CLIMATE ACTION MODEL VILLAGE PROJECT (CAM PROJECT)

AGROECOLOGY TRAINING MANUAL

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1 Introduction

1.1 About CAM Project

The living situation of people in Nebbi and Pakwach districts is characterized by extreme poverty and a high dependence on traditional subsistence agriculture with very low knowledge and market participation and a high susceptibility to climate change. Discrimination against women is immense as only 20% of women own land, only 27% of them make decisions regarding the use of family land and only 10% decide on the use of family income for major expenses. The high pressure on natural resources resulted in enormous environmental degradation (only 3.3% of the land is now forested). This situation was exacerbated by the COVID-19 pandemic as many households (58%) reported a decline in income; they spent their savings (37%) and depleted their assets boys resorted to theft (8%) and girls to survival sex (10%) and child marriage (18%); women faced more sexual gender-based violence (23%). Together, these factors have reduced the resilience of many households and the prospects for independent recovery is considered very low.

In order to strengthen the resilience of communities in Nebbi and Pakwach in regards to climate, health and economic shocks, AFARD in partnership with AWO International secured EUR 913,400 from the German Federal Ministry for Economic Cooperation and Development (BMZ) to implement a 3.5-year (Oct. 2022 – March 2026) Climate Action Model Village (CAM) Project in Nebbi and Pakwach districts targeting directly 3,190 people (60% female and at least 10% individuals with special needs) composed of vulnerable smallholder farmers; primary school pupils (P5-7) and their teachers and management committees; district and sub county local government officials; traditional, religious and opinion leaders; and AFARD staffs.

The overall project goal is, “Communities in Nebbi and Pakwach Districts are resilient to climate change, health and economic shocks.” The project specific objective is, “Targeted communities in Nebbi and Pakwach districts have food and income security and serve as replicable examples for Climate Active Model Villages by March 2026” and this will lead to the following positive gains: 75% of target households are food secure; 65% of target households are income secure to withstand climate, health, and economic shocks; 45% of households plan their family size; disaster preparedness interventions of CSCGs and SHECs have resulted in a 25% decline of infectious and vector-borne diseases (malaria, covid-19, cholera, diarrhoea, and gastrointestinal worms); residents of the climate action model villages use the forest planted on 15 acres for their own food (e.g., mangoes and oranges), food preparation (firewood), and health (shade, and utilization of the bark, sap, or leaves for medicines); and 08 climate action villages serve as models for replication through knowledge sharing with local governments, networks of AFARD, universities & partners of AWO International in Uganda.

1.2 Project Approach

The CAM Project is planned to empower the population of at least ten villages in Nyaravur and Alwi sub-counties to transform their villages into Climate Active Model Villages through: 1) the establishment of 15 Climate Smart Champion Groups (CSCGs) and 05 School Health and Environment Club (SHEC); and 2) capacity development of these civil society structures on sustainable agricultural intensification, income generation and management, gender equality, sexual and reproductive health and rights (SRHR), preventive public health, environmental conservation, biodiversity and climate change mitigation. A cooperative will be formed with members from at least 06 CSCGs to drive inclusive and sustainable value-added market participation. For these civil society strengthening to attain the above results, the project will use a 4-pronged interlinked approach:

1. Increasing agricultural production and productivity through intensification of production, technologies used and practices using improved agricultural inputs (seeds, livestock and ox teams) and training in climate- smart agricultural skills (using the resilience design approach) and value addition.
2. Livelihood diversification for alternative income generation through promotion of VSLA, IGA - SPM and financial literacy trainings to target households

to enable them to save, identify locally viable investment opportunities, take necessary loans and start/build businesses to generate alternative income for food security and health service utilization among others.

3. Promote public health and prevent avoidable diseases in schools and target communities for reduced student absenteeism and increased adult labour productivity.
4. Preserving the environment and biodiversity by changing awareness on the one hand and creating access to sustainable forest and non-timber products on the other, enabling communities to value an intact environment, take action against environmental degradation, green their villages and thus protect the climate.

1.3 About the manual

This manual is a consolidation of information from different sources on agroecology and basic production practices. It aims at imparting knowledge to those who intend to implement or facilitate/train on agroecology farming

The manual has been arranged into 2 parts. Part 1 elaborates on the basic practices implemented under agroecology that include Agroecology farm planning and design, soil and water conservation, soil fertility management, pest, and disease management. Part 2 dwells on crop specific production practices for the 4 crops of focus under the Climate Action Model village (CAM) Project. Where possible, illustrations have been provided in the manual to emphasize the suggested practices/technologies.

How to use the Manual

The manual has been compiled in an easy-to-use format for farmers who intend to implement agroecology. It is advised that they internalize and contextualize it to fit the local context. This could be through simulations with fellow colleagues but also enriching it with own experiences to make it more applicable.

The manual will be used by agroecology champions under the CAM project to engage beneficiaries and communities to transform and promote livelihoods through agriculture and other natural resource related fields. The manual therefore primarily targets producers doing agroecology. They will use it to train communities on how to plan and execute agroecology farming.

2 Background and Rationale

For decades, the question of feeding the growing population of the world has attracted every one's attention with innovations coming on board. The industrial farming system was introduced in the 1960s to solve the problem of feeding the increasing population of the world. However, after many years of promoting conventional farming, despite undeniable progress in reducing rates of undernourishment and improving levels of nutrition and health, almost 800 million people are chronically hungry and 2 billion suffer micronutrient deficiencies.

High-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil degradation, loss of biodiversity, high levels of greenhouse gas emissions leading to climate change and a rise to non-communicable diseases among all age groups and classes of people cannot deliver sustainable food and agricultural production. Needed are innovative systems that will increase productivity of healthy foods at the same time conserve the natural resource base with more socio-economic benefits and with less environmental consequences. Needed is a transformative process towards 'holistic' approaches, such as agroecology, agroforestry, and conservation agriculture, which also build upon indigenous and traditional knowledge.

On the other hand, critical parts of food systems are becoming more capital-intensive, vertically integrated and concentrated in fewer hands. This is happening from input provisioning to food distribution. Small-scale producers and landless households are the first to lose out and increasingly seek employment opportunities outside of agriculture. This is driving increased migratory flows, especially of male and youth members of households, which in turn has left the old and weak as well as 'feminization' of farming in many parts of the world. A more inclusive farming system is needed that will strike a balance in division of labour in farming households among the female and male but most importantly the youths

Agroecology Definition and Practices 3

3.1 Definition

As defined by the Food and Agriculture Organization (FAO), Agroecology is the science of applying ecological concepts and principles to manage interactions between plants, animals, humans and the environment for food security and nutrition.

Agroecology is farming that "centres on food production that makes the best use of nature's goods and services while not damaging these resources."

The science of agroecology explicitly recognizes the value of bottom-up participatory research and knowledge and promotes: (i) bridging formal and informal innovation processes; (ii) combining local expertise, with scientific knowledge; (iii) acknowledging and respecting farmers as owners of knowledge and co-researchers and innovators.

The choice of management practices and technologies to achieve agroecology or to move towards an agroecological transition is always location specific, shaped by a given social-ecological context.

3.2 Agroecology Practices

This section highlights the fundamental practices for agroecological production. The practices have been selected depending on the major challenges that farmers face during agricultural production. These practices are in 4 categories namely: a) Farm planning and design, b) Soil and water conservation, c) soil fertility management, d) integrated pest and disease management. Below are highlights of the practices

3.2.1 Farm planning and design

Like any other business or project, its success is dependent on planning and understanding the dynamics of implementing the project. To successfully run a farm that is agroecological, planning and designing are very important aspects that look at placing the different elements of the farm in the appropriate locations. Science in agroecology now answers the WHAT HOW and WHY an element is placed in a particular location. Farm planning and design is on all principles and elements of agroecology such as diversity, recycling, efficiency, synergies, and resilience among others.

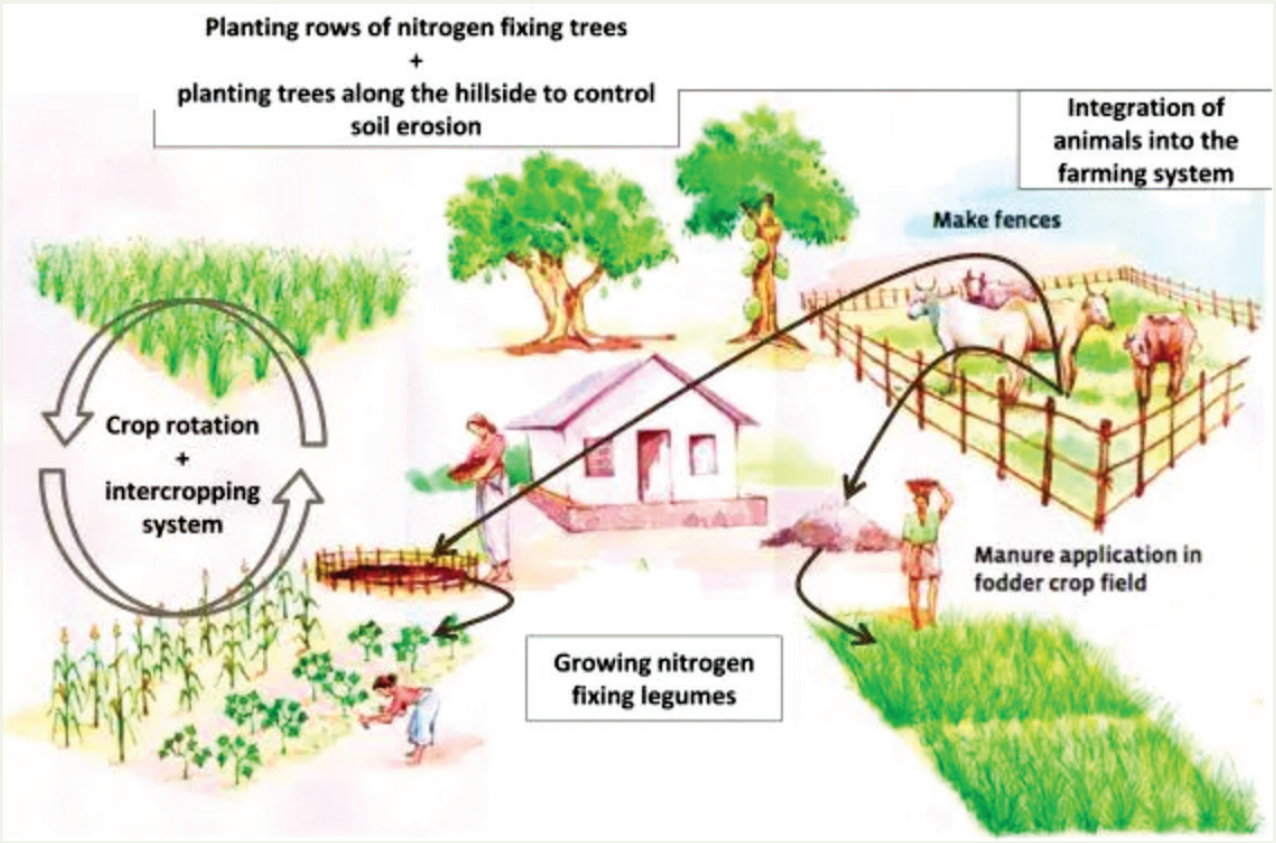
Diversity

Diversity as one of the elements of agroecology that needs to be thought through while developing a farm plan. Diversity is seen at four levels of crops, animals, trees, and livelihood activities. While planning for your farm there is need to mix the different elements that will bring out diversity on the farm. Diversity can further be detailed by looking at the different crop varieties and animal breeds. Diversity on the farm contributes to other elements of agroecology like synergies.

