UPSIDE

Northern Uganda Resilience Initiative (NURI)

Climate Smart Agriculture (CSA) Training Manual

Women Refugee Groups

Version no.

1

Government of Uganda
Danida

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List of Acronyms

Abb.	Full text
ARUDIFA	Arua District Farmers' Association
AEO	Agricultural Extension Officer
AES	Agricultural Extension Supervisor
AESA	Agri Ecological System Analysis
AFARD	Agency For Accelerated Regional Development
ALIC	Agricultural Livelihoods Improvement Component
APM	Agricultural Production and Marketing
ASL	Above Sea Level
CF	NURI Coordination Function
CSA	Climate Smart Agriculture
DANIDA	Danish International Development Assistance
DAR2	Development Assistance to Refugee Hosting Areas, Phase II
DAR3	Brand name from previous phases used in West-Nile
DEC	District Executive Committee
DES	District Extension Supervisor (employed by DFA)
DFA	District Farmers Association
DKK	Danish Kroner
DLG	District Local Government
DPO	District Production Officer
DRC	Danish Refugee Council
DTPC	District Technical Planning Committee
FG	Farmer group
FMNR	Farmer Managed Natural Regeneration - Follows on-farm tree management techniques
FPO	Focal Point Officer
GAP	Good Agricultural Practices
M&E	Monitoring and Evaluation
MC	Marketing Committee
NURI	Northern Uganda Resilience Initiative
PHH	Post-Harvest Handling
PMP	Production and Marketing Plan
RALNUC2	Restoration of Agricultural Livelihoods in Northern Uganda, Phase II
RALNUC3	Brand name from previous phase used in Acholi Sub-region
RAU	Resilience Agricultural Unit
RDE	Royal Danish Embassy
RDNUC	Recovery and Development in Northern Uganda Component
RWC	Refugee Welfare Committees
SACCO	Savings And Credit Cooperative Organization
Ushs	Ugandan Shillings
VSLA	Village Savings and Loan Associations

SECTION 1 – INTRODUCTION

1.1 Purpose and Scope of the Manual

The purpose of this manual is to provide guidelines on how farmer groups are to be trained in CSA in the NURI program. It covers the scope of the training, as well as technical information on CSA. This training manual is specifically for Women refugee farmer Groups located in selected refugee settlements in Arua, Madi Okollo, Obongi, Adjumani and Lamwo Districts.

The manual is aimed at staff of implementing partners and the participating District Local Governments[1]. It is based on the **Management Manual**, which contains the general guidelines for implementation of NURI.

Other manuals and toolkits used are:

- Accounts Manuals (for the various implementing partners)
- M&E Manual
- CSA Training Manual for national farmer groups
- Collective Marketing Manual
- VSLA manual
- Rural Infrastructure Manual
- Tool-kit for selecting or forming groups in refugee settlements

1.2 Content of Manual

The manual consists of four sections: Section 1 covers introduction to the manual and the stakeholders involved; Section 2 provides guidance on how the facilitation of the Group training should be handled; Section 3 provides training session to be conducted to the women refugee groups in Climate Smart Agriculture (CSA) and associated technologies and Section 4 offers detailed information on growing different crops targeted in this programme.

This manual shall be used together with the grain sack charts and any other crop specific trainers' guides available to give additional practical information. Facts sheets for selected crops shall also be provided to farmers to help them for future reference.

1.3 Maintenance and Distribution of the Manual

This manual is distributed to the IPs and their relevant staff. A distribution list is maintained by the NURI Coordination Function. CF is responsible for updating the manual.

2. STAKEHOLDERS

The major stakeholders involved in the training of the farmer groups are described below:

2.1 Refugee women group members in NURI CSA groups

The refugee women here refer to women from the refugee households. In some cases, small numbers of male members may be included at the request of the group. It is important in such cases to ensure men do not dominate leadership positions and decision making. The role of the group members, including youth who are members of refugee women groups, is to participate actively in all group activities. In general, participating households will mainly have access to the plots of household land allocated by OPM. Participating households should be willing to use these plots for cultivation of food crops, vegetables and fruit trees.

Members should be willing to share information on their household and their access to land, as well as, on their participation in any other programmes;

- Participate actively in trainings and group activities,
- Interact with other members in a positive way,
- Keep peace and contributing to ideas and discussion;
- Make changes to their current farming/gardening practices and try new technologies;

2.2 Implementing Partners/Units

The Implementing Partners (IPs)/Unit for Climate Smart Agriculture are:

- Arua DFA
- RAU Kitgum / Lamwo
- RAU Moyo / Obongi
- RAU Adjumani

IP/Unit will familiarise her staff with the NURI CSA plans, workplans and budgets as these will guide implementation. The staff will be responsible for mobilization of refugee women to form groups or identify already existing groups who need support. The staff will facilitate overall activity implementation in the settlements including group trainings. Each IP/Unit will procure and distribute the inputs required for implementation of planned activities.

The IPs/Units are staffed with Coordinators, Assistant Coordinator or CSA Coordinator (for some), Agricultural Extension supervisors, VSLA supervisors, Agricultural Extension Officers and VSLA Officer. In addition CBTs will be recruited to facilitate VSLA activities.

2.3 OPM/UNHCR

OPM and UNHCR will ensure a peaceful and conducive environment for supporting the refugees in the settlements. They will allocate area of work to NURI implementing partners/units in a manner that avoids duplication with other agencies. They will thus coordinate the relevance of the agencies' work and coordinate sector working groups. They will provide information on the population living in those zones and about other agencies working in the areas. OPM and UNHCR will be involved in quarterly monitoring activities. The OPM and UNHCR will be provided with information about the groups once they are formed.

2.4 District Local Governments

The District Executive Committee (DEC) shall carry out quarterly monitoring of NURI activities on behalf of the council while the technical officers shall supervise technical areas of NURI. The DEC shall give feedback reports through the district Focal Point Officer (FPO). The District Technical Planning Committee (DTPC) functions as the District Steering Committee for NURI. The DTPC will be provided with information about the groups once they are formed.

The Lower Local Government (LLG) at Sub-county and Parish level are involved in sensitisation and quarterly monitoring of the activities and report submissions for the monitoring carried out.

2.5 Refugee Welfare Committees

Refugees are represented through Refugee Welfare Committees which act as channels of communication between refugees and IPs/Units. Information on the importance of respecting Ugandan law, peace and conflict resolution mechanisms, and safety of aid workers in the Settlement is passed via RWCs to the wider refugee community. Focal persons of different agencies link with RWCs to coordinate activities according to need. RWCs mimic Local Government structures with RWC I, II and III level in settlements. The RWCs membership may vary per settlement.

The below table outlines settlement administrative structure

Level		**RWC level**	**RWC Members**
Settlement	Entire settlement	RWC III	Has 12 executive members
Zone	A number of villages	RWC II	12 elected members
Village	A number of blocks	RWC 1	12 elected members
Block	A number of households	Block leaders	12 elected members

In NURI activities, RWC will participate in quarterly monitoring activities.

2.6 NURI Coordination Function

NURI Coordination Function (CF) provides support to programme implementation. CF is responsible for the development of this toolkit and updating it if necessary. It has overall responsibility for monitoring and to ensure the farmer groups training is properly done.

CF's first point of contact in NURI program are the Regional Coordinators.

SECTION 2: FACILITATION GUIDANCE

1. Group Organisation and Management

The AEO plays an important role in building the capacity of the refugees to become a cohesive group. A well-functioning refugee women group can play a vital role in building relations between host and refugee communities that can make life better for both and lead to better utilization of land resources.

AEO may need to assess the group's functionality and work around strengthening of weak areas. This helps the AEO to focus support to groups that need specific support. Please re-cap the group development sessions found in the toolkit for forming or selecting refugee groups.
During start-up the group develops a constitution or by-laws for smooth running of the group activities. AEOs and group members should be aware of these rules and keep them in mind.

During initial sessions the AEO should explain and repeat to the group how the training will be run, members' involvement, and information about timing activities and inputs use.

Group members should be registered at each training sessions and any other activities as per Annex 1.

2. Planning Training

AEOs should take time to plan and prepare each training session. For each session they should:
a) Establish training goal i.e. what are the main lessons all members should understand by the end of the session, and what will they gain from the training;
b) Review training content i.e. go through the technical material to be used, be clear on all aspects and answer confidently any questions from the group;
c) Prepare a simple plan for the session, considering the specific strengths and weaknesses of the group and any practical exercises, requirements for tools or other materials.

It is important to be detailed, organised and realistic in planning and delivering the training.
Make use of supervisors and colleagues if you are in doubt or need support on technical or practical issues.

3. Adult Learning

We know that people learn better, if they are actively engaged in the learning process. Studies have shown that we remember only 20% of the information we hear and 40% of the information we see and hear. However, when we see ideas represented visually and also actively engage with the information through discussion, debates, role-plays or other participatory teaching methods, learners retain 80% or more of the information that is presented to them. Clearly as instructors, it is worth the time and effort to create participatory, multi-sensory presentations. The training manual is designed to assist you in this effort. There is no one way to use it. You may devise alternative methods that help you achieve effective adult learning. This facilitator's guide is written in English, but depending on your audience, you may need to make your presentation in the local language. Read through the guide and consider how you translate concepts into the local language.

Farmer training will be based on principles of adult learning based on problem solving. By following the 10 adult learning principles below, the AEOs will be able to choose the most practical farmer training methodologies to use:

- **Adults must be motivated:** The farmers must want to learn. If they have no motivation, they will not learn. The skill or technology to be demonstrated must be farmer demanded.

- **Adults have a wide experience** and must use this experience. AEOs should respect the experiences and opinions the farmers bring with them.

- **Adults must see relationships with reality:** Farmers are more likely to try new ideas, new ways of doing things, if they can see how they may improve life. Training sessions must be seen to have potential to change things.

- **Adults learn by doing:** Farmers need to be able to do, try using new ideas and new ways of doing things. Practical involvement at the demo-plot and replication of learnt skills in own garden should be emphasized.

- **Adults learn by solving problems:** Farmers have to solve problems every day of their lives. New ideas should be in form of problems to solve and questions to answer.

- **Adults like discussion:** Most Farmers like to discuss things; you share ideas and find new ways to solve problems. Field days and farmer to farmer visits should be encouraged.

- **Adults learn at different speeds:** AEOs must expect this and show that it is acceptable. Arrange your materials and activities to allow for it.

- **Adults need to feel good:** Be friendly and approachable, smile, have a joke. Show that you are human.

- **Adults respond to the classroom atmosphere:** if there is pressure and anxiety, learning will not occur. If the trainer is too casual or seems not to care, learning will not occur. So be professional but not solemn.

- **Adults respond to suitable language and materials:** The language you use should be simple, clear and to the point. No long words or special jargon of your own particular field.

4. Gender

The term 'gender' is often confused to refer to women, which is not the case. Gender refers to relations between male and female sexes and also includes youth. All these have that relationship of either being males of females therefore it is the sex, roles and relationship that describe gender. Therefore, as a facilitator it is important to understand gender in its broader context and carry out trainings with this context in mind.

Working with different communities – nationals and refugees – there may be different gender norms amongst the members of a single group. AEOs need to look for and recognize challenges and barriers that undermine gender integration into implementation of training and implementation of activities. For example, in some communities, males find it difficult to closely interact with women publicly, women are restricted in expressing their views publicly or youth may feel restrained in contradicting older members. In such cases, training exercises that create groups where women or youth are with their peers and can feel confident to express themselves may be useful.

In addressing gender, the trainer should:

- Recognize gender-based challenges and barriers that affect individuals and households in participating fully and find ways to address these challenges;
- Assesses the issues of how different gender negatively or positively affects the training outcomes;
- Examine the effect of the training as it relates to gender integrations and gender empowerment;
- Take note of operational challenges, opportunities and lessons learned for guiding future training exercises;
- Document and provide feedback from beneficiaries on how the training fitted the different gender expectations and norms.

5. Managing backyard gardens

In the NURI Programme, Refugee women Groups will be supported with two improved vegetables seeds and one field crop seeds as indicated in the guidelines, to plant at their backyard gardens. Each household will manage her own plot. This will serve as a learning site but also a source of food for their households.

The women refugee groups will be supported for two years and two seasons per year. The AEO shall visit regularly the homestead gardens and shall advise the farmers accordingly. The problems which cannot be resolved by the AEO should be referred to the AES who will do his/her best to solve and/or revert to higher authorities for guidance.

6. Records and Administration

Administration of the agriculture training exercises and record keeping will be done by the IPs/Units. The AEO is responsible for all farmer trainings while AES is to supervise and administer all aspects of farmer training for the IP/Unit.

Report from Each Training Session
Annex 4 shows the format for the report that the AEO should prepare immediately after each training session s/he has had with a farmer group. The report should be prepared in two copies of which one is given to the AES and one is kept with the AEO.

SECTION 3: TRAINING SESSIONS

This section is the main section of the manual that the AEOs should pay attention to. In total there are eight sessions but the AEO can even break it further for proper delivery of the training to the farmers. Practical issues such as intercropping, soil and water conservation should be integrated at the relevant time, whereas social issues such as gender should be discussed and addressed when they fit naturally into the discussion. Grain charts are self-explanatory and should be used at the relevant places.

The 8 sessions are as follows:

1. Brief introduction to CSA with focus on the 3 pillars on available technologies and practices. CSA is contextual as such some practices may be CSA here and not in another place.

2. Intercropping with focus on the principles, practices and types. It has a number of advantages and disadvantages.

3. Introduction to Soil and water conservation: Soil fertility management is included but is a cross cutting issue and should be referred to when relevant during all sessions. In all crops this is emphasised. Water conservation is important aspect as simple ways of water conservations are discussed e.g. mulching, digging trenches etc and has to be crop specific.

4. Introduction to the crop: This section covers areas such as the importance of the crop and the growth conditions or environment required as well as a discussion of varieties.

5. Planting: This section covers land preparation, seed and variety selection, timing and spacing, thinning and in some cases specifics about intercropping.

6. Weed control and other agronomic practices: This section covers common weeds and their control. Besides weed control, there are a number of agronomic practices to be discussed with the farmers and this includes, mulching, staking, pruning, propping and it should be relevant to a specific crop. Familiarise with these in relation to different crops.

7. Pest and Disease Control: Covers briefly common pests, diseases and their control. Field identification will help to enhance learning. Integrated control methods should be emphasised.

8. Harvest and Post-Harvest: Covers harvest timing and methods as well as a range of issues on post-harvest handling that vary widely depending on the crop. This has been kept simple but AEO can go into details as deemed fit.

