MINISTRY OF AGRICULTURE
ANIMAL INDUSTRY AND FISHERIES

Maize Training Manual for Extension workers in Uganda

Partners

Ministry of Agriculture Animal Industry and Fisheries (MAAIF)

Feed the Future Uganda Enabling Environment for Agriculture (FTF/ EEA)

Ministry of Trade Industry and Cooperatives (MTIC)

Makerere University College of Agriculture and Environment Sciences

International Institute of Tropical Agriculture

Table of Contents

Forward & Acknowledgement

One of the key objectives of the agricultural extension policy is: "To empower farmers and other value chain actors (Including youth, women and other vulnerable groups) to effectively participate and benefit equitably from agricultural extension processes and demand for services".

Maize is an important food and income security crop that supports livelihood of millions of small-scale farmers in Uganda. However, average yields of maize have remained as low 2.2-2.5 MT/ha, compared to the potential of 8 MT/ha. The quality standards of maize grain produced is generally low, and losses during harvesting, transport, storage and processing are relatively high.

In order to achieve the broader policy goals and strategic objectives, the Ministry of Agriculture Animal Industry and Fisheries with support from USAID Feed the Future Uganda Enabling Environment Activity and Sasakawa Global developed a harmonized Maize Training manual with a corresponding User's Guide.

This training manual has been designed for extension workers engaged in training farmers but can be used by other value chain actors in the maize production. The objective is to transform maize production from a predominantly subsistence, low input and low productivity activity, to a fully commercialized farming business consequently improving household incomes of rural farmers who form the majority of the population in Uganda. The manual will also enable farmers make informed decision regarding maize production. The

The manual covers the aspects of maize crop production, post-harvest handling, marketing, value addition, standards, farming as a business and climate change

This is therefore to urge all service providers to widely use this manual and to say that it can be multiplied for the purposes of training at various levels. It is a free public document and not for sale.

I wish to thank everyone who contributed to the development of this document, particularly; stakeholders that provided input into the drafting and validation of this document; members of the development team for reviewing the document and steering the whole process, Feed the Future Uganda Enabling Environment for Agriculture Activity for facilitating the process and Sasakawa Global 2000 for its technical expertise in the development of the document.

It is my hope that this manual will be resourceful and used adequately by extension workers and other value chain actors to strengthen the beans sub-sector in Uganda.

Yours faithfully

Pius Wakabi Kasajja
PERMANENT SECRETARY,
MINISTRY OF AGRICULTURE ANIMAL INDUSTRY AND FISHERIES

Acronyms & Abbreviations

CBO	Community Based Organizations
CSP	Climate Smart Practices
CT	Conservation Tillage
DAP	Di Ammonium Phosphate
EAC	East African Community
EAS	East African Standard
EIL	Economic Injury Level
GAP	Good Agricultural Practices
GHP	Good Hygiene Practices
GMP	Good Manufacturing Practices
Ha	Hectare
ICT	Information Communication Technologies
IPM	Integrated Pest Management
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
NAADS	National Agricultural Advisory Development Services
NARO	National Agricultural Research Organization
MC	Moisture Content
MFIs	Micro Finance Institutions
MT	Metric Tones
MTIC	Ministry of Trade Industry and Cooperatives
NGO	Non-Government Organization
PHH	Post -Harvest Handling
QDS	Quality Declared Seed
UCOP	Unit Cost of Production
UNBS	Uganda National Bureau of Standards
WFP	World Food Program
WRS	Warehouse Receipt System

Module One:
Introduction & Background

1.1: *Importance of maize*

Maize is an important food and income security crop that supports livelihood of millions of small-scale farmers in Uganda. Production of maize has increased from 2.8 million MT (2015) to 4 million MT (2017). Maize importance is associated with increasing demand and favourable climate that enables two cropping seasons in a year. Increased demand for poultry products due to rising income has further increased demand for maize as animal feed. This implies that there is a large local potential market for maize. Maize is also a staple food for majority of people in neighbouring countries especially Kenya who are major importers of Ugandan maize grain. Example Kenya alone demands more average of 600,00MT annually and is likely to go up to 1,000,000MT hence increasing demand on the regional market.

1.2: *Ecological Requirements*

Maize can be grown on a wide variety of soils, but performs best on well-drained, well-aerated, deep warm loams. It is well adapted in warm condition with optimum temperature for plant growth ranges of 30oC – 34oC. Temperatures below 10oC and above 40oC result in poor growth and death of the maize plant. Maize prefers rainfall of 500 to 600 mm as the optimal range and well distributed over the growing season.

1.3: *Challenges and the Opportunities*

Maize current production, productivity and quality have stagnated due to several biotic and abiotic factors including, pests and diseases, declining soil fertility, drought stress and inadequate extension services among others. Average yields have remained as low 2.2-2.5 MT/ha, compared to the potential of 8 MT/ha. The quality standards of maize grain produced is generally low, and the post-harvest losses during harvesting, transport, storage and processing are relatively high. This coupled with aflatoxin contamination render Ugandan maize uncompetitive on the regional market. Addressing constraints associated with the maize subsector requires all value chain actors from production to consumption be provided with relevant technologies, skills and up to date extension information. Farmers hold a key to food security and food nutrition, improving both farmers' yield and quality of maize in Uganda will go a long way to addressing development challenges.

1.4: *Maize chain actor and their Roles*

In maize value chain, the main market actors include producers (farmers), rural aggregators/traders, big buyers/exporters, millers and consumers while the support service actors include; the input suppliers, transporters, extension service providers and financial institutes. All these actors interact, either directly or indirectly, with maize products at various nodes of the chain.

Module Two:
Pre-Planting and Planting Activities

This module covers recommended pre-planting and planting activities for maize production. These are site selection, land preparation, basal fertilizer application and planting

Maize production requires proper management practices to attain its potential yields. Maize takes105- 210 days from planting time to maturity. To attain high yields, there is need to apply Good Agricultural Practices (GAPs). GAPs are a set of practices for crop cultivation and farm management that help farmers to best use resources to achieve high yields while minimizing costs of production. GAPs are the foundation for better yields and a profitable maize production venture.

GAPs should be observed at all stages of maize production right from site selection, land preparation, seedbed preparation, seed selection, planting, weed management, soil fertility management, harvesting, postharvest handling and storage

2.1: *Planning at household level*

At household level, the family there is need for family members to agree on the variety of maize to plant, the purpose, acreage and when to plant. This brings in sense of ownership and togetherness for sustainable management of commercial maize production.

2.2: *Site Selection*

Maize production requires a suitable site that will support optimal maize growth through the life cycle of the crop.

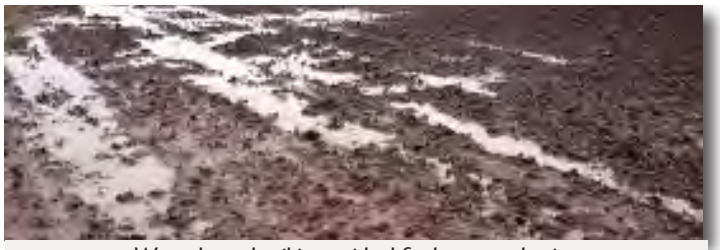
The recommended site for maize planting should have the following;

a) Deep fertile well drained and aerated, sandy loams or loamy soils which are fertile.
b) An optimum soil pH 5.0 – 7.0
c) Signs of soil fertility such as presence of indicator plants eg elephant grass, Guinea grass (Panicum maximum), Commelina sps
d) For steeply sloping areas, consider contour hedgerows and terraces along the contour to stabilize the soil and minimize the runoff

Loam soils make a ball that breaks on slight pressure

During site selection avoid the following;

a. Water logged areas because maize does not tolerate water logged places.
b. Very sandy soils
c. Soils that are compacted (clay) and too alkaline



Water logged soil is not ideal for bean production

2.3: Soil testing

It is essential to assess soil health before any soil management operations are implemented. Constraints such as soil acidity and soil nutrient deficiency can lead to significant reductions of crop yields. The soil pH and nutrients levels can be determined by conventional soil analysis in addition to observation methods of crops growing in the field.

Soil testing is an essential crop management decision-making tool that enables to:

i) Determine acidity level (soil pH);
ii) Identify any soil nutrient deficiencies;
iii) Estimate fertilizer requirements for target yields;
iv) Estimate the cost of fertilizer needed and the returns

In the field, a soil testing kit can be used and for further analysis soil samples should be taken to a recommended laboratory to inform on nutrient deficiency.

Taking soil samples

ALWAYS get advice on how to test soils from extension workers

2.4: Land Preparation

Land preparation involves; bush clearing, removal of tree stumps, termite mounds, and ploughing. Maize requires warm and moist soil, well supplied with air, and fine enough to allow rapid germination of the seeds, proper growth of roots to absorb the available soil nutrients. Well prepared seedbed reduces on the number of weeding times.

2.4.1 Timing of land preparation

The timing of land preparation is extremely important. Land preparation should begin either at the end of the harvesting period or at least three weeks (21 days) before planting to allow breakdown of organic matter. Land should be ploughed at least twice to obtain a fairly rough seedbed. The farmer should avoid excessive tillage as it damages the soil structure (clods) leading to soil erosion.

