planting holes.

Good Practice: Planting holes pre-pared with hoes before transplanting

Practical examples of transplanting technique

Good Practice:

✓ Refilling the planting hole with the subsoil, by hand and with a hoe.

Good Practice:

✓ Soil around the seedling compacted to form a small basin,

✓ On a warm, dry day, the seedling is given a quick watering.

Good Practice:

✓ Collection of plastic planting bags for safe disposal

Poor Practice:

× Plastic planting bags left in the field after transplanting.

Good Practice:

- ✓ Planting bag was used to protect the roots during transport.
- ✓ Planting bag is being removed at the planting site.

Poor Practice:

- × Planting bag was not removed, which inhibits root development.
- × Several seedlings growing in the same bag, which is unnecessary for Gliricidia.

7.2.6. Planting cuttings

For Gliricidia, Moringa and Leucaena, it is also possible to plant cuttings from an existing tree. Propagating this way saves time and is more cost effective than raising seedlings in a nursery. However, it relies on a large stock of healthy trees close to where the cuttings will be planted. It is therefore suited to expanding or gap filling Gliricidia fields, Moringa plots or Leucaena fences. Cuttings are particularly useful for fencing, since they can act as fence posts immediately.

Selection and cutting

Select cuttings only from healthy trees which have strong upright growth. Branches should be at least 1-year old with well-developed and undamaged bark, and should have a diameter of at least a bottle cap. The cuttings should be hardened and not still green wood.

Cut at the onset of the rainy season and then plant the fresh cutting immediately. The cut should be made with a machete, sharp axe or hoe. Cut at an angle to prevent rotting. The cutting should have a length of around 1m. To ensure a fast development of roots and better access to water, the cutting must be planted 30-40cm deep into the soil.

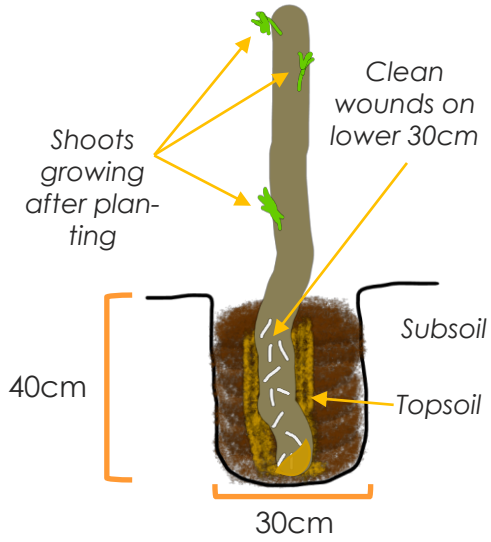
Good Practice: Gap-filling and extending a Gliricidia alley cropping field with fresh Gliricidia cuttings

Planting and management

Prune all leaves and major side branches from the cutting, adding the leaves as green manure to planting holes. Before planting the cutting, 'wound' the lower 30-40cm by making small cuts with a clean, sharp knife in the bark, which will promote more stable side rooting.

Plant the cutting 30-40cm (approximately one third of the cutting length) deep into the planting hole of size **30cm x 30cm x 40cm.** Planting to a good depth into nutrient-rich topsoil is vital for root development**.** The soil must already be moist, and if there is no rain in the days after planting, manually water the cuttings. Cuttings will survive only with sufficient soil moisture during their early establishment. Farmers must be informed that overwatering can cause roots to rot.

Figure 8: Planting a cutting



If using cuttings for live fences, allow thinner cuttings to establish for 2-3 months before attaching any wire, because otherwise the wire might 'strangle' them, inhibiting growth.

Good Practice:

- ✓ Cuttings have a bottle cap diameter.
- ✓ Sticks are healthy and not damaged.
- ✓ Cuttings are approximately 1m long, with 70cm above ground and 30cm buried in a moistened planting hole.

Poor Practice:

- × Using a cutting that is too wide and not straight, which rapidly dried out.
- × Using a damaged cutting, which will dry out and die in the field.
- × Visibly dry planting hole suggests insufficient management.

7.2.7. Direct Seeding

Direct seeding is another cost-effective way of establishing agroforestry activities with lower input and labor costs. Quick growing species including Gliricidia, Moringa and Leucaena are well-suited for direct sowing. Farmers should however consider the downsides of direct seeding, namely the possibly lower survival rate and slower growth rate compared to well-raised seedlings from the nursery. Direct seeding is appropriate for live fences and alley cropping, although the plots must be very well protected from disturbances given the vulnerability of the very young trees during establishment.

Good Practice:

- ✓ Directly sown Gliricidia for a live fence.
- ✓ The area around the seedlings has been weeded and is kept clear of competition for the seedlings.

Preparation

Farmers should use direct seeding for agroforestry activities where they plan to have a very large number of trees, which usually means alley cropping, live fences or marking boundaries. As the seeds germinate and begin to establish, they are especially vulnerable to disturbances and pests, and so direct seeding should only be used if livestock are controlled and kept away.

Good soil moisture is a mandatory prerequisite for direct seeding, so farmers must be prepared to sow as soon as rains are consistently established. This is often at the same time or immediately after main crops are planted. Weeding is a second prerequisite, to reduce potential competition for nutrients and light, and remove hosts for pests.

To boost the germination of the seeds, farmers can soak the seeds in clean water before planting:

- Gliricidia should be soaked in warm water and then cooled for 24 hours to hasten germination. The germination of fresh seeds is usually high, at over 90%.
- Moringa should be soaked overnight to enhance germination. When planted, it germinates best in half-shade.
- Leucaena should be soaked in boiling water for 3-5 minutes, which leads to around 70% germination.

Planting and management

Timing is vital in direct sowing, because the seeds need sufficient and consistent soil moisture to establish. Therefore, sowing should be done within a wet week of the rainy season beginning, directly after main crops are planted.

Seeds have a better chance of germinating and surviving in looser soil where roots can easily develop, so before sowing, farmers should dig and churn the top 20cm of soil where they are sowing the seeds. Plant 2-3 seeds approximately 2-3cm deep at each planting station and cover with the loose soil. The rule of thumb is to plant at a depth 2-3 times the seed diameter.

Gliricidia takes 3-15 days to germinate, Moringa takes 7-14 days and Leucaena takes 5-7 days. Farmers must monitor germination progress and frequently remove weeds that appear during the first months of establishment.

Poor Practice: Gliricidia sown directly in a stony soil which was not churned and drains poorly. Therefore, only one seed has germinated for the live barrier.

7.3. Transplanting trees for agroforestry - Gliricidia alley cropping

7.3.1. Objectives

The objectives of Gliricidia alley cropping include restoring and enhancing soil fertility, boosting crop yields, and promoting sustainable land use. Alley cropping, in general, integrates trees or shrubs into hedgerows with crops planted in the spaces between these rows, offering numerous benefits. Gliricidia is a fast-growing leguminous tree that is commonly used in alley cropping systems for its nitrogen-fixing properties and ability to improve soil health.

Benefits: Alleys of Gliricidia provide a windbreak, green manure and fix N to the soil where maize has been planted.

7.3.2. Benefits of Gliricidia alley cropping

The benefits of Gliricidia alley cropping are extensive, contributing to both agricultural productivity and environmental sustainability. Here are the key advantages:

- **Soil fertility improvement:** Gliricidia is a nitrogen-fixing tree, which enhances soil fertility by increasing nitrogen levels. Using the pruned leaves as green manure significantly boosts soil organic matter and nutrient content, leading to improved crop yields.
- **Increased crop yields:** Studies have shown that intercropping maize with Gliricidia can lead to a significant (almost 30%) increase in maize production compared to traditional methods[1]. This is attributed to enhanced soil health and nutrient availability.
- **Supply of fuelwood or poles for fencing:** Farmers can harvest poles during the off-season for fuelwood or for fence posts, reducing pressure on forests for these products. Gliricidia poles are also well-suited to supporting tomato vines.
- **Weed suppression:** The pruned branches and leaves from Gliricidia can be used as mulch, which helps suppress weeds and conserve soil moisture, further benefiting crop growth.

[1] A COMACO Monitoring and Evaluation Department study in April 2024 found that: Average maize yield per hectare under Gliricidia soil treatment without chemical fertilizer: 2650 kg/ha. Average maize yield per hectare under chemical fertilizer: 2056 kg/ha.

- **Erosion control:** The presence of Gliricidia in alley cropping systems helps stabilize the soil, reducing erosion and improving water infiltration.
- **Sustainable land use:** This practice provides a sustainable alternative to conventional farming methods, reducing reliance on chemical fertilizers and promoting more resilient agricultural practices.
- **Livestock feed:** The foliage of Gliricidia is rich in protein and serves as high-quality fodder for livestock, improving animal nutrition and productivity.
- **Carbon sequestration**: Gliricidia contributes to carbon sequestration through biomass accumulation, helping mitigate climate change effects.
- **Economic benefits:** By increasing crop yields and providing poles and fodder, Gliricidia alley cropping can enhance household income and food security for farmers. Farmers can also save money on chemical fertilizers.

Good Practice:

✓ Gliricidia poles used to support tomatoes growing in the garden.

Overall, Gliricidia alley cropping results in a wide variety of improvements to agricultural systems while simultaneously promoting environmental health.

Good Practice: Gliricidia alleys shelter a sunflower crop, and the leaves have been pruned for green manure.

Good Practice: Poles cut from approx. 1300 Gliricidia trees in lines covering a 0.6 ha field.

7.3.3. Field preparation and seedling selection

We recommend preparing the planting holes some days in advance and burying a handful of Bokashi under topsoil. When gap-filling, add Gliricidia leaves from nearby trees to the holes.

The seedlings should be around 25-30cm tall (suiting the 2:1 shoot-to-root-ratio in a standard small planting bag), should have healthy roots which do not extend beyond the planting bags, and must have gone through at least two weeks of hardening off. Avoid planting trees into fields which are suffering from pests or diseases.

Overgrown seedlings above 40 cm should be topped (cut) at least one week before transplanting.

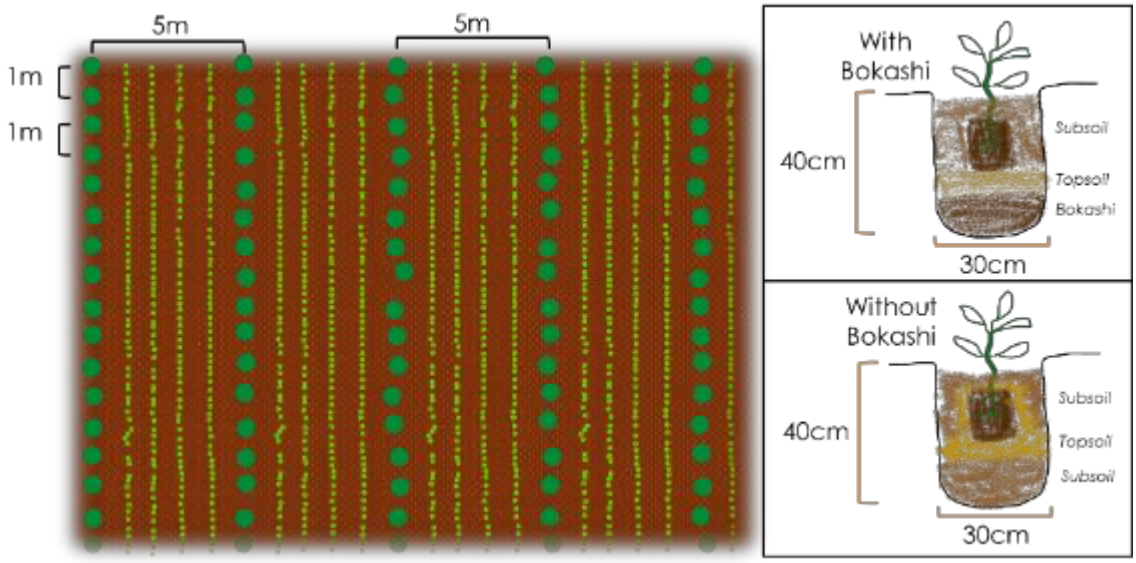
Good Practice: A healthy seedling with pruned roots and a suitable shoot:root ratio, ready in a prepared planting hole (without Bokashi).

7.3.4. Planting Gliricidia for alley cropping

Planting holes for Gliricidia should be: **30cm wide x 30cm long x 40cm deep**.

Spacing of planting holes for Gliricidia should be: **1m** within the row, **5m** between the rows.

Figure 9: Spacing for Gliricidia alley cropping and recommended planting hole contents



We recommend a minimum plot size of **30m x 30m** – equivalent to 180 Gliricidia trees in total, for example in 6 rows of 30.

7.3.5. Managing Gliricidia in alley cropping

First season (planting)

In the first season of establishment, the seedlings will be vulnerable to a range of pressures and disturbances. The focus is to look after the seedlings alongside the crops and ensure that they survive the first dry period.

Weeding and protection: Weed the fields as soon as weeds compete with or shade the Gliricidia trees. Before the crops are harvested, livestock are normally kept away from the fields, but for the rest of the year, livestock must be herded to avoid destruction of the vulnerable young trees.

Harvesting crops: Take care to avoid cutting the Gliricidia plants when harvesting, especially when digging out plants (e.g., groundnuts).

Post harvesting: Continue to protect the young trees from livestock and fire year-round. By March, make sure there is a sufficient fire break around the field.

Good Practice:

- ✓ Strong group involvement to plant a large field of Maize and Soybean with lines of Gliricidia.

Second season

In the second season, the focus should still be on protecting the trees, particularly when ripping or making basins in the field.

Careful field preparation: Prevent damaging Gliricidia trees when preparing the field with ox-power. To protect the existing Gliricidia seedlings, farmers should dig basins by hand or hoe and drive their oxen carefully between rows. If the inter-row spacing guidelines are followed, there is enough space for oxen.

Use leaves as green manure: Cut leaves and small branches above 1 m from the tree and cover the soil with them – or add the leaves to the rip-lines or basins as green manure.

Weed and protect: Weed the field as usual and keep livestock away.

Gapping: Replant at all stations where the seedling did not survive the first year to guarantee fully stocked Gliricidia rows.

Harvesting crops: Take care to avoid damaging the Gliricidia plants when harvesting, especially when digging out plants (e.g., groundnuts).

Post harvesting: Continue to protect the young trees from livestock year-round. By March, make sure there is a sufficient fire break around the field.

Mulching: Before going into the second planting year, use the pruned leaves and small branches as mulch to enhance soil moisture retention, suppress weeds, and improve soil fertility. This practice also helps in maintaining high organic matter levels in the soil.

Good Practice:

- ✓ Field is weed-free and Gliricidia leaves have been used as green manure.
- ✓ Gaps in the Gliricidia lines are being filled (the existing 1m-tall Gliricidia trees are 1 year old).

Poor Practice:

- × Gliricidia lines have many gaps and are overgrown with weeds.

Farmers should control weeds as they appear, rather than allowing them to establish in the field, which makes future field preparation harder.

Third season and beyond

By the third season, Gliricidia trees are ready for more intensive management, including coppicing and pruning to harvest sticks/poles and leaves. By their third season in the field (2 years of growth), Gliricidia can reach heights of 3m and above. Gliricidia will re-grow very well if it is only cut during periods of active growth (not during dry or cool spells).

Coppicing: Between November and December (at the same time as field preparation for the crops), Gliricidia trees can be coppiced to harvest poles and leaves for green manure.

- Use a machete or saw to cut the trees with a clean cut at waist height – around 1m above ground. Leave one stem uncut as the main stem. Cut all other stems. Remove all leaves and distribute them between the rows.
- The cut branches can be used for fuelwood, poles for light construction (e.g., fence-making), or as cuttings to be planted.
- We recommend stripping branches and leaving only the leaves in the field, but any branches left in the field must be placed parallel to the rip-lines, as otherwise they will obstruct the oxen when ripping.

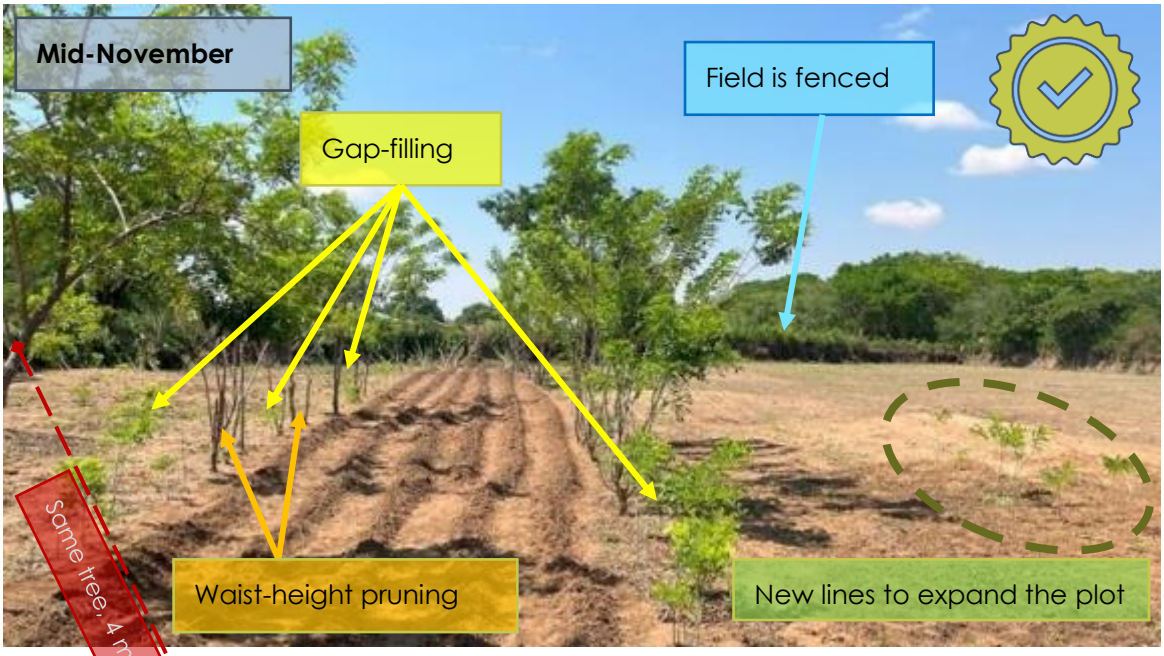
Field preparation: Continue to take care of the trees while making rip-lines or digging basins. Coppicing directly before field preparation will make this easier and will provide fresh leaves for green manure.

Gapping: Replant all Gliricidia seedlings which have not survived to guarantee fully stocked Gliricidia rows.

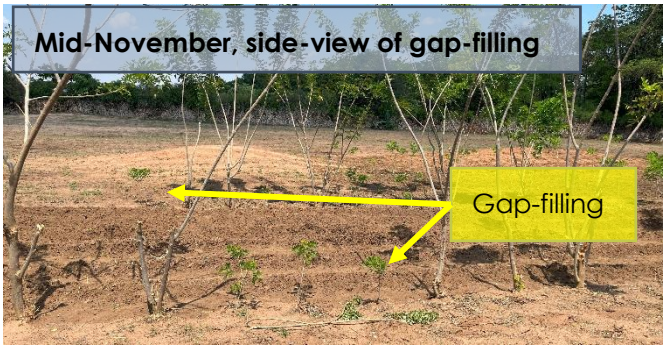
Applying the leaves as green manure: Leaves can be applied as green manure twice during the crop growing season. The first application is when the coppicing and field preparation is done, and the second application is 6-8 weeks later (depending on the regrowth).

Leaves should be stripped from the stems by hand and applied while fresh to the basins or rip lines (first application) - or to the base of the crops (second application). Ideally, the leaves should be covered with a thin layer of soil.

Examples of Gliricidia management practices from the field



✓ Maize has grown well in the alley between Gliricidia lines.



Good Practice:

- ✓ Two lines of Gliricidia have been gap-filled with new seedlings.
- ✓ New lines of Gliricidia are being planted.
- ✓ Weeds have been removed from the field, and rip-lines have been carefully dug in between the Gliricidia trees.
- ✓ Field is fenced from all sides.

Best Practice:

- ✓ *Left:* Gliricidia cut at waist height, leaving one stem to continue growing.
- ✓ *Right*: Leaves and green stems applied as green manure to the soil.

Best Practice:

- ✓ **Before**: Gap-filled lines of Gliricidia, with irrigation for crops in between.
- ✓ **After**: Mature Gliricidia cut to waist height, green material added to cropping lines as green manure.
- ✓ The central stem of each pruned Gliricidia tree is allowed to continue growing.

Poor Practice:

- × Gliricidia cut at the base, rather than around waist height (1m). This will promote more shrubby growth, which impedes planting in the alleys between Gliricidia lines.

Poor Practice:

- × Gliricidia has been cut too low.
- × Livestock are free to graze and disturb young seedlings.
- × Lines have not been gap-filled.

Poor Practice:

- × Gliricidia in the dry season. Most stems have been coppiced too low.

Poor Practice:

- × Gliricidia that has been cut at ground level, and is struggling to re-grow, reducing its positive effects in the field.

7.4. Transplanting trees for agroforestry - live fences

7.4.1. Objectives

Protecting trees and crops from livestock is essential to reducing disturbances and increasing survival rates. We recommend that all agroforestry activities are done in live-fenced fields. Furthermore, live fences have a positive influence on deforestation as it shows ways to prevent cutting stems or poles in the remaining forests to use them for fencing – as seen commonly in Katete district.

7.4.2. Benefits of live fences

Live fences share some functions with ordinary fences, as well as adding extra benefits:

- **Protection from livestock**: Live fences control the movement of livestock to prevent grazing in agroforestry and crop fields.
- **Demarcating boundaries**: Live fences clearly mark field boundaries and act as well-rooted windbreaks that reduce soil erosion.
- **Time-, cost and labor-saving**: Building a conventional fence needs time and labor for cutting and transporting poles from forests. Seedlings are lighter and easier to transport, while maintaining a live fence is also less demanding, since cuttings or seeds can be collected from the existing fence trees.
- **Extra production**: Depending on the species used, live fences can be a source of poles, green manure (e.g., Gliricidia), or fodder (Leucaena).
- **Field improvements**: Depending on the species used, live fences can bring soil fertility benefits (e.g., Gliricidia) or act as natural insect repellents (e.g., Tephrosia).

Good Practice:

✓ Gliricidia planted to supplement and then replace a dead fence of poles cut from the forest.

Poor Practice:

× Farmers cut large quantities of wood from forests to construct Kraals and to fence their fields.

7.4.3. Planning and preparation

To plant a live fence, farmers must know and mark the boundaries of the field, to prevent any social conflict. Additionally, farmers should discuss with their neighbors the benefits of the fence and agree on the harvesting of products.

Before planting a live fence, it is important to consider the land use pattern throughout the year. In early stages of growth, farmers must protect the fence itself from livestock grazing and commit to making firebreaks since many species are vulnerable to fire. Farmers must also have a large supply of seedlings, cuttings or seeds, because the planting pattern needs to be dense to make a robust barrier. We recommend using cuttings or direct sowing, due to the low cost and large amount of trees that must be planted for an effective fence.

Ideally, live fences consist of a staggered double row of trees (see diagrams for each species below), so farmers must consider and mark out the space required for planting the fence.

7.4.4. Planting a live fence

There are three options when planting a live barrier or fence:

1. **Use of seedlings**. In this case, farmers should transplant seedlings in 30cm x 30cm x 40cm planting holes and use a planting distance between 30-50cm between each hole, depending on the desired thickness of the barrier.
2. **Direct Seeding**. In this case, farmers should plant 2-3 seeds in moist shallow planting stations every 30cm, and cover with a thin layer (1-2cm) of the topsoil. Best results can be expected when placing a handful bokashi at the bottom of the planting station.
3. **Use of cuttings**. To plant live fence posts, cuttings are most appropriate, as they are ready to use almost immediately. Cuttings should be selected for their straightness, diameter and height.

Specific guidelines on all three options is presented in Module 7.0. All planting, but especially cuttings and direct sowing, needs the soil to be moist. If possible, planting holes should therefore be dug before the day of planting, to allow a buildup of moisture. Planting should be done when there is a fair expectation of consistent rains in the following days.

When direct seeding or using seedlings, the fence will not be immediately effective, so we recommend planting it along the line of an existing fence if possible.

Best Practice:

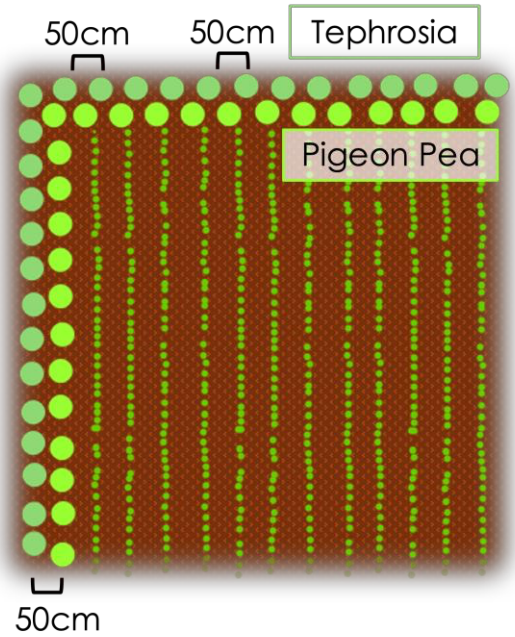
✓ Gliricidia seedlings planted to replace a dead fence around a garden.

Live barrier

A live barrier consists of one or two lines of densely planted trees that grow into a thick barrier.