Connectivity/Synergy

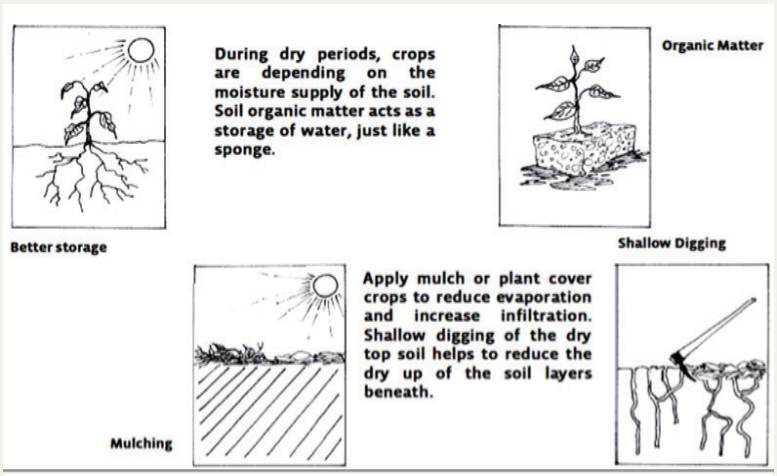
Everything is connected to everything else i.e. every element of the farm must be placed at the place in relation to other elements to enable recycling of energy resources. In this regard ***"There is no waste to waste"*** in agroecology. i.e what seems to be waste from one element is an input to a different element. For example, the cow dung that is waste from animals is manure (input) for plants.

Illustration of the principle of connectivity/synergy.



3.2.2 Soil and water conservation

Soil and water conservation is a technique of controlling soil erosion and good use of water by all users sustainably. The effective soil and water management practices can improve soil fertility and increase yields in a sustainable way. These techniques conserve soil and water, preserve soil moisture and/or drain water sustainably to avoid soil erosion and depletion of soil nutrient. Different soil and water conservation measures are used in agroecological farming including terracing, Continuous Contour Trenches (fanya juu and fanya chin, bench terraces, stone terraces), grass/contour bounds, use of cover crops, mulching, water harvesting measures (underground tanks, water ditches,) etc.



Approaches for water conservation: Better water retention through high contents of soil organic matter; reduced evaporation through mulching or shallow digging

Well applied practices for water and soil conservation benefit farmers by.

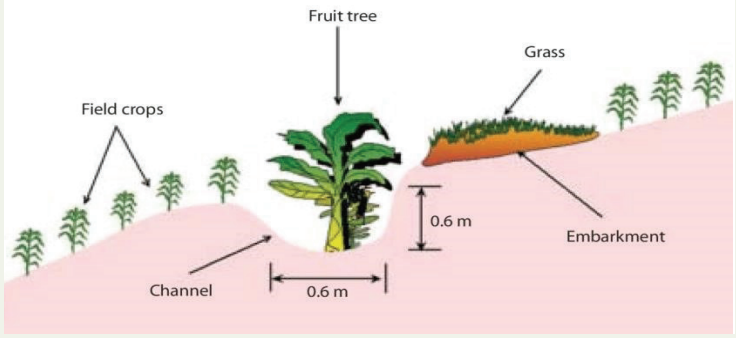
- Reduction of the amounts and velocity of surface runoff
- Removal of unwanted excessive runoff easily
- Maintenance and improvement of soil fertility
- Conservation and retention of soil moisture
- Prevention or minimizing the effects of raindrop impacts on the soil.

Below are procedures for making some of the water and soil conservation practices.

Contour Trenches

Contour trenches are ditches dug along a hillside in such a way that they follow a contour and run perpendicular to the flow of water. The soil excavated from the ditch is used to form a berm (a narrow shelf) on the downhill and uphill edge of the ditch. The berm can be planted with permanent vegetation (native grasses, legumes) to stabilize the soil and for the roots and foliage in order to trap any sediment that would overflow from the trench in heavy rainfall events. Contour trenches can be of two forms;- Fanya Jju and Fanya Chini

Illustration of Fanya juu terraces



Fanya juu terraces

- Dig a trench of 60cm width and 60cm depth.
- Throw the soil upwards to form a ridge of 40cm to 60cm in height
- The trenches could be 10cm to 20cm apart depending on the steepness of the field
- Grasses, crops, trees can be planted on the ridges. These provide food for animals and humans in addition to stabilizing soils against runoffs

Fanya chini means throw soil downhill. Dig the soil and throw downhill to establish a ridges. These terraces are usually used in areas with moderate slopes.

Grasses, crops, trees can be planted on the ridges. These provide food for animals and humans in addition to stabilizing soils against runoffs

Diversion ditches and cut off drains

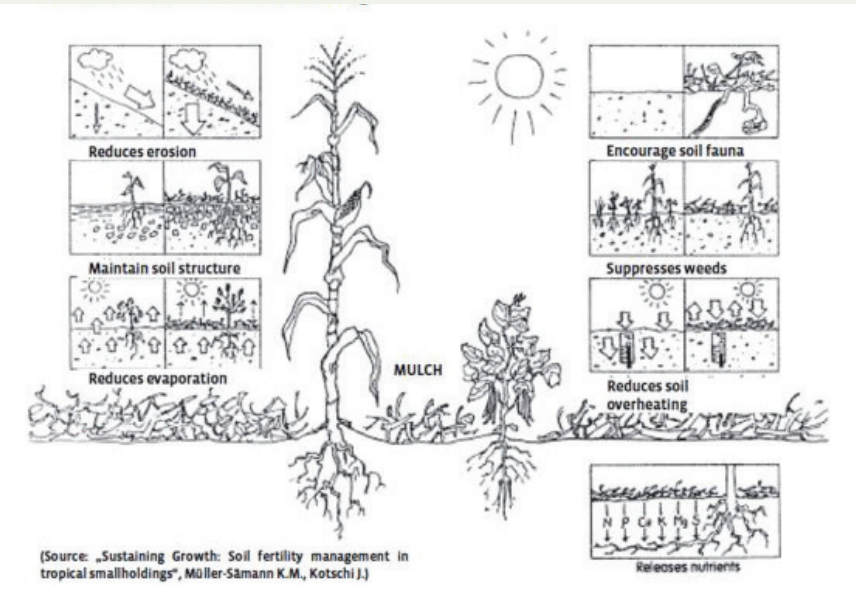
Diversion ditches-excavated graded channels to intercept surface water runoff down the slope and diverted to a safe outlet, water way or farm. The structures can be in the form of a trench, a narrow base channel or a hillside ditch.

Cut off drains are channels built to collect runoff from the land above and divert the water safely to water ways thus protecting the land below from excessive erosion.

The ditches can be made of earth, stones depending on the available materials'

Cover cropping

On a larger scale leguminous broad-leaved climbers are used in this process. Cover cropping is a multi-beneficial practice during the soil and water conservation. The practice reduces on the speed of water runoff, keeps soil moist for a longer time, and improves on soil fertility since it's a legume crop used in the practice.



Mulching

This is the covering of soil surface using dry crop residues, stones, wood shelves and shade net. Mulching can be heavy or light mulches hence blanket or light depending on the heat intensity, the type of crop, and the amount of mulch available. Mulches reduce on direct sun heat on the soil and rainwater droppings impact on the soil surface. In the long run, mulches decompose and form manure hence improving soil fertility and soil moisture content.

Water Absorption Trenches

These are dug at the upper side of the catchment and are constructed by digging 1m wide, 1m deep and 5m in length. These are more less like the Fanya chin and soil is poured on the lower side of the slope which is then reinforced with grass and or shrubs.

Stone bands

Stones are piled perpendicular to the slope to help in reducing the speed of water but also filter and enhance percolation.

3.2.3 Soil Fertility management

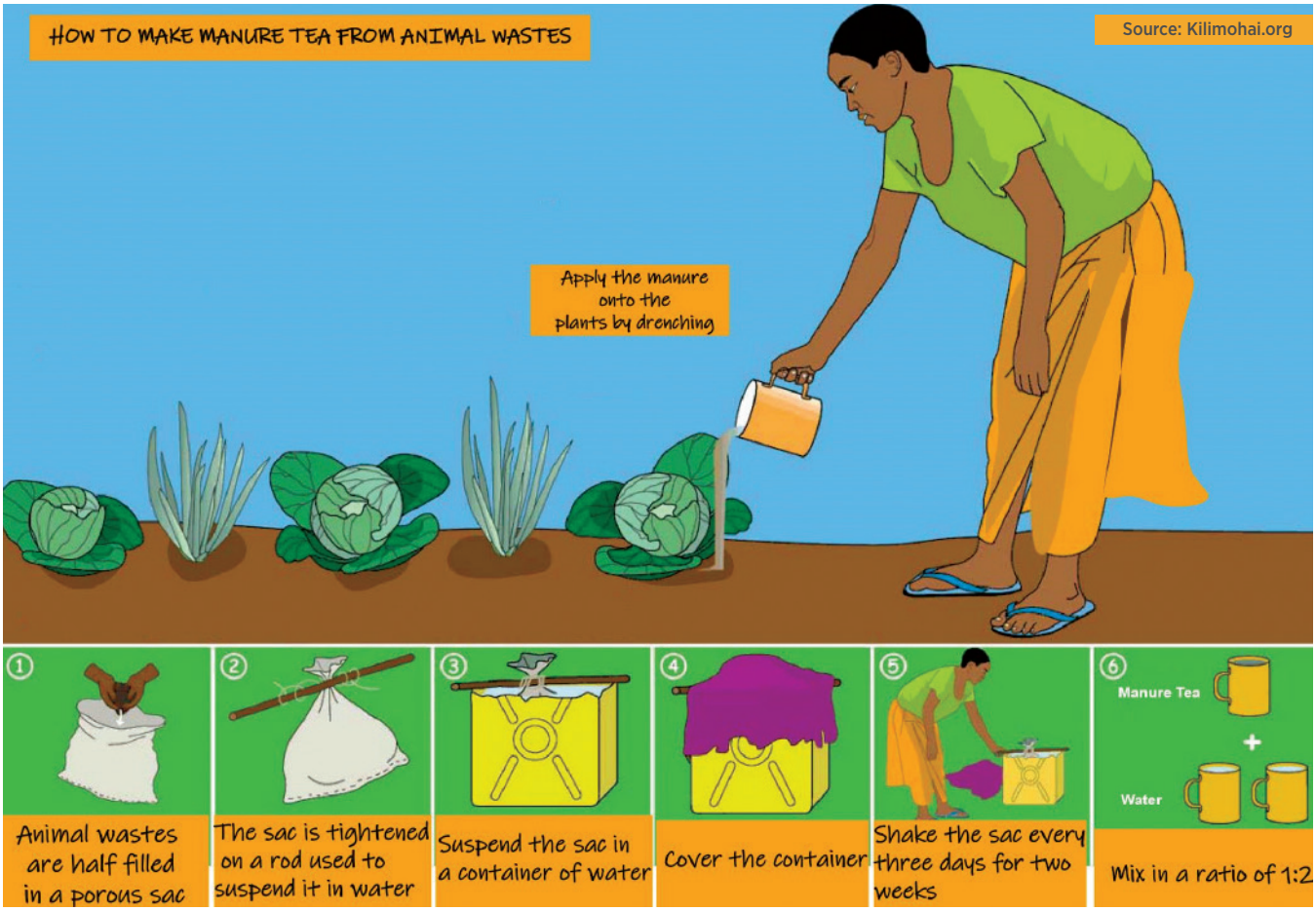
Ensuring healthy and fertile soils is very important for sustainable agriculture production as this continuously leads to better yields. Managing soil health and fertility allows producers to work with the land to reduce erosion, maximize water infiltration, improve nutrient recycling, save money on inputs, and ultimately improve the resilience of their working land. Management of health soils requires to maximize soil cover (plant cover crops, leave crop residuals, use organic mulch), maximize biodiversity (plant diverse cover crops, use diverse crop rotation and companion planting), maximize presence of living roots (Living roots reduce soil erosion and provide food for organisms like earthworms and microbes that recycle the nutrients). Therefore, for sustainable production, soil health and soil fertility are key. Addition of organic fertilizers and manures is one of the ways of maintaining soil fertility.