If the site is very bushy, first clear land by slashing down all plants, leave them on the ground, then plough the plant residues into the soil using appropriate equipment. This will help soil to conserve moisture; improve the water-retention capacity, water-infiltration capacity and increase soil fertility.

Bush Slashing

If the field was previously covered with weeds like Amaranthus spp, which produce a lot of seeds, then the land needs to be prepared early in the season. This will encourage most of the weed seeds to germinate as soon as the soil gets any moisture. The field can then be lightly tilled down or sprayed with non-selective herbicides (glyphosates) before maize is planted.

DO NOT BURN PLANT RESIDUES :

as this destroys plant nutrients from the residues which cannot easily be replaced.

2.4.2 Methods of land preparation and related equipment

Seedbeds for maize production are prepared either using the conventional tillage procedures or conservation tillage.

1. Conventional tillage:

The farmer uses equipment like hand hoes, animal traction, and conventional and walking tractors to till land.

a) The **hand hoe** is the most commonly used equipment by small holder farmers though it is slow and labour intensive.
b) **Animal traction:** this involves use oxen to plough land, although it is not suitable under heavy soils and steep terrain. This method is the most appropriate, affordable, reliable and proven technology for small and medium scale farmers;
c) Conventional **tractors** open extensive land for commercial farming.
d) **Walking tractors** (power tillers) can be used by small and medium scale farmers.

Hand hoeing

Animal traction

Power Tiller (walking tractor)

Tractor ploughing

If ploughing is to be done using oxen or tractor, care must be taken to work the land when it is dry

2. Conservation Tillage (CT):

CT is also referred to as no-till/zero till, minimum /reduced till, and ridge (ripper) till. It is an agricultural management approach that aims to minimize the frequency or intensity of tillage operations in an effort to promote certain economic and environmental benefits. The principle of conservation tillage involves maintenance of at least 30% surface soil cover through retention of crop residues. Retention of crop residue protects the soil from direct impact of raindrops and sunlight while the minimal soil disturbance enhances soil biological activities as well as soil air and water movement.

Under CT use of non-selective herbicides eg Glyphosate is paramount. Depending on the area to be tilled, remove all tree stumps and other barriers like ant-hills. If the area is covered with thick thicket, first slash down the bush, wait for the new germination of weeds and then spray them herbicides (Round-up, Weedmaster, Mamba, Weedall).

CT allows timely planting at a reduced cost, improves soil structure, increases water infiltration and soil moisture retention. In addition, it creates more soil organic matter, controls weeds, reduces soil erosion, reduce labour and energy requirements.

Under CT, the farmer should adhere to the adequate planting depth since the seed needs more energy to penetrate the sub-soil with its roots and the top soil with its shoot as compared to a ploughed field.

Conservation tillage is suitable for all categories of farmers and higher returns are realized if GAPs are followed.

2.4.3 Application of manure

Compost or animal manure should be added earlier after the first cultivation in land preparation to allow for adequate decomposing. At second ploughing the manure is churned into the soil prior to planting. Compost manure is applied at a rate of 4 – 6tons per acre.

Under CT, the compost manure is applied to the holes/basins where the maize seeds are to be planted.

2.5: Source of quality seed

High maize yield begins with good quality seed. Farmers should always be advised to use improved quality seed (Annex 1). The seed should be bought from recognized seed companies or their registered and licensed stockists.

2.5.1 Choice of Suitable Maize varieties

There are two categories of maize varieties in Uganda; Open Pollinated Varieties-OPVs and Hybrids (see Annex 1).

Selection of cobs for OPV seed

Improved OPVs are higher yielding than traditional varieties and seed can be recycled for two years by the farmers without a reduction in yield. Selection should be done before harvesting by marking the best plants with sticks or ribbon. The plants should have big healthy grains, no signs of disease or pest attack on stems, leaves and grains.

The plants should be harvested separately, dried and stored for the next season. While in storage check frequently for any signs of pests and disease attack.

Hybrid varieties under good management yield more than OPVs. However, hybrid seed has to be bought every season. Recycling hybrid seed reduces yield potential.

2.5.2 Criteria for variety selection

Selection of maize varieties to be grown will depend on the factors listed below:

a. **Adaptability and yield potential.** Maize is produced under a wide diversity of conditions. A farmer should select seed variety that is adaptable to the prevailing production conditions but at the same time gives yield that measure up to the potential of the seed.
b. **Resistance to Pests and Diseases:** A wide range of pests and diseases will attack the maize at the different stages of its growth cycle. A farmer therefore should select a variety that can tolerate both pest and disease attack. Several tolerant maize varieties have been developed by NARO (Annex 1)
c. **Length of Growing Season:** The length of the growing season of varieties plays an important role, especially when there is unpredictable variation in the amount and distribution of rainfall. Farmers should use varieties that have early maturity period and drought tolerant

Farmer buying improved seed from a certified stockist

Always seek advice from registered extension service provider or certified seed company agent

2.5.3 Attributes of quality maize seed

- Uniformity
- High germination rate > 85%
- Well dried to 13% moisture content
- Purity 98%: Ensure all seeds are of the same variety
- Clean: not mixed with foreign matter like stones or dirt, or other seeds
- Not damaged, broken, shrivelled, mouldy, or insect damaged
- Not rotten or discoloured faded
- All non-conformity should not exceed 2%.

2.5.4 Steps in conducting Germination Test

It is important to use seeds that will germinate and give healthy plants, therefore, seeds should be tested for their ability to germinate.

1. A week before planting, take a sample, count off 100 seeds randomly.
2. Put the seeds in a container with sand. The container should be pierced at the bottom to let water drain

3. Keep the seeds moist, but not wet. Too much or too little water can prevent seed germination
4. After 7 days, carefully dig the seedlings up from the sand, put them on a paper and count seedlings in each category below:

a. Normal seedlings: Well-developed roots, stems, leaves,
b. Abnormal seedlings: Have any of the following signs: no root, weak roots, no leaves, weak leaves,
c. Rotten, diseased and unviable seeds which have not germinated.

Record your results as below

Batch	Total ≠ seeds	Normal seedlings	Abnormal seedlings	Rotten, diseased, unavailable
Container 1	100	X	Y	Z

If about 10 seeds (10%) have failed to germinate (90% germination) then use the recommended seed rate

If germination is below 90% but above 85%, increase the seeds per acre at planting following calculation below:

Recommended seed rate = 10 kg per acre
Percentage germination = 85%
Adjusted seed rate = (100÷85) x 10kg = 12kg

The new seed rate will be 12 kg per acre
If germination percentage is below 85% reject the seed.

Always report back to the stockiest, extension worker or the seed company (supply) within 10 days after planting in case of germination failure.

2.6: *Planting*

Planting should be done on the onset of rains. Early planting takes advantage of the nitrogen flush effect which is the release of accumulated nitrogen in the soil during the dry season.

Normally the first season planting is in March and harvesting is in July-August, while the second season is from August to January (Annex 2). Farmers should avoid late planting since it leads to increased incidences of pests and disease attacks hence reduced yields.

2.7: *Planting*

Plant in lines (rows) in order to achieve optimum plant population and also ease field operations like weeding, spraying and harvesting.

To ensure proper spacing for a maize monocrop, mark out the field using marked strings at 75cm for spacing between rows. Place pegs at each 75cm spot and a string marked at every 60 cm for spacing between holes till the end of the end of the field. Plant two seeds per hole at every 60cm mark along the string. This takes 10kg of seed per acre and optimum plant population of 21,000 plants.

Field marking using strings

At a spacing of 75 cm (2.5 ft) by 30cm (1foot) and one seed per hole, the farmer still uses 10kg of seed per acre and optimum plant population of 21,000 plants.

Spacing of maize depends on the soil fertility, plant type and growth habits, rainfall, purpose for which the crop is intended for and cropping pattern.

Optimum plant population is critical because:

- It also provides a favourable environment for crop growth and optimum yield output
- It reduces competition among the plants
- It reduces pests and disease pressure

Intercropping

- Maize can be intercropped with legume crops such as beans, soybeans, peas.
- Where intercropping is done, adjust the inter-row spacing as shown below:
  a) One row of maize with three rows of beans at 120cm by 60cm and two seeds per hole
  b) One row of maize with two rows of beans with at a spacing 100cm by 25 cm for maize and 50cm by 10cm for beans
  c) Two rows of maize with two rows of beans.

Beans - maize intercrop

2.8: *Planting depth:*

The speed at which seed germinates and emerge out of soil depends on planting depth, soil moisture and temperatures. For uniform plant growth, ensure uniform planting depth. For moist soils place seeds at a depth of 2-3cm, and for dry planting, place seeds at a depth of 5-10cm (deep seed placement under dry planting is recommended so that seed germinate only after adequate rains).

2.9: *Methods of planting and related equipment*

Traditionally, farmers in Uganda use hand hoes. For ease of work, farmers should work in teams of three people; one for digging hole, second person placing fertilizers and covering it with a thin soil layer and the third person placing seeds and final covering.