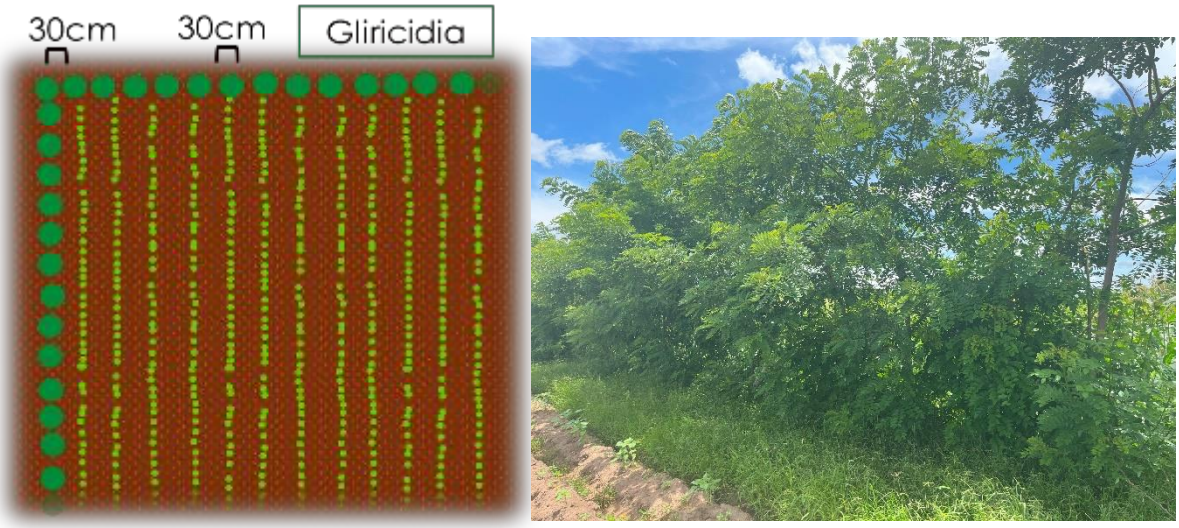
We recommend planting a staggered double row, so that the trees have space to grow, but also form a dense and robust barrier. For a single line, the trees need to be planted closer together (see diagrams).

Figure 10: Recommended spacing for a double-row live barrier



This single row of Tephrosia would be more robust coupled with a row of Pigeon pea or more Tephrosia.

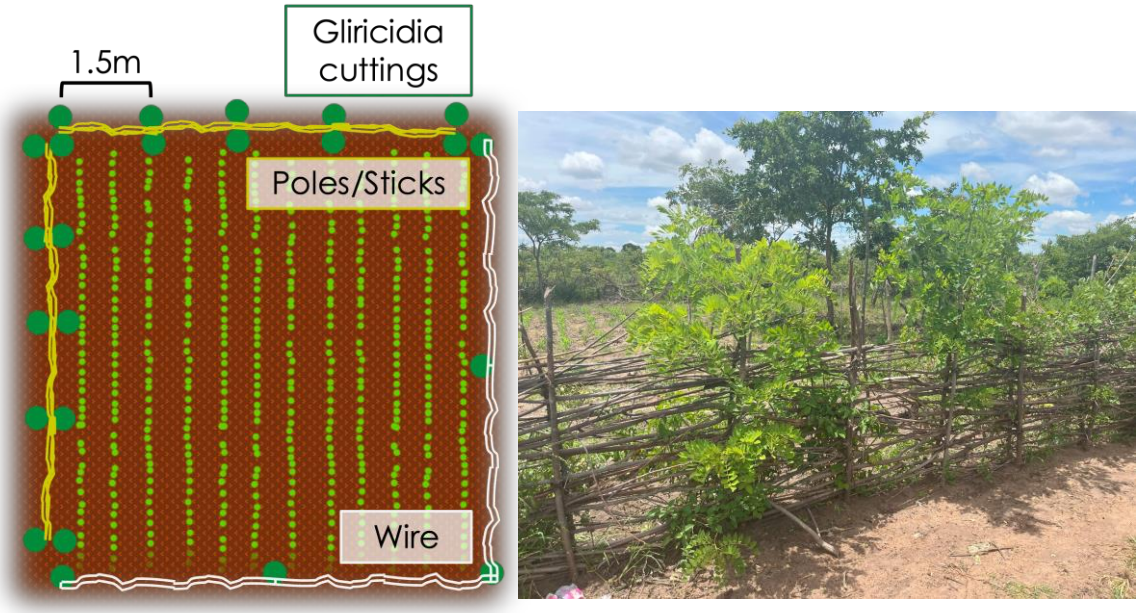
Figure 11: Recommended spacing for a single-row live barrier



Live fence posts

Tall cuttings of Moringa or Gliricidia are well suited to be used as live fenceposts for a wire fence, which requires less-dense spacing. Alternatively, stack sticks or poles in between 2 straight cuttings of Gliricidia. Over time, as the poles and sticks are broken or lost, replace with fresh poles from the Gliricidia.

Figure 12: Spacing recommendation for live fence posts using Gliricidia or Moringa cuttings



Poor Practice: A Sisal fence has been planted with dead Gliricidia poles (no longer viable as cuttings). If cuttings had been used, there would have been a supply of poles. Instead, a source of replacement poles must be found elsewhere.

Best Practice: Gliricidia seedlings planted to add a second layer of protection to a Sisal living fence.

7.4.5. Details about live fence species

There are several well-suited live fence species. In the context of the Katete agroforestry project, the following species were promoted.

Best Practice: Gliricidia sown directly around an existing dead fence. This will replace the dead fence without cutting down existing trees, and the farmer will benefit from Gliricidia. products after 2-3 years.

Gliricidia

Gliricidia is a versatile species that can be used in several different types of live fence construction. Additionally, farmers can use seedlings, cuttings or direct sowing to plant a Gliricidia live fence.

Tephrosia

Tephrosia is a short-lived, quick growing, and nitrogen-fixing species which is best known for the pesticidal and repellent properties of its leaves and bark. Camp extension officers must warn farmers about the dangers of misusing the pesticide produced from Tephrosia and guide them on safe use.

Tephrosia grows best in rich, slightly alkaline, and well-drained soils that do not flood. It can also tolerate poorer acidic soils.

- **Preparation**: Soaking the seeds in warm water overnight before planting can increase germination speed and survival rates. Without soaking, germination rate is usually around 65%, and survival rate is 60% (PACE Project, 2021).
- **Planting**: Sow **2-3 seeds** in moist planting stations every **30-50cm** under a thin layer of the topsoil.
- If the farmer does not have enough seeds for a full fence, prioritize planting the up-wind boundaries of the field.
- Tephrosia is suited to being the outer row when paired with Pigeon pea planted in a parallel inner row 50cm away.
- For a square 1ha field (four 100m edges), a single row of Tephrosia fence needs around 4,000 seeds.
- **Management**: Germination should occur after 8-10 days. Tephrosia can grow up to 2m within a year, but in the first weeks of growth, farmers must weed around the young seedlings.
- **Seed Harvesting**: The trees produce brown seed pods from July to September. Dry the pods for 2 to 3 days until they open, then thresh and sieve to separate the seeds from pod fragments. Dry the seeds for 3-4 more days, and then store in cool, dark, and sealed storage.

Pigeon pea

Pigeon pea is a short-lived legume shrub that can improve soil fertility, fixes nitrogen, and can reach up to 4m in height. Pigeon pea is suited to a range of different soil types and qualities, with deep taproots reaching up to 2m in depth, which also helps to improve soil structure where Pigeon pea is planted. The leaves can also be used as green manure to rapidly improve the topsoil fertility.

For live fencing, Pigeon pea can be planted alongside Tephrosia in an inner row.

- **Preparation**: fresh seeds do not require treatment, but old seeds should be soaked in water for 24 hours before planting.
- **Planting**: Pigeon pea should be broadcast or drilled to a depth of 5-10cm. For live fencing, it should be planted between 15-30cm apart. Pigeon pea takes 7-14 days to germinate.
- **Management**: Weed control is important during early months, since Pigeon pea is slow to establish. Once established, it will grow quicker and survive for 4-5 years. Pigeon pea should be cut back when planting crops at the onset of the rains each year, but not cut to less than 50cm height. Cut branches and leaves can be used as a green manure top fertilizer.
- **Harvesting**: The immature pods, immature seeds and mature seeds can all be eaten and are widely consumed as food. Seeds can be eaten whole, deshelled, or once ground to a flour. The slow initial growth of Pigeon pea means that it is harvested after most other crops. For green manure, Pigeon pea should be cut during flowering to get the maximum nitrogen content.

Moringa

Moringa is a quick growing, low-maintenance tree species suitable for live fence posts with leaves and seeds used for medicinal and nutritional purposes (**see woodlot model**). Moringa also grows effectively from cuttings, so farmers should follow the general guidelines and select healthy, straight branches from existing trees to become fence posts.

- **Planting**: Farmers should follow the general guidelines for planting cuttings. For Moringa, the cuttings should be between 4-10cm in diameter, and up to 1.5m long. The cutting can be cured for up to 3 days in a dry, shaded place before planting. Trees can be planted as close as 1m apart (which will promote leaf growth), or around 3m apart (for seeds).
- **Management**: Moringa trees do not need much watering, but in very dry conditions they should be watered for the first 1-2 months. Moringa naturally grows very straight, producing pods and leaves only at the crown.
- To encourage more branches and production of leaves and pods lower to the ground, aggressively prune the growing tip of the tree when it is around 1.5m tall, and then regularly prune shoots to encourage bushier growth.
- **Harvesting:** Harvest young leaves and growing tips for leaf sauces, and older leaves for dried leaf powders.

Sesbania sesban

Sesbania sesban is a short-lived, quick-growing, and nitrogen-fixing shrub, suited to live barriers. Sesbania tolerates a variety of soil conditions and can also survive waterlogging. It can grow up to 4m in as little as 6 months, and the poles can be used for firewood, the leaves can also be used for green manure or fodder, and both the leaves and fresh roots are used in traditional medicine. Sesbania is also commonly used in improved fallows for soil fertility improvement.

- **Preparation**: Soak the seeds in warm water to boost germination rates directly before sowing at the beginning of the rainy season.
- **Planting**: Sow 2-3 seeds in shallow basins or loosened soil at a depth of 5-10cm, spaced 30-50cm apart. Germination is about 65% for seeds that are soaked, and takes 14-21 days. Due to the short lifespan (3-5 years), a Sesbania sesban live barrier will need re-planting after several years.

Good Practice:

- ✓ Sesbania sesban planted as a living barrier around a weakening garden fence.
- ✓ The Sesbania fence also has benefits for the soil fertility.

- **Management**: Farmers should remove weeds during establishment. Sesbania thrives with coppicing, and when healthy can be cut back 3-4 times per year, but no lower than 50cm above the ground. Leaves can then be used as a green manure top fertilizer.
- **Harvesting:** The leaves are a good source of protein for ruminants, but direct grazing can damage the trees, so we recommend cut-and-carry forage instead.

7.4.6. Managing a live fence

To ensure that live fences fulfil their purpose, and don't become competition for crops, there is a need for regular pruning. For some species, such as Gliricidia, this can also be a good way to promote horizontal growth around the base, forming a better barrier. In all cases, we recommend cuts should not be made lower than knee height, and ideally around waist height. Harvesting products, including poles or leaves, also helps to manage the growth of the fences.

7.5. Transplanting trees for agroforestry - Woodlots

7.5.1. Objectives

Woodlots are an agroforestry practice that bring farmers benefits over the medium- to long-term and offer an opportunity to diversify farm income. Depending on the species, woodlots can provide valuable products annually, while also reducing pressure on native forests for the same products. Woodlots are especially focused on the trees for their *products* rather than their soil fertility or ecosystem services, and so the health of the trees is of paramount importance.

Best Practice: A large Khaya nyasica (red mahogany) woodlot with 3-year-old trees. The woodlot has also been used for intercropping with soybeans and groundnuts.

7.5.2. Benefits of woodlots

Each species offers specific benefits in a woodlot, although common benefits include:

- **Timber products**: Woodlot trees should grow taller and larger than in other agroforestry activities, which makes their timber more useful for construction purposes, and therefore more valuable. Poles for lighter construction and fuelwood are also woodlot products.
- **Seed banks**: Woodlots can function as seed banks, allowing farmers to collect seeds for sale or to sustain and expand their agroforestry activities.

- **Intercropping and shade**: During the first years, woodlots can be mixed with crops until the crowns start touching each other and shade the woodlot area.
- **Soil improvement**: Woodlot trees are given time to develop extensive root systems, which can protect soil from erosion, and improve water retention and soil stability.

7.5.3. Specific woodlot trees and their benefits:

- **Khaya nyasica:** Khaya is a tall hardwood that grows easily and is a high quality timber for construction and high-value furniture. It can grow up to 1.5m per year and reach heights of around 30m in a garden or woodlot setting, with a rounded crown producing dense shade. The bark is used for cold medicine, while oil from seeds is traditionally used to kill lice.
- **Moringa oleifera:** Moringa is best known for the excellent nutritional and medicinal properties of its leaves, either fresh or in a dried powder. The pods of Moringa trees can be eaten and are prepared like green beans. The seeds can be eaten when still green, pressed to extract oil for use in cooking or perfumes, or ground to a powder for treating water. Moringa wood is not suited to construction but can be used for firewood.

Good Practice:

✓ 18-month-old Moringa woodlot intercropped with vegetables.

- **Gliricidia sepium:** Gliricidia grown in a woodlot can be a source of poles for light construction or firewood, as well as leaves for green manure. Additionally, Gliricidia grown in woodlots should be allowed to grow long enough to produce seeds (which the more intensive management and coppicing in agroforestry fields prevents). Gliricidia can also improve soil fertility, like its function in alley cropping.
- **Leucaena leucocephela:** Leucaena is known for its soil improvement, firewood, and fodder functions. The fast growing species can reduce soil erosion and increase the water retention of soils, while also rapid production of firewood. The key benefit is for feeding livestock, either through direct grazing or cut-and-carry feeding, thanks to the high protein content of the leaves. Farmers should be aware that Leucaena should make up only one part of the livestock diet (at most 20% of feed intake), as excessive consumption can cause adverse effects.
- **Senna siamea:** Senna siamea grows 15-20m tall and can be used for poles, firewood and some higher quality timber uses (e.g., furniture), while the bark can be used for medicine. Senna siamea is commonly planted for shade, windbreaks or as an ornamental tree. Additionally, the foliage can be used for fodder, although only for cattle, sheep and goats (it is toxic to non-ruminants). Leaves can be used as green manure.

- **Senna spectabilis:** Senna spectabilis grows 7-10m tall and can be used for firewood and some higher quality timber uses (e.g., tool handles). It provides services including shade, windbreaks and as an ornamental tree. The leaves of Senna spectabilis are also a good green manure and are often used when making Bokashi.
- **Azadirachta indica:** Neem can grow up to 30m tall and is planted around homesteads and in gardens especially for making medicines and insecticides. The trees are fast growing and generally drought resistant. Medicines, insecticides and repellents are generally produced after extracting oil from the Neem seeds, which contain up to 45% oil. Neem typically begins producing seeds after 3-5 years. Leaves can be used as green manure or fodder.

7.5.4. Site and seedling selection

We recommend that farmers prepare areas either close to the homestead for planting a woodlot or in their garden. Woodlots must be fenced to protect young seedlings and help them grow into strong trees. Make sure the plot has good access to a water source, since most species require watering through their first year of establishment after the end of the rainy season.

Figure 13: Required site characteristics for woodlots

Good Practice:

- ✓ A woodlot protected by a fence (the fence could be better using cuttings).
- ✓ Bokashi (*used sack is circled*) has been used in the planting holes.
- ✓ Spacing follows the guidelines for Senna species and Moringa but are too close for Khaya.

Poor Practice:

- × A woodlot planted in an open space where cattle can graze.
- × The seedlings are too small and have not been hardened off.

Farmers see returns from a woodlot over the medium to long term, so they must select the highest quality seedlings to ensure the best survival and growth rates. In addition to good site selection, farmers should select the healthiest seedlings for transplanting. Module 7.0 provides more guidance on selecting the right seedlings.

Khaya seedlings require a much longer time in the nursery before they are ready for transplanting. We recommend that Khaya seedlings overstay one dry season in the nursery being constantly watered. This maximizes their chance of survival and quality of growth in the woodlot. For the other woodlot species, the time they should spend in the nursery is outlined in Module 5.

Good Practice: A Khaya woodlot planted with 12-month-old seedlings. The seedlings were planted with Bokashi in the basin, and the basins are kept clear of weeds.

The spacing is currently tighter than the guidelines, but the farmer can selectively 'thin' the woodlot after 2-3 years, removing trees that have grown poorly to allow the strongest trees more space to grow.

7.5.5. Planting specifications

Before planting, farmers should remove all weeds from the plot, because they can host pests and compete with the seedlings for nutrients. Farmers should follow the general guidelines for planting, according to the minimum spacing and planting hole dimensions set out in the table below.

To boost the growth farmers must add Bokashi or manure to the planting holes for the technique). Farmers should also maximize the water harvesting potential of the planting hole, by making sure that the soil is compacted around the seedling to form a shallow basin to retain water.

Table 13: Planting conditions for woodlot species

Tree species	Minimum spacing (m)	Planting hole *length x width x depth* (cm)	Ideal soil conditions
Khaya	3 x 3	30 x 30 x 40	Moist, well-drained and deep soils.
Moringa	3 x 2	30 x 30 x 40	Well-drained sandy loam. Avoid waterlogged areas.
Gliricidia	3 x 3	30 x 30 x 40	Best in deep, well-drained, fertile and neutral soils, but tolerates a variety of soils.
Leucaena (*Fodder*)	1 x 1	10 x 10 x 40	Well-drained, neutral soil. Avoid acid, saline, or waterlogged areas.
Leucaena (*Seed or poles*)	3 x 1	30 x 30 x 40	
Senna siamea	2 x 2	20 x 20 x 40	Tolerates a variety of soils. Best in well-drained, fertile soil. Avoid saline soil.
Senna spectabilis	2 x 2	20 x 20 x 40	Moist sandy loam.
Neem	3 x 3	30 x 30 x 40	Tolerates a variety of soils and can grow in poor soil. Best in well-drained soil.

Best Practice:

- ✓ **1**: Adding manure (or Bokashi) to the planting holes is particularly important in woodlots to boost the early growth and ensure that the trees have sufficient nutrients to survive the dry season.
- ✓ **2**: The manure should then be mixed with topsoil in the bottom of the planting hole.

Best Practice:

- ✓ **3**: Once the topsoil and manure (or Bokashi) is mixed at the bottom of the planting hole, the planting bag is carefully stripped off the seedling.
- ✓ **4**: By hand, a small hole is dug in the topsoil and manure mix where the seedling will be placed. After this, the farmer will re-fill the hole with the subsoil and then compact the soil to make a basin that will retain moisture.

Best Practice:

- ✓ **5**: To further boost growth, the farmer can add cattle manure slurry to the basin.
- ✓ **6**: Monitoring and managing the woodlots during the early establishment is vital to achieving good survival and growth rates, and to grow valuable trees. For Khaya, watering is a key part of this management throughout the dry season.

7.5.6. Woodlot management

To promote rapid growth, woodlot trees, particularly Khaya nyasica, require watering beyond the end of the rainy season during their first year. Farmers should regularly check the soil moisture in the planting holes, and we recommend watering once every 2 weeks during the first two months of dry season (usually June-July), and then once every week until the rain resumes

(usually November-December).

Aside from Khaya, if the seedlings are planted early enough in the rainy season, they should generally survive through the dry season without additional watering. However, for all species, farmers should adapt their watering regimes according to the health of the tree. The basins should also be mulched to promote the retention of moisture.

Additionally, farmers must keep the woodlot free of weeds, pests, and livestock, which can negatively impact the growth of the trees in early establishment. The recommended method to prevent weeds and pests is to plant cover crops in between the trees, which keeps the plot productive even before the trees themselves are ready for production.

Poor Practice: Moringa that has been coppiced too low to the ground.

We recommend pruning at waist height, like Gliricidia, to promote more shoots and protect the tree's health.

Poor Practice: Protecting each tree individually from livestock.

We recommend fencing is a better protective measure that does not impede seedling growth (by blocking light) and remains beneficial even once the seedlings are fully grown.

To shape the growth of trees according to the desired products, farmers can also prune or pollard the trees.

- **Pruning** is the removal of lower branches of a tree to produce knot-free poles or timber and promote upwards growth. Cuts for pruning should be made at an angle, to allow water to drain away from the cut surface. When pruning a tree for timber production, make the cut close to the stem.

- **Pollarding** is the cutting back of the crown at a height of 2m to promote the development of multiple stems and a thicker crown. The entire crown should be cut, and branches and leaves can be harvested.
- **Coppicing:** Coppicing involves cutting trees or shrubs back to the ground to encourage new growth from the remaining stumps or roots. For species that can regrow after severe pruning (such as Gliricidia, Leucaena, or Moringa), this, enables repeated harvesting of wood without killing the tree. We recommend that farmers **do not** cut too close to the ground, and instead coppice at around waist height.

Table 14: Management practices for woodlot species

Tree species	Management practices
Khaya	• Watering in the first dry season • Pruning to ensure straight growth • Mulching the basin. • Thinning after 4-5 years by selectively cutting badly shaped trees or less healthy trees to support the growth of vital and straight individuals.
Moringa	• Pollarding or coppicing to promote multiple branches to grow • Mulching the basin.
Gliricidia	• Pruning to ensure straight growth • mulching the basin.
Leucaena (*Fodder*)	• Cutting foliage (for cut-and-carry feed) • Pollarding to promote multiple branches to grow
Leucaena (*Seed or poles*)	• Coppicing before seeds are ripe to prevent uncontrolled spread of seeds.
Senna siamea	• Pruning to ensure straight growth • Mulching the basin.
Senna spectabilis	• Pruning to ensure straight growth • Mulching the basin.
Neem	• Watering young trees during very dry periods • Mulching the basin • Pollarding to promote multiple branches to grow, increasing the seed production.

7.5.7. Intercropping

During the first years of woodlot development, before crowns form a denser shade, the plots can be used for planting crops between the trees (we recommend low height crops in the first year, such as beans or groundnuts). Farmers should take care around the basins when planting and harvesting these crops, since the main priority of the woodlot is the higher value products provided by the trees.

After the second or third year, farmers will have to cut back the canopy if they want to grow crops in the woodlot, so they may be compromising on the quality of tree growth if they intercrop light-demanding crops. We recommend that the farmers prioritize the tree quality in a woodlot, rather than crop production.

Good Practice:

✓ 18-month-old Moringa woodlot intercropped with vegetables.

Poor Practice:

- × A neglected Khaya woodlot, overgrown with weeds.
- × The trees have not been pruned or provided with Bokashi or nutrients, resulting in weak, inconsistent and unstructured growth.

Poor Practice:

- × Intercropped Khaya woodlot, where the trees have been pruned too much to allow light for crops, compromising the tree growth.

Best Practice: Intercropped Khaya woodlot where the crops have been kept in orderly lines. With these 3-year-old trees, the farmer should consider less pruning of the Khaya, prioritizing timber quality rather than crop production

7.6. Transplanting trees for agroforestry - Orchards

7.6.1. Objectives

By planting orchards farmers can diversify their income by adding high-value fruit production while also supplementing the diet of their families. However, raising productive fruit trees takes time, effort, and resources over several years before farmers see a return. Farmers must therefore be both capable and committed to managing the trees.

Besides many suitable commercial fruit trees, this document refers to the following species which have been promoted in Katete District:

- **Citrus** sinensis (lemon, orange). The *Valencia* and *Washington Navel* orange varieties are promoted for budding lemon rootstocks (see Module 6).
- Mangifera indica (**Mango**). The *Kent* and *Tommy atkins* mango varieties are promoted for grafting onto local mango rootstocks (see Module 6).
- Carica papaya (**Papaya**, Pawpaw)
- Tamarindus indica (**Tamarind**)

7.6.2. Benefits of orchards

The main benefit of orchards is fruit production, which helps farmers earn extra income. Once the trees are fully grown, they will still require proper management to produce fruit each year, in particular consistent irrigation and the control of pests and diseases. Farmers can also collect seeds to grow more trees and use the fruit trees, which generally have deep and stable root systems, as windbreaks. The timber of these fruit trees itself is also valuable, for example Tamarind in furniture making.

7.6.3. Site and seedling selection

Due to the value of the fruits produced, we recommend that farmers prepare orchards either close to the homestead or in their garden. The orchard must be fenced and have reliable access to water.

Figure 14: Requirements for an orchard site

Seedling selection

For Mangoes and Citrus, seedlings must be healthy and fully recovered from the budding or grafting process. Seedlings must be in condition to withstand hardening-off and the shock of transplanting.

The seedlings should be around 30-45cm tall (following the 2:1 shoots to roots ratio, given that fruit trees are often in larger planting bags), should have healthy roots which do not extend beyond the planting bags, and must have gone through at least 2 weeks of hardening off. Avoid using seedlings which are suffering from pests or diseases.

Best Practice:

✓ Papaya orchard protected with a fence to reduce disturbance from livestock and the risk of theft.

Alternative Practice:

A Papaya tree protected individually. We recommend fencing the whole orchard to also protect intercropped produce.

7.6.4. Planting specifications

Before planting, farmers should remove all weeds from the plot, because they can host pests and compete with the seedlings for nutrients. Farmers should follow the general guidelines for planting, according to the minimum spacing and planting hole dimensions set out in the table below.

Best Practice:

- ✓ Mango trees with water bottles for drip irrigation to improve the water supply.
- ✓ Extensive mulching with dried grass. By the end of the rainy season, farmers must make sure that this does not cause a fire risk.

Best Practice:

- ✓ Orange trees planted with a water source nearby (and a hose pipe for watering).
- ✓ Basins have been mulched.

Fruit trees generally have wider and deeper planting holes, and given the higher value of their products, we recommend that farmers add at least 1 or 2 handfuls of Bokashi or manure to the planting holes to boost early growth (for further details, see Module 4). Farmers should also maximize the water harvesting potential of the planting hole, by making sure that the soil is compacted around the seedling to form a shallow basin to retain water. Ideally, cover the basin with dried grass or leaves as mulch.

Table 15: Planting specifications for orchards

Tree species	Minimum spacing (m)	Planting hole *length x width x depth* (cm)	Ideal soil conditions
Citrus	5 x 5	60 x 60 x 60	Well-drained, fertile and sandy soils.
Mango	7 x 7	60 x 60 x 60	Tolerates a variety of soils. Avoid waterlogged areas.
Papaya	5 x 5	60 x 60 x 60	Neutral, sandy loam soils. Avoid waterlogged areas, as roots are sensitive to excessive moisture.
Tamarind	10 x 10	50 x 50 x 40	Tolerates a variety of soils. Avoid waterlogged areas.