Soil is a living thing that needs to be looked after well. It requires feeding like any other living thing. Soil can be fed through composting, green manuring, plant tea, manure tea. Compost is a complete soil meal that contains nitrogen (legumes and animal waste), potassium (wood ash), magnesium, phosphorus (wood ash), calcium, trace minerals and carbon (dry matter). On the other hand, green manuring involves use of fresh green grass, dry grass or animal waste. Below are some of the examples of manures/fertilizers used to maintain fertility of the soils

Liquid manure
This is of two types; the plant tea and manure tea.

a) Plant tea
This is generally made from plant leaves. The common plants used are; tithonia, ground nuts, beans, jack bean, elephant grass, pumpkin, etc. Basically, hairy leaves are the best for making plant tea as they can easily decompose. Plant tea is made by chopping the leaves into small pieces which are filled in a container ¾. The container is then filled with water and the leaves are left to rot under shade for two weeks. Keep string after every three days. After the two weeks, sieve the tea and mix in the ratio of 1 tea to 2 of water. Spray on the leaves of the crops. The residues after sieving are used as mulch.

b) Manure tea
This is made from animal droppings. The droppings are filled in a sac and suspended in a container with water. The sac is shaken after every three days for two weeks under shade. The tea is sieved and mixed in a ratio of 1:2; tea: water and sprayed on the crops. Ash is added in the tea. See Illustration below



Compost
Compost is made from a range of materials which include green matter, dry matter, animal droppings, water, ash and top soil. To make compost, one needs to select an appropriate site that is under shade.

The Composting Process
The compost area must measure 1 m in width and any length depending on the availability of materials. The soil is loosened where the compost heap is to be set up. The compost is prepared as follows.

a) A layer of dry matter (grass, decomposable sticks, leaves, and cereal stems etc.) is set up first on the loosened soil. This helps in aeration. Wood ash is spread, and water sprinkled on it.

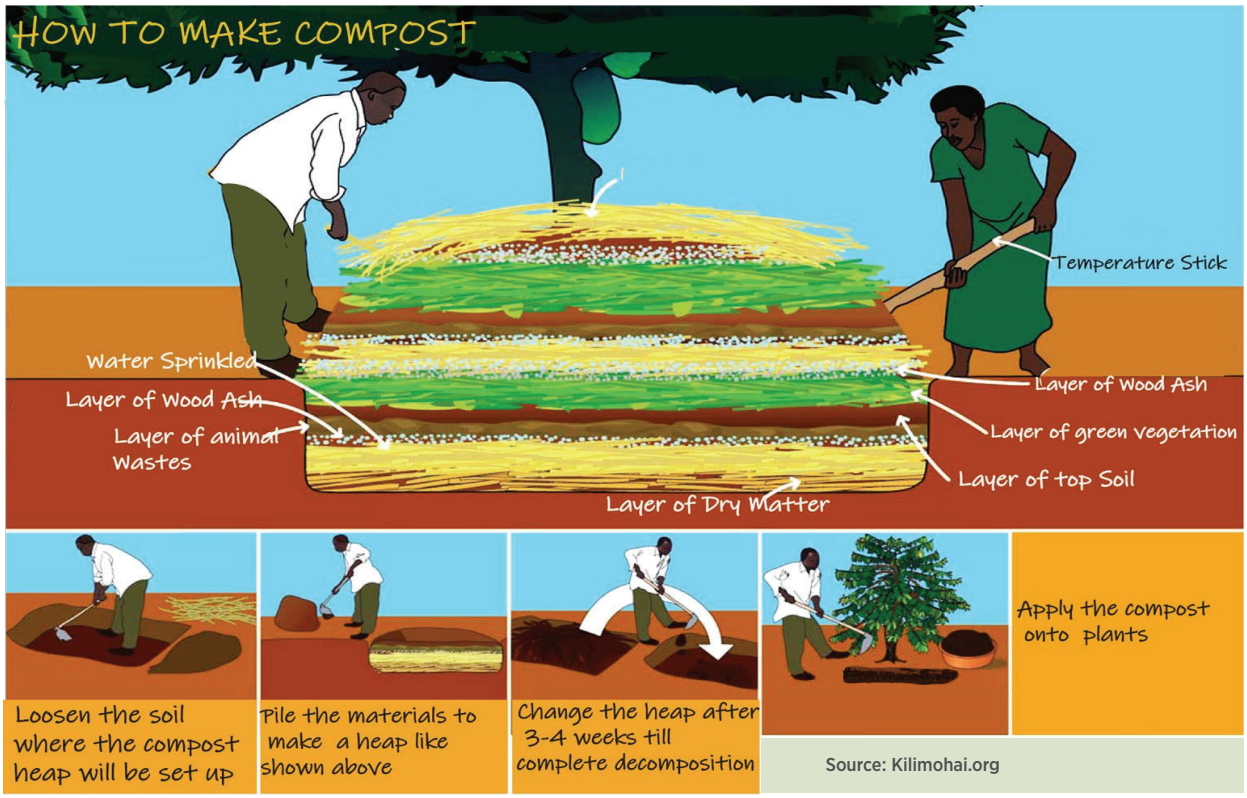
b) A layer of animal waste is then added. This can be cow dung, chicken refuse, and goat/sheep droppings.

c) Top soil is added to inoculate living organisms that aid in decomposition. Wood ash is spread on the heap and water sprinkled.

d) It is followed with a layer of green matter. Leaves with rough hairy surfaces are recommended as they decompose faster compared to the smooth surface leaves. Wood ash is added, and water sprinkled.

Once the heap has been set up, a dry stick is pushed diagonally across. This is used to check the level of decomposition and temperature. If the stick is dry or has vapour, then it means the temperature is high that can't allow for aerobic respiration. Continuous watering is thus carried on regulating the temperature.

The heap is turned after 3-4 weeks for three months, and compost will be ready for use in the garden. For a fast compost making, make a small heap and turn it after 2 weeks and will be ready after a month. See Illustration Below



3.2.4 Integrated Pest and Disease Management (IPDM)

Agroecological farming uses of combined efforts to control and repel pests because equally they are also important in the ecosystem and if biodiversity balance exists, production can be done without chemicals in the system.

With IPDM, you take actions to keep pests from becoming a problem, such as by growing a healthy seed in a health soil to give a health crop that can withstand pest attacks, using disease-resistant plants (crops that are resilient). Rather than simply eliminating the pests you see right now, using IPDM means you'll look at environmental factors that affect the pest and its ability to thrive. The aim is to create conditions that are unfavorable for the pest.

Monitoring/Scouting

In IPDM, monitoring/scouting and correct pest identification is key for the farmer as it guides on the right decision to take in management of the pests and diseases.

Monitoring means checking your field to identify which pests are present, how many there are, or what damage inflicted and mode of feeding. Correctly identifying the pest is key to knowing whether a pest is likely to become a problem (beyond economic injury level) and determining the best management strategy. After monitoring and considering information about the pest, its biology, and environmental factors, you can decide whether the pest can be tolerated or whether it is a problem that warrants control. If control is needed, this information also helps you select the most effective management methods and the best time to use them.

What is a pest?

A pest is any living organism which adversely affects human activities.

The intensification of agriculture has created new or greater pest problems in several ways:

Monoculture
Planting only a single crop in a bed (monoculture) encourages large numbers of pests to breed and spread. Pests breed when they have a large area of their favorite type of crop growing. If many different crops are growing in the same garden pests get confused.

Use of Chemicals.

- Insect Mutations. The use of agricultural chemicals has led to breeding of super pests which are resistant to many sprays.
- Pest resurgence. Broad spectrum sprays kill off many useful predators which help control pests such as ladybird beetles, spiders, preying mantids, frogs, lizards, and wasps.

Change in weather patterns (Climate change).
Insect outbreaks, especially of migratory pests, are often associated with particular weather patterns, e.g. outbreaks of the desert locust and butterflies (Spodoptera spp.) The weather can also directly affect population development, if temperatures are favorable for population growth at an appropriate period during the insect's life cycle, then outbreaks can occur.

Integrated pest management (IPM)
This is a broad-based approach that integrates practices and measures of controlling pest populations below the economic injury level (EIL).

Methods used to control pests
a) Cultural methods (Culture; -way of life)

Good crop management is the best way to prevent pest and disease outbreaks in the first place.

Keeping crops healthy: enough nutrients and water so they use their own defences against pests. Too much water and chemical fertilizers make plants grow too fast and make them weak and susceptible to pest and disease attack. ***Use healthy seedlings.*** Collect your own seeds.

Some of the cultural practices include,

Crop rotation
Intercropping – (Push Pull technology).
Under this technology, one crop repels the insect and another attracts the insect. the insect repelling plant is usually intercropped with the main crop. as they pest is repelled away from the crop-repellant intercrop, they get attracted to another plant/crop usually planted at the boundary of the fields. Therefore, instead of the main crop being attacked by the pest, the pest settles on the attracting crops and this saves the main crop. e.g Use of *desmodium spp.* and elephant grass in the growing of maize. The desmodium spp. repels the insects and the elephant grass attracts the pest (stalk borers)

Timing of planting. Ensure that crops are planted at the correct time of year for their requirements. Planting crops at the right time enables the crops to benefit from the nitrogen flush, grows with vigor and be able to resist the invasion by pests. By the time the pest sets in, the crop would have in some cases reached maturity and thus the effects of the pest infestation does not reach economic injury levels.

Trellising. Crops with weak herbaceous stems are normally supported by the farmers to access sunlight and bare fruits are required. Trellising supports/ suspends the crop above the ground level and reduces the chances of pest affecting these crops.

Rouging: Destroying infected plant material. Diseased or insect infested plants are removed from the garden to avoid the spread of the disease or the multiplication of the pest to other crops. By doing this, the farmer reduces the chances of pest and disease spread to other crops in the garden. This can be done by uprooting, cutting down, etc.

Weeding. Weeds provides habitat for some pest and subsequently diseases which can attack the crop planted by the farmers. weeding at the right time enables the chance of pest infestation to be reduced. Since weeds compete with crops for nutrients, sunlight, and growth space, keeping weed under control ensures that crops are healthy and able to resist invasion by pests and diseases.

b) Biological control

This means using other plants or animals to help control pests. This helps to create a natural balance between pests and other living organisms.

Predators (Predator attractants)
Ponds, bird baths, piles of rocks and bushes around the garden help attract predators like lizards, skinks, frogs, chameleons and birds which eat many insects. Fish and frogs eat many insect pests. Many predatory insects such as dragonflies lay their eggs in or near water. Encourage owls, which eat mice and rats. Banana groves attract bats which help control night-flying insects.