Digging and placement of basal fertilizers

Jab Planter

Jab planters: The planter is manually operated, and the advantage is that it digs the hole, places fertilizer, seed and covers it.

Planting basins

Planting basins are small pits in the ground used for planting many types of crops. They are about 15 cm wide, 30–35 cm long, and 15 cm deep – about the size of a man's foot.

Planting basins can be dug at any time during the dry season, so they are ready for planting at the beginning of the rainy season.

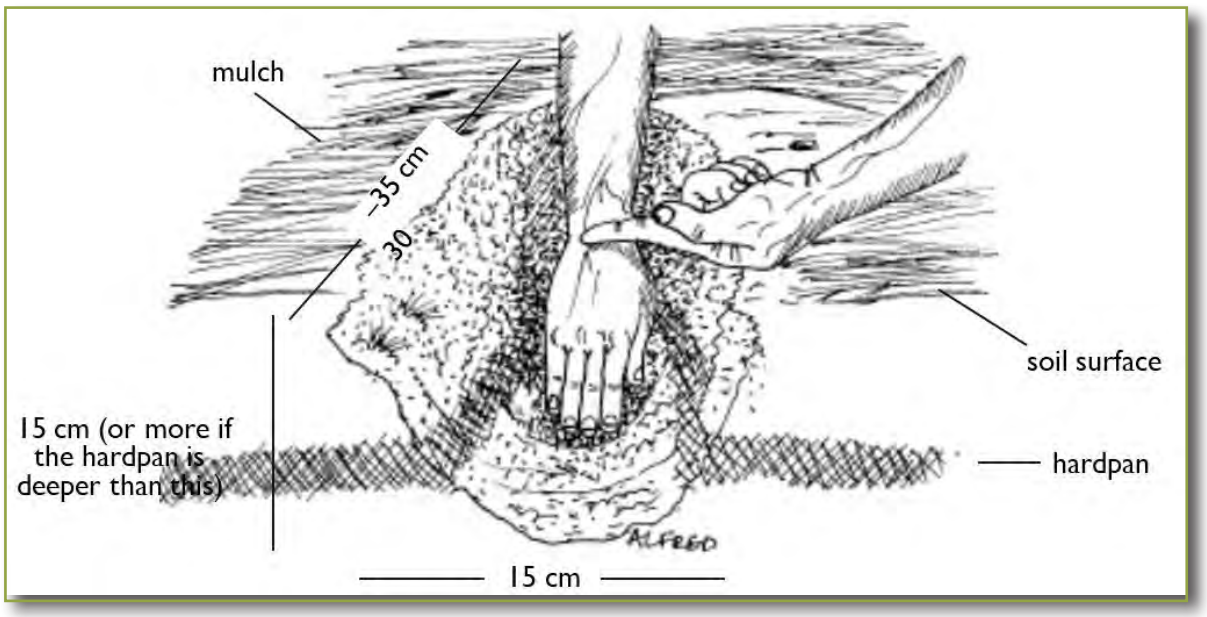
Basic equipment needed

- A hoe, long string (for measure off the correct distance between the basins e.g 60 cm for two seeds). Tie knots in the string or clamp bottle tops to the string at the correct intervals with pliers
- Two sticks to mark rows and two strong pegs to hold the string at both ends

Making basins

1. Stretch the rope across the field, at right angles to the slope, and fix both ends in place using the two pegs. Keep the string well clear of the ground so that it stays straight despite any vegetation. The knots or bottle tops mark where to dig each basin They act as guides for accurate spacing, since you will use the same basins again and again in the following seasons.

2. Starting at the first knot or bottle top at one end of the string, dig a rectangular basin about 15 cm wide and 30–35 cm long (about the size of a man's foot). The basin should be about 15 cm deep (about as deep as your hand). If there is a hardpan, make sure you dig deep enough to break through it.



Close-up of a planting basin. The hand shows how deep the basin is: it should break through the hardpan

3. At the next knot or bottle top, dig another basin the same size. Work backwards along the string so you do not tread on the basins you have already dug.
4. When you reach the end of the row, use the sticks to measure the distance to the next row. Move the pegs and stretch out the string again between them. Stagger the holes so they are not directly next to the holes in the previous row. This will help catch more rainwater and stops it from running away downslope.
5. Apply well composted manure or fertilizers about 2 weeks before before planting.

Manure Put 1-2 drink cans of manure (400g) in each basin. This amounts to 4 tons of manure per acre

Compound fertilizer Put a small container (5-7 g) of compound fertilizer in each basin. NB compound fertilizer may be applied at planting time instead of 2 weeks beforehand.

After you have applied manure or fertilizer use a hoe to partially fill the basins with soil. Leave the surface about 5 cm (2 inches) lower than the original ground level so water can collect in the basins

6. Plant 2 seeds per basin.

Mechanized planting

For mechanized planting, animal traction and tractors mounted with special equipment for planting are used. It involves digging of holes, placing of fertilizers, placing of seed and covering simultaneously. Check the equipment well before use and make proper adjustments. Always read the operator's manual and seek advice from the suppliers for effective usage.

Oxen-driven planter

2.10: *Basal fertilizer application*

In case of poor soils, farmers should apply basal fertilizer (organic and or inorganic) at planting. Use only recommended fertilizers especially after testing your soils. Follow recommended application rates e.g. 50kg of DAP per acre (one bottle cup per hole) depending on initial soil fertility status, use crop specific fertilizers (blended fertilizers) where available

Always cover the fertilizers lightly with soil before placing the seed, because most fertilizers are corrosive.

After planting inspect your field 3 to 4 days after germination to ensure that a healthy crop is produced. Any gaps in the row as result of seed failing to germinate or other seedling damages should be addressed immediately by gap filling.

Module Three:
Crop Management Practices

This module focusses on management practices during crop growth and includes; weed management, soil fertility management and pests and disease control.

3.1: *Weed Management*

Effective weed control is a prerequisite for high maize yields. Early control of weeds recommended at 2-3 weeks after planting is extremely important, because the root system of the plant develops at this stage and some weeds secrete chemical inhibitors which limit plant growth. It is also recommended to weed 5-6 weeks after planting to avoid weeds to adversely affect the quality of the crop. Control of weeds can be manually done using hand hoes, hand pulling, mechanical weeders or by chemical means.

3.1.1Weeds and their effects on maize

Weeds are plants that grow where they not wanted. It is very important to control weeds in the early stages of crop development to avoid their effects on the crop.

Effects of weeds on maize

- Weeds reduce yield by competing with the maize crop for minerals, light and moisture especially during the early stages of crop growth.
- Some weeds are alternative hosts of pests and diseases
- Some weeds are parasitic and poisonous to maize e.g Striga weeds.A thick growth of weeds in maize makes harvesting difficult.

Maize suffocated by weeds

maize well weeded

3.1.2 Categorizes of weeds

Annual weeds: These complete their life cycle within one season. In most cases, the seeds produced by annual weeds will germinate very fast and even grow faster than the maize crop itself. The weeds will interfere with the growth of the crop during the critical period of the first three weeks. Annual weeds also produce a lot of seed which can survive and germinate the following season. The most dangerous weed in maize garden is the Striga sp. Other examples of annual weeds include black jack, goat weed, wandering jew etc

Striga is a parasitic weed and can cause up to 100% of maize yield losses at farm level. It is common where soil nutrients have been depleted. The weed seeds are normally dispersed by wind, water, man, farm machinery and contaminated crop seeds. Each striga plant is capable of producing up to 500,000 seeds which remain viable in the soil for over 10 years. The seeds normally germinate only in response to chemical stimulants exuded by the host roots. Once germinated, the weed establishes parasitic attachments with the root of the host and starts deriving all nutrients from the host.

Perennial weeds: These carry on from one season to another. The weeds persist in maize garden all time every year and reproduce through roots and stems. It is very difficult to control perennial weeds using mechanical methods because only the top of the weed is cut, the bottom continues consuming the nutrients and water meant for the maize plants. Perennial weeds should be controlled early before the beginning of the planting season. Examples include; couch grass, spear grass, etc

Common weeds in maize field

Annual Weeds		
Striga Sp(witch weed) 	Rag weed (Ambrosia sp) 	Lions ear 
Black jack 	Pig weeds 	Amaranthus sp. weeds 
Wandering jew (Commelina sp) 	Galinsoga sp 	Velvetleaf 
Perennial Weeds		
Couch grass 	Giant foxtail 	Crab grass 
Nut edge grass 	Guinea grass (Panicum sp) 	Bermuda grass (Cynodon sp.) 

3.1.3 Methods of weed control

Weed management must be addressed with a holistic approach and begins with correct land preparation. Identification of the main weed types will determine the correct control methods to use. The common methods of control include cultural practices, mechanical and application of chemicals using selective herbicides.