7.6.5. Orchard Management

To promote growth and protect the young trees in their first year, the fruit trees should be watered every 1-3 days throughout the dry season (usually June to November) and until the beginning of the rainy season. Farmers should monitor the health of the trees to decide when they need more moisture. The retention of water can also be improved by widening the basin after a year (by digging a small trench to expand the basin area) and mulching the basins. Farmers should take care to avoid damaging roots when widening the basins and then add a 5-10cm layer of dried grass or leaves as mulch which helps suppressing weeds.

For lemons and oranges, to have year-round fruit production, farmers should water the trees year-round even after the first year of establishment.

Farmers should monitor the orchards, removing weeds whenever they appear. Additionally, trees and fruits should be regularly inspected for signs of pests, such as aphids and fruit flies, or fungal infections. If pests are identified, farmers should consider using organic pesticides as a remedy, for example those derived from Tephrosia or Neem. Farmers should contact their camp officer if they need help with pests or diseases.

To boost the growth of the trees, farmers can apply Bokashi, organic manure, or compost, when widening the basin, which also helps increase moisture retention. We recommend that farmers aim to do this once or twice per year. Ideally, this is done at the beginning of the flowering stage.

Farmers can prune their fruit trees to encourage branching and keep the fruit at a lower height for easier harvesting.

Table 16: Key management practices for orchards

Tree species	Management practices
Citrus	‣ Water management (basin widening, year-round watering, mulching), ‣ Fertilizer application (Bokashi). ‣ Pest monitoring and management
Mango	‣ Water management (basin widening, year-round watering, mulching), ‣ Fertilizer application (Bokashi). ‣ Pest monitoring and management
Papaya	‣ Water management (basin widening, year-round watering, mulching), ‣ Fertilizer application (Bokashi). ‣ Pest monitoring and management
Tamarind	‣ Pollarding and coppicing, ‣ Water management (basin widening, watering during dry periods, mulching), ‣ Fertilizer application (Bokashi)

Good Practice:

- ✓ A mixed Papaya and Citrus orchard where the area has been slashed to clear weeds and reduce the risks of pests.

Good Practice:

- ✓ Papaya orchard in a fenced garden.
- ✓ The planting holes are mulched to improve water retention.

Good Practice: *An agroforestry plot combining:*

- ✓ A Gliricidia and Tephrosia live fence surrounding the plot,
- ✓ Citrus trees budded to produce oranges,
- ✓ Leucaena lines to improve soil fertility and provide green manure from pruned leaves.

Mixed Practice:

- × Orange tree was not effectively pruned, so fruit is being produced out of reach from the ground.
- × The trees are well-spaced and have access to the water in the garden.

7.6.6. Harvesting fruit

Farmers can expect to start harvesting fruit from:

- **Citrus** that have been budded (to produce oranges) after 3 years. Without budding, fruiting begins after 4-5 years. The productive life span is usually 35-40 years with good management.
- **Mango** that have been grafted after 3-5 years. Without grafting, fruiting begins after 5-8 years. Mango yields will increase for the first 20 years and decline after around 40 years. It is

Best Practice:

- ✓ A farmer has planted a succession of Papaya to ensure continuous production even after the first trees stop producing fruit after 4 years.

common to have a better fruit harvest every other year.

- **Papaya** after 6-12 months. The trees can produce fruit all year round and have a productive life span of 4 years.
- **Tamarind** after 6-10 years. Maximum yields occur around 15 years after planting, and the trees can live and produce for around 200 years.

Best Practice:

- ✓ 3-year old budded Citrus trees that are beginning to produce oranges.
- ✓ The orchard is irrigated and lines have been made for intercropping.

Best Practice:

- ✓ 6-month old Papaya for fruit production and Gliricidia for soil improvement.
- ✓ Weeds have been cleared.

Note: We would recommend thinning out the Papaya lines after observing which grow best.

7.6.7. Intercropping

Similar to intercropping in woodlots, the space in between fruit trees can be efficiently used for crops. Intercropping can be done in an orchard even after the first years of establishment, since pruning orchard trees should promote growth closer to the ground rather than promoting a dense overhead crown which is not suitable for fruit picking.

We recommend planting low height crops (such as beans or groundnuts), especially in the early years of orchard development. Additionally, since orchards must be fenced, the space in between fruit trees is suitable for horticultural production, with tomato vines a popular choice amongst farmers. Farmers should take care around the fruit tree basins when planting and harvesting their crops, since the main priority of the orchard is the higher value products provided by the trees.

Best Practice:

- ✓ Adding tomato vines in between orange trees.
- ✓ Both the oranges and tomatoes benefit from the availability of water, and the space between trees is used efficiently.

Good Practice:

- × Orange trees amongst tomato vines in a garden.

During the first years before the oranges are producing fruit, such a tight spacing is feasible. Once fruit production begins, the oranges should be given more space.

Best Practice:

- ✓ Mango trees intercropped with Maize. This helps to make an investment in irrigation more cost-effective, since it contributes to more production.

8. Livestock-agroforestry integration through pasture production

8.1. Objectives

Planting productive pastures introduces livestock farmers to sustainable land use and connects them to agroforestry activities.

The main objective of developing pastureland is to improve the quality and quantity of livestock feed throughout the year by growing highly nutritious forage crops (grasses and legumes). The pastures can be directly grazed or used to produce feed for the dry season through hay baling.

Left: Velvet beans. *Right: Rhodes grass*

Objective: A well-planted pasture plot that can produce multiple forage species to mix into hay bales for supplementary feeding of livestock.

Maintaining or expanding pasture production can become self-sustaining through good planning and management to ensure an annual supply of seed is spared each year

8.2. Benefits

Engaging farmers in pasture production brings several benefits, including:

- **Fodder production:** The forage harvested from pasture plots can be made into hay bales to supplement livestock diets throughout the year, particularly during the dry season.
- **Improving fodder quality**: The forage crops represent more nutritious material with high energy (grasses) or protein content (legumes) which can increase livestock health and productivity. Fodder is highly palatable and highly digestible for the livestock, and in some cases (such as velvet beans) is known to improve meat taste and quality too.
- **Reduced free-roam grazing**: The provision of an alternative or supplement to roaming livestock grazing during the dry season reduces pressure on other grazing areas and encroachment on farmland and agroforestry plots. This benefits livestock farmers and the wider community.
- **New income opportunities**: As farmers become more familiar with the benefits of pasture, farmers can sell hay bales or raw forage. Additionally, farmers can sell seeds to enable other farmers to grow pastures.
- **Raising awareness among livestock farmers regarding agroforestry:** Pasture production and hay baling is the entry door for promoting additional agroforestry practices such

as living fences, living kraals, Bokashi making and generally the use of trees to increase agricultural and livestock production.

8.3. Organizing individual and communal pasture production

8.3.1. Organizing individual pasture production

Selection of livestock farmers for individual pasture production

When starting individual pasture activities in new camps, it is important for livestock farmers to be sensitized to the benefits of planting pastures. The simplest way of doing this is for the veterinary assistants (VAs) to convene meetings with the crushpen committees under their supervision. Each crushpen committee consists of around 10 livestock farmers who are influential in their communities. The selection of farmers should take place during the dry season, from July-August.

In the first year of establishing pasture activities, each VA should work with the crushpen committee to identify 20 farmers that have the capacity to grow pasture and are interested in the benefits. The minimum plot size that the farmer must have available is 50m x 50m (a quarter hectare). VAs should also discuss with the MOA-camp extension officer to link these farmers with the existing agroforestry groups in the zone.

Over time, livestock farmers must be connected to agroforestry groups so that pastures can be combined with agroforestry trees, for example intercropping pasture with fruit trees, fertilizer trees, planting live fences or using tree fodder banks (such as Leucaena).

Seed allocation and distribution

Once each VA has confirmed the number of farmers that they have engaged, they must communicate this number with the Extension Service Provider by the end of August to organize the allocation and distribution of seeds. This follows the same process as seed allocation and distribution for agroforestry trees.

Ideally, seeds are procured locally where farmers have already been growing the forage crops, or, if not locally available, from institutions such as GART. The prices given in Table 17 reflect the prices from GART in 2023 and 2024.

Good Practice: Velvet beans purchased from a local farmer

Table 17: Seed procurement and distribution considerations for forage species

Forage species	Harvesting period	Procurement period	Seed price per kg (ZMW)	Number of seeds per kg	Seed quantity
Rhodes Grass (*Chloris gayana)*	June – August	August – September	300.00	4,000,000	5-7 kg/ha = *1.5kg per plot**
Guinea Grass (*Panicum Maximum)*			300.00	1,500,000	3-5 kg/ha = *1kg per plot**
Sunn hemp (*Crotalaria juncea)*			25.00-30.00	25,000	25-50 kg/ha (drilled) = *9kg per plot** 35-60 kg/ha (broadcast) = *12kg per plot**
Velvet Beans (*Mucuna pruriens*)			35.00	1,500	20-30 kg/ha = *6kg per plot**

***Standard overall pasture plot size is 50m x 50m.**

Once seeds have been procured, the Extension Service Provider must pack them into small packages to distribute to each farmer, keeping each species separate. Seeds will be distributed to VAs after a TOT in **October**. VAs must then deliver the seeds to the farmers immediately.

Depending on seed availability, not all farmers will receive every species. Where possible, each farmer should receive a mixture of both grasses and legumes to balance the nutritional benefits of each for the livestock. The benefits of each species are summarized in Table 18, although in general grasses are valued as an energy source and legumes as a source of protein.

Left: Velvet beans. *Right: Sunn hemp*

Best Practice: The farmer has divided their pasture into strips of different forage species for easy harvesting.

Table 18: Key benefits of forage species

Forage species	Key Benefits	Key nutritional qualities	Issues
Rhodes Grass (*Chloris gayana)*	Highly palatable, adaptable to different conditions, and drought resistant.	CP: 8-13% (*young material has higher CP)* Digestibility: 80% *(early cut)*	CP% and digestibility declines after flowering.
Guinea Grass (*Panicum Maximum)*	High biomass, rich in minerals, adaptable to different conditions	CP: 8-14% Digestibility: 50-80%	Becomes very stemmy if not frequently cut or grazed.
Sunn hemp (*Crotalaria juncea)*	High protein, N-fixing, and can suppress weeds	CP: 8-10% (*stems*) and 25-30% *(leaves)* Digestibility: 60%	Seeds are **highly toxic** to livestock.
Velvet Beans (*Mucuna pruriens*)	High protein, N-fixing, improves soil structure, can suppress weeds	CP: 20-30% Digestibility: 60%	Grains are **toxic to livestock** unless they are heated.

CP: Crude Protein

8.3.2. Organizing pasture production on communal rangelands

Benefits of communal rangelands

A communal rangeland is a designated area for pasture production managed by a community for a shared benefit. This brings the benefits of pasture production to a larger number of livestock farmers and acts as a demonstration site to sensitize communities to the benefits. The rangeland is managed by a local committee who represent the villages involved, in cooperation with the VA. The forage and seeds from the pasture should be shared with the farmers involved or used to expand the pasture area for the following season.

Rangeland committee establishment

Due to the broader involvement of the community and use of communal land, establishing a communal rangeland requires the DVO (District Veterinary Officer), VA and Extension Service Provider to formally engage with the traditional chief, as well as village headmen and other local stakeholders around the proposed rangeland site. The Extension service Provider should support the DVO and VA to organize a stakeholder meeting to:

1. Present and discuss the communal rangeland approach and benefits,
2. Get feedback about the specific local demand and expectations for pasture production,
3. Explain the organizational structure, including the formation of a rangeland committee,
4. Agree on the next steps to come,

5. End the meeting with a locally produced and prepared lunch.

The rangeland committee should have representatives from each village that will be using the rangeland. It should be chaired by a representative of the traditional chief. The committee should have 7-10 members. The community, not the VA or district officials, should select committee members. A mix of men, women, younger, and older farmers is recommended.

Best Practice: Rangeland Committee members attend a demonstration of live fence preparation and planting from the Extension staff.

Seed allocation and distribution

Once the committee has been formed, the VA must meet with them to agree on the size of the pasture plot to be planted, and on the species to use. We advise that the committee does not over-commit to too large an area (we recommend a maximum of 1ha) in the first year and instead sets a plan for annual development of the communal rangeland space. Once this is communicated to the Extension Service Provider, procurement and distribution occurs in the same way it does for individual farmers.

8.4. Pasture preparation and planting

8.4.1. Field demonstration and training for individual farmers

In October the VA should run a field demonstration and training for the 20 farmers in each crushpen area. The training should cover field planning and marking, field preparation, sowing and management. The training is also an opportunity for VAs to highlight the benefits of growing pasture, and answer questions from the farmers.

Field planning and marking

We recommend working with farmers which have a plot of at least 50m x 50m that is protected from livestock and available for pasture planting. Farmers can use small wooden posts to mark the field. Table 19 shows the conditions that are optimal for each species to grow. In most cases, the farmer will plant all species at the same site, so a well-drained light soil with neutral pH and a reasonable amount of rainfall will suit all species. A rule of thumb is that seed size is a good indicator of what soil type is best – smaller seeds need lighter and better prepared soils.

Table 19: Growth conditions for forage species to consider during field planning

Forage Species	Soil type	Optimal pH range	Annual rainfall needs	Light and moisture conditions
Rhodes Grass (*Chloris gayana)*	Well-drained soils, especially loamy or sandy.	pH 5-8: slightly acidic to slightly alkaline	500mm-1200mm	Grows well in moist soils, and poorly in shade
Guinea Grass (*Panicum Maximum)*		pH 5-7: slightly acidic to neutral	550mm-1200mm	Grows well in moist, well-drained and fertile soils. Avoid waterlogging. Can grow in shaded and unshaded areas
Sunn hemp (*Crotalaria juncea)*	Well-drained soils, especially light soils	pH 5-8.5: slightly acidic to slightly alkaline	200mm-1200mm	Tolerates dry spells and a variety of soils. Plant early for best N fixation. Grows best with consistent direct sunlight.
Velvet Beans (*Mucuna pruriens*)	Well-drained and light soils, especially sandy soils	pH 5-8: slightly acidic to slightly alkaline	400mm-2500mm	Needs high light intensity and grows best in humid or high rainfall areas.

Good Practice: *Rhodes grass*

- ✓ Plot kept clear of weeds, sown in orderly lines.
- ✓ Well-timed planting so no bare patches
- ✓ Planted in between Gliricidia rows that improve soil fertility.

Poor Practice: *Rhodes grass*

- × Seeds were sown before a heavy downpour that washed seeds out and left bare patches.
- × Low germination in sandy, dry soil.
- × Weeds not effectively cleared

We recommend that farmers rotate where they plant the legume species, since they are nitrogen-fixing and are therefore useful for soil improvement. For example, where a farmer

planted velvet beans in year 1, they can plant a grass or another crop, such as maize, on that plot in year 2.

8.4.2. Seed distribution:

At the October training, VAs should hand out the prepared seed packages to all farmers. This means that each farmer will be able to prepare and plant without delay once the rain arrives. The VAs should also explain the specific benefits of the grasses and legumes (see section 8.1). Farmers should keep the seeds in sealed plastic bags, and store them in a cool, dry place until they sow.

After the first year, by sparing between a quarter and a third of their pasture from cutting (harvesting), farmers will have their own source of seeds for following years, to either keep, sell or share with other farmers.

8.4.3. Field preparation:

Ideally, fields should be prepared **before the onset of consistent rain**. This allows moisture to build up during the first spells of rain and enables farmers to sow immediately after rain is consistently established. Once the rain has begun and the soil is moist, farmers can also prepare the field directly before sowing.

Table 20 summarizes our recommendations for preparing the different pasture plots.

Good Practice: Breaking clods to prepare pasture field for sowing

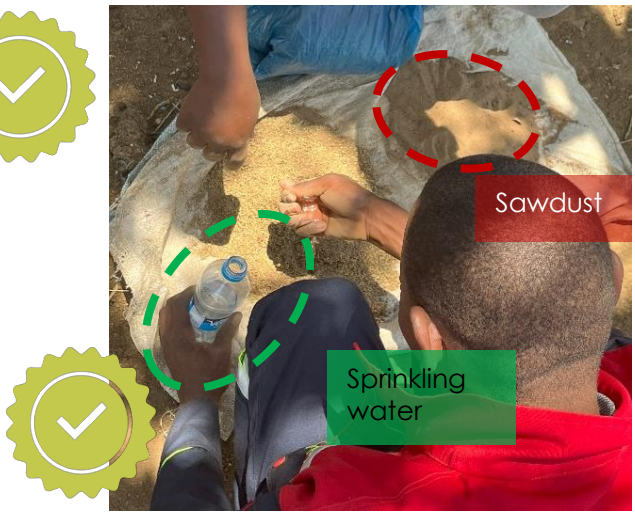
Table 20: Field preparation for forage species

Species	Field preparation	Spacing recommendation
Rhodes Grass (*Chloris gayana)*	Break clods and remove weeds. Plough soil 20-25cm deep. Seedbed should be fine but firm tilth	30cm between rows 3-5cm within the row
Guinea Grass (*Panicum Maximum)*		
Sunn hemp (*Crotalaria juncea)*	Break clods and remove weeds. Seedbed should be fine tilth	30cm between rows 5cm within the row
Velvet Beans (*Mucuna pruriens*)	Break clods and remove weeds. Dig shallow basins 3-7cm deep. Can tolerate rougher tilth.	1m between rows, 40-50cm between basins

8.4.4. Sowing

Forage crops should be planted at the onset of consistent rain once the soil is moist. This maximizes the number of harvesting cuts that can be made during one rainy season. Especially for the grasses, it is of upmost importance that farmers sow only **after** intense rainfalls, since the small seeds can be easily washed out. Table 21 details the sowing specifications for each species.

Good Practice: Soil is loosened directly before Sunn hemp is sown. This is good practice when the soil has already built up some moisture.



Good Practice: Small seeds (Rhodes grass and Panicum maximum) are mixed with sawdust and sprinkled with water before sowing.

Best practice: *preparing and sowing Velvet beans*

- ✓ **1**. Shallow basin dug with a hoe. We recommend basins are dug 40-50cm apart.
- ✓ **2.** 2-3 seeds sown in the middle of the basin.
- ✓ **3.** Thin layer of soil is carefully pushed back on top of the basin to cover the seeds.

We recommend that farmers **spare a small portion (10%) of seeds** for replacement sowing in cases of poor germination.

Table 21: Sowing specifications for forage species

Species	Seed quantity required	Spacing recommendation	Planting technique	Germination time
Rhodes Grass (*Chloris gayana)*	5-7 kg/ha *= 1.5kg per plot**	30cm between rows Approx. 3-5cm within the row	Mix seed with sand or sawdust as a spreader (ratio 1:2) and then moisten this mix. Broadcast or drill, no deeper than 1cm. **Best practice**: Roll or compact soil to increase seed-soil contact and germination.	3 - 7 days
Guinea Grass (*Panicum Maximum)*	3-5 kg/ha *= 1kg per plot**			7 - 28 days
Sunn hemp (*Crotalaria juncea)*	25-50 kg/ha (drilled) *= 9kg per plot** 35-60 kg/ha (broadcast) *= 12kg per plot**	30cm between rows 5cm within the row	Drill seeds at 1-2 cm depth or broadcast and cover with soil.	3 - 7 days
Velvet Beans (*Mucuna pruriens*)	20-30 kg/ha *= 6kg per plot**	1m between rows, 40-50cm between basins	Drill seeds at 3-5 cm depth and cover with soil. For intercropping, plant 3-4 weeks after other crops emerge.	3 - 14 days

***Standard plot size is 50m x 50m.**

Fertilizer can be applied to hasten germination, although these species, particularly the legumes, generally have very strong germination rates without expensive fertilizer use, and fertilizer is usually not cost-efficient for smallholder farmers.

Good Practice: Velvet beans spaced in weed-free field.

8.4.5. Preparation of communal rangelands

Preparation for planting a communal rangeland is similar to preparing individual plots. The key difference is that the communal land may not already be fenced, and so the committee, VA and Extension Service Provider must work together to find a solution. We recommend establishing a live fence using seedlings, direct seeding or using cuttings (see **Module 7.2 on Live Fences**). The fence is vital to ensure that there is not uncontrolled grazing of the pastures.

8.4.6. Practical examples of pasture plots

Good Practice: *Sunn hemp*
- ✓ Sunn hemp has been sown in clear lines, in two batches.
- ✓ Weeds removed from plot.

Poor Practice: *Sunn hemp*
- × Weeds competing with the Sunn hemp during establishment.

Good Practice: *Velvet beans*
- ✓ Velvet beans sown between lines of Gliricidia. The farmer should plant another crop (e.g., Maize) here next year.
- × Weeds not fully suppressed.

Poor Practice: *Velvet beans*
- × Weeds competing with the Velvet beans during establishment.
- × Planted in very dry soil.

8.5. Pasture management, forage harvesting and hay baling

8.5.1. Pasture management practices

Pastures do not need much management if farmers plant them at the right time and in suitable areas. During the first weeks of establishment, we recommend that farmers weed

the pasture field. Once established, the four forage species promoted work well as cover crops that suppress weeds, prevent soil erosion, and can improve soil health. These species are also resistant to most pests. If aphids appear, we recommend the use of organic pesticides. If germination is poor, farmers can oversow with extra seeds to improve pasture growth (they should have saved 10% of their seeds for this purpose). The cutting involved in "cut-and-carry pasture utilization" is also a management practice which enables repeated re-growth and reduces the risks of bush fires or overgrazing of the pasture.

8.5.2. Types of pasture utilization:

Farmers can use pasture in two main ways for feeding their livestock:

1. through allowing animals to directly graze the pasture, or
2. to harvest the forage as cut-and-carry fodder.

We recommend cut-and-carry as the preferred option, since it can provide supplementary nutrition for the livestock over the course of the year and gives farmers more control of the livestock diet.

Best Practice: Producing hay bales enables farmers to improve the quality, quantity and control of feed that their livestock can access during the dry season.

Grazing

Farmers who choose grazing should monitor their animals to prevent overgrazing. They should also ensure livestock eat a mix of legumes and grasses. We recommend rotational grazing, whereby animals graze only small portions of the pasture area at a time, which allows pasture regrowth. However, this kind of well-managed grazing requires farmers to watch and herd their animals closely. This can reduce the labor advantage of grazing compared to the cut-and-carry method.

Cut-and-carry

Cut-and-carry harvesting is the preferred method for utilizing pastures to feed livestock immediately or at a later stage. Although it is labor-intensive, it allows farmers to conserve the forage through hay bales and directly control the diet of their livestock. This brings multiple benefits, including preserving nutrients to feed animals during dry season, to generate income through selling the fodder, and to protect the pastures from bush fires or over-grazing.

Table 22: Key recommendations for pasture utilization

Key recommendations for pasture management, harvesting and use	
✓ **Cut forage to promote re-growth** by cutting at least 20cm above the ground and allowing at least 4 weeks of re-growth between cuts. ✓ **Leave 30% of the forage to mature and flower** to establish a seedbank that will provide seeds for the following year. ✓ **Feed the first cut as fresh forage to the livestock** rather than trying to dry while the rainy season is ongoing.	✗ **Do not allow weeds to establish in the field** because they compete with the forage and will reduce the quality of hay. ✗ **Do not allow grazing of the pasture during the rainy season**, as this will reduce the amount of feed that can be grown and conserved for the dry season. ✗ **Do not make hay bales when the forage is still moist.** Check the moisture using the **snap test** or the **salt test** (see below).

8.5.3. Forage harvesting and hay baling

Hay is a stable, high-quality animal feed which farmers produce at peak growing times and then use as fodder later in the year during the dry season. Making hay bales is labor intensive and for the hay to be useful, farmers must also have a secure and dry storage space for the bales. The key stages are the cutting (which may be repeated several times), the drying, the baling and the storage.

Harvesting

It is important to time the harvesting at the correct stage of plant growth.

As a rule of thumb, grasses will be most nutritious when harvested at or before flowering. Legumes should be harvested at the early bloom (see

for species-specific timing). After these points in time, the nutritional value will decline.

To promote re-growth and increased forage production, farmers must:

- Cut at least 20cm above the ground to promote regrowth.
- Cut after a sufficient interval, usually at least 4 weeks. Too frequent cutting will reduce re-growth and nutritional value.
- Leave around 30% of each species alone, to allow these sections to mature fully and produce seeds (seedbank).

Good Practice: *Sunn hemp*
- ✓ *Left*: Sunn hemp at early flowering stage was cut.
- ✓ *Right*: A portion of the pasture is left to fully mature as a seed source.

Good Practice: *Sunn hemp*
- ✓ The Sunn hemp has been cleanly cut to a 20cm height.

Table 23: Harvest intervals and cutting details for forage species

Species	First harvest	Repeat harvest interval (after first cut)	Cutting detail
Rhodes Grass (*Chloris gayana)*	At early (0-25%) flowering.	25-50 days*	*Normally only 1 good cut is possible due to the time taken to begin flowering.
Guinea Grass (*Panicum Maximum)*	At flowering - grass will be approx. 60-90cm	25-30 days*	
Sunn hemp (*Crotalaria juncea)*	At early flowering – when 45-90cm tall with good leaf material.	4 weeks	3 or 4 cuts can be made if planted on time.
Velvet Beans (*Mucuna pruriens*)	At early (0-30%) flowering, before pods develop	6-8 weeks	1 or 2 cuts can be made, although the second cut is often poor.

Once the cut has been made, the forage can be fed as fresh forage or dried for hay. When feeding fresh, farmers must make sure animals get a mixture of grass and legumes. We recommend **feeding the first cut as fresh forage**, since weather conditions are unlikely to be suited to drying by this time.

Drying

Drying is vital to prepare the forage for hay baling. Drying is easiest when the weather is sunny and dry, and is more logistically challenging, slower and labor intensive when it is done before the end of the rains. Dampness will cause mold or spoilage and presents a

major fire risk if moisture remains in hay bales. Therefore, we recommend that forage which is cut before the end of the rains is fed fresh to livestock.

Warning: Never underestimate the fire risk of hay bales containing traces of moisture!

To dry the cut forage in the sun, it should be spread out in the field to maximize exposure to sun and air for drying. Farmers must turn the forage every day over the following to improve the speed and consistency of drying. Farmers should take care to avoid damaging leaves with legumes. Forage must be dried for at least 4-5 days of good sunny and dry conditions.

