UGANDA FORUM FOR AGRICULTURAL ADVISORY SERVICES

EXTENSION PRACTITIONERS MANUAL

(On Selected and Implemented Circular Bio-based Agro-ecology Breakthrough Innovations)

for

Accelerating agroecological transformation through Rural Advisory Services (ÆRAS)

July 2026

In Partnership With

African Forum for Agricultural Advisory Services
Knowledge & Novelty for Africa's Livelihoods

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Under the 'Global Programme for Small-scale Agroecology Producers and Sustainable Food Systems Transformation (GP-SAEP) Project in Uganda

The work of the GP-SAEP Project is supported by:

FOREWORD

It gives me great honor on behalf of the Uganda Forum for Agricultural Advisory Services (UFAAS) to present this *Ag-extension Practitioners' Manual on Agroecology Innovations*. Developing this guide represents a major milestone under our Strategic Objective on Resilient and Inclusive Agri-Food Systems in Uganda. Ugandan smallholder farmers face severe environmental pressures, including declining soil health, land degradation, rising feed and fertilizer prices, and climate change. Agroecology offers a proven path forward by replacing expensive external inputs with resource-efficient, natural ecological principles. Through the *Global Programme for Small-scale Agroecology Producers and Sustainable Food Systems Transformation (GP-SAEP)*—implemented by UFAAS alongside AFAAS and GFRAS, with European Commission support—we have seen the power of participatory extension. Connecting advisory actors, master trainers, and smallholders across Bugiri, Buikwe, Lira, Ssembabule, and Soroti, the project has trained thousands of farmers via Farmer Field Schools, Access Agriculture video tools, and peer-to-peer learning.

This manual compiles practical, low-cost solutions tailored for local application. It presents Black Soldier Fly Larvae (BSFL) and Azolla as alternative livestock feeds that can help reduce feed costs while promoting the recycling of organic resources. For energy and forestry conservation, the manual presents the Lorena energy-saving stove, which reduces firewood consumption and associated carbon emissions. It also covers innovations for improving soil health, pasture production and sustainable crop management, including Biochar, Tumbukiza pits, Kitchen Gardens, Cover Crops and Bio-fertilizers. Together, these innovations promote efficient use and recycling of locally available resources, reduce dependence on costly external inputs, and support more productive, resilient and sustainable farming systems.

This action-oriented resource equips extension workers, Rural Advisory Services Facilitators (RASFs), farmer organizations, NGOs, and smallholders to work with pride and effectiveness. I sincerely thank the European Commission, GFRAS, AFAAS, Access Agriculture, YPARD, our local RASPOs (including FINASP), our Patron, Board members, UFAAS Secretariat, master trainers, and the participating smallholder farmers. I urge all extension providers and partners to actively use this guide to scale agroecological innovations across Uganda. It is dedicated to our members.

Dr. Richard Miiro, **Chairperson, Board of Directors, Uganda Forum for Agricultural Advisory Services (UFAAS)**

TABLE OF CONTENTS

Figures

MANUAL DEVELOPMENT TEAM

This manual is an effort of the project implementation team that is composed of the UFAAS technical staff, technical working group lead and the field-based Master trainers (MTs) from the target Districts. The MTs compiled the notes that were being used for each innovation to train farmers. The contribution to the manual is recognized below.

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WORD FROM THE MANUAL DEVELOPMENT LEAD

Agriculture remains central to the livelihoods, food security and economic well-being of millions of Ugandans. Yet, smallholder farmers continue to face challenges including declining soil fertility, climate variability, rising input costs, limited access to quality livestock feeds, land constraints and environmental degradation. Addressing these challenges requires practical, affordable and locally adaptable innovations that enhance productivity while strengthening the resilience and sustainability of farming systems.

Through the Global Programme for Small-scale Agroecology Producers (GP-SAEP), the Uganda Forum for Agricultural Advisory Services (UFAAS), working with partners and local organizations, has promoted farmer-centred agroecological learning and innovation in selected districts of Uganda. The programme emphasizes learning and co-creation with farmers, enabling them to experiment with innovations, adapt them to local conditions and share experiences through farmer-to-farmer learning.

This Farmers' Training Manual on Selected Agroecology Innovations consolidates practical knowledge and experiences generated through this process. It provides guidance on Black Soldier Fly Larvae (BSFL), Azolla, biochar, Tumbukiza pasture establishment, Mucuna and Jack bean cover crops, farm-made bio-inputs, kitchen gardening and the Lorena energy-saving stove. These innovations demonstrate how locally available resources can improve soil health, livestock nutrition, household food and nutrition security, natural-resource management, climate resilience and livelihoods while reducing dependence on costly external inputs.

The manual is intended as a practical learning resource for farmers, extension and advisory service providers, farmer organizations and development actors. Users are encouraged to experiment, adapt the practices to their local circumstances, learn from experience and seek appropriate technical guidance where necessary.

UFAAS appreciates the farmers, extension workers, partners and technical teams whose knowledge and experiences contributed to this manual. We hope it will support the adoption, adaptation and scaling of agroecological innovations, contributing to more productive, resilient, inclusive and environmentally sustainable farming systems in Uganda and beyond.

Beatrice Luzobe
Focal Person, GP-SAIP Project, Uganda
Chief Executive Officer,
Uganda Forum for Agricultural Advisory Services (UFAAS)
2026

ACKNOWLEDGEMENTS

This manual is a result of collaborative efforts of the various team and actors along the cycle of the GP-SAEP Project. This is therefore, an acknowledgement of all those who supported and participated in the GP-SAEP work at all levels, which made it easy to put together this manual.

We extend our sincere gratitude to European Union (EU) for the generous funding through the International Fund for Agricultural Development (IFAD)

To the Global Forum for Rural Advisory Services (GFRAS) and the African Forum for Agricultural Advisory Services (AFAAS), for the technical support and supervision throughout the GP-SAEP project.

Access agriculture, the farmer videos have been a real change maker, on which many of the innovations were hinged. For some of the new innovations like BSFL, Azolla weed and Biochar, the videos were a good starter menu.

YPARD, thank you for supporting the Youth Fellows who participated to have a rich agroecology experience.

We appreciate the local based partners, the Rural Advisory Services Provider Organization (RASPO) for the overall supervision of the project work within tithe targeted districts. We also appreciate the good hosting of the project and master trainers that provided a great enabling environment.

For the Master Trainers GP-SAEP work would never have been complete without their committed their field supervision, training, and mentoring of the Rural Advisory Services Facilitators (RASFs). Also, thanks for contributing to the content of this manual

Our thanks also go to the RASFs for training farmers and demonstrating the agro-ecology innovations.

Lastly, but not least, our deepest appreciation goes to the smallholder farmers who were the ultimate beneficiaries and champions of the GP-SAEP project. We are especially grateful to the farmers who generously shared their experiences, hosted demonstrations, participated in video recordings and case studies, and inspired fellow farmers through peer-to-peer learning. Their knowledge, dedication, and lived experiences have enriched this manual and will continue to guide and motivate many others on the journey towards sustainable food systems.

ACRONYMS

AA	Access Agriculture
AFAAS	African Forum for Agricultural Advisory Services
AEAS	Agricultural Advisory and Extension Services
ÆRAS	Accelerating Agroecological Transformation via Rural Advisory Services
BSF	Black Soldier Fly
BSFL	Black Soldier Fly Larvae
DW	Dry Matter
ERA	Entrepreneurs for Rural Access
EU	European Union
FAO	Food and Agriculture Organization
FFLGs	Farm Family Learning Groups
FFS	Farmer Field Schools
FYM	Farmyard Manure
GAP	Good Agricultural Practices
GFRAS	Global Forum for Rural Advisory Services.
GP-SAEP	Global Programme for Small-scale Agroecology Producers and Sustainable Food Systems Transformation
IFAD	International Fund for Agricultural Development
IMO	Indigenous Microorganisms BSFL Advisory Services
NGO	Non0-Governmement Organization
RASPO	Rural Advisory Services Provider Organization
RASFs	Rural Advisory Service Facilitators
TWG	Technical Working Group
UFAAS	Uganda Forum for Agricultural
YPARD	Young Professionals for Agricultural Development

ABOUT THE PROJECT

The Uganda Forum for Agricultural Advisory Services (UFAAS) is a professional network that brings together Agricultural Advisory and Extension Services (AEAS) actors in Uganda. UFAAS is one of 40 country fora under the African Forum for Agricultural Advisory Services (AFAAS), which serves as the continental umbrella for AEAS in Africa and is part of the Global Forum for Rural Advisory Services (GFRAS). With support from GFRAS and AFAAS, UFAAS is implementing the Global Programme for Small-scale Agroecology Producers and Sustainable Food Systems Transformation (GP-SAEP) in Uganda. Funded by the European Commission, the project runs from 2023 to June 2026 and aims to transform food systems through agroecology by improving small-scale farmers' access to knowledge, advisory services, appropriate technologies, and markets, thereby strengthening resilience, food security, nutrition, and household incomes.

The project contributes to Component 3 – Accelerating Agroecological Transformation via Rural Advisory Services (ÆRAS), implemented by GFRAS in partnership with Access Agriculture and the Young Professionals for Agricultural Development (YPARD). The component promotes participatory Rural Advisory Services, farmer-to-farmer learning, and video-based extension to accelerate agroecological transitions.

In Uganda, GP-SAEP is implemented in Bugiri, Buikwe, Lira, Soroti, and Ssembabule through four Rural Advisory Services Provider Organizations (RASPOs). The project applies Farmer Field Schools (FFS), Farm Family Learning Groups (FFLGs), and Peer Learning Teams to encourage knowledge co-creation, collective learning, and adaptation of innovations to local conditions. A team of 62 agricultural professionals, including Master Trainers, Rural Advisory Service Facilitators (RASFs), YPARD Fellows, and Access Agriculture Entrepreneurs for Rural Access (ERAs), supports implementation.

The project directly targets 3,843 farmers organized into 133 farmer groups, achieving an extension-to-farmer ratio of 1:128, far below Uganda's national average of 1:1,800. By October 2025, over 15,000 farmers had been trained through more than 1,200 video-based and advisory sessions, while eight agroecological innovations—including biochar, Black Soldier Fly larvae, Azolla, kitchen gardens, improved cookstoves, Indigenous Microorganisms (IMO), bio-inputs, and improved pastures—were being promoted to enhance sustainable food production, climate resilience, and rural livelihoods.

ABOUT THE MANUAL

Introduction

Agriculture is the backbone of Uganda's economy, yet smallholder farmers face declining soil fertility, land degradation, climate change, biodiversity loss, pests and diseases, and rising production costs. Agroecology offers a sustainable solution by applying ecological principles to farming, promoting healthy soils, biodiversity, efficient use of locally available resources, and reduced dependence on costly external inputs.

In Uganda, innovations such as Black Soldier Fly Larvae (BSFL), Azolla, biochar, bio-fertilizers and pesticides, kitchen gardens, improved energy-saving stoves, improved pasture management methods, and cover crops are increasingly promoted to improve soil fertility, livestock feeding, household nutrition, energy efficiency, and climate resilience.

However, many farmers and ag-extension practitioners still lack access to practical, easy-to-use technical information needed for effective adoption and scaling of these innovations. This manual has therefore been developed under the GP-SAEP project to provide practical guidance for strengthening their capacity to promote sustainable, climate-resilient, and productive agroecological farming systems. It combines practical field experiences with simple technical guidance.

Why this Manual?

GP-SAEP has been a capacity-strengthening programme, building knowledge and skills among programme staff, Master Trainers (MTs), Rural Advisory Service Facilitators (RASFs/frontline extension workers) and farmers. Farmer assessments demonstrated significant progress in farmers' transition towards agroecological farming, particularly through practical innovations. Farmers identified their agricultural challenges, while technical personnel supported them to select appropriate agroecological solutions. These innovations were widely embraced and farmers began realizing tangible benefits.

As the project ends, there remains a need to continue training, promoting, adapting and scaling these innovations. During implementation, technical personnel relied on training notes compiled from various sources and enriched by field experience. This manual therefore consolidates and organizes these materials into a practical reference for farmers, extension workers, trainers and other actors. It aims to preserve knowledge generated through GP-SAEP, sustain project gains, and support continued adoption and scaling of agroecological innovations within targeted communities and beyond.

Who can use this manual?

This manual is intended to be a practical reference resource material for organizations, trainers, extension workers, and farmers involved in agroecology projects and sustainable agricultural development. It is designed to support capacity building, farmer training, field demonstrations, and the implementation of agroecological innovations by government agencies, non-governmental organizations, farmer organizations, training institutions, and development partners.

How to use this manual?

The manual is suitable for use as an extension reference material during training and demonstration sessions on the selected innovations in here. The farmers implementing or wishing to do so, may also use it as a guide, with or without the technical guidance, depending on their education level. Later when UFAAS obtains resources, farmers popular versions may be extracted for all or individual innovations.

How this manual is organized?

This manual is organized into innovation-specific sections to make it practical, easy to follow and useful for farmers, Rural Advisory Service Facilitators (RASFs), trainers and other agricultural actors.
The content for each innovation is presented under the following key sections:

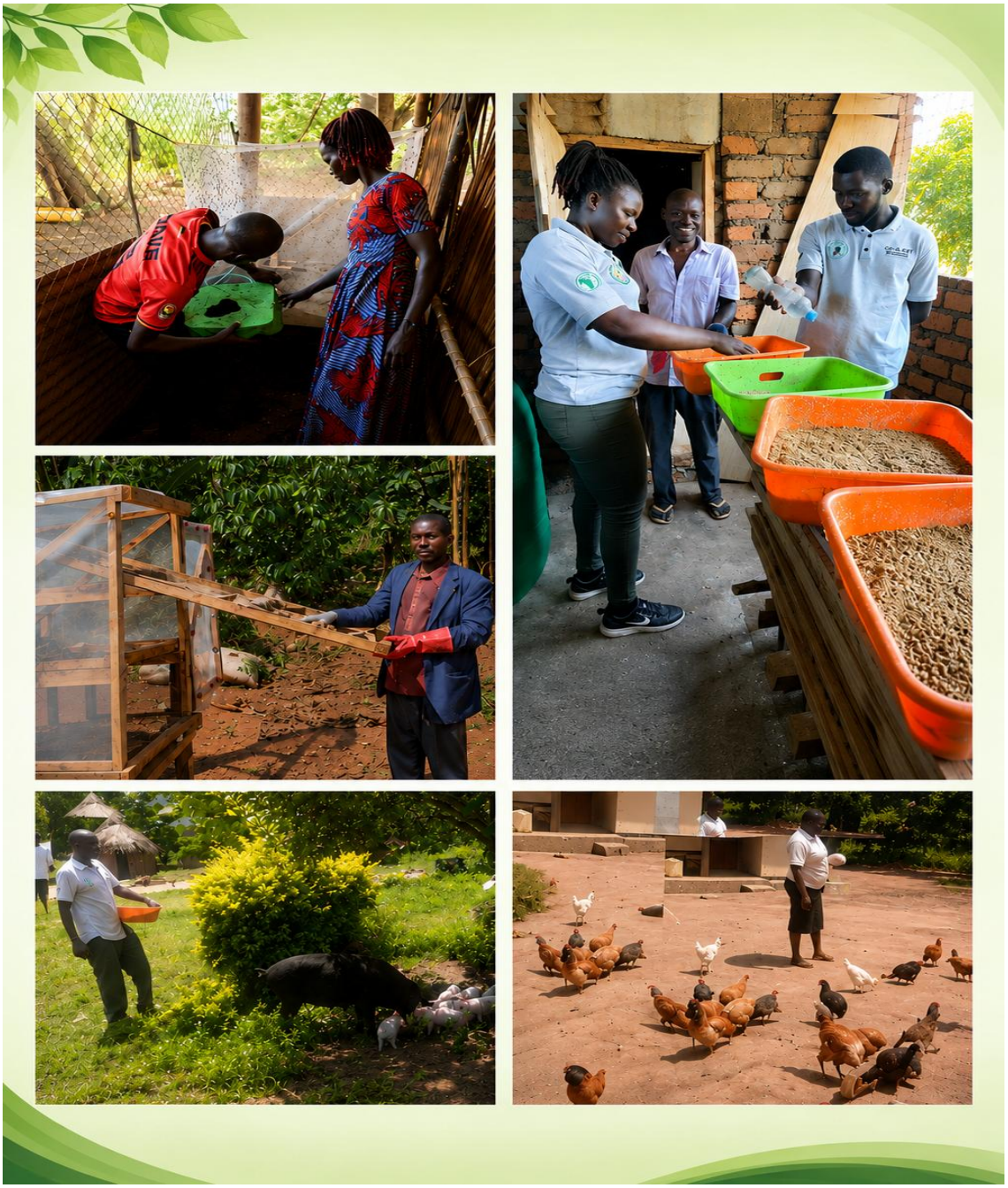
- Begins with a clear title and the agroecology principles to which it contributes, plus a statement on the ***EU Technology Readiness Levels (TRLs)*** ***https://www.euacc.ai/guides/trl-levels-guide***
- A pictorial collection of field photographs illustrating farmers' experiences and practical application of the innovation.
- Innovation context in Uganda introducing its relevance and application within Uganda's farming systems.
- Definition – provides a simple explanation of the innovation and its purpose.
- Practical Guidelines/Steps on establishment, preparation or implementation.
- Management and Maintenance practices required to sustainance and good results.
- Economic Benefits – highlights potential savings, productivity improvements, income opportunities and other livelihood benefits.
- Challenges and Solutions – identifies common challenges farmers may encounter and provides practical solutions.
- Additional Guidance – where relevant, important tips, reminders and technical notes are highlighted in boxes for easy reference.

Throughout the manual, special captions and experience boxes also capture lessons and observations from the innovation surveys and farmers' practical experiences, linking the technical guidance to realities from the field.

INNOVATION 1: BLACK SOLDIER FLY LAVAE (BSFL)

Aligned Agroecology Principles: *Recycling, Input reduction, Soil health, Animal health and Economic diversification*

EU Technology Readiness Levels (TRLs) ***https://www.euacc.ai/guides/trl-levels-guide*** **: 5,6,7**



1.1 Introduction to BSFL Farming in Uganda

The high cost of animal feeds remains a major challenge for livestock farmers in Uganda. Protein sources such as fish meal and soybean meal are increasingly expensive, reducing farmers' profits and limiting livestock production. At the same time, large amounts of organic waste from households, markets, and agro-processing are poorly managed, contributing to environmental pollution.

Black Soldier Fly Larvae (BSFL) farming offers a sustainable and cost-effective solution by converting organic waste into high-quality protein and fat for livestock feed while producing nutrient-rich organic fertilizer (frass). BSFL are rich in protein and fat, making them an excellent feed for poultry, pigs, fish, rabbits, ducks, and pets. This supports a circular economy by reducing waste and improving soil fertility. Besides producing quality animal feed, BSFL farming helps reduce household and market waste while creating an additional source of income.

This training is intended to equips farmers, extension workers, youth groups, and agriprenuers with practical knowledge and skills on how to establish and manage BSFL production. Participants will learn BSFL biology, production techniques, waste management, harvesting, processing, feed utilization, hygiene, and enterprise development. Adopting BSFL technology can lower feed costs, improve livestock productivity, increase incomes, and promote environmentally sustainable farming systems in Uganda.

1.2 What are Black Soldier Flies?

The Black Soldier Fly (BSF), *Hermetia illucens*, is a non-pest insect widely distributed in tropical and warm-temperate regions. Its larvae are voracious feeders on decomposing organic materials and can efficiently convert organic waste into valuable insect biomass. BSF larvae contain high levels of protein, reported at approximately **37–63% of dry matter**, depending on the rearing substrate and production conditions. These characteristics have led to increasing use of BSF larvae for organic waste management and as an alternative protein ingredient in livestock, poultry and fish feeds (Barragan-Fonseca et al., 2017)

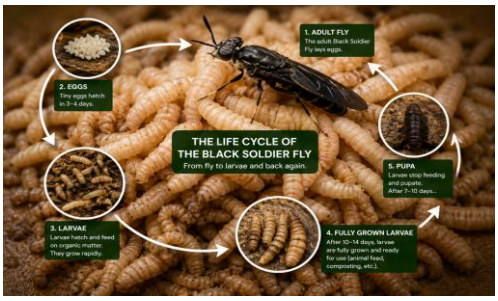


Figure 1.1: The Life Cycle of the BSF

Unlike houseflies, adult Black Soldier Flies:

- Do not spread diseases because do not feed on human food or animal waste during adulthood.
- Live for only about **10–14 days**, during which they mate and lay eggs before dying
- The larvae are the useful stage that farmers harvest and feed to livestock.

Understanding the life cycle helps maintain continuous production. The complete life cycle takes approximately 35–45 days.

1.3 Benefits of BSFL Farming

Due to their high protein (about 35–45%) and fat (about 25–35%) content, BSFL are increasingly used as a sustainable ingredient in feeds for poultry, pigs, rabbits, fish, and other livestock. Hence the benefits of the BSFL are:

- Produces high-quality protein feed.
- Reduces feed costs.
- Converts organic waste into valuable products.
- Produces organic fertilizer (frass).
- Reduces environmental pollution.
- Creates employment and income.
- Suitable for both small-scale and commercial farming.

1.4 Materials Required

Before starting, prepare the following materials:

Breeding Materials

- BSFL pupae from a recognized farmer or BSFL center
- Netting material for constructing a fly cage
- Wooden or metallic frame
- Eggies (laying trays)
- Cotton wool
- Small basin
- Small water containers
- Fresh fruits (ripe bananas, oranges or pineapple)

Figure 1.2: Key Breeding materials

Suitable organic wastes include: Banana peels, cassava peels, market waste, kitchen leftovers, fruit waste, vegetable waste, brewer's waste, poultry manure, and maize bran.

Materials to avoid

☒ **Meat:** Decomposes quickly, producing foul odors that attract houseflies, rodents, dogs, and other pests. It can also increase harmful bacteria in the BSFL unit.