Sessions	**Content / scope**	**Training materials**	**When**
1. Climate Smart Agriculture practices and technologies available	• Introduction to CSA concept • 3 objectives of CSA, • Adaptation and mitigation measures for farmers in northern Uganda, • Review of the farmers' farming system (conventional) and comparison with CSA. • How to improve food security	Flip charts, markers	Prior to GAP training

2. Intercropping guidelines and principles	• What is intercropping • Advantages and disadvantages of intercropping • Types of crops and sequence of intercropping • when to do intercropping •	Flip charts, markers	Prior to GAP training
3. Soil and water conservation	• Soil nutrients • How soil nutrients are lost • Soil fertility improvement • Organic fertilizers • Compost making and fertilizer application • Inorganic fertilizers • Water conservation practices including simple rain water harvesting techniques • Permaculture/perma gardening • Farmer Managed Natural Regeneration (FMNR)	Flip Charts, markers, Soil samples, Kitchen and other bio-degradable waste Poles for making A-frames	Prior and during GAP training
4. Introduction to the crop and growth requirements	• Discuss the importance of the crop • Proper and timely cultivation for successful crops establishment	Flip charts, markers Grain sack charts	Start of GAP training
5. Planting of the crop	• Different crop varieties • land preparation • Nursery bed preparation, establishment and management • How planting is done with field practical • Gap filling	Flip Charts Grain sack charts Seeds / seedlings	From site selection, nursery, field planting
6. Weed control and other management practices	• Weed control methods • Other management practices e.g. pruning, staking, mulching, propping as applicable to crop	Flip Charts Grain sack charts Plant samples	In the field planted
7. Major pests and diseases of the given crops and their control	• Disease and pest identification and control (presentation and field practical) Paying attention to what is happening in the demonstration plot.	Flip Charts Grain sack charts Plant samples	From planting to harvest of the where possible
8. Post-harvest handling	• Harvesting the crop • Process from harvest to storage e.g. drying threshing and storage (theory and practical) • How you can add value to a product	Flip Charts Grain sack charts Plant samples	Maturity of crop and after post-harvest where possible

1. Climate Smart Agriculture (CSA)

The AEO should begin this session by asking the farmers what they understand of weather and climate. After submissions clarify the difference between the two as stated below:

- **Weather** describes environmental/atmospheric conditions prevailing outdoors in a given place at a given time. It is what happens from minute to minute, day by day. The weather can change a lot within a very short time e.g. cloudy in the morning, shiny in the afternoon and possibly very cold at night.
- **Climate** refers to the average weather experienced over a long period, typically 30 years. The weather elements which change, include: temperature, wind, humidity and rainfall patterns.

When the farmers have understood climate, now ask how do they see climate say 30 years ago and now. Is it the same? If not, what has changed? Is the change positive or negative? After a few submissions from the farmers, agree and say there is climate change. The changes in climate have resulted in changes in temperature and in rainfall patterns. Ask the famers to list some examples that they have observed for rainfall pattern and temperature.

- **Onset of the rains:** It has become more unpredictable. Example: in 2018 the rains set in February while in 2019 rains set in April.
- **The duration of the rainy season:** The rainy season has become shorter, reducing the growing period for crops. Example of 2018 second season.
- **Total amount of rainfall:** In recent years, the total daily, monthly or annual rainfall has varied from year to year, thus, there have been wet years (floods) and dry years (drought). Some years have been wetter than others e.g. 2019 very wet while 2018 dry. Studies also indicate modest decrease in annual rainfall in the districts of Gulu, Kitgum, and Kotido.
- **Rainfall distribution:** At present, the rainfall distribution in Uganda varies from place to place and within a specified period of time, i.e. within a week, a month or a year. The rainfall pattern has been erratic; and has had adverse impact on farming activities.
- **Temperature increase:** Analyses have found a statistically significant increase in temperature in the 30 years period, ranging from 0.5 - 1.2ºC across the country.

Ask farmers what effects that have come with climate change to them and more so agriculture. Climate change has brought droughts and floods which impact negatively on our agriculture and food security. These have increased in frequency, intensity and magnitude over the past 20 years. It is estimated that droughts and floods currently affect over a million people annually in Uganda; and that they are the leading causes of chronic food insecurity. From 1991 – 2000, there were 7 droughts compared with 1981 – 1990 where there were only two droughts. Floods are also frequent with most reported as 2007 in the north and eastern part of the country.

Farmers should note that climate change is real and there is need to take it into account in their farming activities. This has brought in new approaches of dealing with the situation. Climate-smart agriculture is an approach that works to maximize the adaptive capacity of farmers and in so doing minimises their ultimate vulnerability to changing climate conditions.

Climate smart agriculture (CSA) aims to address 3 pillars:
1) Increasing agricultural productivity
2) Adaptation to climate change and shocks and
3) Climate change mitigation through reduced emissions and/or increased carbon sequestration.
Issues of social equity and environmental sustainability are also considered when assessing the climate-smartness of technologies.

Climate smart agriculture goes beyond the technical know-how of climate smart practices and needs a more holistic approach. An agricultural system in a specific location has crops growing on a plot in a farm that is managed by a household living in a community in a certain landscape functioning in a specific market and policy environment that are governed by formal (e.g. policies) and informal (e.g. gender norms) institutions. Climate smart agriculture then should have integration of interventions at each level of this system with the support of diverse and interdependent actors (Table 1).

Table 1: Possible interventions at different levels in agricultural system.

Level	**Examples of possible intervention**
Plant	Drought-tolerant and resistant crops e.g. maize variety
Plot	Intercropping legumes in cassava plots at sequence
Farm/household	Crop residues, kitchen waste + leguminous tree as forage for small livestock and use manure at planting Train on intra-household decision making
Landscape/community	Land/water-use planning + protect environment ICT for enhanced extension+ credit services
Markets and other institutions	Market access for commodities produced by farmers + strengthen women groups
Policy	Policy action to mainstream CSA at district level including bylaws, budgets, joint planning

2. Intercropping Guidelines and Principles

Intercropping is the growing of two or more crops in the same field at the same time. Common examples are maize and beans, maize and groundnuts or maize and potatoes. To accomplish this, four things need to be considered:

1) spatial arrangement: This can be row, strip, mixed or relay intercropping.
2) density: To optimize plant density, the seeding rate of each crop in the mixture is adjusted below its full rate. If full rates of each crop were planted, neither would yield well because of intense overcrowding. By reducing the seeding rates of each, the crops have a chance to yield well within the mixture.
3) maturity dates of the crops being grown: Planting intercrops that feature staggered maturity dates or development periods takes advantage of variations in peak resource demand for nutrients, water and sunlight. Having one crop mature before its companion crop lessens the competition between the two crops e.g. climbing beans planted when maize is almost mature.
4) plant architecture: It is commonly used strategically to allow one member of the mix to capture sunlight that would not otherwise be available to the others e.g. widely spaced maize plants growing above an understory of beans.

Intercropping, also known as interplanting, provides additional income, increased yield, food and shade, fixes nitrogen, and controls weeds, pests and soil erosion. It also provides a lot of biomass to form residues to be returned to the soil in form of mulch and compost. The major plants used in intercropping include beans, soybeans, cowpeas, pigeon peas, onions and some vegetables. Care should be taken when intercropping as some plants host pests and diseases and can transmit to the main crop. For example, yam, pumpkin, watermelon and cucumber should not be intercropped with banana as these serve as alternate hosts for viruses that can affect bananas.

It is important to look at some of the principles by which intercropping relies. By understanding these principles we can utilize them to reduce costs and increase profitability, while at the same time sustaining our land resource base.

- Diversity: We can realize some of the benefits of diversity by planting mixtures of different crops. When one crop fails, you can get the other.
- Cooperation is more apparent than competition: There is far more cooperation in nature than competition. Cooperation is typified by mutually beneficial relationships that occur between species. By planting legumes and cereal crop, the legume fixes nitrogen which is used by cereal crop as well.
- Stability tends to increase with increasing diversity: This can be typified by agroforestry system where you can have animals kept, trees and crops grown in one plot.

The advantages of intercropping, however, do not come for free. There are often additional management needs and intercropping requires careful timing of field operations. Reducing competition between the intercropped plants requires careful management. Also, a crop mix that works well in one year may fail in the next, if weather favours one crop over the other. A mixture of crops with different growth habits or timing of development may make cultivation and use of mulches more difficult and intercropping also poses problems for crop rotation.

It will be important for trainers to understand the costs and benefits of intercropping and discuss them during the training. Under NURI CSA training, intercropping will be encouraged due to shortage of land in the settlements for the refugees. With this practice the farmers can maximise the use of the small plots. The purpose of this sub-section is to outline some of the basic principles for using intercropping successfully and further details can be got in the specific crops details provided in section 4.

Some practices of intercropping are:

2.1 Inter-planting Crops with Partially Overlapping Growing Seasons

For example, in a maize-bean intercrop, the maize is planted earlier. Then the beans are planted once the maize has sprouted and harvested before the maize matures, because the two crops have different growing periods. The beans use part of the field that is not used by the maize.

2.2 Intercropping Legumes with Non-legumes

Legumes like beans and cowpeas are nitrogen-fixing plants. There is scientific evidence that has documented the value of intercropping legumes with non-legumes, especially grain crops.

2.3 Using Tall Crops to Reduce Drought or Heat Stress of Shorter Crops

Here you can intercrop fruit trees when the canopy has not developed with vegetables thus making better use of the available land.

2.4 Using Intercropping to Disrupt Pests

Intercropping reduces densities of insect and mite pests in about 50% of the cases, usually by disrupting the ability of the pest to find its host. They make mixtures of dissimilar crops unattractive to pests compared to monocultures. This is good for integrated pest management for some crops.

What to do:

- Avoid using the plants from the same family in the same grouping.
- Group crops with similar water needs together.
- Choose crops with different root systems so that they aren't competing underground.
- Consider how the crops might affect each other's sunlight. Shade isn't always a bad thing, but it might be for the wrong plant.
- Time-sequencing can be very useful, and combining crops with different growth rates means they won't be interfering with the other at the most crucial points of development.
- Legumes and green manures are great plants to include as they help to continually revitalize soils.

3. Soil and Water Conservation

Soil and Water Conservation (SWC) is an integral part of Climate Smart Agriculture. It includes such technologies as terracing, mulching, trash lines, contour cultivation, bio-swales to slow, spread and sink runoff/ plant rain water, conservation agriculture and zero tillage, planting of woodlots, boundary planting and agroforestry. Despite the many years of promotion of SWC technologies in Uganda, its adoption levels are still very low. There are many reasons for low adoption rates including land size, the complex and labour demanding nature of some SWC technologies, lack of access to extension services, gender and level of education of the household head, socio-economic constraints, and location of the farmers.
Generally, more educated farmers are more willing to adopt soil and water conservation technologies, and the most profitable technologies are most adopted.

The advantages of SWC include prevention of soil erosion, containment of flood water, increasing water percolation and retention in soils; enhance groundwater recharge and aquifer volumes, among others.

3.1 Soil Fertility Management

While each crop has particular demands in terms of soil nutrients there are a number of basic rules and principles in soil fertility management which apply to all crops. Details for individual crops are in the relevant sections under Section 4.

The main soil nutrients required for crop growth are nitrogen, phosphorous and potassium and most soils contain levels of these nutrients required for plant growth. However, continuous cropping leads to these nutrients being diminished. Especially if the same crop is grown repeatedly, then certain nutrients will be drained from the soil. One tonne of maize, for example removes 24.3 Kg Nitrogen, 10Kg Phosphorus and 21.1Kg Potassium from the soil. These nutrients need to be replenished or even the most fertile soils will gradually become unproductive. This is one of the reasons inter-cropping and rotation can give yield benefits.

Leguminous plants like beans, groundnuts and pigeon pea get some of their nitrogen requirements from the air, and fix nitrogen in the soil. In a crop rotation the crops grown after a leguminous crop will benefit from the nitrogen the legume has fixed in the soil. Some legumes are better at fixing nitrogen than others, and if the whole plant including roots are removed from the field the benefit is minimal. Some leguminous plants need inoculation with the relevant Rhizobium bacteria to efficiently fix nitrogen.

How soil fertility is lost by farmers' activities
Soil fertility gradualyl diminishes by some farming activities such as:

- Erosion of top soil due to poor farming practices

- Crop removal / harvesting (nutrient mining)
- Frequent cultivation of the same piece of land
- Removal of weeds and other residues from the plot
- Burning of bush and crop residues
- Mono-cropping
- Excessive/ misuse of chemical fertilizers

Soil fertility Management practices

- Farmers can maintain and/or improve soil fertility in the following ways:
- Adding organic manures to the soil.
- Improvement of soil drainage
- Control of soil erosion
- Planting rain water/controlling run off and replacing it by slowing, spreading and sinking runoff.
- Crop rotation by growing crops which have different growth habits and nutrient requirements.
- Practicing Minimum tillage
- Timely weed control.
- Use of both organic and inorganic fertilizers.
- Land resting/fallowing where applicable
- Mulching and use of cover crop
- Intercropping –Planting both leguminous and non – leguminous plants in the same plot
- Practicing cover cropping
- Conserving trees on farm to aid nutrient replenishment from litter

Organic fertilizers

- Crop residues (maize stove, cassava peelings etc), Liquid manure, green manures, kitchen refuse, Animal waste (e.g. cow and chicken manure).
- Farmers can apply these fertilizers individually and directly or can be combined and composted and incorporated to the soil during seedbed preparation.
- Discuss with farmers on how to make Liquid manure/compost and recommend simple ways of making compost looking at the amount of biomass that comes out from the refugee households.
- Plant species like MUCUNA and CANAVALIA that can be used to increase soil fertility and productivity

Inorganic fertilizers

Not many farmers in Uganda use fertilizers for various reasons, however the benefit of increased yields as a result of fertilizer application out-weights the cost of buying fertilizer. Amounts required vary with soil fertility and crop requirements. Refer to crop specific information in section 4 or get from other information sources.

3.2 Water conservation and simple irrigation technologies

Water conservation is cardinal in vegetable and fruit trees production especially under the refugee setting. Various techniques can be used to conserve and/or harvest water. Here are some that AEO may discuss with farmers and what works best to conserve water will depend on what kind of soil being managed. Water harvesting and soil moisture retention practices are highly site specific and vary depending on the local situation. Details refer to http://www.fao.org/3/a-bl061e.pdf

- Retention ditches / trenches: These are large ditches, designed to catch and retain all incoming runoff and hold it until it infiltrates into the ground. They are sometimes also called infiltration ditches. In semi-arid areas, retention ditches are commonly used for trapping rainwater and for growing crops that have high water requirements.