Good Practice: *Velvet beans*
- ✓ *Left*: Portion of the Velvet bean plot that was cut at early flowering before pods develop. The harvested material has been removed to allow re-growth.
- ✓ *Right*: The harvested forage being dried in an area without other crops growing.

To check that the hay is ready for baling, there are 2 tests farmers can easily conduct. They should do each test with several different handfuls of hay, and from different places.

- **Snap test**: Take a handful of stems and for each one, bend it by hand. If it is dry enough, it will clearly snap, rather than flex.
- **Salt test**: Add a handful of salt and some of the hay to a small plastic bottle (e.g., a 500ml soft drink bottle). Close the lid and then shake well and leave for 5 minutes. If the salt grains are still dry and loose, the hay is ready. If the salt sticks to the hay or bottle, then it is too moist.

Baling

The hay must be fully dry to be baled. To make the bales, place the hay into a wooden mold on dry ground, alternating layers of legumes and grasses, and then compact it. We recommend a ratio of 1 part legume to 3 parts grass when making mixed bales. The bales should be 80cm long, 60cm wide and 60cm tall. Once compressed, the bales should be tied with string to hold their shape. The average weight of an 80 x 60 x 60 cm hay bale in the Katete agroforestry project was 32 kg.

Good Practice: *Hay baling*

- ✓ **1**: The baling mold consists of firmly grounded wooden stakes, removable flat wooden endpieces, and twine securing the structure during baling.
  - We recommend that the internal dimensions of the mold are: **80cm length, 60cm width and 60cm height**.
- ✓ **2**: The farmer prepares the mold by laying twine on the ground and temporarily fastening it to the stakes.
  - After filling the mold with the dried forage, the twine is unfastened from the stakes and the farmer can easily tie the ends together to secure the bale.

Good Practice: *Hay baling*

- ✓ **3**: The farmer begins adding layers of dried forage to the mold.
- ✓ **4:** The farmer stands on the bale to compress the layers and ensure that all the stems fit into the box.
- ✓ **5**: It is important to add a mixture of grasses. After the final layers are added, the bale can easily be tied with twine and lifted out of the mold.

Bales must then be stored in a dry, well-ventilated storage area to protect them from moisture and pests which could cause spoilage. Good hay is green, tender and full of nutrients, with a nice smell. Poor hay can be identified by the brown or black coloring, hardness and poor odor.

Good Practice:

✓ The bales are green, tender and dry, having been stored in a well-ventilated shed, and on a platform that allows air to circulate underneath the bales.

Poor Practice:

× The bales are dry but too brown and too hard, due to being stored with too much exposure to sunlight.

8.5.4. Seed harvesting

We recommend that farmers spare 30% of their pasture area from the cuts, in order to harvest the seed for the following year. Timing is important when harvesting seeds, since the plants must have reached the correct maturity and the weather should be dry to prevent rotting or mold. Seed harvesting is usually in June or July. A rule of thumb is that grass seeds will be ready to harvest when they are golden brown, and the seeds have hard coats. Seed should be harvested once at least 60% of the grass saved for seed production has reached this stage of maturity. For the legume seeds, it is important that the beans or pods which contain the seeds are carefully pressed to open them and get the seeds out.

Once harvested, the seeds should be kept in a cool, dry and airtight storage, for example a plastic bottle or sealed bag.

8.5.5. Feeding and monitoring livestock

The hay bales can be used to supplement livestock feeding during the dry season when other grazing is less available. In general, there is enough forage freely available for grazing and feeding during the rainy season and up to June and July. Therefore, the bales are used to supplement the diets of livestock from August to November, before rains re-start and other food sources re-grow. Farmers must remove the twine from the bale and can spread out the hay to make feeding easier for the animals.

Best Practice: A livestock farmer has spread out a hay bale to feed his cattle in November.

We recommend that farmers base their supplementary feeding on the following calculations:

- For cattle, the supplementary feed should be around 1.5% of body weight. Therefore, a cow with a 200kg body weight will need around 3kg hay per day, or 366kg in total from August to November.
- 10 cattle of this size would need 3660kg of hay over a 4-month period. This equates to 115 hay bales with an average weight of 32kg.
- For goats, between 500g and 1kg of supplementary feed per day is sufficient.

With all supplementary feeding, farmers must regularly monitor the health and productivity of their livestock. We also recommend VAs assist farmers in experimenting with different feeding regimes to improve how they utilize the hay bales. For example, splitting the livestock into groups with different levels of hay in their diets to determine which group remains healthier and more productive.

A 1. Annex: Species description (Katete Agroforestry Promotion Project)

A 1.1. LIVESTOCK FODDER TREES



Name	**English**	**Nyanja**
	Lead Tree, Reuse Wattel, White Popinac, Horse Tamarind, Wild Tamarind	Lukina, Lusina
Botanical Name	*Leucaena leucocephala*	
Ecology	An attractive fruit tree which has been distributed all over the tropics and subtropics.	Mtengo wowoneka bwino womwe wopezeka ponseponse pa malo otentha ndi malo otentha pang'ono.
Site conditions	Originated from Central America. Grows best in sandy loam with good drainage; 0 - 2,200 m altitude; a mean annual temperature of 25 - 30°c and a mean annual rainfall of 650 - 3,000mm. Plants are drought tolerant and fire hardy.	Udachokera ku Central America. umakula bwino kudothi ya lomu losakanizidwa ndi mumchenga wotaya madzi bwino; 0 mpaka 2,200 mmwamba; Kutentha kwa pachaka kwa 25 mpaka 30 ° C ndi mvula pachaka ya 650 mpaka 3,000mm. Mtengoyu ndiwolimba ku chilala ndi moto.
Agro-Forestry Technology	Nitrogen fixing, used for soil improvement and in reforestation (as a pioneer species for woodland cover, watersheds and grasslands restoration); used in soil stabilization projects and as a shade plant for coffee. Its deep roots bring up nutrients; one of the first species to be used for the production of green manure in alley-cropping systems with maize; is also a good species for slash-and-burn cultivation.	Umapanga nayitrogeni, ithandizila kokonza nthaka ndi ntchito zobzalanso nkhalango (monga mtundu woyamba wa nkhalango, mathithi ndi kubwezeretsanso nkhalango); Umagwiritsidwa ntchito polimbikitsa nthaka komanso ngati mthunzi wa khofi. Mizu yake yozama imatulutsa zakudya; imodzi mwa mitundu yoyambirira yogwiritsidwa ntchito popanga manyowa obiriwira m'njira zolimapo chimanga; ndi mtundu wabwinonso pa ulimi wokwapa-kulima-ndikutentha.

Uses	**Fodder**	Fodder (leaves, shoots). Young leaves, pods and flower buds are eaten raw by humans, steamed, in soups, or cooked with rice. When used as fodder, Leucaena leaves should not exceed 20% of the feed intake because they contain a toxin (called mimosine) which may cause hair loss and stomach problems if fed in excess to animals.	Zakudya (masamba, mphukira). Masamba achichepere, nyemba ndi maluwa zimadyedwa ndi anthu, ngati zosaphika, kapena zophika ndi mpunga. Mukamagwiritsa ntchito ngati chakudya chaziweto, masamba a Leucaena sayenera kupitirira 20% ya chakudya chifukwa ali ndi poizoni (wotchedwa Mimosine) omwe angayambitse kuchepa tsitsi komanso mavuto a m'mimba ngati atadyetsedwa mopitilira ku nyama.
	Nitrogen fixing	Able to fix atmospheric nitrogen in the soil.	Imatha kukonza nayitrogeni m'nthaka.
	Firewood	For domestic energy supply	Nkhuni za panyumba
	Seed / Seedpods	When dried, the seed can be roasted and used as a coffee substitute	Ikauma, mbewu imatha kukazingidwa ndikugwiritsidwa ntchito m'malo mwa khofi
	Ornamental	Home gardens, yards and roadsides	Minda yapanyumba, mayadi ndi misewu
	Others	Bee forage.	Chakudya chanjuchi
Description		An evergreen shrub or tree, with a leafy canopy or fairly open, rounded crown.	Chitsamba kapena mtengo wobiriwira nthawi zones wokhala ndi masamba ambiri kapena otseguka, ndi kolona yozungulira.
		Height of mature tree: 5-20 m	Kutalika kwa mtengo wokhwima 5 mpaka 20 m
		Diameter at Breast Height of mature tree: 10 – 50 cm	M'mimba mwake pa chifuwa pa mtengo wokhwima 10 - 50 cm
		Recommended spacing: 1 X 1m (Fodder)	Kubzala kovomerezeka: 1 x1m (zakudya zanyama)
		Number of years for first harvest: 1 year (Fodder)	Chiwerengero cha zaka zokolola 1 (chakudya cha ziweto)
Propagation		Seedlings, direct seeding. Soak in hot water and allow to cool for 24 - 48 hours. Storage: Seed can be stored for long periods	Mbande, kubzala njele. Viikani in madzi otentha ndi kulola kuti zizizire pa maola 24 – 48. Kasungidwe: Mbeu ingasungike pa nthawi yayitali.
Seed		High germination rate. Treatment is not needed.	Mbeu imamela bwino kwambiri. Chithandizo sichofunikira.
Management		Pollarding, lopping, coppicing.	Kudulira, kudula nthambi, kuphukira



Name		English	Nyanja
		Pigeon pea	Nyamundolo
Botanical Name		*Cajanus cajan*	
Ecology		Originated from South East Asia. Grown in the tropics and subtropics, brought to West Africa as a food crop. Found in grassy habitats in savannahs, shrub land and waste land	Anachokera ku madzulo cha kumwera kwa Asia. Amakula m'madera otentha ndi otentha pang'ono, anabweretsedwa ku madzulo kwa Africa monga mbewu ya chakudya. Amapezeka m'malo a udzu m'masavannah, malo a zitsamba ndi malo owonengeka
Site conditions		Widely grown on a variety of soils, (especially well drained); 0- 3,000 m in altitude. prefer a rainfall in the region of 500 - 1,000mm per year; temperature range of 20 - 30°c; produce deep tap roots, hence they can succeed in poor soils	Amamela kwambiri pa dothi losiyanasiyana, (makamaka lotayira bwino); 0 mpaka 3,000 m kutalika pamwamba pa nyanja. amakonda madera ya mvula ya 500 mpaka 1,000mm pachaka; kutentha kwapakati pa 20 mpaka 30 ° C; zimatulutsa mizu yozama kwambiri, motero zimatha kuchita bwino mu dothi lanthaka ing'ono.
Agro-Forestry Technology		Windbreak and nitrogen fixing. Green manure and cover crop. Hedgerow intercropping, the hedges should be cut at height of 50 - 100cm when the grain crop is fully mature. The hedges can be cut 2 - 3 times a year in areas where the dry season lasts 4 - 6 months. At pod maturity, the branches are cut at about 50cm	Kugwiritsidwa ntchito kumachepetsa liwiro la mphepo ndikupanga nayitrogeni. Manyowa obiriwira ndi mbewu zophimba. M'mizere yopingasa mizere, mipanda iyenera kudulidwa kutalika kwa 50 mpaka 100cm mbewu ikakhwima. Mipanda imatha kudulidwa kawiri kapena katatu pachaka m'madera omwe nyengo yamvula imatha miyezi inayi kapena isanu ndi umodzi. Pakukhwima, nthambi zimadulidwa pafupifupi 50cm
Uses	**Nitrogen fixing**	For soil improvement	Kuti nthaka ikhale yabwino
	Firewood	For domestic energy supply	Nkhuni za pa khomo
	Fodder	Fodder (leaves and pods)	Zakudya za ziweto (masamba ndi makoko)
	Seed / Seedpods	Food (young seeds and leaves); young seeds in rice dishes. Mature seeds are dried and added to soups and stews. Leaves and young shoots - cooked and used as a vegetable	Chakudya (mbewu ndi masamba aang'ono); mbewu zazing'ono mu mbale za mpunga. Mbewu zokhwima zimawumitsidwa ndikuwonjezeredwa ku supu ndi mphodza. Masamba ndi mphukira zazing'ono - zophikidwa ndikugwiritsidwa ntchito ngati ndiwo za masamba
	Medicine	Root extract is used for treating stomach-ache. An infusion of the leaves is used as a treatment for coughs and bronchitis. The leaf juice is taken internally in the treatment of haemorrhages, coughs and diarrhoea	Madzi a mizu amagwiritsidwa ntchito pochiza kupweteka kwa m'mimba. Kulowetsedwa kwa masamba kumagwiritsidwa ntchito ngati mankhwala a chifuwa ndi bulonkaitisi. Madzi a masamba amatengedwa mkati pochiza kukha magazi, chifuwa ndi kutsekula m'mimba
	Others:	Bee forage and shade, stems are of use in basketry and thatching or as brooms	Chakudya cha njuchi ndi mthunzi, kupangira madengu, kubvimbira nyumba komanso monga ni vipyango.

Description	Short-lived (dying after 1 - 5 years), erect, slender shrub, annual or perennial, becoming woody with age.	Zazifupi (zomwalira pambuyo pa zaka 1 - 5), zowongoka, zowonda, zapachaka kapena zosatha, zokhala zamitengo pokalamba
	Height of mature shrub: up to 4m	Kutalika kwa chitsamba chokhwima: mpaka 4m
	Recommended spacing: 30-45cm between plants and 40 – 60cm between rows	Mipata yobvomerezedwa: 30-45cm pakati pa zomera ndi 40 - 60cm pakati pa mizere.
	Number of years for first harvest: dwarf varieties can commence 5 months after sowing (8 - 12 months for taller varieties for perennials; common in Eastern Province, where the plant is often left to grow for 2 or more years).	Chiwerengero cha zaka zokolola koyamba: mitundu yaifupi imatha miyezi isanu mutabzala (miyezi 8 - 12 kwa mitundu yayitali; zofala ku dera la ku m'mawa, komwe mbewuyo imasiyidwa kuti ikule kwa zaka ziwiri kapena kuposerapo).
Propagation	Direct seeding, seedlings. Vegetative	Kubzala njele, mbande. Zamasamba
Seed	Seed highly susceptible to insect attack. Treatment: Soak old seeds in cold water for 24 hours. Fresh seeds do not require pre-treatment.	Mbewu imatha kugwidwa ndi tizilombo. Chithandizo: Viikani mbewu zakale m'madzi ozizira kwa maola 24. Mbewu zatsopano sizifuna kuviika
Storage	Storage: Seed stores well if protected from insects.	Kusunga: Mbewu zimasungidwa bwino ngati zatetezedwa ku tizilombo.
Management	The tree types require pruning if they are Species is an ideal, non-competitive crop to plant with cereals. A useful high-yielding extremely drought resistant crop once established, suitable for dry areas but susceptible to many pests and diseases. to be intercropped.	Mitundu ya mitengoyo imafunika kudulira ngati iyenera kulimidwa ndi mbewu zina. Mitundu ndi yabwino, yosapikisana ikabzalidwa ndi chimanga. Mbewu yothandiza yobereka kwambiri yosamva chilala ikangokhazikitsidwa, yoyenera kumadera owuma koma yomwe imatha kugwidwa ndi tizirombo ndi matenda ambiri
Remarks		



Name		English	Nyanja
		Prairie acacia. Timbre. Fernleaf Acacia	Acacia
Botanical Name		*Acacia angustissima (Acaciella angustissima)*	
Ecology		Originated from North America (Mexico and southern United States). Shrub that prefers hillsides, rock slopes, summits and grassland, often in deciduous or semi-deciduous forest. Mostly on rather dry, often rocky, brushy slopes or in thin forest, frequent in pine-oak forest, sometimes in hedges, up to 2,700 m altitude.	Unachokera ku mpoto kwa America (Mexico ndi kum'mwera kwa United States). Chitsamba chomwe chimakonda mapiri, malo otsetsereka a miyala, mapiri ndi nkhalango za mitengo, nthawi zambiri m'nkhalango zobiriwira kapena zobiriwira nthawi zaina. Nthawi zambiri pamapiri owuma, omwe nthawi zambiri amakhala amiyala, otsetsereka kapena m'nkhalango yopyapyala, amapezeka m'nkhalango za pine-oak, nthawi zina m'mipanda, mpaka 2,700 m kutalika.
Site conditions		Prefers areas with well-drained dry or moist sandy, loamy or clay soils; mean annual temperature of 5 to 30°c; and mean annual rainfall of 895 to 2,870mm. It cannot grow in the shade and is drought tolerant.	Imakonda malo okhala ndi mchenga wouma bwino kapena wonyowa, dothi yosakanizana kapena dongo; kutentha kwapachaka kwa 5 mpaka 30 ° c; ndi mvula yapachaka ya 895 mpaka 2,870mm. Sizingamere mumthunzi ndipo simatha kupirira chilala.
Agro-Forestry technology		Nitrogen fixing. Also as nurse crop for more valuable tree species.	Kukonzekera kwa nayitrogeni. Komanso ngati namwino mbewu zamtengo wapatali zamitundu yina
Uses	**Fodder**	Leaves are good for fodder during the rainy season.	Masamba ndi abwino kudyetsa ziweto chakudya m'nyengo yamvula.
	Nitrogen fixing	Able to fix atmospheric nitrogen in the soil. Planted in soil reclamation schemes.	Kutha kukonza nayitrogeni wa mumlengalenga m'nthaka. Zobzalidwa m'malo yofunikira kukonza nthaka.
	Seed / Seedpods	The seedpods have been used for food by people.	Makoko amagwiritsidwa nthito ngati chakudya cha anthu
	Medicine	Herbal remedy for dysentery, diarrhoea, toothache, internal bleeding. As a wash, they are used to treat wounds, perspiring feet, some eye problems and as a mouth wash.	Mankhwala azitsamba a kamwazi, kutsegula m'mimba, kupweteka kwa mano, kutuluka magazi mkati mwathupi. Monga zotsukira, amagwiritsidwa ntchito pochiza zilonda, kutuluka thukuta, mavuto a m'maso komanso ngati kutsuka pakamwa.
	Others:	Extracts from bark are used in the making of alcoholic drinks. Species is attractive to wildlife (increased biodiversity).	Zomwe zimatengedwa kuchokera ku khungwa zimagwiritsidwa ntchito popanga zakumwa zoledzeretsa. Mtundu uwu umakopa nyama zakuthengo (Zachilengende zosiyanasiyana)

Description	Very variable, relatively fast-growing, ever-green, thorn-less shrub or small tree with a rounded crown.	Zosintha kwambiri, zomwe zimakula mwa-changu, zobiriwira nthawi zonse, zopanda minga kapena mtengo wawung'ono wokhala ndi korona wozungulira.
	Height of mature tree: 2 - 5 m	Kutalika kwa mtengo wokhwima: 2 mpaka 5 m
	Recommended spacing: 2 X 2 m	Mabzalidwe yoyenera ndi 2 x2 m
	Number of years for first harvest: 5 m height and 6 cm diameter after 2 ½ years	Chiwerengero cha zaka zokolola koyamba: 5 m kutalika ndi 6 cm m'mimba mwake pam-buyo pa zaka 2 ½
Propagation	Seed - germinates best when soaked for 12 hours in cold water prior to sowing.	Mbewu - imamera bwino ikaviikidwa maola 12 m'madzi ozizira musanafese.
Seed	If it is to be directly seeded, the seeds should be sown on the surface of cultivated soil and covered with a layer of soil equal to the width of the seed.	Ngati iti ibzalidwe, njere ziyenera kubzalidwa pamwamba pa dothi lolimidwa ndi kufokela ndi dothi lolingana ndi kukula kwa mbewu.
Management	Regular cutting and coppicing.	Kudula pafupifupi ndi kudula kufuna kuti mtengo uphukire
Remarks	It is fast growing. Though the growth of the tree is retarded after attack by insects (Leu-caena psyllid), this species is not believed to be under any threat.	Umakula mofulumira. Ngakhale kuti mtengowo umachedwa kukula pambuyo podedya ndi tizilombo (Leucaena psyllid), mtundu uwu siuli pa chiyopsezo.

A 1.2. SOIL FERTILITY TREE SPECIES



Name		English	Nyanja
		Mother of cocoa, tree of iron, Mexican lilac, quick stick	Gliricidia
Botanical Name		*Gliricidia sepium*	
Ecology		Originated from Central America. Tree is often cultivated in many tropical countries including in Africa (mainly in lowlands below 500-2,000 m in altitude).	Inachokera ku Central America. Mitengo imalimidwa m'maiko ambiri otentha kuphatikiza ku Africa (makamaka m'madera otsika pansi pa 500 mpaka 2,000 m kutalika).
Site conditions		It can grow in a wide variety of soils (both alkaline and acidic), including low-fertility soils; annual daytime temperatures are within the range 15 - 30°c and mean annual rainfall in the range 600 – 3, 500mm.	Itha kukula mu dothi lamitundumitundu (lonse lamchere ndi acidic), kuphatikiza dothi lopanda chonde; Kutentha kwapachaka kwa masana kumakhala pakati pa 15 mpaka 30 ° c ndipo pafupifupi mvula imagwa pa 600 mpaka 3, 500mm.
Agro-Forestry Technology		A very valuable multipurpose tree and important component of various Agro-forestry systems. Good for mulch, green manure, nitrogen fixing, soil conservation.	Mtengo wamtengo wapatali wogwiritsidwa ntchito zosiyana siyanai komanso gawo lofunikira pamachitidwe osiyanasiyana a ulimi wa mitengo ndi mbeu nkhalango.Zabwino ku zinyalala, manyowa obiriwira, kukonza nayitrogeni, kuteteza nthaka.
Uses	**Nitrogen fixing**	Trials for use in fallows and fodder banks continue in Eastern Province at Msekera Research Station.	Kafukufuku yamagwiritsidwa a ntchito mu ulimi wogoneka malo ndi nkhokwe zodyetserako ziweto akupitilira ku dela la ku'mawa pa bungwe la kafukufuku la Msekera.
	Timber	Fence posts; live fence, live stakes.	mizati ya mpanda; mpanda wamitengo yamoyo, zikhomo zamoyo.
	Firewood	For domestic energy supply and used for manufacturing charcoal	Nkhuni za panyumba komanso zopangira makala
	Fodder	Fodder (leaves, shoots, pods). Although leaves are fodder for goats and cattle, they are toxic to non-ruminants like horses, donkeys and pigs. Livestock do not find these leaves very palatable; so they should be mixed with grass, straw or other roughage as a high-protein supplement. Allowing the leaves to wilt before feeding to livestock also improves their palatability.	Zakudya za ziweto (masamba, mphukira, makoko). Ngakhale masamba ndi chakudya cha mbuzi ndi ng'ombe, ndi poizoni ku zoweta monga akavalo, abulu ndi nkhumba. Ziweto sizipeza masambawa kukhala okoma kwambiri; choncho zifunika azisakanizidwa ndi udzu, mapesi ndi zina zotero monga chowonjezera cha ma protein. Kulola masamba kufota asanadyetse ziweto kumathandizanso kuti zikome
	Food / Fruit	Flowers are edible, eaten when cooked	Maluwa amadyedwa, amadyedwa akaphikidwa
	Ornamental	Home gardens	Minda yakunyumba
	Others:	Bee forage.	Chakudya cha njuchi

Description	A small semi-evergreen tree; the trunk very short with a spreading crown.	Mtengo wawung'ono wobiriwira nthawi zonse; thunthu lalifupi kwambiri ndi korona wofalikira.
	Height of mature tree: Up to 15m	Kutalika kwa mtengo wokhwima is 30cm
	Diameter at Breast Height of mature tree: up to 30cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: Mpaka 30cm
	Recommended spacing: 0.5 X 2.5 m	Kubzalidwe kovomerezeka: 0.5 X 2.5 m
	Number of years for first harvest: After 3 - 4 years, when grown as a fuel crop	Chiwerengero cha zaka zokolola koyamba: Pambuyo pa zaka 3 - 4, zikabzalidwa ngati mbewu ya nkhuni
Propagation	Seedlings, cuttings, direct seeding	Mbande, tumitengo todula, kubzala njele
Seed	Good germination (More than 90%). Treatment: Soak seed in hot water and cool for 24 hours. Storage: It is best to use fresh seed; but it will store up to 1 year.	Imamera bwino (Kuposa 90%). Chithandizo: Ziviike mbeu m'madzi otentha ndikuziziritsa kwa maola 24. Kusungirako: Ndi bwino kugwiritsa ntchito mbewu zatsopano; koma idzasunga mpaka chaka chimodzi.
Management	Coppicing. Pollarding at 2m or above is recommended for optimal wood biomass production	Kudulira, kudula nthambi, kudula kufuna kapena kulola kuti mtengo uphukire
Remarks	Slow growing in Eastern Province but has potential of becoming invasive since the seeds are ejected from exploding pods up to a distance of 25m. The tree is termite-resistant.	Imakula pang'onopang'ono ku dela tha kum'mawa koma kumatha kukhala kosokoneza chifukwa njere zimachotsedwa pakuphulika mpaka mtunda wa 25m. Mtengowo ndiwolimba ku chiswe.