Preventative and Cultural weed methods refer to any technique that involves maintaining field conditions such that weeds are less likely to become established and/or increase in numbers. They include use of clean seed (uncontaminated by weed seeds), site selection, land preparation, timely planting, soil fertility management, proper spacing, crop rotation, mulching etc

Manual weed control involves the use of farm tools and equipment like hoes, rakes, fork jembes, and pangas, among others. It should be done carefully to avoid damages to the crop.

Mechanized weed control: Involves use of mechanized farm equipment such as ox-traction weeders, tractor weeders (tines) that remove weeds from the gardens. Maize must be planted in rows and weeding takes place at particular crop growth

Chemical control- This method of weed control either speeds up, stops, or changes the weed's normal growth patterns. This in turn causes the leaves, stems and roots to dry out.

Herbicides are very effective if used properly. Farmers using herbicides need to know the type, the correct dosage and stage to apply the herbicide.
All safety precaution measures need to be adhered to and all label instructions strictly followed.

Advantages of Chemical weed control

- Herbicides are very effective and take a short time to work.
- Reduces the amount of tillage hence labour saving
- There no root damage and no soil disturbance to bring more weeds seeds to the surface for germination
- Herbicides are a must under zero or minimum tillage

If the incorrect herbicide is used, the consequences could be disastrous. Herbicides are also expensive and may be a health hazard (poisonous) to the user when not properly used

Only selective herbicides should be used during weeding. Selective herbicides act against weeds by killing all other plants and leave only maize to grow. The herbicides are translocated in plant system of the affected weeds. Selective herbicides are most effective if applied on weeds when they are actively growing. Examples include 2,4-D, Tembofrione, Auxo, Maguguma (Annex 3)

Always wear protective clothing when using herbicides. Apply herbicides at the recommended rates (refer to module 4)

Where Striga is a problem;

- Hand weed regularly (but is labor intensive) and burn all the weeds
- Practice crop rotation
- Intercrop maize with "Striga chaser" Celosia.
- Inter crop with legumes like cowpea and pigeon pea – can cause suicidal germination of Striga seed,
- Intercrop with Desmodium to reduce seed bank of Striga in the soil (push and pull),
- Use tolerant varieties e.g Kayongo Go
- Boost plant health through manure/fertilizes application

3.2: *Improvement and Management of Soil Fertility*

Plants need nutrients and water to grow and give good yields. Most of the nutrients come from the soil and hence soils have to be fertile to sustain plant yields.

A fertile or healthy soil should:

a. Be deep enough and well drained
b. Have good structure, texture and well aerated for proper root development.
c. Have a favourable soil reaction (i.e. degree of acidity and alkalinity pH range 5.5 to 6.5 for most crops)
d. Have a good supply of both available and reserve plant nutrients
e. Be able to store soluble nutrients
f. Contain sufficient organic matter >2%
g. Support a wide range of micro and macro organism (fauna and flora)

3.2.1 Causes of Soil Nutrient losses/Soil infertility

Nutrient mining is the removing of more essential nutrients (from the soil through crop harvest, soil erosion, etc.) than what is replaced through addition of organic and inorganic fertilizers. This is caused by:

a. Loss of soil cover by destruction or removal of crop residues;
b. Accelerated loss of soil organic matter through destruction of vegetation, ploughing, burning of crop residues, decomposition etc.;
c. Poor soil physical properties leading to limited water infiltration and restricted rooting caused by soil compaction;
d. Soil erosion
e. Leaching
f. Unusually low or high soil pH levels

3.2.2 Essential plant nutrients

Nutrients that are required for the entire plant growth cycle are called essential nutrients. Deficiency of any one of these will make the plant have limited growth, affect flowering and or seed formation. The essential plant nutrients are divided into two groups: macro nutrients and micro nutrients.

i) Macronutrients are required by plants in relatively large quantities are nitrogen (N), phosphorus (P), and potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg)
ii) Micronutrients (Trace elements) are required in small (or micro) amounts by plants. They include manganese (Mn), iron (Fe), boron (B), zinc (Zn), copper (Cu), molybdenum (Mo), etc.

3.2.3 Signs of major macro and micro nutrient deficiency in maize

Nutrient deficiency in soil can led to reduced yield in maize. This requires the farmer to routinely scout through the maize field to identify nutrient deficiency symptoms and take corrective actions to mitigate losses.

Role	Deficiency signs	
Nitrogen	Lower leaves have yellow mid-rib; Entire plant has a light green color	

Role	Deficiency signs	
Potassium	Symptoms appear on bottom or older leaves; yellow and brown margins beginning at leaf tips	
Phosphorous	Purple margins; symptoms appear on older/bottom leaves	
Zinc	Light to white interveinal striping from the base of the leaves spreading towards the tips Leaves may be abnormally small and necrotic. Internodes are shortened	
Magnesium	Interveinal chlorosis on the older leaves and progresses upwards as the deficiency intensifies. Older leaves may become reddish-purple and the tips and margins may die. Older leaves may fall off with prolonged deficiency.	 
Boron	Shortened internode resulting in bushy appearance; growing points may die; leaves may become curled. Severe B deficiency results in short bent cobs with underdeveloped tips and poor kernel development.	 

3.3: *Soil fertility management*

Maize is a heavy feeder crop and grows best on fertile soils. Where soils are deficient in nutrients, the use of fertilizers is encouraged.

Soil fertility can be improved through use of:

1 Organic manure
2 Inorganic fertilizer
3 Other soil amendment practices.

Studies have shown that use of fertilizers give a 30% increase in yield

3.3.1 Organic manure

These are decaying organic matter or humus derived from plant and animal residues. They include: farm yard manure, compost manure, green manure and organic mulches. Organic fertilizers maintain soil structure, improve water holding capacity and improve aeration in addition to providing the majority nutrients for plant growth.

Application of organic manure

In one acre of well ploughed, use 4 to 6 tons. Organic manure should be applied during ploughing but should be well decomposed two to three months, and planting is done after two to three weeks from the date of application.

Compost manure

Crop residues and organic household wastes are left to decompose for two to three months, after which the compost is ready for use.

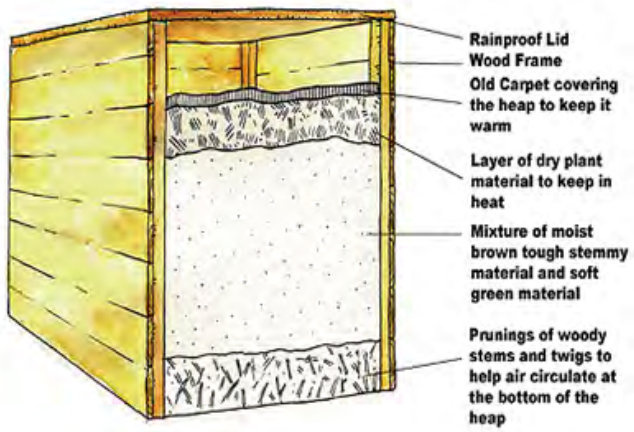
The compositing process

Requirement: dry plant materials, water, ash, green plant materials, animal droppings and top soil,

Steps in a three –pit compost

1. Making the base: Find a shady area, dig a pit for the compost and make a bed with twigs or stalks
2. Chop the materials and heap the layers; sprinkle water to help the heap rot; add animal droppings from chicken, goat cow; add top soil for insects and worms; add green plant material; sprinkle with ash for potassium, and water. Repeat the layers 3 or 4 times and cover with soil and dry grass to keep the compost moist.
3. After 3 weeks, turn the heap layer by layer (this helps the rotting process). After another 3 weeks, the compost will be ready.

NB: Use a temperature stick to monitor the rotting of the heap. Composting manure is applicable for smallholder farmers



Compost heap illustration using wooden box design

Application of compost manure:

- Using a small container to a size of 3 spades, or a half basin,
- distribute the well decomposed manure in the field evenly

and hallow/dig it up, so that it mixes well into the soil and plant after 2 to 3 weeks

Benefits of compositing

- It's cheap because of the readily available raw materials
- It improves soil texture, water holding capacity and nutrient up-take
- Gradually release of nutrients for a period of time

3.3.2 Inorganic fertilizers

These are manufactured fertilizers which rapidly provide/release nutrients to the plant. The inorganic fertilizers provide specific nutrients, which are lacking in the soil. Examples of inorganic fertilizers include DAP, UREA, MOP, NPK, TSP, blended fertilizers to cater for specific crop needs.

Fertilizer is supplied in form of Nitrogen (N), Phosphorous (P) and Potassium (K). For the solid particles, mineral fertilizers can be of many different sizes and shapes: from granules, pellets to fine powder (dust), but also available in larger compacted granules that release nutrients slowly.

Powder (e.g. single superphosphate

Crystals (e.g. ammonium sulphate)

Prills, granules (e.g. urea, diammonium phosphate)

Supergranules (urea supergranules)

Liquid fertilizer

i) Factors to consider when using fertilizer:

- Availability,
- Affordability
- And accessibility
- awareness

Accessibility

Fertilizers are in most cases with the agro-dealers, stockists in urban, and at Sub county level, in most cases fertilizer distribution chain stops at Sub County level. Farmer need to be aware of the distribution chain. Always buy recommended inorganic fertilizers from reputable supplier or dealers. Ensure that the bags are well labelled with all necessary information such as the numbers and nutrient symbols of the contents (percentage of content by weight), the total weight and expiry date.