- Contour farming: It means that field activities such as ploughing, furrowing and planting are carried out along contours, and not up and down the slope. The purpose is to prevent surface runoff downslope and encourage infiltration of water into the soil. Structures and plants are established along the contour lines following the configuration on the ground. Contour farming may involve construction of soil traps, bioswales, bench terraces or bunds, or the establishment of hedgerows or grass strips.
- Planting pits are the simplest form of water harvesting in areas with minimal rainfall amounts. Small holes are dug at a spacing of about 1 m. During rainstorms the planting pits catch runoff and concentrate it around the growing plant. Crops are planted in the pits and thereby benefit from the increased moisture availability in the pits. Compost or manure is placed in the pits before planting to improve soil fertility. It is not necessary to follow the contour when constructing planting pits.
- Semi-circular bunds are earth bunds in the shape of a semi-circle with the tip of the bunds on the contour. The size of the bunds varies, from small structures with a radius of 2 m to very large structures with a radius of 30 m. They are often used to harvest water for fruit trees and are especially useful for seedlings.
- Earth basins are square or diamond shaped micro-catchments, intended to capture and hold all rainwater that falls on the field. The basins are constructed by making low earth ridges on all sides of the basins. These ridges keep rainfall and runoff in the mini-basin. Runoff water is then channelled to the lowest point and stored in an infiltration pit. The lowest point of the basin, might be located in one of the corners (on sloping land) or in the middle (on flat land). Earth basins have proven especially successful for growing fruit crops, and the seedling is then planted in or on the side of the infiltration pit. The size of the basin is usually 1-2 m being larger on flat land and smaller on sloping land.
- Mulching is done by covering the soil between crop rows or around trees or vegetables with cut grass, crop residues, straw or other plant material. This practice helps to retain soil moisture by limiting evaporation, prevents weed growth and enhances soil structure. It is commonly used in areas subject to drought and weed infestation. The layer of plant material protects the soil from splash erosion and limits the formation of crust. The choice of mulch depends on locally available materials.
- Cover crops are usually creeping legumes which cover the ground surface between widely spaced perennial crops such as fruit trees, or between rows of vegetables. They are grown to protect the soil from erosion and to improve soil fertility. Cover crops protect the soil from splashing raindrops and too much heat from the sun. Most of the plants used as ground cover are legumes, such as different varieties of beans and peas.
- Conservation Tillage refers to the practice in which soil manipulation is reduced to a minimum. This practice preserves soil structure and, increases soil moisture availability and reduces runoff and erosion. Conservation tillage takes various forms, depending on the prevailing soil and farming conditions. Each farmer's plot has specific soil characteristics and management needs. Conservation tillage has four main application principles: No soil turning, Permanent soil cover, Mulch planting (direct sowing), Crop selection and rotation.
- Simple irrigations methods. Bottles and some jerrycans can be used to release water to plants slowly and good for fruit trees. If on reasonable scale of production and reliable water source, you can use treadle or solar or motorised pumps for irrigation.
- Make Ridges or beds in areas of poor drainage and water logging. In some cases refugees have settled in such places. Alternatively dig channels to take away excess water.

SECTION 4: CROP SPECIFIC DETAILS

1. CASSAVA

Introduction
Cassava is a valuable subsistence and cash crop in many countries. It is the most important tropical root crop. Its starchy roots are a major source of dietary energy for more than 500 million people. It is known to be the highest producer of carbohydrates among staple crops. The leaves are relatively rich in protein and can be consumed. Cassava can be stored in the ground for several seasons, thereby serving as a reserve food when other crops fail. Cassava is also increasingly used as an animal feed and in the manufacture of different industrial products. It is also used in industrial processes. Discuss other uses of cassava you know.

Variety selection
There are many improved varieties of cassava, but the most promoted recently in Uganda in light of viral diseases are NAROCAS 1, NAROCAS 2, NASE 19, NASE 14, NASE 13. These are all sweet varieties, have low cyanide content and are resistant to cassava mosaic virus disease (CMD) and to some extent cassava brown streak disease.

Variety	Maturity period (months)	Yield T/acre	Attributes
NAROCAS 1	12	25	Large roots with brown outer skin colour, resistant to CMD and brown streak disease, sweet with low cyanide content
NAROCAS 2	12	20	Roots are moderate and brown in colour, resistant to CMD and brown disease, sweet with low cyanide content. Requires fertile soil.
NASE 19	12	25	Roots are moderate, resistant to CMD and brown streak disease, sweet with low cyanide content

Growth environments
Cassava grows on poor soils, but for good growth and yield it requires friable, light textured and well drained soils containing sufficient moisture and a balanced amount of nutrients. Stress of Phosphorous in soil increases cyanogenic content in tubers.

Soil fertility management
Cassava can do well in poor soil with reasonable yields compared to cereals hence grown in poor soils. This is why it normally comes last in the crop rotation. It however can perform better with improved soil fertility. Careful use of fertilizers is required in cassava production as may encourage vegetative growth at the expense of root tuber growth. In early stages of growth, it is vulnerable to soil erosion so effort should be made to prevent this.

Land Preparation.
Do not burn bushes and plant matter in the clearing process. A rough seed bed will do. Cassava responds positively to deep tillage especially in drought prone areas. Flat seedbed is a common practice Uganda. First and second ploughing will give a good seedbed. Zero tillage is also possible.

Planting
Healthy, fresh stem cuttings (or stakes) from mature plants are best for planting. Over mature and tender stems give poor germination. If planting is delayed stems should be stored in dry,

well ventilated, shaded areas away from direct sunlight. For example, stems can be arranged vertically under a tree with the oldest part of the stem buried in the soil.

Planting is recommended at a spacing of 1m x 1m for optimum plant population of 4,000 plants per acre. Stake length of 25 - 30cm is recommended. Use pest and disease-free cuttings which should not be bruised or which have not started sprouting. Horizontal planting of stems is a common practice and deeper planting is recommended for dry, sandy soils and shallow planting for moist and heavy soils. Vertical planting on ridges is done in dry areas.

Plant at the onset of each rainy season for proper establishment and tuberization. Cassava can be grown together with other crops. For example, in cassava and bean intercrop, good performance is realised when cassava is spaced at 1m x 1m and beans 50cm x 20cm, both crops planted at the same time. In Cassava and maize intercrop, it is important to introduce maize 2 months after planting cassava.

Weed control

Weeding is necessary every 3-4 weeks until 4 months after planting. Afterwards the canopy may cover the soil and weeding becomes less frequent. The number of times a farmer has to weed will depend on the type of weeds present and the varieties of cassava grown. Early branching varieties develop canopies which reduce weed growth. Mulching cassava, especially after planting, is helpful when growing cassava in dry areas or on slopes. Intercropping also helps to suppress the weeds.

Pests and Diseases Control

Major diseases	**Casual-agent**	**Control**
Cassava mosaic disease (CMD)	Viral	IPM- Resistant variety, rogue infected plants , plant clean materials, and plant at close spacing
Cassava Brown Streak Disease (CBSD)	Viral	IPM - Use clean planting materials, resistant variety, destruction of infected plant debris and strict by-laws to reduce spread
Minor disease		
Anthracnose	Fungal	Resistant variety , avoid poorly drained soils
Bacterial wilt	Bacterial	Resistant variety
Major pests		
Cassava green mite		IPM - Plant resistant varieties, plant early in the season
Cassava mealy bug		IPM - Use biological enemy such as E.Lopez, Select clean planting materials, plant resistant varieties
Minor pests		
Elegant grasshopper		Chemical may be required using insecticide.
Cassava scales		Chemical may be required using insecticide.

Harvesting and Post-harvest

Cassava matures in about 8 – 12 months. Harvesting can be piece meal or entire plant harvested. Avoid damaging the root tubers during and after harvest. Keep fresh tuber roots under shade or in soil if their use is extended to a period exceeding one day. Process bitter cassava varieties using manual /power graters, chippers/slicers, or a hydraulic press

Dry in a clean dryer, drying racks, or clean surface free of soil. The shelf-life of cassava is prolonged by processing it into bakery and confectionery products using a range of processing equipment available on the market. Storage technologies include cement brick silo, mud-straw and basket woven granaries and drum hermetic storage. Store in cool, dry and hygienic place.

2. SWEET POTATO

Introduction

Sweet Potatoes (*Ipomoea batatas*) are grown practically in every part of Uganda where crop cultivation is possible. It is one of the most important starchy food crops grown in the country. Some are rich in vitamin A. The root tuber is the centre of interest, although the leaves may also be eaten as vegetables. Entire plant can be used as animal feed. It is also a source of income. It occupies about 9% of the food crop acreage and the fourth most important crop after millet, bananas and cassava in the country.

Variety Selection
There are several varieties of sweet potatoes that have different characteristics and attributes e.g. high and low dry matter; skin colour (white, pinkish), flesh colour (white, yellow & orange). The most common varieties include Tanzania, Tororo 3, New Kawogo, Kakamega, Sukaali, Amongin and Mbaale. Recent varieties that have been introduced by research include the orange-fleshed vitamin A rich namely; Kabuja, Ejumula, Vita, Naspot 12, and Naspot 13. The choice of the variety to grow depends on the characteristics the farmer is interested in.

Growth Environment
Sweet potatoes grow best at temperatures of 24^{o}C, abundant sunshine, and warm nights. Thus, do not grow under heavy shade unless for preservation of vines.

They require rainfall ranging between 750 – 1000mm per annum with a minimum of 500mm of rain fall in the growing season. The crop is sensitive to drought at the tuber formation stage, which occurs 50–60 days after planting, and it is not tolerant to water-logging, because this causes tubers to rot and reduce growth of food storage roots. This is further worsened, if aeration in the soil is generally poor.

Sweet potatoes grow on a variety of soils, but well-drained, light- and medium-textured soils with a pH range of 4.5-7.0 are best. They can be grown in poor soils with little / no fertilizer.

Planting

Land Preparation
Seedbed for sweet potato should be fertile and well prepared without big soil clods. Large soil clods can interfere with tuber development during growth and development of the crop. Land preparation for sweet potato cultivation involves clearing the land and ploughing using hand-hoe, ox-plough or tractor twice. With fine tilth make the mounds or ridges again by hand hoe, ox plough or tractor on which the potato vines will be planted. In some communities, sweet potatoes are planted on flat ploughed land. Select the method which increases yields.

Planting
Sweet Potatoes are propagated vegetatively using its vines, which are taken from the top of the old stems. Use fresh and healthy vines although some farmers allow them to wilt abit. Avoid deformed vines (i.e. with chloric, mottled, wrinkled) or infected vines (i.e. with mosaic patterns – which is an indication of viral disease). Vines should be taken from mature stems. A good vine cutting should be about one foot long or about 6 nodes.

When mounds are used, they should not exceed a height of 1m in height and diameter. The size of the mound however varies with the type of soil. In soils that are prone to drying, small mounds are used, because big mounds become exposed to too much sunshine and they dry out very fast, thus affecting the planted crop.

The numbers of vines planted vary with the size of mound i.e. small mounds take fewer vines compared to bigger mounds. Two vines may be used on small mounds and up to four vines on larger mounds. On ridges 1m apart, cuttings should be placed at intervals of 30cm. Planting is mostly done by hands, but you can plant sweet potatoes using forked sticks in some cases.

Sweet potatoes are intercropped with many other crops namely; okra, maize, soybeans, beans and research is trying many more. Examples; grow two rows of sweet potatoes and one row of maize, sweet potatoes with 1 m spacing of ridges then 3 okra seeds can be planted at the side of the ridges at a spacing of 1 x 0.5 m and later thinned to one per stand. Discuss how best to intercrop.

Weed Control and earthing up

Sweet potatoes should be kept weed free in the first 1 – 2 months of growth. Weeding is normally done by hand. After about 2 months, the canopy of the crop is normally big enough, covering the ground and this helps to keep away weeds, making additional weeding optional or unnecessary. During weeding, earthing up is done by adding more soil to maintain the size of mound or ridge.

Pests and Disease Control

a) Pests and control

Sweet Potato pests attack at different stages of growth and development, including after harvesting and these include:

- Leaf Pests: include Sweet Potato Butterfly; Beetles; Sweet Potato Hornworm; Armyworms; Leaf Folders; Weevils. Grasshoppers and Locusts are minor leaf pest for sweet potatoes.
- Stem/ vine pests: include Stem borers; Weevils and Beetles
- Storage pests: Sweet Potato Weevils and White Grubs

There is no single control method for the control of sweet potato pests, but a combination of approaches (IPM) is recommended including cultural practices such as:

- Use of clean and healthy planting material, especially vine tips;
- Crop rotation;
- Removal of volunteer plants and crop debris (sanitation);
- Timely planting and prompt harvesting to avoid a dry period.
- Removal of alternate, wild hosts.
- Planting away from weevil-infested fields.
- Hilling-up of soil around the base of plants and filling in of soil cracks.
- Applying sufficient irrigation to prevent or reduce soil cracking.

b) Diseases and control:

These include fungal, viral and bacterial. The most serious are viral diseases.
The most common viral diseases affecting sweet potato with the potential to reduce yields are caused by Sweet potato feathery mottle virus (SPFMV) and Sweet potato chorotic stunt virus (SPCSV), which together are referred to as the Sweet Potato Virus Disease (SPVD). Viral infections may be controlled and/or avoided through IPM by:

- Make sure cuttings are from healthy plants and if possible from healthy plants
- Remove and burn or feed to livestock any diseased plants
- Avoid planting new crops where you grew sweet potato last season
- Plant your new crop away from old crops,

Fungal and bacterial diseases are not very serious and are not discussed here. Good sanitation practices coupled with other IPM practices can help contain these diseases.

Harvest and Post-Harvest

Depending on the cultivar and conditions, sweet potato matures in three to nine months. However, most common varieties mature between 4-7 months.

To harvest entire plants, you can use a hand hoe or digging fork to gently remove the soil from the ridges or mounds. When digging up your ridges and mounds during harvest, start at the top following the stem and roots of the vine. You will find the sweet potato tubers along the roots just under the vine stems. In piece meal harvest, using hand or a stick, large tubers can be harvested while leaving the smaller tubers to grow in the mounds / ridges. Sweet Potato yields are in the range of 13.2 – 35.0 tonnes per hectare. However, higher yields are possible with improved farming practices.

Post-Harvest Handling
Sweet Potatoes suffer significant post-harvest losses mainly attributed to handling and the thin nature of their skin. They experience up to 65% yield loss due to weevils, fungal/ bacterial rotting and sprouting of potatoes while in the store. It is believed that up to 25% of the Sweet Potato yield is lost during transportation. It is therefore necessary that these losses are prevented. There is no proven method for storing fresh tubers because of the high moisture content they have. Available methods are for short periods only. For long term storage, it is better to peel the tubers, slice and dry on a clean surface and then store them. Be aware of storage pests that can attack them.

3. OKRA

Introduction

Okra (*Abelmoschus esculentus)* is a flowering plant that produces edible green seed pods upto 18cms long. When cooked, it produces a nutritious mucus-like (mucilaginous or slime) sauce. Okra seeds may be roasted and ground to form a caffeine-free substitute for coffee. Okra seeds when pressed produce greenish-yellow oil, which is good for cooking foods and it has a pleasant taste and smell and is rich in unsaturated fats. The pods are ideal for both thickening and flavouring stews and soups because of the high mucilaginous content. The pods can also be boiled or fried and eaten as a vegetable.

Growth Environment
Okra is among the most heat- and drought-tolerant vegetable species in the world thus suitable in the changing climatic conditions. It grows best in temperatures that range between 22°C and 35°C. Okra can be grown on a wide range of soils, provided the soil drainage is good, but may tolerate soils with heavy clay and intermittent moisture. Soils high in organic matter are preferred. Okra is a heavily foliaged crop, so its water requirement is high.

Planting

Land Preparation: Thorough soil preparation commencing two to three months before planting is recommended, to allow organic matter in the soil time to break down.

Soil Fertility: Okra grows well in a wide range of soil types even without fertilizer application. However, in the event that fertilizers are applied, it responds very well.