Livestock- Ducks and geese eat slugs and snails. Chickens eat many pests including grasshoppers, cutworms, caterpillars and bugs. They also remove weeds and eat weed seeds and improve soil with their manure. If fencing is available livestock can be kept and rotated in orchard areas. Predator insects include ladybirds, preying mantis, parasitic and predatory wasps.

Repellents
Strong-smelling plants such as marigolds, nasturtiums, basil, onions and garlic contain chemicals that repel many pests. Eg control flies and mosquitoes around buildings, by planting rosemary, lavender and lemon grass on the edges of gardens or around the base of fruit trees. Prune the leaves for strong-smelling mulch. Sun hemp repels nematodes and improves soil. Vetiver and lemon grass repel soil insects and moles.

Trap crops
These are grown to attract pests to them and away from your main crop. Aphids will collect

on milkweed rather than on crops. Always leave some milkweed plants in vegetable beds. (Push Pull technology to control striga and maize stem borers)

Physical/ Mechanical control Hand-picking pests

- Hand pick and feed to birds and animals
- Swarms can be removed by brushing plants with a soft broom.
- Squash them on the side of the plant. The smell repels other insects.

Mulching
Spiky grass or leaf mulch repels nematodes, cutworms, grasshoppers, ground beetles, termites, thrips, slugs and snails. Mulch made from clippings of strong-smelling plants such as herbs, Mexican marigold, Zumbani, lantana or gum trees repels insects. Ash deters ants which attack strawberries, beans and carrots.

Windbreaks
To stop the spread of flying insects and wind-borne pests, plant barriers and windbreaks of strong-smelling plants such as rosemary, lavender, and lemon grass around gardens and orchards.

Traps

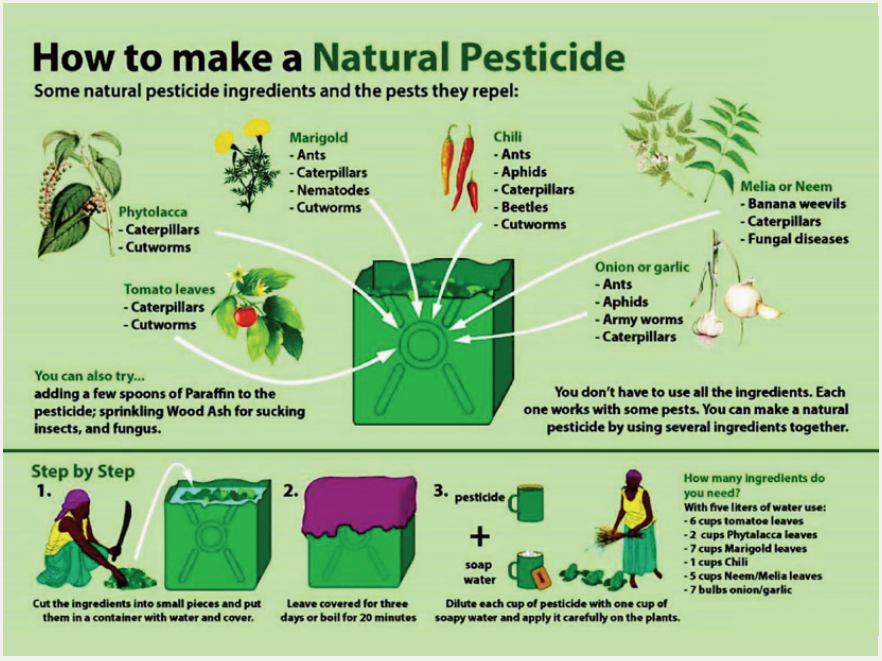
- Light traps can be used to help catch night-time pests such as moths.
- Pheromone traps can be used in the management of fruit flies

Barriers

- Metallic cones on maize cribs
- Smear stems or trunks of plants with a ring of cooking oil or petroleum jelly to prevent insects from reaching the juicy tips leaves, or fruits of the plant.

Chemical methods (Do not use synthetic chemicals but natural concoctions)
Instead of using chemicals that are detrimental to environment and human health; in combination with the above control methods, plant extracts/concoctions are used

Organic Alternatives



- Boil 10 liters of water and allow it to cool to lukewarm temperate. Water is boiled to disinfect it from any fungal microorganisms that may be present before application to the target plant. For pest management other than diseases, water may not be boiled.
- Add 100g of baking soda and 2teaspoons of vegetable oil in the warm water. Steer the mixture well until it dissolves, leave it to cool and spray.
- Weekly sprays are effective. Do not let plants to be infested by the pathogens causing fungal diseases.

Part II Crop Specific Agronomy

Introduction

This part of the manual addresses the general elementary agronomy of the 4 specific crops targeted by the CAM project. They include cassava, sorghum, bananas and orange flesh sweet potato. It gives easy-to-use information for the agroecology champions and individual farmers will find it helpful while carrying out farming activities in the production of the four crops. It tackles the uses, ecological requirements, planting, weed management, pest and disease management, harvesting and post-harvest management of the different crops.

Sorghum Production

Sorghum is an important income and food security crop for those living in drought-prone regions of Uganda. Many races of the cereal are grown in almost all zones but the northern region is the highest producer followed by eastern, western and lastly the central. Much as the northern region is the highest producer of sorghum, the region experiences the lowest productivity indicating that production is due to the increased area in cultivation.

- Food security
- Acts as Ingredients for livestock feed formulation.
- Source of Raw materials for brews.
- Source of Income for households.
- mulching material.
- construction materials.
- staking tomatoes.
- Animal feeds.

Variety	Days to maturity	Average yield (kg/acre)	color	Unique Attributes
NAROSORG-1	110-120	3000-3200	Cream white	medium maturity and excellent for brewing
NAROSORG-2	100-110	2700-3000	Red	Good for yeast and not much affected by birds.
NAROSORG-3	110-120	3000	Chalky white	Midge resistant
NAROSORG-4	90-100	2300-2500	Brown	Good for food and much affected by birds.
SESO 1	90	3000	White	Early maturity and good for brewing.
SESO 2	100	2500	White	Forage and resistant to logging.
SESO-3	95	3000	Brown	Good for food and not much affected by birds.

Ecological Requirements

- The best time to plant is when there is sufficient water in the soil and the soil.
- Sorghum is grown mostly in areas with an annual rainfall range of 300 to 750 mm. It is grown in areas which are too dry for maize as the crop is drought tolerant.
- Sorghum can be grown on many different soils, but best yields are obtained on deep, fertile, well-drained loamy soils. However, it is quite tolerant of shallow soil and drought conditions.
- Sorghum grows poorly on sandy soils, except where heavy textured subsoil is present.
- Sorghum can better tolerate short periods of waterlogging compared to maize. Soils with a clay percentage of between 10 and 30 % are optimal for sorghum production.

Site Selection

- Select a site with fewer trees to minimize bird damage.
- The site should have well drained fertile soils and free from high humidity and strong winds during ripening period.
- In swampy sites sorghum should be planted on ridges to avoid water logging.
- Land Preparation and Planting
- Land preparation for sorghum production should be at least one month before planting for better emergence and seedling development.
- Land may be prepared using a hand hoe, ox-plough or a tractor.
- It should be ploughed twice to obtain a fine field for better crop establishment and good yield.
- In dry areas it is important to adopt cultivation practices which maximize moisture conservation and preventing soil compaction.

Planting

- Planting can be done by row or broadcasting method.
- Row planting is the most recommended compared to broadcasting because there is full utilization of seeds that eliminates wastage.
- It is advisable to plant timely at the onset of rains so that the crop reaches peak water requirement when adequate moisture is still available.
- Spacing of (60*20cm) for short variety and (90*30cm) for tall varieties.
- Planting depth of 25-50mm is recommended with sufficient water.
- 2-3 sorghum seeds can be planted per hole.
- Inter-cropping can be done with legumes such as beans, soybeans

Organic Fertilization

- Fertilizer can best be applied after soil testing, but early land preparation doesn't require fertilizer application.
- Apply 1-2 handfuls of well-rotted manure/compost in each basin and mix with the soil.
- NB: Dwell more on early field preparation and composts.

A farmer is encouraged to apply organic manure to the sorghum field.

Intercropping

Sorghum can be intercropped with legumes like groundnuts and cowpea.

Weed management in sorghum

- Mulching
- Intercropping with legumes
- Hand hoe
- Uprooting by hands

Management of weeds

- Weeds lower yields in sorghum so they should be controlled within the first 6 to 8 weeks after planting.
- Weeds vigorously compete with sorghum for nutrients and water during this period.
- Sorghum is normally weeded once but it is recommended to weed at least twice.
- The first weeding should be done 2-3 weeks after germination while the second weeding should be done 6 weeks after germination depending on weed intensity.
- Weeding is done using hand hoe, but animal traction is also effective.
- During weeding thinning and gap filling should also be done to a desirable plant population. This should be done immediately after or during the first weeding. Gap filling during second weeding should not be done as those plants will not catch up in time
- Thin to 1 or 2 plants per hill for grain and seed production respectively. This should be carried out when there is adequate moisture in the soil to avoid stress.

Sorghum Pests and Disease Management

Pests

Stem/stalk borers

- Many types of stem borers affect sorghum in the field causing great yield loss.
- However, four types stem borers are common in Uganda in particular where their larvae are the destructive stage.
- These include the spotted stem borer, sugarcane borer, maize stalk borer and the pink borer.

Control

- Crop rotation
- Early planting on the onset of rains
- Planting Napier grass around the sorghum fields as a catch crop

- Intercropping sorghum with none host crops such as beans and cowpeas
- Spraying with an insecticide once every 2 weeks and integrated pest management is effective in reducing crop damage

Fall army worm

Ragged appearance on the leaves resulting from heavy consumption by larvae. As plants begin to boot larvae may damage the panicles.

Locusts

Large swarms of locusts can completely strip the foliage and stems of plants such as forbs and grasses causing destruction

Sorghum midge

- Moderate infestations leave a few round, full grains amongst undeveloped shriveled grains. However, when infestations are severe, full grains are absent.
- The female sorghum midge lays 30-120 eggs, which hatch within 2-3 days, in the flower spikelets.
- The larvae move and feed on the developing ovary, preventing normal seed development. Larval period lasts 9-12 days and is the destructive stage of the pest that can cause up to 100% sorghum crop loss.
- Larvae pupate inside the spikelet and pupal period lasts 3-8 days.
- Before the adults emerge, the pupae move to the tip of the spikelet, and on emergence, the pupal case remains attached to the chaffy spikelet.

Control

- Early planting at the onset of rains to escape the sorghum midge population build up.
- Planting sorghum varieties with same maturity period at the same time within the communities.
- Sorghum that flowers later than the rest is exposed to higher populations of the sorghum midge for a longer period and suffers severe damage.
- Removing alternative hosts such as Johnson grass and Sudan grass to reduce on the initial early buildup of the pest.
- Field sanitation before the onset of the rains lowers the carry over effect of the diapausing larvae or pupae to subsequent seasons.
- Crop rotation with other none host crops.
- Land fallowing reduces the carry over and build up of sorghum midge populations and use of resistant or tolerant sorghum varieties.
- Use of inorganic insecticides as the last resort to prevent severe damage can be done and a combination of the above sorghum midge control strategies as integrated pest management is effective in reducing crop damage.