Name		English	Nyanja
		Pigeon pea	Nyamundolo
Botanical Name		*Cajanus cajan*	
Ecology		Originated from South East Asia. Grown in the tropics and subtropics, brought to West Africa as a food crop. Found in grassy habitats in savannahs, shrub land and waste land	Anachokera ku Kumwera cha kumadzulo kwa Asia. Imamera m'malo otentha ndi madera osatentha kwambiri, idabweretsedwa ku Mazdulo kwa Africa ngati mbewu ya chakudya. Imapezeka m'malo audzu wa savana m'malo otsetsereka, m'malo a zitsamba ndi nthaka yopanda chonde
Site conditions		Widely grown on a variety of soils, (especially well drained); 0- 3,000 m in altitude. prefer a rainfall in the region of 500 - 1,000mm per year; temperature range of 20 - 30°c; produce deep tap roots, hence they can succeed in poor soils	Imalimidwa kwambiri pa dothi losiyanasiyana, (makamaka lotayira bwino); 0 mpaka 3,000 m kutalika. Imachita bwino pa mvula yoyambira pa 500 mpaka 1,000mm pachaka; kutentha kwapakati pa 20 mpaka 30 ° C; zimatulutsa mizu yakuya, motero zimatha kuchita bwino mu dothi ya nthaka yochepa
Agro-Forestry Technology		Windbreak and nitrogen fixing. Green manure and cover crop. Hedge row intercropping, the hedges should be cut at height of 50 - 100cm when the grain crop is fully mature. The hedges can be cut 2 - 3 times a year in areas where the dry season lasts 4 - 6 months. At pod maturity, the branches are cut at about 50cm	Kuteteza ku mphepo ndi kukonza nayitirogeni. Manyowa ya masamba obiriwira ndi mbewu zophimba. M'mizere yopingasa mizere, mipanda iyenera kudulidwa kutalika kwa 50 mpaka 100cm mbewu ikakhwima. Mipanda imatha kudulidwa kawiri kapena katatu pachaka m'madera omwe nyengo yamvula imatha miyezi inayi kapena isanu ndi umodzi. Pakukhwima, nthambi zimadulidwa
Uses	Nitrogen fixing	For soil improvement	Kuti nthaka ikhale yabwino
	Firewood	For domestic energy supply	Nkhuni za pa nyumba
	Fodder	Fodder (leaves and pods)	Zakudya za ziweto (masamba ndi makoko)
	Seed / Seedpods	Food (young seeds and leaves); young seeds in rice dishes. Mature seeds are dried and added to soups and stews. Leaves and young shoots - cooked and used as a vegetable	Chakudya (mbewu zing'ono ndi masamba); mbewu zazing'ono mu mbale za mpunga. Mbewu zokhwima zimawumitsidwa ndikuwonjezeredwa ku supu ndi mphodza. Masamba ndi mphukira zazing'ono - zophikidwa ndikugwiritsidwa ntchito ngati masamba
	Medicine	Root extract is used for treating stomachache. An infusion of the leaves is used as a treatment for coughs and bronchitis. The leaf juice is taken internally in the treatment of haemorrhages, coughs and diarrhoea	Madzi a mizu amagwiritsidwa ntchito pochiza kupweteka kwa m'mimba. Kulowetsedwa kwa masamba kumagwiritsidwa ntchito ngati mankhwala a chifuwa ndi bronchitis. Madzi a masamba amatengedwa mkati pochiza kukha mwazi, chifuwa ndi kutsekula m'mimba
	Others:	Bee forage and shade, stems are of use in basketry and thatching or as brooms	Zakudya za njuchi ndi mthunzi, tsinde limagwiritsidwa ntchito popanga madengu ndi udzu wophimbila kapena vipyango

Description	Short-lived (dying after 1 - 5 years), erect, slender shrub, annual or perennial, becoming woody with age.	Zamoyo waufupi (zomwalira pambuyo pa zaka 1 - 5), zowongoka, zowonda, zapachaka kapena zosatha, zokhala zamitengo ndi ukalamba.
	Height of mature shrub: up to 4m	Kutalika kwa chitsamba chokhwima: mpaka 4m
	Recommended spacing: 30-45cm between plants and 40 – 60cm between rows	Kutalikirana komwe kuli kovomerezeka: 30-45cm pakati pa mbewu ndi 40 - 60cm pakati pa mizere.
	Number of years for first harvest: dwarf varieties can commence 5 months after sowing (8 - 12 months for taller varieties for perennials; common in Eastern Province, where the plant is often left to grow for 2 or more years).	Chiwerengero cha zaka zokolola koyamba: mitundu yayifupi imatha kukololedwamera pakatha miyezi 5 mutabzala (miyezi 8 - 12 kwa mitundu yayitali kwa mbewu zosatha; zofala ku Eastern Province, komwe mbewuyo imasiyidwa kuti ikule kwa zaka ziwiri kapena kuposerapo).
Propagation	Direct seeding, seedlings. Vegetative	Kubzala njele , kubzala mbande. Zamasamba
Seed	Seed highly susceptible to insect attack. Treatment: Soak old seeds in cold water for 24 hours. Fresh seeds do not require pretreatment.	Mbewu imatha kugwidwa ndi tizilombo. Chithandizo: Ziviike mbewu zakale m'madzi ozizira kwa maola 24. Mbewu zatsopano sizifuna chithandizo kuti zimere bwino
Storage	Storage: Seed stores well if protected from insects.	Kusunga: Mbewu zimasungidwa bwino ngati ndi zotetezedwa ku tizilombo.
Management	The tree types require pruning if they are to be intercropped.	Mitundu ya mitengoyo imafunika kudulira ngati iti ikhale yolimidwa ndi mbeu zina
Remarks	Species is an ideal, non-competitive crop to plant with cereals. A useful high-yielding extremely drought resistant crop once established, suitable for dry areas but susceptible to many pests and diseases.	Mitundu ndi mbewu yabwino, yosapikisana ngati mwabzala ndi chimanga. Mbewu yothandiza yobereka kwambiri yosamva chilala ikangokhazikitsidwa, yoyenera kumadera owuma koma yomwe imatha kugwidwa ndi tizirombo ndi matenda ambiri.



Name		English	Nyanja
		River bean (Indigenous)	Jelejele, msalasese, chigoma, soyo
Botanical Name		*Sesbania sesban*	
Ecology		One of the species cultivated in tropical Asia and Africa which can grow in shallow water and also fix nitrogen, 100-2,000 m attitude. It is widely distributed in Zambia, found on the flood plain, swamps and in most river valleys.	Imodzi mwa mitundu yomwe imabzalidwa kumadera otentha ku Asia ndi Africa yomwe imatha kukula m'madzi osaya komanso kukonza nayitrogeni, imapezeka pa molo ya 100 kufikira 2000 m kukwera kwache. Imapezeka kwambiri ku Zambia, yomwe imapezeka m'malo otsetsereka, madambo komanso m'zigwa zambiri za mitsinje.
Site conditions		In Eastern Province, it grows around dams and dambos; very common in Luangwa Valley. Tolerates both seasonal and permanent water-logging; daytime temperatures are within the range 18 - 28°c and a mean annual rainfall in the range 800 - 2,000mm.	Ku dela la ku m'mawa kwa Zambia, imamera mozungulira madamu ndi madambo; zambiri m'chigwa cha Luangwa. Imakulabe bwino ku malo yosefukila madzi kwa nyengo ndi kwanthawi zonse; Kutentha kwa masana kumakhala pakati pa 18 mpaka 28°c ndi mvula yapachaka ya 800 mpaka 2,000mm.
Agro-Forestry Technology		Nitrogen fixing, soil improvement (rotation fallows). Used to shade plantations of coffee, tea and cocoa; to provide a windbreak for bananas, citrus and coffee; used as green manure for rice. Species has been extensively tested by researchers for use in improved fallows and technology adoption process by farmers in Eastern Province is on-going	imakonza nayitrogeni, kukonza nthaka (Ulimi wa kansinthasintha). Amagwiritsidwa ntchito pamthunzi minda ya khofi, tiyi ndi koko; imapereka chotchinga mphepo kwa nthochi, ndi zipatso za gulu la malalanje ndi khofi; imagwiritsidwa ntchito ngati manyowa yamtengo yosauma pa mpunga. Mtunduyu wakhala ukuyesedwa kwambiri ndi ofufuza kuti ugwiritsidwe ntchito polima bwino komanso njira zotengera luso la alimi ku m'mawa kwa Zambia.
Uses	**Nitrogen fixing**	Can increase maize yields without the application of nitrogen fertilizer.	Itha kuonjezera zokolola za chimanga popanda kuthira feteleza wa nayitrogeni.
	Firewood	Popular crop for firewood and charcoal because it produces a high woody biomass in a short time	Mbewu zotchuka pa nkhuni ndi makala chifukwa zimatulutsa mitengo ochuluka m'kanthawi kochepa
	Fodder	Leaves and pods)	Masamba ndi Makoko
	Food / Fruit	Flowers are edible when cooked, leaves eaten as vegetables	Maluwa amadyedwa akaphikidwa, masamba amadyedwa ngati ndiwo za masamba
	Medicinal	The fresh roots and leaves are used to treat scorpion stings, boils and abscesses; extract obtained by boiling leaves is used to treat sore throat, gonorrhoea, syphilis, spasmodic fits in children and jaundice during pregnancy	Mizu ndi masamba atsopano amagwiritsidwa ntchito pochiza mbola za zinkhanira, zithupsa ndi zilonda; Madzi ya masamba owiritsa omwe amagwiritsidwa ntchito pochiza zilonda zapakhosi, chinzonono, chindoko, kukomoka kwa ana ndi jaundice pa azimayi a pakati.

Description	Short-lived semi-deciduous shrub or small tree with a narrow crown; branching and giving light shade.	Chitsamba chaching'ono chokhala kapena mtengo wawung'ono wokhala ndi korona wopapatiza; nthambi ndi kupereka mthunzi wopepuka.
	Height of mature tree: Up to 8 m	Kutalika kwa mtengo wokhwima: Kufikira 8 m
	Recommended spacing: As a fence, it is planted at 1-2 m in single rows; as an alley crop, rows are planted 2-10 m apart, with plants spaced 25-50 cm within rows. As a protein bank, in rows 1-2 m apart with plants spaced 25-50cm apart within rows.	Kutalikirana kovomerezeka: Ngati ni mpanda, imabzalidwa pa 1-2 m mu; Ngati mbewu ya kamsewu, mizere imabzalidwa motalikirana 2-10 m, ndi mbewu zotalikirana 25-50 cm mkati mwa mizere. Monga nkhokwe ya mapuloteni, m'mizere 1-2 m motalikirana ndi zomera zotalikirana 25-50cm mkati mwa mizere.
	Number of years for first harvest: reported to attain a height of 4 – 5m in only 6 months; cut at frequencies of 3 - 4 cuts/annum, yielding 4-12 tons / ha dry matter per year	Chiwerengero cha zaka zokolola koyamba: zanenedwa kuti zafika kutalika kwa 4 - 5m m'miyezi isanu ndi umodzi yokha; kudula pafupipafupi katatu kapena kanayi pa chaka, kupereka zololowa zouma mpaka matani 4 mpaka12 matani pa hekitala imodzi pa chaka.
Propagation	Direct seeding, seedlings. germination rate of treated seed is about 65% in about 16 days	Kubzala njere, mbande. kumera kwa mbeu yothiridwa mankhwala ndi pafupifupi 65 pa 100 (65%) mkati mwa masiku 16
Seed	High germination rate. Treatment is not necessary, but hot-water treatment may hasten germination. Seed can be stored for long periods.	kameredwe ndikabwino kwambiri. Chithandizo sichofunikira, koma chithandizo chamadzi otentha chikhoza kufulumizitsa kumera. Mbewu imatha kusungidwa kwa nthawi yayitali.
Management	Coppices well only when young.	Imaphukira bwino pokhapo ngati mtengo ndi wawung'ono.
Remarks	Very fast growing but and shoots and roots often attacked by insects and diseases. This tree has a short life span, often dying before it is 10 years old; thus requiring replanting	Imakula mofulumira kwambiri koma mphukira ndi mizu zimagwidwa ndi tizilombo ndi matenda. Mtengo uwu umakhala ndi moyo waufupi, nthawi zambiri umafa usanakwanitse zaka 10; motero ufunika kubzalidwanso

A 1.3. WOODLOT TREE SPECIES

		English	Nyanja
Name		Red mahogany (Indigenous)	Mubaba, M'lulu
Botanical Name		*Khaya nyasica*	
Ecology		A tall tree which grows from Tanzania south to Mozambique. It is found throughout Zambia, at medium to low altitudes, normally beside rivers and it has been widely planted for timber around settlements in Eastern Province.	Mtengo wautali womwe umamera kuchokera ku Tanzania kummwera mpaka ku Mozambique. umapezeka ku dziko lonse la Zambia, pamalo okwera mpaka otsika, nthawi zambiri m'mphepete mwa mitsinje ndipo umabzalidwa mozungulira midzi mozungulira midzi ya kum'mawa.chifukwa mtengoyu ndi wa matabwa.
Site conditions		It grows best in deep well-drained soils but can withstand seasonal flooding. Prefers terraces and stable, gently sloping riverbeds in riparian forests; grows well on slopes at margins of floodplains.	Imakula bwino m'nthaka lotaya bwino madzi koma imatha kupirira kusefukira kwamadzi. Imakonda masitepe ndi mitsinje yokhazikika, yotsetsereka pang'ono m'nkhalango za m'mphepete mwa nyanja; imakula bwino m'mphepete mwa malo yosefukila madzi
Agro-Forestry technology		Woodlot. Intercropping.	Munda wa mitengo, Kulima pamodzi mbewu zosiyanasiyana.
Uses	**Timber**	An indigenous fine hardwood. Timber (quality furniture). The timber is pale pink when fresh but red-brown on exposure. It is the most popular local timber for furniture as it is easy to work, polishes well and is also durable; resistant to borers and termites. Poles for construction and fencing	Mtengo wokhazikika wachilengedwe. Mitengo (mipando yabwino). Mitengoyi imakhala yotumbululuka yotumbululuka ikakhala yatsopano koma yofiira pakuwonekera. Ndi matabwa a m'deralo odziwika bwino a mipando chifukwa ndi osavuta kugwiritsa ntchito, amapukuta bwino komanso ndi olimba; kugonjetsedwa ndi bore ndi chiswe. Mitengo yomanga ndi mipanda
	Fire-wood	For domestic energy supply	Nkhuni za pakhomo
	Medicine	The bark is used to treat colds. Oil from seeds is rubbed on the scalp to kill lice.	Khungwa limagwiritsidwa ntchito pochiza chimfine. Mafuta otengedwa ku njere amapakidwa pamutu kuti aphe nsabwe.
	Others:	Bee forage, shade	Chakudya cha njuchi, Mthunzi
Description		Semi-evergreen tree with straight trunk up to 30 m before branching; buttressed at the base, the crown dense and rounded.	Mtengo wobiriwira wokhala ndi thunthu lolunjika mpaka 30 m usanapange nthambi; m'munsi mwake, korona wandiweyani komanso wozungulira.
		Height of mature tree: 30 - 50 m	Kutalika kwa mtengo wokhwima: 30 mpaka 50 m
		Diameter at Breast Height of mature tree: 120 - 500 cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: 120 – 500 cm
		Recommended spacing: a few hundred seedlings/ha	Kutalikirana kovomerezeka: mbande mazana angapo pa hekitala imodzi
		Number of years for first harvest : Poles: 8 – 10 years, Timber: 30 years	Chiwerengero cha zaka zokolola koyamba : Mitengo: 8 - 10 zaka, Matabwa: zaka 30

Propagation	Seedlings, wildings, direct seeding	Mbande, tuana twa mtengo omela, kubzala njere
Seed	Produces 30 - 60 seeds per fruit. Germination is very good and fast. Can be stored for some time	Imatulutsa mbewu 30 - 60 pa chipatso chilichonse. Kumera ndikwabwino kwambiri komanso mwachangu. Ikhoza kusungidwa kwakanthawi
Management	Coppicing (is possible but level of success low), pruning	Kukopera (kutheka koma mulingo wopambana ndi wotsika), kudulira
Remarks	A tree whose present heavy exploitation by pit-sawyers is worrying. However, this tree is easy to grow and therefore, planting in school compounds and on farm should be encouraged.	Mtengo umene kugwiritsiridwa ntchito kwambiri kwake ndi ocheka matabwa pa dzenje ndi kodesa nkhawa. Komabe, mtengo uwu ndi wosavuta kukula, choncho, kubzala pa masukulu komanso pafamu kuyenera kulimbikitsidwa.



Name		English	Nyanja
		Yellow cassia	Makeche
Botanical Name		*Senna siamea*	
Ecology		Originated from South-East Asia. A medium-sized, evergreen to large tree with a crown that is usually dense and rounded when young, later becoming irregular and spreading with drooping branches. It is cultivated all over the lowland tropics with a monsoon climate from sub-humid to semi-arid and even arid zones.	Unachokera ku mwera cha ku m'mawa kwa Asia. Kukula kwake ndi wapakatikati kukula kwake, wobiriwira mpaka waukulu wokhala ndi korona womwe nthawi zambiri umakhala wandiweyani komanso wozungulira ukakhala wachichepere, kenako umakhala wosakhazikika komanso wofalikira ndi nthambi zogwa. Amalimidwa m'madera otentha kwambiri okhala ndi nyengo ya monsoon kuchokera kumadera ocheperako kupita kumadera ouma komanso owuma.
Site conditions		Succeeds at elevations up to 1,300m; mean annual rainfall ranges from 500 - 2,800mm; temperature ranging from 14 - 36°c and on deep, well-drained, fertile soils. Commonly grown in Eastern Province.	Umachita bwino pamtunda mpaka 1,300m; mvula yapachaka imagwa kuchokera pa 500 - 2,800mm; kutentha kwapakati pa 14 - 36°c ndi pa nthaka yakuya, yopanda madzi bwino, yachonde. Nthawi zambiri amalimidwa ku Eastern Province.
Agro-Forestry		Wood plantations, hedgerow for alley cropping or as a shelterbelt. Mulch, soil conservation, windbreak and as an avenue tree	M'minda yamatabwa, mipanda yolima mumsewu kapena ngati lamba ya mitengo. Zinyalala, kusamala nthaka, mphepo yamkuntho komanso ngati mtengo wanjira
Uses	**Timber**	Timber (furniture) and poles. Caution: sawdust may cause some nose, throat and eye irritation while the wood sometimes produces a yellow powder that may cause skin irritation.	Mitengo (mipando) ndi mitengo. Chenjezo: utuchi ukhoza kuyambitsa kuyabwa kwa mphuno, kukhosi ndi m'maso pomwe nkhuni nthawi zina zimatulutsa ufa wachikasu womwe ungayambitse kuyabwa pakhungu.
	Firewood	For domestic energy supply	Nkhuni za pa khomo
	Fodder	Foliage is used as fodder for cattle or sheep but is poisonous to pigs	Masamba amagwiritsidwa ntchito ngati chakudya cha ng'ombe kapena nkhosa koma ndi poizoni kwa nkhumba.
	Medicine	Bark is used to treat sexually transmitted diseases and diarrhoea. Fruit is used to remove intestinal worms and to prevent convulsions in children.	Khungwa limagwiritsidwa ntchito pochiza matenda yakatengera komanso kutsekula m'mimba. Chipatso chimagwiritsidwa ntchito kuchotsa mphutsi za m'mimba komanso kupewa kukomoka kwa ana.
	Others:	Charcoal, shade. Ornamental tree on road sides	Makala, mthunzi. Mtengo wokongola m'mbali mwa msewu

Description	An evergreen tree, often smaller or shrub-like.	Mtengo wobiriwira, nthawi zambiri wawung'ono kapena wonga chitsamba
	Height of mature tree: 18m - 30 m	Kutalika kwa mtengo wokhwima: 18m mpaka 30 m
	Diameter at Breast Height of mature tree: up to 30cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: Mpaka 30cm
	Recommended spacing: fuel wood plantations, from 1 x 1m to 1x 3 m; In hedges used for alley cropping or as a shelterbelt, spacing between plants in the row should be 25 - 50 cm	Kutalikirana kovomerezeka: minda mitengo nkhuni kuyambira 1 x 1m mpaka 1x 3 m; M'mipanda yomwe imagwiritsidwa ntchito polima kapena ngati mpanda wa nthunzi, kusiyana pakati pa mbewu pamzere kuyenera kukhala 25 to 50 cm.
	Number of years for first harvest: Seedling trees start flowering and fruiting at the age of 2 - 3 years	Chiwerengero cha zaka zokolola koyamba: Mitengo ya mbande imayamba kuphuka ndi kubereka zipatso ali ndi zaka 2 - 3
Propagation	Seedlings, wildings, direct seeding	Mbande, tumitengo tomela kuchokera ku make, kubzala njele
Seed	Fresh seed requires no pre-treatment but old seed should be soaked in cold water for 24 hours. Seed can be stored for up to one year but germination rate drops with time.	Mbewu zatsopano sizifuna kuzithandiza koma mbewu zakale ziyenera kuviikidwa m'madzi oizira kwa maola 24. Mbewu imatha kusungidwa mpaka chaka chimodzi koma kameredwe kake kamatsika pakapita nthawi.
Management	Lopping, coppicing and pollarding.	Kudulira, kudula mthambi, kuduma mtengo ndi cholinga chakuti umerenso
Remarks	Tree crop is easy to establish because it is low-input, fast growing, not browsed by domestic animals and is termite-resistant; thus ideal for school compounds. Species is widespread and its population is not considered to be in decline or threatened.	Mbeu yamitengoyi ndiyosavuta kukhazikika chifukwa siyimafuna zambiri, imakula mwachangu, siyimadyedwa ndi ndi ziweto komanso imalimbana ku chiswe; motero ndiyabwino kubzala pa masukulu. Mitundu ndi yofala ndipo chiwerengero chake sichikuganiziridwa kuti chili pachiwopsezo chochepetsedwa kapena kuthelatu.

A 1.4. ORNAMENTAL TREE SPECIES



Name		English	Nyanja
		Golden cassia.	Makeche
Botanical Name		*Senna spectabilis*	
Ecology		Originated from Tropical America. Most common in open formations, found in moist and seasonally dry, disturbed or secondary woodland and savannah forests	Unachokera ku mayo yotentha ya ku America. Imapezeka kwambiri m'malo otseguka, omwe amapezeka m'nkhalango zonyowa komanso zowuma, nkhalango zosokoneza kapena zomeranso za savannah.
Site conditions		Grows well in tropics and subtropics, where it is found at elevations up to 2,000m; annual daytime temperatures are within the range 15 - 25°c; mean annual rainfall in the range 800 - 1,000mm and prefers a well-drained, deep, moist, sandy or loamy soil. Established plants are drought tolerant.	Imakula bwino m'malo otentha kwambiri ndi otentha pang'ono, komwe imapezeka pamalo okwera mpaka 2,000m; kutentha kwa masana pachaka ndi 15 - 25 ° C; mvula yapachaka ya 800 - 1,000mm ndipo imakonda nthaka yotayidwa bwino, yakuya, yonyowa, yamchenga kapena yotayirira. Mitengo yokhazikika imapirira chilala.
Agro-Forestry Technology		Grown for shade, hedge and as a boundary marker. Leaves can be used as mulch.	Imakula ngati mthunzi, mpanda komanso ngati malire. Masamba atha kugwiritsidwa ntchito ngati zinyalala za m'munda.
Uses	Ornamental	With showy flowers in gardens , parks, avenue tree and along the street	Ndi maluwa owoneka bwino m'minda, m'mapaki, munjira komanso mumsewu
	Timber	Timber (tool handles), poles, small implements	Matabwa (zogwirira zida), nsandamina, zida zing'ono zing'ono
	Firewood	For domestic energy supply	Nkhuni za pa khomo
	Medicinal	Plant is used to treat ringworm and skin diseases	Mtengo umagwiritsidwa ntchito pochiza zipere ndi matenda a khungu
	Others:	Charcoal, bee forage, shade, windbreak and excellent shade when in leaf	Makala, chakudya cha njuchi, mthunzi, chotchingira mphepo ndi mthunzi wabwino kwambiri ngati ilindi masamba
Description		Semi-deciduous tree, short bole, branching to give a rounded or flat crown.	Mtengo wa wotaya mayani nthawi zina, tsinde lalifupi, nthambi kuti lipereke korona wozungulira kapena wosalala.
		Height of mature tree: 7 – 18 m	Kutalika kwa mtengo wokhwima: 7 - 18 m
		Diameter at Breast Height of mature tree: Up to 30 cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: Mpaka 30 cm
		Recommended spacing: 2 X 2m	Kutalikirana kovomerezeka: 2 X 2m
		Number of years for first harvest: Reaches a height of 3.5m within 2 years from seed	Chiwerengero cha zaka zokolola koyamba: Imafika kutalika kwa 3.5m mkati mwa zaka ziwiri ngati mwabzala mbeu
Propagation		Seedlings, direct seeding	Mbande, kubzala njele
Seed		Treatment: Immerse in hot water and allow to cool for 24 hours. Storage: Seed can be stored for up to 2 years under cool, dry conditions.	Chithandizo: Viikani m'madzi otentha ndipo lolani kuti azizire kwa maola 24. Kasungidwe: Mbewu ikhoza kusungidwa kwa zaka ziwiri pansi pa malo ozizira, owuma.

Management	Coppicing.	Kudula ndi kulola kuti mtengo uphukirenso
Remarks	Very common in Zambia; Wood is termite-resistant. Easy to raise as it is fast growing on good sites.	Zofala kwambiri ku Zambia; mitengo imalimbana ndi chiswe. Ndiwosavuta kulima chifukwa ikukula mwachangu m'malo ya abwino.




Name		English	Nyanja
		Jacaranda, Blue Jacaranda, Black Poui, Nupur or Fern tree.	Jacaranda
Botanical Name		*Jacaranda speciformis*	
Local Name (Nyanja)		Jacaranda	
Ecology		Originated from Tropical and Subtropical America. Widely grown throughout tropical and the subtropical regions of the world.	Anachokera ku malo yotentha kwambiri ndi yotentha pang'ono ya ku America. imakula kwambiri kumadera otentha komanso kumadera otentha pang'ono padziko lonse lapansi.
Site conditions		Jacaranda grows in well-drained soil and in areas with elevation up to 2, 600m and, is drought tolerant and thrives in sandy soils.	Jacaranda imamera m'nthaka yopanda madzi bwino komanso m'madera okwera kufika pa 2,600m ndipo, imapirira chilala komanso imakula bwino m'dothi lamchenga.
Agro-Forestry Technology		Used as roadside or avenue planting	Amagwiritsidwa ntchito kubzala munjira ndi kapena kubzala m'mphepete mwa msewu
Uses	**Ornamental**	Known for its attractive and long-lasting violet-colored flowers	Amadziwika ndi maluwa okongola achikasu
	Timber	Dries without difficulty and is often used in its green or wet state for bowl carving.	Imauma mosavutikira ndipo imagwiritsidwa ntchito nthawi zambiri ngati yobiriwira kapena yonyowa posema mbale.
	Seed/ Seedpods	Unusually shaped tough pods are used to decorate Christmas trees	Makoko ake ndi olimba komanso osawoneka bwino ndipo amagwiritsidwa ntchito kukongoletsa mitengo ya Khirisimasi
Description		Shrub to large trees.	Kuchokera pa vitsamba ku fikira ku mitengo ikuluikulu.
		Height of mature tree: From 20 to 30 m	Kutalika kwa mtengo wokhwima: Kuyambira 20 mpaka 30 m
		Diameter at Breast Height of mature tree: 40 – 50cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: 40 - 50cm
		Recommended spacing: Roadside: 5 X 5m; avenue: 3 X 3m	Mipata yolangizidwa: M'mphepete mwa msewu: 5 X 5m; njira: 3 X 3m
		Number of years for first harvest: Plants grown from seed will start to bloom after 8 - 10 years.	Chiwerengero cha zaka zokolola koyamba: Zomera zomwe zamera kuchokera kumbewu zimafika pa chimake pakatha zaka 8 - 10.
Propagation		Grafting, cuttings and seeds, though plants grown from seeds take a long time to bloom.	Kumezanitsa, zodula mbewu, ngakhale zomera zomwe zimakula kuchokera ku mbewu zimatenga nthawi yaitali kuti ziphuke.
Remarks		Valued for their intense flower displays; resistant to pests and diseases and are moderately drought-tolerant (though they require watering during extended dry periods). Species has shown potential of being invasive in South Africa.	Imakondedwa chifukwa cha mawonekedwe ya maluwa awo ; imapirira ku tizirombo ndi matenda ndipo imapirira chilala (ngakhale imafuna kuthirira pakanthawi kouma). Mtengoyu wawonetsa kuthekera kowononga ku South Africa.