Planting: Okra seeds are soaked overnight prior to planting to a depth of 1-2 centimetres. Germination occurs between six days (soaked seeds) and three weeks. Seedlings require ample water. Okra plants may be established either by direct seeding in the field (most common by small farmers), and by growing seedlings in a nursery seedbed. Seedlings are ready for transplanting when they reach 10 to 15 cm in height and are planted in single rows by hand. Plants are spaced in single rows 30 to 45 cm apart. Row spacing may vary from 1.0m to 1.5m.

Pruning: Okra may not develop any branching until the plant reaches a height of about 30 to 40cm. Normally 8 to 14 fruit-bearing shoots develop with minimal further branching. If further offshoots develop, some branch thinning will be necessary. Opportunities also exist for ratooning by cutting the bushes back.

Weed Control

Okra is harvested over a long period and weed control remains important throughout the season. Hand weeding or slashing can be used to keep weeds to a minimum.

Pest and Disease Control

Pests: There are many insect pests which may attack okra, but the most troublesome are Silver leaf whitefly, heliothis, rough bollworm, looper caterpillars, green vegetable bugs and root-knot nematodes. Aphids and mites may also occur on okra crops.
Pest management in okra is very difficult as only a small number of insecticides are registered and available for application in Okra. Monitoring the crop regularly for pests is essential.

Root-knot nematodes (*Meloidogyne* species) cause severe galling on okra roots. Crop rotations are an important management tool.

Diseases: Fungal infections are the most common diseases of Okra. They include those that cause yellowing and wilting disease (*verticillium* wilt) in leaves; powdery mildew and leaf spots. The control measures recommended are crop rotation and the destruction of diseased plants.

Harvest and Post-Harvest

Okra pods rapidly become fibrous and woody and, to be edible as a vegetable, they must be harvested when immature, usually within a week after pollination. When cooked, the red okra pods turn green.

The pods should be ready for harvesting within 10 weeks of planting, and regular picking every 2 to 3 days is essential for maximum yields. Mature pods left on the plant will reduce flowering and fruit set. The market demand is for young tender pods about 7 to 10 cm long. Older, tough or stringy pods are not easy to sell. Discard pods showing spine growth on the fruit.

Yields of 0.3 to 0.5 kg/plant can be expected. Cut the tender pods from the stalks and handle them carefully, otherwise they may bruise and discolour.

The pod can also be cut and sun dried for future use. Dry on a clean surface.

4. SUKUMAWIKI

Introduction

Sukuma Wiki is a Kiswahili term literally meaning to "push the week" or "stretch the week". It is a vegetable that is generally affordable and available all-year round in this region. It forms part of the staple dishes in the East African region. Sukumawiki's botanical name is *Brassica oleracea* and in English called Kale. It is related to cabbage, broccoli and cauliflower.

It is rich in roughage and essential nutrients including Vitamin C, K, Carotene, Lutein, Zeaxanthin, iron, calcium and is thought to reduce the risks of several human cancers.

Growth Environment
The plant prefers well-drained, fertile soil high in organic matter, pH 6.0 to 7.5 and can tolerate slightly alkaline soil. It prefers plentiful, consistent moisture and can tolerate drought, but under these conditions, the quality and flavor of leaves is lost. It is also moderately sensitive to salinity. It has an upright stalk, often growing up to two feet tall.

Seed and Variety Selection
Varieties commonly grown in the East African region include:

- ***Sukuma Siku Hybrid*** – Curled leaves, soft texture. Has good tolerance to Diamond Back Moth. Leaves have a good cooking flavor. These can be harvested over a longer period (6-9 months).
- ***Marrow stem*** – Dark green leaves. It prefers cool climate with moderate to fairly heavy and well-distributed rainfall.
- ***Thousand headed*** – Smaller leaves than Collard. It is slow growing compared to other varieties. Very branching and frequently produces many heads hence requires frequent pruning. Has long harvesting period.
- ***Collards southern Georgia (sukuma wild):*** This is a drought tolerant variety that withstands high temperatures. It is a shorter variety with large, tender, bluish green leaves that spread widely. These are tolerant to Soft and Black Rot.
- ***Collard Mfalme Fl*** – A hybrid with short internodes and many leaves per internode hence more yield per unit area. It is tolerant to a wide range of diseases. Have tender Leaves.

Planting
Land preparation:
The field should be ploughed 2-3 weeks in advance at least 8 inches deeper to allow better and faster root development. Aggressive perennial weeds should be removed before planting. Early land preparation is recommended to expose pests to sunlight and birds. Land should be dry to avoid soil crumbling and creation of a hard pan. Harrow the field 2-3 weeks later after ploughing to get a fine tilth.

Nursery bed establishment:

- Site nursery where vegetables in the same family as kale has not been grown for 2 years.
- The nursery beds should be about 1 meter wide and of the required length. In wet areas and sites with heavy soils, raised beds are recommended to prevent water logging.
- Manure and phosphate fertilizers like DAP should be applied and worked well into the soil. A nitrogen fertilizer like CAN is top dressed two weeks after germination only on poor soils.
- The drills are made across the beds at a spacing of 10-15cm apart and 2cm deep.

- The seeds should be sown thinly and covered lightly with soil. Cover the nursery bed with a thin layer of dry grass removed after germination.
- In hot areas, a shade (about 1m high) is necessary. However, excessive watering and shade favors the development of powdery mildews.
- You can prick out seedlings leaving 2-3cm apart to reduce competition for nutrients and prevent damping-off disease
- Water once or twice daily. Irregular watering also promotes dumping-off disease.
- Pests and diseases in the nursery should be controlled to ensure healthy seedlings.
- The seedlings are transplanted when four to five true leaves are formed. This takes a period of about four weeks.

Transplanting:

The best time for planting is late in the evening when sun is cool or on a cloudy day. The seedlings must be wetted an hour before transplanting and should be planted at the same depth as in the nursery. The seedlings' spacing in the garden varies with variety, but generally 60cm x 60cm for large-headed varieties, 60cm x 45cm for medium sized and 30cm x 30cm for small heads should be applied. Manure application is necessary to improve soil structure and to slowly provide extra nutrients. This is done at planting time by applying 10-30 tons per hectare.

Weed Control and other practices

Keep fields free of weeds to reduce competition for nutrients, light and space. Also to reduce pests and disease infestation. Mulching with crop residues significantly increases the soil organic matter content and improves soil fertility besides water conservation.

Pest and Disease Control

Pests: Sukumawiki is affected by Root-knot nematodes; Cabbage loopers; Beet armyworms; Cutworms; Flea beetles; Thrips (Western flower thrips & Onion thrips); Cabbage aphid; Large cabbage white (Cabbageworm); and Diamondback moth pests. Spraying with contact insecticides.

Diseases: Sukumawiki is affected by Black rot (Leaf spot); *Alternaria* leaf spot (Black spot, Gray spot); Anthracnose and Downy mildew all diseases caused by Fungi.

Harvest and Post-Harvest

Timing of harvest depends on need and flavor preference as older leaves have a stronger flavor. Harvesting can start soon after the plants start to produce leaves and older leaves can be eaten as salad. Continuous removal of leaves encourages a continuous cycle of growth.

As the plants mature and lower leaves are harvested, plants begin to look less like a clump and start to resemble small palm trees with a cluster of leaves at the top of a long stem

Fresh Sukumawiki leaves can be stored for up to 10 days in a refrigerator to just above freezing (1°C) at high humidity (>95%). Once cooked, they can be frozen and stored for greater lengths of time.

5. AMARANTHUS

Introduction

The edible Amaranth/Amaranthus is an ancient food plant that grows well in warm climates. It is a common vegetable dish in Uganda locally called Dodo. All the many members of the genus Amaranthus are edible, some are better than others. Amaranth can be grown both for the leaves and the grains/ cereals.

Like other traditional vegetables amaranthus is a cheap source of minerals, vitamins, calcium, phosphorus, ascorbic acid and various micronutrients. They add to taste, increase palatability and complement the nutritional value of basic staple foods, and are good supply of dietary fibre. The leafy amaranthus, can be harvested within 3 to 4 weeks after planting.

Growth Environment
Like all fast growing leafy greens, amaranth loves rich soil with steady moisture, and a good supply of nutrients especially nitrogen to facilitated foliar growth. However, will tolerate a wider range of soils than other grain crops and optimum well-drained loam soil.

Amaranth shows remarkable adaptation to a wide range of climates. Minimum germination temperature is around 13°C, but best results are at 15-18 degrees. Amaranth like a warm open site best, with good drainage and full sun. It is more tolerant of drought than most other leafy vegetable.

Planting

Land Preparation: Prepare a fine bed, because the seeds are very small. Prepare the garden 2-3weeks in advance.

Seeds and Variety Selection: The Amaranth varieties grown in Uganda include amaranthus caudatus; amaranthus hypochondriacus; and amaranthus cruentus for grains; amaranthus blitum; amaranthus dubius; amaranthus tricolor; and amaranthus viridis grown for the green leaves.

Planting Amarantha:

- Amaranth propagation is by seed and with appropriate conditions these seeds germinate in 7-10 days from sowing. Direct seeding in the field is common practice. In some cases, this is done by first germinating the seeds in a nursery bed and then transplanting the seedlings to the garden.
- Amaranthus seeds are very small and difficult to handle. Mix the seeds with dry sand or ash in the ratio of 1:20. Then either broad cast or apply in the grooves made by a rake or just a stick. Transplanting is rarely used because it is laborious.
- For home consumption, Amaranthus can be grown in sacks full of soil and manure. Just place the sacks near the kitchen where they can always be irrigated using water from kitchenware washing.

Weed Control and other practices

Amaranth should be weeded as seedlings emerge, as at this stage they would be requiring nutrients for growth which are competed for by the other weeds.

Amaranth is responsive to nitrogen and phosphorous. Plants grown in average garden soil will be four-feet to six-feet tall, while those grown in rich soil or compost may reach over eight feet.

Pest and Disease Control

Pests: Insect pests affect amaranth most and these include: Pigweed weevil (*Hypolixus haerens),* which causes withering of plants resulting in the plants to bend and collapse. Adult weevils feed on foliage; larvae hollow out stems; damage promotes colonization of fungi and other pathogens. The pests are managed by uprooting and destroying infested plants to limit weevil population

Diseases: Diseases caused by Fungi are the commonest and these include:

- Anthracnose (*Colletotrichum gloeosporioides*), which causes necrotic lesions on leaves; dieback of leaves and branches. This can be controlled by avoiding damage to plants and creating wounds for pathogen to enter; plant resistant varieties
- Damping-off (*Rhizoctonia* spp. *Pythium* spp.), which causes poor germination; seedling collapse; brown-black lesions girdling stem close to soil line; seedlings fail to emerge from soil. Wet soils favour the emergence of the disease. This disease can be controlled by avoiding planting seeds too deeply; do not plant seeds too thickly to promote air circulation around seedlings; do not over-water plants
- Wet rot (Choanephora rot) *Choanephora cucurbitarum, which causes w*ater-soaked lesions on stems; may cause loss of leaves. The fungus mainly attacks plants that have been damaged by insects or by mechanical means; spread by air currents and via infected seed. Warm and moist conditions favour the emergence of the disease. Plant varieties resistant to disease; only use certified seed; do not plant crop densely; treat disease with copper fungicides if it emerges

Harvest and Post-Harvest

Harvesting amaranth is the simplest and either involves collecting the leaves or the grains. For a leaf harvest, pick off leaves or young shoots as soon as they are large enough to handle. Keep pinching back any flower-buds to keep the plant producing more leaves: eventually it will bolt regardless, but don't worry, you can collect a second crop of seeds. Collect the foliar parts early in their growth when they are still succulent, so as to give you the best test. In some cases young plants are uprooted when about 10 cm tall.

To harvest the seeds, the grains are harvested after the plant has flowered. Shake the spikes on a warm dry day to see if the grains are ready to drop. Cut-off the fruiting stalks and lay them on a large piece of paper in a box; then set the box in a warm place to dry, turning the stalks occasionally. This can be done inside the house or under shade, but watch out for mice. The seeds will fall out onto the paper and can be collected into a large jar or stout bag when fully dried. Use harvested grain as food within 6 months of harvest. Flowering amaranth can still have their leaves harvested - only use a few leaves from each plant for cooking to give highest yields.

6. COWPEA

Introduction

Cowpea (*Vigna unguiculata*) is an annual herbaceous legume. It is an important source of protein for resource-poor farmers, as well as, an essential component of cereal-based cropping systems. It is consumed both as a grain and a vegetable. Cowpea possesses multiple advantages for farmers, including high yields on poor soils unsuitable for the production of other crops, high rates of symbiotic nitrogen fixation and lower fertilizer requirements. It requires very few inputs and is well-suited to intercropping with other crops. The whole plant is used as forage for animals, with its use as cattle feed is thought to be a derivative for its name.

Varieties
Many cowpea cultivars exist characterised by growth habit, seed color, size, shape etc. Local varieties include Mitali, Miseriseri found in western Uganda, Ebelat Ekowo and Ecirikukwai in North and North Eastern Uganda, Amul, Agondra and Osunyirikia in West Nile.
Improved varieties include SECOW 1T a large seeded variety with tan colour and matures in 90 days; and SECOW 2W, a large white seeded variety that matures in 70-85 days.

Growth Environment
Soils should be free draining. Cowpeas are grown on a wide range of soils, but grow best in sandy soils, which tend to be less restrictive on root growth. It is more tolerant to infertile and acid soils than many other crops. Cowpeas are shade tolerant, making them a good choice for growth alongside taller crops. Cowpea has a strong taproot and many spreading lateral roots in surface soil. It is more tolerant to drought and high temperatures than other grain legumes. It can grow is areas that receive rainfall ranging from 400 - 750mm per annum and it is why it is an important crop in the semi-arid regions, especially northern and North Eastern Uganda.

Ordinary, it is not necessary to apply fertilizers to cowpeas, because they are usually self-fertilizing. The Rhizobium bacteria that naturally form nodules on the crop roots help fertilizing the crop with nitrogen. However, application of phosphate fertilizer can increase yields.

Planting
- Clear bushes and plough once or twice depending the finish.
- Plant in a fine seedbed and when there is enough moisture in the soil.
- Use quality seeds of a recommended variety. Home processed seed can be of good quality if well stored.
- Seeds to be used for planting must be sorted to make sure that they are free from insect damage or any inert materials and are free of disease.
- You may consider to do a germination test although cowpeas usually have good germination and over 85 % is good enough.
- For production of green peas, row spacing of 60cm x 30cm is recommended. For production of dried peas, plant spacing of 50 x 20cm is optimum. Recommended seed rate is 15-30 kilograms per hectare.
- To plant, sow 3 seeds per drilled hole of about 3-4cm deep, and then gently rake the soil to cover the seeds. After two weeks when the seeds have emerged, thin the seedlings to leave two plants per stand.
- For optimum yield, cowpeas should be planted at the onset of short season rains. Sometimes its planted such that harvesting of the crop would coincide with the dry weather.
- Where the cowpea is to be intercropped or relayed with other crops like maize, cassava etc and a spacing of 50cm x 20cm should be used for cowpeas and maize planted at 100cm x 50cm.

