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Northern Uganda Resilience Initiative (NURI)

Climate Smart Agriculture (CSA) Training Manual 2020

Mixed Groups

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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
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 – General Introduction

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 Mixed farmer Groups of refugees and nationals in NURI, located in selected 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 guidance on Climate Smart Agriculture (CSA) and associated technologies and Section 4 offers information on the crops and related enterprises that will be involved in this programme.

This manual shall be used together with the grain sack charts and crop specific trainers' guides provided 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 and National Members of Mixed Farmer Groups

The female/male refugees, as well as the nationals and youth who are members of Mixed farmer groups shall participate actively in all group activities. The nationals shall identify land for demonstration plots. The group members then establish and maintain the demonstration plots and replicate what has been learnt at household level.

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

- 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 practices and try new technologies;
- Nationals with sufficient land should be willing to offer refugees use of their land for agriculture

2.2 Implementing Partners

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

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

IP/Unit staff notably Agricultural Extension Officers (AEOs) will go on to facilitate the group training and activity implementation supervised by Agriculture Extension Supervisors (AESs).

The relevant IP/Unit will procure and distribute the inputs required and staff will familiarise themselves with the NURI CSA plans, workplans and budgets as these will guide implementation.

2.3 OPM/UNHCR

OPM and UNHCR will ensure a peaceful and conducive environment in and around refugee settlements. They will continue to allocate areas for various agencies to work in to avoid duplication and ensure maximum coverage and 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.

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 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 a channel of communication between refugees and agencies providing services. 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 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 refugee and national members to become a cohesive group. A well-functioning Mixed 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 on 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 developed 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 and inputs. This is to level expectations

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

2. Plan 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(s). Read through the guide and consider how you translate concepts into the local language.

Farmer training will be based on principles of adult learning and 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, child-headed households, the disabled and the elderly. 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 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 learnt for guiding future training exercises;
- Document and provide feedback from beneficiaries on how the training fitted the different gender expectations and norms.

5. Managing Demonstrations

In NURI, Mixed Groups will be supported with improved seeds to establish a demonstration plot of approx. 1 acre (4,000m^2). This will serve as a learning site but also a seed multiplication plot as the seeds that come out of it will be shared by farmers for individual production. It is hoped this process will not only encourage nationals and refugees to expand their area of production but will also encourage nationals to allow access to land by the refugee community as well as income generation.

The seeds are to be provided once and only one variety per demonstration plot since it is also a multiplication. For comparison with demonstration, farmers can plant their own seeds in their homes. The seeds varieties for demonstrations were arrived at after consulting the IPs and DPOs.

Procedure;

- The training session on planting should coincide with the planting of the demonstration plot. Inputs should therefore be organized.
- Demo-plots should be established on farmers' fields. These plots will be owned and managed by farmers and they need to be well looked after.
- The demo-plots should as much as possible be established in a communally central place where group members can reach easily preferably along main village paths and roads in the community so that the public will be able to see, appreciate and may be learn something. However
- The land should be even with no/little variation. Where variations occur appropriate measures should be taken to reduce variability for example avoid anthills, shade from trees, manure pits and the layout should take note of the slope of land.
- Once planting has started it should be quickly completed to minimise variation.
- The demo-plot shall have a label and not sign post showing the variety grown.

- Protection: the security of the demo from stray animals and thieves should be top priority. Where land is available it can be planted far away or it should be fenced off. Discuss what works best.
- The AEO should visit regularly the demo-plot and record progress. Any problems should be discussed with the farmers. This could include, pest and disease management, making sure management operations are implemented appropriately at the correct time. The problems which cannot be resolved should be referred to the AES.

5.1 Farmer hosting a demonstration:

A farmer hosting a demonstration plot needs to understand clearly what the demonstration is designed to achieve, and how it will be implemented. This can be achieved in group briefing sessions, or one-on-one visits by AEO. The host farmer should have some qualities as listed below:

- Willing to offer land for the demonstration
- Willing to take responsibility of the demonstration
- Willing to participate actively and voluntarily
- Respected and liked in his/her group and community
- Be trainable and can train others in the practices/technologies
- Be cooperative, dependable/reliable and honest/trustworthy and flexible

5.2 Taking demo-results measurements

Demo data is very useful and will be collected by AEOs. Farmers should be encouraged to make frequent observations of the demonstration and to especially note different attributes of the variety demonstrated against the ones they grow e.g. germination, growth vigor, yield, period to maturity, taste etc.

The AEO should collect the following data: area planted and area harvested, date of planting, germination date, weeding frequency, pests and diseases and the control, labour for different operations, yield etc. This will be defined by IP and how it should be recorded.

6. Records and Administration

Administration of the agriculture training exercises and the keeping of records will be done by the IPs. The IP staff responsible for farmer training are the AEOs and AES'.

Report from Each Training Session
Annex 4 shows the format for the report that the AEO should prepare immediately after each training session he/she 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.

This manual should be used in association with other resource materials, learning aids, demonstration plots etc. A number of these will be provided to the extension staff. These serves as a guide on what areas that need to be covered. As every group and every season is different the technical information provided may not contain all the details necessary so users should consult other resources and apply the technical knowledge flexibly.

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	• Introduction to CSA concept • 3 objectives of CSA, • Adaptation and mitigation measures	Flip charts, markers	Prior to GAP training

technologies available	for farmers in northern Uganda, • Review of the farmers' farming system (conventional) and comparison with CSA. • How to improve food security		
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 including fallowing FMNR • Inorganic fertilizers • Water conservation practices including simple rain water harvesting techniques • Permaculture/perma gardening	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 maize variety
Plot	Intercropping legumes in cassava plots
Farm/household	Crop residues + 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 strengthen women groups
Markets and other institutions	well-functioning markets and access to financial services , insurance of risks
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

Inter-planting crops that share the field for only part of the season can increase the capture of sunlight over the course of the whole year. 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 have nitrogen-fixing bacteria associated with their roots. Consequently, they compete only slightly with non-legumes for soil nitrogen and in some

cases even supply nitrogen to adjacent plants via leakage and root decomposition (fine roots grow and die rapidly within the season, even in healthy plants).