A 1.5. MEDICINAL TREES



Name		English	Nyanja
		Moringa, Drumstick tree or Horseradish tree	Moringa
Botanical Name		*Moringa oleifera*	
Ecology		Grows in semi-arid, tropical and sub-tropical areas.	Imakula m'madera ouma, otentha komanso otentha kwambiri.
Site conditions		Prefers well-drained, sandy or loamy soil. Suitable for dry regions, as it can be grown using rainwater only	Imakonda nthaka yotayidwa bwino, yamchenga kapena lomu. Ndiyoyenera kumadera owuma, chifukwa imatha kulimidwa pogwiritsa ntchito madzi amvula okha
Agro-Forestry Technology		Home gardens and as living fences	minda zapakhomo komanso ngati mipanda ya-moyo
Uses	**Medicine**	Bark, sap, roots, leaves, seeds and flowers are used in traditional medicine. Used in treatment of diabetes and asthma and in increasing breast milk. Tree contains proteins, vitamins and minerals thus, can be used to combat malnutrition (by adding Moringa powder to food) among infants and nursing mothers. Not for expectant mothers	Khungwa, madzi ya mtengo, mizu, masamba, mbewu ndi maluwa amagwiritsidwa ntchito pa-mankhwala. Amagwiritsidwa ntchito pochiza matenda a shuga ndi mphumu komanso kuwonjezera mkaka wa m'mawere. Mtengo uli ndi mapuloteni, mavitamini ndi mchere motero, ungagwiritsidwe ntchito polimbana ndi matenda ya za kusowa kwa zakudya m'thupi (powonjezera ufa wa Moringa ku chakudya) pa-kati pa makanda ndi amayi oyamwitsa. Osati kwa amayi oyembekezera
	Fodder	Fodder (leaves)	Zakudya za ziweto Masamba
	Seed	Can be used in production of bio-fuel. Can be removed from mature pods, cut, and cooked for consumption	Itha kugwiritsidwa ntchito popanga mafuta. Atha kuchotsedwa ku makoko okhwima, odu-lidwa, ndi kuphika kuti adye
	Others:	Seed cake is used in water purification, oil (kernel) can be used as food supplement (for cooking) and as base for cosmetics	Keke yambewu imagwiritsidwa ntchito poyeretsa madzi, mafuta (kernel) amatha kugwiritsidwa ntchito ngati chakudya (pophikira) komanso ngati maziko a zodzolad-zola.
Description		A fast-growing, drought resistant tree.	Mtengo womwe ukukula msanga, wosamva chi-lala.
		Height of mature tree: 10 - 12 m	Kutalika kwa mtengo wokhwima: 10 - 12 m
		Diameter at Breast Height of mature tree: 45 cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: 45 cm
		Recommended spacing: 1.5 - 3 x 1.5 - 3 m	Kutalikirana kovomerezeka: 1.5 - 3 x 1.5 - 3 m
		Number of years for first harvest: 6 – 8 months (flowering)	Chiwerengero cha zaka zokolola koyamba: 6 - 8 miyezi (maluwa)
Propagation		Seed (Direct seeding) or cuttings (1m length and 4cm diameter)	Mbewu (kubzala mjele) kapena zodulidwa (m'litali 1m ndi 4cm m'mimba mwake)
Seed		High germination rate. Treatment: Not necessary	Imamela bwino kwambiri. Chithandizo: Sicho-funikira

Management	Pollarding, coppicing, lopping and pruning (allowed to re-grow so that pods and leaves remain within arm's reach)	Kudula, kukopera, kudulira ndi kudulira (kuloledwa kukulanso kuti nyemba ndi masamba zikhalebe pafupi ndi mkono)
Remarks	Moringa is one of the world's most nutritious crops; the leaves have more beta-carotene than carrots, more protein than peas, more vitamin C than oranges, more calcium than milk, more potassium than bananas, and more iron than spinach	Moringa ndi imodzi mwa mbewu zopatsa thanzi kwambiri padziko lapansi; masamba ali ndi beta-carotene yambiri kuposa karoti, mapuloteni ambiri kuposa nandolo, vitamini C wochuluka kuposa malalanje, calcium yambiri kuposa mkaka, potaziyamu kuposa nthochi, ndi iron yambiri kuposa sipinachi.



Name		English	Nyanja
		Neem	Nimu
Botanical Name		Azadirachta indica	
Ecology		Originated from N.E. India and Burma. One of the most widely planted trees in Africa and all over the tropics, in arid and semi-arid regions. Suitable tree for improving degraded soils. The roots grow deep and wide.	Wochokera ku mpoto cha ku m'mawa kwa maiko ya India ndi Burma. Imodzi mwa mitengo yobzalidwa kwambiri ku Africa komanso ku-madera otentha, m'madera ouma komanso owuma pang'ono. Mtengo woyenera kukonza dothi lowonongeka. Mizuyo imakula mwakuya ndi kufalikira.
Site conditions		Does best in the Valley in Eastern Province. Found at elevations up to 1, 500m; annual daytime temperatures range is 26 - 40°c while mean annual rainfall range is 450 - 1,200mm. It is very drought-resistant, does well on poor but well-drained soils, but does not withstand water-logging.	Imakula bwino ku Chigwa ku dela la ku m'mawa. Imapezeka pamalo okwera mpaka 1,500m; Kutentha kwapachaka masana ndi 26 - 40°c pamene mvula ya pachaka ndi 450 - 1,200mm. Imalimbana ndi chilala, imachita bwino pa dothi la nthaka lochepa koma lopanda madzi, koma silipirira kukhazikika kwa madzi. .
Agro-Forestry		Intercropping. Soil conservation and improvement, windbreaks. Leaves and small twigs are used as mulch and green manure	Kulima mbewu zosiyanasiyana. Kusamalira ndi kukonza nthaka, zotchingira mphepo. Masamba ndi nthambi zazing'ono zimagwiritsidwa ntchito ngati zinyalala ndi manyowa obiriwira
Uses	Medicine	Leaves, bark and roots can be used as medicine for 40 different diseases. Used to treat malaria, stomach-ache, cough and diarrhoea. Not usually administered to the very young, the old or the weak.	Masamba, khungwa ndi mizu zitha kugwiritsidwa ntchito ngati mankhwala a matenda 40 osiyanasiyana. Amagwiritsidwa ntchito pochiza malungo, kupweteka kwa m'mimba, chifuwa ndi kutsekula m'mimba. Nthawi zambiri samaperekedwa kwa achichepere, achikulire kapena ofooka
	Fodder	Foliage, oil seed cake	Masamba, keke yambewu yamafuta
	Timber	Timber (furniture) and poles. Wood is tough and resistant to decay and termites.	Matabwa (mipando) ndi nsandamina. Mitengo ndi yolimba komanso yosavunda ndi chiswe.
	Firewood	For domestic energy supply	Nkhuni za panyumba
	Fruit / Food	Eaten fresh or cooked, or prepared as a drink. Young leaves and flowers are cooked and eaten as a pre-meal appetizer.	Zimadyedwa za ziwisi kapena zophikidwa, kapena yokonzedwa ngati chakumwa. Masamba ang'onoang'ono ndi maluwa amaphikidwa ndikudyedwa ngati chakudya choyambirira.
	Ornamental	Tree used in towns and villages	Mtengo wogwiritsidwa ntchito m'matauni ndi m'midzi
	Others:	Charcoal, bee forage, shade, insecticide, oil (seeds), soap (seed oil).	Makala, chakudya cha njuchi, mthunzi, mankhwala ophera tizilombo, mafuta (mbewu), sopo (mafuta ambewu).

Description	Fast-growing, medium-sized tree with a dense, leafy, oval-shaped canopy, evergreen except in the driest areas.	Mtengo wokula msanga, wapakatikati wokhala ndi denga lolimba, lamasamba, lozungulira wobiriwira nthawi zonse kuchotselako m'malo owuma kwambiri
	Height of mature tree: 15 – 25 m	Kutalika kwa mtengo wokhwima: 15 - 25 m
	Diameter at Breast Height of mature tree: Up to 100 cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: Kufikira 100 cm
	Recommended spacing: 5X 5m to 10 X 10m	Kutalikirana kovomerezeka: 5X 5m mpaka 10 X 10m
	Number of years for first harvest: Bear fruit between 3 and 5 years	Chiwerengero cha zaka zokolola koyamba: Kubala zipatso pakati pa zaka 3 ndi 5
Propagation	Seedlings, wildings, cuttings, direct seeding	Mbande, tumitengo tun'gono, zodula, kubzala mbeu
Seed	Treatment is not necessary. Storage: sow seed immediately after collection and extraction. Avoid storage.	Chithandizo sikofunikira. Kasungidwe: Bzalani mbeu mukangotola ndi kuzidula. Pewani kusunga.
Management	Coppicing, lopping and pollarding.	Kudula kuti mtego uphikire, kudulira ndi kudula nthambi.
Remarks	Slow growing only in the first year, then relatively fast. Tree highly valued for hardiness, it's almost year-round shade, and its multiple wood and non-wood products. A most useful tree whose cultivation should be encouraged.	imakula pang'onopang'ono m'chaka choyamba, kenako mofulumira. Mtengo wamtengo wapatali kwambiri chifukwa cha kulimba, pafupifupi mthunzi wa chaka chonse, ndi zotuluka m'matabwa ake zingapo komanso zinthu osati zamatabwa. Mtengo wothandiza kwambiri womwe kuyenera kulimbikitsidwa kulimidwa

A 1.6. PESTICIDE TREES



Name		English	Nyanja
		Neem	Nimu
Botanical Name		Azadirachta indica	
Ecology		Originated from N.E. India and Burma. One of the most widely planted trees in Africa and all over the tropics, in arid and semi-arid regions. Suitable tree for improving degraded soils. The roots grow deep and wide.	Wochokera ku mpoto cha ku m'mawa kwa daziko la India ndi Burma. Imodzi mwa mitengo yobzalidwa kwambiri ku Africa komanso kumadera otentha, m'madera ouma komanso owuma pang'ono. Mtengo woyenera kukonza nthaka lowonongeka. Mizuyo imakula mwakuya ndi kufalikira.
Site conditions		Does best in the Valley in Eastern Province. Found at elevations up to 1, 500m; annual daytime temperatures range is 26 - 40°c while mean annual rainfall range is 450 - 1,200mm. It is very drought-resistant, does well on poor but well-drained soils, but does not withstand water-logging.	Imakula bwino ku chigwa ku dela la kum'mawa kwa Zambia. Amapezeka pamalo okwera mpaka 1,500m; Kutentha kwapachaka masana ndi 26 - 40°c pamene mvula ya pachaka ndi 450 - 1,200mm. Imalimbana ndi chilala, imachita bwino pa dothi lochepa chonde koma lopanda madzi, koma silipirira kukhazikika kwamadzi.
Agro-Forestry		Intercropping. Soil conservation and improvement, windbreaks. Leaves and small twigs are used as mulch and green manure	Kuilima ndi mbewu zina. Kusamalira ndi kukonza nthaka, zotchingira mphepo. Masamba ndi nthambi zazing'ono zimagwiritsidwa ntchito ngati zinyalala ndi manyowa amasamba obiriwira
Uses	Pesticide	Seeds are dried, crushed and soaked in water overnight to produce a liquid pesticide that is applied directly to crops. Crushed seed kernels are used as a dry pesticide application, to control stem borers on young plants.	Mbewu zimawumitsidwa, kuphwanyidwa ndikuviikidwa m'madzi usiku wonse kuti apange mankhwala amadzimadzi omwe amathira mbewu. Mbeu zophwanyidwa zimagwiritsidwa ntchito ngati mankhwala owuma ophera tizilombo, pothana ndi tizirombo toyambitsa matenda
	Fodder	Foliage, oil seed cake	Masamba, mafuta ya keke yambewu
	Medicine	Leaves, bark and roots can be used as medicine for 40 different diseases. Used to treat malaria, stomach-ache, cough and diarrhoea. Not usually administered to the very young, the old or the weak.	Masamba, khungwa ndi mizu zitha kugwiritsidwa ntchito ngati mankhwala a matenda 40 osiyanasiyana. Amagwiritsidwa ntchito pochiza malungo, kupweteka kwa m'mimba, chifuwa ndi kutsekula m'mimba. Nthawi zambiri samaperekedwa kwa achichepere, achikulire kapena ofooka
	Timber	Timber (furniture) and poles. Wood is tough and resistant to decay and termites.	Mitengo (mipando) ndi mitengo. Mitengo ndi yolimba komanso yosavunda ndi chiswe.
	Firewood	For domestic energy supply	Nkhuni za pa nyumba
	Fruit / Food	Eaten fresh or cooked, or prepared as a drink. Young leaves and flowers are cooked and eaten as a pre-meal appetizer.	imadyedwa yayiwisi kapena yophikidwa, kapena yokonzendwa ngati chakumwa. Masamba ang'onoang'ono ndi maluwa amaphikidwa ndikudyedwa ngati chakudya choyambirira.
	Ornamental	Tree used in towns and villages	Mtengo wogwiritsidwa ntchito m'matauni ndi m'midzi
	Others:	Charcoal, bee forage, shade, oil (seeds), soap (seed oil).	Makala, chakudya cha njuchi, mthunzi, mafuta (mbewu), sopo (mafuta ambewu).

Description	Fast-growing, medium-sized tree with a dense, leafy, oval-shaped canopy, evergreen except in the driest areas.	Mtengo womwe ukukula mwachangu, wapakatikati wokhala ndi denga lolimba, lamasamba, lowoneka ngati lozungulira, lobiriwira nthawi zonse kupatula m'malo owuma kwambiri.
	Height of mature tree: 15 – 25 m	Kutalika kwa mtengo wokhwima: 15 - 25 m
	Diameter at Breast Height of mature tree: Up to 100 cm	M'mimba mwake pa chifuwa cha mtengo wokhwima mpaka 100cm
	Recommended spacing: 5X 5m to 10 X 10m	Kutalikirana kovomerezeka: 5X 5m mpaka 10 X 10m
	Number of years for first harvest: Bear fruit between 3 and 5 years	Chiwerengero cha zaka zokolola koyamba: Imabala zipatso pakati pa zaka zitatu andi zisanu
Propagation	Seedlings, wildings, cuttings, direct seeding	Mbande, tumitengo twatungono, kudula, kubzala njele
Seed	Treatment is not necessary. Storage: sow seed immediately after collection and extraction. Avoid storage.	Chithandizo sikofunikira. Kasungidwe: Bzalani mbeu mukangotola ndi kuzidula. Pewani kusunga.
Management	Coppicing, lopping and pollarding.	Kudula ndikulola kuti iphukire, kudulira ndikudula nthambi
Remarks	Slow growing only in the first year, then relatively fast. Tree highly valued for hardiness, it's almost year-round shade, and its multiple wood and non-wood products. A most useful tree whose cultivation should be encouraged.	imakula pang'onopang'ono m'chaka choyamba, kenako mofulumira. Mtengo wamtengo wapatali kwambiri chifukwa cha kulimba, pafupifupi mthunzi wa chaka chonse, ndi matabwa ake ogwiritsidwa ntchito zingapo komanso zinthu zopanda matabwa. Mtengo wothandiza kwambiri womwe ulimi wake uyenera kulimbikitsidwa.



Name		English	**Nyanja**
		Fish bean or Fish poison bean	Buba
Botanical Name		Tephrosia vogelii	
Ecology		Tropical Africa including Angola, Malawi, Mozambique, Zambia and Zimbabwe. Found in savannah-like vegetation, grassland, forest margins and shrub-land, wasteland and fallow fields; with elevations from sea level up to 2,100 m	Upezaka m'malo yotentha ya Africa kuphatikiza Angola, Malawi, Mozambique, Zambia ndi Zimbabwe. Umapezeka m'malo obiriwira obiriwira, m'malo a udzu, m'mphepete mwa nkhalango komanso m'malo otsetsereka, m'malo opululukira komanso m'minda yolima; ndi okwera kuchokera kumtunda kwa nyanja mpaka 2,100 m
Site conditions		Grows best in areas where annual daytime temperatures are within the range 20 - 28°c; a mean annual rainfall of 1,300 - 1,500 mm; on soils that are not subject to flooding and on well drained loams; established plants are drought and wind tolerant.	Imakula bwino m'malo omwe kutentha kwapachaka kwa masana kumakhala pakati pa 20 - 28 ° C; mvula yapachaka ya 1,300 - 1,500 mm; pa dothi lopanda madzi osefukira komanso pa dothi lotayirira bwino; zomera zokhazikika zimapirira chilala komanso mphepo.
Agro-Forestry Technology		Nitrogen fixing. Used as a green manure crop, windbreak and hedge plant; temporary shade crop in cocoa, coffee, tea, rubber and coconut plantations; it is suitable as a hedge plant because of its dense growth	Imakonza nayitrogeni munthaka. Imagwiritsidwa ntchito ngati manyowa yobiriwira yobiriwira, yotchinga mphepo ndi mpanda wa zomera; mbewu yamthunzi m'minda ya koko, khofi, tiyi, labala ndi kokonati; ndi yoyenera ngati chomera champanda chifukwa cha kukula kwake kowundana
Uses	**Pesticide**	Crushed leaves are used as insecticide against lice, fleas and ticks	Masamba ophwanyidwa amagwiritsidwa ntchito ngati mankhwala ophera nsabwe, utitiri ndi nkhupakupa
	Nitrogen fixing	Boundary, barrier or support planting, erosion control or dune stabilization and soil improvement	Malire, zotchinga kapena zothandizira kubzala, kuletsa kukokoloka kapena kukhazikika kwa milu ndi kukonza nthaka.
	Ornamental	Used in gardens for its variously coloured flowers	Amagwiritsidwa ntchito m'minda za maluma chifukwa cha maluwa ake amitundu yosiyanasiyana
	Others:	Used traditionally as a fish poison (stupefying) but the fish remain perfectly edible for humans	Kaŵirikaŵiri amagwiritsidwa ntchito ngati poizoni wa nsomba (kuphera nsomba) koma nsombazo zimakhalabe zodyedwa bwino ndi anthu kopanda vuto lili lonse

Description	Soft, woody branching herb with dense foliage; stems and branches densely covered with long and short white or rusty-brown hair	Chitsamba chofewa, chamitengo chokhala ndi masamba owundana; nthambi zimakhala ndi tu tsitsi tufupi ndi tutali twa maonekedwe a dzimbiri-bulauni
	Height of mature tree: 0.5 – 4 m	Kutalika kwa mtengo wokhwima: 0.5 - 4 m
	Recommended spacing: 0.4 x 0.4 m (Green manure crop) and 0.5m between rows (for hedges)	Kutalikirana kovomerezeka: 0.4 x 0.4 m (mbewu ya manyowa obiriwira) ndi 0.5m pakati pa mizere (kwa hedge)
	Number of years for first harvest: 2-3 months old plants have Nitrogen content of 3.7 g/100 g dry matter and flowering and fruiting starts 10-12 months after planting	Chiwerengero cha zaka zokolola koyamba: Zomera za miyezi 2-3 zimakhala ndi nayitrojeni wokwanira 3.7 g pa 100 g iliyonse youma ndipo maluwa ndi zipatso zimayamba pakadutsa miyezi 10-12 mutabzala.
Propagation	Store seed for 2 months before planting; Soak the seed for 24 hours in cold water prior to sowing.	Ungani mbeu kwa miyezi iwiri musanabzale; Ziviikeni mbeu kwa maola 24 m'madzi ozizira musanabzale.
Storage	No loss in viability when stored (open storage) 2-3 years	Mbeu ingamele patapika zaka ziwiri kapena zitatu ngati yasungidwa motseguka
Management	Pruning, lopping	Kudulira, kudura
Remarks	Fire tolerant, re-sprouting after a fire due to its deep root system. However, the plant is short-lived plant, sometimes; only living for a few years.	Umapirira moto, umakuphukiranso pambuyo pa moto chifukwa cha mizu yake yakuya. Komabe, mtengoyu ulindi umoyo wawufupi, nthawi zina; umakhala zaka zochepa chabe.

A 1.7. FRUIT TREES

A 1.7.1. Mango

Name		English	Nyanja
		Mango	Mango
Botanical Name		*Mangifera indica*	
Variety		*Kent*	
Ecology		Originated from Northern India or Burma. Now grows at elevations usually below 500m; naturalized in many places, including Zambia, 0 - 2,000 m altitude. Roots grow deep.	Unachokera ku Northern India kapena Burma. Tsopano umamamera pamalo okwera nthawi zambiri pansi pa 500m; zachilengedwe m'malo ambiri, kuphatikiza Zambia, 0 - 2,000 m okwera. Mizu imakula kwambiri.
Site conditions		Hot areas with a pronounced dry season are best for regular fruiting, best in areas where annual daytime temperatures are 24 - 30°c; a mean annual rainfall in the range 600 - 1,500mm.	Malo otentha okhala ndi nyengo yowuma ndi yabwino kwa zipatso zokhazikika, zabwino kwambiri m'malo omwe kutentha kwapachaka ndi 24 - 30°c; mvula wapachaka wapakati pa 600 - 1,500mm.
Agro-Forestry Technology		Home gardens, orchards or yards.	Minda yakunyumba, minda ya zipatso kapena mayadi.
Uses	Food / Fruits	The fruit used as food is rich in vitamins A and C, eaten as raw, fruit juice or as jam. Good for fruit because it has little fibre although the skin not free from turpentine smell.	Chipatso chomwe chimagwiritsidwa ntchito ngati chakudya chimakhala ndi mavitamini A ndi C ambiri, omwe amadyedwa ngati yaiwisi, madzi a zipatso kapena jamu. Zabwino kwa zipatso chifukwa zimakhala ndi ulusi pang'ono ngakhale khungu silikhala lopanda fungo la turpentine.
	Timber	Wood is used for indoor construction, meat-chopping blocks, furniture, carpentry, flooring, boxes, crates and building of dugout canoes	Mitengo imagwiritsidwa ntchito pomanga m'nyumba, zodulira nyama, mipando, ukalipentala, pansi, mabokosi, mabokosi ndi kumanga mabwato.
	Firewood	For domestic energy supply and is used for making excellent charcoal	Popereka nkhuni zapakhomo ndipo amagwiritsidwa ntchito popanga makala abwino kwambiri
	Fodder	Fodder (leaves). Young leaves can be cooked as vegetable	Zakudya za ziweto (masamba). Masamba ang'onoang'ono akhoza kuphikidwa ngati ndiwo zamasamba
	Medicine	A mouthwash made from the leaves is effective in hardening the gums and helping to treat dental problems	Chotsukira pakamwa chopangidwa kuchokera kumasamba chimathandiza kuumitsa mokhala mano komanso kuchiza matenda a mano
	Ornamental	For planting along avenues	Ku kubzala mbali mwanjira
	Others:	Bee forage, shade, windbreak. Bark and the leaves are the source of a yellowish-brown dye used for silk.	chakudya cha njuchi, mthunzi, chitetezo ku mphepo yamkuntho. Khungwa ndi masamba ndi amene amapangira utoto wachikasu wofiirira umene umagwiritsidwa ntchito popanga silika.

Description	Mango is a dense leafy evergreen tree with a short trunk, one of the oldest cultivated plants in the world. Kent is a cultivar with smoother flesh and sweeter juice than Tommy Atkins. Kent mangoes also develop yellow tones and wrinkles as they ripen.	Mango ndi mtengo ndiweyani wa masamba obiriwira nthawi zonse wokha la ndi thunthu lalifupi, limodzi mwa zomera zakale kwambiri padziko lonse lapansi. Kent ndi mtundu womwe uli ndi thupi losalala komanso madzi okoma kuposa Tommy Atkins. Mango a Kent amakhalanso achikasu komanso makwinya akamapsa.
	Height of mature tree: 10 - 45 m	Kutalika kwa mtengo wokhwima: 10 - 45 m.
	Diameter at Breast Height of mature tree: 60 – 120cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: 60 - 120cm
	Recommended spacing: between 4-8 m in the row and 7-10 m between row	Kutalikirana kovomerezeka: pakati pa 4-8 m mzere ndi 7-10 m pakati pa mizere
	Number of years for first harvest: 5 - 8 years (Seedlings) and 3 - 5 years (Grafted)	Chiwerengero cha zaka zokolola koyamba: zaka 5 - 8 (mbande) ndi zaka 3 - 5 (zomezanitsidwa)
Propagation	Seedlings, direct seeding, grafting.	Mbande, mwachindunji seeding, zomezanitsidwa.
Seed	High germination rate. Treatment: Not necessary, but remove pulp from seed. Storage: Dry seed can be stored. For best results, fresh seed should be used.	Imamera bwino kwambiri. Chithandizo: Sichofunikira, koma chotsani zamkati mumbewu. Kasungidwe: Mbeu zouma zitha kusungidwa. Kuti mupeze zotsatira zabwino, mbewu yatsopano iyenera kugwiritsidwa ntchito.
Management	Lopping.	Kudulira
Remarks	Yields increase up to the 20th year, decline after the 40th year and the tree may live for 100 years or more. Trees for commercial fruit production are usually grafted specimens. However, in Eastern Province the mango production is not on a commercial scale.	Zokolola zimachuluka mpaka zaka 20, zimachepa pambuyo pa chaka cha 40 ndipo mtengowo ukhoza kukhala ndi moyo zaka 100 kapena kuposerapo. Mitengo yopangira zipatso zamalonda nthawi zambiri imakhala yomezanitsidwa. Komabe, ku dera la kum'mawa kwa Zambia ulimi wa mango siuli pamalonda.