Sorghum shoot fly

- The female shoot flies lay eggs singly on the lower surface of the leaves from 5 to 25 days after seedling emergence.
- The eggs hatch within 1- 2 days and the larvae moves and bores into the base of the shoot, damaging it to cause wilting and subsequent dead heart symptom.
- The plant may produce tillers as a survival mechanism in response to damage.
- Shoot fly population is normally high if sorghum is planed late (usually a month after the onset of rains).
- During off season the shoot fly survives on alternative hosts such as millet and maize.

Control

- Use of shoot fly resistant varieties.
- Early planting at the onset of the rains.
- Use a botanical insecticide Neem oil 2%.
- A Combination of the above as integrated pest management is effective in reducing crop damage.

Bird damage in sorghum

- Birds are very destructive pests affecting sorghum productivity in Uganda.
- Several bird species are destructive but the Quelea quelea and the weaver birds are the most important.
- The Quelea quelea affects mainly the soft dough stage of especially the white/cream seeded varieties while the weaver birds affect the hard dough stage.
- Depending on the season the red seeded varieties may be less affected.
- Birds. Bigger birds such as doves consume whole seed while smaller birds such as the Quelea quelea break the seed and eat portions exposing the white endosperm of the seed mainly during milky stage.

Common sorghum Diseases

Striga (witch weed):

Striga, commonly known as witch weed, is a parasitic weed the affecting many cereals including sorghum. It causes 20-80% grain yield loss under severe infestation.

Sorghum rust:

Rust disease, caused by Puccinia purpurea, manifests as brown blister-like pustules formed on the upper and lower side of the leaf.

Northern leaf blight:

Symptoms of Northern corn leaf blight disease include long elliptical shaped lesions with grey centers and tan to red boarders.

Anthracnose:

Small circular leaf lesions develop into mature lesions with straw-colored centers that are reddish and blackish purple, and later coalesce into larger necrotic tissue.

Covered kernel smut:

Covered kernel smut disease (Sporisorium sorghi) affects the panicle damaging developing sorghum grains.

Sorghum Havesting

Harvesting is done when the crop reaches physiological maturity which is indicated by the following indicators: ·

- The spot where the grain attaches to the inflorescence turns from green to black.
- Yellowing and drying of leaves

Post-harvest Handling of sorghum

- Field drying
- Threshing
- Winnowing
- Packaging
- Transportation
- Sorting and grading
- Storage
- Marketing

Cassava Production

Introduction

Cassava is the second major staple food in Uganda. It is important as it is also a source of household income and can be used for industrial use such as pharmaceuticals, and livestock feeds. In the Greater Nebbi districts (Pakwach, Nwebbi and Zombo), it was identified as a strategic crop by the district production departments.

Common Cassava Varieties

Variety	Maturity period	Yield (kg/acre)	Tolerance to Cassava Brown Streak Disease (CBSD)	Resistant to Drought
NASE 14	12-18 months	10,000 – 12,000	Tolerant	Resistant
NASE 19	12-18 months	10,000 – 12,000	Tolerant	Resistant
NARO CASS 1	12-18 months	10,000 – 12,000	Tolerant	Resistant
NARO CASS 2	12-18 months	10,000 – 12,000	Tolerant	Resistant

Ecological Requirements

- Cassava grows at all altitudes but best on low to medium altitudes. (800-1,500 a.s.l)
- Cassava thrives best when rainfall is well distributed throughout the growing season at 1,000-1,500 mm.
- Avoid acidic soils which is generally noticed by presence of ferns.
- Cassava needs an optimum temperature range of about 25-32 degrees centigrade in order to thrive.

Pre-cultivation Requirements

- Do a price and market survey on the cassava products you are to sell.
- Do supply requirements in terms of quantity and frequency to those you are selling to.
- Know your potential buyers.

Site Selection

- Choose deep flat soils as they are best for cassava, but gentle slopes could also be used.
- Fertile loam soils are the best, test using hands by moulding moist soil into a ball that breaks easily
- In hilly areas, dig terraces to avoid soil erosion.
- In swampy areas, plant the cassava on a ridge, this improves drainage.

- Avoid stony, clay or places that periodically have water logging
- Avoid re-planting cassava in areas that have been used for cassava production in the immediate previous season to avoid build up of pests, diseases and soil nutrient depletion.

Size and shape of cuttings

- Use a sharp machete/panga and avoid damaging the cuttings.
- The cuttings should have 5-7 nodes.
- The average size of the cutting should be 15-25cm.
- Cuttings should be well packaged and labelled for traceability.
- Avoid cuttings from the tip of the cassava stalk as they may fail to sprout.

Land Preparation and Planting

Land Preparation

- Should be deep ploughed to allow root penetration and root filling.
- 1st land opening should be at least 2 months to the time of planting to allow decomposition to take place. for weeds to dry up and the remains ploughed into the field.
- Cassava can also be planted on ridges for good root penetration.

Planting

- In Uganda cassava is planted by hand. Planting is done at the onset of the rain season.
- Stem cuttings are planted at a spacing of 1x1m give 4,000 plants per acre.
- You can cut the sticks obliquely or at a right angle to the stem being cut.
- You can then plant your cutting vertically or at an angle, with half their length in the soil, or horizontally, flat below the surface and cover the entire cutting with soil.
- Take care not to put the cuttings too deep and covering with a lot of soil as this will delay sprouting
- Plant using a hoe, in lines for optimum plant population
- Locally you can use Neem leaf powder. In 5liters of water add 1 kg of the powder
- Measure out the required quantity and then put the cuttings in to the solution for 10 min to kill of some of the pests and disease-causing organisms before planting

Fertilizer: A farmer is encouraged to apply organic manure to the cassava field.

Intercropping

- Cassava can be intercropped with beans
- Intercropping should only be done in the first 3 months, after which the cassava should be left to grow alone in the field.

How to weed cassava in Uganda

- Weeding your cassava plantation is so important during the early stages.
- It's good to interplant your cassava with other crops like beans during early stages to suppress the weeds, you need to weed 3 to 4 weeks after planting.
- Earth up plants (add soil on plants) during weeding as this greatly helps in tuber formation.
- You may also use some chemicals to control weeds.

Management of weeds

- Weed control is very critical in the 1st to 3rd month of the cassava crop.
- Weed competition can cause about 30-60% yield loss.
- Do your 1st weeding in the 6th week after planting and weed the crop 2 – 3 more times to keep away competition for nutrients by weeds and providing alternative host plants for pests and diseases.

Cassava Pests and Disease Management

Pests

Cassava Green Mite

- To avoid this pest, make sure to plant early at the onset of rains.
- Biological control through using predatory mites and parasites.
- Carry out crop rotation.
- Integrated Pest Management is also highly advisable.

Cassava Mealy Bugs

- They are effectively controlled by their natural enemy, a parasitic wasp.
- Use integrated pest management.
- Routine checks through the garden are also highly advised.
- Plant resistant and tolerant varieties.

Termites

- Termites attack cassava plants at any stage.
- They eat up the cuttings and they fail to sprout
- They can eat up the growing cassava stems leading to drying and death of the plants. This is more pronounced during the low soil moisture periods

Common Cassava Diseases

Cassava Mosaic Disease

This is a viral disease which is usually transmitted through infected planting material and by whiteflies. Infected leaves are yellow, mottled, and distorted. If leaves are yellow or brown all over but are a normal size that does not indicate CMD

Symptoms

- Chlorosis where plants produce insufficient chlorophyll.
- Mottling of leaves
- Leaf fall.

Control

- Plant resistant or tolerant varieties e.g. the NASE varieties (e.g. NASE 14, 15, 19, NAROCAS 1, 2).
- Practice crop rotation with legumes.
- Use disease-free planting material.
- Rogue infected plants
- Use clean planting materials
- Avoid too wide spacing

Cassava Brown Streak Disease

Symptoms

- Venial necrosis.
- Brown streaks on the stem.
- Necrotic dry rot on the roots.

Control

- Planting cuttings from disease-free areas/gardens after being certified by MAAIF.
- Planting tolerant varieties e.g. NASE 14, 19, and NAROCAS1. (Farmers should from time to time seek advice from Extension staff on the latest tolerant varieties)
- Uprooting and burying or burning diseased plants or entire field.
- Integrated disease management.
- Most CMD resistant/tolerant varieties are susceptible to CBSD but the tolerant varieties currently recommended to farmers include NASE 14, 19 and NAROCAS1.

Cassava Bacterial Blight

Symptoms

- Angular leaf spots on the under the leaf surfaces,
- Leaf blighting and wilting,
- Gum exudate on the stems,
- Shoot tip die-back.

Control

- plant healthy plants
- plant tolerant varieties like Nase3,14.

Cassava Harvesting

Depending on the variety, harvesting cassava for food could begin from the 7th month after planting for early maturing varieties, or after the 10th month for late varieties. For a smallholder farmer you can harvest the tubers as you need them; without cutting the stems, begin by taking the biggest tubers from each plant, leaving the small ones to give them time to fill up. Commercial farmers would typically harvest all the cassava at the same time.

Once cassava is ready it should be harvested, because when left in the ground for a long period your cassava tubers will lose quality due to hydrolysis of starch.

Harvesting Stem Cuttings

- Harvest the stems and roots at maturity period: 12-18 months.
- The stem should be preserved under a tree shade and the ground kept moist.
- Ensure only mature and healthy cassava stems are cut and stored.

Harvesting Cassava

- For long term storage (1-3 months), and/or during a prolonged dry spell, tie the stems into bundles and store upright under a shaded tree and moisten the soil regularly.
- For short term storage (2-4 weeks), put stems horizontally for support under the shade.
- Use a wheelbarrow, basket or bicycle to transport cassava from the garden.

Post-harvest Handling of cassava

- After harvesting, the cassava can be processed in different ways depensing on the intended use. However, regardless the use, the following are basic points to note.
- Harvest the tubers with care to ensure minimum damage to them. This ffects the quality of the final product expected.
- Transport the cuttings immediately after harvesting and ensure they are handled with care to avoid post-harvest damage.
- Proper peeling is then done not later than 24 hours after harvest. Keeping the cassava unpeeled for longer periods will lead to discoloration of the tubers
- The peeled tubers are then washed to remove any soil that could have got into contact with the tubers
- It is then cut into chips and spread on a tarpaulin or other material for drying. Never dry cassava chips on bare ground.
- Ensure the moisture content of the chips is monitored to avoid quality deterioration in storage.
- Pack the properly dried chips in a safe place, protected from rodents and rain as these can lead to high storage losses.

Carefully harvest the ready tubers. Sort the tuber according to damage, colour.

Transport the tubers home and put in a shade. Sort the tuber according to damage, colour.