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

Two approaches are often applied in using tall crops to reduce drought- or heat-stress of shorter crops i.e. partial shading and reduction in wind speed. Partial shade cast by a trellised[2] crop or a well-spaced planting of Maize can reduce heat stress for spinach or lettuce or cabbage intercrop. This may be useful in preventing early bolting. On windy sites, periodic rows of tall crops can reduce water stress by slowing wind speed.

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. Choosing an intercrop that does not host key pests on the main crop is critical. They make mixtures of dissimilar crops unattractive to pests compared to monocultures. Another approach applied to reduce pests is the use of "Trap Crops" which is strongly preferred by the pests compared to the main crop. These are planted on the edges of the garden like a fortress around the main crop. This works well for pests that attack the crop from the edges.

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, 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
- Intercroppin –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. Some apply also to field crops and carefully select such. 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 SESSIONS

1. BEANS

Under NURI program and for mixed groups, beans in most cases will be planted as intercrop thus some sessions will not be relevant in the training. In other words will not be covered.

Variety selection

There are many improved varieties available in the market. Examples of Bush beans: K20 (Nambale), K131 (Kabalira), K132 (Kawomera), NABE 1, NABE 2, NABE 3, NABE 4, NABE 5, NABE 6 NABE 15 and NABE 16. Early maturing beans like K20, K131 and NABE 4 can be harvested in 10-11 weeks after planting, with green pods harvested at 6- 8 weeks.

Variety	Maturity period (days)	Yield Kg/ acre	Attributes
K131	90	600-1200	Bush type. Small, brown, mottled
K132	80	600-1200	Large, red, mottled seed
NABE 1	80-85	600-1200	Bush type. Small, red seed
NABE 2	90	600-1200	Bush type. Small, black seed
NABE 3	88	600-1200	Bush type, disease resistant, high yielding
NABE 4	82	600-1200	Bush type. Medium size, red, mottled seed
NABE 5	85	600-1200	Bush type. Medium size, cream, mottled seed, lodges
NABE 6	90	600-1200	Bush type. Small, white seed
NABE 15	58-70	700-800	Medium seeded pink with red striped variety. Early maturing. Resistant to foliar diseases.
NABE 16	62-75	700-800	Cream with red mottles, resistant to foliar diseases (Common bean blight, Rust, Halo blight, Anthracnose). Early maturing

Growth Environment

Beans can be grown on almost all soil types so long as the required nutrients are in correct proportions. The soil should be free draining. The pH should be above 5.0 although some varieties tolerate acidic soil (K131) but not below pH 4.0. Rainfall above 1000mm per annum is satisfactory for bean growth. Very wet conditions during planting and harvesting should be avoided as they encourage spread of diseases.

Beans are not suitable for areas where temperatures exceed 35°c. They perform best with high sunshine; under humid conditions, beans are prone to fungal and bacterial diseases.

Land Preparation

Prepare a fine seedbed to ensure uniform and proper growth right from germination. This also reduces the number of times to weed.

- Land for beans should be cleared by late December/ early January: bush must be removed
- First ploughing should be deep
- Do a second ploughing three weeks after the first one to kill weeds
- Dig or harrow two weeks after ploughing to soften the soil remove any remaining weeds and to make a flat seed bed.

Planting

Farmers should plant beans at the beginning of the rains when soil moisture is enough. Beans can be produced in both first and second seasons although this varies from one place to another.

- Spacing: 50 cm x 10 cm. This makes it easier to weed and carry out other operations.
- For certified seeds plant one seed per hole while for locally acquired plant 2-3 seeds per hole
- Seed rate is 20 kg/acre for small seeded varieties and 35 kg/acre for large seeded varieties. Plant seeds with over 80% germination rate.
- Planting depth should be 2-3 cm and not deeper than 5 cm.
- Gap filling done in case of poor germination 7 days after emergence.

Intercropping beans with other crops such as maize, cassava, sorghum, bananas, cotton is common. Various plant patterns can be used but row planting is recommended.

- Beans and maize intercrop: Maize planted at 90 cm between rows and one or two lines of beans are planted in between.
- Beans and cassava: cassava spaced at 1.5m X 1.5m and 2 rows of beans in between.
- The beans need to be planted at the same time as maize, sorghum and cassava.
- Note that intercropping makes the management of the crop more difficult and harvest of beans is less.

Soil Fertility management

Locally available organic material like cow dung, compost, green manure and mulching are sufficient. Apply 5-10 tons/ha or 2-4 tons/acre of organic material or 1 kg of compost per 8 holes depending on the fertility status of the soil. No training will be given on inorganic fertilisers.

Weeding

It is important that beans be weeded at the earliest possible time because beans are weak competitors compared to weeds. Weeding at 3 weeks after planting and later at 6 weeks should control the entire weed. If herbicides are used at the beginning, then weeding once should suffice.

Pests and diseases control

Because beans are attacked by a wide range of pests and diseases, the most effective control measures farmers should use are integrated management approaches which combine different measures such as resistant or tolerant varieties plus cultural practices and chemicals. AEO should discuss available options to use with farmers.