Availability

This depends on what farmers demand and what the stockists have in stock

Affordability
The fertilizer should be cost effectiveness, and farmers must be willing to pay for the fertilizers.

Awareness
Farmers knowledge of soil nutrients availability and need for the nutrients

ii) The 4Rs of fertilizer application:

a) The Right Source of nutrients needed by a plant - Matching fertilizer type to crop need eg application TSP, DAP, SSP at planting time in the soils which are low in phosphorous to establish roots; Urea for top-dressing in soils lacking nitrogen.

NOTE; in highly acidic soils, lime should be applied in appropriate rate to allow uptake of nutrient by the crop.

b) At the Right Rate to supply the quantity needed by the plant - Matching amount of fertilizer type to crop needs or growth stage. For instance, at planting, plants require more of P for root development. Amount to apply should be equivalent to the amount the crop is likely to remove from the soil. e,g

In the case of maize, one ton of the grain (1000 kg) takes from the soil 24.3 kg Nitrogen, 10 kg of phosphorus and 21.14 kg of Potassium.

Targeting 3 ton/ acre, fertilizer should aim at 73 kg of nitrogen, 30 kg of phosphorus and 63.42 of potassium assuming the soil had basic fertility.

c) At the Right Time to be taken by the plant - fertilizers should be applied when the soil is moist. Under water stress crops, the nutrients cannot move from the soil through the plant system. Rapid nitrogen uptake by the maize plant begins about 5 weeks after germination (30-40 days) and will continue up to 10 weeks. Nitrogen fertilizer needs to be available during these stages.

d) In the Right Place accessed by plant roots (within 10cm in farrows)- Keep nutrients where crops can use them. Place fertilizer near plants but avoid contact between fertilizer with seed or plant


Top dressing of maize

Other methods to manage soil fertility include:

- Practice minimum tillage. In a used field, spray with a non-selective herbicide (Glyphosate), after 14 days, make fallows or hole (basins) and plant with minimal disturbance of soil. Moisture can be conserved through mulching.

- Soil and water conservation: construct contour bunds and terraces on steep slopes, plant cover crops to limit loss of water and soil nutrients


Maize under conservation tillage

- Correct soil pH by liming: Maize grows well an optimum soil pH) ranges from 5.5 to 7.0. In acidic soils, the roots of a maize crop suffer impairment from aluminium toxicity, limiting nutrient uptake. Example, Phosphorous, a critical element in enhancing development of a good root structure, is fixed by other minerals in an acid soil, making it unavailable (even as farmers apply fertiliser), and leading to reduced crop production

- Crop rotation: Maize should be grown in a rotation sequence of maize, legume, root crops and back to maize so as to reduce; the risk of depleting the soil of specific nutrients and to break disease and pest cycles
- Intercropping: Maize can be intercropped with legumes to manage soil fertility.
- Fallow management: for farmers with adequate land, fallowing or allowing the land to rest for at least 2 years to rejuvenate the soils is advisable. However, in case, of inadequate land, a rotation program should be observe to reduce pests and disease accumulation.

Always use the right type of fertilizers, the recommended rates and methods of application after carrying out soil testing.

3.4: *Field Pests and Disease Management*

Mize is attacked by numerous pests and diseases while in field. The level of pests and disease incidence depends on the presence of the causing organisms, weather, soil conditions, and the relative resistance or susceptibility of the variety. Management techniques to minimize losses due to pests and disease attack include:

- Biological
- Habitat manipulation
- Modification of cultural practices and
- Use of resistant varieties
- Chemical control (Annex 3)

3.4.1 Major Maize Insect Pests and their Management

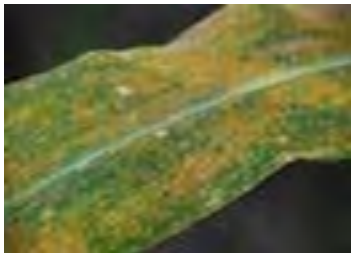
Pest	Symptom	Management
Fall Army Worm (FAW)	A migratory pest causing heavy damage when the attack comes at an early plant growth stage. They feed heavily on shoot leaving only stems and mid-rib of leaves sometimes cause growing points to die. They first appear as large numbers of minute green caterpillars feeding on the leaves. Fully grown armyworms are velvet black with fine yellow lines, are about 35 cm long. 	Remove all crop residues right after harvesting Timely planting Deep plough the soils to bury the larvae and pupae Chemical control at a young stage using recommended chemicals preferably systemic insecticides (Refer Annex 4) Apply a band spray along the edge of the field to prevent the worms from 'marching' into the field.

Pest	Symptom	Management
Stem borers	Bores into leaves, stems and maize cobs causing damage, retarded growth and reduced yields 	Plant early Uproot infected plants Remove maize stalks after harvest and use as mulch in banana or coffee gardens Practice crop rotation Use recommended insecticides eg Bulldock, Dimethoate
Cutworms	Are greasy-looking, grayish caterpillars, which feed on green plant material. They grow up to 40 mm long and tend to curl into a 'C' shape when disturbed. Cutworms emerge at night and cut the seedling off at soil level soon after germination causing reduced plant population. 	Use treated seed
Termites	May attack all parts of the maize plant causing felling and damage to the cob 	Destroy all termite ant-hills in the field Use recommended insecticide.
Maize weevil	Larvae bore into grain making small holes. Adults are shiny black 	Timely harvesting

3.4.2 Major Disease Attacking Maize and Associated Control Measures

Most diseases affecting maize may be controlled by use of certified resistant varieties.

Disease	Transmission	Symptoms/signs	Control
Maize lethal necrosis disease	Seed-borne and spread is by maize thrips and leaf beetles	Yellowing/dying of leaves leading to premature plant death, failure to tassel, maliformed or no ears, rotting of cobs 	Uproot and burn diseased plants Avoid moving infected material Practice general field hygiene
Maize streak virus (MSV)	Transmitted by leaf hoppers feeding on leaves	Small round scattered yellow spots on the leaves that later join into the typical leaf streaks. Severe infection leads to stunting and plants die prematurely without developing cobs 	Uproot and destroy infected plants Use resistant varieties Use recommended insecticides to control leaf hoppers
Maize smut	Soil-borne	Penetrates seedlings and grows inside with no visible symptoms until tasseling. Tassels become malformed and overgrown. Black masses develop in place of the ears and male florets 	Uproot and burn infected crops Plant resistant varieties A well-balanced fertilizer regime will reduce disease severity.
Gray leaf spot (GLS)	Spread by rain, dew and cloudy conditions	Small leaf spot which later develop into brown gray long and narrow spots growing parallel to the veins. Symptoms usually appear on lower leaves. when it attacks the plant early, it destroys the photosynthetic factory in the leaf leading yield loss of up 70% 	Use resistant varieties Practice crop rotation Deep plough under the infested plant debris Use recommended fungicide to protect the crop,

Disease	Transmission	Symptoms/signs	Control
Maize rust	Airborne	Small elongated powdery dark brown spots on both surfaces of the leaves. Most common when plants are approaching tasselling 	Practice crop rotation Spray with copper-based fungicides
Northern (Turcicum) leaf blight (NLB)		Small water soaked elongated /oval spots on the lower leaves causing blighting of leaves; at times premature withering and leaf shedding leading to reduction in plant growth 	Crop rotation with noncereal crops Use resistant varieties Bury infected crop residues after immediately harvesting. Spray with recommended fungicides as soon lesions are noticed.
Ear rot		Irregular bleached areas on husks which enlarge until the husks become completely dried, although the plant is still green. Ears appear chaffy, with a white, cottony growth between the kernels. Stem borer injury in the ear often increases incidence of this disease 	Timely harvesting in very important. Reduce the infestation of stem borers and the fall army worm

Famers should be advised to use integrated Pest Management. IPM is a pest management system that utilizes a combination of all suitable techniques and methods in as compatible a manner as possible to maintain the pest population at levels below those causing economic injury. IPM is based on the understanding that no single pest control method will be successful over a long period of time. Examples IPM include planting resistant maize varieties, cultural practices such as crop rotation, timely planting, and biological control. Under IPM, chemicals are used as a last resort.

Module Four:
Safe Handling and use of Agro-chemicals

Agro-chemicals are crop protection products used in production and preservation of crops or crop products. Agro-chemicals are becoming an increasingly integral part of crop production.

4.1: *Agro-Chemicals*

4.1.1 Groups of Agro-Chemicals

- Herbicides (for killing weeds/herbs)
- Insecticides (for insect pests
- Fungicides (for fungal diseases)
- Nematicides (for nematodes)
- Rodenticides (for rodent pests)
- Fertilizers (providing plant nutrients)

4.1.2 Advantages of using agro-chemicals

1. Increases food production
2. Improves quality of produce
3. Decrease costs of production e,g use of herbicides
4. Are labour saving
5. Increased profits for farmers

However, Agro-chemicals are very harmful if not properly handled, can cause detrimental health hazards to the user, consumer and the environment.