☒ **Fish remains:** Rot rapidly, creating strong odors and attracting pests. They may also contaminate the larvae and reduce hygiene in the production unit.

☒ **Dairy products (milk, cheese, yogurt, etc.):** Spoil easily, encourage the growth of harmful microorganisms, and produce unpleasant smells that attract unwanted insects.

☒ **Chemicals (pesticides, detergents, oils, disinfectants, etc.):** These substances are toxic to BSFL and can kill the larvae or leave harmful residues that may be passed on to livestock.

Note:

- *While BSFL can technically consume meat and fish under controlled commercial systems, these materials are generally **not recommended for smallholder farmers** because they are much harder to manage hygienically and are more likely to attract pests and create odor problems.*
- *Using fruit and vegetable waste, crop residues, brewer's waste, and poultry manure is safer, simpler, and more reliable.*

1.5 Setting Up a BSFL Production Unit

Figure 1.3: Cage Construction

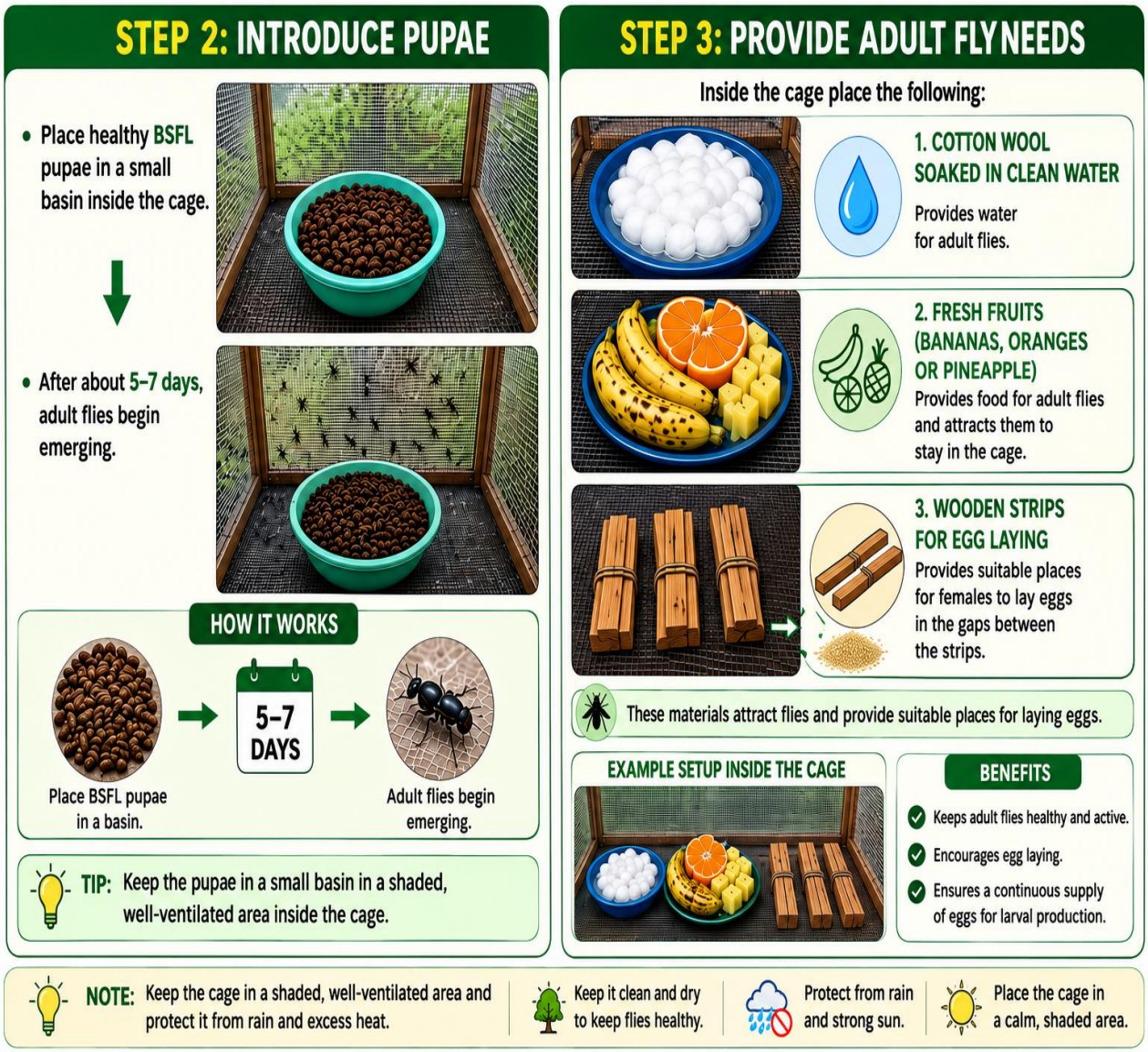


Figure 1.4: Steps for Introducing the pupae and providing for the adult fly needs

Note:

- *The adult housefly only feeds on water*
- *Cotton wool placed in water prevents housefly from drowning in water.*
- *The house flies lay eggs in the aggies which are placed on top of the tins with water and fruits*

1.6 Step-by-step guide to raising BSFL

Figure 1.5: Step-by-step guide to raising BSFL

Important Notes:

- *Maintain good moisture, a Shade, Clean conditions and good aeration*
- *Do not overfeed.*
- *And avoid rotten materials with foul smells.*

1.7 Management Practices

Good management ensures high production.

a) **Moisture; t**he substrate should remain moist but not too wet.
b) **Temperature, k**eep the unit under shade with maximum heat or light requirements, avoid direct sunlight.
c) **Hygiene**
   - ✓ Remove old waste regularly.
   - ✓ Clean surrounding areas.
   - ✓ Prevent contamination.
d) **Pest Control**

Protect the unit from:

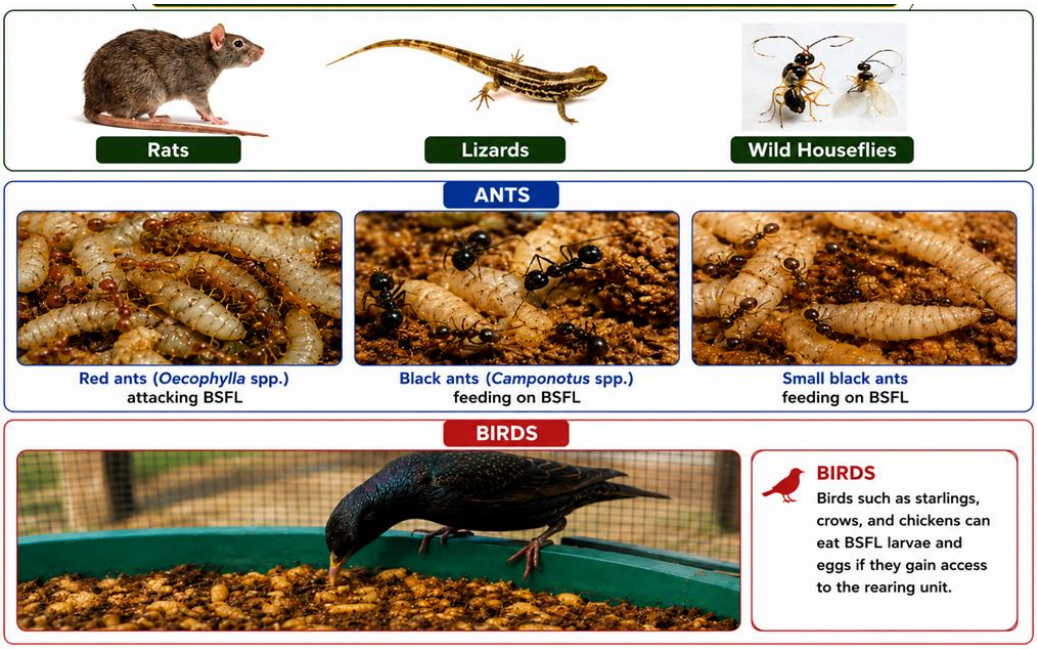


Figure 1.6: Common pests that eat the larvae

Natural pest control

- ➢ Garlic and ash can be used to repel ants
- ➢ Use burnt oil on the poles to still control the ants
- ➢ Use rat guards on the house unit to prevent the rats

Important Note:

Don't use any chemical as the larvae will be killed

1.7 Harvesting the Larvae

Larvae are ready for harvesting after approximately **15–18 days**.
Healthy larvae are:

- Cream to light brown in colour.
- Active.
- Large and firm.

Harvest by separating them from the substrate using sieves or hand picking.

1.8 Processing and Storage

Larvae can be fed to animals while fresh or dry

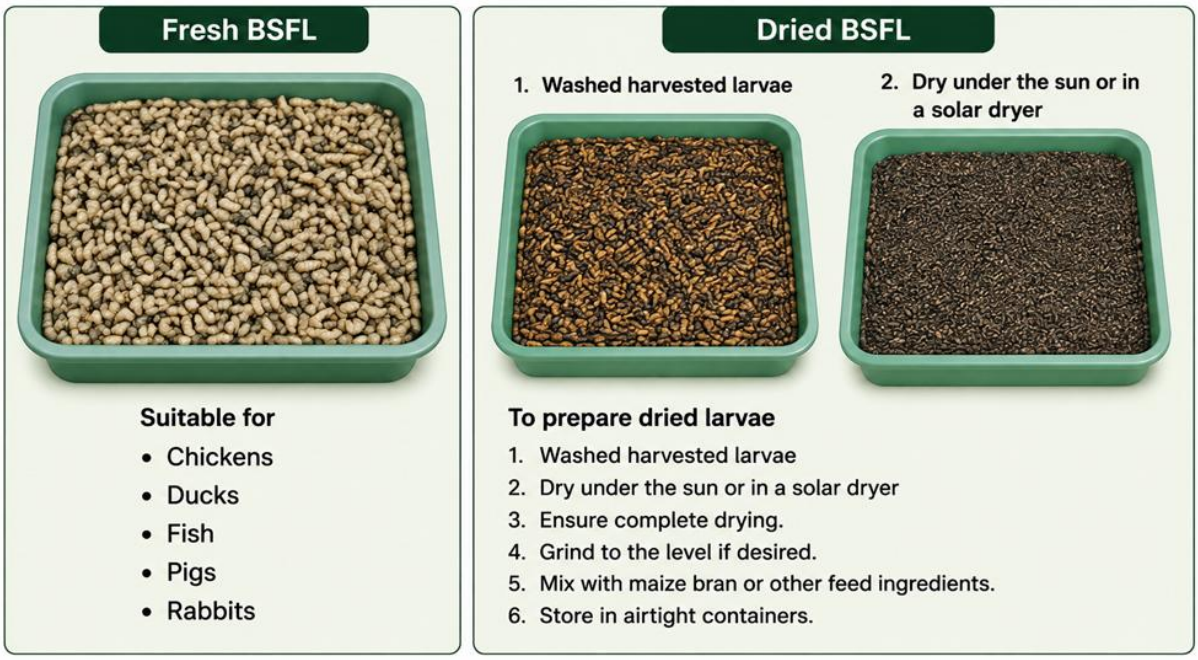


Figure 1.7: Options of BSFL feeding to animals

Important Notes:

Properly dried larvae can be stored for several months.

- **Fresh larvae should be fed soon after harvesting** because they contain high moisture and spoil more quickly than dried larvae.
- **Do not use larvae that smell rotten, are mouldy, or appear contaminated**, as these may pose risks to animal health.

1.9 Maintaining the Breeding Cycle

Not all larvae should be harvested. Always leave some mature larvae to continue the production cycle. These larvae will:

- Become prepupae.
- Change into pupae.
- Hatch into adult flies.
- Mate.
- Lay new eggs.

Remember:

- *Adult flies live only 10-14 days.*
- *Production depends on maintaining this cycle.*

1.1 Common Challenges and Solutions

BSFL production may face common challenges often resulting from different causes and there are measures that can save the situation, if put into place or followed..

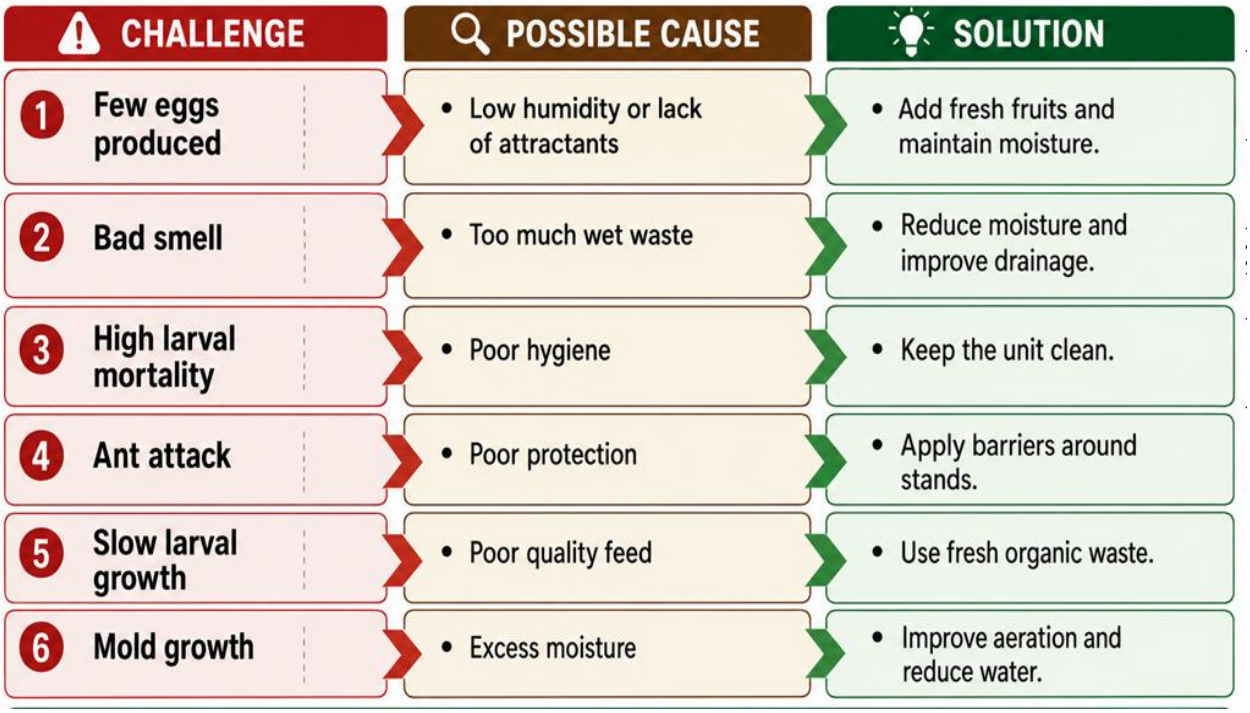


Figure 1.8: Common Challenges and solutions in BSFL production

1.10 Hygiene and Biosecurity

Good hygiene and biosecurity are essential for maintaining a **healthy and productive BSFL rearing unit** and ensuring that the larvae produced are safe for animal feeding. Simple practices that prevent contamination, disease and pest entry should therefore be followed throughout the breeding, feeding, harvesting and handling processes. Always:

- Wash hands before and after handling larvae.
- Use clean equipment.
- Remove spoiled waste promptly.
- Keep livestock away from breeding cages.
- Protect the unit from rain.
- Wear gloves when handling waste.

1.11 Economic Benefits

BSFL production can provide farmers with an additional source of income while reducing livestock production costs. Farmers can sell different BSFL products and by-products, making the enterprise suitable for both household use and commercial production.

Farmers can generate income by selling fresh larvae, dried larvae, BSFL meal, pupae, eggs and organic fertilizer (frass).

Figure 1.9: Different commercial products from in BSFL production

These products can be sold to livestock farmers, other BSFL producers and crop farmers depending on local demand.

Producing BSFL on the farm can help reduce dependence on expensive commercial protein feeds, particularly for poultry, pigs and fish.

Locally produced larvae can therefore contribute to lower feeding costs and improved farm profitability.

1.12 Initial costs at farmer level

Starting a small BSFL production unit requires investment in basic materials such as netting, a wooden frame, trays and basins, egg-laying materials and starter pupae. The estimated initial investment is about UGX 320,000, although actual costs may vary depending on the size of the unit, location and availability of local materials.

No.		Item	Estimated Cost (UGX)
1		Netting	90,000
2		Wooden frame	50,000
3		Trays and basins	50,000
4		Egg laying materials	20,000
5		Starter pupae	60,000
6		Miscellaneous	50,000
TOTAL INITIAL INVESTMENT			320,000

Equivalent to about $88

Figure 1.10: Common Challenges and solutions in BSFL production

Important note:

- Farmers can reduce establishment costs by using suitable locally available or recycled materials where possible.
- Once established, some of the major materials can be reused for several production cycles, making subsequent BSFL production less costly.

> ***Economic value**: Research in East Africa has shown that replacing conventional soybean and fishmeal protein with BSFL meal can reduce feed costs while maintaining broiler performance. In one study, the conventional diet was 19% more expensive, while the BSFL-based diet achieved a 25% improvement in return on investment (Onsongo et al., 2018)*

1.13 How to compound a general feed with BSFL incorporated

At farm level, Black Soldier Fly Larvae (BSFL) meal can be incorporated into locally available feed ingredients as a valuable source of protein for livestock and fish, to replace the expensive and highly competitive fish and soya meals by humans. Proper feed compounding involves measuring the required ingredients accurately and mixing them thoroughly to produce a uniform ration that supports animal growth, health and productivity. However, feeding with BSFL is still at testing level and there are no official formulations released. At least none has been found.

Ingredient	Local Chicken (kg)	Growing Pigs (kg)	Rabbits (kg)
Maize bran	55	50	33
Rice bran	21	24	40
BSFL meal	15	18	10
Dried Azolla meal	7	7	15
Premix	0.5	0.25	0.5
Salt	0.5	0.25	0.5
Feed-grade limestone	1.0	0.5	1.0
TOTAL (kg)	**100**	**100**	**100**

Shared from Learn Enterprises Agroecology Farm, Buddugala, Mukono

Disclaimer: *These feed formulations are indicative farmer-level formulations currently being tested and refined under farm conditions and should not be considered as standardized or fully validated feeding recommendations.*

Figure 1.11: Example of farmer-level formulations with BSFL and Azolla incorporated

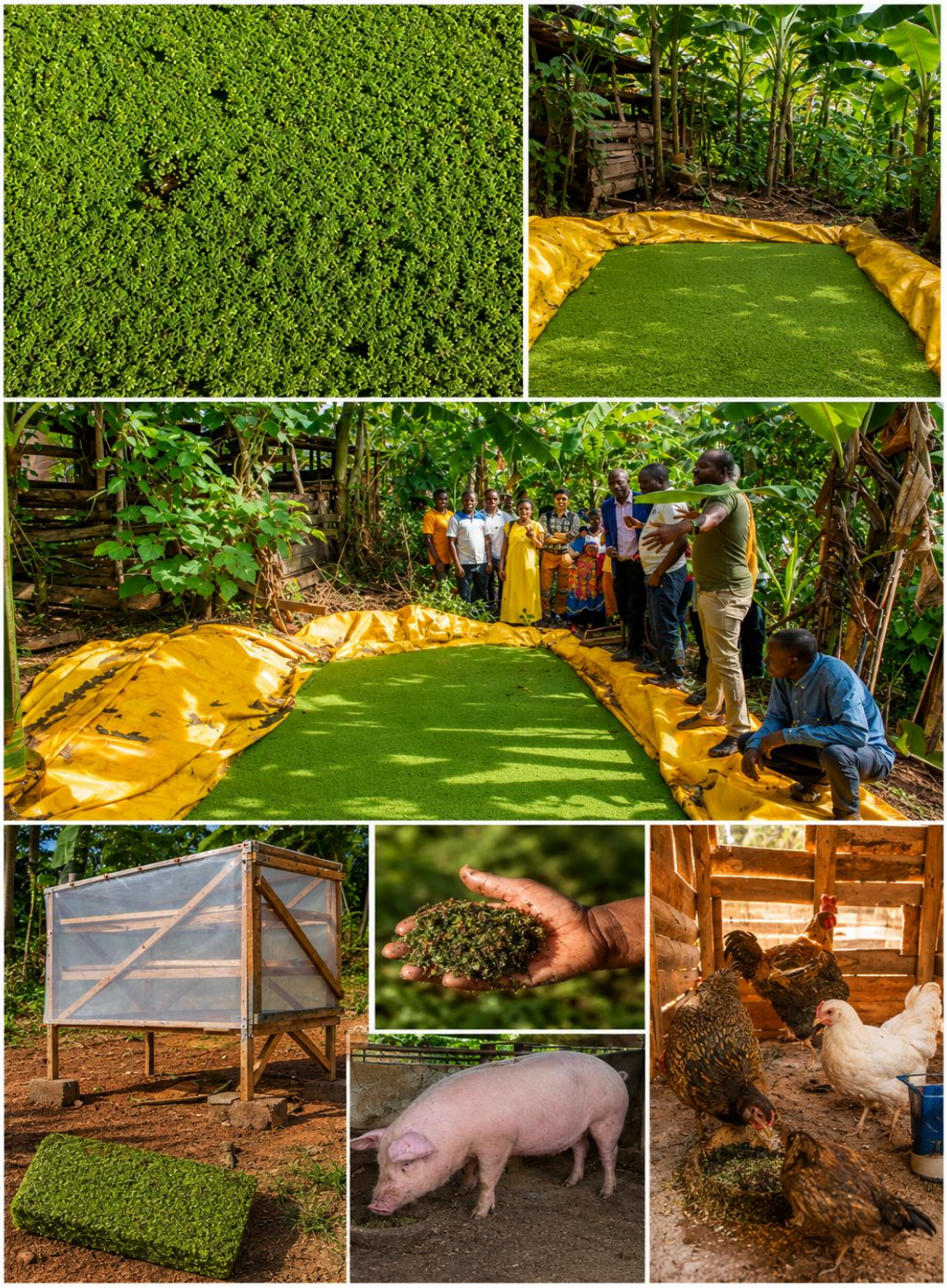
Conclusion on BSFL Adoption

Black Soldier Fly Larvae production is a simple, low-cost, and environmentally friendly technology that transforms organic waste into valuable livestock feed and organic fertilizer. With proper management of the breeding cycle, regular feeding, good hygiene, and timely harvesting, farmers can maintain continuous BSFL production, reduce feeding costs, improve livestock productivity, and generate additional income while contributing to a cleaner environment.