- **Alphids and Flower Thrips:** Use Dimethoate (Rogor) or Sumithion against aphids and flower thrips.
- **Pod Eating Caterpillars:** Use Ambush or Bulldock against pod eating caterpillars.
- **Leaf Eaters:** Unless they are removing more than 1/3 of the total leaves. If this is the case, use same chemicals as pod eating caterpillars
- **Bean Stem Maggots:** treat your seed before planting with systemic insecticides such as Endosulfan, Acephate; early planting, earthing up and mulching after the first weeding; application of manure or fertilizer at planting.
- ***Fungal diseases***: Anthracnose, angular leaf spot, bean root rot, seedling and collar rots, rust, ascochyta blight, web blight, floury leaf spot, powdery mildew and white mould. To control use clean seed, observe crop hygiene or spray with protectant or systemic fungicides like benlate and Dithane M45 and use resistant varieties.
- ***Bacterial Diseases:*** Common bacterial blight and halo blight. Control measures include**:** Use of clean seeds and resistant varieties, uprooting of infected plants (rogue), crop rotation 3-years and elimination of weed reservoirs.
- ***Viral diseases:*** Bean Common Mosaic Virus (BCMV) and black rot. Control measures include**:** Plant resistant varieties like K131 and use of virus free seeds. Spray the aphids, which transmit the disease with Ambush and Sumithion.
- ***Nematodes:*** Root knot nematode. This is controlled through**;** Crop rotation, fallows, and burial of debris to reduce nematode populations. Some common weeds (e.g. Tagetes minuta) are antagonistic to nematodes. Nematicides are effective but usually impracticable.

Post-harvest Handling

At physiological maturity bean seeds have moisture content of 35 -55% and the pods have just turned yellowish. Majority of the pods usually does not reach this stage at the same time. When the maturity is not uniform, do selective harvesting. Harvest timely for a better quality product. Harvest is preferably done in the morning to avoid shattering by uprooting the entire plant. Don't leave beans to dry in the field after harvesting.

After harvesting, dry beans in pods for about 3 - 4 days before threshing on raised ground or tarpaulins till they become fairly hard. Thereafter thresh the beans to expose the seeds on a tarpaulin or threshing rack. This can be done by beating using sticks. This is followed by winnowing to remove chaff, dust and other rubbish.

Dry the threshed and cleaned again on clean surface such as tarpaulins, mats, plastic sheets etc. for 1 - 3 days to reach 13 – 15% MC. If not properly dried they may rot.

Beans are best stored as grains/seeds in PICS bags, gunny bags, silos etc. The bags/containers should be put on a raised flat surface or platform. Don't store old and new stock of beans together. Observe cleanness in the store and control storage pests.

In storage, beans may be attacked by bruchids also known as weevils. To reduce losses, practice timely harvesting, sort out damage grains before storage, proper drying, use of botanical e.g. ground tobacco leaf powder, neem powder.

2. 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.

3. COWPEA

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.

4. GROUND NUT

Variety selection Many varieties are available. The commonly grown once include: Red Beauty which is red seeded and other more recent varieties like Serenut 2T, Serenut 3R, Serenut 4T, Serenut 5R, Serenut 12 R upto Serenut 14R. Get certified seed at regular intervals, preferably every 2–3 years.

Variety	Maturity period (days)	Yield (bags/acre)	Attributes
Serenut 2	115-120	800 kg(20 bags of 40 kg)	Bunch type; Resistant to rosette; large tan seeded, 47% oil content
Serenut 4	90 -100	1080 Kg (27 bags of 40kg)	Bunch type; Resistant to rosette; drought tolerant; small tan seed 43% oil content
Red Beauty	90-100	800 Kg (20 bags of 40kg)	Bunch type; susceptible to rosette; medium red seed with short pods.

Growth environment

Grown all over Uganda and does best at altitudes of below l, 500m ASL. It requires rainfall of at least 1,016 mm. Its water requirement is greater at flowering, pegging and pod filling. However, dry weather is required for harvesting and drying. The crop cannot tolerate water logging. Well-drained sandy loam is preferred, with a high sulphur content and aeration.

Land preparation

- The farmer should prepare a good seedbed for good root growth and to allow the groundnut pods to grow and fill well
- The residue from the previous crop should be managed as the first step in seed bed preparation.
- The soil should be dug/ ploughed deeply by hand/ ox plough or tractor to deeply turn the soil to bury residues
- Weed 3-4 weeks before planting.
- Plant in a moist seed bed to ensure good germination

Planting

Pods should be shelled 1–2 weeks before sowing and only good quality seed should be selected for sowing. Spacing is 45cm x 15cm for spreading types ; and 45 x 10cm for bunch types like Red Beauty, Serenut 14, and Serenut 4. The recommended planting depth is up to 5cm deep; and the seed rate is 32 kg/ Acre for spreading varieties and 40Kg/ acre for bunch types. Maturity depends on the variety used, but varies from 90-135 days (3 - 4.5 months)

Weed Control

Keep the crop weed free. Early weed control is essential in order to achieve maximum economic yields. Two or three times are necessary in hand hoed fields. Herbicides, if applied judiciously, may be used e.g. roundup for bush clearing before ploughing, and or Stomp at planting. Weeding using oxen is becoming common. Once flowering and development of the pod into the soil begin, it is advisable to weed by hand pulling, rather than by using a hoe, as this is less likely to disturb any developing pods.

Pests and diseases control

- ***Viral* diseases*:*** Groundnut rosette is the most serious disease. Spray 4 times against the vector (Aphids) for susceptible varieties, using Rogor or Fenkill. Start the first spray at 10 days after emergence after the first weeding and thereafter at 10 day intervals for 3 more times. Use of resistant varieties such as Serenut 2, Serenut 14, and Serenut 4 eliminates use and costs on chemicals.
- ***Fungal* diseases*:*** Cercospora leaf-spots. Spray with Dithane, Benlate, Brestan if severe, however, it may not be necessary.
- ***Pests:*** The leaf miner larvae can cause severe leaf damage to leaves. It binds the leaves and bores the leaf surface and feeds between the leaf tissues causing leaves to dry. If it is not controlled, it can cause severe loss to yield especially if the crop if still young. Use a systemic insecticide like Rogor as soon as sings of the pest are noticed.