Example of health hazards include; Nausea, diarrhea, stomach ache, nasal bleeding, vomiting, loss of sight, dizziness, and sometimes death.

Environmental hazards include pollution and contaminated of water bodies, bees and livestock death

Agro-chemicals are poisonous substances that must be handled carefully and safely

4.2: *Safe use of agro-chemicals*

To optimize use of agro-chemicals, it is important that proper identification of the exact problem is undertaken.

4.2.1 Identification of the pest

The farmer should make sure that he/she has scouted his/her field and has identified the pest and level of infestation. In case of any doubt, consult the extension worker or take a sample with you to the trusted and qualified input stockiest or plant clinic.

4.2.2 Buying agro-chemicals,

Always buy chemicals from licensed and registered agro-input dealer shops.

- Read the label on the container for expiry date and any other important messages e.g active ingredient.
- Always buy pesticides in their original containers and also make sure the containers are intact.
- Where possible verify whether chemical is not a counterfeit by using **Kakasa (e-tag)** application.

Always get a receipt from the agro-input dealer indicating date of purchase, name of chemical and batch number

4.2.3 Transporting the agro-chemicals

- Ensure that all containers are tightly sealed and the mode of transportation does not cause any leaks or spillage.
- Never transport agro-chemicals with any food or feed items.

4.2.4 Storing Agro-Chemicals

In case a farmer is not using the agro-chemical immediately, he should store agro-chemicals in safe isolated places (cupboards, shelves that are safely located) away from children and family members.

4.3: Application of agro-chemicals

4.3.1 Reading the Product label

The label provides all the necessary information such as, active ingredient, mixing and application rates, first aid, disposal of containers, pre-harvest and pre-entry intervals etc. Read the product label and follow instructions on how to handle and apply the chemical. If you do not understand the instruction, seek advice from extension agents.

Put on the necessary protective clothing as recommended on the product label (cap, masks, overalls, gumboots, gloves, goggles)

Look out for colur coding, warning symbols, pictogram, or any additional safety instructions on the label. (Agro-chemicals are also classified according to their toxicity and should be used as recommended on the label of the product).

Color Coding

Class 1a	*RED - C*	*Extremely Toxic*
Class 1b	*RED - C*	*Highly Toxic*
II	*YELLOW - C*	*Moderately Toxic*
III	*BLUE 293 - C*	*Slightly Toxic*
IV	*GREEN 317 - C*	*Handle with care*

4.3.2 Determining how much pesticide to use

The single most asked question in pesticide application is: **"How much pesticide (ml) do I put in a knapsack (20lts)?"** The answer is; it depends on the calibration of your sprayer. In short, how many square metres one spray pump full of water + pesticide will cover.

Always Read the label for dilution rate or dosage.

It is important that the amount of pesticide to be used is precise to avoid excess that could lead wastage of resources, damage of the crop and contamination of the environment. When quantity is inadequate, it is likely that the pest will not be controlled which could also result into pest resistance.

Always Read the label for recommended dilution rate or dosage.

Knapsack Spray pump

Steps of calibration of a knapsack sprayer

Every sprayer has a different capacity, different nozzles with higher or lower output. Also spray operators work at a different speeds and pump at a higher or lower pressure. To realize appropriate application, there is need to calibrate the spray equipment as follows:

1. Measure and mark out an area of 10m x 10m = 100sq.m
2. Fill the knapsack with known volume of water e.g 15 litres of water
3. Put the knapsack on your back and start pumping, walk at a steady walking pace, spraying with the nozzle at knee height and recite the word 'one thousand' over and over again making one pump stroke per 'one thousand'.
4. Spray the marked area.
5. After spraying, measure the litres of water that has remained in the spray tank (e.g 10lts remained)
6. Amount used to spray area of 100sq.m = 15lts -10lts = 5lts
7. To work out how much pesticide to measure into the sprayer is now very easy. Look at the application rate on the product label.

eg. Roundup is 1.5L (=1500ml) per Acre and an acre = 4,000 sq. metres

To calculate how much to measure into your sprayer:

8. Calculate the volume of water needed to spray an acre

   If 5lts covers 100sq.m

   An acre = $\frac{4000\text{sq.m} \times 5\text{lts}}{100\text{sq.m}}$ = 200lts

9. Using Round up at a rate of 1.5lts/acre, calculate the amount of chemical for a knap sack of 20lt capacity as 200lts of water is need to dilute 1.5lts of Round up

   Therefore a knapsack will require: $\frac{20\text{lts} \times 1.5\text{lts}}{200\text{lts}}$ = 0.15lts of Roundup

   1litre = 1000ml

   0.15 x 1000ml = 150mls

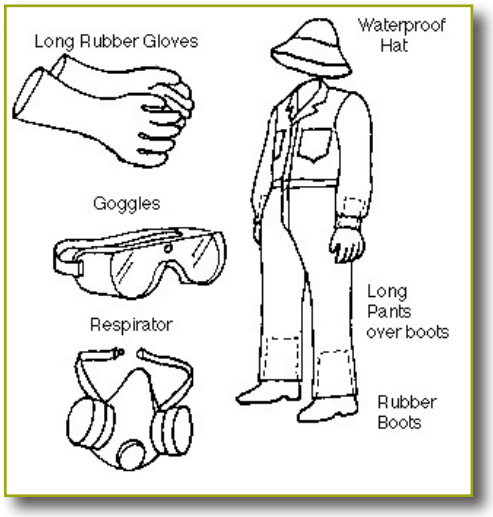
10. Farmer can also calculate needed mls per litre of water = 150ml/20 = 7.5ml.

Mixing Agro-Chemicals

Always wear full protective gear to prevent skin contamination

Mixing and filling operations are the highest risk time for pesticide accidents.

- Read the label carefully and understand the instruction.
- Ensure recommended rates are followed
- Always mix and fill outdoors to avoid pesticide fumes that can concentrate in closed area
- Open pesticide containers with extreme care
- In case of spillage, wash it off with clean water as soon as possible
- Use clean water to mix chemicals
- Use suitable equipment for measuring out chemicals.
- Never use hands as scoops or for stirring liquids
- Add only enough pesticide to the tank for the job you will be doing



Before Spraying

- Before spraying, check the spraying pump for any leaks, use the right nozzle for the particular activity, i.e the flat nozzles are for herbicide application, the cone nozzles are for spraying fungicides and insecticides.
- Check the nozzle for blockages, if clogged, do not try to blow it out with your mouth, use a small soft twig or grass or soft brush to remove the clogs.
- Wear protective gear before spraying activities

Spraying in teams

During Spraying

- Put warning signs in field during spraying to alert the community
- Do not spray near other people or water sources
- Spray in the direction of the wind.
- Walk within the rows and direct the nozzles to the targeted pest
- Preferably spray in the morning hours before 11.00 am or late in the evening after 4.00 pm bearing in mind when the pest is most active
- Do not spray when it is about to rain or when it is raining
- Do not eat, drink or smoke while working with chemicals
- Minimize talking when spraying
- Do not touch your face or any other bare skin with soiled hands or gloves
- Apply the pesticide evenly and in the right amounts
- Turn off the equipment whenever you pause.
- If your co-worker shows signs of pesticide poisoning, stop the spraying immediately and begin first aid measures.

After spraying:

- Use all the pesticide in the sprayer, at least spray it over adjacent field if it remains
- Do not leave pesticide containers at the application site
- Do not re-enter the treated area until after sometime (at least 24 hours)

Disposal of empty containers

- Rinse the empty container at least three times pour the rinse back to the spray pump
- If it a metallic, puncture it or if plastic bottle, cut it several times to avoid re-use.
- Select a disposal site away from home and mark it properly " Container disposal"
- Disposal off the containers following the guide lines on the label

Cleaning the spray pump and yourself

- While still dressed in protective gear, wash the knapsack and rinse it well to ensure that no residues remain
- Pour all the washing on bare ground
- Do not wash spray pumps near water sources like rivers, lakes or swamps
- Remove the protective gear ending with gloves. Wash the protective gear.
- Wash your body thoroughly well with clean water after spraying.
- Put on clean clothing
- Store the clean spray pump properly.
- Keep records of spray application

Washing of spray pump

Bathing after spraying

Module Five:
Harvesting and Post-harvest Handling

The Market requires supply of quality maize in desired quantities at desired time. Good quality maize attracts better market price that help farmers earn high income. Many times, farmer experience high losses of their quality maize right from harvesting to marketing. It is estimated that farmers in Uganda lose up to 40% of their produce from harvesting to marketing as a result of poor postharvest handling practices which leads low quality of the maize. It is therefore crucial for farmers to adhere to good practices to maintain the quality of maize during harvesting and postharvest handling.

5.1.1 Harvesting

This is the process of detaching the maize cob from the mother plant after it has attained full physiological maturity. To ensure quality, harvesting should be carried out on time to avoid food losses and deterioration of quality.