INNOVATION 2: AZOLLA : GROWING GREEN PROTEIN FOR FEED

Aligned Agroecology Principles: *Recycling, Efficiency, Input reduction, Soil health, Animal health and Co-creation of knowledge*

EU Technology Readiness Levels (TRLs) https://www.euacc.ai/guides/trl-levels-guide **: 5,6,7**



2.1 Introduction to Azolla Farming in Uganda

In Uganda, Azolla farming is still an emerging innovation and is gradually gaining attention among livestock and fish farmers seeking affordable alternatives to increasingly expensive conventional feeds. Azolla can be produced on-farm using locally available materials and used as a supplementary feed for poultry, pigs, fish, rabbits and cattle. However, its potential remains underexploited in Uganda, highlighting the need for increased farmer awareness, practical training, demonstrations and continued advisory support (Nakibuuka, 2026).

Through GP-SAEP, Azolla was among the agroecological innovations selected and promoted for animal feeding, using participatory Rural Advisory Services (RAS), farmer experimentation, peer learning and video-supported training. Its ability to be produced in relatively small spaces and incorporated into farm-made feeds makes Azolla particularly promising for reducing dependence on costly external feed ingredients and strengthening more circular, agroecological farming systems. Growing and Using Azolla Weed for Sustainable Farming.

2.2 What is Azolla?

Azolla is a small, free-floating aquatic fern that grows on the surface of freshwater. It has a symbiotic relationship with the nitrogen-fixing bacteria (*Anabaena azollae)*, which enables it to obtain nitrogen from the atmosphere and makes it useful as a natural biofertilizer. Under favourable growing conditions, Azolla grows rapidly and can double its biomass within 3–5 days. It is also rich in nutrients, containing approximately 25–30% crude protein on a dry-matter basis, making it a valuable supplementary feed for poultry, livestock and fish (Yuan et al., 2026).

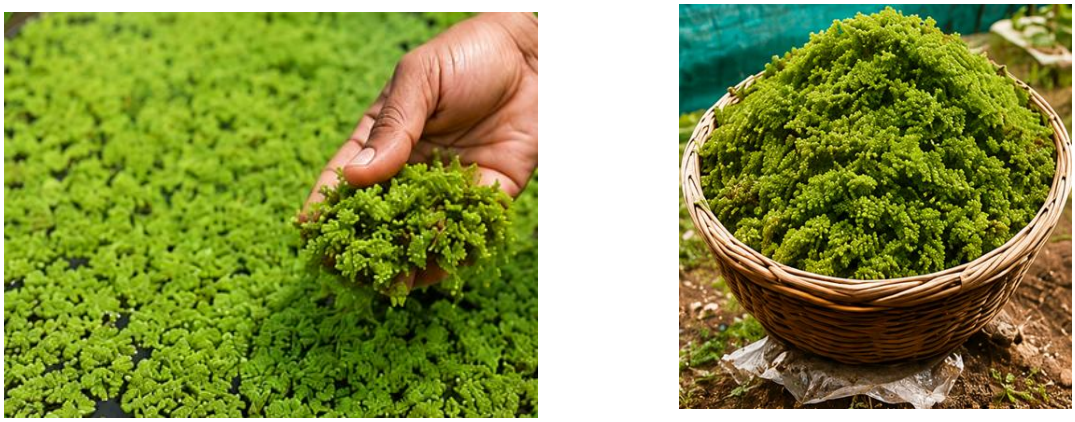


Figure 2.1: Azolla samples

2.3 Benefits of Growing Azolla

Azolla is a multipurpose agroecological innovation that can provide farmers with benefits beyond its use as animal feed. When properly produced and utilized, it can contribute to improved livestock nutrition, soil fertility and nutrient recycling, while providing a low-cost source of biomass that can reduce dependence on purchased farm inputs. Its rapid growth and ability to produce biomass continuously also create opportunities for farmers to lower animal-feeding costs and generate additional income from surplus production. These combined benefits make Azolla a useful innovation for promoting integrated, resource-efficient and sustainable farming systems.

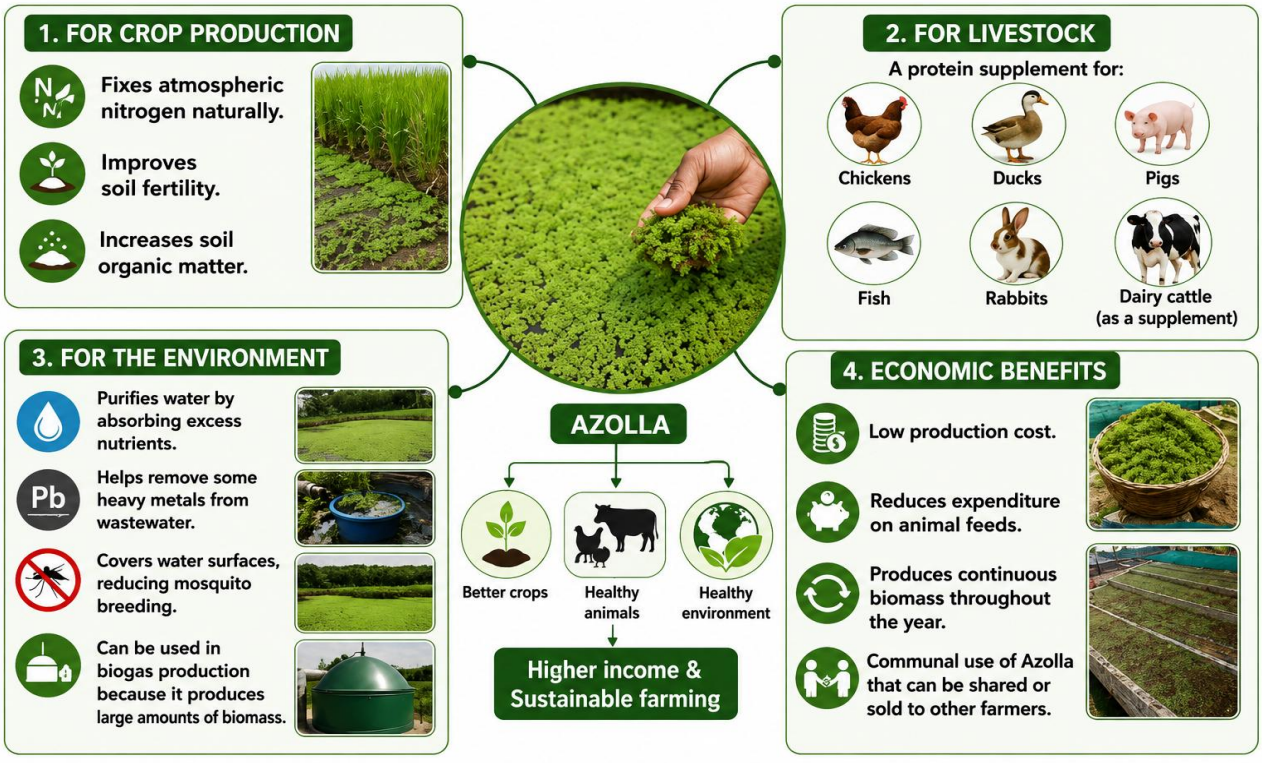


Figure 2.2: Benefits of growing Azolla

2.4 Materials Needed

Establishing a productive Azolla unit requires only a few simple and locally available materials for pond preparation, nutrient management, establishment and harvesting. Having these materials ready before starting makes the process easier and helps create suitable conditions for healthy and continuous Azolla growth.

Before starting, prepare the following materials: Shovel or hoe, Polythene sheet or plastic container, Water (rainwater or pond water), Cow dung or compost (1–2 kg), Healthy Azolla (200–500 g), Harvesting net or sieve and watering can or bucket

Figure 2.3: Materials needed for Azolla production

2.5 Step-by-Step Guide: How to Grow Azolla

Successful production involves preparing a suitable pond or container, providing clean water and organic nutrients, introducing healthy starter Azolla, and maintaining the unit through regular watering, protection and harvesting. With good management, Azolla multiplies rapidly and can provide farmers with a continuous source of nutritious biomass for animal feeding and other farm uses.

The steps in figure 2.4 provide a simple practical guide for establishing, managing and harvesting Azolla at farm level.

Following the steps in the correct sequence helps create suitable growing conditions, promotes rapid multiplication and ensures a continuous supply of healthy Azolla for animal feeding and other farm uses.

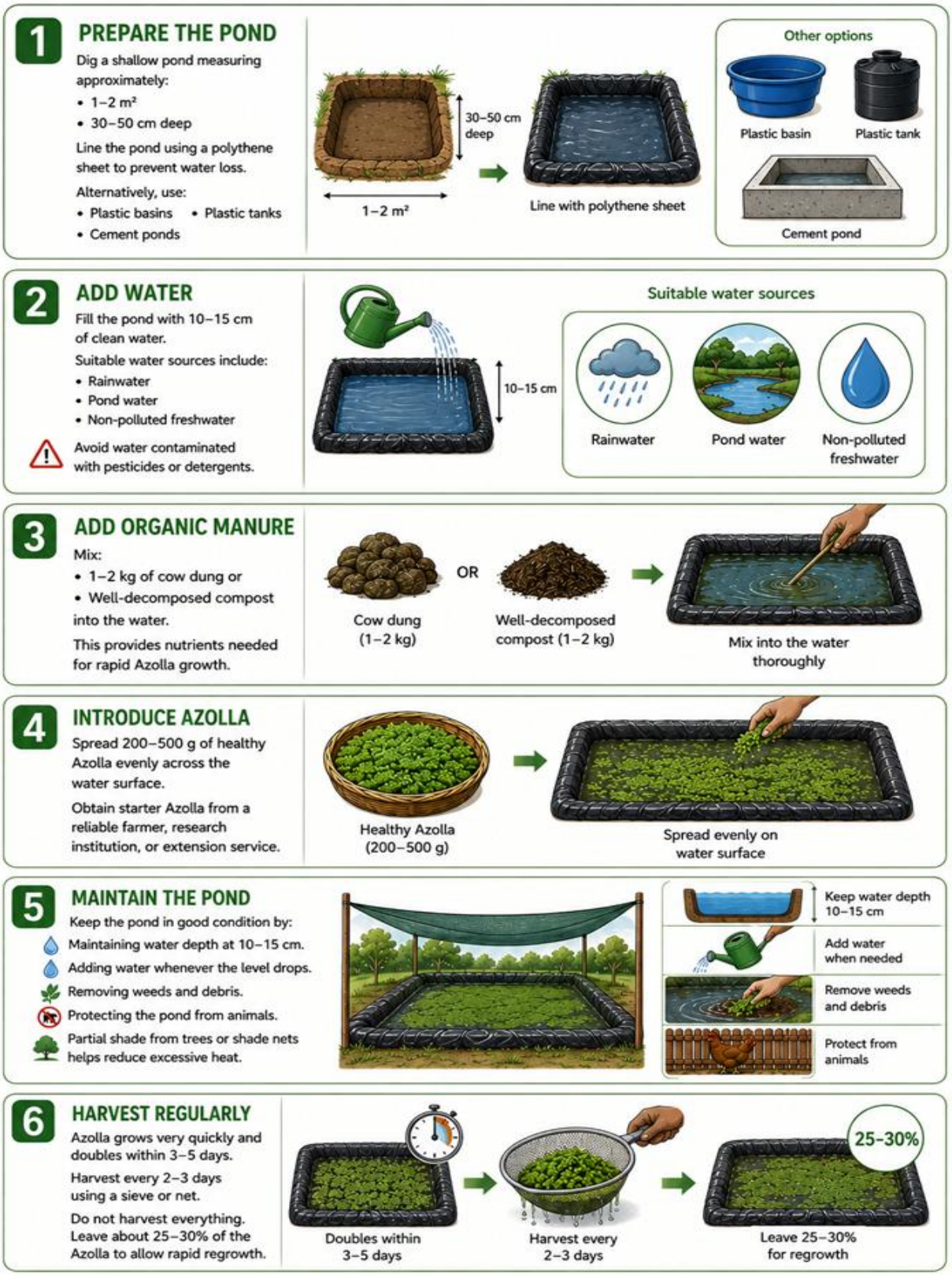


Figure 2.4: Steps for growing Azolla

2.6 Conditions and good management Practices for Azolla

Successful Azolla production depends on maintaining **favourable growing conditions and applying good management practices throughout the production cycle**. Appropriate water depth and quality, adequate nutrients, suitable pH, partial shade and regular harvesting promote rapid and healthy growth, while good pond management helps prevent contamination, drying and loss of the Azolla crop.

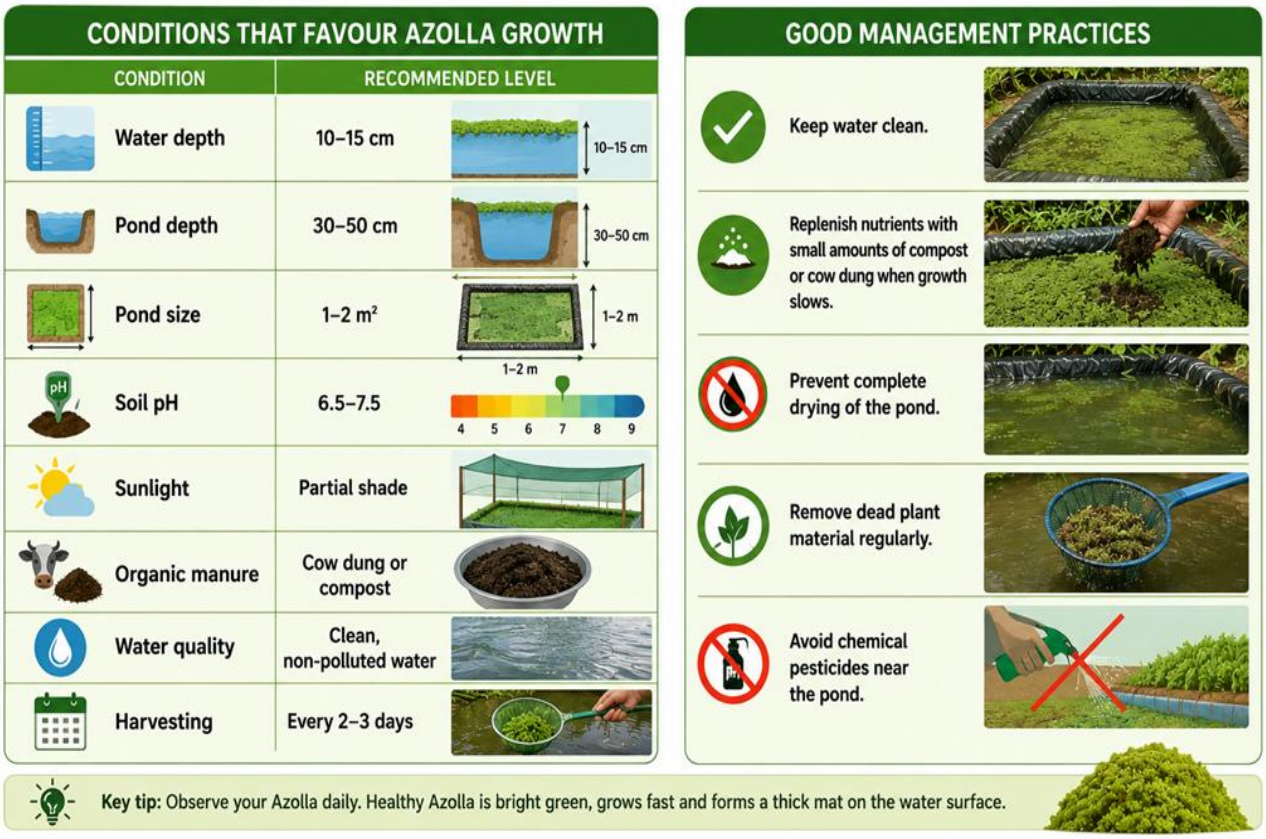


Figure 2.5: Good conditions and management practices for Azolla Production

2.7 Key Technical Considerations for Successful Azolla Production

Successful Azolla production requires more than establishing a pond and introducing the starter culture. Farmers need to pay attention to several technical factors that influence establishment, growth, multiplication and continuous production. These include obtaining healthy and reliable starter culture, handling it carefully during transportation and establishment, using suitable and clean water sources, and maintaining favourable temperatures. Proper management of these factors helps minimize losses, promotes rapid Azolla growth and ensures a consistent supply of quality biomass for animal feeding and other farm uses.

2.8 Seed (Starter Culture) Sourcing

Successful Azolla production begins with obtaining a **healthy starter culture (commonly referred to as Azolla seed by farmers)**. Since Azolla reproduces vegetatively, farmers establish new ponds using fresh, living Azolla rather than true botanical seeds.

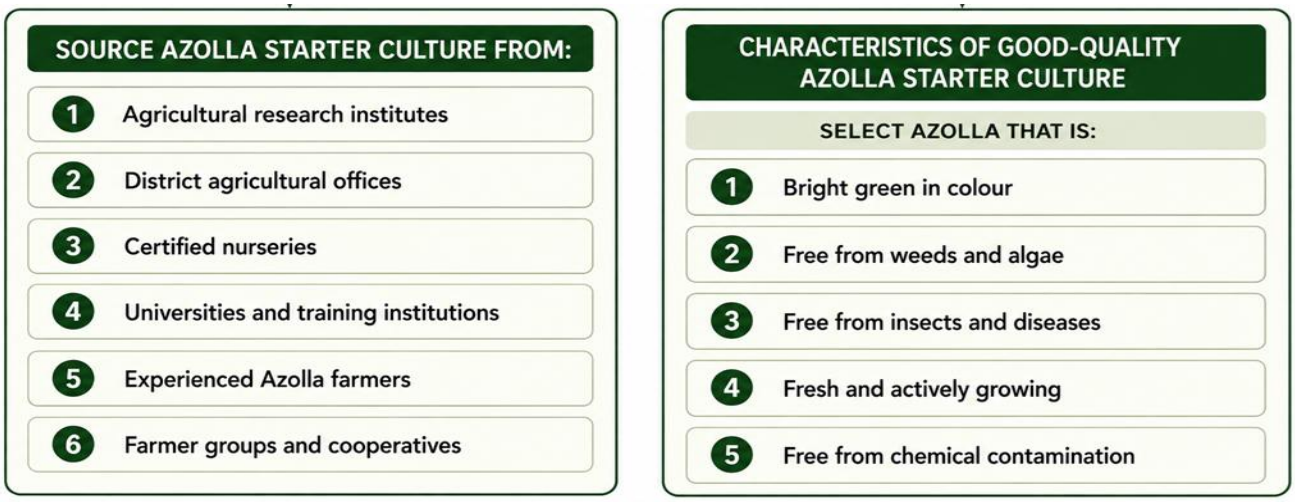


Figure 2.6: Azolla Seed Sourcing

2.9 How to Handle Azolla Starter Culture

Proper handling helps maintain the vitality of Azolla and ensures rapid establishment.

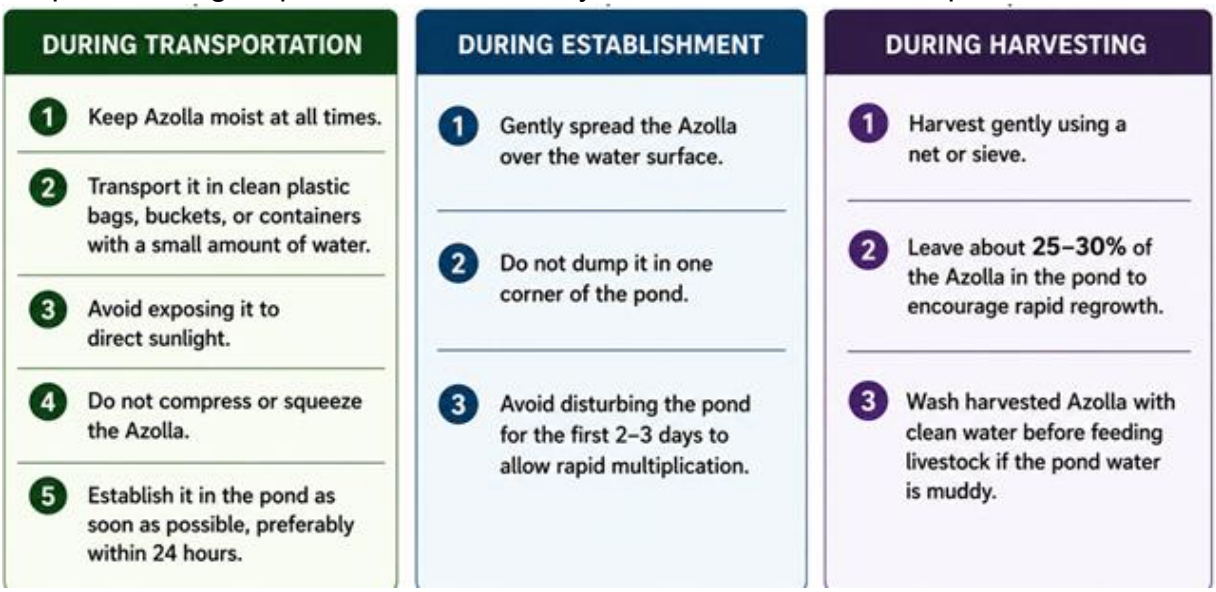


Figure 2.6: How to Handle Azolla Starter Culture

2.10 Suitable Water Sources

Water quality greatly influences Azolla growth.