Harvest and Post-Harvest

Harvest when the inside of the pod turns dark brown and seed has attained its real colour. Other maturity indicators are; shedding of leaves and vines turning yellowish. Discuss others. Harvest and leave in windrows for three days before plucking. Clean the pods by removing the soil and other dirt and dry properly before storing in a well-ventilated place.

The harvesting is mainly done by hand pulling, digging using a hand hoe or by groundnut plough attachment lifter. Harvesting by hand only is more suitable for groundnut bunch varieties that grow erect (upright), in sandy, loam soils which are free of water that has settled in it.

Post-harvest Handling

a) **Drying of groundnuts**

For good storage and germination, the moisture content of the pods should be reduced to 6-10%. Dry on tarpaulins, improved dryers, cement-brick and stabilised grounds. Correct drying of the harvested groundnuts is very important as poor drying leads to fungal growth which produce poisonous chemicals (aflatoxin contamination) and reduce seed quality for consumption, marketing and germination for the following season's planting.

b) **Shelling of groundnuts:**

Storage life of Groundnut seeds outside the shell is short and quality can deteriorate fast. Groundnuts seeds should therefore be shelled as and when need arises. Use manual groundnut Sheller, seed/grain cleaner/sorter to shell, clean and sort groundnuts or by hand which is commonly done by farmers.

c) **Storage**

It is best to store groundnuts in their shell. Good drying of the pods to 7–8% moisture content will help to ensure that the seeds remain in good condition during storage. Never bag groundnuts for storage if the pods are still damp. Before storing; poor, damaged,

shrivelled, rotten, or dieses-infected pods should be removed. Whatever the storage container, it is important to ensure that the store is dry and that there is good ventilation so that the pods/seeds do not increase in moisture content, which would encourage fungal growth. Ideally the store should be cool, as this prolongs the storage life of the pods.

5. MAIZE

Maize is one of the major food and cash crops in the country. Annual production is estimated at 1,500,000MT with 90% used as food. Its production has increased over the years due to increased demand. It can be produced in most parts of the country except in the most arid parts of Karamoja. The uses of maize include food, animal feed, raw material in breweries, starch factories etc. There is regional demand for maize such as Kenya, S. Sudan and the country can exploit such opportunity. Maize has less labour requirements compared to millet, sorghum and rice.

Growth requirements of maize

- Maize does best on soils that are well drained, well aerated, and fertile.
- It does not do well in water logged (killed if stands in water for 2 days) and in poor sandy soils.
- Maize grows well with 600 – 900 mm rainfall well distributed throughout the growing period. The rainfall is most critical at flowering and silking stage as drought interferes with pollination and drastically reduces yield. Towards harvesting, dry conditions are required to facilitate drying of the grain.

Varieties of maize and their attributes

Maize has a number of varieties the farmers can choose from. It is important the farmers consider the varietal attributes when selecting maize for planting. The table below shows some of the varieties in Uganda.

Variety	Type	Maturity period (days)	Yield/acre	Other Attributes
Longe 1	composite	120	2,000 Kg	resistant to MSV
Longe 4	composite	105	1,600 Kg	resistant to drought & MSV
Longe 5	composite	120	2,000 Kg	resistant to MSV and has a high protein content
Longe 2H	hybrid	125	3,200 Kg	resistant MSV
Longe 3H	hybrid	125	3,200 Kg	resistant MSV
SC 627 (ZIM)	hybrid	125	2,400 – 3,200 Kg	Resistant to MSV, NLB and GLS, high yielding
PAN 67 (SA)	hybrid	120	2,400 – 3,200 Kg	Resistant to MSV, NLB, GLS, tolerant to drought
SC 407	hybrid	110	2,400 – 3,200 Kg	Early maturing, yield stability
DK 8051	hybrid	145-150	2,400 – 3,200 Kg	Resistant to MSV, NLB, GLS

Quality of seeds

Farmers should plant only good quality seed of improved varieties. Quality seeds can be obtained from reputable agro input dealers / seed companies, NGOs and Government programs.

Quality of maize seed is very important because it greatly affects farmers' yields. Good quality seed… Will have a good yield

Farmers should test seeds for germination before planting. This will tell farmers how much seed they need to plant per unit area. For the details refer to maize grain sack training chart.

Plant seeds with a high germination rate of over 80 %.

For open pollinated varieties (OPVs) farmers need to replace with a new stock after few seasons of growing to maintain a good yield while they should not replant hybrid maize seeds, why?

Advantages of planting improved seeds

- Lower seeding rate
- Higher seedling emergence, usually above 85%
- Vigorous seedlings
- More uniform plant stand
- Faster growth rate
- Better resistance to stress, pests and diseases such as maize streak disease
- Uniformity in ripening
- Improved seeds can contribute upto 30% increase in the grain yield (DAR/RALNUC data).

Soil Fertility Management

Maize requires nutrients for proper growth, however some soils have limited nutrients owing to continuous cropping. One tonne of maize removes 24.3 Kg Nitrogen, 10Kg Phosphorus and 21.1Kg Potassium. These nutrients need to be replenished in the soil in form of organic or inorganic fertilizers. If not done, even the most fertile soils will gradually become unproductive.

Fertilizers for maize production

Organic fertilizers

- Crop residues (e.g. bean hulls and stalks, groundnut residue, maize stovers, sorghum residues), green manures and animal waste (e.g. cow and chicken manure).
- These fertilizers can be applied individually and directly, or can be combined, and composted. These need to be incorporated to the soil during seedbed preparation. Farm yard manure is applied at rate of 5-10 tonnes/ha.

Inorganic fertilizers

- Apply the fertilizer in weed free fields and at right soil moisture.
- At planting use DAP (Diammonium Phosphate). A farmer will need 38kg per acre at a rate of one bottle top of Fanta/Coca cola per hole.
- Top dressing by Urea at a rate of 50kg/acre when maize is about 3-4 weeks after planting and again at tasselling. It is applied around the plant at 2 bottle tops per hill. Farmers can also use SA or CAN at same rate, drilled and covered.
- Farmers should note that the fertilizer rates provided are just indicative and may be less or more depending on fertility status of the soil.