Weed management
Weed within 2-4 weeks after germination as weeds can compete with the cowpeas leading to low yields. In most cases one weeding is sufficient. Good seedbed preparation minimizes the growth of some weeds, giving cowpea plants better growing conditions.

Pests and diseases control

- ***Diseases:*** Cowpeas is attacked by many diseases; stem rot, bacteria blight, Fusarium wilt, bacterial canker, Cercospora leaf spot, rusts and powdery mildew. *Control:* by seed dressing with Fernasan D. Plant in the second rains. Spraying with Dithane M-45 although not economical. These are best controlled by IPM.

- ***Pests:*** Cowpea Pod borer, Aphids, Thrips, leaf beetle, pod sucking bugs

Control: by spraying with Fenitrothion and dimethoate before flowering stage and again at pod formation. To control Bruchids (storage pest), farmers mix cowpeas with ash. This is a highly recommended approach, because it is cheap and safe to use. It is advisable not to use chemicals in stored food.

Harvesting and yield

- Cowpeas take 12-14 weeks from planting to harvesting dry peas. For green peas, harvest at 10 weeks. At maturity, leaves will dry down, but may not drop off completely. They need to be harvested when seed moisture content is 14 to 18%, depending on the consumer's requirement. Cowpea harvesting is done by picking dry or partially dry pods from plants or by uprooting plants in the morning hours to prevent pods from shattering.
- As green vegetables, can be from 3 weeks after planting. Harvesting can be uprooting entire plant or picking the soft leaves continuous until no more. If interest is grain, once flowering has begun the harvesting of leaves should stop to allow the crop to produce pods and develop seeds.
- Yield is about 1 ton per hectare of shelled peas on well-managed plots. It is slightly lower (about 600kg/ha) with average management practices. New varieties yield between 1200 – 1500kg/Ha.

Post-Harvest Handling of Grain

- Drying: Dry the pods after harvest immediately on clean surface. Seed quality is important, so care in harvesting and post-harvest handling is very important to avoid cracked or split seed.
- Threshing and cleaning: Once the pods are properly dry, thresh by beating gently in a threshing cage. However farmers commonly beat in the open and on bear ground. Clean the grain. Some farmers can store it without threshing.
- Seed Drying & Packaging: sun dry grain again on a clean surface to reduce the moisture content to about 12% if necessary before storage. Test for dryness of the grain. It stores better and longer when the moisture content is 8 to 9%.
- Seed Storage: It is important to store harvested and dried cowpea seeds in a pest free environment. Cowpea weevil (*Callosobruchus maculatus* & *Coleoptera -Bruchidae*) are the most serious storage pests for cowpeas. The storage life of cowpea depends on its moisture content before storage. The lower the moisture content, the better the quality of seeds in storage.

Post-Harvest handling of Leaves:

- Steaming/ Boiling of Leaves: Leaves are first steamed, dried on a clean surface and stored for the dry season. Storage of cooked and dried leaves is possible for up to one year period, because they are not affected by pests the same way as dried seed. Also partial cooking of the leaves preserves or avoids loss of P-carotene, vitamin C and amino acid lysine which are important nutrients in the leaves. These nutrients are usually lost or destroyed during sun drying of leaves.

- Chopping and spreading fresh leave to dry on open direct sunshine preserve the leaves for a year and when cooked, taste like fresh leave. These are some practical emerging technology commonly used in the villages now days.

7. ONIONS

Introduction

Onions are a popular, high-value crop, but onion production is also labour intensive if good results are to be achieved. Onions have high vitamin and mineral content and have many health benefits, including reduced obesity, heart disease and cancer. Onions are a source of income to a number of farmers and can be grown in rainy seasons or during dry seasons by using irrigation methods.

Varieties:
The common Onion varieties grown in Uganda include; Red Creole, Jambar F1, Red passion F1, and Bombay red and Red pinoy. These have a lower yield but are in high demanded and they fetch a high price than the Jambar F1. Always use quality seeds of a recommended variety. Quality seeds are a fundamental requirement for good production.

Growth requirements
Bulb onions do best in well drained, sandy loam soils with a pH range between 6.5 to 7.0. Seedlings are fairly tolerant to high rainfall, which towards crop maturity may result in increased incidences of thick necks. Adequate soil moisture is required throughout the growing season for optimum yields. Onions need a dry period prior to harvest, therefore plan to start your nursery bed according to the dry season of your planting area. Count back 4½ months so that you can harvest during a dry period.

Bulb onions require soils rich in organic matter. Farmers can make compost. Dressing of NPK at a rate of 560kg/Ha spilt applied 14 day intervals after bulbs begin to swell will promote bulb development.

Planting

Onions can be planted from seeds, sets or transplants. An onion set is a small dormant bulb that will produce a larger bulb or many small bulbs once it's planted. Onion transplants are where seeds are germinated in a nursery bed before transplanting to the main garden. AEOs to discuss and practice with farmers setting up nurseries and manage them till stage of transplanting.

After clearing the land, plough the field for the first and second time and can be followed by harrowing to make a fine tilth. Then onions can be planted on flat seedbed or on raise beds especially on lowlands. Avoid shady areas. Manure or compost can be incorporated into the soil during seedbed preparation.

Onions are best planted at the onset of the rains to maximize the growth period. If some form of irrigation is available planting date is more flexible. It may take up about 4 – 6 weeks for onions to be ready for transplanting.

Rows should be 30 cm apart, and onions transplanted 10 cm apart in 1cm deep holes in the soils. If possible mix manure into the soil of the furrow prior to planting. Transplanted onions should be pencil thick at the time of transplanting. Gently cover the new transplants with soil. Water thoroughly after planting, and regularly thereafter when it does not rain.

Onion can also be sown directly in the field which is less laborious than transplanting, but thinning is required. However, seedlings can best be watered and kept weed-free in a nursery bed.

Weed Control, soil and water conservation

In the nursery bed and in the period after transplanting the young onions do not compete well with weeds thus the field should be kept weed free. Weeding should be done regularly to remove weeds between and within rows and earthing up by adding soil to the base of plants is recommended. Mulching is recommended for soil and water conservation.

Pests and Disease Control

Insect pests: Thrips are the most serious pests. Other common pests are onion fly, and onion neck rot disorder.

Control: Spray with endosulfan 50% WP (10gms in 10l water) repeated at 10-14 day intervals.

Fungal diseases: Purple blotch, downy mildews, smudge, neck rot and black soft rot can be controlled by spraying with dithane M45 or antracol; crop rotation, rouging infected plants, use of resistant varieties and field hygiene**.**

Harvest and Post-Harvest handling:

Onions need around 4 months to mature after transplanting. Maturity signs are; the tops of the onions turn brown or yellow and fall over. It is time to plan for harvest; ideally the plant will have about 13 leaves at this point. The last 3 weeks before harvesting, the weather should be rain free. To avoid sprouting in storage, onions require 'curing'. Curing involves bending the 'necks' of the plants when they are mature. The plants are then left in the field for 7 to 10 days, during which a chemical process takes place within the plant which prevents sprouting during storage. To harvest, pull the onions early in the morning on a sunny dry day, shake off excess soil.

Cure the onions by putting them in to sun to dry for at least 2 days spread on a single layer. Then transfer your onions to a shaded warm, dry, and well-ventilated room to enable them to completely dry and cure. Proper treatment at harvest maximizes the amount of time you will be able to store your onions without rotting and sprouting.

8. CABBAGE

Introduction

Cabbage is one of the most popular vegetables grown for food and other uses around the world. It is an excellent source of vitamins and minerals which are important for healthy functioning of the body. Farmers earn good money from growing cabbage which can be grown twice a year or more.

Cabbage grows best in partial shade, in firm, fertile, free-draining soil. Cabbage prefer fertile soils high in organic matter and can tolerate slightly acid soils. They need adequate and consistent moisture.

Varieties

There are many varieties of cabbage in the market including hybrids and they vary depending of colour of leaves, size of the head and maturity period. Some below:

- ***Large headed:*** Drumhead, Gloria, and Sugarloaf.
- ***Small headed:*** Red drumhead, Copenhagen, Chinese cabbage. Copenhagen and Sugar loaf are also early maturing and hence escape black rot disease.

Planting

Cabbage seeds should be sown in a nursery bed prior to transplanting. Use improved seeds for better results. Sow into a well-prepared seed bed or germination tray. Open up holes in a row then sow seeds 1-2 cm deep and rows should be spaced 5 cm apart. Water the seeds to provide the moisture needed for germination. Seed germination will be seen 4-7 days after planting. Seedlings should be thinned after germination.

Cabbage is ready for transplanting when the seedlings are between 6 - 8 cm high and should be hardened off before transplanting. Water the main garden the day before planting and keep them well watered until established.

Prepare your soil for seeds or seedlings by digging it over with a garden fork, then rake it to make a fine seed bed. Can be planted on flat land, lowland or upland if terraced. Cabbage needs a firm soil base to keep their roots anchored because cabbage heads are heavy. You can sow along a single row or along staggered wide rows.

Early varieties require closer spacing of 60cm between the rows and 45cm between the plants while late varieties require wider spacing of 60cm by 60cm. Generally, the wider you space the plants the larger the size of the head that will be obtained.

If possible fertilize your plants when growing especially after transplanting and then add nitrogen when the cabbage is half grown. Best is manure application.

Weed Control, soil and water conservation

Always weed your cabbage vegetable garden as the need arises to control grass and other weeds because cabbage is a shallow rooted crop, and its cultivation is shallow. Cabbages thrive in moist soils so mulching can be a good strategy, also for keeping away weeds.

Pest and Disease Control

Cabbage is a host to several pests that include diamond back month (DBM), aphids and cabbage saw fly. Diseases that attack cabbage include black rot, fungal spots and bacterial soft rot.

For optimum cabbage production knowledge on diseases and pest management by the producer is very crucial. Pests and disease pressure can be managed by scouting and timely intervention. Integrated pest and diseases management method including judicious and timely application of insecticides and fungicides targeting specific pests, only if the pest population is above the maximum economic threshold levels.

Harvest and Post-Harvest

Cabbages are harvested by cutting through the stem; just above ground level with a sharp knife. If you want to get the highest yields, cut the cabbage's head when it is solid (firm to hand pressure), but before it cracks or splits when head are mature. Sudden heavy rains may cause cabbage heads to crack or split wide open.

9. EGG PLANT (*Solanum melongena*)

The fruit is one of economic importance consumed as a vegetable. Eggplant is a high-fiber, low-calorie food that is rich in nutrients viz; vitamins such as B1 and B6 and also rich in minerals, including potassium, copper, manganese, and magnesium. It thus comes with many potential health benefits. From reducing the risk of heart disease to helping with blood sugar control and weight loss, eggplants are a simple and delicious addition to any healthy diet. It is a source of employment for many people giving them income.

Varieties

These differ in appearance and growth. The size, shape, colour, and maturity time will all depend on the variety planted. In Uganda common ones are Early Long Purple and Black Beauty. Others, Lavaya and Florida.

Growth environment

- Almost any soil can be used. They require fertile soils that are well drained.
- Well adapted to lowland tropics.
- Do best in high sunshine.
- Evenly distributed rainfall

Planting

Eggplants grow well in flatland, lowland and even upland gardens if terracing and raised beds are formed to control soil erosion. In lowlands, dig channels to drain or divert excess water. Eggplants grow well in lowlands during the dry season (off season). The site should not have tree shades.

The seed is main planting material used. The seedlings are first raised in a nursery bed before transplanting to field. AEO should discuss the nursery stage with help of grain sack chart. Plant quality seeds for better results. Recommended spacing is 90 x 60cm. For a dwarf crop, 60 x 60cm is satisfactory. The plants can also be ratoons to get fresh re-growth.

Clear the field of bushes and plough once or twice then harrow to get a fine tilth before transplanting is done. Make maximum use organic matter.

Weed control and other management practices

Keep crop free of weeds and early weeding recommended. Close spacing renders crops free of weeds. Mulching is recommended. Manure or fertilizer application will make the crop perform better. Fertilizer helps eggplant production, as they are heavy feeders however avoid high levels of nitrogen fertilizers. For small scale farmers use of manure/compost is recommended.

Pruning is done to remove older leaves and all the lateral branches growing below the first flower cluster. Also remove the first female flower to emerge on plants as it will help the plant become vigorous and set many large fruits later.

Pest and Disease control

Lace bugs, flea beetles, tomato hornworms, mites, aphids, thrips, and cutworms are some of the pests that attack eggplants. Controlled by IPM through keeping weeds and other debris to a minimum and rotate crops every other year or so.

There are several eggplant diseases that affect these crops. Some of the most common include damping off, blossom end rot, brown spot, black rot, eggplant rust, southern stem blight, fusarium wilt, bacterial wilt and verticillium wilt. Many of these eggplant diseases can be

eliminated or prevented by practicing IPM such as crop rotation, reducing weed growth, and providing adequate spacing and uniform watering.

Harvesting and post-harvest handling

- Best harvested when fruits still tender with young seeds and when the skin of the fruit is shiny and un-wrinkled
- Cut fruits with their stalk using knifes and not pulling.
- Fruits can be harvested 16 to 24 weeks after sowing seed and the plants will continue producing fruits that can be harvested for several weeks after the first harvest. If you harvest early the plant will produce more fruits.
- The fruits can be cut and sun dried for future use. Dry is a clean place.

10. TOMATO (*Lycopersicum esculentum*)

Tomato is an annual vegetable crop that grows within two and a half to three months after transplanting, depending on the variety. Tomato production is a great source of income for farmers due to short growth period and high demand. Tomatoes also have a great nutritive value, being rich in vitamins C, A and B.

Varieties

There are many varieties of tomatoes including hybrids and the choice of variety to be planted is based on fruit quality (size, colour, shelf life, juice), adaptability, reliability, growth habit, and susceptibility to diseases and pests.

Some of common varieties in Uganda include - Money maker, Tengeru 97 (Determinate/ bush type), Rio Grande, Roma VF, CAL J and NURU F1 (Indeterminate type). Other varieties are Bonny Best, Marglobe, Amateur Rodade, Heinz, and New fortune maker F1.

The use quality seeds is fundamental requirement for good production as well as following the right agronomic practices.

Growth environment

- Tomatoes grow well on different terrain, including flatland, lowland and upland gardens if terracing and raised beds are used to control soil erosion.
- Light evenly distributed rainfall throughout the growing period. Early stages of growth however require about 40 inch (1000mm) of rainfall.
- Very wet weather and little sunshine encourages excessive vegetative growth at the expense of fruit formation. Also can be prone to diseases.
- Can be grown on a variety of soils but should be well drained and fertile. In lowland areas, dig channels to drain or divert excess water. Tomatoes grow well in lowlands during the dry season (off season).