Name		English	Nyanja
		Mango	Mango
Botanical Name		*Mangifera indica*	
Variety		*Local Big Mango*	*Mango ya bolomwa*
Ecology		Usually growing in the more open, secondary formations, at elevations usually below 500m. Roots grow deep.	Nthawi zambiri imamera pamalo otseguka, achiwiri, pamalo okwera nthawi zambiri pansi pa 500m. Mizu imakula kwambiri.
Site conditions		Very poor soil, or shallow land, is unsuitable. It prefers well-drained soil, does not tolerate flooding and survives in very dry areas.	Dothi lopanda nthaka, kapena losazama, ndilosayenera. Imakonda nthaka yotayidwa bwino, simalola kusefukira kwa madzi ndipo imapulumuka kumadera ouma kwambiri.
Agro-Forestry Technology		Home gardens, orchards or yards.	Minda yakunyumba, minda ya zipatso kapena mayadi.
Uses	Fruits	The fruit used as food is rich in vitamins A and C, eaten as raw, fruit juice or as jam. Good for fruit juice making because it has little fibre although the skin not free from turpentine smell.	Chipatso chomwe chimagwiritsidwa ntchito ngati chakudya chimakhala ndi mavitamini A ndi C ambiri, omwe amadyedwa ngati yaiwisi, madzi a zipatso kapena jamu. Ndibwino kupanga madzi a zipatso chifukwa ali ndi ulusi wochepa ngakhale khungu lilibe fungo la turpentine.
	Timber	Wood is used for indoor construction, meat-chopping blocks, furniture, carpentry, flooring, boxes, crates and building of dugout canoes	Mitengo imagwiritsidwa ntchito pomanga m'nyumba, zodulira nyama, mipando, ukalipentala, pansi, makereti, mabokosi ndi kumanga mabwato.
	Firewood	For domestic energy supply and is used for making excellent charcoal	Nkhuni zapanyumba ndipo amagwiritsidwa ntchito popanga makala abwino kwambiri
	Fodder	Fodder (leaves). Young leaves can be cooked as vegetable	Zakudya za ziweto (masamba). Masamba ang'ono-ang'ono akhoza kuphikidwa ngati ndiwo zamasamba
	Medicine	Bark is used to treat sore throats, coughs, bronchitis and diarrhoea.	Khungwa limagwiritsidwa ntchito pochiza zilonda zapakhosi, chifuwa, buronkaitisi ndi kutsekula m'mimba.
	Ornamental	For planting along avenues	kubzala mbari mwa njira
	Others:	Bee forage, shade, windbreak. Bark and the leaves are the source of a yellowish-brown dye used for silk.	chakudya cha njuchi, mthunzi, chitetezo ku mphepo yamkuntho. Khungwa ndi masamba ndi amene amapangira utoto wachikasu wofiirira umene umagwiritsidwa ntchito popanga silika

Description	Mango is a dense leafy evergreen tree with rounded crown; one of the oldest cultivated plants in the world, having been grown in India 4,000 years ago. This variety is preferred for juice production because it has little fibre.	Mango ndi mtengo wobiriwira wokhala ndi masamba obiriwira okhala ndi korona wozungulira; imodzi mwa zomera zakale kwambiri padziko lonse lapansi, yomwe idakula ku India zaka 4,000 zapitazo. Mtunduwu umakondedwa kwambiri popanga madzi chifukwa umakhala ndi ulusi wochepa.
	Height of mature tree: 10 - 45 m	Kutalika kwa mtengo wokhwima: 10 - 45 m
	Diameter at Breast Height of mature tree: 60 – 120cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: 60 - 120cm
	Recommended spacing: between 4-8 m in the row and 7-10 m between rows	Mipata yovomerezeka: pakati pa 4-8 m pamzere ndi 7-10 m pakati pa mizere
	Number of years for first harvest: New plants from seed take 5 - 8 years before they begin to fruit but grafted plants commence bearing in 3 - 5 years	Chiwerengero cha zaka zokolola koyamba: Zomera zatsopano kuchokera kumbewu zimatenga zaka 5 - 8 kuti ziyambe kubereka koma zomezanitsidwa (zokwatisidwa) zimayamba kubala pakadutsa zaka 3 - 5.
Propagation	Seedlings, direct seeding, grafting.	Mbande, kubzala njele kulumikiza kapena kukwatisa
Seed	High germination rate. Treatment: Not necessary, but remove pulp from seed. Storage: Dry seed can be stored. For best results, fresh seed should be used.	Kumera bwino kwambiri. Chithandizo: Sichofunikira, koma chotsani zamkati mumbewu. Kasungidwe: Mbeu zouma zitha kusungidwa. Kuti mupeze zotsatira zabwino, mbewu yatsopano iyenera kugwiritsidwa ntchito.
Management	Lopping.	Kudulira
Remarks	Yields increase up to the 20th year, decline after the 40th year and the tree may live for 100 years or more. Trees for commercial fruit production are usually grafted specimens. However, in Eastern Province the mango production is not on a commercial scale.	Zokolola zimachuluka mpaka zaka 20, zimachepa pambuyo pa chaka cha 40 ndipo mtengowo ukhoza kukhala ndi moyo zaka 100 kapena kuposerapo. Mitengo yopangira zipatso zamalonda nthawi zambiri imakhala yomezanitsidwa. Komabe, ku dera la kum'mawa kwa Zambia ulimi wa mango siuli pamalonda.

A 1.7.2. Citrus (Lemon and Orange)



Name		**English**	**Nyanja**
		Orange	Lalanje
Botanical Name		*Citrus sinensis*	
Variety		*Washington navel*	
Ecology		Originated from Southern China or Vietnam. Oranges are the most widely grown and important citrus fruit, very widely grown both in the tropics and subtropics. The tree is to be found in all districts planted either by individual farmers or institutions.	Unachokera ku mwera kwa China kapena Vietnam. Malalanje ndi chipatso chomwe chimabzalidwa kwambiri komanso chofunikira kwambiri, chomwe chimabzalidwa kwambiri kumadera otentha kwambiri komanso kumadera otentha pang'ono. Mtengowu uyenera kupezeka m'maboma onse omwe abzalidwa ndi alimi kapena mabungwe.
Site conditions		Does not do well in very wet areas or at high altitudes. Heavy loam with a generous amount of compost and sand added; optimal mean day-time temperatures are 25 - 30°c They produce more fruit with irrigation.	Siuchita bwino m'malo onyowa kwambiri kapena pamalo okwera. Nthaka ya bwino loam wolemera ndi kuchuluka kwa kompositi ndi mchenga wowonjezera; Kutentha koyenera masana ndi 25 - 30°c Umabala zipatso zambiri ndi ulimi wothirira.
Agro-Forestry Technology		Home gardens, orchards or yards.	Minda yakunyumba, minda ya zipatso kapena mayadi.
Uses	**Food / Fruits**	Eaten both fresh (food) and for juice: a ripe orange contains about 12% sugar. A glass of orange juice provides the daily requirement of vitamin C.	Umadyedwa ngati chipaso komanso amapanga zamadzimadzi: lalanje lakupsa lili ndi pafupifupi 12% shuga. Kapu yamadzi a lalanje imapereka kufunikira kwa tsiku ndi tsiku kwa vitamini C.
	Ornamental	For planting along avenues.	Kwa kubzala mbari mwa njira.
	Others	Bee forage: The strong fragrance attracts bees to the flowers which have much nectar and sticky pollen. Essential oils can be extracted from flowers, leaves and peel.	Zakudya za Njuchi: Fungo lamphamvu limakopa njuchi ku maluwa omwe ali ndi timadzi tokoma komanso mungu womata. Mafuta ofunikira amatha kuchotsedwa mumaluwa, masamba ndi makungwa a chipatso

Description	In general, an orange is a well-shaped tree with dense foliage and rather thin spines beside leaves. The twigs are angled when young. Washington navel is one of the most popular citrus trees to grow in Zambia and is the most beloved orange tree for backyard growers.	Nthawi zambiri, lalanje ndi mtengo wowoneka bwino wokhala ndi masamba owundana komanso minga yopyapyala pambali pa masamba. Nthambizo zimapindika akadakali aang'ono. Washington Navel ndi imodzi mwamitengo ya lalanje yomwe imamera ku Zambia ndipo umakondedwa kwambiri alimi amene akonda kubzala mbeu kuseri kwa nyumba.
	Height of mature tree: 6-13m	utalika kwa mtengo wokhwima: 6-13m
	Recommended spacing: 6 X 6 m	Kutalikirana kovomerezeka: 6 X 6 m
	Number of years for first harvest: starts flowering and bearing fruit after 3-5 years	Chiwerengero cha zaka zokolola koyamba: imayamba kutulutsa maluwa ndi kubala zipatso pambuyo pa zaka 3-5
Propagation	Budding or grafting on rootstock of rough lemon. Layering	kulumikiza kapena kukwatisa pa mtengo wa lemon. Kubzala pa mtengo wina
Management	Pruning to encourage branching and to keep the fruit low for harvesting. Watering and mulching	Kudulira pofuna kulimbikitsa kupanga nthambi komanso kuti zipatso zikhale zochepa kuti zikololedwe. Kuthirira ndi kuvinikira ndi zinyalala
Remarks	This is one of the many desirable cultivars raised from grafting. It is one of the most common varieties in Eastern Province besides Valencia though it is has bigger fruit with less seed and a more juicy fruit.	Ichi ndi chimodzi mwa mbeu zofunika kwambiri kuchokera ku zolumikiza Ndi imodzi mwa mitundu yodziwika bwino ku Eastern Province kupatula ku Valencia ngakhale ili ndi zipatso zazikulu zokhala ndi njere zochepa komanso zipatso zowutsa mudyo.



Name		English	Nyanja
		Orange	Lalanje
Botanical Name		*Citrus sinensis*	
Variety		*Valencia*	
Ecology		Originated from Southern China or Vietnam. Oranges are the most widely grown and important citrus fruit, very widely grown both in the tropics and subtropics. The tree is to be found in all districts planted either by individual farmers or institutions.	Unachokera ku m'mwera kwa China kapena Vietnam. Malalanje ndi chipatso chomwe chimabzalidwa kwambiri komanso chofunikira kwambiri, chimabzalidwa kwambiri kumadera otentha komanso kumadera otentha pang'ono. Mtengowu uyenera kupezeka m'maboma onse utabzalidwa ndi alimi kapena mabungwe.
Site conditions		Does not do well in very wet areas or at high altitudes. Heavy loam with a generous amount of compost and sand added; optimal mean day-time temperatures are 25 - 30°c They produce more fruit with irrigation.	Mtengoyu Siuchita bwino m'malo onyowa kwambiri kapena pamalo okwera kwambiri. Nthaka yabwino yolemera ndi kuchuluka kwa zinyalala zowolela ndi mchenga wowonjezera; Kutentha koyenera masana ndi 25 - 30°c. Umabala zipatso zambiri ngati uthililidwa ndi madzi.
Agro-Forestry Technology		Home gardens, orchards or yards.	Minda yakunyumba, minda ya zipatso kapena mayadi.
Uses	**Food / Fruits**	Eaten both fresh (food) and for juice: a ripe orange contains about 12% sugar. A glass of orange juice provides the daily requirement of vitamin C.	Imadyedwa ya tunthu komanso komanso madzi a muchipaso angafinyidwe ndi kumwedwa. lalanje lakupsa lili ndi pafupifupi 12% shuga. Kapu yamadzi a lalanje imapereka kufunikira kwa tsiku ndi tsiku kwa vitamini C.
	Ornamental	For planting along avenues.	Kubzalidwa mbari mwa njira.
	Others	Bee forage: The strong fragrance attracts bees to the flowers which have much nectar and sticky pollen. Essential oils can be extracted from flowers, leaves and peel.	Zakudya za Njuchi: Fungo lamphamvu limakopa njuchi ku maluwa omwe ali ndi timadzi tokoma komanso mungu womata. Mafuta ofunikira amatha kuchotsedwa mumaluwa, masamba ndi makoko.

Description	In general, an orange is a well-shaped tree with dense foliage and rather thin spines beside leaves. The twigs are angled when young. Valencia is a sweet orange cultivar, originated from a backcross hybrid between pummelo and mandarin orange and named after the famed oranges in Valencia, Spain.	Nthawi zambiri, lalanje ndi mtengo wowoneka bwino wokhala ndi masamba owundana komanso minga yopyapyala pambali pa masamba. Nthambizo zimapindika ukadakali wa ung'ono. Valencia ndi mtundu wotsekemera wa malalanje, wochokera ku mtundu wosakanizidwa wa backcross pakati pa pummelo ndi mandarin orange ndipo umatchedwa dzina la malalanje otchuka ku Valencia, Spain.
	Height of mature tree: 6-13m	Kutalika kwa mtengo wokhwima: 6-13m
	Recommended spacing: 6 X 6 m	Kutalikirana kovomerezeka: 6 X 6 m
	Number of years for first harvest: starts flowering and bearing fruit after 3-5 years	Chiwerengero cha zaka zokolola koyamba: imayamba kutulutsa maluwa ndi kubala zipatso pambuyo pa zaka 3-5
Propagation	Budding or grafting on rootstock of rough lemon. Layering	kulumikiza kapena kukwatisa pa mtengo wa lemon. Kubzala pa mtengo wina
Management	Pruning to encourage branching and to keep the fruit low for harvesting. Watering and mulching	Kudulira pofuna kulimbikitsa nthambi komanso kuti zipatso zikhale m'musi kuti zikololedwe bwino. Kuthirira ndi kuika zolowela mbali mwa mtengo
Remarks	There are many cultivars, and desirable ones are grafted onto rootstock trees grown from seed. Most citrus can be both self- and cross-pollinated. This is one of the most common varieties in Eastern Province besides Washington Navel; it is sweeter.	Pali mitundu yambiri yopangidwa, ndipo yofunikira imamezetsanidwa pamitengo yachitsa yobzalidwa ku njele. Mitundu yambiri ya imatha kukhala yodzipangira nokha komanso yodzipangira mungu. Iyi ndi imodzi mwa mitundu yodziwika bwino ku dela la kum'mawa kwa Zambia kupatulako Washington Navel; ndi zokoma.



Name		English	Nyanja
		Lemon	Ndimu
Botanical Name		Citrus limon	
Ecology		Likely originated from Northeastern India, Northern Myanmar or China. Widely grown for its edible fruit in warm temperate and tropical zones.	Ayenera kuti adachokera kumpoto cha-kum'mawa kwa India, ku mpoto kwa Myanmar kapena China. Amabzalidwa chifukwa cha zi-patso zake zodyedwa m'madera otentha pang'ono komanso otentha kwambiri.
Site conditions		Growing conditions preferred are: mod-erately heavy loam soil (with compost and sand added) and temperature be-tween 25 - 30°c. Plants are intolerant of water logging and manure.	Umakula bwino mu nthaka: ya bwino yolema pang'ono (yowonjezera kompositi ndi mchenga) ndi kutentha kwapakati pa 25 - 30 ° C. mtengoyu sumachita bwino ku madzi ya mbiri
Agro-Forestry Technology		Home gardens, orchards or yards.	Minda yakunyumba, minda ya zipatso kapena ma-yadi.
Uses	Food / Fruits	Fruit (with very acid taste and rich in Vit-amin C) is eaten raw or cooked. Mainly used as a drink, as a flavouring in salad dressings	Chipatso (chokoma kwambiri cha asidi komanso vitamini C wochuluka) chimadyedwa chosaphika kapena chophikidwa. Amagwiritsidwa ntchito makamaka ngati chakumwa, monga chokom-etsera zakudya za masaladi
	Timber	Nicely veined wood can be polished beautifully and useful in carpentry.	Mitengo yamitsempha yabwino imatha kupukutidwa mokongola komanso yothandiza pantchito ya ukalipentala.
	Leaves	Dried leaves are mixed with tea leaves for use as flavouring while flowers are eaten in ice creams, fritters and jams.	Masamba owuma amasakanizidwa ndi masamba a tiyi kuti agwiritsidwe ntchito ngati zokom-etsera, pamene maluwa amadyedwa mu ayis-ikilimu, zitumbuwa ndi jamu.
	Medicine	Vitamin C found in the fruit helps the body to fight off infections; juice is used as a gargle for sore throats and as a sub-stitute for quinine in treating malaria and other fevers; skin of the ripe fruit is be-lieved to tone the stomach, improve its function and increase appetite.	Vitamini C wopezeka mu chipatsocho amathandiza thupi kulimbana ndi matenda; madzi amagwiritsidwa ntchito ngati fungo la zilonda zapakhosi komanso m'malo mwa kwinini pochiza malungo ndi matenda oten-tha thupi ena; Khungu la zipatso zakupsa li-manthandiza kuti mimba izigwira bwino ncthito yake komanso ndi kuonjezera njala.
	Others:	Oil obtained from the seed is used in soap making, while juice of the fruit is used for removing ink stains and as a bleaching agent.	Mafuta otengedwa ku njere amagwiritsidwa ntchito popanga sopo, pomwe madzi a chipatsocho amagwiritsidwa ntchito pochotsa madontho a inki komanso ngati mankhala yoletsera nsalu

Description	Lemon is a spiny, evergreen small tree with sweetly scented flowers	Ndimu ndi mtengo waung'ono wobiriwira nthawi zonse wokhala ndi maluwa onunkhira bwino
	Height of mature tree: 3 - 6m	Kutalika kwa mtengo wokhwima: 3 - 6m
	Recommended spacing: 4.5 X 4.5 m	Kutalikirana kovomerezeka: 4.5 X 4.5 m
	Number of years for first harvest: 3-5 years (seedlings) and 1 - 3 years (grafted)	Chiwerengero cha zaka zokolola koyamba: zaka 3-5 (mbande) ndi zaka 1-3 (zomeza-nitsidwa kapena zokwanitsana)
Propagation	Seeds, cuttings and layering	Mbewu, tu mitengo to dula. Kubzala pa mtengo wina
Seed	High germination rate. Treatment: Thoroughly wash seed before sowing. When large enough to handle, prick the seedlings out into individual pots and grow them on until they are 10cm or more tall before planting out into their permanent positions.	Zimamera bwino kwambiri. Chithandizo: Tsukani bwino mbeu musanabzale. Mbande zikakula mokwanira, bayani mbande mupepala yake yokhayokha ndikulolola kuti ikule mpaka 10cm kapena kupitilira apo musanabzale pamalo.
Remarks	Lemon contains a wide range of active ingredients and research is still underway in finding uses (including medical) for them. Thus, propagation of this species is encouraged.	Ndimu ili ndi zinthu zambiri zomwe zimagwira ntchito ndipo kafukufuku akadali mkati mwa kupeza ntchito (kuphatikiza zachipatala) zomwe mtengoyu ungagwire.. Choncho, kubzala mtunduwu kumalimbikitsidwa.



Name		English	Nyanja
		Tangerine, Mandarin or Nuts	Mandalena
Botanical Name		Citrus reticulata	
Ecology		Likely originated from East Asia (Probably China or Indo-China). Widely grown for its edible fruit in warm temperate and tropical zones.	Uyenera kuti udachokera ku m'mawa kwa Asia (Mwina China kapena Indo-China). Umalimidwa chifukwa cha zipatso zake zodyedwa m'madera otentherako pang'ono komanso otenthelatu.
Site conditions		Growing conditions preferred are: moderately heavy loam soil (with compost and sand added) and temperature between 25 - 30°c. Plants are intolerant of water logging and manure.	Kuti mtengowu ukule bwino umafuna: nthaka ya bwino yolemera pang'ono (yowonjezera kompositi ndi mchenga) ndi kutentha kwapakati pa 25 - 30 ° C. Siumakula bwino ku malo yochuluka madzi manyowa.
Agro-Forestry Technology		Home gardens, orchards or yards.	Minda yakunyumba, minda ya zipatso kapena mayadi.
Uses	Food / Fruits	A thin-skinned fruit with a very pleasant, acidic-sweet flavour and delicious is eaten raw or cooked. Mainly used in cakes	Chipatso chopyapyala chokhala ndi kukoma kokoma kwambiri, asidi-lokoma ndi zokoma zimadyedwa zosaphika kapena zophikidwa. Imagwiritsidwa ntchito ku makeke
	Medicine	Fruit and it skin is used as antidote for cough (with profuse phlegm), hiccup and vomiting. Seed is used in the treatment of hernia and, pain or swelling of the testes	Chipatso ndi khungu lake zimagwiritsidwa ntchito ngati mankhwala a chifuwa , kuvutika kupuma ndi kusanza. Mbewu imagwiritsidwa ntchito pochiza chophukacho, kupweteka kapena kutupa kwa ma machende
Description		Small thin-skinned variety of orange belonging to the mandarin orange species, evergreen tree with axillary thorns	Mitundu yaying'ono yakhungu yopyapyala yamtundu walalanje wa mandarin, mtengo wobiriwira wokhala ndi minga ya mbari
		Height of mature tree: 3 - 8m	Kutalika kwa mtengo wokhwima: 3 - 8m
		Recommended spacing: 4 X 5m	Kutalikirana kovomerezeka: 4 X 5m
		Number of years for first harvest: 3 - 4 years (Seedlings)	Chiwerengero cha zaka zokolola koyamba: 3 - 4 zaka (mbande)
Propagation		Seeds, cuttings and layering	Mbewu, zodula, kubzala pa mtengo wina
Seed		High germination rate. Treatment: Thoroughly wash seed before sowing. When large enough to handle, prick the seedlings out into individual pots and grow them on until they are 10cm or more tall before planting out into their permanent positions.	Imemela bwino kwambiri. Thandizo: Tsukani bwino mbeu musanabzale. Mbande zikakula mokwanira, bayani mbande mutumapulasiti ndikuyikulitsa mpaka 10cm kapena kupitilira apo musanabzale pamalo ake okhazikika.
Remarks		Popular fruit, widely available in countries around the world. It has been in cultivation for at least 3,000 years; fruit has a wide market since it is sweet. Tangerine contains a wide range of active ingredients and research is still underway in finding uses (including medical) for them. Thus, propagation of this species is encouraged.	Zipatso zotchuka, zomwe zimapezeka kwambiri m'maiko padziko lonse lapansi. Yakhala ikulimidwa kwa zaka zosachepera 3,000; zipatso zili ndi msika waukulu chifukwa ndizo tsekemela. Tangerine ili ndi zinthu zambiri zomwe zimagwira ntchito ndipo kafukufuku akadali mkati mwa kupeza ntchito (kuphatikiza zamankhwala) za izo. Choncho, kubzala mtengoyu kumalimbikitsidwa.

A 1.7.3. Other fruit trees



Name		English	Nyanja
		Pawpaw	Papayi
Botanical Name		Carica papaya	
Ecology		Originated from Tropical America and Southern Mexico. A small, fast-growing but short-lived, evergreen fruit tree grown in the tropical and subtropical areas with a mild climate including in Africa. It has a shallow root system.	Amachokera ku Tropical America ndi Southern Mexico. Mtengo wawung'ono, womwe ukukula mwachangu koma waufupi, wobiriwira nthawi zonse womwe umamera m'madera otentha komanso otentha komanso nyengo yabwino kuphatikiza ku Africa. Ili ndi mizu yozama.
Site conditions		Produces best at elevations below 900m; annual daytime temperatures of 21 - 30°c; mean annual rainfall of 1,500 - 2,500mm; suitable soils are humus- rich, well drained and fertile and in areas sheltered from strong winds. It is planted around homesteads throughout Zambia.	Imakula bwino pamalo okwera pansi pa 900m; kutentha kwa masana - 21-30 ° C; mvula yapachaka ya 1,500 - 2,500mm; Nthaka yoyenera imakhala ndi zowolela, yotayidwa bwino komanso yachonde komanso m'malo otetezedwa ku mphepo yamphamvu. Amabzalidwa mozungulira nyumba madela onse za Zambia.
Agro-Forestry Technology		Home gardens, orchards or yards; young leaves are used as mulch	minda yanyumba, minda ya zipatso kapena mabwalo; masamba ang'onoang'ono amagwiritsidwa ntchito ngati zinyalala za m'munda
Uses	Food / Fruits	Food (fruit); raw or cooked. Made into drink (fruit), meat tenderizing (leaves or fruit). Can be preserved, dried or cooked in pies and made into jam. Immature green fruit can be eaten as a vegetable (boiled, baked or added to vegetable soups).	Chakudya (chipatso); yaiwisi kapena yophikidwa. Amapangidwa kukhala chakumwa (chipatso), nyama tenderizing (masamba kapena zipatso). Zitha kusungidwa, zouma kapena kuphikidwa mu pie ndikupangidwa kukhala kupanikizana. Zipatso zobiriwira zosakhwima zimatha kudyedwa ngati masamba (yophika, yophika kapena kuwonjezeredwa ku supu zamasamba).
	Medicine	Leaves are used to treat whooping cough and roots to treat sexually transmitted diseases. Juice of the fruit is used to treat diabetes and hypertension. Leaves and seeds are used locally to rid the body of threadworms and roundworms. Immature seeds are swallowed to treat diarrhoea	Masamba amagwiritsidwa ntchito pochiza chifuwa cha chiphuphu komanso mizu pochiza matenda opatsirana pogonana. Madzi a chipatsocho amagwiritsidwa ntchito pochiza matenda a shuga ndi matenda othamamga mtima. Masamba ndi njere zimagwiritsidwa ntchito kuchotsa ulusi ndi nyongolotsi. Mbewu zosakhwima zimamezedwa pochiza matenda otsekula m'mimba
	Others:	Meat can be tenderized by wrapping it in pawpaw leaves.	Nyama imatha kufewa poyikulunga m'masamba a papaya

Description	A tree-like herb, the soft fibrous trunk to 20 cm across, narrowing to a crown of leaves.	Chitsamba chofanana ndi mtengo, thunthu lofewa la ulusi mpaka 20 cm m'litali, locheperako mpaka korona wa masamba.
	Height of mature tree: 3-10 m	Kutalika kwa mtengo wokhwima: 3-10 m
	Diameter at Breast Height of mature tree: 10 - 30cm	M'mimba mwake pa chifuwa cha mtengo wokhwima :10 - 30cm
	Recommended spacing: 2.1 – 3.7m apart (For plantation)	Kutalikirana kovomerezeka: 2.1 - 3.7m motalikirana (Podzala)
	Number of years for first harvest: 6 months old and can produce fruit all year round	Chiwerengero cha zaka zokolola koyamba: miyezi isanu ndi umodzi ndipo imatha kubala zipatso chaka chonse
Propagation	Seedlings, direct sowing at site; grows easily from seed. Grafting, greenwood cuttings	Mbande, kubzala mbeu pa malo; chimakula mosavuta kuchokera ku mbewu. Kulumikiza, zodula, zobiliwira
Seed	Collected seed from ripe fruit. Dry in air. Store under cool and dry conditions. Viability is up to 3 years.	Mbeu zotoledwa ku zipatso zakupsa. Umitsani mu mphepo. Sungani pamalo ozizira ndi owuma. Mbeu ingamele angakhale patapita zaka zitatu.
Management	Germination takes 1- 4 weeks. Weeding is essential as pawpaw is sensitive to root damage. In plantations, space plants 2- 4 m apart and have 1 male tree for every 25 female trees.	Kumera kumatenga masabata 1-4. Kupalira n'kofunika chifukwa nkhape imamva kuwonongeka kwa mizu. M'minda, zomera zakuthambo zimatalikirana ndi 2- 4 m ndipo zimakhala ndi mtengo wamphongo umodzi pamitengo 25 iliyonse yaikazi.
Remarks	Trees do well for 3-4 years then yield falls, so plant every 4 years on a fresh site. The tree is attacked by several insects.	Mitengo imakula bwino kwa zaka 3-4 kenako zokolola zimagwa, choncho bzalani zaka zinayi zilizonse pamalo atsopano. Mtengowo umagwidwa ndi tizilombo zingapo.