Planting

Land preparation for Maize growing

Farmers should dig or plough the land enough times to kill the weeds. It is recommended to clear land, and then do the first and second ploughing. Maize does not need a very fine/ smooth seedbed: a rough seedbed allows better water infiltration and control of erosion. Early preparations ensure timely planting for better yields. Hand hoes and oxen are

commonly used although sometimes tractors. Under conservation agriculture herbicides may be used to clear weeds before planting.
Rainy seasons have changed a lot over the last years. Farmers should plant at the onset of rains, and dry planting done when rains are expected. The planting depth will according to how wet/ moist the soil is. If the soil is wet/ moist, plant 2-3 cm below the ground and if the soil is dry, dig 5-10 cm deep to plant the seed i.e. dry planting. Maize planted with fertilizers are at least 10 cm deep to allow for fertilizer, soil, seed and final covering. Planting is done by hands or planters and seed rate is 10 kg per acre.

Spacing option 1: 75 cm x 30 cm (2.5 ft x 1 ft) for one seed per hole
Spacing option 2: 75 cm x 60 cm (2.5 ft x 2 ft) for two seeds per hole.

Intercropping with other crops
Maize is commonly intercropped with other crops. For this use a wider spacing so that you can plant another crop like beans in between rows of maize. The recommended spacing is 90cm cm x 30cm (3ft x I ft) for one seed per hole or 90cm x 60cm (3ft x 2ft) to plant two seeds per hole, then plant beans in between. For Maize-sesame intercropping; plant maize in rows with 75 cm between rows and 60 cm for 2 plants per hole and sow sesame 2 weeks after maize has been planted. As for Maize-cowpea intercropping: plant maize and cowpea simultaneously. For highest yields, plant maize rows 75 cm apart with in-row spacing of 30 cm and plant cowpea in rows midway between maize rows with in-row spacing of 15 cm.

Note that intercropping makes the management of the crop more difficult and you are likely to harvest less of each crop.

Weed control / gap filling / thinning

A young maize crop is very sensitive to weed competition. Checking weed growth in the first 45 days of growth is critical for better yields.

- First weeding should be done at 3 weeks after planting
- Second weeding at 8 weeks after planting.

Weeds may be controlled by hand weeding which is the most common method used by small-scale farmers. Mechanical and chemical methods of weed control also exist.
Each control method has advantages and disadvantages. A combination of methods can help give best results.

Farmers should gap-fill within 7 days after emergence. This is only necessary with less than 80% germination. Thinning is done when excess plants exist per hill the first weeding to avoid waste of soil nutrients. The use of good quality seeds, planting at optimum moisture, right spacing, seed rate and depth can help avoid need for gap filling and thinning.

Pest and Disease Control

Farmers should know that maize is attacked by a number of pests and diseases.

a) Pests of maize

- **Fall Army Worm:** This is one the recent pests with far devastating damage to maize. It all above ground parts of a maize plant
- **Stem borers**: are among the most important insect pests of maize. Severity and nature of stem borer damage depend upon the borer species, the plant growth stage,

the number of larvae feeding on the plant, and the plant's reaction to borer feeding. Almost all plant parts, leaves, stems, tassels and ears are attacked.

- **Termites:** Several species attack maize. Damage particularly noticeable during dry seasons or in areas with erratic rainfall. Roots and lower part of the stem might be destroyed resulting in lodging.
- **Leafhoppers**: are important as vectors of maize streak virus (MSV). They are small (about 2-3 mm long), pale, yellow and wedge-shaped insects. Adults are commonly found resting on the upper surface of young maize leaves.
- **Vertebrate pests (rodents, birds, domestic animals, monkeys, wild pigs, thieves/human beings)** whose damage varies according to location and numbers that attack maize.
- **Army worms, grasshoppers, locusts, cutworms etc** are minor and/or sporadic pests.

b) Diseases of maize

- **Maize lethal necrosis disease**: a new devastating viral disease first reported in Kenya in 2011 and has since spread to Uganda. By 2014 the disease had been confirmed in 14 districts of eastern Uganda. It makes the plant to wither and wilt before maturity. Plants appear weak, start shrinking with leaves turning yellowish and eventually they fall off and dry. No resistant maize varieties developed yet.
- **Maize Streak Virus (MSV):** The virus is transmitted by Leafhoppers. Early disease symptoms consist of very small, round, scattered spots in the youngest leaves which become more profuse at leaf bases and are particularly conspicuous in the youngest leaves. Fully elongated leaves develop chlorosis with broken yellow streak along the veins. Severe infection causes stunting and plants can die prematurely.
- **Gray Leaf Spot (GLS):** Is a fungal disease. Lesions begin as small, regular, elongated brown-gray necrotic spots growing parallel to the veins and can result in severe leaf senescence leading to poor grain filling.
- **Northern Leaf Blight (NLB):** A fungal disease*,* early symptom is slightly oval, water-soaked, small spots produced on the leaves. Can lead to complete burning of the foliage. When infection is severe, it may cause significant economic damage.
- **Maize smut** is a fungal disease and the infection is systemic. Symptoms: abnormal development of the tassels, black masses of spores that develop inside individual male florets and masses of black spores in place of the normal ear.

General Control

- Planting disease free seeds, destruction of affected plots, crop rotation, and fertilizer application.
- Use of resistant varieties such as Longe 1, Longe 2H and Longe 4. Planting early in the season will reduce incidence.
- Phytosanitary measures, planting resistant varieties such as Longe 2H, 6H, 7H, 8H, early planting and use of certified seed. Seed dressing with Organic-mercury compounds controls smut.
- Stalk borer can be controlled using a dash of Sevin dust in the maize funnel and resistant varieties. Control armyworms and cutworms using Dimethoate. Control termites using granular Dursban 5% at the base of the plants or kill termites in the mound using Dimethoate.