3

Peel the cassava tubers wholly, on the same day of harvest

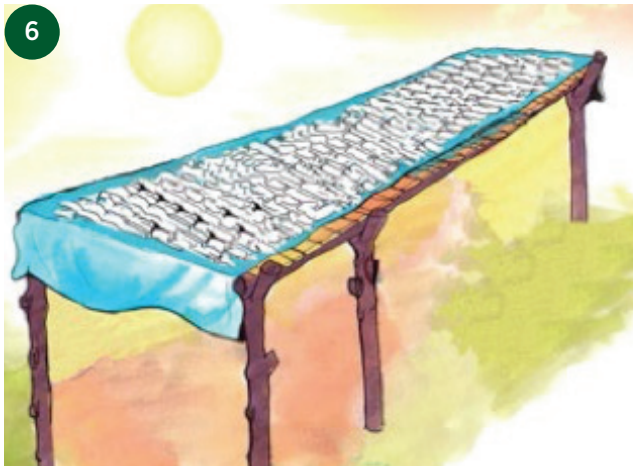
4

Wash the peeled cassava tubers with clean water

5

Slice the cassava into thin pieces to facilitate fast drying

6

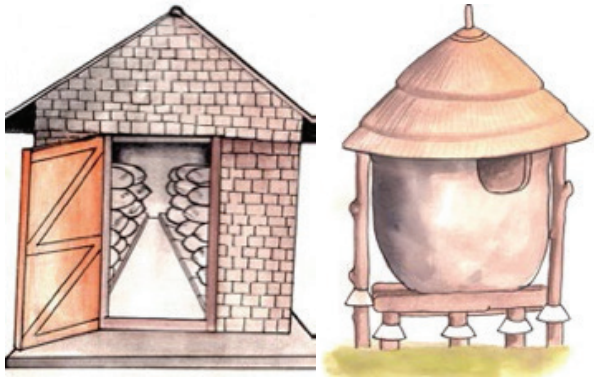


Thoroughly sundry the cassava chips for 3 to 5 days

7

Break the cassava chips and see if there is no moisture or pound the chips in a mortar to obtain fine flour.

8



Pack the dry chips in clean bags and put the bags on pallets in a well-managed store or granary

Banana Production

Introduction

Bananas/plantains rank highest amongst the most important food crops in Uganda. Annual producüon is currently estimated at 8.45 million tons, accounting for 15% of total world banana/plantain output. In Uganda, over 7 million people including 65% of the urban population depend on the crop as their staple. It is estimated that 75% of the fanners grow the crop on 1.3 million hectares.

Importance of banana growing

Apart from providing food, bananas ensure income to the farmer throughout the year, play a key role in import substitution, provide soil surface cover, reduce soil erosion on steep slopes and ate a principal source of mulch for maintaining soil fertility and improving penetration of water into the soil. Bananas also provide feeds for animals.

Bananas make a major contribution to the economy of Uganda. Production is mainly by small-scale farmers with two main objectives: (1) food for humans and livestock; and (2) income. Bananas are an essential component of household food security in many districts because they are harvested throughout the year with peak production during certain months.

In spite of its economic importance, the banana is currently under threat posed by constraints such as declining soil fertility, pests and diseases. This manual outlines key management practices used in the growing of bananas. It has been written as a reference source suitable for various banana producers.

Banana Plantation Establishment

Requirements

Climate

Bananas grow best in areas with a monthly temperature range of of 2TC. The lowest mean annual temperature for growth is 120C and temperatures beyond 3TC can cause leaf scorching. They have a high water demand, with approximately 25 mm per week being the minimum for optimum growth. An average annual rainfall of 1500-2500 mm, which is well distributed is considered the most optimal. However, with good management of available water, bananas can even grow in areas with mean annual rainfall lower than 1200 mm.

Soil requirement

Bananas require a deep, well-drained loam soil with high humus content. Bananas require considerable amounts of Nitrogen, and Potassium to maintain high yields.

Preparing the field

If the plantation is to be established on fallow land (3 to 5 years), the field should be slashed and left without being burned. Burning is not usually recommended because useful organic matter is destroyed.

Generally, two ploughings are suffcient to provide a good seedbed for the banana plantation. About four weeks should be left between each cultivafion to allow germination of weed seeds that are then killed by the following cultivation. However, planting holes may be made directly in cleared land. The successive weeds are then cleared with a hoe.

Spacing and hole size

The recommended spacing is 3m between and 3m within the row (3m x 3m). Rows should be straight in flat fields to allow plants to receive maximum amount of sunlight. On sloping land, rows should follow the contour lines to decrease soil erosion.

Dig holes that are 45cm deep and 45cm wide.

Planting Material

Source

The planting material should be obtained from healthy plantations (free of soil borne diseases and pests). All planting materials should first be treated (see section 2.4.4 and 4.1.2) to remove or kill pests in the corm and roots. Micro propagated plants (tissue culture plants) are the best for pest/disease free planting material.

Cultivars

A number of banana cultivars exist in Uganda, some are local, while others are exotic. Some cultivars are preferred over others, and preference varies from one place to another. Although the criteria for cultivar preference also varies among farmers and/or locations, that give a bunch a good market value are considered first. Generally the most preferred culfivars include those, which have one or a combination of more than one of the following characteristics: big bunch, compact bunch, medium size fruits and tasty food.

Several Matooke cultivars that have the above mentioned qualities have been identified by the National Banana Research Programme, which promotes their distribution and cultivation countywide.

All the other banana types imported into the country long after existence of the Traditional types are referred to as exoüc. 'Ihey include early introductions like Bogoya, Ndiizi, Kayinja (Plate 1b), Kisubi and Kivuvu, and recent introducüons like FHIA 01, FHIA 03 Kabana 1, 17 Kabana 2, 21, FHIA 23 Kabana 4, and Km5 as shown in Plate 3.

Types of planting material

Below is a list of different forms of planting materials including the few that are currently recommended in Uganda

a) Sword sucker (sucker 30 - 100 cm high and with narrow leaves)
b) Maiden sucker (about 2 m high, and not yet flowered) or its corm.
c) Bullhead (corm from a plant which has been harvested) with or without a sword
d) Bullhead sections (corm pieces with a bud/eye)
e) Tissue culture plantlets

Sword sucker | Maiden sucker | Tissue culture plantlets | Bullhead sections | Aerial view of a Bullhead

Sword suckers, maiden suckers and tissue culture plantlets are the ones most recommended currently. Avoid water suckers (field suckers with broad leaves) shown in figure above

Preparation of Planting Material

Uproot a selected sucker using a very sharp hoe to reduce damage to the mother plant. If it is a maiden sucker cut it back just below the crown. If a lot of planting material is needed and is collected from far, the maiden sucker may be cut at about 15 cm above the conn - pseudostem joint (Figure 2a) to reduce bulk. Sword suckers (Figure 2b) should not be cut back. To avoid taking weevils and [or nematodes to new fields all roots and the outer layer of the corm, and old leaf sheaths should be peeled off. Try to remove all tunnels (formed by weevil larvae) and reddish-brown or black tissues (necrosis due to nematodes). If the tunnels go deep into the corm then such a sucker should be discarded for it may be carrying weevil larvae inside the tunnels. Cleaning of suckers should be carried out in the field where the planting material is obtained to avoid contamination of the new field with the pests.

Figure 2.Preparing, cleaning and sorting planting materials

As an additional treatment, suckers can be dipped in hot later at a temperature between 5200 and 550C for 20 minutes or in a pesticide solution to kill the deeply embedded pests (See section 4.1.2 for details). For better germination, it is advisable to plant the treated/ cleaned planting material within a week of uprooting. If there is need to store them temporarily, they should be kept in shade (never exposed directly in the sun) and away from an established plantation as the latter may be infested with weevils. The weevils may attack and lay eggs on the cleaned material before it is planted.

Planting

Planting should be done at the beginning of a rainy season, as banana suckers need 4-6 months of growth without water stress. The sucker is placed in the hole and its conn is covered, first with the topsoil, mixed with manure and then topped up with the subsoil. If the land is sloping, the sucker should be so oriented that the future ratoon emerges against the slope.

Note: If the planting materials were not cleaned further with a pesticide, you may apply insecticides or nemaücides in the hole and on top of the soil after planting, using recommended manufacturers' rates.

Banana Plantation Management

Weed Control

Weeds compete with the banana plants for nutrients and water. This may lead to stunte growth of plants. Banana plantations must therefore always be kept weed fiee Different methods exist for controlling weeds and their suitability depends on the age o the plantation and availability of labour/funds. They include weeding by hand, hoe herbicide.

Hand weeding

If weeding is by hand, the weed residues should be heaped together in the plantation so as to confine the weed seeds in one or a few places. Although it is laborious, hand weeding is better than hoe weeding as it is less destructive to the delicate banana roots and soil structure. It is however most applicable where weed density is very low, such as in mulched plantations.,

high-density weeds can be removed faster by hoe weeding and fastest by spraying Otherwise with a herbicide. Note that hoe weeding is not recommended because of the damage it causes to the feeder roots.

Mulching and cover crops

Mulching reduces the amourt of weeds in a plantation by choking the established weeds and denying light to those that require it for germination. Additionally, mulch helps water to penetrate deeper into the soil and it prolongs its retention. It also returns nutrients to soil as it rots, thus improving soil fertility. The following are some of the sources of mulch:

a) Banana plant residues. When leaves get old (senescent) prune them off and spread them between rows of the banana plants also split pseudostems of harvested, pruned and toppled plants and place them between rows.

b) Annual crop residues, e.g. maize stover, bean trash, etc..

c) Grasses, e.g. elephant grass, swamp grass, Guatemala grass and Guinea grass (chopped and dried).

Farmers should note that mulching sometimes provides good homes for pests such as the banana weevil. Mulches should therefore be placed away from the base of the mat so as to reduce weevils that may get in contact with the plants. The recommended distance is 45 cm (1.5ft) from the mat. Sometimes, instead of using mulch, cover crops are used with the same benefits.

Plant nutrition

As a plant grows it takes up nutrients from soil. A large amount of the nutrients taken up from soil by a banana plant goes into the fruits (bunch). When banana fruits are harvested, they go with the nutrients especially in the peel. So the only way to maintain soil fertility is by regularly or continuously putting back nutrients in form of organic fertilizers. If fertility is not maintained in this way, even the most fertile soils will gradually become unproducüve. Farmers commonly use farmyard or compost manure. Well-rotted manure may be placed in planting holes or on the soil surface.

Organic fertiliser sources

The following are some of the organic materials that provide essential nutrients.

- Crop residues e.g. bean hulls and stalks, maize, sorghum and millet stover,
- Other plant residues e.g. swamp and elephant grass (chopped and dried)
- Animal waste e.g. cow and chicken manure

The above materials can be applied individually and directly or can be combined and composted. Mature compost manure is mixed with soil and placed in a planting hole at planting. In established plantations it may be placed on the soil surface in a ring or furrows 45 cm from a mat or be ploughed in the soil.

Fertilizer application

Remove trash up to 30 cm away from the plant. Spread well-rotted manure about 30cm away from the stool.

Nutrient deficiency symptoms

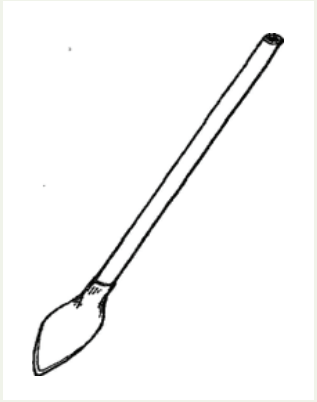
Nutrient symptoms can easily be mistaken for diseases and so, technical advice should be sought from the sub county Agriculture staff for proper identification and guidance. Most deficiency symptoms are shown in the leaves eg the colour, size and numbers as well as bunch size and rate of growth of the plant itself.