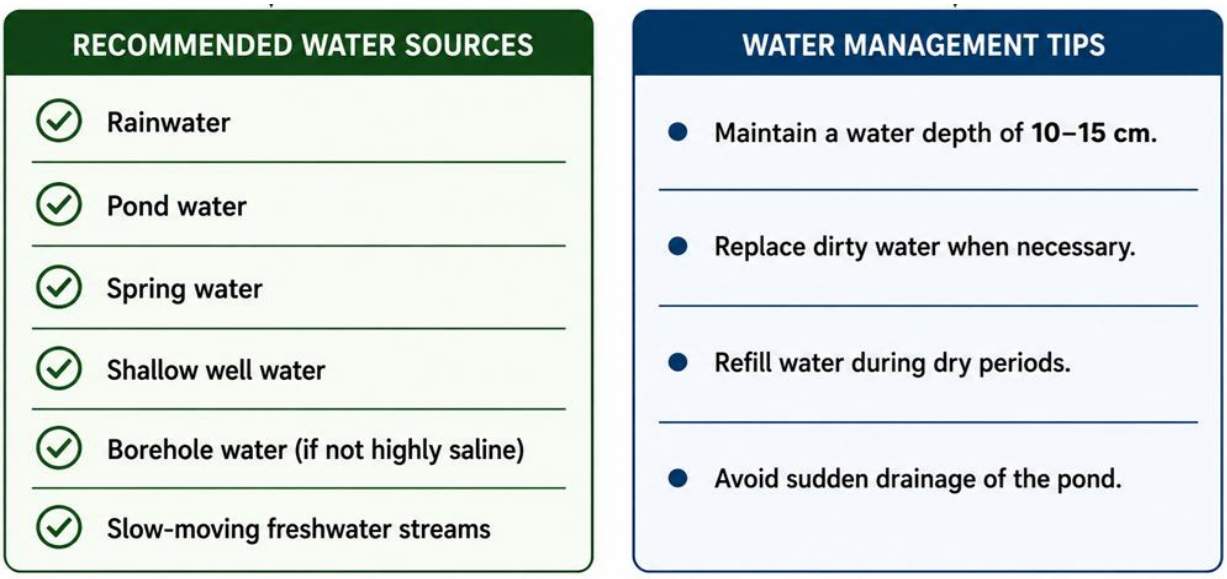


Figure 2.7: Suitable Water Sources and Management

2.11 Temperature Requirements

Temperature is one of the most important factors affecting Azolla growth.

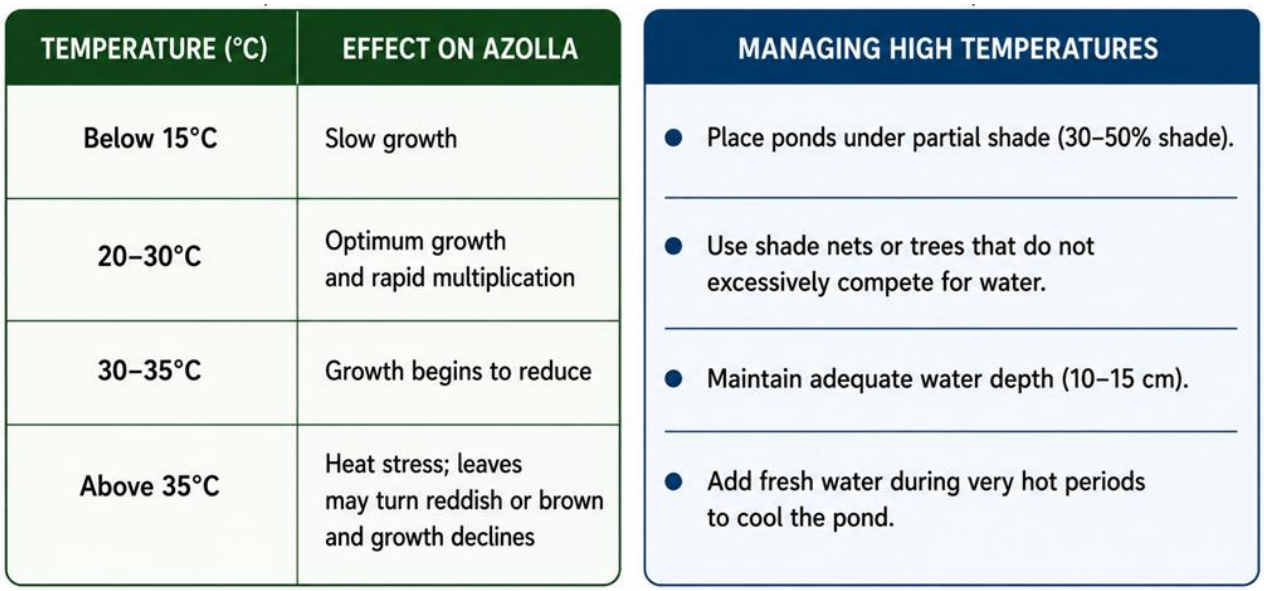


Figure 2.8: Temperature Requirements for Azolla Growth

Extension Tips for Farmers

- Start with **200–500g of healthy Azolla starter culture** from a trusted source.
- Keep the starter culture moist and protected from direct sunlight during transport.
- Use clean, non-polluted water to establish the pond.
- Maintain temperatures between **20–30°C** for the best growth; provide shade during very hot weather.
- Harvest regularly but always leave some Azolla in the pond for continuous multiplication.
- Integrate Azolla into crop and livestock systems to recycle nutrients, reduce external inputs, and strengthen agroecological farming practices

In local chickens, inclusion of 20% Azolla microphylla in commercial feed reduced feed cost by about 17% and increased income per bird without negatively affecting final body weight ***(Setiadi et al., 2016)***

INNOVATION 3: BIOCHAR FOR SOIL HEALTH

Aligned Agroecology Principles: *Recycling, Efficiency, Soil Health, Synergies*

EU Technology Readiness Levels (TRLs) ***https://www.euacc.ai/guides/trl-levels-guide*** **: 5,6,7**

3.1 Introduction to Biochar Use Farming in Uganda

Uganda's agricultural productivity depends largely on the health of its soils, yet many parts of the country are experiencing serious soil degradation. The problem is particularly pronounced in Eastern Uganda, where districts such as Bugiri, Busia, Pallisa, Butaleja, Tororo, and Namutumba have experienced declining soil fertility due to continuous cultivation, soil erosion, nutrient mining, population pressure, and limited replenishment of soil organic matter. In many areas, farmers cultivate the same land season after season with little or no addition of organic matter, resulting in depleted soils that are less productive and more vulnerable to drought. Consequently, crop yields have declined, threatening household food security and incomes. Climate change, characterized by prolonged dry spells and intense rainfall, has further accelerated soil degradation through erosion and nutrient loss.

One promising solution to restoring soil health is the use of biochar. In Uganda, biochar is increasingly being promoted by research institutions, universities, development partners, NGOs, and agricultural extension programmes as part of climate-smart agriculture, agroecology, and regenerative farming. When used together with compost or animal manure, biochar significantly improves soil fertility and crop productivity. As Uganda seeks sustainable solutions to restore degraded soils, especially in Eastern Uganda, biochar offers a practical, low-cost technology that transforms agricultural waste into a valuable resource for improving soil health, increasing farm productivity, and strengthening the resilience of smallholder farming systems.

3.2 What is Biochar?

Biochar is a stable, carbon-rich material produced by heating organic biomass—such as maize cobs, rice husks, coffee husks, groundnut shells, sawdust, and other agricultural residues—in a low-oxygen environment through a process called pyrolysis. Rather than allowing these residues to be burned in the open or left to decompose, they can be converted into biochar and returned to the soil as a valuable amendment.

When incorporated into the soil, biochar improves soil structure, increases water-holding capacity, enhances nutrient retention, stimulates beneficial soil microorganisms, and improves fertilizer use efficiency. It also helps restore soil organic carbon, making soils more resilient to drought and heavy rainfall. Because biochar remains stable in the soil for many years, it also stores carbon, helping to reduce greenhouse gas emissions and contributing to climate change mitigation. Biochar is an important agroecological innovation because it converts farm waste into a valuable soil amendment while reducing environmental pollution (Lehmann & Joseph, 2015).

3.3 Benefits of Biochar in Agroecology

Biochar contributes to sustainable farming through: recycling crop residues into useful soil inputs; improving soil fertility and biodiversity naturally; increasing water retention during dry periods; and reducing dependence on chemical fertilizers. Also, biochar stores carbon in the soil, helping to reduce climate change and supporting long-term sustainable crop production.

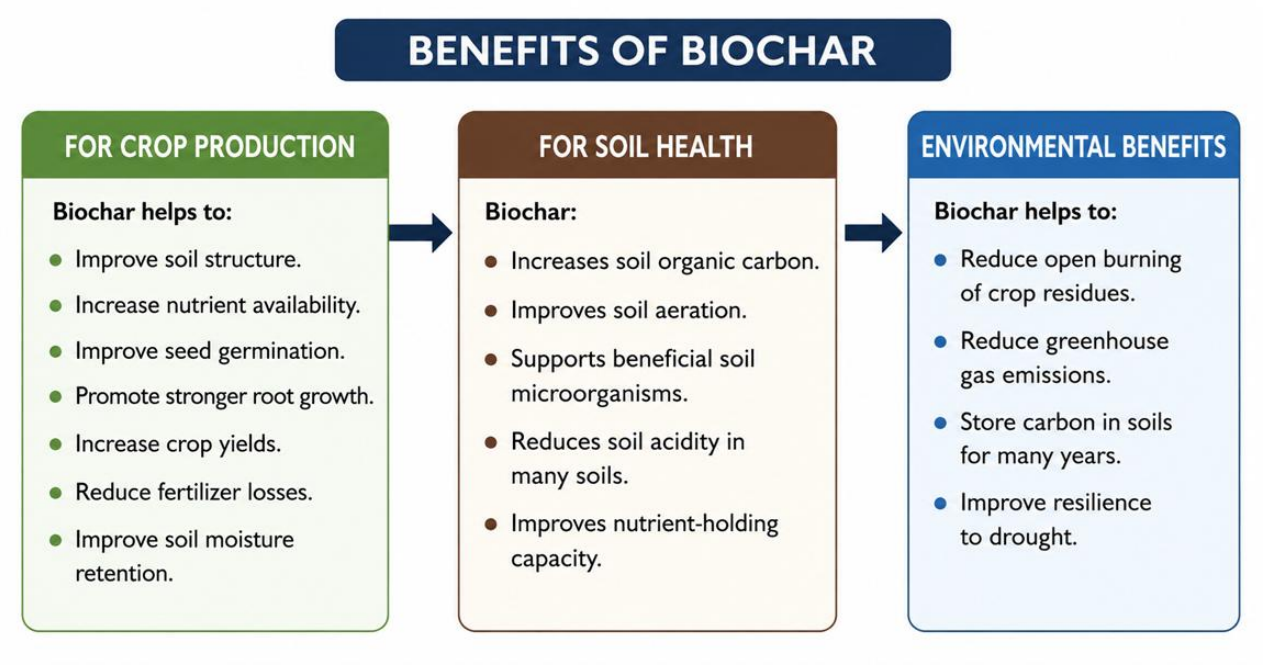


Table 3.1: Benefits of Biochar summarised

3.4 Materials Needed for making Biochrar

The su**itable biomass includes:** Maize stalks, Rice husks, Coffee husks, Bean residues, Dry grass, Groundnut shells, Sorghum stalks, Millet stalks, Dry banana leaves and Small tree branches

Table 3.2: Materials needed for making Biochar

3.5 Step-by-Step Production Guide

Making biochar at farm level involves the controlled heating of dry plant biomass under limited oxygen to produce a stable, carbon-rich material that can improve soil health and productivity. A drum is particularly suitable for smallholder farmers because it is relatively affordable, locally available, easy to operate and allows better control of airflow and burning than open burning methods. By limiting the amount of oxygen reaching the biomass, the drum helps convert more of the material into biochar rather than allowing it to burn completely into ash, while also making the process easier to manage at farm level.

The following steps provide a practical guide for preparing the drum and biomass, controlling and stopping the burning process, cooling and crushing the biochar, and finally charging and applying it to the soil. Careful attention to each step helps produce good-quality biochar while minimizing the loss of biomass to ash.

Table 3.3: Steps for making Biochar in a drum

Proper use of Biochar

The last three steps outline how biochar is properly prepared before it is applied to the soil to maximize its benefits to crops. After production, biochar should be crushed and charged with compost, manure or urine before soil application to improve nutrient and moisture retention, support beneficial microorganisms, and enhance soil fertility.

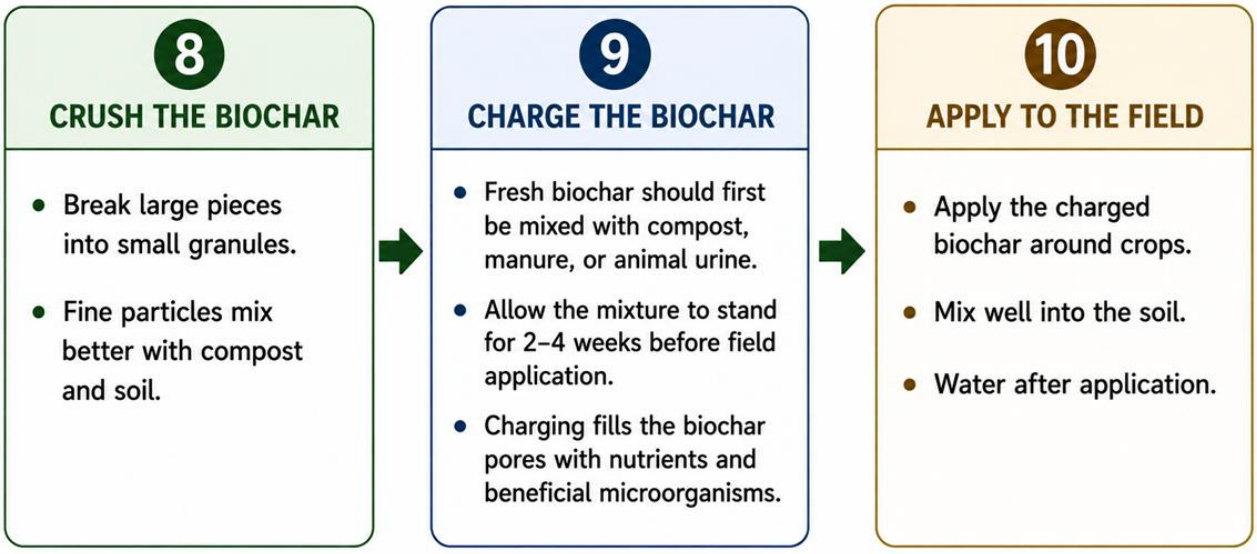


Table 3.4: Proper preparation and application of Biochar

3.6 Conditions for Good Biochar Production

Good-quality biochar production depends on carefully controlling the materials and conditions during the burning process. Using dry biomass, limiting oxygen, maintaining a slow and controlled burn, cooling the biochar promptly, and storing it in a dry place help prevent the material from turning into ash and ensure production of stable, high-quality biochar suitable for soil improvement.

PARAMETER	RECOMMENDED	
Biomass	Use dry plant materials with little or no moisture.	
Drum	Use a standard 200-litre metal drum.	
Oxygen	Limit the amount of air entering the drum.	
Burn	The fire should move slowly from the top downwards.	
Cooling	Pour water to stop the burn as soon as it is ready.	
Storage	Store biochar in a dry place protected from rain and moisture.	

Table 3.5: Conditions good for Biochar production

3.7 Seasonal Calendar (Uganda)

Biochar activities can be undertaken throughout the year, but their timing should follow the local rainfall and cropping seasons to make production easier and more effective. The dry season is generally more suitable for collecting and drying biomass and producing biochar, while the rainy season provides favourable conditions for preparing compost and applying charged biochar before planting. Proper seasonal planning helps farmers use available biomass efficiently, reduce production difficulties and ensure that biochar is ready when needed for crop establishment.

ACTIVITY	DRY SEASON (December – February & June – August)	RAINY SEASON (March – May & September – November)
	Best time when there are more ticks ✓	Best time when there are more ticks ✓
1 Collect biomass	Best time – dry and easy to store	Possible – may be wet; dry and store under cover
2 Make biochar	Ideal time – easier to control	Possible – more difficult to control due to wet conditions
3 Prepare compost	Good time – faster; materials easier to handle and manage	Best time – keep pile covered to maintain heat and reduce excess moisture
4 Charge biochar	Good time – easier mixing and drying	Good time – ensure mixture is not too wet and store in a covered place
5 Apply before planting	Possible – if field is workable and not waterlogged	Best time – apply before planting

Table 3.6: Conditions good for Biochar production

3.8 Cost-Benefit Analysis of Biochar

Biochar can be produced at relatively low cost at farm level, particularly when farmers use locally available crop residues and their own labour. Although some initial investment may be required for a metal drum and basic tools, these can be reused for several production cycles. The main benefits come from improved soil fertility, better moisture and nutrient retention, reduced dependence on purchased soil amendments, and possible improvements in crop productivity. The initial Costs in Ugx. for the for the external materials are indicated below: Drum -100,000, Chimney-30,000, and Tools -20,000. Totalling -**150,000** ***(about $42)***

Note: The above quotations are based on costs in Bugiri District

Economic benefit: *Biochar can generate economic returns through improved crop productivity and longer-term soil improvement, particularly when produced from locally available biomass at low cost. A Ugandan maize study reported a benefit–cost ratio of 3.71 for biochar, indicating that the value of benefits was substantially greater than the costs under the study conditions (Ssekandi et al., 2026)*

INNOVATION 4: THE LORENA ENERGY SAVING STOVE

Aligned Agroecology Principles: *Input reduction, Economic diversification, Social Values / Diets and Fairness*

EU Technology Readiness Levels (TRLs) *https://www.euacc.ai/guides/trl-levels-guide* **: 5,6,7**

4.1 Introduction use of improves stoves in Uganda

Uganda relies heavily on biomass for household energy, with over 85% of households using firewood and charcoal for cooking. Firewood is the main fuel in rural areas, while charcoal is more common in urban centres. However, widespread use of traditional three-stone fires and inefficient charcoal stoves has led to deforestation, excessive fuel consumption, indoor air pollution, and health problems, especially among women and children who spend long hours cooking. Improved cookstoves offer an affordable and practical solution by using less fuel, producing less smoke, retaining heat more efficiently, and reducing cooking costs.

Over the past two decades, the Government of Uganda, development partners, NGOs, and the private sector have promoted these stoves to improve access to clean energy, protect the environment, enhance public health, and reduce household expenditure on fuel. Common improved cookstoves available in Uganga include improved charcoal stoves, rocket stoves, Lorena (mud) stoves, institutional stoves, and cleaner fuel stoves using briquettes, biogas, Liquefied Petroleum Gas (LPG), or electricity where available (UBOS,2024).

4.2 The Lorena Energy saving stove

Figure 4.1: The Lorena Energy saving Stove

The Lorena stove is one of Uganda's most widely promoted improved biomass cookstoves. It is a fixed, fuel-efficient stove built from locally available materials such as anthill soil (clay), sand, sawdust or dry grass, bricks, and a chimney. Designed to replace the traditional three-stone fire, it improves heat transfer, reduces smoke, and lowers firewood consumption. Its affordability, durability, and ease of construction have led to widespread use in rural households, schools, refugee settlements, and other institutions. Uganda adopted the Lorena stove in the late 1990s and early 2000s to address deforestation, indoor air pollution, rising fuel costs, and reliance on firewood. The Ministry of Energy and Mineral Development, with GTZ, developed the improved Rocket-Lorena Stove and published national construction guidelines in 2003, revised in 2005.

4.3 Benefits of the Lorena as an energy saving stove

The Lorena stove provides several economic, health, environmental and household benefits compared with the traditional three-stone fire. Its improved design uses firewood more efficiently, reduces smoke exposure and cooking time, improves kitchen safety, and helps households save money while conserving the environment.

Figure 4.2: The benefits of the Lorena Energy saving Stove

4.4 Materials and Equipment Required TO Construct a Lorena

The materials required to construct a Lorena stove are simple, affordable and mostly locally available, making the technology suitable for rural and low-income households. Most materials, such as anthill soil, sand, straw, banana pseudo-stems, water and bricks, can be obtained locally, while only a few basic household tools are required for construction.

Figure 4.3: Materials for making a Lorena Stove

4.5 Step-by-step guide to constructing a Lorena Stove

i. Mix clay or soil with sand or silt at a ratio of 1:1. Using a basin or wheelbarrow

ii. Mix the two portions with water (preferably using your feet), so well into a moldable mixture that does not stick to your hands of feet

iii. Mapping:

- Find a place in the kitchen that is facing the door, along the back wall
- Make sure the place is clean
- Line up the two saucepans to map the ground, using the full width of your hand as shown in the figure below. There should be no space left between the hand and the pots. The lager saucepan is also used to mark the height, while lying.