Land preparation and planting

- Land preparation starts with cutting down trees and bushes. This is done to ease the ploughing process and all other farming activities.
- After clearing the land, plough the field twice and possibly harrow or use hand hoes to beat clogs and make a fine seed bed. Ensure the main garden is prepared a week or more before transplanting the seedlings.
- Is propagated from seeds and seedlings are better raised in raised nursery bed. Ensure to spray seedlings with fungicides if disease pressure is high.
- Seedlings are transplanted after 18 to 30 days. By this time, they should have attained about 15cm in height. It is important that they are hardened for about a week before transplanting to reduce shock.
- Avoid transplanting during hot sun if there are no measures in place to provide water. Best done in morning or evening or on cloudy day.
- Seedlings are usually ready for transplanting 3-4 weeks after sowing, when they are 12-15 cm tall. Transplant on healthy seedlings.
- Spacing depends on variety grown and methods of training (staking or no staking). Dig holes for the transplants at a spacing of 70cm by 50cm (indeterminate varieties) and 100cm by 50cm (determinate/bush varieties).

Agronomic practices

- Keep the crop free of weeds. The first weeding should be done about two weeks after transplanting. Use mulching or dig through the field.

- During weeding, plants may be earthed up to cover the lower 5-10cm of the stem.
- Young seedlings respond to nitrogenous liquid fertilizers applied at planting time and again 6 weeks later. Dressings of potassium sulphate at the rate of 168kg/Ha, split at 3 intervals is also recommended. Alternatively apply manure. It supplies plants with necessary nutrients and improves the water holding capacity of soil, resulting in higher yields. Apply 1 spade full per 1 square meter.
- Tomato plants should be pruned as soon as flowers emerge and continuously thereafter. Prune by pinching off older leaves that are yellowing. For indeterminate plant varieties, remove suckers or tiny branches that sprout where branches meet the plant stem. Pruning influences the flowering and fruiting of tomato plants
- Mulch newly transplanted tomatoes with dry grass or banana leaves.
- Indeterminate tomato varieties should be staked to reduce diseases by supported so plants will grow upward and off the ground.

Pests, diseases and control

Fungal: Fusarium wilt, Sclerotium wilt, Early blight and Late blight. Late blight is most serious at elevations above 1000m.

Bacterial: Bacterial wilt; common in the lowland tropics.

Control:

- Dithane M-45 (50gms or 6 soup spoons per 15 litres CP 15) of a broad-spectrum fungicide that is excellent against Late blight.
- Use Antracol WP (50gms or 6 soup spoons per 15 litres CP 15) to control Early blight.
- For wilt diseases, use resistant varieties (MT series).
- Use clean seeds and practice crop rotation as well as field hygiene.

Insect pests: Leaf miners, bollworm, Flower midge, Cutworms, Caterpillars and Root-knot nematodes.

Control: Use crop rotation and to some extent resistant varieties. Chemical control is also possible.

IPM is the best for control of pests and diseases in tomatoes as it has devastating diseases.

Harvesting and post-harvest handling

- Most tomato varieties are ready for harvest 75 days from transplanting.
- Pick mature fruits that have started turning red. Pick fruits with a stalk on. For distant markets, harvest when mature but greenish and without calyx attached.
- Carry in a wooden box with smooth lining such as wooden crates, cardboard boxes, woven palm baskets or plastic crates.
- Harvesting should be done either in early or late hours of the day to avoid strain from excessive heat. Tomatoes should be stored in cool environments to increase shelf life.
- It is important to handle tomatoes carefully. Rough handling of tomatoes has a drastic effect on the post-harvest quality and shelf life of harvested fruits.
- Clean the harvested produce before taking it to the market.
- Sort the fruits by removing diseased, rotten and damaged fruits from healthy and clean ones.
- Grade the fruit on the basis of colour, size, and stage of maturity or degree of ripening.
- Package the fruit in manageable portions for easy handling. Use containers such as
- Tomatoes can also be solar dried and preserved.

11. Green Pepper

Green pepper is a tender, warm season vegetable. Green pepper has ready market in supermarkets, hotels, restaurants, vegetable markets and even road side stall.

Common Varieties in Uganda

The common varieties on the market include; Ace, Banana supreme, Bell boy, Sweet red cherry, Lilac Bell, and California wonder - this gives the green blocky shaped fruit common to us.

Requirements for growing Green Pepper

Many soil textures are used for green pepper production, the plants do well on organic, rich, well drained sandy soil for best growth. Green pepper like plenty of sunlight and moist, warm soil.

Planting and management of the crop

- Start up your green pepper plants using disease free seeds from trusted input suppliers. These should be able to emerge into seedlings in 6-10 days from sowing.
- Plant the seeds in the nursery bed preferably
- Till up land meant for planting twice if possible and harrow to get a fine seedbed.
- Before planting, incorporate up to two handfuls of well composted manure such as dung chicken maure into each hole 2 cm deep meant for planting pepper transplants. Alternatively incorporate manure in the entire field or plot.
- Transplant seedlings and place them 100 cm between rows, and 40 within the rows.
- Cover the transplants with soil and then water gently.
- Spray the seedlings with a fungicide and pesticide immediately to keep off pests and fungal diseases. A spraying interval of 2 weeks must be adopted up to 3 weeks before harvesting. Green peppers are relatively pest- and disease-free, but fruit flies can be a problem. If the leaves become wrinkled and distorted by aphids, spray with soapy water.
- Weed the field at an interval of at least 2 weeks to prevent competition with weeds.
- Mulching the pepper is another way of minimizing the rate of weed growth.

Harvesting of Green Pepper

Green peppers will start bearing fruit about 11 weeks after transplanting. Pepper fruits require 35-45 days to mature from flowering to full color (green, red, yellow, or orange) depending on temperature and variety. Don’t leave fruit on the plants for too long as this will inhibit flower production. The variety of the pepper plant and the stage of the ripeness determine the flavor and color of each pepper.

To harvest make a cut above the cap of the pepper with a sharp knife, leaving a portion on the stem still attached. Fruits should be firm plump, and smooth skinned for the best flavor and quality.

12. JUTE MALLOW

Jute mallow is an important African Leafy Vegetable with attractive bright green leaves and it is highly nutritious and source of income for farmers. Among the refugees, especially in West Nile, it's one of the highly consumed vegetable locally referred to "*Kundura*" an Arabic word. Jute mallow is rich in iron, calcium, vitamins A, C, E, K, potassium, calcium and magnesium and contains beta carotene. It is said to aid digestion, improve vision, lower stress, increase libido among other health benefits and fight against dry scaly skin. Its leaves and tender stems are eaten boiled, stew, stir-fried, or in soup. It is eaten with starchy foods like ugali. The cooked leaves are mucilaginous thus used as vegetarian spread and dried leaves can be used as a thickener in soups or brewed as tea.

Growth requirement

The optimum temperature is 25°C to 32°C and does not tolerate cold weather. It performs best in areas with 600 – 2000mm rainfall per year and is sensitive to prolonged drought conditions. It prefers well drained rich loam soils though it can grow in a wide range of soils. The optimum pH is 4.5 to 8.2. It does not do well under shade.

Planting

Jute mallow is a small-seeded plant, there-fore, thorough land preparation is required to promote good growth. Plough and harrow the field, then form beds with the distance between furrows of 150 cm.

Jute mallow is planted either by direct seeding or transplanting. Direct seeding is used when seeds are plentiful. Trans-planting is preferable when there is limited supply of seed, plenty of labor, and during the wet season when there is high risk of washing out of seeds due to heavy rains. Planting is done at the beginning of rains when the soil is warm. It can be planted either as a monocrop or intercropped with other crops. The seeds are drilled uniformly 10 to 12 cm apart into furrows or at the rate of 5 to 6 kg of seeds per hectare. At a planting depth of 0.5cm deep is recommended. For largescale planting and in open places, seeds are judiciously broadcast and lightly covered with fine soil by passing a wooden harrow over the surface.

Weeding and thinning

Thorough land preparation is essential, especially when direct-seeding and weeds must not be allowed to crowd or overgrow the young plants. When plants are 20 to 25 cm tall, a wooden plough/stick or cultivator should be passed between the rows to hill-up, which can help to suppress the growth of weeds. Mulching is recommended for controlling weeds, reducing soil erosion and conserving soil moisture as well as weed control measure. Seedlings may be thinned to 1 plant per hill when they have two to three true leaves.

Pest and disease control

The most serious pests are nematodes from the genus Meloidogyne, leaf-eating beetles and caterpillars. If it is dry, eight to ten weeks after planting, yield losses can occur due to leaf bugs and spider mite attacks resulting in terminal shoot wilt. Jute mallow is also susceptible to attacks by weevil species and yellow mites. Damage by nematodes can be minimized by crop rotation.

Diseases (bacterial and virus infections) are not as serious as pests. Seedling damp-off occurs but can be reduced by good drainage and cultivation in humus-rich soils with adequate water holding capacity.

Harvesting and Post-Harvest Management

The jute mallow plants grow quickly and are ready for the first cutting in about 30 – 60 days after planting depending on varieties. Harvest by cutting the upper 6-8 inches of growth. The

tender stems from this region are also edible if finely cut up along with the leaves. Repeated cutting can be made from each flush of new growth for 3 to 4 seasons. Alternatively, you can sow seeds in succession and harvest the entire young plant at once. The leaves may be dried and stored for later use. Preservation is done by sun-drying. The leaves may be dried and stored for up to one month though this practice greatly reduces the nutritive value and changes the texture.

13. Nakati (Solanum aethiopicum)

Nakati is known by the same name across the country but it has different pronunciation in Luganda, Luo and in Ateso. The nakati leaves or plants are usually picked when green and eaten as a vegetable. It's a highly nutritive and very adaptable to wide range of soils.

Variety selection
Use quality seeds of a recommended variety. Quality seeds are a fundamental requirement for good production. Home processed seed can also be of good quality if it is well processed and stored. Using quality seeds ensures: Lower seeding rate, Higher seedling emergence, usually above 85%, Vigorous seedlings, More uniform plant stand, Faster growth rate, Better resistance to pests and diseases, Uniformity in maturity and the plant is more tolerant to drought.

Growth requirement
It grows well on flatland, lowland and upland if terracing and raising of beds is practiced. In lowlands, dig channels to drain or divert excessive water. Nakati grows well in lowlands during the dry season (off season). Fertile loam soil is the best soil for growing if not apply manure and the site should not have tree shades as some trees have pests and diseases. It thrives well under adequate water throughout its growing cycle. A pH 5.5 to 6.8 is recommended.

Land preparation
Land preparation starts with clearing or cutting of all the tall grasses, removing trees including stumps, cutting down bushes, and removing stones and other obstacles from the field. This is done to ease the ploughing processes and all other farming activities. Do not burn the bushes because burning exposes the soil to erosion and also reduces soil fertility due to loss of nutrients. After clearing the land, plough the field for the first time and ensure that the soil has very small debris. A second ploughing is followed by harrowing until the soil makes fine tilth.

Planting
Plant at onset of rains but farmers who have the capacity to irrigate can grow nakati year-round. Nakati is planted in rows at a spacing ranging from 10cm to 20cm between rows and 5cm to 10cm from plant to plant. The planting depth is no more than 2 cm.
Planting in lines ensures the crop is well spaced whilst it also becomes easier to weed and manage the crop. In addition, the recommended plant population is attained and the farmer will plant adequate seed (not too much or too little) for the given area. The seeds of Nakati are very small and the farmer risks pouring too many seeds in the same spot during planting. This can result in crowding of plants which will reduce the yields. To avoid this, the farmer can use the following method:

- Take 2kgs of nakati seeds and 8kgs of well decomposed and dry soil/manure to plant 1 acre. Fresh manure will destroy the seed so only use well decomposed dry manure mixed with soil, as this will not destroy the seeds.
- Mix the seeds with the soil/manure in a big basin and put the mixture in a large mineral water bottle and make a hole in the bottle top for pouring the mixture in minute quantities.
- Nakati should not be replanted in the same plot the next season but can be rotated with other crops e.g. Amaranthus or Maize

Weeding and thinning
Weed once or twice to increase the yield. Timely weeding minimizes competition for food and light between weeds and nakati. It will give nakati better conditions to grow. Weeding also reduces pest and disease infestation at the early stages which will lead to increased yields. Weeding should be done as soon as weeds emerge and before the flowering of weeds.

Thinning is done at the time of weeding. During thinning the less vigorous, off-types or relatives and diseased plants are removed. The good quality thinned plants can be sold or consumed at home. Rouging of off-types should be done at flowering and at fruiting (early maturity) when it's easy to identify the off-types. Mulching is recommended for controlling weeds, reducing soil erosion and conserving soil moisture as well as weed control measure.

Pest and disease management

Leaf defoliators, aphids, whiteflies and scale insects are some of the common pests that attack Nakati while powdery mildew is a common disease which is fungal. Pest and disease management should be a continuous effort by the farmer to ensure early intervention in case of an outbreak. Both organic and inorganic pesticides can be used to control pests and diseases. Pre harvest spray intervals not less than 10 days should be observed.

Note: The farmer should monitor the field to ensure quick action is taken in case of break out of pests and diseases. The farmer must also mulch.

Post-Harvest Handling

Nakati is ready for harvesting starting from 45 days after germination. The crop can be harvested in two ways:

- Uprooting (Week 10-11): This is mostly done in commercial production by uprooting the whole plant.
- Cutting tender stems (Week 12-16): This is commonly done in kitchen gardens for home consumption. The tender stems are cut every 1-2 weeks until the plant flowers.

No long term storage of fresh vegetables is possible however the dried form can be stored for long.

14. Entula – African Eggplant *(Solanum gilo)*

African eggplant is known by different names across the country: in Luganda Entula, in Acholi Tula and in Ateso Entula. African eggplants range in shapes, sizes and colour. The African eggplant fruit is usually picked and eaten as a vegetable.

Variety selection
Use quality seeds of a recommended variety. Quality seeds are a fundamental requirement for good production. Home processed seed can also be of good quality if it is well processed and stored. Quality seeds has numerous advantages. AEO can discuss some of them with the farmers.

Growth requirement
Entula requires free draining sandy loams rich in organic matter. A pH 5.5 to 6.8 is recommended. Entula thrives well under adequate water throughout its growing cycle.
It can grow well on flatland, lowland and upland. In lowlands, dig channels to drain or divert excessive water. Can be grown on lowlands during the dry season (off season).

Land preparation
Land preparation starts with clearing or cutting of all the tall grasses, removing trees including stumps, cutting down bushes, and removing stones and other obstacles from the field. This is done to ease the ploughing processes and all other farming activities. Do not burn the bushes because burning exposes the soil to erosion and also reduces soil fertility due to loss of nutrients. After clearing the land, plough the field for the first time and ensure that the soil has very small debris. A second ploughing is followed by harrowing until the soil makes fine tilth.

African eggplants grow best when propagated in a nursery bed and then transplanted into the main garden. To establish an African eggplant nursery bed, ensure the following: select a site for the nursery bed, ensure that it is not near drainage channels, not on a slope and near a clean source of water. The nursery bed should be raised at least 20cm from the ground. Recommended width is 1 metre by any convenient length. Loosen the soil for easy penetration of roots. Add well decomposed manure to the soil before sowing the seeds. Make drills 15cm apart and 2cm deep. Sow the seed and cover with a thin layer of soil. Apply mulch and water through the mulch. Continue watering to keep the soil moist and it is preferable to water in the evening. Seeds will germinate 10-14 days after sowing. Remove mulch from the seedlings and put it between rows. Set up a shade over the nursery bed and the shade should be 1m high. Ensure that the nursery bed is facing away from the sun. The shade roof should be made out of light materials to allow sunshine to reach the seedlings. Seedlings are ready for transplanting 1-1.5 months after germination.