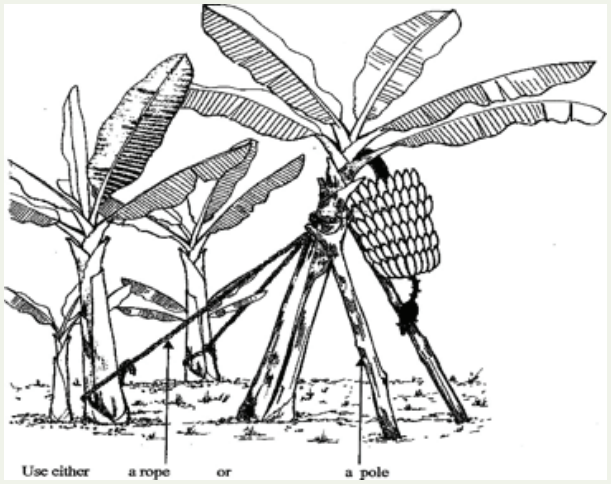
Sucker removal and mat management

Sucker removal is carried out to maintain the appropriate plant density and ensure that the number of bunch bearing plants is maintained at a level which reduces competition (for water, light, nutrients) and gives high yield. Farmers are advised to maintain 3 plants on each mat: a mother, one daughter and one granddaughter. That is, only one sucker from each successive generation is allowed to grow. ft is better to select easterly facing suckers to maximize on morning sunshine the plantation is on a slope. While pruning make sure that the growing point of the unwanted sucker is killed. This is best done by using a spear-like tool. Cutting off the sucker at ground level is not effective as the sucker will grow again. The growing point is in the corm at about 5 - 10 cm below the ground. To kill it the sucker's pseudostem is cut off near its corm and the pointed tool (Figure 5) is twisted in the growing point, thus killing it.

Leaf removal

Leaf removal is important for maintaining plantation hygiene and light penetration. Dead hanging leaves cover Figure 5. A tool for removing young suckers while old sheaths on the base of pseudostem provide a home for adult banana weevils. The non-functional leaves also reduce air movement around plants thus encouraging high humidity build up. Therefore, old leaves and sheaths should be removed and can be used as mulch. Note that only those leaves whose green part is less than 50% should be cut off The plant should be left with at least 9 functional leaves at flowering and should be having at least 4 leaves at harvest. Complete removal of leaves from the plant prior to harvesting is not recommended, as it will start the ripening process prematurely.





Bud removal

The male bud should be removed when the peduncle is at least 15 cm below the last female hand or when the fingers on clusters just turn upwards. Break/ cut the peduncle 15 cm below the false cluster/hand taking care not to damage the fingers. Bud removal helps to reduce fruit diseases like cigar end rot, which are transmitted by insects that visit the bud bracts and leads to bigger banana fingers in some cultivars (e.g. FHIA 21).

Propping/ Guying up

Propping/guying up of banana is done in order to prevent the plants with maturing bunches from breaking or toppling. The heavy weight of the banana bunch bends the bearing plant and can cause doubling (pseudostem breaks), snap-off (corm breaks, leaving a part in the ground) or uprooting, also called toppling (the entire corm with roots comes out ofthe yound).

Plants are generally weak during the dry season. Strong winds, nematodes and weevils also increase the chances and/or rate of plant toppling. For these reasons, bearing plants, especially those with heavy bunches, always need either wooden pegs (poles) or ropes can be used as shown in Figure 6.

Intercropping

Bananas can be combined with practically any type of cultivated or wild plant, which has similar requirements. Young banana plants are excellent nurses for other crops and forest plants (cocoa, coffee, black pepper etc.), which can be planted very close to the bananas. During the first year bananas should be intercropped with shallow rooted crops for ease of weeding.. However, it is important to give each crop its right spacing. It is noted that intercropping, especially in newly planted fields, has some advantage in that the land gives a return before the banana crop is ready for harvest. It is best not to inter-crop green manures such as tephrosia, mucuna and canavalia in banana. Green manures and other inappropriate intercrops compete with banana for nutrients and water, which may lead to soil exhaustion and plant health problems Supporting of fruit-bearing plants: either ropes or poles are used.

Soil and Water conservation measures

Fanya juu, fanya chini

If your banana plantation is on a steep slope, make fanya juus (Figure 7). That is, dig trenches 60 cm (2 R) wide and 60 cm 2 ft deep across the slope putting soil on the upper side of the trench. These should be 10 to 20 paces apart. Fanya juus prevent the washing away of soil down the slope when it rains. They also increase the amount of water entering the soil. The same (preventing soil erosion and increasing water entering the soil) can be achieved by use of grass bands. Vetiver grass is recommended for this, as it does not compete with the bananas for nutrients. Grass (vetiver) can also be grown on the fanyajuu to stabilize it. Dig ditches or trenches in your field to hold rainwater flowing down a slope. This increases the amount of rainwater entering the soil and reduces soil erosion

Water retention ditches

Dig ditches or trenches in your field to hold rainwater flowing down a slope. This increases the amount of rainwater entering the soil and reduces soil erosion

Banana Pest Control

The banana weevil and plant parasitic nematodes are the most destructive pests of bananas in Uganda. These pests may cause severe yield loss if not controlled.

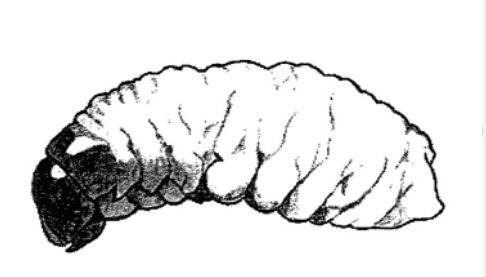
Banana Weevil

Banana Weevil damage and symptoms

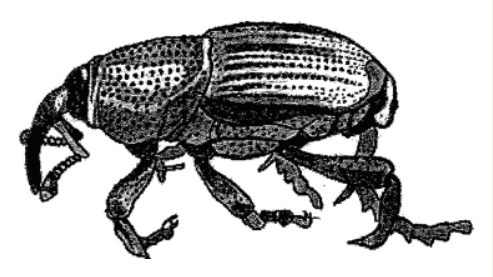
Weevil damage results from larvae (Figure 9a) feeding and tunnelling into banana corms and pseudostems. The larvae hatches from an egg which is laid near the conn by an adult weevil (Figure 9b). On hatching the larvae attack the underground part, boring tunnels in it. As weevil larvae grow in size, they make large tunnels in the corm and sometimes up in the pseudostem (Figure 10). The damage interferes with uptake of nutrients and water thus weakening the plant.

Weevil infestation of young plants causes stunting of growth, disruption and delay of fruiting, production of small bunches and sometimes plants death. Heavily infested and damaged plants easily snap (breaking of pseudostem just above the ground as shown (figure 10) under a mild wind, especially flowered plants.

The banana weevil larva (a) and adult (b)



a) Banana Weevil Larva



b) Adult Banana Weevil

Control of the Banana Weevil

The banana weevil is controlled by using cultural practices (e.g. clean planting material, proper field sanitation and trapping), biological agents (e.g. fungal pathogens) and resistant cultivars.

Use of clean plaiting material:

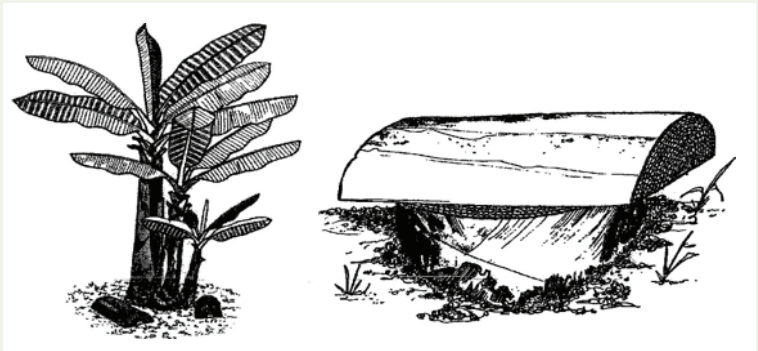
Clean (weevil free suckers/corms) planting material should be used when establishing a new plantation. Such material is obtained by selecting suckers from a plantation with low weevil and nematode infestation.

The suckers or corms are pared (carefully peeling the corm to expose the inner white tissue) to remove symptoms of weevil and nematode damage. Deeply tunnelled corms should be discarded. The pared material should be removed from the plantation immediately to avoid adult weevils laying eggs in it. To ensure a greater level of cleanliness the pared corms can be subjected to hot water treatment

Note that weevils from neighbouring fields can move into the new field and attack the planted clean materials. Field sanitation and trapping should therefore be regularly done to keep immigrant population in check.

Good husbandry: field sanitation

This involves clean weeding, sucker removal, pruning, manuring and mulching. These lead to production of vigorous plants, which are less affected by weevil darnage compared to stressed (poorly managed) plants. In order to reduce hiding and breeding sites for adult weevils, always split or chop up harvested and toppled plant's pseudostems into small pieces that can dry up quickly. Also remove and chop up old corms/ stumps to expose weevil larvae and eggs to desiccate.



Trapping

There are two types of traps most widely used, split pseudostem and disc-on-stump traps. The split pseudostem traps are made from 35-45 cm long pseudostem pieces of fresh material cut into 2 equal pieces lengthwise. The two halves should be placed with the flat side facing down on the cleared soil surface close to and on opposite sides of a mat.

The disc-on-stump traps are cut from stumps of lecently harvested plants. The stump is cut horizontally 15-25 cm above ground level and a 8-10 cm disc of pseudostem is placed on top. The traps should be turned up to remove the trapped weevils three days after laying the traps.

Nematodes

Nematode damage and symptoms

Nematodes are very small worms and cannot be seen with naked eyes. ‘They live and feed inside roots and corm thus destroying them. (They, however, move out into soil when conditions are not favourable in roots.) A mot or corm damaged by nematodes shows reddish-purple lesions or patches (necrosis) when split or peeled. Root necrosis results in premature root death. The necrosis interferes with the water and nutrient movement into the plant.

The most obvious symptom of nematode damage is the toppling over of the entire plant, particularly those bearing fruits

Management of nematodes

Use of clean planting material in clean field:

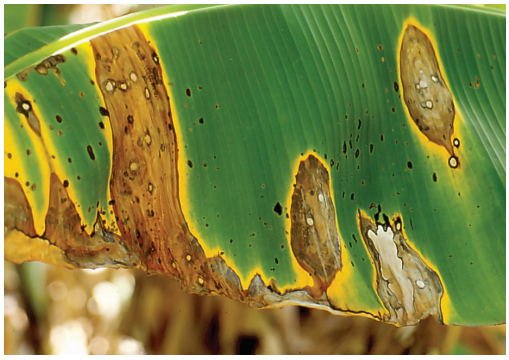
In general, damage to the banana root system results in stunted plant growth, premature leaf drop, reduced vigour, delayed maturation, slow ratooning, small and poorly filled bunches and increased susceptibility to water deficiency.

Banana Diseases

Bananas and plantains in Uganda are attacked by several pathogens some of which are fixngal, others viral, and others bacterial. They cause different diseases including leaf spots and vascular wilts.

Leaf spots

There are two economically important leaf spot diseases on bananas in Uganda. These are black Sigatoka and leaf speckle. Black Sigatoka causes rapid death of the banana leaves. It is therefore the most important as it can kill all leaf, thus reducing the ability of the plant to manufacture the food needed for growth and filling up of the bunch



Factors that favor leaf spot diseases

Leaf spot diseases, especially black Sigatoka is seen to be more serious in the rainy than dry season. This is because the fungus requires water for producing and spreading the spores that infect other leaves or plants. High humidity in the field also encourages rapid development of the disease. Conditions that encourage high humidity in the field include high plant density, poor field sanitation, high weed growth and poor drainage, in addition to heavy rainfall.