Wall

Figure 4.4: Making the ground map with the saucepans and hand

iv. Using a charcoal piece, mark the lines as shown in the figure below

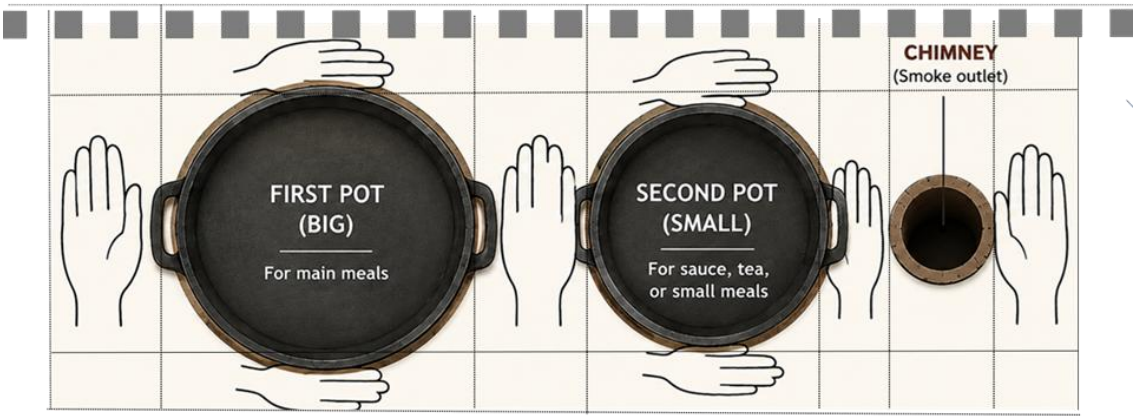


Figure 4.5: Marking the foundation

v. Remove the saucepans and make the stove foundation using the bricks around the outside

vi. Lay a banana stem in the fire inlet and a smaller one in the chimney outlet

vii. Start pilling (using a lot of force) the soil mixture on the stems to make an appropriate mound up to the measured height.

viii. Level the top.

ix. Map the pot holes using the pots and again.

x. Use a knife and spoon to scoop out the mud from the pot holes outlines.

xi. At about 1 inch deep leave a provision where the saucepan will rest (by reducing the radius by about 1 inch).

xii. Scoop up to the stones and make holes connecting the pot holes and the chimney (from the big hole, move slightly upwards).

xiii. Make a ridge in the smaller pot hole to prevent direct escape of heat from the large hole to the chimney.

xiv. Cut off all the unnecessary soil and smoothen the stove with your hands or polythene paper and water.

xv. Remove the small pseudo stem and make the chimney go through the wall to direct smoke out.

xvi. Turn the saucepans every morning for about 5 days, to keep the hole in the right size and shape. After this period you can remove the big pseudo stem from the fire inlet, shape and smoothen it well

xvii. Leave it to dry for 3 weeks to dry.

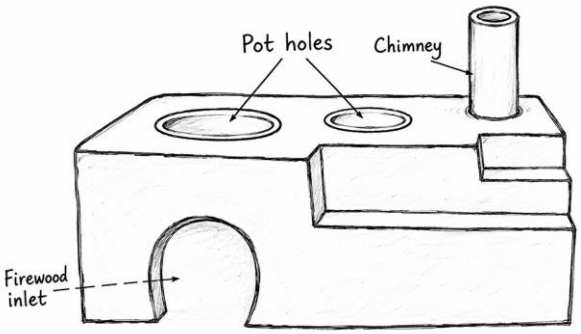


Figure 4.6: The Sketch of a finished Lorena

Note:

- *Never use it before it dries*
- *Always repair it when it cracks*
- *Use very little fire wood or else the fire will be to much*

Caution:

- *It takes long to dry*
- *Laborious to make, it needs group work*
- *It cracks*

4.6 Challenges

Despite their many advantages, Lorena stoves face some challenges:

- They require skilled construction for optimum performance.
- Mud stoves need protection from prolonged exposure to rain or flooding.
- Poorly built stoves may develop cracks or perform inefficiently.
- Chimneys require periodic cleaning to maintain proper airflow.
- Some households continue to prefer traditional cooking methods due to familiarity or cultural practices.

4.7 The Economic Benefits of the Lorena Stove

Beyond improving cooking efficiency, the Lorena stove provides important household economic benefits by substantially reducing firewood consumption and the associated costs and time spent collecting fuel. Evidence from Uganda indicates that Rocket Lorena stoves can reduce firewood consumption by approximately 50–60%, translating into considerable savings for households while also reducing pressure on forest resources. Habermehl, H. (2007). Figure 4.7 illustrated the economic benefits using the findings.

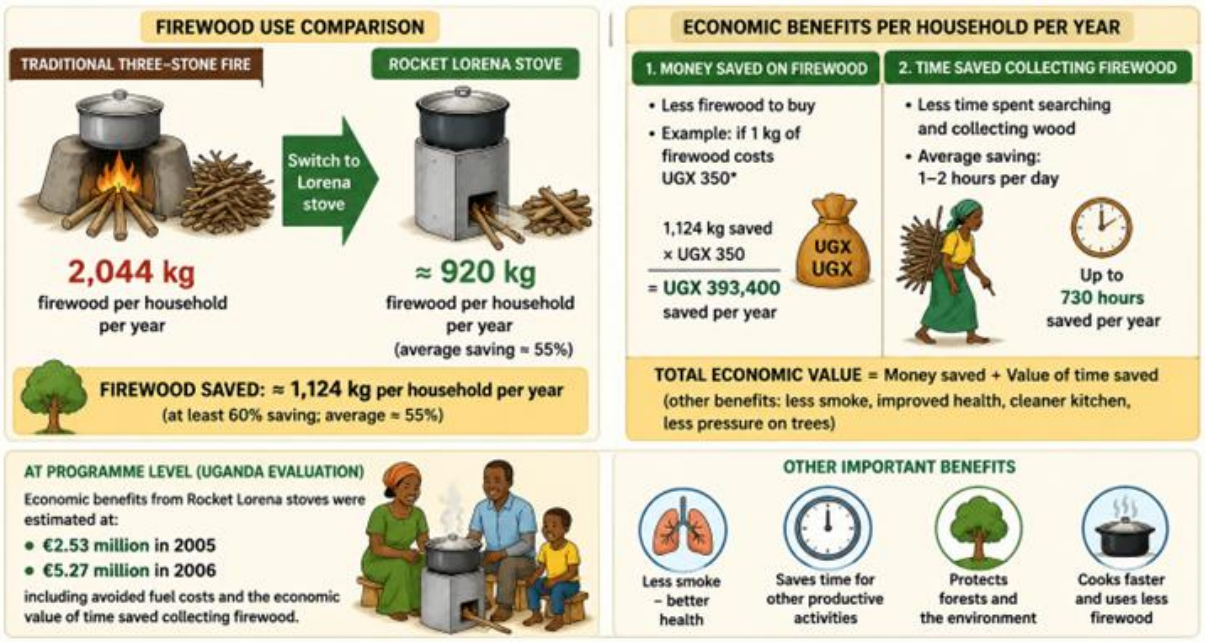


Figure 4.7: Illustration of the economic benefits of the Lorena Stove

Conclusion: The Lorena stove has become one of Uganda's most successful improved cookstove technologies. Adapted from a Central American design and enhanced through the Rocket-Lorena model, it provides a practical, low-cost solution to household cooking energy challenges.

INNOVATION 5: THE TUMBUKIZA METHOD FOR SUSTAINABLE PASTURE ESTABLISHMENT

Aligned Agroecology Principles: *Input reduction, Soil health, Animal health, Biodiversity, Resilience and Economic diversification*

EU Technology Readiness Levels (TRLs) ***https://www.euacc.ai/guides/trl-levels-guide*** **: 5,6,7**

5.1 Introduction to Improved Pasture Establishment in Uganda

Livestock production is an important source of livelihood for many households in Uganda, providing milk, meat, income, manure, animal traction, and household security. In districts such as Sembabule, cattle farming is a major economic activity supporting thousands of smallholder farmers.

However, livestock productivity is increasingly affected by challenges such as: Declining pasture availability, long dry seasons, overgrazing, land degradation, low soil fertility and increasing costs of commercial livestock feeds.

During dry periods, many farmers experience shortages of quality livestock feed, leading to reduced milk production, slow animal growth, weight loss, and increased livestock diseases.

Improved pasture establishment provides a practical solution by enabling farmers to produce nutritious livestock feed throughout the year. Technologies such as the Tumbukiza method help farmers grow more forage on small pieces of land by conserving water, improving soil fertility, and increasing pasture survival during drought periods.

5.2 The Tumbukiza Pit Method for Pasture Establishment

Tumbukiza as a Kiswahili word meaning “placing in a hole” and explain that the farmer-developed method uses pits and integrated nutrient management to improve Napier grass production Nyambati et al (2011). Tumbukiza is an adapted Zai pit that is dug much larger and deeper to support high-yield, moisture-loving crops like Napier grass or bananas (https://sti-portal.fao.org/innovations/zai-or-tassa-planting-pits. It is prepared and enriched with manure or compost mixed with topsoil before planting. The method concentrates nutrients and moisture around the plant roots, helping improve soil fertility, water retention and crop growth, and is commonly used in East Africa for establishing Napier grass and other fodder crops.

The pits act as small water and nutrient reservoirs around plant roots. They capture rainwater, reduce runoff, improve nutrient availability, and allow pasture plants to continue growing even during dry periods. The method is especially suitable for smallholder farmers because it uses locally available resources such as: animal manure, compost, crop residues, locally available planting materials and family labour

A properly managed Tumbukiza pasture can provide reliable livestock feed for several years while reducing dependence on expensive purchased feeds. The recommended Tumbukiza Pit size is 2fet (60cm) in length, width and depth.

5.3 Benefits of Establishing Pastures Using the Tumbukiza Method

Adopting the Tumbukiza method can help farmers establish productive and resilient pastures by concentrating soil nutrients and moisture around the plants. The method can increase livestock feed availability, improve soil fertility and water conservation, reduce feeding costs, strengthen resilience to drought and climate change, and create additional income opportunities from fodder and planting materials.

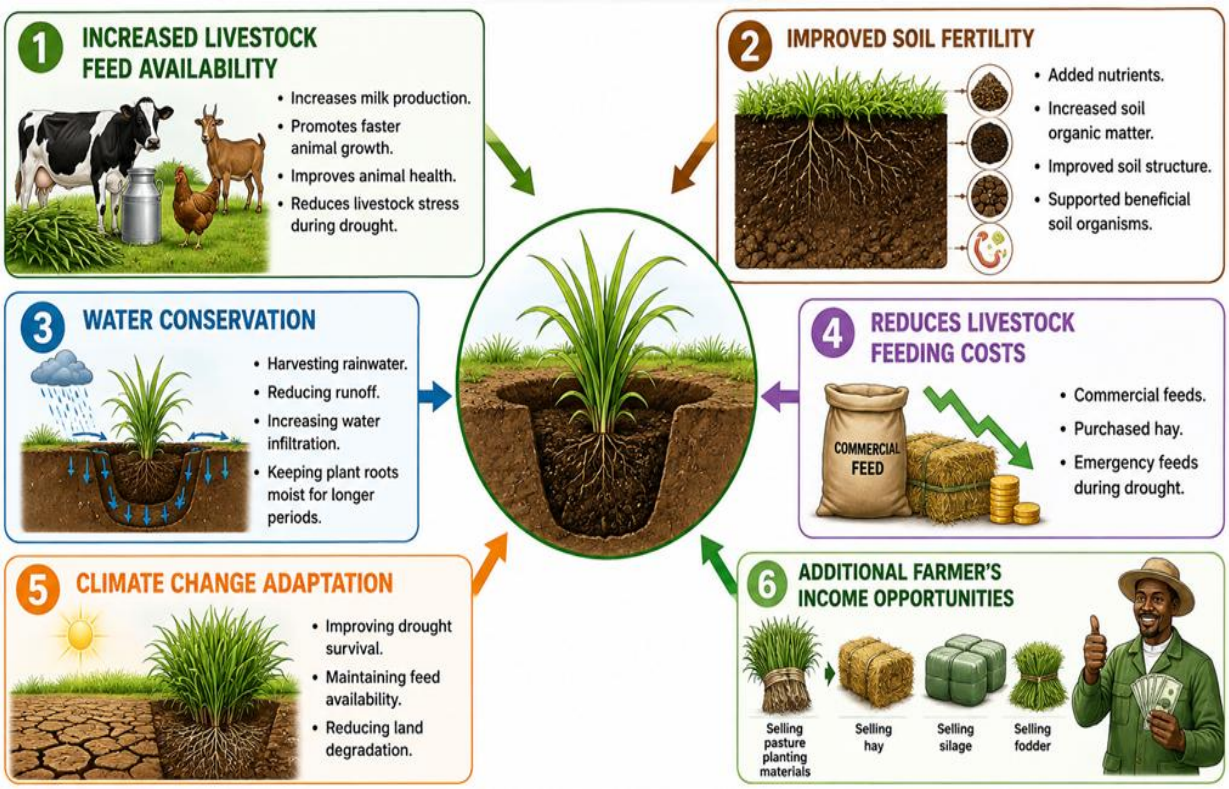


Figure 5.1: The benefits of Tumbukiza method in pasture establishment

5.4 What Materials and Equipment are Required

Most materials and equipment required for establishing pasture using the Tumbukiza method are simple, affordable and readily available at farm or community level. These include organic soil amendments, pasture planting materials, mulch, water and basic farm tools, making the method practical and accessible to smallholder farmers.

MATERIAL/EQUIPMENT	PURPOSE	ILLUSTRATION
Well-decomposed animal manure	Improves soil fertility and moisture retention	
Fertile topsoil	Provides a growing medium	
Compost	Adds nutrients and improves soil health	
Pasture planting materials (Napier grass cuttings and legume seeds)	Establishes forage crops	
Dry grass/crop residues	Used for mulching	
Water	Supports planting and establishment	
Hoe	Digging pits	
Spade	Soil preparation	
Panga	Clearing vegetation	
Measuring tape/string	Measuring pit spacing	

Figure 5.2: The Materials and Equipment used in the Tumbukiza method

5.5 Recommended Pasture Species for Tumbukiza Planting

For better livestock nutrition and sustainable pasture production, farmers are encouraged to establish a mixture of grasses and forage legumes using the Tumbukiza method. High-yielding grasses provide abundant fodder, while herbaceous legumes and legume shrubs supply protein-rich feed, improve soil fertility through nitrogen fixation, and strengthen pasture resilience, helping maintain quality livestock feed throughout the year.

A. GRASSES

Pasture Species		Main Benefit
Pakchong Napier		Produces high amounts of livestock feed
Elephant Grass		Fast-growing fodder

B. HERBACEOUS LEGUMES

Pasture Species		Main Benefit
Lablab		High protein feed and improves soil fertility
Silver Leaf Desmodium		Improves animal nutrition and soil fertility

C. LEGUME SHRUBS

Species		Main Benefit
Calliandra		Protein-rich livestock feed
Leucaena		Drought tolerant and nutritious
Sesbania		Improves soil fertility

Figure 5.3: Recommended pasture species

5.6 Step-by-Step Guide to Establishing Tumbukiza Pastures

Successful establishment of Tumbukiza pastures involves careful site selection, proper land preparation, preparation of nutrient-rich planting pits, and timely planting. Following the recommended steps helps conserve soil moisture and nutrients while creating favourable conditions for grasses and legumes to establish together, resulting in productive, nutritious and resilient pastures for livestock.

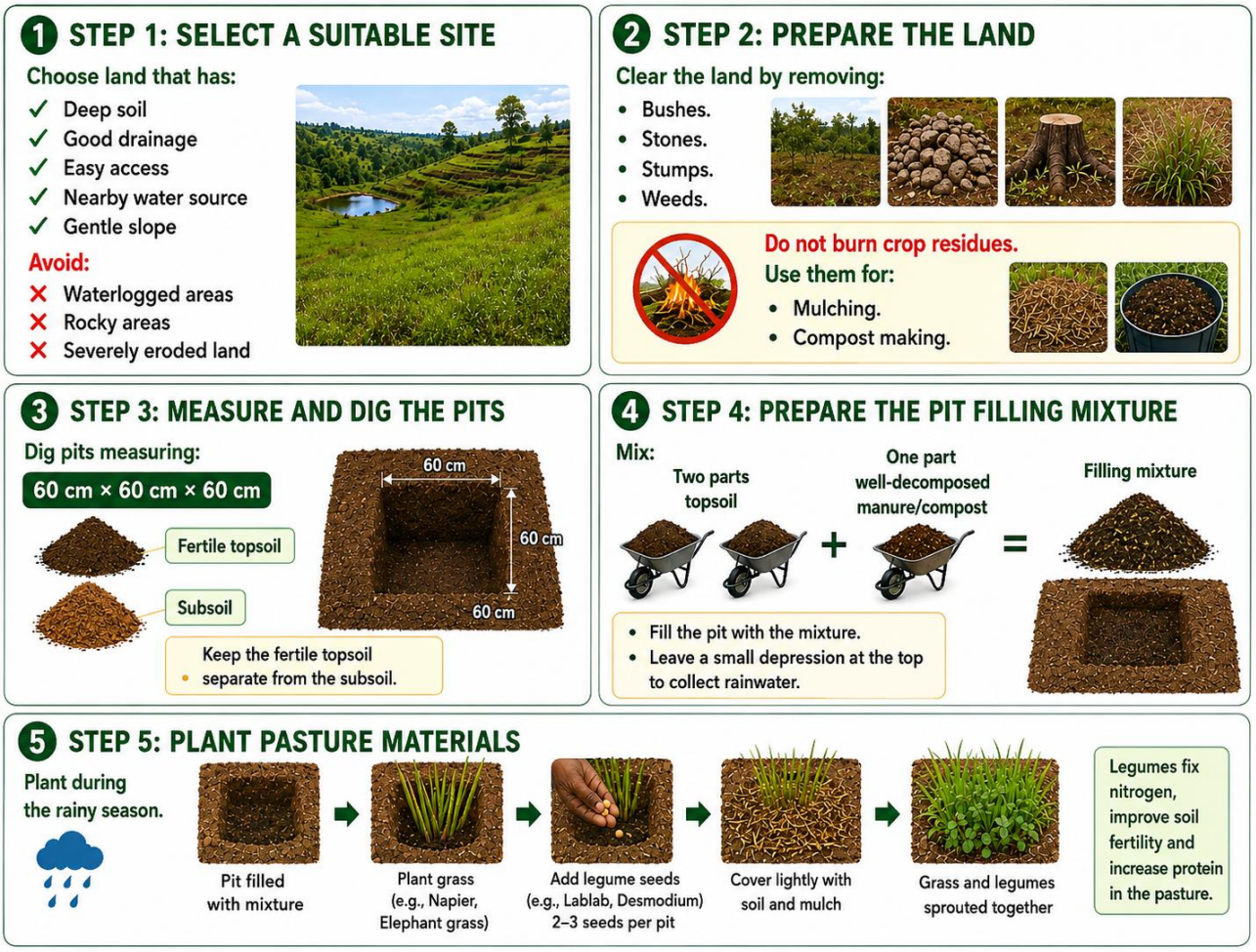


Figure 5.4: Guidelines to establishing Tumbukiza planted pastures

Planting Tips:
For:
- Pakchong Napier-Use healthy stem cuttings with 2–3 nodes
- Lablab - Plant 2–3 seeds per hole
- Desmodium-Mix seed with sand and sow lightly
- Calliandra -Plant healthy seedlings

5.7 Management of Tumbukiza Pastures

Proper management is essential for maintaining healthy, productive and sustainable pastures throughout the year. Regular weed control, replenishing soil nutrients with well-decomposed manure, and careful water management—including rainwater harvesting, mulching and supplementary watering during severe dry periods—help sustain pasture growth, improve fodder availability and support better livestock production.

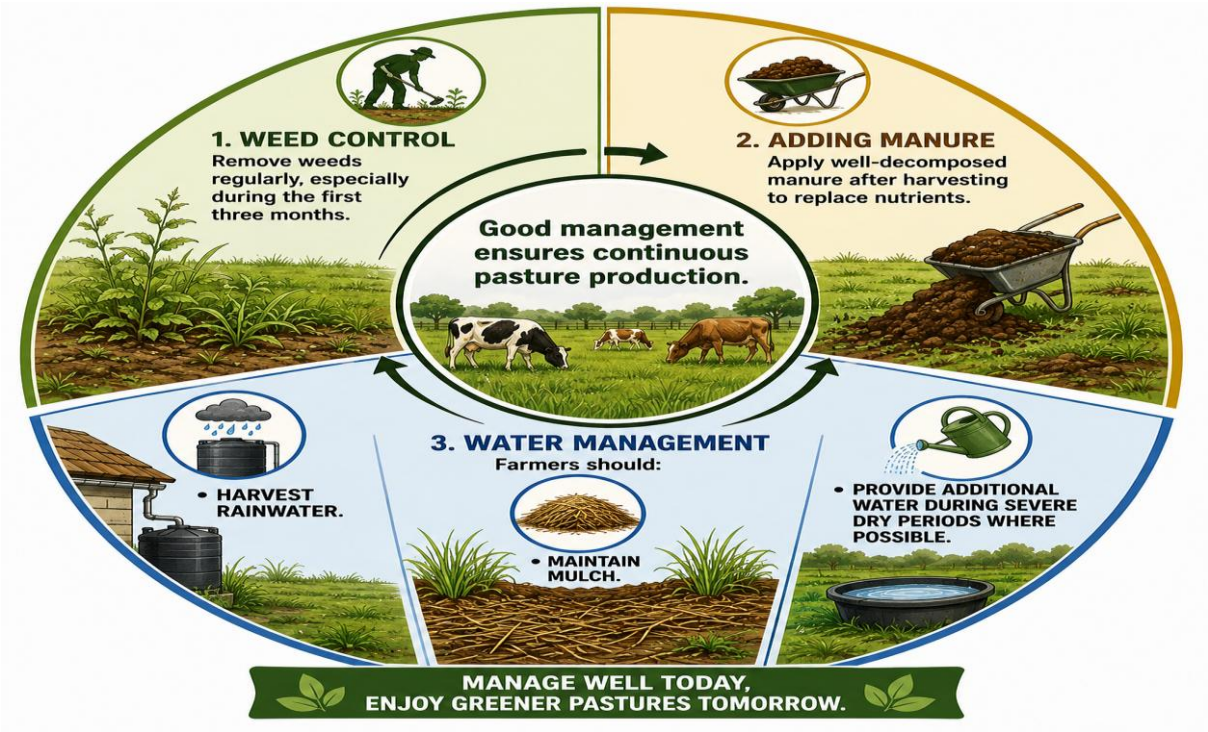


Figure 5.5: Management of Tumbukiza planted pastures

Tips on Harvesting Pastures

Pakchong Napier

- First harvest: 3–4 months after planting.
- Later harvesting: Every 6–8 weeks.
- Leave 10–15 cm above the ground for regrowth.

Lablab and Desmodium

Harvest when leaves are still tender and nutritious.