Transplanting
Dig a hole of 2ft wide and 2ft deep. Fill each hole almost completely with manure using a spade or plate. Make a 2cm deep hole in the middle of the manure for the seedling. Cover the plant with the same mixture. When transplanting make sure that the roots of the plants do not break or get damaged when you pick these out from the nursery bed. Use a hand fork to gently pick out the seedlings from the nursery bed and transplant in the evening to avoid the seedlings getting too much sun and heat. If the main garden is far from the nursery bed, use a basin with water to transfer seedlings from the nursery bed to the garden. Keep the garden free from weeds to avoid competition for nutrients. Spacing should be 1m x 1m. If possible, the farmer must can mulch.

Weeding and GAP practices

Timely weeding the crop. It will give African eggplants better conditions to grow. Weeding also reduces pest and disease infestation at the early stages which will again lead to increased yields. Weeding should be done as soon as weeds emerge and before the flowering of weeds. Entula should not be replanted in the same plot the next season but can be rotated with other crops e.g. Doodo, Sweet potato

Pest and disease control

Leaf defoliators, aphids, whiteflies and scale insects are the most common pests. Fungal diseases: powdery mildews and leaf spots. Bacterial wilt is a serious challenge with some landraces. Pest and disease management should be a continuous effort. Both organic and inorganic pesticides can be used to control pests and diseases. Pre-harvest spray intervals not less than 10 days should be observed. It is recommended to always seek advice from an agriculture extension worker on pest and disease identification and management.

Post-Harvest Handling

African eggplants are usually ready to be harvested within 60 - 90 days from transplanting. Depending on the market/consumption demand, harvesting can be done 1-2 times a week and can continue for 6 months where good agricultural practices are followed. The African eggplants should be eaten within one week of harvesting by keeping under cool conditions. It can also be processed into powder and powder should be kept in a clean and airtight container. The powder can be added to beans, groundnuts, beef stews to make them more nutritious.

15. PIGEON PEA AS FENCE

Pigeon peas can be used in a number of way in homestead gardens:

- ***Hedge crops or windbreakers***. In such situations, the crop is planted in a row about one to two feet apart – giving the hedge a regular "cut" yields mulch for nearby plants. At harvest time, the crop yields a lot of pigeon peas;

- ***Fence plants around young fruit trees***. The pigeon peas are routinely trimmed to make sure they are never higher than the young fruit trees. In this way, they provide shelter for the fruit trees, but they do not shade them. The trimmings are then used as mulch for the fruit trees. As the fruit trees become older and taller, trimming is no longer necessary. The pigeon peas will continue growing, self-seeding, dying and feeding the trees with nitrogen and organic matter.

- **Cover Crops:** These are best applied during the wet season where torrential rains tend to wash away soils and nutrients. The pigeon pea offers anchorage to the soil (soil erosion control) and tie-up nutrients – which are eventually realized as organic matter. In such a case, the pigeon pea seeds are planted in the unused space in the garden as an intercrop. When the rains are over, the pigeon peas are cut and used as mulch or on the compost. The roots stay in the ground and release nitrogen.

- ***Living trellis:*** Pigeon peas may be used as living trellis to support creeping plants such as tomatoes. The pigeon pea crop is pruned back toward the ground to allow young tomato plants to receive sufficient sunshine and also have supports on which to climb and grow. This allows tomatoes to grow above ground and improve yields.

- ***Other Uses of Pigeon Peas***

Dried pigeon pea stalks are used as firewood, with a heating value of 3700 kcals/ kilogramme. The bushes serve as barriers along field borders preventing soil erosion and animals from destroying crops.

The elderly also weave baskets with the stalks to get extra income. After being soaked in water for a day, the stalks become pliable and can be made into baskets for vegetable sellers, construction workers and gardeners.

Pigeon pea stalks are also used to build fences and as thatch for houses. Nothing goes to waste as livestock are fed with the leaves, pod shells and broken seeds.

16. CITRUS (Citrus spp.)

Introduction
It is a crop of economic importance and also a valuable source of vitamin C. It can be made into juices, concentrates, marmalade, jams, etc. The fruits are highly marketable and are a good source of income for households, especially in urban areas.

Varieties
Varieties depend on characteristics such as size, colour, flavour, seed quantity, taste and juice content of the fruits. Types of citrus are; Sweet Orange, Lime, Lemon, Mandarin, Tangerine and Grapefruit. In NURI, the focus is sweet oranges. The varieties of sweet orange include Washington Navel, Valencia, and Hamlin. There are other new varieties. Washington navel is suitable for direct eating as a table fruit, fruit is seedless and matures early. Valencia has a lot of juice thus suitable for juice extraction, matures late in the season and the fruit has a rough skin. Hamlin on the other hand, has good juice extraction properties, fruit small fruit with a smooth and shiny skin.

Growth environment
- Tolerates high temperatures. Below 12°C tree growth is reduced.
- For good production oranges require well distributed rainfall or supplementary irrigation throughout the year. In Uganda, it is mainly grown under rain fed conditions. To encourage fruit development during the dry season, irrigation is recommended.
- Grows in wide range of soils but should be deep loams with good fertility and well drained.

Land preparation and planting
- Choose the location for citrus trees carefully since they are perennial thus not easy to relocate.
- Seeds, Grafted and T-budded seedlings are used. Budded or grafted seedlings take about 2 years to flowering after transplanting. Seedlings raised from seed will take 8 years and above. Full productivity is reached in about 10 years.
- Medium fine field is needed. Clear all perennial grasses. Dig holes about 60cm deep x 60cm wide separating top soil from sub soil. Fill holes with top soil, decomposed manure and 1/2kg of SSP. Plant seedlings at onset of rains at a spacing of 6m x 6m.
- For large canopy varieties such as Valencia, plant 8m x 8m. Also high density planting at 3m x 3m can be done to maximize returns on first harvest and later they thinned.
- Remove the polythene sleeves and place seedlings in the centre of the dug holes. Cover with top soil first and firm the soil around the seedling leaving a basin like depression to trap water for the seedling.
- When planting ensure that the graft joint/budded areas are kept well above the ground to avoid infection. A stake is planted alongside to support the buddling.

Agronomic practices
- A cover crop of beans or groundnuts may be planted during the first 3 years until the tree canopies have closed in. After the trees are fully grown leave it as a mono-crop. Avoid planting the cover crop very close to the orange stalk.
- Before planting, soil can be amended with compost to improve the texture, nutrient content and aeration of the soil. Then farmyard manure should be added at a rate of 2 Debes per tree per year.
- 750gm of Muriate of potash applied per tree per year increases fruit sweetness. Nitrogen and Potash should be split into 2 - 3 doses.

- As weeds compete with young oranges, you can ring weed then slash the orchard. Do not dig deep near the plants as this will damage roots and cause root rot diseases. For mature orchard, you can also use herbicides.
- Dig trenches in the field to retain water depending on the slope of the land. Alternatively explore other water harvesting techniques. Simple irrigation such as use of bottles or polybags can be applied for the case of seedlings or use of kitchen water poured as this can improve survival rates and good growth.
- Where plenty of mulching materials are available, mulching is encouraged.
- Any shoots, which grow below the point of union should also be removed.
- Selective and timely pruning of orange tree branches results in higher yields of fruits. Growing seedlings require air and sunshine. Abundant sunshine reduces insect pests and diseases and encourages good quality fruit growth. It is advisable to prune and manage the tree to about 3-4m in height. Trees should not be left to grow higher than 5-6 metres. This makes harvesting and pest and disease control difficult.
- For the 1 to 3 years, intercrop the garden with low growing and carpeting crops like beans, groundnuts, cowpeas, and soybeans. These are all suitable crops that can add nitrogen to the soil. When intercropping, keep a distance of 0.5 meter from the tree stands. When the trees have grown, it may not be easy to intercrop unless the crops like shade.

Pests, diseases and their control

Diseases
Viral: **Tristeza Disease (Quick decline):** *control:* Use indexed healthy planting material.
Fungal: **Citrus Scab:** *Control:* Spray with Copper fungicide.
Green mould: *Control:* Avoid damaging of the fruit.
Leafspot: *Control:* Spray once every two weeks with copper fungicide alternated with Benlate or Bavistin in case of heavy infection.

Pests:
Leaf miner: Very serious pest of oranges right from the nursery to the field which causes curling of the leaves. Bulldock alternated with Folimat can control leaf miners effectively.
Citrus Aphid: controlled by spraying with Fenitrothion, Ambush, Dursban, Rogor (Dimethoate)
Citrus psyllid: Controlled by spraying with Sumithion or Rogor
Orange dog: Controlled remove and kill the caterpillars. Where infestation is high, spray using dimethoate.
Woolly whiteflies: Controlled by use of biological control agent, Cales noacki from NBCU Namulonge. In this case apply insecticides by drenching to avoid killing the parasitoids.

Harvesting and PHH
Orange fruits stay on the tree for 6-9 months depending on the variety and climatic conditions. Maturity indicator is color changing to slightly yellowish or the taste. Harvest mature fruits. Harvest citrus fruits by clipping with a sharp tool like secateur or hand picking for short trees. For tall trees use a long stick with knife and basket at the tip or climb with ladder. This is to prevent damage when they fall on the ground. Collect fruits in a wooden box with smooth inner surface. Avoid picking fruits from the ground. The average yield in Uganda is 4 - 5 tons/acre/year. With good management one can get 16 tons/acre/year. One tree can produce 2 sacks (90-130kg)/tree per season.

17. MANGO (*Mangifera indica*)

Mango is one of the most important fruit crops in the tropical and subtropical lowlands. Economically mangoes are consumed as fresh fruits, a source of income, a source of foreign exchange, and a source of employment while trees help to conserve the environment.

Varieties

Three types of mangoes:

- Small canopy, early maturing and heavy yielding varieties: Florigon, Glenn, Dancan, Early Gold, Erwin, Palmar, Palvin.
- Medium canopy and fairly early yielding varieties: Zillate, Pinero, Alfonso, Kent, Keit.
- Large canopy and fairly early yielding varieties: Boribo, Ssejjembe, Bire, Tommy Artkins.

Most of these are tolerant to anthracnose and powdery mildew and they have export market.

Growth Environment

- It requires a dry period of at least 3 to 4 months and sufficient light to induce flowering.
- It requires atleast 600mm of rainfall per year or more. Once the trees are established, they can tolerate drought except during flowering and fruit setting. Sufficient water is needed after transplanting, at flowering and at fruit setting. In dry weather, fruits fall off and this calls for irrigation during very dry periods.
- Mangoes can be grown successfully in a wide range of soils, but a healthy, high-yielding plantation is only possible on fertile, deep and well-drained soils.
- Some trees bear 2 times a year depending on the weather conditions. Most varieties show biennial tendencies in production and a poor harvest may follow a good one.

Land preparation and planting

- Mango trees raised from seeds take about 10 years to reach maturity while those grafted take about 3 - 4 years. Use improved quality seedlings for better results.
- Medium fine field is adequate.
- Dig holes at least 60cm deep and 60cm wide, while keeping topsoil separate from red soil.
- Fill the hole with decomposed manure mixed with topsoil at 1:1 ration.
- Make a small hole with in the middle and plant in the grafted seedling.
- Remove the polythene pot before planting. When covering the hole, a basin should be made around each plant for harvesting water. Each plant should be mulched around and a cage or perimeter fencing put in place to avoid damage by animals. One month after transplanting, the grafting tape should be removed. Any shoots, which grow below the point of union should also be removed.
- When planting is done during low rainfall season, the young plants should be watered at least once a week to avoid drying. You can use bottles or polybags to irrigate.
- Spacing varies a lot depending on the soil fertility, varieties and management practices. Distance between plants ranges between (10-12m) for heavy rain areas and giant varieties. For medium canopy plants space trees at 5m x 5m and for short small canopy grafted varieties use an intensive high plant density at a spacing of 3m x 3m.

Agronomic practices

- Apply manure once a year at the beginning of the rainy season. Put at least 2 tins (Ddebes) per tree, applied around one meter from the tree. For artificial fertilizers, put about 1 plastic tumpeco around the tree. Avoid putting too much nitrogen fertilizers to your mango plants during the productive stage. Smoking in the field and cutting the bark of the tree encourages flowering.
- Slash the orchard regularly. Do not dig through as this will damage roots.
- Where mulching materials are available, mulching is encouraged.

- Pruning should be done to control the height of the trees, remove shoots below graft union, dead branches, cut off branches too near the ground. This should be done every year.
- Intercropping: Since mango trees grow slowly, so you can intercrop with short crops e.g. beans legume crops, vegetables, or cereals or other fruit crops such as papaya and pineapples. Mango trees can also be planted as border trees to improve diversification on the farm, it can protect the soil and other crops against wind and it can enhance the income of the farmer. Mango trees in agroforestry systems can include crops such as bananas, papayas, cocoa, etc or in silvi-pastoral systems.
- Pegging heavy branches: With some mango varieties, the tree branch may become so heavy with mango fruits that it eventually breaks if not supported.

Insect pests, Diseases and their control

Mango can be attacked by many diseases which reduce quality and yield. The major diseases of economic importance in Uganda are: anthracnose and powdery mildew.

- Anthracnose: The disease attacks young shoots, flowers and fruits causing leaf spots, drying twig tips and dark spots on fruits. Black spots develop on fruits, which leads to cracking. Remove rotting fruits from the orchard. Where the disease is severe, apply fungicides before flowers set to reduce flower infection. Fungicide such as Ridomil and Antracol alternated at 10-15 day intervals at quantities indicated on the package are recommended. Control and prevention is best through IPM.
- Powdery mildew: The disease appears as white powdery fungal growth on leaves, stalks and flowers. Rain and cool nights are favourable conditions for disease spread. Young leaves when infected develop white patches and later become curled and distorted. The fungus persists on older leaves and when conditions are favourable spores are blown onto susceptible tissue. Control Ridomil, Antracol or Thiovit sprays alternated with Dithane M45 at 10-15 day intervals. Once young tissue has hardened it is no longer susceptible and spraying can be stopped.

The major pests attacking mangoes include: fruitfly and mango seed weevil. Minor ones are scales and mealy bugs.

- Fruit fly: This is one of the most serious pest of mango in the country affecting the marketing of fresh fruits. The female punctures the maturing fruits and lays eggs in small clusters inside the fruit. After hatching, the larvae feed on the fruit that appears normal from outside. The maggots later fall on the ground for further growth. When infested fruits are cut open, maggots of the fruit fly are seen in the damaged flesh. Controlled by collection and burying of infested and dropped fruits, use pheromones, spraying with suitable insecticide e.g. Dimethoate, 7 weeks and 3 weeks before picking. Salut and Dursban can also be used.
- Mango seed weevil: This is a serious pest of mangoes in the tropics. The female lays eggs on partially developed fruits. The eggs hatch and the maggots bore through the flesh into the seed where they feed and develop damaging the seed. There is a discoloration at the point of entry. Controlled by removing the fallen fruits and burying them in a pit. Spraying the trees, especially the stems, with a suitable insecticide e.g Dimethoate or Dursban.