- Scaring away the pest, trapping and poisoning them.

Integrated Pest or Disease Management is best approach to control pests and diseases of maize (combines use of improved varieties, cultural practices such as closed season; rogueing affected plants; early planting and crop rotation, use of chemicals)

Harvest and Post-Harvest

i. **Harvesting of Maize:** To harvest maize, remove cob, de-husk and put in a sack or tarpaulin. After harvesting; transport the maize home and spread maize cobs on a clean surface such as concrete floor, tarpaulin etc to dry. Quality control of the maize starts here.

ii. **Drying of maize:** Dry the maize immediately after harvest to the right moisture content (12-13.5%) for storage. Small holder farmers dry using sun energy on mats, raised platform/racks, maize crib, concrete slabs/yards, tarpaulin or plastic sheet. For a rectangular crib, orientation and width are important for proper drying. Maize is first dried in the cobs and then after shelling further drying done before storage.

Testing if the maize is properly dry can be done by: biting grain and if it breaks easily then it is dry, pushing a hand in a sack of grain, shaking a sample of grain in a tin and salt. For salt method, put 20 g of salt together with about 160 g of maize grain in a clear plastic or glass bottle, shake vigorously for 2 minutes and allow settling for 15 – 30 minutes. If the wall of containers becomes foggy/ cloudy, then moisture content is more than 13.5 %, so continue to dry the produce. AEO should practically demonstrate this with farmers.

iii. **Shelling and cleaning of maize:** Maize can be stored as cobs or grain. For long term storage and marketing maize is usually shelled. Before shelling farmers should sort away damaged or discoloured maize cobs to improve quality. Different methods of shelling exist: hand held shellers, beating cobs with sticks in the bags, and mechanized shelling. Beating with sticks although popular in the community is not recommended as it leads to physical damage of the maize grains which can be easily attached by insects and moulds.

iv. **Storage of maize:** Maize is best stored when well clean and dried. Improved storage methods include raised granaries with rat guards, silos both plastic and metallic, sacks including super bags. The bags need to be stack on pallets and away from the walls. While storing do not stack together crops that share pests and diseases. Super bags and silos should be sealed air-tight to keep out air that makes maize go bad through supporting life of storage insects. The storage should not allow re-wetting of the grain and easy to inspect.

iv. **Storage Pests**

The greatest damage to stored maize grain is generally caused by insects account for about 25 % of the damage

- **Maize Weevil**: Weevils are the most important pests of stored-maize. The overall life cycle takes 24-60 days depending on temperature and humidity. Damage is caused by

adult feeding and larvae tunnelling within the grains. Infestation normally starts in the field. Early harvesting will reduce infestation; a tight long husk cover will also reduce it.

- **Larger Grain Borer (LGB).** The LGB can bore and live in wood, dry cassava and on maize. Its life cycle takes about 27 days under favourable conditions. Its infestation can occur both in the field and in storage. Damage is by both adults and larvae. The beetle feeds on the most nutritious part of the maize kernel that is endosperm. Damage is severe and losses of maize stored in cribs are as high as 34 % after 3-6 months storage. Grain dust is produced by the adults as they feed.
- **Rodents:** these eat the maize grain and also contaminate with faeces.

v. **Management of maize storage pests**

- Preventive methods: resistant varieties, timely harvesting, cleaning of store before new harvest, removal of infected cobs before storage, proper drying of grain, minimal damage on the grain, use of smoke
- Addition of substances: wood ash, inert dusts, fine sand, dried and crushed tobacco leaves, neem or red pepper
- Physical methods (preventive and curative): mechanical method, use of heat, airtight storage, chemical application (fumigants, dressing etc). Insecticides recommended are (g/100 kg maize): Permethrin 0.5 % dust - 55 g, Deltamethrin 0.2 % dust - 50 g, Fenvalerate 1.0 % dust - 50 g, or 2% Actelic dust – 40 g.

vi. Aflatoxins in Maize

Farmers should be made aware of aflatoxins. Aflatoxins are natural toxic by-products produced by a fungus *Aspergillus flavus* and other related fungi. The fungus which is present in the air and soil invades several crop species including maize under high temperatures, drought, and terminal water stress prior to harvest producing aflatoxins. This fungus is an opportunistic pathogen whereby insect or mechanical damage to seeds can increase the infection rate and aflatoxin levels. This can also worsen with insufficiently dried seeds prior to storage which provides an ideal environment for fungal growth. The fungi grow and produce aflatoxins under high moisture and warm temperatures.

Contaminated grain and food/feed is toxic to humans and animals (cattle, small ruminants, poultry, especially young ones) and results in illness. They cause liver cirrhosis, liver cancer, and immunosuppression. They are also associated with malnutrition syndrome, and can lead to many other disorders and even death. Aflatoxins are great concern because the climate under which maize is grown favours fungal infestation and aflatoxin production. Once aflatoxin is produced on the grain, it cannot be destroyed by cooking or heating the grain.

vii. Aflatoxin Management

- Sanitation of grain handing equipment
- Plant maize with first possible rains and harvest crop at correct maturity.
- Remove dead plants and plants showing severe stress due to pest or pathogen attack.
- Remove weeds and protect crop from borer damage.
- Visually inspect maize for fungal infections/damage and discard the affected ones.
- Avoid mechanical damage to seed during threshing, drying, transportation and storage.
- Dry the maize grain well to 13 – 15 % moisture content
- Stack bags on wooden pallets and store them in well aerated waterproof area.

6. SESAME

Variety selection

Many varieties of sesame are available. The new improved varieties are Sesame 2 and Sesame 3. The new varieties are non-shattering and resistant to the gall midge. Average maturity is attained 120 days after planting. Most cultivars take between 90 and 130 days.