Control of leaf spot diseases (black Sigatoka and leaf speckle)

The cheapest and most effective method of controlling plant diseases is by use of resistant cultivars. They can also be controlled by practices that reduce humidity in the field. These include maintenance of correct spacing, good field sanitation, absence of weeds and good drainage. Good fertilisation of the banana plant also reduces the impact of leaf spot diseases

Fusarium wilt disease

Fusarium wilt, also Imown as Panama wilt is a soil bome disease. It is known to be the most destructive disease of bananas in Uganda as it may lead to losses of up to 100% in a farm of susceptible cultivars. It is known to attack four types of bananas in Uganda: Bogoya (Gros Michel), Sukari-Ndiizi (apple banana), Kisubi and Kayinja.

Symptoms of Fusarium wilt

Symptoms of the Panama disease include yellowing of leaves, or premature collapse of leaves. Exarnination of a cross section of a pseudostem and/or corm reveals a characteristic discoloration of the vascular bundles, usually stained purplish brown. Sometimes the leaf sheaths loosen and/or the pseudostem splits. A severely infected plant fails to flower, or if it does, the bunch fails to develop and fill up.

Control of Fusarium wilt

It has been observed that the severity of banana wilt diseases can be minimized by applying sanitary measures like removing infected plants and applying properly decomposed household refuse to banana fields.

Harvesting and Post Harvest Handling

Generally, bunches take 3 to 5 months to mature from the onset of flowers. Hybrids and exotic bananas have been found to take slightly longer than local cultivars.

The fruit is cut from the stems in the field and the stems remain to provide valuable mulch to enrich the soil.

When to harvest

To develop their fill characteristic flavour, taste and colour during storage (or when intentionally ripened) fruits need to be picked at optimum maturity. Fruits harvested young are more susceptible to shriveling, mechanical damage and have poor eating quality when cooked or upon ripening

How to harvest

The harvesting system depends upon the type of banana and the market In every case though, a cut should be made with a panga in the pseudostem (trunk) which allows the bunch to descend slowly under its own weight or with the help of a tug on the lower end of the bunch stalk. For local market fruit the upper end of the stalk above the fruit should be sliced through whilst holding the lower end up (Figure 15). The bunch will then fall through 180 degrees and land balanced on the thick end of the stalk, with no damage to fruit. Some bunches may be too heavy or too high for this system to work, bm every effort should still be made to prevent the bunch falling heavily on to the ground. Fruit that is bruised during harvesting has a shorter post-harvest life, ripens quickly, and may not have good eating quality.

Figure 15. Harvesting should be carried out without the bunch bouncing on the ground

Storage

Bananas often have to be stored for a few hours or days, and at different points in the markefing chain, before they are finally sold. The most important point to remember during storage is that the fruit should be kept as cool as possible.

In major exporting countries, refrigeration is often used during storage and transport, to ensure a long shelf life and good quality. In Uganda this is not available so bananas must be stored in a well ventilated pace, out of the sun. The common practice of leaving the fruits exposed to direct sunlight and in heaps should be avoided.

Bananas must not be stored where there is smoke or exhaust gases from trucks since these cause ripening to take place quickly.

Figure 16. Dehanding and drying of latex for export

Alternative uses of bananas

Bananas in Uganda ate currently largely used in their fresh form (i.e. either in leaves and steamed, boiled or roasted). Dessert bananas (Bogoya and Ndizi) are usually eaten ripe and used for making pancakes (Kabalagala). The most common form of processing is beverage production from beer6uice banana cultivars (juices, beer, waragi).

Apart from these common uses, bananas can be processed into other products such as figs and flakes by drying ripe bananas. Green bananas can be fried to make crisps. They can also be dried into chips, which can later be reduced into flour. The flour can then be used to make many different bakery and fried products, or could be used as ugali. Juice processing can also be improved by employing enzymatic extraction and preservation of the final product.

Bananas are also a key source of raw materials for art and crafts. They are sources of banana fibres that are used in weaving baskets and mats, as well as locally made balls. They are also used as decoration materials

They also supply a key component in animal feeding.

Orange Flesh Sweet potato Production Manual

Introduction

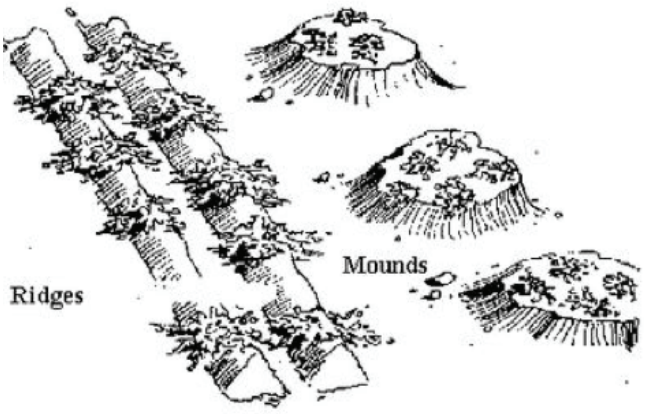
Sweet potatoes are an important food crop grown and consumed by majority of Ugandans. It takes a relatively short time to reach maturity in about 3 to 6 months as compared to cassava which requires longer periods to mature. This means that sweet potatoes can be a faster solution to food insecurity given year. Additionally, potatoes can be produced under marginal conditions such as low soil fertility and low moisture supply

Planting

Sweet potato is either planted on mounds or on ridges using vine cuttings. A good vine cutting should be about one foot long or about 6 nodes and should be disease free. 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.

Importance Of Orange Flesh Sweet Potato

The orange flesh sweet potato is rich in important minerals that are require in the human diet. They supply up to 100% of the vitamin A required in the body to provides a much-needed boost to the immune system and helps prevent serious conditions like early



onset of blindness. Storage roots can be eaten, boiled or even processed into simple products such as chips, juice, pan-cakes and composite flour. Potatoes can also be sold to supplement family income. The stems and leaves are used to feed livestock, while tender (young) leaves are consumed as vegetables. Sweet potato has a wide range of use and benefits, among them, chipped and milled into flour for making snakes and baby foods and boiled and eaten as food for families. Orange-flesh sweet potato (OFSP) is rich in pro-vitamin A, which contributes to normal eyesight, healthy skin and mucous membranes, healthy cell growth, reproduction, and immunity to diseases such as malaria, measles, and respiratory diseases.

Site Selection and Land Preparation

Sweet potatoes can be produced in low and high altitudes as long as the soils are fairly fertile. Moderately fine deep sandy loam soils are ideal. Avoid swampy or water logged areas because excessive moisture lead to tuber rotting.

Seedbed for sweet potato should be fertile and well prepared without big soil clods in a well-drained area. Land should be prepared early enough to allow decomposition. In soils that are prone to drying, small mounds are used; big mounds in such a case are over exposed to sunshine and they dry out very fast.

The numbers of vines used do vary, as small mounds will take few vines and the big mounds accommodate more vines. Planting is mostly done by hands, but you can plant sweet potatoes using forked sticks in some cases. Vines for planting should be picked and allowed to wilt in the shade for a week before planting.

This ensures that the vines do not break during planting as fresh vines are brittle. These vines also root easily and ensure faster establishment of the crop in the soil. Plant each vine 15cm deep so that many nodes are covered by the soil. While it is recommended to plant at 30cm between plants and 60-90cm between the ridges, where planting is done on mounds, it is the size of the mounds that will determine the spacing. Ridges should be 0.5 to 1 m high.

Selection and Preparation of Planting materials

Propagation is commonly done using vines. They should be selected from a healthy known garden free of pests and diseases. The vines are cut 30-45cm long using a sharp knife. They are then left for 2-3 days to allow loss of some water and develop nodes, after which they are planted.

Weed Management

Sweet potatoes should be kept weed free in the first month this is done by weeding around the ridges/mounds, normally done with a hoe in between the ridges. The ones on plants can be hand-picked. After about 2 months, the canopy of the crop is normally big enough, covering the ground and this helps to keep away weeds.

Pests Management in Sweet Potatoes

Wireworms

Symptoms

Like the sweetpotato weevil, the wireworm larvae destroy sweet potato roots. The firm-bodied larvae can live in the soil up to four years, and they eat tiny, circular holes in the roots.

Control

Early planting and deep plowing can kill larvae

Potato Weevil

Symptoms

- Thickening and malformation of vines and often cracking of the tissue.
- Discoloration, cracking, or wilting of damaged wines.
- An infested tuber is often riddled with cavities or tunnels.
- Attacked tubers become spongy, brownish to blackish in appearance.

Control

- Crop rotation with rice between two sweet potato plantings
- Use insect-free vines as planting material
- Harvest the crop immediately after maturity
- Avoid or minimise cracks in the soil
- Soil up at 50 days after planting

Potato stem Borer

Symptoms

Larvae bores into the stem leading to the storage roots. Feeding in the crown region leads to wilting, yellowing and dying of plant. The borers can be easily identified by the presence of fecal matter on the soil surface and holes on the stem.

Control

Keep the field free from weeds especially Ipomoea spp. Fallow the land for few season if infestation is more. Use insect free planting material. Use pheromone traps to monitor and control the insect

White grab

Grub feeds on underground parts including main stem and roots. They also feed on tubers by making tunnels. The infected plant become wilted and die eventually.

Control

Cultural practice: Deep summer ploughing to expose grub and pupa present in soil. Provide proper drainage to soil to avoid excess moisture. Follow crop rotation with soybean to reduce grub population. Application of biocontrol agents like Bacillus popilliae and B. lentimorbus bacteria kill the grubs.

Other pests include rats and animals like goats and cows as well as monkeys

Diseases Management

Black Rot

Symptoms

Stunted plants; wilting plants; yellowing plants; dropping leaves; plant death; circular brown-black patches of rot on tubers

Control

- Only disease-free vines should be planted;
- Avoid planting potatoes in the same place season after season to avoid disease build up.

Harvesting

A sweet potato plant matures between 4-6 months depending on the variety. To harvest you can use a hoe or digging fork to gently remove the soil from the ridges or molds.

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. This can be done by slowly loosening the soil while taking care not to damage the tubers. The vine is then held and pulled. The vine then collected and cleaned. For hardening the tubers, some vegetative leaves(vines) can be cut 2 weeks before harvesting. Piecemeal harvesting, where only enough is taken for one or two meals, is a common practice for home consumption and small-scale marketing.39 Mature roots, harvested from the mound, make room for additional roots to develop. The process of piecemeal harvesting can continue for about three months, again depending on the cultivar and conditions, but after that time any roots remaining in the soil will succumb to sweet potato weevil attacks or other pests, or otherwise deteriorate. The harvesting of roots close to or protruding from the ground might, however, help deter weevil attacks.

Post Harvesting

Packaging

Because piece meal harvesting is common Uganda, most of the sweet potato is packaged in baskets or sacs depending on the availability, quantity of potatoes and distance of transportation.

Curing

Curing is reduction of the moisture content of the potato tubers. It determines the keeping time and quality of the tubers. Curing sweet potato can also be done by cutting off the vines and leaving the tubers in the soil for another 2 weeks before harvesting is done. It can also be done by exposing the whole tubers to sun heat for some days but for longer storage, the tubers are cut into slices and exposed to sun heat for drying. This can enable storage of the potatoes for periods beyond six months.

Different uses potatoes

Potatoes can be eaten in form of steamed/boiled tubers, made into ships, made into flour and porridge, or mingled into potato bread. Young tender leaves can be eaten as a vegetable. Additionally, leaves and stems can be fed to livestock. Potatoes also form a major source of starch for industrial use.