Green Maize ready for harvesting

Maize is harvested at different physiological stages depending on the intended use. When it is for fresh eating, it is harvested when the cob is green and the grains are beginning to harden. If it is meant for silage making, the whole plant is harvested at milk stage, and when it is meant for grain, it is harvested when it has dried and achieved full physiological maturity.

Maize Physiological Maturity: Is stage when the crop has achieved maximum growth and has the following indicators:

- Maize stalk system and cob sheath turn brown
- Ears begin to droop from the stalk and bend downwards depending on the variety
- The grain is hard and has a floury texture when bitten.
- If a moisture meter is available, the grain moisture content is between 18-24 per cent.
- Grains form a black layer at kernel tip

Drooped ears ready for harvesting

5.1.2 Methods of harvesting

Maize can be harvested manually or mechanically

Manual/ Hand harvesting.

This is the commonest method in Uganda and is considered practicable for crops of under 30 acres. It involves the use of the following techniques.

- Pulling of ears from the stalk of the plant
- Removal of the husks covering the ears
- The activity requires 6-10 people per acre per day

Manual Harvesting of maize

Mechanized harvesting:

This is the harvesting of maize using machines (e.g. combine harvesters) and is suited for large commercial farms. Machines simultaneously harvest and remove ears, shells and do partial cleaning of the grain. It has an advantage of ensuring quality, reducing losses in addition to time and labour-saving.

Machines harvesting of maize

Common practices to avoid during harvesting:

- Premature/early harvesting: this results into shriveled and rotten maize.
- Throwing cobs on the bare ground and use of dirty containers during harvesting. This increases risks of aflatoxin and other contaminants.
- Late harvesting; leads to attack of pests, loss of grain and rotting.

Quality control measures (the DO's) ALWAYS:

- Harvest grains when they are physiologically mature
- Harvest on time
- Use clean containers/bags to collect the cobs during harvesting
- Collect the cobs in the garden on a tarpaulin or mat

5.2: *Postharvest handling (PHH)*

Postharvest handling practices are activities carried out immediately after harvesting and they include transportation, drying, threshing/shelling. Packaging and storage. Good PHH practices ensure that the harvested product reaches the consumers in the desired quality and quantity.

5.2.1 Transportation:

Maize is transported home for other activities to be carried out. Transportation is done on head, bicycle, motorcycle, vehicles, depending on the volumes.

5.2.2 Drying of beans in the pods

This is the process of separating the maize grain from the cobs. The process makes grain available for utilization (processing, consumption and marketing). During shelling, measures to minimize grain damage and grain loss should be put in place. Cobs that are well dried are easily shelled.

Methods of shelling

Hand shelling: Maize cobs are shelled using hands. It is slow and relatively painful on the thumb when large amounts of maize are to be shelled. For farmers using OPV seed, this is the best method since it does not damage the germ and it allows for sorting of seed form the best from cobs.

Mechanical Shelling:

Manual sheller: It is carried out using hand and peddle operated sheller.

For the machine to perform optimally, the maize should be dry (13-14% MC). It is a low capacity tool. Used by the farmers that have very low volumes

Motorized maize shellers: They are powered by electrical mortars. They are stationed or mobile, imported or fabricated within the country. They can shell between 800kg – 3000kg per hour. The mobile maize sheller have been designed to ease issues of accessibility. Using motorized shellers reduces postharvest losses and hence more returns to the farmers. Use of motorized maize shelling has increased among farmers as a result of individuals especially youth adopting the technologies to offer shelling services as a business.

Manual shellers

Locally fabricated Non mobile motorised maize sheller

Mobile motorised maize sheller

5.2.3 Drying of maize

Drying is the systematic reduction of crop moisture down to safe levels for storage. It is one of the key postharvest operations that ensures maize grain quality. During harvesting the moisture content of grain is between18-24 and this should be reduced to 12-13% for safe handling. Drying also reduces chances of rotting and germination of the grains.

Method and technologies of drying

a. Sun Drying:

Cobs are dried in open air on tarpaulin, drying yard, collapsible dryer, drying racks and in cribs.

Note: It is recommended to use a maize crib because it protects maize grains from animal attack and against bad weather

Poor drying practice

Drying maize by hanging

Drying maize on tarpulin (a tick)

Drying maize using collapsible driers

Drying of maize in a crib

During drying of the grains, take note of the following precautions to ensure quality

- Turn the grain regularly to hasten and ensure uniformity
- Keep animals away from the maize to avoid contamination with animal droppings
- Protect the grain from adverse weather conditions by covering it with tarpaulins or keeping it under a well-ventilated facility
- Ensure close monitoring of the moisture content to ensure that recommended standard is achieved
- Dry the grains until required moisture content is attained

Turning maize for uniform drying

b. Mechanical drying

Hot air is blown in the grain to remove excessive moisture under controlled conditions. Hot air is generated using burning fuel, solar, electricity and biomass.

- Ensure appropriate temperature is maintained through close monitoring of the temperature. and care should be taken not to exceed 400C for maize grains.
- Keep monitoring the moisture content to ensure that recommended standard is achieved
- ensure appropriate temperature is maintained

5.2.4 Methods of checking moisture contents

Traditional methods (non-standard)

- Shaking grain in a tin and judging from the sound made: grain with high MC gives a dull sound compared to the sharp sound made by dry grain.

Biting the grain with teeth

Deeping the hand into the grain

- Pushing the hand into grain bulk: wet grain offers more resistance to penetration than dry grain. In addition, grain with high moisture content has high temperatures in the middle due to high metabolic rate while grain with optimum moisture content is cold in the middle.

- Biting with teeth: dry maize grain is hard and cracks when you bite with teeth, while grain with high moisture content is soft, the teeth penetrates when you try to bite

- Salt method: Take a small sample of the maize grain mixed with dry salt, put it a clean dry jar, shake it vigorously for several minutes and allow it to settle. If salt becomes wet and sticks on the wall of the jar, then the grain has high moisture content above 15% and therefore it needs to be dried further.

Scientific methods

Moisture meter: It is the equipment used for measuring moisture content in grain. It measures the percentage moisture content in a given sample. Different types exist on the market depending on the manufacturer.

Testing MC using a moisture meter

5.2.5 Grain cleaning

It is the removal of foreign material and non-conforming grains from the normal ones. A number of technologies are employed to clean the grain and they include traditional and mechanical cleaners (manual and motorized)

Traditional winnowing

Cleaning technologies

Traditional winnower- Common at small holder farmer level, winnowers of different shapes and material are used to clean the grain. Farmers usually take advantage of the wind so that it can remove some of the light dirt during winnowing. One person can clean 100 kgs per hour

Use of screen/sieve

Common at bulking sites and warehouses. A screen/sieve mounted on a wooden frame is used for cleaning. It is more efficient than using a traditional winnower. One person can clean 500 kgs per hour. Foreign materials and dirt that are smaller than the screen size pass through. One of its shortcomings is that grains that can pass through the screen have to be sorted from the dirt and this increases the labour and time. On the other hand, foreign material that is bigger than the screen hole size and none conforming grains have to be removed manually.

Motorized bean thresher

Mechanical cleaners

These are machines that are operated by engines or mortars and have capacity to clean above 1ton/h with automated sorting system based on the quality parameters like colour, size, and shape. They are appropriate for seed companies and warehouses where big volumes of grain are being handled.

5.3: *Storage*

Storage is the process of keeping grains until an appropriate time of use. The primary aim of storage of grain storage for quality maintenance, food and nutrition security, seed and better prices

Good storage does not improve grain quality but maintains it.

5.3.1 Storage Technologies

Various storage technologies (traditional and modern) can be used by smallholder farmers to store maize grain and these include;

Traditional technologies	Modern technologies
• Mud and wattle granaries • Baskets • Pots • Jute bags	• Hermetic storage o PVC Tanks/ Silos o Metallic tanks/ Silos o Cocoons o Triple/Pics bags • Warehouse • Grain store

Traditional technologies cannot keep grain over a long period of time. The type of storage facility will depend construction materials available in the locality, the expertise in construction, available financial resources, the quantity of maize to be stored the desired storage period and general weather conditions.

FTraditional (granaries) storage facilities

Hermetic storage is an airtight facility that allows for maximum protection of stored products from insect infestation. It seals off the exchange of oxygen and moisture between the produce and environment

A famer displaying hermetic storage facilitiess

Advantages of hermetic storage include:

- eliminates the use of chemicals in controlling storage pests
- maize can be stored safely for more than12 months
- stores seed (OPV)without losing seed viability
- Simple to use
- affordable by small holder farmers

Where big volumes of produce are required to be stored, a grain store/bulking centre/ware house is used and good storage management practices are required to ensure grain quality. The type of storage facility depends on the volume of grain, purpose and the financial resources.