Calliandra

Regularly prune young shoots

5.8 Pasture Conservation for dry seasons

Pasture is often abundant during the rainy season but becomes scarce during prolonged dry periods, leading to feed shortages and reduced livestock productivity. Farmers should therefore harvest and conserve surplus pasture as hay or silage when it is plentiful, store it properly, and use it during feed-scarce periods to maintain animal productivity, reduce feed costs and strengthen farm resilience.

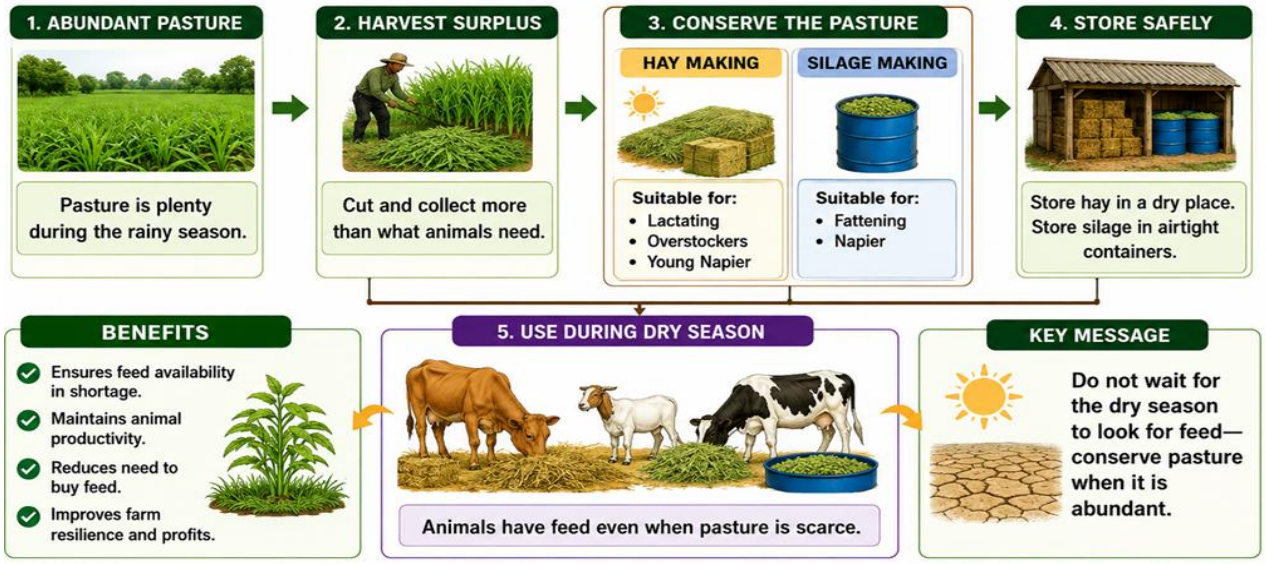


Figure 5.6: Pasture Conservation for dry seasons

5.9 Estimated Requirements for One Acre

Input	Requirement
Manure	4–6 tons
Pakchong Napier cuttings	4,000–5,000 cuttings
Lablab seed	8–10 kg
Desmodium seed	2–4 kg
Calliandra seedlings	300–400 seedlings
Mulching materials	As available

*****Based on costs in Sembabule district***

Economic benefit: *The Tumbukiza method enables farmers to produce more fodder from limited land by concentrating manure, moisture and plant nutrients within planting pits. Although it requires greater labour at establishment, research in Kenya found a* ***benefit–cost ratio of 5.27****, compared with 4.83 for conventional establishment with DAP and 3.03 for conventional establishment with farmyard manure. Its higher fodder productivity and reduced land requirement make Tumbukiza particularly attractive to land-constrained smallholder livestock farmers (Muyekho et al., 2003)*

5.10 Challenges and Solutions pasture establishment

Successful pasture establishment can be affected by challenges such as drought, poor plant growth, weed competition, limited planting materials, high labour requirements and low farmer adoption. Identifying these challenges early and applying practical, locally appropriate solutions helps farmers establish productive and sustainable pastures.

Figure 5.7: Pasture establishment challenges and solutions

Conclusion

The Tumbukiza method provides a simple, affordable, and climate-resilient solution for livestock feed challenges among smallholder farmers.

By combining:

- Proper pit preparation.
- Organic manure.
- Improved pasture species.
- Good management practices.

farmers can produce nutritious livestock feed, reduce feeding costs, improve animal productivity, and conserve their soils.

The method demonstrates that using locally available resources can create stronger, more sustainable livestock farming systems

INNOVATION 6: BIO-INPUTS-(MAKING NATURAL CONCOCTIONS FOR FERTILISERS AND PESTICIDES)

Aligned Agroecology Principles: *Input reduction · Soil health · Recycling · Biodiversity · Natural pest regulation · Resource efficiency · Economic diversification*

EU Technology Readiness Levels (TRLs) *https://www.euacc.ai/guides/trl-levels-guide* **: 5,6,7**

6.1 Introduction to Farm-Made Bio-Inputs in Uganda

In Uganda, bio-inputs are increasingly important as farmers seek affordable and environmentally friendly alternatives to synthetic fertilizers and pesticides. They include organic fertilizers, compost, animal manure, biofertilizers, biopesticides, botanical extracts and beneficial microorganisms used to improve soil fertility, crop nutrition and pest and disease management.

Many smallholder farmers can produce bio-inputs using locally available materials such as livestock manure, crop residues, plant materials, wood ash and other farm-based resources. Their use supports agroecological, organic, regenerative and climate-resilient farming by recycling farm resources, improving soil health and reducing dependence on costly external inputs. Locally produced organic fertilizers and biopesticides can contribute to nutrient cycling, soil fertility, biodiversity conservation and reduced production costs. However, appropriate training, scientific validation and standards for preparation, dosage, application, storage and quality control are important to ensure their effectiveness and safe use (Dagoudo et al., 2024).

6.2 What are Bio-Inputs?

Bio-inputs are agricultural inputs prepared from organic materials, plants, microorganisms or naturally occurring substances and used to improve soil fertility, plant growth, crop health or pest management.

Bio-inputs can broadly serve two important functions in crop production:

Bio-inputs as fertilizers: These are used primarily to improve soil fertility and plant nutrition by supplying nutrients, increasing soil organic matter, stimulating beneficial soil microorganisms and improving nutrient availability. Examples include compost, animal manure, liquid organic fertilizers, biofertilizers and microbial inoculants.

Bio-inputs as pesticides: These are used to prevent, repel, suppress or control crop pests and diseases using plant-based substances, beneficial microorganisms or other naturally derived materials. Examples include neem extracts, chilli-garlic preparations, botanical pesticides and microbial biopesticides.

6.3 Benefits of Farm-Made Bio-Inputs

Home-made bio-inputs enable farmers to use locally available materials and knowledge to improve crop production while reducing dependence on expensive external inputs. Their key benefits are included in the figure below.

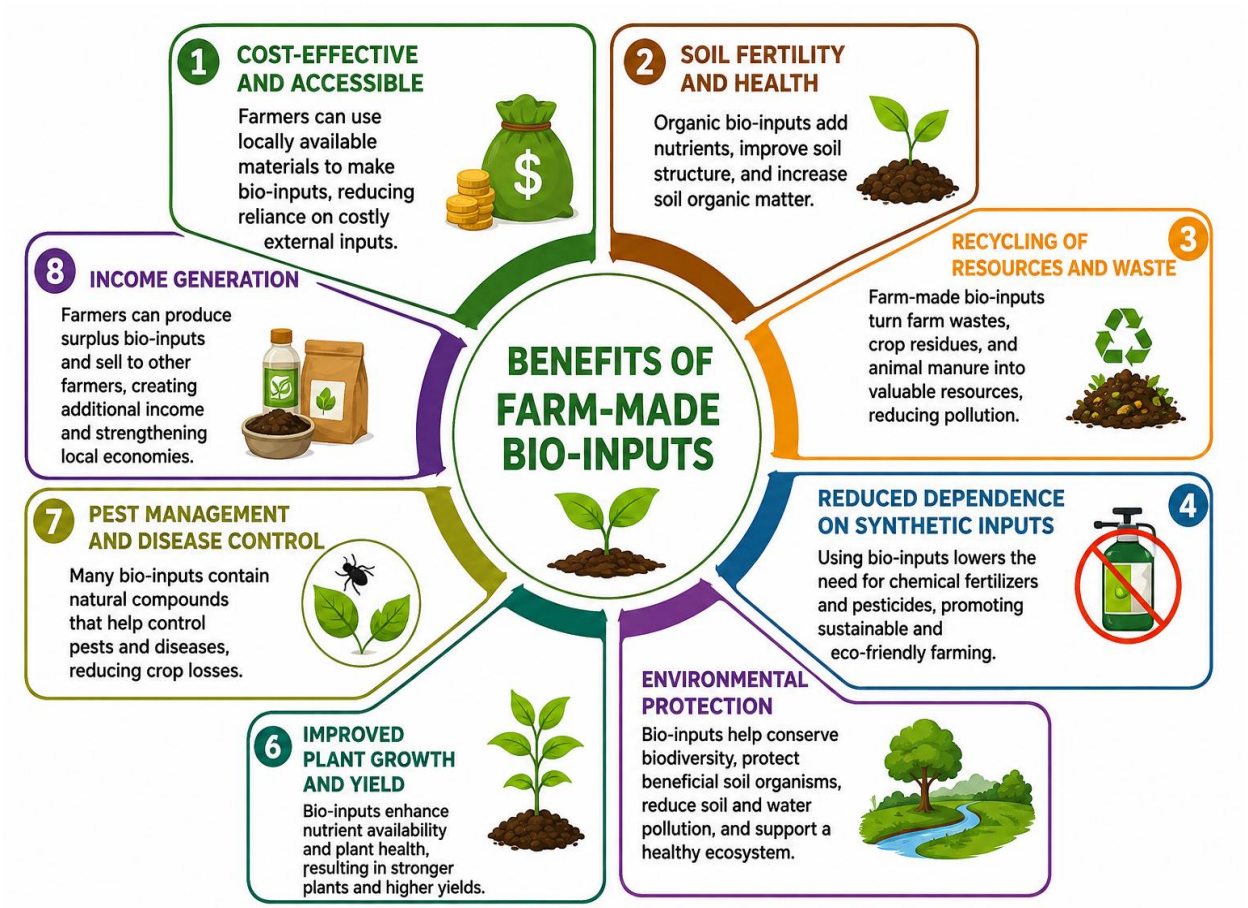


Figure 6.1: Pasture establishment challenges and solutions

6.4 Important Principles When Making Bio-Inputs.

Good bio-input preparation depends on several important principles. A successful bio-input preparation requires farmers to follow simple principles that ensure the products are safe, effective, and suitable for crops.

Careful selection of materials, cleanliness, good hygiene, correct proportions, proper preparation and clear labelling, proper storage, and appropriate application are important for achieving good results and avoiding damage to crops.

Following these basic principles helps farmers maintain the quality, effectiveness and safety of bio-inputs for crops, people, animals and the environment.

Figure 6.2: Important Principles when Making Bio-inputs

6.5 Natural Fertilizer Preparations

Bio-fertilizers and soil fertility inputs are natural preparations or organic materials used to supply plant nutrients, improve soil fertility and build long-term soil health. Many can be prepared on the farm using locally available materials, making them affordable and accessible to farmers. Bio-fertilizers benefit the soil through:

- Supplies nutrients: Provides nitrogen, phosphorus, potassium and other nutrients that are gradually released to crops.
- Improves soil structure: Adds organic matter, making the soil more friable and improving root development.
- Improves moisture retention: Increases the soil's ability to retain water, particularly important during dry periods.
- Promotes soil life: Provides food and favourable conditions for beneficial microorganisms and earthworms.
- Supports long-term soil fertility: Regular application helps build soil organic matter and improves nutrient cycling over time.

Important: Bio-fertilizers should always be well decomposed before field application. Proper storage and handling also help conserve nutrients and reduce weed seeds and potential pathogens.

1. Farmyard Manure (FYM)

Farmyard manure is an organic soil fertility input made from a decomposed mixture of livestock dung and urine, bedding materials and leftover animal feed. When properly collected, stored and decomposed, it provides nutrients and organic matter that improve soil health and support crop growth.

Figure 6.3: Composition of Farmyard Manure

2. Compost

Compost is a nutrient-rich organic material produced through the controlled decomposition of plant and animal materials such as crop residues, dry leaves, grass, kitchen waste and animal manure by microorganisms. When properly prepared, compost becomes a dark, crumbly, soil-like material that can be applied to fields and gardens to add organic matter and nutrients, improve soil structure and moisture retention, and support beneficial soil organisms.

Step-by-step on how to lay the materials when making compost manure

Compost is prepared by layering different organic materials so that they decompose into nutrient-rich organic manure. Select a well-drained site, preferably close to a water source, and prepare a compost heap of a manageable size.

i. Begin with a layer of coarse dry plant materials, such as maize stalks, dry grass or small twigs, to allow air circulation. Add a layer of green plant materials, such as fresh grass, weeds, leaves, vegetable residues and other fresh crop materials.

ii. Follow this with a layer of animal manure, which supplies nutrients and microorganisms that accelerate decomposition. Sprinkle a thin layer of fertile topsoil or old compost over the materials.

iii. Moisten each layer with water as the heap is being constructed, but avoid making it waterlogged. Repeat the layers—dry materials, green materials, manure and a little soil—until the heap reaches about 1–1.5 metres high.

iv. Finally, cover the heap with dry grass, banana leaves or other suitable plant material to conserve moisture and heat. Turn the compost periodically to improve aeration and ensure uniform decomposition.

The compost is ready when it becomes dark, crumbly, has an earthy smell, and the original materials are no longer easily recognizable.

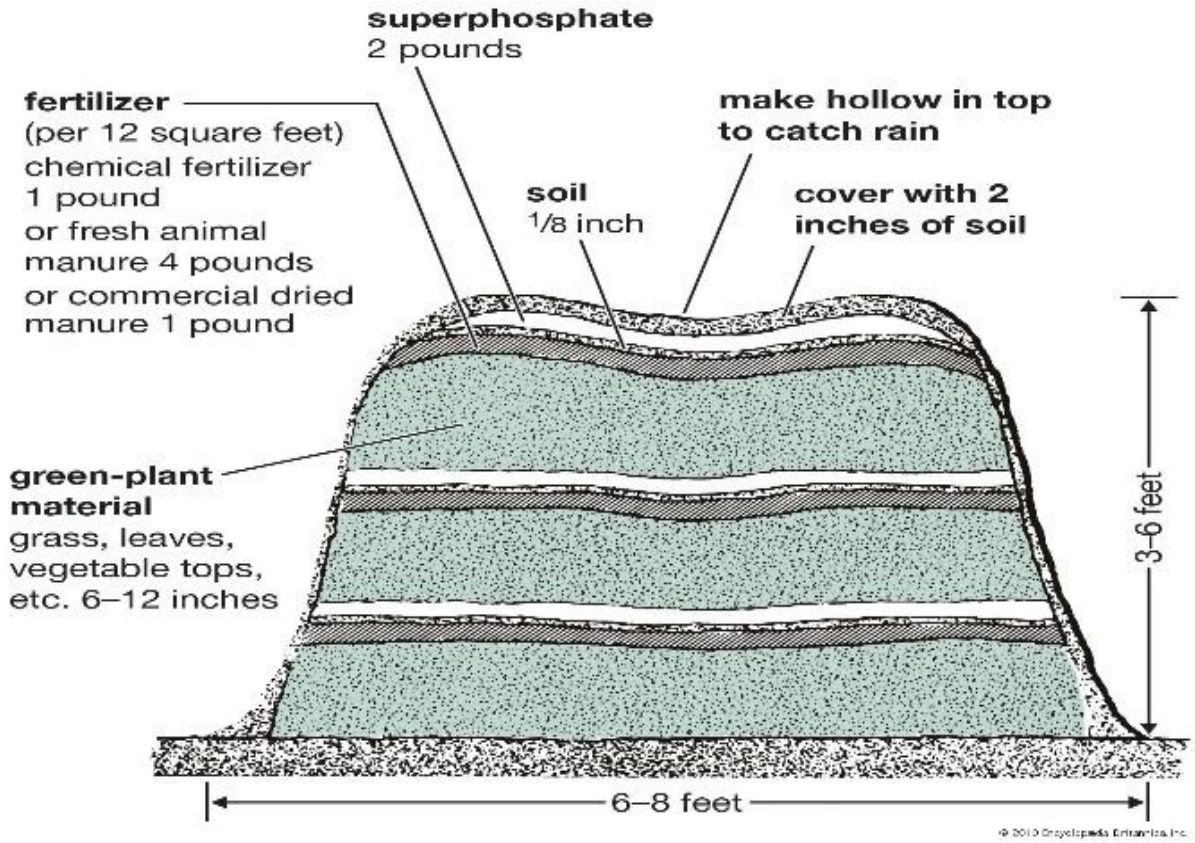


Figure 6.4: Composting process

Important Note: For agroecological farm-made compost, chemical fertilizer and superphosphate shown in the illustration are not necessary; animal manure, green materials and other locally available organic resources can provide the nutrient-rich layers.

How do I know my compost is ready?
Typically, it's ready for use after around four to six months of starting your bin. Though this process could take up to 12 months to fully decompose depending on the materials used. It will be a rich, dark and crumbly substance which presents a pleasant earth odour.

NOTE: Farmers can use a simple wooden pole to monitor the temperature of a compost heap. The pole is inserted into the center of the heap and left for some time. When it is pulled out, the farmer checks its temperature by touch. If the pole feels excessively hot, water should be added carefully to the compost heap to help regulate the temperature and maintain adequate moisture. Excessive heat should be avoided because it can reduce beneficial microbial activity and interfere with proper decomposition.

Figure 6.5: Testing readiness of compost

3. Organic Liquid Fertilizers

Organic liquid fertilizers are prepared by extracting or fermenting nutrients from plant materials, manure or other organic resources.

They are commonly applied to the soil or, where appropriate, to crop foliage as a supplement.

Organic liquid fertilizers can be prepared using locally available, nutrient-rich materials such as animal manure, green leaves and other plant materials, compost, crop residues, wood ash and clean water. Materials should be fresh or well decomposed as appropriate, free from plastics, chemicals and other contaminants, and combined in recommended proportions to produce a safe and effective fertilizer for improving soil fertility and crop growth.

Materials and their uses are reflected in the figure below

PLANT MATERIAL	PART COMMONLY USED	MAIN PURPOSE
Neem	Leaves, seeds	Repels and controls many insect pests
Chili	Fruits	Repels and controls chewing insects
Garlic	Bulbs	Repels insects
Lantana	Leaves	Helps repel some insect pests
Tobacco	Leaves	Insect control – use with caution
Tephrosia	Leaves	Traditional root pest management
Mexican marigold	Leaves and flowers	Repellent properties
Eucalyptus	Leaves	Repellent properties
Aloe vera	Leaves	Can be included in some plant-based preparations
Ginger	Rhizomes	Repellent properties
Onion	Bulbs	Repels some insect pests
Tomato	Leaves	Traditional insect repellent preparation
Papaya	Leaves	Used in some traditional pest-management preparations

Figure 6.6: Possible Materials for Organic Liquid Fertilizer

Preparation procedure

Liquid biofertilizers can be prepared on the farm using fresh nutrient-rich plant materials, clean water and, where appropriate, mineral-rich materials such as wood ash. The plant materials are cleaned, chopped into small pieces, placed in a clean container and mixed with water to encourage the release of nutrients and decomposition. The mixture is then loosely covered and kept under shade, where it is stirred periodically to promote even fermentation.

During this period, farmers should observe changes in smell, colour and bubbling as indicators of the fermentation process. Once sufficiently fermented, the liquid is strained to remove solid materials and diluted appropriately before application to crops. Clean equipment, appropriate proportions and careful monitoring throughout the preparation process are important for producing a safe and effective liquid biofertilizer**.**

Important precautions

- Use well-decomposed manure, particularly for crops that are harvested and eaten fresh.
- Avoid applying strong manure preparations directly onto edible plant parts.
- Do not use contaminated manure.
- Keep the preparation away from drinking water sources.

Figure 6.7: Preparing Organic Liquid Fertilizer

6.6 Organic pest and disease inputs (Natural Pesticide Concoctions)

These are preparations from plants or biological materials that may repel, deter, or suppress certain pests. Examples include: Neem extract, chilli extract, garlic extract, tephrosia extract, tithonia extract, soap-based plant extracts, and ash-based pest control preparations.

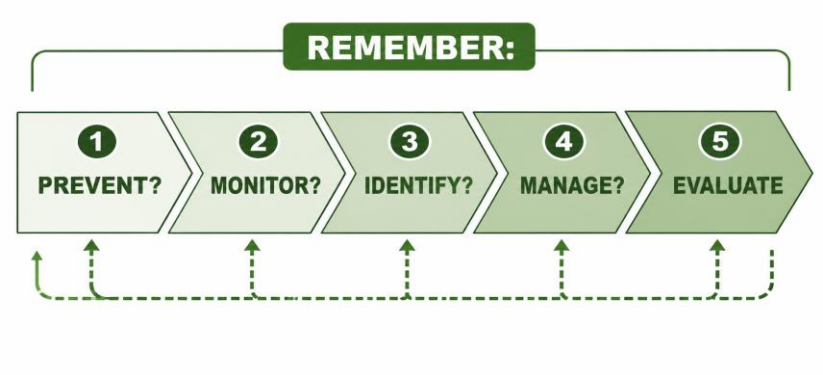
These are prepared from plants and other natural materials to help repel, suppress or manage agricultural pests and some materials that can help manage pests and diseases. They work by:

- Repelling insects;
- Reducing feeding;
- Interfering with insect development;
- Reducing pest populations;
- Making plants less attractive to pests

Figure 6.8: Possible Materials for Natural pesticide concoctions

Important notes

- Botanical pesticides should be considered part of an Integrated Pest Management (IPM) approach rather than the only method of pest control.
- Organic pesticides should not replace good crop management.
- Farmers should first use preventive and ecological approaches such as, Healthy planting materials, crop rotation, proper spacing, field sanitation, removal of heavily infested plant parts, conservation of beneficial insects, intercropping, mulching, resistant varieties where available, regular scouting.