Name		English	Nyanja
		Tamarind (Indigenous)	Mwemba
Botanical Name		Tamarindus indica	
Ecology		A well-known, long lived and beautiful fruiting African tree from West to South Africa. In Zambia, it is very common in the Zambezi and Luangwa Valleys on river banks and on anthills. Elsewhere, it is only found around lakes Tanganyika and Mweru	Mtengo wodziwika bwino, wokhala ndi nthawi yayitali komanso wokongola wa zipatso za ku Africa kuchokera Kumadzulo mpaka ku South Africa. M'dziko la Zambia, umapezeka kwambiri m'zigwa za Zambezi ndi Luangwa m'mphepete mwa mitsinje ndi pa zitunda. Kumalo ena, umapezeka pafupi ndi nyanja Tanganyika ndi Mweru
Site conditions		It is a very adaptable species but prefers semi-arid areas and is drought-resistant once the deep roots are established. Associated with termite mounds in wooded grassland, and found along stream and riverbanks at 0-1500 m in altitude; with annual daytime temperatures of 20 - 35°c; mean annual rainfall of 800 - 3,000mm; well-drained, fertile and sandy soils.	Ndi mtundu womwe umatha kusintha pa malo yosiyana soyana koma umakonda madera ouma ndipo sumva chilala mizu yakuya ikakhazikika. Zogwirizana ndi machulu a chiswe m'malo a nkhalango wamitengo, ndipo amapezeka m'mphepete mwa mitsinje ndi m'mphepete mwa mitsinje pamtunda wa 0-1500 m; kutentha kwa masana ndi 20-35 ° C; mvula yapachaka ya 800 - 3,000mm; dothi lotayidwa bwino, lachonde komanso lamchenga.
Agro-Forestry Technology		Nitrogen fixing, suitable for firebreaks as no grass will grow under the trees and as windbreaks (deep roots make it very resistant to storms).	Kupanga nayitrojeni, koyenera pozimitsa moto chifukwa palibe udzu umene ungamere pansi pa mitengo komanso ngati zotchingira mphepo (mizu yozama imapangitsa kuti zisawonongeke ku mphepo yamkuntho).
Uses	Food / Fruits	Food (fruit, pulp for drink, spice); the fruit pulp is used to make a drink and the pulp is also mixed with porridge. This fruit pulp is very rich in vitamin C.	Zakudya (zipatso, zamkati zakumwa, zonunkhira); chipatsocho chimagwiritsidwa ntchito popangira chakumwa ndipo zamkati zimasakanizidwanso ndi phala. Chipatso ichi chili ndi vitamini C wambiri.
	Timber	Dark-brown heartwood is tough and well grained, used for carpentry, wooden utensils, agricultural tools, mortars, boat planks, toys, panels and furniture	Mitengo yamtundu wakuda ndi yolimba komanso yopangidwa bwino, imagwiritsidwa ntchito ndi akalipentala, ziwiya zamatabwa, zida zaulimi, matope, matabwa a ngalawa, zosewerets a, mapanelo ndi mipando.
	Firewood	Provides a good firewood with high calorific value and the wood produces excellent charcoal	Zimapereka nkhuni zabwino zokhala ndi mphamvu zopatsa mphamvu zambiri ndipo nkhunizo zimatulutsa makala abwino kwambiri
	Fodder	Fodder (leaves, fruit)	Chakudya cha ziweto (masamba, zipatso)
	Seed / Seedpod	Seedpod eaten raw and cooked. Used as a seasoning and also to make juices and paste. Immature pods are eaten fresh or mixed with spices or added whole to soups	Makoko a mbewu zimadyedwa zosaphika komanso zophikidwa. Amagwiritsidwa ntchito ngati zokometsera komanso kupanga timadziti ndi phala. Makoko osakhwima amadyedwa mwatsopano kapena osakanizidwa ndi zokometsera kapena kuwonjezeredwa ku supu

Uses	**Medicine**	Powdered seeds to cure dysentery and diarrhoea. Sweetened extract obtained by boiling leaves is good against throat infection, cough, fever, and intestinal worms.	Ufa wa mbewu umachiza kamwazi ndi kutsekula m'mimba. Zotsekemera zotengedwa ndi masamba owira zimakhala zabwino motsutsana ndi matenda a pa khosi, chifuwa, kutentha thupi, ndi mphutsi za m'mimba.
	Ornamen-tal	For planting in home gardens.	Za kubzala m'minda yapanyumba.
	Others:	Bee forage, shade, windbreak, tannin (bark).	Chakudya cha njuchi, mthunzi, chitetezo ku mphepo ya m'mkuntho, taninini (makungwa).
Description		Large semi-evergreen tree with a heavy, dense crown, a short trunk and drooping branches.	Mtengo wawukulu wobiriwira wokhala ndi korona waukulu, wandiweyani, thunthu lalifupi komanso nthambi zogwa.
		Height of mature tree: Up to 30 m	Kutalika kwa mtengo wokhwima: Kufikira 30 m
		Diameter at Breast Height of mature tree: 100 – 200cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: 100 - 200cm
		Recommended spacing: 12 X 12m	Kutalikirana kovomerezeka: 12 X 12m
		Number of years for first harvest: Bearing fruit at 7 - 10 years of age with maximum yields being obtained from about 15 years onwards; trees can continue yielding for 200 years.	Chiwerengero cha zaka zokolola koyamba: Kubala zipatso pa zaka 7 - 10, ndipo zokolola zambiri zimapezedwa kuyambira zaka 15 kupita mtsogolo; mitengo ikhoza kupitiriza kubereka kwa zaka 200.
Propagation		Seedlings, wildings, direct seeding, air – layering, grafting and cuttings of greenwood	Mbande, tumitengo, kubzala mbewu, kubzala pa mtengo wina, kulumikiza ndi kudula tumitengo to biliwira.
Seed		High germination rate. Treatment: Soak seed in hot water and allow to cool for 24-48 hours. storage: Seed can be stored for more than 2 years	Zimamera bwino kwambiri. Chithandizo: Zilowetseni mbeu m'madzi otentha ndikulola kuti zizizire kwa maola 24-48. kasungidwe: Mbewu zitha kusungidwa kwa zaka ziwiri
Management		Pollarding, coppicing.	Kudulira, kudula ndikulola kuti mtengo uphikire
Remarks		No known threat as the population is quite large. Not very compatible with other plants in Agro-Forestry because of its dense shade, broad spreading crown and growth inhibiting effects on neighbouring plants.	Palibe chiwopsezo chodziwika chifukwa chiwerengero chake ndi chachikulu. Sugwirizana kwambiri ndi zomera zina za ulimi wa mitengo pamodzi ndi mbeu zina chifukwa cha mthunzi wake wandiweyani, korona wofalikira komanso kulepheretsa kukula kwa zomera zoyandikana nazo.



Name		English	Nyanja
		Avocado	Kotapela
Botanical Name		*Persea americana*	
Variety		*Hass*	
Ecology		Originated from America. An attractive, large, spreading, evergreen fruit tree with an irregular, dense crown. Tree has been distributed all over the tropics and subtropics. Found in humid lowland forests on limestone formations.	Inachokera ku America. Mtengo wokongola, wawukulu, wofalikira, wobiriwira nthawi zonse wokhala ndi korona wosakhazikika, wandiweyani. Mtengowu upezeka m'madera onse otentha komanso otentha pang'ono. Umapezeka m'nkhalango zonyowa pamapiri la dothi la limestone
Site conditions		Grows at elevations as high as 2,800m; with an annual rainfall of 500 - 2,000mm; annual daytime temperatures of 14 - 40°c and sandy loam well-drained soil - the plant is intolerant of waterlogging Requires wind-sheltered area and watering every two to three days.	Imakula pamalo okwera mpaka 2,800m; ndi mvula yapachaka ya 500 - 2,000mm; Kutentha kwapachaka masana kwa 14 - 40°c ndi dothi la loam lamchenga lotayidwa bwino - mbewuyo simachita bwino ku malo yokhazikika madzi. Imafuna malo otetezedwa ndi mphepo ndikuthirira pakapita masiku awiri kapena atatu aliwonse.
Agro-Forestry Technology		Home gardens, orchards and yards. Difficult to intercrop due high competition with crops.	Minda yakunyumba, minda ya zipatso ndi mayadi. Ndiyovuta kuilima ndi mbewu zosiyanasiyana chifukwa cha mpikisano waukulu ndi mbewuzo
Uses	Food / Fruits	Food (fruit); the fruit is very nutritious, rich in fat, protein and vitamins. Eaten raw or used as a sandwich spread	Chakudya (chipatso); chipatsocho ndi chopatsa thanzi kwambiri, chimakhala ndi mafuta ambiri, mapuloteni ndi mavitamini. Imadyedwa yaiwisi kapena kugwiritsidwa ntchito ngati zopaka pa sangwenji
	Timber	Wood used for house building, light construction, furniture, cabinet making, agricultural implements and carving. It also yields a good-quality veneer and plywood.	Mitengo yomangira nyumba, ntchito zomangamanga zing'onozing'ono, ya mipando, yopangira makabati, zida zaulimi ndi zosemasema. Zimaperekanso matabwa abwino komanso plywood
	Fodder	Not suitable; bark, leaves and seeds are toxic to browsing livestock.	Zosayenerera; Khungwa, masamba ndi njere ndi poyizoni ku ziweto zodyera kumitengo ndi vitsamba
	Medicine	An infusion of boiled leaves is said to be good for anaemia and dysentery. It is also used for relieving coughs, lowering blood pressure, treating liver obstructions	Madzi ya masamba owiritsa ndiyabwino kwa anthu ochepa magazi m'thupi komanso anthu odwala kamwazi. Amagwiritsidwanso ntchito pochotsa chifuwa, kuchepetsa kuthamanga kwa magazi, kuchiza matenda a chiwindi
	Others:	Oil (fruit), shade, cosmetics. A tea can be made from the leaves. Toasted leaves are used as a flavouring in stews and bean dishes	Mafuta (chipatso), mthunzi, zodzoladzola. Tiyi akhoza kupangidwa kuchokera masamba. Masamba ofufuzidwa amagwiritsidwa ntchito ngati chokometsera mu mphodza ndi ndiwo za nyemba

Description	Generally, Avocado is a densely leafy evergreen tree with a straight bole. The Hass is a cultivar with dark green–colored, bumpy skin. It was first grown and sold by horticulturist Rudolph Hass from USA, who also gave it his name. Hass is a large-sized fruit weighing 200 to 300 grams.	Nthawi zambiri, kotapela ndi mtengo wobiriwira wokhala ndi mtengo wowongoka. Hasi ndi mtundu wa mbeu wokhala ndi khungu lobiriwira-lakuda, lopindika. Idayamba kukula ndikugulitsidwa ndi katswiri wamaluwa Rudolph Hass waku USA, yemwe adayipatsanso dzina lake. Hass ndi zipatso zazikulu zolemera 200 mpaka 300 magalamu.
	Height of mature tree: 8-10 m, sometimes up to 20 m	Kutalika kwa mtengo wokhwima: 8-10 m, nthawi zina mpaka 20 m
	Diameter at Breast Height of mature tree: 45cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: 45cm
	Recommended spacing: 7 X 7 m to 10 X 10 m	Kutalikirana kovomerezeka: 7 X 7 m mpaka 10 X 10 m
	Number of years for first harvest: 6- 8 (Seedlings) and 2 (Grafts)	Chiwerengero cha zaka zokolola koyamba: 6-8 (mbande) ndi 2 (Zomera)
Propagation	Grafted materials (improved varieties), seedlings.	Kukwatitsa (ndi mitundu yabwino), mbande.
Seed	Germination takes 4-6 weeks. Treatment (remove seed coat to reduce germination to about 17 days) is not necessary. Seed sown fresh for best results. Storage: Seed does not store well. Use fresh seed	Kumera kumatenga masabata 4-6. Chithandizo (chotsani chikhoto kuti mbeu zimere mwansanga mpaka masiku 17). Mbewu yofesedwa ikhale ya tsopano kuti ichite bwino. Kusunga: Mbewu sizisungika bwino. Gwiritsani ntchito mbewu zatsopano
Management	Can be side-pruned to obtain the desired shape. Reduce fire hazard by pruning. To promote flowers and fruit, cut roots in a trench, narrowly ring bark and even beat with a stick!	Ikhoza kudulidwa mbali kuti mupeze mawonekedwe omwe mukufuna. Chepetsani ngozi ya moto podulira. Kuti maluwa ndi zipatso zichuluke , dulani mizu mu ngalande, pangani mphete zing.ono m'makungwa komanso kumenya ndi ndodo!
Remarks	The high demand for fruit in Eastern Province is currently met from outside the Province. Hass avocado fruit has great potential on the export market. Due to popularity of the fruit, the wood is seldom used but has been used	Kufunika kwakukulu kwa zipatso m'chigawo cha kudela la Kum'mawa kukukwaniritsidwa kuchokera kunja kwa Chigawochi. Chipatso cha kotapela cha Hass chili ndi kuthekera kwakukulu pamsika wa kunja. Chifukwa cha kutchuka kwa chipatsocho, mtengoyu siumagwiritsidwa mu ntchito zina



Name		English	Nyanja
		Guava	Gwawa
Botanical Name		Psidium guajava	
Ecology		Originated from South and Central America. A small fruit tree widely cultivated in the tropics, including Africa. Common in disturbed places often forming thickets in pastures, plantations and other similar habitats. It is grown at altitudes of 0 - 2,700 m and found all over Zambia in villages and gardens	Unachokera ku South ndi Central America. Mtengo wawung'ono wa zipatso womwe umalimidwa kwambiri kumadera otentha, kuphatikiza Africa. Zofala m'malo osokonekera nthawi zambiri zimapanga nkhalango m'malo odyetserako ziweto, m'minda ndi malo ena ofanana. Amabzalidwa pamalo okwera 0 - 2,700 m ndipo amapezeka ku Zambia konse m'midzi ndi m'minda.
Site conditions		Highest yields at mean temperatures of 23 - 28°c; annual rainfall of 1,000 - 3,000mm and a fertile, moisture-retentive soil (Does not withstand water-logging) and is drought-hardy.	Zokolola zapamwamba kwambiri pa kutentha kwapakati pa 23 - 28 ° C; mvula yapachaka ya 1,000 - 3,000 mm ndi nthaka yachonde, yosasunga chinyezi (Siimapirira kuchuluka kwamadzi) ndipo imalimbana ndi chilala.
Agro-Forestry Technology		Orchard, home gardens, yards. Excellent pioneer species for establishing woodland gardens; It is best planted away from crops due to root competition.	Zipatso, minda yakunyumba, mayadi. Mitundu yabwino kwambiri yopangira minda yamitengo; Zimafunika kubzalidwa kutali ndi mbewu chifukwa cha mpikisano wa mizu.
Uses	Food / Fruits	Food (fruit, jam, jelly, juice); the fruit is rich in vitamin C.	Zakudya (zipatso, jamu, odzola, madzi ya zipatso); ndi vitamini C wambiri.
	Timber	Timber (tool handles), fence posts	Mitengo (zogwirira zida), nsanamira za mpanda
	Firewood	For domestic energy supply	Nkhuni za pa nyumba
	Medicine	Medicine (bark, leaves, roots); boiled leaves are used to treat diarrhoea and bleeding wounds, while leaves boiled with sugar and salt are used to treat eczema and abscesses	Mankhwala (makungwa, masamba, mizu); masamba owiritsa amagwiritsidwa ntchito pochiza matenda otsekula m'mimba ndi mabala otuluka magazi, pomwe masamba owiritsa pamodzi ndi shuga ndi mchere amagwiritsidwa ntchito pochiza chikanga ndi zilonda.
	Ornamental	For planting in home gardens and orchards.	Za kubzala m'minda yapanyumba ndi minda ya zipatso.
	Others:	Shade.	Mthunzi.
Description		A small evergreen tree, branching irregularly.	Mtengo wawung'ono wobiriwira nthawi zonse, wopanga nthambi mosakhazikika.
		Height of mature tree: 3 - 10 m	Kutalika kwa mtengo wokhwima: 3 - 10 m
		Diameter at Breast Height of mature tree: 20 – 30 cm	M'mimba mwake pa chifuwa cha mtengo wokhwima: 20 - 30 cm
		Recommended spacing: 6-9 m	Kutalikana kovomerezeka: 6-9 m
		Number of years for first harvest: Trees begin to bear fruit after 3 years and continue fruiting up to 30 years.	Chiwerengero cha zaka zokolola koyamba: Mitengo imayamba kubala zipatso pakatha zaka zitatu ndikupitiriza kubereka mpaka zaka 30.

Propagation	Seedlings, direct seeding.	Mbande, kubzala mbeu
Seed	Treatment is not necessary. Storage: Seed can be stored.	Chithandizo sikofunikira. Kusunga: Mbewu zimatha kusungidwa.
Management	Pollarding, lopping, pruning, coppicing.	Kudula, kudulira, kudula nthambi.
Remarks	Common around homesteads. Drought-resistant than most tropical fruit crops and may become a weed on good sites. Wood is termite-resistant. In Eastern Province there has been an increase in planting of this tree by small-scale farmers.	Zofala kuzungulira nyumba. Kusamva chilala kuposa mbewu zambiri zamitundu zazipatso zopezeka m'malo yotentha ndipo zitha ku-khala mbeu yosafunika (ma udzu) pamalo abwino. Matabwa amalimba ku chiswe. M'chi-gawo cha Kum'mawa ulimi wa mtengowu ndi alimi ang'onoang'ono wakula.


Name		English	Nyanja
		Mexican Apple or White Sapote	Mbangonge, Nyakoko
Botanical Name		Casimiroa edulis	
Ecology		Originated from Central America to Mexico. Cultivated in warm temperate, subtropical and higher elevations of the tropics i.e. in subtropical deciduous woodlands, low forests and dryish highland forests at elevations of 1,000 – 2, 000m.	Inachokera ku Central America kupita ku Mexico. Imalimidwa m'malo otentha, otentha pan'gono komanso okwera kwambiri kumadera otentha mwachitsanzo, m'nkhalango zotsika kwambiri, komanso nkhalango zowuma zamtunda wa 1,000 - 2,000m.
Site conditions		Optimum temperature between 18 - 26°c; with annual rainfall 0f 500 - 3,000mm and well-drained loamy soil. Established plants are drought resistant, though adequate moisture is needed for fruiting.	Kutentha kwabwino kwa 18-26 ° C; ndi mvula yapachaka ya 500 - 3,000mm ndi dothi lotayirira bwino la loam. Mitengo yokhazikika imalimbana ndi chilala, ngakhale kuti chinyezi chokwanira chimafunika po bereka zipatso
Agro-Forestry Technology		Home gardens, orchards or yards.	Minda yakunyumba, minda ya zipatso kapena mayadi.
Uses	Food / Fruits	Fruit (as rich in protein, carbohydrate and vitamins as a banana) is eaten raw or cooked.	Chipatso (zomanga thupi, zopatsa mphamvu ndi mavitamini yambiri ngati nthochi) amadyedwa yaiwisi kapena yophikidwa.
	Timber	Wood is yellow in colour, fine-grained, moderately dense and resistant is employed in carpentry and manufacture of domestic furniture only occasionally because it is not durable for long.	Matambwa ndi yachikasu maokedwe yake, yowoneka bwino, yowundana bwino komanso yosamva mphamvu amagwiritsidwa ntchito muukalipentala ndi kupanga mipando yapakhomo mwa apo ndi apo chifukwa siakhala yolimba kwa nthawi yayitali.
	Medicine	Leaf decoction is used as a treatment for diabetes. Crushed and roasted seeds are effective in healing rotting sores.	Madzi yamasamba amagwiritsidwa ntchito ngati mankhwala ya matenda a shuga. Mbewu zophwanyidwa ndi zokazinga zimachiritsa zilonda zowola.
	Ornamental	In gardens	M'madimba
Description		Casimiroa edulis is an evergreen tree with spreading, often drooping branches and a broad leafy crown	Casimiroa edulis ndi mtengo wobiriwira nthawi zonse wokhala ndi nthambi zotambalala, nthawi zambiri zogwa komanso korona wamtali.
		Height of mature tree: Up to 18 m	Kutalika kwa mtengo wokhwima: Kufikira 18 m
		Diameter at Breast Height of mature tree: 6 – 11cm	M'mimba mwake pa chifuwa pa mtengo wokhwima: 6 - 11cm
		Recommended spacing: 4.6 X 4.6 m	Kutalikirana kovomerezeka: 4.6 X 4.6 m
		Number of years for first harvest: 7 - 8 years (seedlings) and 3 - 4 years (grafted)	Chiwerengero cha zaka zokolola koyamba: zaka 7 - 8 (mbande) ndi zaka 3 - 4 (zomezetsanidwa)
Propagation		Air-layering, grafting, seeding and budding.	Kubzala pa mtengo wina, kulumikiza (kukwatisa) kubzala njele

Seed	Sow seed in deep containers / poly pots since species produces tap-root.	Bzalani mbewu m'tumapulasitili ndi zina zotero zakuya chifukwa imapanga mizu yapakati yayitali
Remarks	Tree can flower and produce fruit at more than one time of the year. There are many named varieties.	Mtengo ukhoza kupanga maluwa ndi kubala zipatso nthawi yoposa imodzi pachaka. Pali mitundu yambiri yotchulidwa.

A 2. Annex: Templates for seed logistics (Module 02)

A 2.1. Demand identification template

Farmer Group	Camp (zone)	Species requested	Purpose	No. of trees to be planted	No. of bags leftover from last year
Example: J. Banda	*Mzime (zone 1)*	*Khaya nyasica* *Gliricidia* *Tamarind*	*Woodlot* *Alley cropping* *Orchard*	*500* *1,800* *400*	*250*

A 2.2. Seed source identification

Provider name	**Location**	**Contact details**	**Species available**	**Quantity available** (kg and number)	**Price per unit** (update every season) ZMW/kg	**Mother tree assessment** (age, number of trees)	**Seed quality** (review every season)
W. Phiri	*Nkhunga (zone 5)*	*Tel: xxx xxxxxxx*	*Khaya nyasica*	*10kg - 25,000 seeds*	*100.00 (2024)*	*25 years old, 3 trees*	*Good germination in last season.*

A 2.3. Seed procurement

Identifier	**Provider Name**	**Contact Details**	**Source** (Location)	**Species**	**Quantity seeds purchased** (kg and number)	**Price** (ZMW per kg)	**Total cost** (ZMW)	**Seed harvest date**
01-Kh	*W. Phiri*	*Tel: xxx xxxxxxx*	*Nkhunga (zone 5), Mr. Phiri's farm*	*Khaya Nyasica*	*10kg – 25,000*	*100.00*	*1,000.00*	*28.09.2024*
01-Ta	W. Phiri	Tel: xxx xxxxxxx	Nkhunga (ozne 5), Mr. Phiri's farm	Tamarind	2kg – 3,000			14.08.2024

A 2.4. Seed storage and sorting

Identifier	**Sorting conducted** (yes/no)	**Cleaning conducted** (yes/no)	**Percentage seeds rejected**	**Storage location**	**Storage duration**
01	*Yes*	*Yes*	*2%*	*Storeroom A*	*3 weeks*

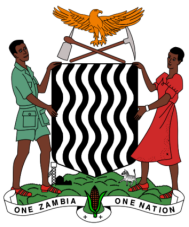
Identifier	**Sorting conducted** (yes/no)	**Cleaning conducted** (yes/no)	**Percentage seeds rejected**	**Storage location**	**Storage duration**

A 2.5. Seed distribution

Farmer Group (Lead Farmer name)	**Camp, zone**	**Species distributed**	**Number of seeds distributed**	**Date of distribution to Camp Officer**	**Date of distribution to farmer group**	**Identifiers distributed**
J. Banda	*Mzime, zone 1*	*Khaya nyasica* *Gliricidia sepium* *Tamarind*	*500* *1,800* *400*	*28.10.2024*	*31.10.2024*	*01-Kh* *02-G* *01-Ta*

COMACO

unique land use



With support from

Federal Ministry of Food and Agriculture

by decision of the German Bundestag

unique land use GmbH
Schnewlinstr. 10
79098 Freiburg, Germany
Tel +49 761 208534 – 0
unique@unique-landuse.de
www.unique-landuse.de