Variety	Maturity period(days)	Yield (Kg/acre)	Attributes
Sesame I	110	200 – 320	42% oil content, green stem, white seed. Non shattering. Resistant to the gall midge.
Sesame II	120	240 - 360	42% oil content, purple stem, white seed. Non shattering. Resistant to the gall midge.
Sesame III	90 – 100	240 - 360	over 41% oil content, green stem, white seed. Non shattering. Hairy, resistant to the gall midge.

Improved seeds are fundamental for high production, why? Sesame is normally self-pollinated, although cross pollination by insects is common. With this happening, farmers need to replace their seeds after a few years with new seed.

Growth environment

Sesame does best in drier climates. In humid conditions the crop gets foliage diseases.

Land Preparation

Sesame is often sown as an opening crop in a rotation, as it requires a fertile soil. In this case grasses must be eradicated as sesame is a poor competitor to weeds. Planting must be done as early in the rains as possible. A fine seedbed is required as the seed is very small. "Starting with a clean field" can help minimise the growth of weeds.

Planting

The optimum depth to sow is around 1.5 to 2.5 cm. It is important to sow at an even depth to ensure simultaneous and uniform growth of the crop. Small-holder farmers will often sow by hand. This method requires 3 kg/acre of seeds. Mixing seed with sand or dry soil will help to make seed distribution more uniform. When grown in pure stand, the seed is broadcast or drilled in rows at spacing of 30 x10 cm. The crop should be thinned when 10 – 15cm high after the first weeding.

Sesame can be intercropped with maize, sorghum, groundnuts, finger millet, beans, pigeon peas, and sunflower, among others. Space maize at 90 cm between rows and plant one row of sesame in the middle. As for millet, 2:1 sesame: finger millet rows

mixture is the best, but farmers who prefer millet will use the 1:2 mixture with less reduction in finger millet yield. Both are grown at 30 cm x 10 cm spacing.

Weeding

Weeding is a must and must be done as soon as weeds emerge. Weeding is done once or twice depending on the field conditions.

Soil fertility management

Most soil in Uganda is depleted of essential soil nutrients. Good management of crop residue like returning the stalks of the sesame to the field after drying can help maintain and improve the soil fertility. Some of the practices are:

- Improvement of nutrient-retaining ability of soil by adding organic manures to the soil.
- Improvement of soil drainage
- Control of soil erosion
- Crop rotation by growing crops which have different growth habits and nutrient requirements. Rotate sesame with crops like cotton, maize, sorghum, groundnuts or soybeans.
- Minimum tillage practices
- Timely weed control.
- Use of both organic and inorganic fertilizers.

Pest and disease control

The gall midge and webworm are major pests. They are controlled by spraying with insecticide e.g. FENKILL or Bulldock. Spray at flowering, bud and capsule formation at 2 weeks interval.

Control fungal diseases using Dithane M45, mix 45-60 gm in 20 litres of water. It is important when there is excessive rainfall and especially at capsule stage

Powdery mildew (*Sphaerotheca fuliginea)*

The disease can infect all aerial parts: leaves, flowers and pods. Characteristic of the disease is white greyish powdery fungal growth on affected plant parts. With time the powdery growth covers the entire lower leaf area. Severe infection causes heavy leaf drop. The fungus survives on perennial pigeon peas and volunteer plants, and on the ratoon growth of the harvested plants

Cercospora and Cylindrosporium leafspots

These are major fungal diseases of sesame which attack leaves. Severe for early planted crops. Control by spraying using Dithane is effective.

Post-harvest handling

Sesame matures between 3-4 months. Harvest when crop has started to shed leaves but before pod shattering. If harvesting is delayed, most of the yield will be lost. The plants are cut at height of 10-15 cm from the ground, or uprooted before the capsules are fully ripened and tied in bundles, which are tied of racks to dry. The capsules are then beaten with sticks to separate the seed. Dry the grain or seed on stabilised floors, tarpaulins or mats.

Sesame can be intercropped with maize, sorghum, groundnuts, finger millet, beans, pigeon peas, and sunflower, among others. Space maize at 90 cm between rows and plant one row of sesame in the middle. As for millet, 2:1 sesame: finger millet rows mixture is the best, but farmers who prefer millet will use the 1:2 mixture with less reduction in finger millet yield. Both are grown at 30 cm x 10 cm spacing.

7. SORGHUM

Sorghum is adapted to a wide range of ecological conditions, surviving in the tropical, sub-tropical and temperate regions. It is planted in areas considered to be too dry and hot for other cereals to survive because of its tolerance to drought and heat stress. It suits well and a favourable crop in the face of climate change.

Variety selection

Common varieties include NAROSORG 1 to 4 and SESO 1 to 3.

Sorghum variety	Year of release	Days to maturity	Average yield/ha	Grain colour	Unique attributes
NAROSORG 1	2017	110 - 120	3000 - 3200	Cream White	Medium maturity and excellent for brewing
NAROSORG 2	2017	100 - 110	2700 - 3000	Red	Good for Yeast and not much affected by birds
NAROSORG 3	2017	110 - 120	3000	Chalky White	Midge resistant
NAROSORG 4	2017	90 - 100	2300 - 2500	Brown	Good for food and not much affected by birds
SESO 1	2011	90	3000	White	Esrly maturity and good for brewing
SESO 2	2011	100	2500	White	Forage and resistant to lodging
SESO 3	2011	95	3000	Brown	Good for food and not much affectd by birds

Growth environment

Sorghum is adapted to a wide range of environmental conditions and will produce significant yields under conditions that are unfavourable for most other cereals. Sorghum is particularly adapted to drought and can tolerate hot and dry conditions. The crop is killed by frost; the optimum temperature is 30°c. It is grown between 40°N & S of the equator. It requires water at germination and for effectiveness of fertilizers. It does well on a wide range of soil conditions but is best on heavy soils with pH range of 5.0 - 8.5.