6.7 Common Challenges and Solutions of Bio-inputs

Farmers may encounter several challenges when preparing and applying farm-made bio-inputs, including poor fermentation, incorrect concentration, ineffective pest control, crop damage and storage problems. Understanding the possible cause of each problem and applying the appropriate corrective measure helps farmers produce safer, more effective bio-inputs and achieve better crop protection and plant growth.

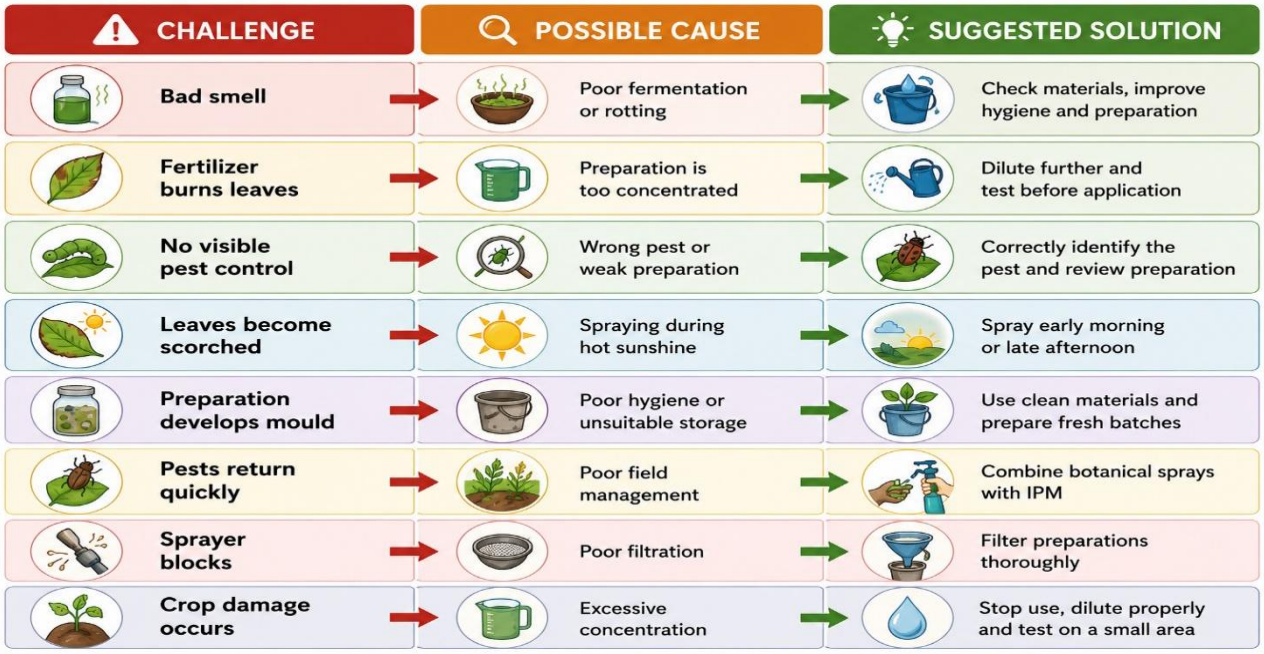


Figure 6.9: Challenges, causes and Possible Solutions

6.8 Good Bio-Safety Measures and practices for bio-inputs farmers

Good bio-safety measures and practices are essential when preparing, handling, storing and applying farm-made bio-inputs. Although bio-inputs are derived mainly from natural materials, some ingredients and concentrated preparations can still pose risks if handled incorrectly. Following proper safety, hygiene, preparation, storage and application practices helps protect farmers, consumers, livestock, beneficial organisms and the environment while ensuring that bio-inputs remain safe and effective

Figure 6.10: Good biosafety measures and good practices

Economic benefit of bio-inputs: Locally produced bio-inputs can reduce farmers' expenditure on commercial fertilizers and pesticides by converting readily available materials—such as manure, crop residues and pesticidal plants—into productive farm inputs. In addition to reducing input costs, they can improve soil fertility, reduce crop losses and increase marketable yields. African studies of botanical pesticides have reported favourable cost–benefit ratios, demonstrating their potential as economically viable alternatives to conventional crop-protection inputs (Amoabeng et al., 2014).

Conclusion

- Farm-made bio-inputs provide farmers with practical opportunities to recycle locally available resources, improve soil health, supplement crop nutrition and manage selected agricultural pests.
- Through proper preparation, dilution, application, hygiene and monitoring, farmers can reduce unnecessary dependence on expensive external inputs while making better use of materials available on the farm.
- The adoption of farm-made bio-inputs therefore contributes to input reduction, soil health, recycling, biodiversity, natural pest regulation and economic diversification, which are important foundations of agroecological farming.
- Farmers are encouraged to begin with simple preparations, test them carefully, keep records of their results and share successful practices with other farmers through peer learning and farmer field demonstrations

INNOVATION 7: VEGETABLE KITCHEN GARDENS

Aligned Agroecology Principles: *Soils Health, Social values and diets and Fairness*

EU Technology Readiness Levels (TRLs) ***https://www.euacc.ai/guides/trl-levels-guide*** **: 5,6,7**

7.1 Introduction to Vegetable Growing at household level in Uganda

Vegetable production plays an important role in improving household food security, nutrition and income in Uganda. Vegetables provide essential vitamins, minerals and dietary fibre needed for healthy diets. However, rapid urbanization, population growth, limited access to productive land and the high cost of agricultural inputs present challenges to conventional vegetable production, particularly for households in urban and peri-urban areas. In addition, unpredictable weather and limited access to water can constrain vegetable production, creating a need for affordable, space-efficient and water-efficient production systems, such as sack gardens, food towers and other forms of kitchen gardening (Mugisa et al., 2017).

One practical solution is the adoption of **sack gardens and cake (tyre) gardens**. These are simple, affordable, and climate-smart vegetable production technologies that enable households with limited land to grow nutritious vegetables throughout the year.
Sack and cake gardens are especially suitable for:

- Urban and peri-urban households
- Rural homes with small compounds
- Schools
- Refugee settlements
- Women's and youth groups
- Elderly farmers

Sack garden: A vertical garden made by filling a sack with fertile soil and compost. Vegetables are planted both on top and through openings made on the sides.

Advantages include: saving space, using little water, easy management and suitable for compounds and backyards

Cake garden (also called a tyre garden or circular raised garden) is a round raised garden made using tyres, bricks, stones, timber, or soil. The Centre often contains compost or manure which gradually releases nutrients to the vegetables.

Figure 7.1: Sack Gardens

7.2 Benefits of Sack and Cake Gardens

Sack and cake (tyre) gardens offer numerous social, economic, nutritional, and environmental benefits, making them ideal technologies for households with limited land and resources. Their key benefits are that they:

- Produce vegetables throughout the year: They provide a continuous supply of fresh vegetables with proper watering and management, even during dry seasons.
- Require very little land: They maximize vegetable production in small spaces, making them ideal for urban and peri-urban households.
- Improve household nutrition: They increase access to fresh, nutritious vegetables rich in vitamins, minerals, and dietary fibre.
- Save water through efficient irrigation: Their design and mulching reduce water loss and ensure efficient use of available water.
- Use household organic waste as compost: They recycle kitchen and farm waste into valuable organic manure that improves soil fertility.
- Reduce food expenses: Home-grown vegetables lower household expenditure on purchasing vegetables.
- Generate additional income: Surplus vegetables can be sold to provide extra income for the household.
- Improve sanitation around the home: Composting organic waste helps keep the household environment clean while reducing waste.
- Suitable for people with limited mobility: Their raised structure minimizes bending, making them easier to manage for the elderly and people with disabilities.
- Promote climate-smart agriculture: They conserve water, recycle organic materials, and support sustainable vegetable production under changing climatic conditions.

Recommended Vegetables

Suitable vegetables include:

- Sukuma wiki (collard greens)
- Nakati
- Doodo (Amaranthus)
- Spinach
- Lettuce
- Cabbage
- Onions
- Spring onions
- Coriander
- Eggplants
- Tomatoes
- Green pepper

7.3 Site Selection

Choose a place that receives 6–8 hours of sunlight daily, close to the kitchen for easy watering, has good drainage, protected from livestock and has access to water as illustrated below.

Figure 7.2: Site selection considerations

7.4 Preparing the Growing Medium

A good growing mixture contains top soil, compost manure and sand as illustrated below.

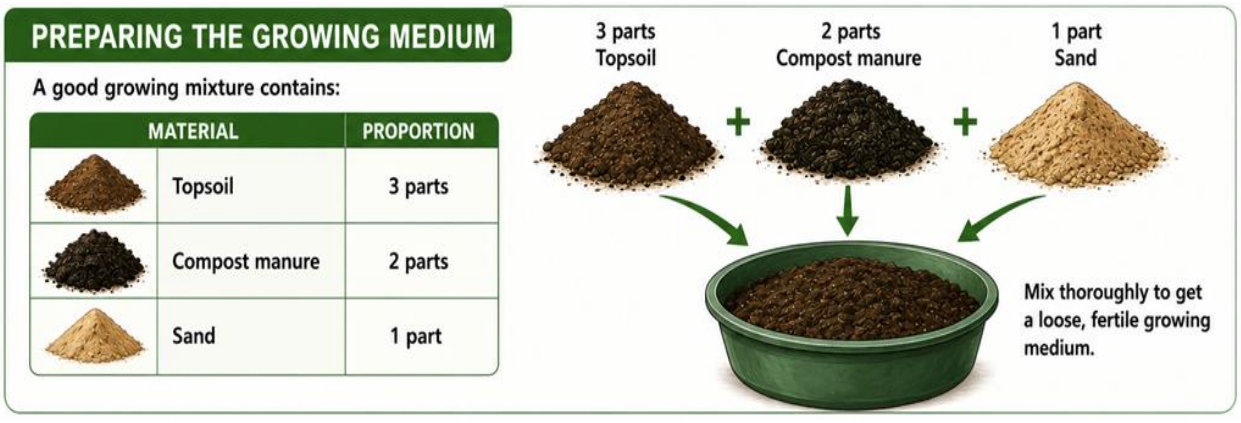


Figure 7.3: Preparing the Growing Media

7.5 How to Construct a Sack Garden

The success of a sack garden depends on the use of appropriate materials that provide structural support, good drainage, adequate moisture retention, and sufficient nutrients for healthy plant growth. Fortunately, most of these materials are inexpensive and readily available within local communities.

Figure 7.4: Materials for a sack Garden

The steps involved in the making of a sack garden are in the figure below

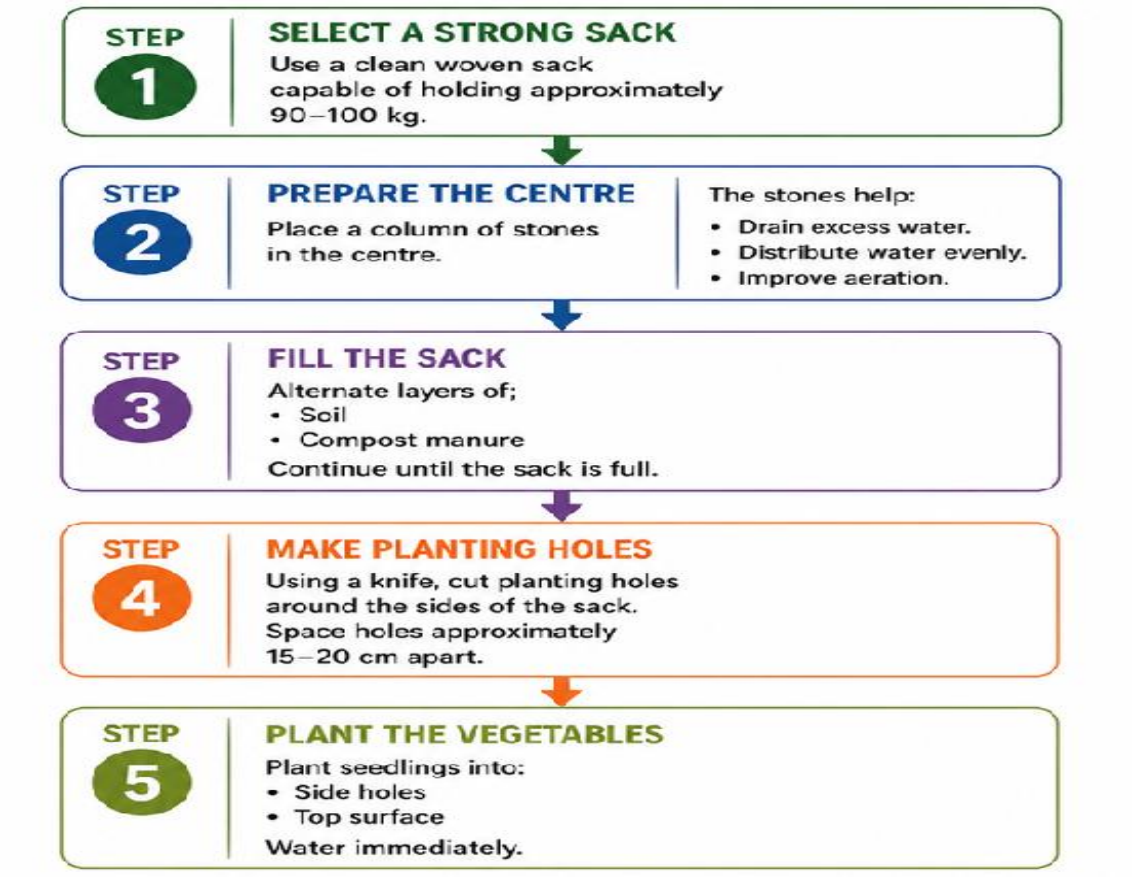


Figure 7.5: Steps for making a Sack Garden

7.6 How to construct a cake garden

Like a sack garden, the cake garden also depends on the use of appropriate on materials that provide structural support, good drainage, adequate moisture retention, and sufficient nutrients for healthy plant growth. These materials are inexpensive and readily available within local communities.

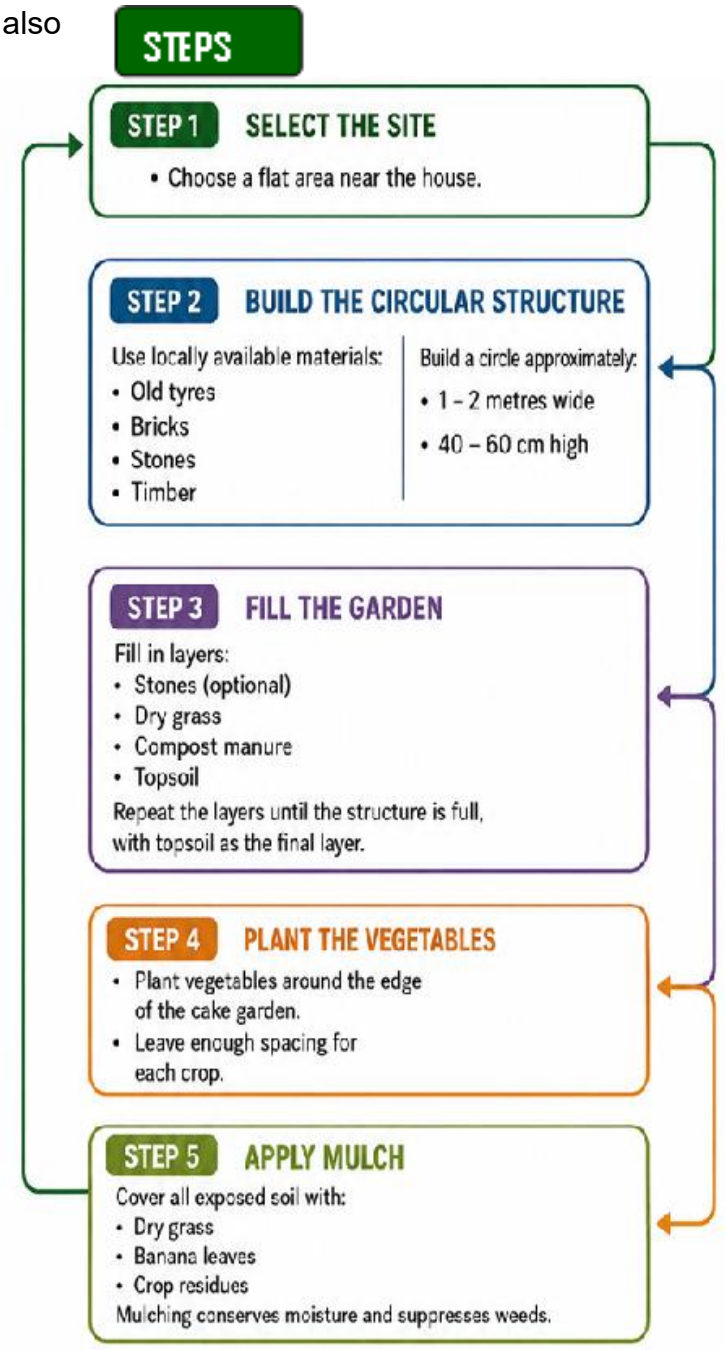


Figure 7.6: Materials and Steps for making a Cake Garden

7.7 Crop and water Management for the Sack and Cake gardens

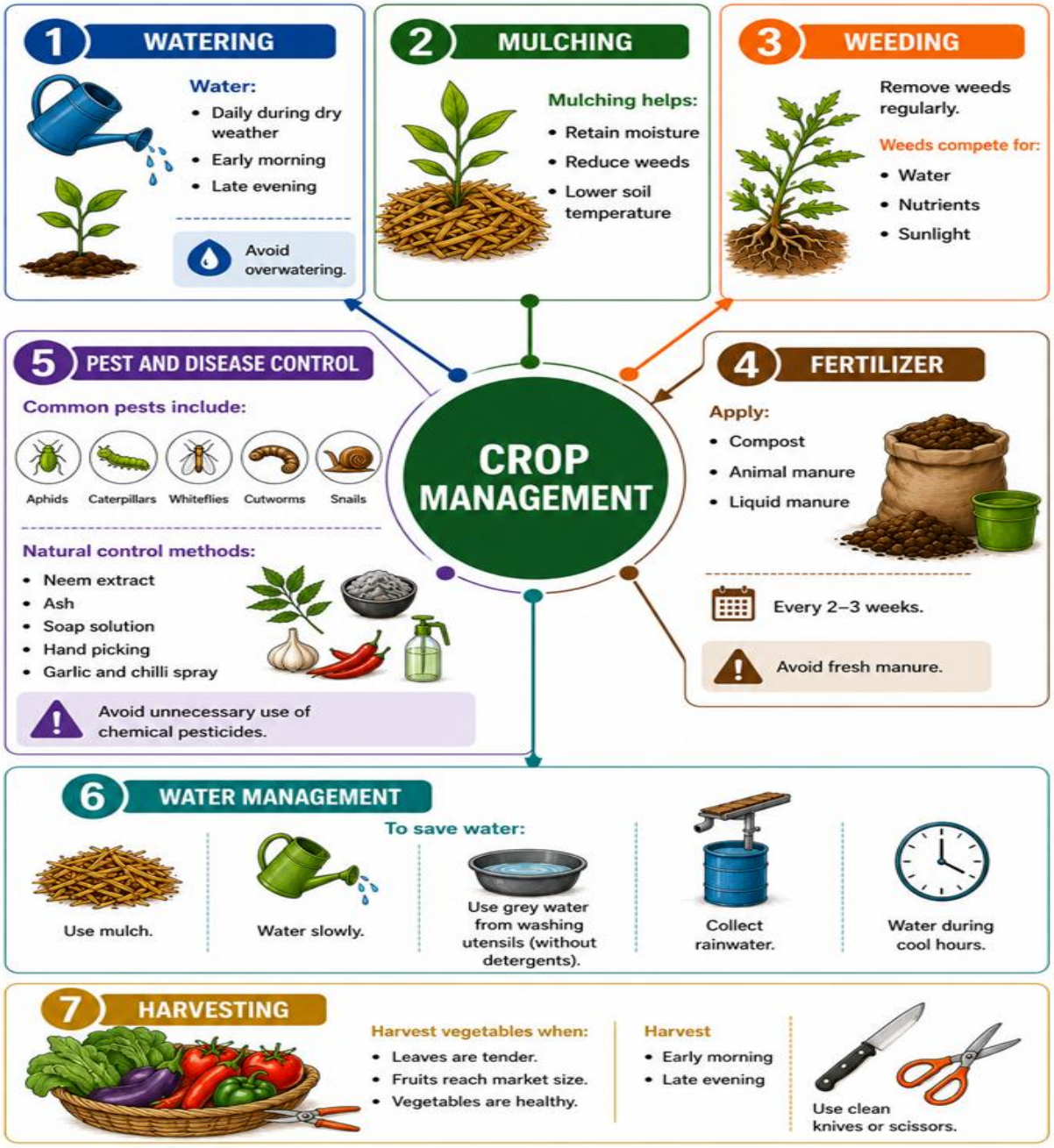


Figure 7.7: Crop and water Management for kitchen gardens (Sack and Cake Garden)

7.8 Common challenges and solutions

Kitchen gardens may face several production challenges, but early identification of their causes and timely application of appropriate management practices can help maintain healthy crops and ensure consistent vegetable production.

CHALLENGE	POSSIBLE CAUSE	SOLUTION
Poor germination	Poor seed quality	Use certified seed
Yellow leaves	Lack of nutrients	Apply compost manure
Wilting	Water shortage	Water regularly
Root rot	Excess water	Improve drainage
Small leaves	Poor fertility	Add compost
Pest damage	Insect attack	Use botanical pesticides
Weeds	Poor maintenance	Weed regularly

Figure 7.8: Challenges and solutions for establishing Kitchen Gardens

7.9 Hygiene and good agricultural practices (GAP)

Good hygiene and Good Agricultural Practices (GAP) are essential for producing safe, healthy and high-quality vegetables while protecting farmers, consumers, soil, water and the environment and promoting sustainable kitchen garden production.