Harvest and Post Harvest Handling

- Depending on cultivars and environmental conditions it takes 90 to 160 days after flowering to reach maturity. Not all fruits on the tree will ripen at the same time.
- The fruits are generally picked when they begin to change colour, first in a small area or the change will cover most of the fruit's surface. You can also examine the colour of the flesh around the seed. When this begins to change from green-white to yellow or orange, it indicates that the fruit is beginning to ripen and may therefore be picked. Also the greater the swelling of the shoulders above the stalk attachment, the riper the fruit is likely to be.

- Harvest mature fruits with smooth and undamaged skin by hand for short trees. Use a long stick with knife and basket at the tip or climbing with ladders.
- Clip them off with a long stalk of about 2 to 3 cm and pack the fruit in a single layer with the stalks facing downwards in the box or crate.
- Yield ranges from 10 to 15 tons per hectare per season.

18. PASSION FRUIT *(Passiflora spp.)*

Introduction

Passion fruit is widely grown and valued throughout the tropics and subtropics. The different varieties have fruit which range in colour, taste, size and shape. The sweeter species eaten as fresh fruit, are the type exported for the fresh market. The seeds are consumed with the pulp. The fruit rich in Vitamins A and C is also made into juice and it is a relatively profitable crop to grow if given sufficient management. Can grow in small areas like the backyard of one's home.

Varieties

- ***Yellow Variety:*** Has a vigorous vine, larger fruit, acidic taste and brown seeds. Average weight and diameter is 56 gm and 5 cm respectively. Good to be used as rootstock.
- ***Local Purple types e.g. Kasese, Mbale:*** Less acidic, richer flavour, and aroma, higher proportion of juice, and has black seeds. Is small sized. Good for the export market.
- ***Kawanda Hybrid:*** a cross between yellow and purple. Big sized fruits, has acidic taste, and same aroma like the purple variety. Good for the export market.

Growth environment

- The purple variety is sub-tropical and can be grown in cooler areas and highlands. Yellow is tropical and is grown in warmer areas / lowland areas.
- Deep and well drained soils are preferred to avoid collar rot incidences, with soils that are high in nutrient content and organic matter.
- Kawanda Hybrid is suitable for both low and highland areas, is more adapted to wide ranges of rainfall and grows on a variety of soils.
- Rainfall should be atleast 900mm but producing areas range between 400 – 2500mm.
- Water availability encourages constant flowering thus in dry periods, irrigation is required.
- Very heavy, poorly drained soils should be avoided.
- Requires full sun – six or more hours of sunlight per day.

Land preparation and planting

- Propagated by seed for the local yellow and purple, or cuttings and grafts for the hybrid. Seeds are removed from the fruit, washed of mucellage, dried a little and planted immediately. Grafting uses the yellow passion fruit as rootstock, which is resistant to nematode and soil borne diseases.
- Clear land of trees and perennial grasses like couch by spraying with herbicide if possible, then plough and level. Incorporate plant materials or compost at this stage.
- For the local purple varieties, spacing should be of 2m x 3m. The yellow variety and Kawanda Hybrid are more vigorous and need 3m x 3m.
- The hole, should be well fertilized and dug at least 2 - 3 months earlier. After the hole is dug, a farmer should put back the top (black) soil and mix it with compost or manure such as poultry litter, cow dung etc.
- Planting: Seedlings should be around 150 mm in length at transplanting and must be hardened off properly by leaving in an open, shaded area for a day or two. Planting should be done at the start of or during the rainy season, otherwise watering is to be done. If the seedling/rooted cuttings are enclosed in polyethylene sleeves, these should be removed. The seedling is planted and the soil firmed around it and the hole is filled up just to leave a shallow basin around it.
- Staking should be provided at the time of filling the hole and planting the plants, which would be firm to give a support to the growing vine.

Agronomic practices

- Apply 1-2 tins or debes of organic manure mixed with 0.5 kg SSP per hole at planting.

- 0.5kg NPK 20:5:5 can be added in split applications in first year. Later, 1.5kg may be applied per plant per year in 2 splits. However, too much nitrogen fertilizers encourage excessive vegetative growth and collar rotting. To further boost their growth, a mixture of NPK and CAN fertilizers can be used at a stage when they are climbing and developing more branches. One can also use foliar fertilizer as well to boost flowers and fruits.
- Hand weed when plants are young but later can slash through the orchard, keeping the area around the stem weed free.
- Trellises are important to hold the vine upright for adequate light inception. Vertical Fence posts 10ft long 4" – 6" diameter are fixed in holes dug to 2ft depth and spaced 20ft (6m) apart. Two lines of wire with one at the top and another at around 1.2 m, of atleast No. 10 gauge, is strained over the fence posts to support for the creeping vine. Alternatively, detached short dry tree branches can be used for the local purple variety.
- Young vines are trained by tying a piece of sisal twine from the base of the young plant up to the first wire. The growing shoot is then trained upwards by twisting it around the twine. Once it reaches the wire, a lateral shoot is allowed to grow along the wire in each direction. A 2-wire trellis provides 4 laterals growing along the trellis away from the vine's trunk. Every other bud on these laterals is then allowed to grow down and it is these shoots which bear the fruit. The tips of these shoots should be kept cut back at least 10 cm from the soil.
- Pruning: Since the passion vines are vigorous growers, pruning is necessary to keep the plants to a desirable size, to improve aeration in the canopy, and to remove dead wood. Unwanted side shoots should be pruned and tendrils can be removed to prevent tangling. Vines should be pruned hard once a year after harvesting.
- Intercropping is a good idea not to waste the large spaces left in between the passion fruit rows. Annual crops such as egg plants, green pepper, onions, carrots and other short term vegetables can be inter planted with passion fruit in the first year when the fruit is just getting established. Crops such as maize, bananas, sugar cane etc which tend to drain the plant nutrients from the soil heavily shouldn't be planted.
- Irrigation: Regular watering will keep a vine flowering and fruiting almost continuously. However, careful attention must be paid to watering since over-watering can encourage diseases such as collar rot and under watering can leave the shallow roots too dry and produce shrivelled fruit. Bottle and polybag irrigation systems can be used.
- Mulch can be applied to cover the ground surrounding passion fruits plants and help conserve moisture content in the soil. Mulch can help young plants continuously grow and older plants increase productivity. Leave a small margin around the plants.

Pests, diseases and control

Woodiness Virus Disease: *Control:* Plant healthy seed and rogue infected plants immediately.

Fusarium Wilt & Collar rot: *Control:* chemically control with copper fungicides, also by grafting Purple and Kawanda onto resistant Yellow or Calabash (hard shell) rootstock.

Termites, mealybug, scales, thrips, aphids: *Control:* Spray with pesticides (Sumithion, Dimethoate, at 30mls or 6 tea spoons per 15 litres of water).

Nematodes: *Control:* Plant resistant variety (Yellow), use nematicide.

Leafspots: *Control:* Spray with Dithane M45, Antracol or a copper fungicide.

Anthracnose: *Control:* Spray with Dithane M45 (50gms per 15 litres of water).

IPM is the best way to manage pests and diseases of passion fruits.

Harvesting and PHH

Grafted passion fruits take 4 months to flowering and they usually take 90 days after flowering to mature. The useful plant - life may be up to 5 years for the Kawanda Hybrid. But because of pest problems, economic production lasts for about 3 years.

Passion fruits are normally hand harvested from vines two or three times per week when colour changes from green to purple colour or yellow, skin begins to wrinkle, or stalk begins to

dry, or from the ground once they are ripe, on a daily basis. For juice processing the fruit is allowed to attain a deep purple or yellow colour before harvesting. Carry them in a box or basket with smooth lining. Maintain a grass mat under the wire so the falling fruits don't get bruised. The fruits may be graded. Yield Range from 2 to 30 tons per hectare.

19. PAWPAW (*Carica papaya*)

Introduction

Pawpaw is a fast growing tree-like herb that reaches 3 to 10 meters tall. Ripe pawpaw is eaten fresh as breakfast and dessert fruit rich in carbohydrates, proteins and vitamins. It is made into fruit salad or juice and can be processed as jelly, marmalade, candies and crystallized fruits. Green fruits are pickled or cooked as vegetable. **PAPAIN** extracted from green mature fruits has industrial uses (for Beer industry, as meat tenderizer, for certain drug preparations, silk degumming, and softening wool). Seeds may be used to expel intestinal worms. Can be a source of income if grown on large scale.

Variety selection

- ***Local big varieties.***
- ***Small varieties*** are recommended for export - Sunrise Solo, Sunset Solo, Kapoho, Kawanda 1 (with red flesh).

Growth environment

- Requires warm climate - good air flow and plenty of sunlight.
- They need adequate moisture and even distribution of rainfall throughout the year.
- Irrigation helps the plants and fruits to develop faster and better.
- Grows best in well drained and deep soils rich in plant nutrient.
- Should be protected from strong winds

Planting

- Pawpaw is propagated by seeds or seedlings already raised. If from seeds, wash them to remove the gelatinous covering as this can inhibit germination and then dry them in the sun or under shade. The seeds must be from healthy ripe fruits of the variety required.
- Plant 2 – 3 seeds in the middle of polythene bags filled with loam soil mixed with manure or in the raised nursery bed.
- Afterwards place the bags containing the seeds under a shed, made from poles, banana leaves or grass. Similar for seeds planted on raised beds. This place should be raised to avoid running water from washing away the seeds.
- Water the nursery bed every day. One month after the seedlings have germinated, spray them with Vegimax, which is a fertiliser to make them grow healthy. Also spray them with Dudu cyper to kill insects that attack the leaves.
- Two months later (about 20 cm tall), transplant to the main garden. Harden them 2 weeks to transplanting.
- Plough the field twice, make holes 25 cm deep and 30 cm wide based on the contours and wind direction. Apply some compost manure. Because seedlings need a lot of water after they are transplanted to grow well, it is better to ensure that transplanting coincides with a rainy season.
- Plant at a spacing of 3 x 3m. Proper spacing is important because if they are not well spaced, they will just grow tall and fruiting will be poor. Carefully remove seedlings from their potting materials and place them in the holes. Avoid bending or damaging the roots.

Agronomic practices

- Keep orchard free of weeds by weeding and slashing. Weeding is most important during the establishment stage of pawpaws. Carefully keep base of the plant free of weeds. If left, weeds compete with pawpaw trees for soil nutrients and water and habour pests and diseases.
- To keep the plot free of weeds during the first year of planting, short duration crops and vegetables can be grown as inter-crops. The following crops are recommended for intercropping with pawpaws: beans, maize, groundnuts, cowpea and onion. Once plants grow tall, they will create shade and it becomes difficult to grow inter crops.

- Mulching the garden using banana leaves or grass is recommended. Mulching is a necessity for water conservation. This is vital for young plants to continuously grow, and for older plants to increase productivity.
- The best fertilizer is the organic compost mixed with the soil during land preparation. This should be augmented with chemical fertilizers high in potash and contain trace mineral elements such as Boron.
- Until the seedlings start to bloom months after germination, there is no reliable way to tell them apart. Retain one female or one hermaphrodite plant per hill by thinning out extra plants at flowering stage. In the absence of hermaphrodite plants, one male plant per 25-100 female plants is retained as pollinator.
- Remove side growths along the leaf axles that occur during the early stages of plant growth. These compete with main plant for nutrients and may harbor pests and diseases.
- Remove all dropped fruits as they harbour pests.
- Strong winds can damage pawpaw plants since they have a shallow root system. If possible plant wind breaks or leave some trees in the field.
- Water the pawpaw plants regularly especially when the climate is hot or dry to prevent growth retardation, flower abortion and dropping of young fruits.
- Prop only leaning plants. Observe what direction the plant is leaning to. This is where you place your poles keeping in mind to contract gravitational force.

Insect Pests and diseases

Diseases:

Papaya mosaic virus (PMV) causing stunting, mottling and distortion of leaves. Others are; Bunchy-top virus, collar rot, anthracnose, powdery mildew, phytophthora blight and another viral disease called papaya ringspot.

Control:

Apply Benlate or Dithane M4S to control fungal diseases. Use healthy plant material to avoid viral diseases. To reduce fruit rot and fungal problems, pick the fruit early and they ripen indoors. IPM is the best control method for the diseases of pawpaws.

***Insect pests**:* Common pest is the mite. Keep an eye out for aphids

Control: Spray with Sumithion, Rogor or Dimecron, especially during the dry season.

Get rid of fruit fly by hanging fruit fly Traps around the trees.

Other pests are: papaya whitefly, leafhoppers and papaya web worm. Pawpaws can also be affected by large pests, such as birds and bats, which like to feed on fruits near the time of harvesting. IPM is the best control method.

Harvesting and yields

- The Pawpaws fruit 9-18 months after planting under good management and climate. The appearance of yellow color traces on the green fruit is an indication of maturity and ready for harvest. Different varieties of pawpaw range in colour from yellow to orange or red when ripe, but they all are green before ripening.
- A good strategy is to harvest the fruit just before it ripens so pick it when it's about one-third golden in colour and allow it to finish ripening indoors. Fruits that are near full maturity are difficult to transport and will spoil quickly and not good for the market.
- Hold on the fruit, twist until it snaps or cut peduncle with a shape knife. Handle the fruit carefully to avoid bruising and unnecessary cuts. Never drop fruits to the ground. On tall trees, use ladder to reach and pick the fruits by hand.
- Collect fruits in a wooden box with smooth inner surface.
- In the good climate, fruits will grow all year round and healthy trees can produce up to 30kg of fruit each growing season. Yields of 10 tons per hectare (5 tons per acre) per season are realised.

ANNEXES

ANNEX 1. Register of Farmers Groups per AEO

Year…… **Settlement ……** **Date……**

Zone…… **Block/Village ……** **Name of AEO……**

SN.	Name of farmer group	Chairperson	Contact (phone no.)	Enterprises	Membership			
					F	M	T	Youth
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
	TOTAL							

Annex 2. Register of Farmer Group Members

Settlement..... Zone..... Block.....

Name of group.....

Name of Group Leader .....Contact.....

Membership: Male..... Female..... Total.....

SN.	Name of farmer (Start with surname)	Age	Sex		Attestation card
			F	M	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					

Number farmers with plots should be noted here as well those with extra land outside their plots.

ANNEX 3. Report Format for Each Training Session

Report from training of farmer groups				**NURI**		
District		Group		Attendance		
Zone		Date		M	F	Total
Block		Session No.				

Demonstration plot or backyard plot status	**Crop**		**Planting date**	
ACTIVITIES (since last session)				
CONDITION (stage, weed, diseases, pests etc)				

Training (this session)	
Subjects covered	
Discussion and decision taken	
Other issues	
(eg. Attendance, motivation, group conflicts)	

Administration			
AEO Name		Next session	
AES Comments			