Planting

Land preparation

A reasonably fine seed bed is required.

Planting

Sorghum is normally grown from seed. For favourable conditions, row spacing of 60 cm and plant-to-plant spacing of 15 cm, giving average populations of about 120 000 plants per ha, are normal. For drier or less fertile conditions, lower plant populations is usually optimal and hence wider spacing of 75 between plants and 30cm between rows is recommended. It can also be propagated by cuttings and rationing. Plant seeds 5cm deep to avoid rotting of seed in case of light rain showers. The seed rate on average is 4 kg/ acre.

Intercropping, sorghum can be intercrop with Cowpea or green gram in a ratio 1sorghum to 2legume and the spacing is 60X20cm.

Soil fertility management and water conservation

Sorghum is known to perform under minimal moisture condition and soil fertility. However, it is important to adopt cultivation practices which maximise moisture conservation and preventing soil compaction.

Weed Control

Weeding is usually done by hand 2 weeks after germination. Thinning is carried out at the same time as hand weeding or at intervals during the crop cycle, particularly where thinning are used to feed livestock. Gapping by transplanting, thinning is encouraged when thinning is done within 2 weeks after emergence and when the soil is moist. Keep the garden weed free as it can cause losses

Pest and Disease Control

Leaf blight: Burn crop residue and deep plough soil at planting and practice crop rotation.
Smuts: Cut off infected heads and bury in soil.
Leaf anthracnose: Destroy all infected crop residue.
Sorghum shoot fly: Control by early sowing or spray using an insecticide such as Fenom P.
Stalk borer: Spray with Ambush or Fenom P.
Birds: Plant in the second rains to avoid massive bird damage. Scare birds starting at the milk stage.

Harvest and Post-Harvest

Post-harvest Handling

Sorghum is usually harvested when they are partially wet. When the Moisture content of sorghum is **16 - 20%**, leaves start drying, grains develop black spot, grains show Golden/whitish colour and fairly hard on biting. However, experience show that Sorghum harvested at physiological maturity is difficult to handle. Hence they are usually left to dry in the field for 1 – 3 weeks beyond physiological maturity. This is done to allow grains to harden so that they can easily be handled with minimum damage.
Sorghum is usually harvested by hand when it has reached physiological maturity which means the grain is hard and does not produce milk when crushed. Cut the heads with sickles or a sharp knife from plants in the field or cut the whole plant and remove the heads later. Sun dry the harvested panicles to moisture level of **12-13 %** and thresh and store the grain.

Care of harvested Sorghum:

During harvesting;

- Put harvested crops on tarpaulins/ mats. This is to reduce soil contamination and losses

After harvesting;

- Stack the crop loosely on a clean & dry place/tarpaulin.
- If inside a cemented house, spread the crop to avoid heat built-up.
- If outside , cover the crop to protect it from rain
- Dry the crop in sunshine for 1-2 weeks before threshing.
- Delay in drying leads to rotting of grains.

When to thresh Sorghum: Sorghum is threshed when grains sufficiently dry and hard with **MC of 12-13%**. Threshing should be done on concrete floor, tarpaulin/ mats, raised platforms, threshing cage, in bags. Never thresh on a bare ground as this leads to grain contamination with sand, filths hence low quality grains.

Recommended Methods of threshing Sorghum: Sorghum is piled on concrete floor/tarpaulin and beaten using sticks. Don't use excessive force during beating as this damages grain.

Handling of threshed grains:

- Clean the threshed grains to remove broken straws, chaff etc
- Sun dry the grains if not properly dry for 1 - 2 days to the right MC: (**Sorghum 10-11%**)
- Spread grain uniformly on tarpaulin/mat/concrete at thickness 30-40mm

8. 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.

9. PIGEON PEAS *(Cajanus cajan)*

Pigeon pea is highly nutritious, improves the soil fertility by fixing nitrogen and the deep-rootedness bring out the minerals that other plant roots do not reach. That is why you find that all places where pigeon peas is grown, the soil fertility increases without even adding the fertiliser."

Varieties

SEPI 1, medium SEPI 2, early and long duration local type (Apio-Elina, Adong)

Variety	Duration to maturity	Yields T/Ha	Attributes
SEPI 1	120 - 140	2.5	Less susceptible to storage pests, indeterminate growth
SEPI 2	110 - 120	2.5	Quick recovery after storage pests attack, Determinate growth

Growth environment

- About 25 inch of rainfall per year.
- It does not tolerate water logging.
- It has high adaptability of soil types. However, these soils should not be deficient in lime.
- The crop is drought resistant and less suitable to very wet conditions.

Planting

- Best is from seeds. Growing period depends on variety. Short duration types take between 90 and 150 days to mature. Long duration take between 180 and 300 days.
- Plants can be cut to regenerate new shoots.
- Row spacing is 30 - 75cm and plant spacing is 30cm.
- It is commonly intercropped with other crops particularly groundnuts, millet, sorghum in Acholi. The crop performs well with 2 rows of cereals (e.g. sorghum, millets), cotton or groundnut

Pests, diseases and control

- ***Fungal:*** Fusarium wilt, powdery mildew and leafspot.

Control: Practice crop rotation and seed dress with Thiram.

- ***Pest:*** Pod borer, flower beetles, thrips and Pod sucking bugs. *Control:* Spray with Fenitrothion before flowering, and at podding stage.

Harvesting and post harvest handling

The crop is usually cut near the ground when most pods are mature, or mature pods are picked individually. Green pods are picked over a long period in home gardens or hedge crops. After harvest its dried and the entire air-dried plants or pods are threshed, usually by hand and seed is cleaned. Clean bins prevent insect attack, which can be considerable.

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					
					Refugees		Nationals			
					F	M	F	M	T	Youth
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										
29										
30										

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			