GOOD HYGIENE / PRECAUTIONS	GOOD TIPS (GOOD AGRICULTURAL PRACTICES)	CLIMATE-SMART PRACTICES
Wash hands before working.	Use fertile soil mixed with compost.	Harvest rainwater.
Use clean water.	Water regularly, especially during dry periods.	Use compost manure.
Use clean tools.	Mulch to conserve moisture.	Mulch all gardens.
Remove diseased plants.	Rotate vegetables where possible.	Practice crop rotation.
Harvest using clean equipment.	Harvest regularly to encourage new growth.	Grow drought-tolerant vegetables during dry seasons.
Keep animals away.	Keep records of planting and harvesting.	Integrate kitchen waste composting.
Use only well-decomposed manure.	Protect gardens from livestock.	Plant shade trees where appropriate.
	Use quality seed or healthy seedlings.	
	Apply compost instead of excessive chemical fertilizers.	

Figure 7.9: Hygiene measure and Good agricultural Practices

7.10 Economic Benefits and Estimated Initial Costs

Establishing a kitchen garden can provide significant benefits to a household at a relatively modest initial cost. By producing vegetables at home, families can reduce food expenditure, improve household nutrition, access fresh vegetables throughout the year, and earn additional income from selling surplus produce. Kitchen gardening can also create small-scale employment opportunities, particularly for women and youth. Establishment costs can be further reduced by using locally available or recycled materials, home-made compost, locally sourced topsoil and farmer-produced seedlings. Once established, good management can enable the garden to continue producing vegetables with relatively low recurring costs. Evidence from urban and peri-urban Uganda shows that crop farming can make an important contribution to household income, while Ugandan home gardens provide both food for household consumption and crops for sale (Lwasa et al., 2017; Whitney et al., 2018).

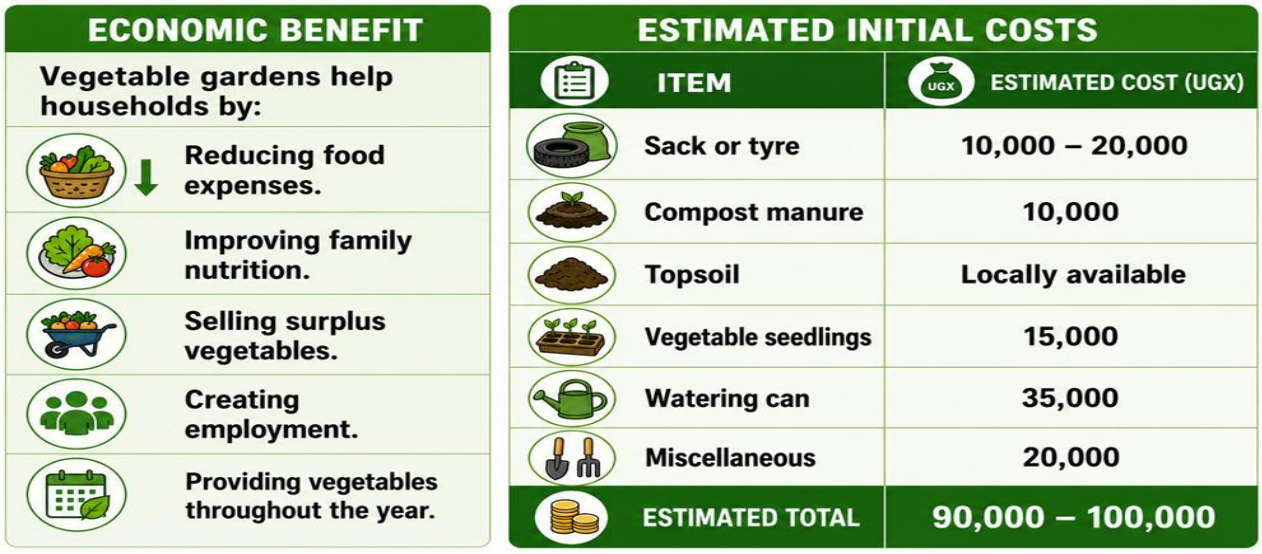


Figure 7.10: Economic benefits and estimated costs

Conclusion: Sack gardens and cake gardens are simple, low-cost, and climate-smart technologies that enable households to produce fresh vegetables using very small spaces. By combining fertile soil, compost manure, regular watering, mulching, and good crop management practices, farmers can harvest nutritious vegetables throughout the year, improve household food security, enhance family nutrition, and generate additional income. These gardens are especially valuable for women, youth, schools, and urban households, making them an important component of sustainable and resilient food systems.

INNOVATION 8: COVER CROPS: REVIVING SOILS WITH MUCUNA AND JACK BEANS

Aligned Agroecology Principles: *Recycling, Soil health, Biodiversity*

EU Technology Readiness Levels (TRLs) *https://www.euacc.ai/guides/trl-levels-guide* **: 5,6,7**

8.1 Introduction to Use of Jack Beans and Mucuna for Soil Restoration in Uganda

Healthy soils are the foundation of productive agriculture. However, many farmers in Uganda are experiencing declining soil fertility due to continuous cultivation, soil erosion, burning of crop residues, overgrazing, and limited use of organic matter. This has resulted in poor crop yields, increased dependence on expensive inorganic fertilizers, and reduced farm incomes.

In Uganda, Mucuna (*Mucuna pruriens*) and jack bean (*Canavalia ensiformis*) are useful leguminous cover crops for agroecological and sustainable soil management systems. These crops can contribute to soil fertility improvement through biological nitrogen fixation and the production of nutrient-rich biomass, while their ground cover can suppress weeds, protect the soil from erosion and help conserve soil moisture. Their biomass can be incorporated into the soil as green manure or retained on the surface as mulch, thereby contributing organic matter and nutrients for subsequent crops (Kaizzi et al., 2007)

This information given, introduces farmers and extension workers to the use of Jack beans and Mucuna as green manure and cover crops for regenerative agriculture. Through proper establishment and management, these legumes can revive degraded soils, reduce fertilizer costs, improve crop productivity, and contribute to climate-resilient farming systems.

8.2 What Are Jack Beans and Mucuna?

Jack beans (*Canavalia ensiformis*) and Mucuna (*Mucuna pruriens*) are vigorous tropical legume cover crops commonly used for soil improvement and conservation agriculture.

They are known for their ability to:

- Fix atmospheric nitrogen through symbiotic bacteria in their root nodules.
- Produce large amounts of leafy biomass.
- Cover the soil quickly, protecting it from erosion.
- Improve soil structure and biological activity.
- Suppress weeds naturally.

Unlike grain legumes mainly grown for food, Jack beans and Mucuna are primarily grown to restore soil health, although Jack beans can also be used as livestock feed after proper processing.

The two legumes present different characteristics in appearance and growth as illustrated and explained in the figure and table below.

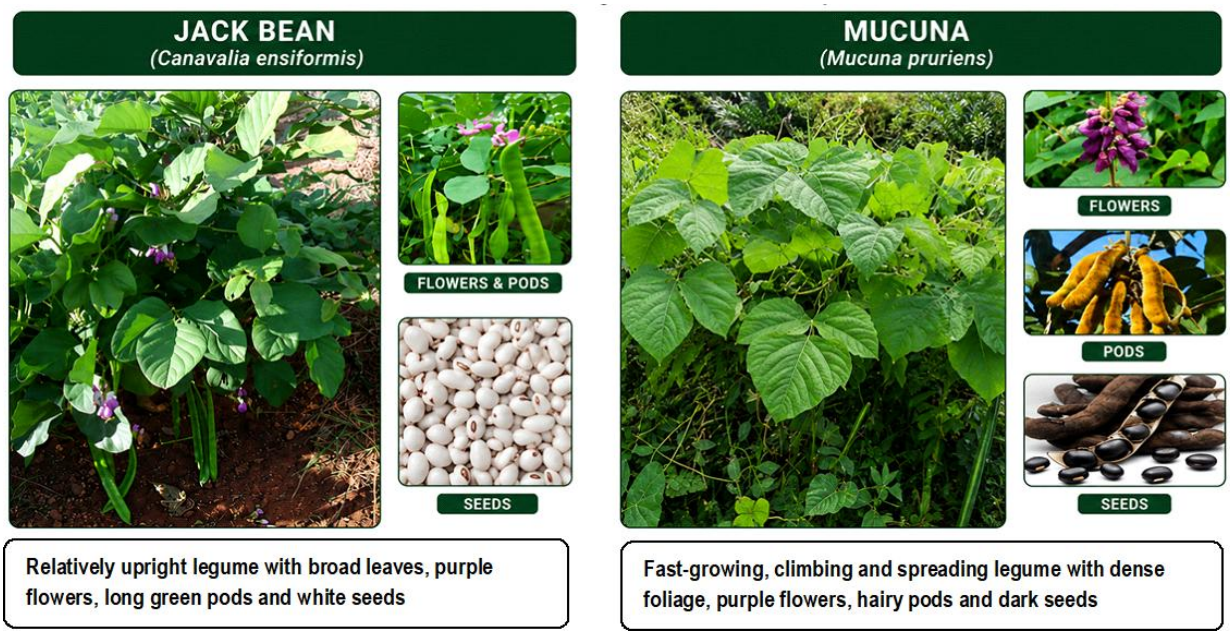


Figure 8.1: Characteristics of the Jack Bean and Mucuna

Table 8.1 Differences between Jack bean and Mucuna

Characteristic	Jack Bean	Mucuna
Plant type & growth habit	Annual/short-lived perennial; erect, bushy (1–2 m)	Annual climbing vine; vigorous twining (3–15 m)
Root system	Deep taproot with nitrogen-fixing nodules	Deep taproot with abundant nitrogen-fixing nodules
Stem & leaves	Thick, branched stem; large trifoliate leaves	Long climbing stems; large trifoliate leaves
Flowers	White to pale purple	Purple, white, or lavender
Pods & seeds	Thick straight pods (20–30 cm); large white/cream seeds with black hilum	Curved hairy pods; black, brown, white, or mottled seeds
Seed size	Large (2–3 cm)	Medium to large (1–2 cm)
Nitrogen fixation	Excellent (150–250 kg N/ha)	Excellent (100–200 kg N/ha)
Biomass production	High (5–10 t/ha dry matter)	Very high (8–15 t/ha dry matter)
Growth rate	Fast	Very fast
Ground cover & weed suppression	Good ground cover; good weed suppression	Excellent ground cover; excellent weed suppression, including *Striga*
Drought tolerance	High	Moderate to high
Rainfall requirement	700–2,000 mm/year	800–2,500 mm/year
Soil adaptation	Well-drained soils; tolerates poor	Well-drained soils; prefers fertile soils but

Characteristic	Jack Bean	Mucuna
	soils; pH 5.0–7.5	tolerates poor soils; pH 5.0–7.5
Maturity period	120–180 days	120–210 days (variety dependent)
Main uses	Green manure, cover crop, forage, erosion control, nitrogen fixation	Green manure, cover crop, forage, erosion control, weed suppression
Feed & food use	Leaves and seeds used after proper processing; seeds require detoxification before consumption	Leaves and seeds used after proper processing; some varieties edible after processing but mainly grown for soil improvement
Major limitation	Seeds contain toxic compounds and require processing	Hairy pods may cause skin irritation; seeds contain anti-nutritional compounds and require processing

8.3 Benefits of Jack Beans and Mucuna

The two crops are powerful leguminous cover crops that improve soil health, conserve resources and boost productivity. Their wide range of benefits makes them valuable allies for sustainable and regenerative farming.

Figure 8.2: Benefits of Jack Bean and Mucuna

8.4 Materials Required for Establishing Jack Beans and Mucuna

Before establishing the cover crops, prepare the following materials:

Figure 8.3: Seeds and other materials required to establish the legumes

8.5 Site Selection and Land Preparation

Jack bean and Mucuna can be grown as stand-alone cover crops, but they are especially valuable when integrated into perennial cropping systems such as banana, coffee, cocoa, fruit orchards, timber trees and other perennial crops. Growing them between crop rows or in available spaces enables farmers to benefit from their ability to improve soil fertility, suppress weeds, conserve moisture, reduce erosion and add organic matter.

Good site selection and land preparation promote rapid germination, vigorous establishment and early ground cover.

- Select a site with good drainage, adequate moisture or rainfall, no prolonged flooding, and manageable weed infestation.
- Prepare the land by clearing bushes and large weeds, digging or ploughing where necessary, breaking large soil clods, and marking planting rows or spaces between the existing perennial crops.

8.6 Step-By-Step Guide to Establishing the Legumes

Figure 8.4: Step-by-step for establish Jack beans and Mukuna

8.7 MANAGEMENT PRACTICES

Proper management of Jack beans and Mucuna is essential for vigorous growth, effective soil cover, improved soil fertility, weed and pest management, and maximum benefits to the farming system.

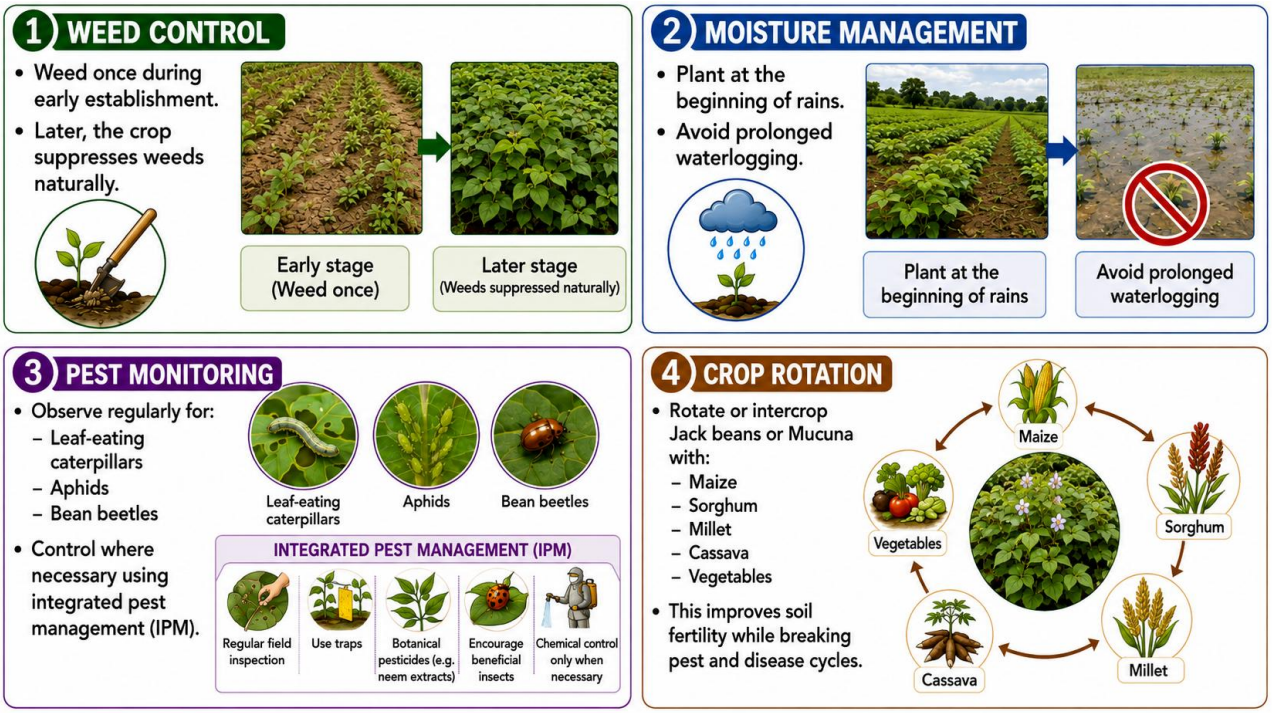


Figure 8.5: Managing the established Jack beans and Mukuna

8.8 Incorporating the Biomass and Maintaining Soil Health

For maximum soil improvement, Jack bean and Mucuna biomass is best managed at the flowering stage, before the seeds harden, when the plant material is still tender and decomposes readily. The biomass may be slashed and incorporated into the soil as green manure, left on the surface as mulch, or composted for later application. Returning large amounts of biomass to the soil gradually builds organic matter and improves soil fertility.

The benefits of these cover crops can be sustained by combining them with other regenerative and agroecological practices, including avoiding the burning of crop residues, maintaining permanent soil cover, minimizing soil disturbance, practising crop rotation and diversification, applying compost and animal manure, and integrating trees with crops.

8.9 Common Challenges these cover Crops ad Solutions

During production, Jack beans and Mucuna may face challenges that affect their establishment, growth and biomass production. Early identification of the possible causes and timely application of appropriate solutions can help farmers maintain healthy and productive cover crops.

CHALLENGE	POSSIBLE CAUSE	SOLUTION
Poor germination	• Low-quality seed	✓ Use certified seed/ Do germination test before planting
Poor crop growth	• Low rainfall	✓ Plant at onset of rains
Excess weeds	• Delayed planting	✓ Plant early and weed once
Pest damage	• Insect attack	✓ Monitor and apply IPM practices
Waterlogging	• Poor drainage	✓ Select well-drained fields
Low biomass production	• Poor soil or late planting	✓ Apply manure and plant on time

Figure 8.6: Challenges and solutions with Jack beans and Mukuna

8.10 ECONOMIC BENEFITS OF COVER CROPS

Jack beans and Mucuna provide important economic benefits to farmers by reducing production costs while improving farm productivity and sustainability. Through biological nitrogen fixation, weed suppression and improved soil health, they can reduce expenditure on fertilizers and weed management while supporting higher crop yields. They may also provide livestock fodder when properly managed, improve resilience to drought, and conserve soil for long-term production. Together, these benefits contribute to greater farm profitability and more resilient farming systems.

Research in Uganda has shown that Mucuna fallows can improve subsequent crop yields and be cost-effective, while Mucuna and Canavalia-based cover cropping can increase maize productivity compared with natural or weedy fallows (Kaizzi et al., 2007; Ddamulira et al., 2015)

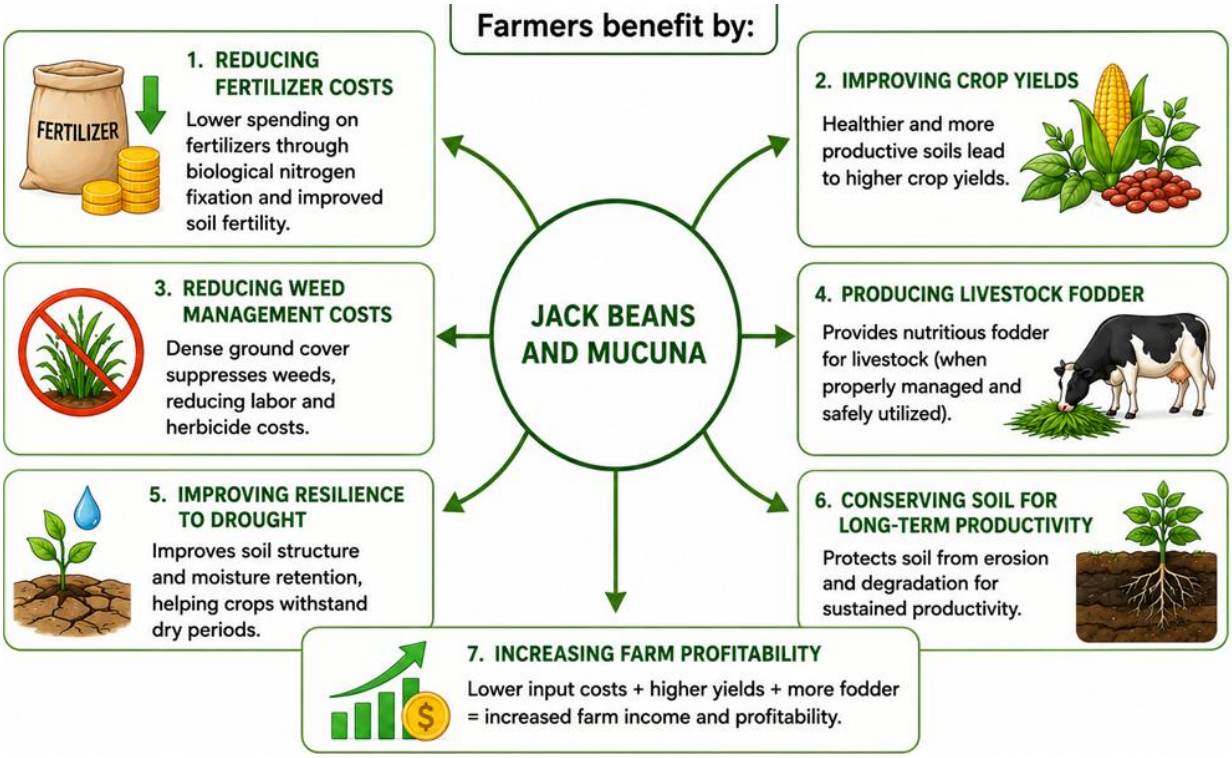


Figure 8.7: Economic Benefits of Jack beans and Mukuna

8.11 Key Farmer Tips/Precautions

- **Plant at the onset of the rainy season.**
- **Use quality seed with good germination.**
- **Maintain recommended spacing.**
- **Weed early before full ground cover.**
- **Do not burn crop residues.**
- Incorporate biomass before plants produce mature seeds.
- Practice crop rotation.
- Monitor pests regularly.
- Maintain soil cover throughout the year.
- Keep records of crop performance and soil improvements.

CONCLUSION: Jack beans and Mucuna are affordable, environmentally friendly, and highly effective cover crops for restoring degraded soils and improving farm productivity. Their ability to fix atmospheric nitrogen, produce abundant biomass, suppress weeds, conserve moisture, and enhance soil health makes them valuable tools in regenerative agriculture. When properly established and managed, these legumes reduce fertilizer costs, improve crop yields, build resilient farming systems, and contribute to long-term food security and environmental sustainability

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