Warehouse and silos for storage of big volumes

5.3.2 Storage Management

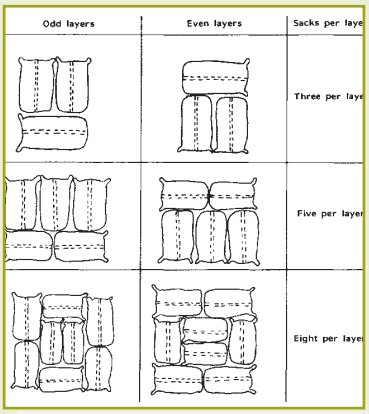
Reception

This is the process of receiving grain into a storage facility and involves the following processes;

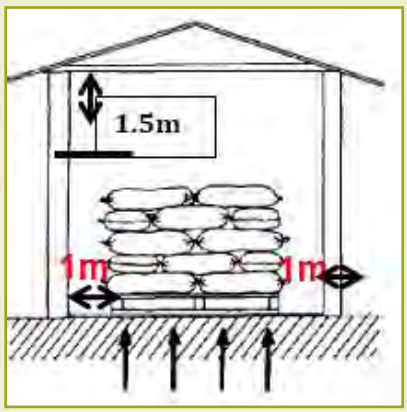
1. Inspection; Bagged grain received for bulking is checked for physical appearance and any possible signs of non-conformity to grain standards.
2. Sampling; small quantities of grain are taken from different bags for analysis (EAS 902).
3. Testing; analysing grain samples as per set quality standard (EAS 2).
4. Off Loading: If the grain meets the set standard then it is off loaded, weighed and recorded.
5. Stacking (bagged); bags are offloaded and placed on pallets in a design that will ensure safety, stock taking, fumigation and ease of movement within the facility. The stacks of the produce should be 1m away from the wall to allow for inspection. Where produce covers a whole store, corridor of 1.5m should be left in the middle. When stacking bags, a space of 1.5m should be left between the last line and the roof. For silos storage, grain is poured on a reception pit and conveyed to the silos by elevators.

Stacking of produce on pallets

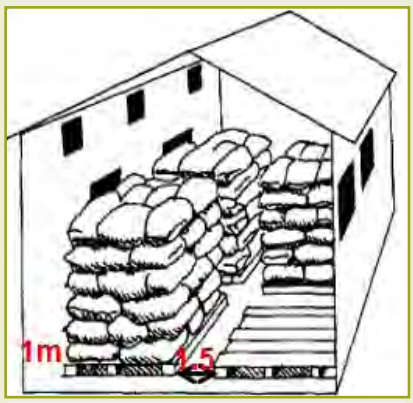
6. Stacks should be placed by crossing the layers to increase stability. Organize the produce in a well-defined pattern to ensure safety, easy stock taking and air flow as indicated in the lay out below. Note: bags of the same weight and shape should be stacked together



Layout of bags



Spacing of bags in the pallets



Warehouse layout

7. Where hermetic grain storage tank/bag has been used, it should be placed on pallets/dunnage poles or a wooden platform

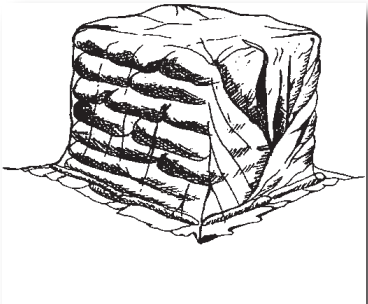
5.3.3 General Hygiene Practices

Health and safety during storage

Storage facilities/collection center and surrounding environment should be kept in good hygienic conditions to ensure quality and safety of the product.

- The store should be cleaned thoroughly before and after keeping in the produce
- The floor, walls and roof should be cleaned regularly to remove the dust, cobwebs and any other dirt
- During cleaning, the stacks should be covered with tarpaulins or canvas to avoid contamination.

- Bush surrounding the storage facility should be cleared regularly to avoid inhabiting rodents and other insects
- Avoid heaping rubbish near the storage facility to keep away rodents and other sources of contamination
- Storage facility should have access to social amenities as per the required standards.
- Storage structures on poles should have rat guards
- Ensure that the store is closed all the time and is opened as and when required
- Ventilators and other outlets should have screens that prevent rodents, birds and insects from entering the store
- Nonfood materials must not be kept in grain store. They should be kept in a separate nonfood store.
- Avoid storing maize grain with chemicals like herbicides, fumigants, pesticides, fuel and other materials that are hazardous (harmful/dangerous) to life.
- Avoid fire in the storage area. It should be a "NO SMOKING" zone. Flammable materials should not be kept near the food store
- In case other types of food are kept it the store, each type of produce stacked separately to avoid mixing of produce and to avoid cross contamination.



Covered produce

Repairing the storage facility

Good storage practices

It is important to inspect the internal and external areas of the store.

- Regularly check the store for signs of water leakage, the floor for cracks and crevices, for signs of damage on bags (rodent or insect) spillage of grain on the floor, presence of live insects and signs of contamination.
- Always inspect the surrounding environment to ensure hygiene.
- Carry out quality control checks on a regular schedule.
- Fumigate to control infestation of storage insects. Use a licensed professional fumigator.
- Ensure FIFO (first in first out) rule when handling stock in storage.

5.3.4 Storage infrastructure design and maintenance:

The following should be taken into consideration to ensure good conditions of maize grain storage:

- The roof should be leak proof. The floor should be impermeable and easy to clean
- The walls should be easy to clean
- There should be sufficient ventilation for easy flow of air to remove disorders that may develop during storage and cool the stored maize grain/ produce. (Note: Fans, cyclones and transparent sheets are not recommended in grain storage structures)

5.3.5 Record keeping

Storage records are required for quality control and good handling practices and business management. They include:

- Stack cards (The stack card fixed to a bag stack, used to keep a tally of the number and weight of bags of grain either added or removed from the stack.
- Received stock ledger book
- Outgoing stock ledger book
- Quality control records
- Cleaning records
- Fumigation records

5.4: *Storage pests, mycotoxins and their control*

During storage, maize like other grains is attacked by insects, moulds, and rodents like rats. Pests form the major problem in a storage especially where good storage management practices are not adhered to.

5.4.1 Storage Pests

A number of pests attack grain during storage and they include;

Sitophilus spp.

Sitotroga cerealella

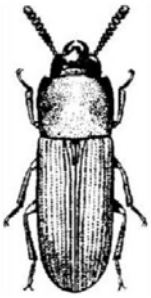
Rhizopertha dominica

Prostephanus truncates

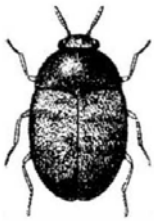
Callosobruchus maculates

Pyralid moths

Tribolium



Gnatocerus



Trogoderma granaria

Oryzaephilus spp

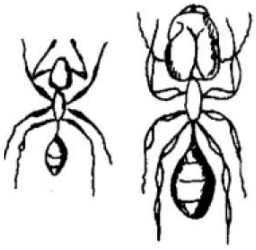
Lasioderma serricorne

Araeocerus fasciculatus

Dermestes spp

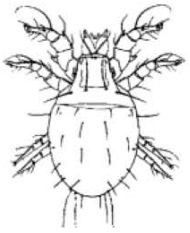
Necrobia ruppes

Carpophilus spp



Termites

Ants



Mite

5.4.2 Control of pests

Storage pests can be controlled physical, chemical and biological methods. Improved storage technologies like the use of hermetic technologies can be used to control pests. Grain infested with weevils when stored in a hermetic storage the insects die due to suffocation.

Fumigation

This is the application of chemicals/fumigants in controlling storage pests of food, mainly grains. Fumigants commonly used include:

• Phosphine • 1,3-dichloropropene • Chloropicrin • Methyl isocyanate • Hydrogen cyanide	• Sulfuryl fluoride • Formaldehyde • Iodoform • Acrylonitrile • Ethylene oxide

Phosphine is the commonly used fumigant for controlling storage insects, however, misuse leads to development of resistance of some storage insects.

Fumigation is a hazardous operation. It is a legal requirement that the operator who carries out fumigation holds official certification to perform the fumigation as the chemicals used are toxic to most forms of life, including humans.

Advantages of fumigants:

- Toxic to a wide range of pests
- Can penetrate cracks, crevices, wood, and tightly packed areas such as soil or stored grains
- Single treatment usually kills most pests in treated area

Disadvantages of fumigants:

- Nonspecific in that they are usually highly toxic to humans and all other living organisms
- Require the use of specialized protective equipment, including respirators specifically approved for use with fumigants

Safety measures during fumigation (see safe use pesticides)

- Keep fumigants safely and out of reach of ordinary persons. Only licensed persons should carry out the fumigation work.
- Wear protective clothing.
- Wash and preferably take bath after fumigation.
- Use a display board indicating the fumigant being used, date of application and person in charge.
- Aerate the grain and stores after uncovering.

5.3.3 Mycotoxins

Mycotoxins are poisonous substances produced by fungi which contaminate grains under poor postharvest handling practices. The common mycotoxins and fumonisms which are known to cause cancer and growth impairment in children and can cause death if taken un high dozes. Humans and animals are all affected through consumption of food and feeds containing mycotoxins.

Mycotoxin are resistant to ordinary food preparations and processing such as cooking; making them a serious public health concern.

Measures to control Mycotoxin Contamination

i) Grow varieties (If available) with resistance to moulds attack
ii) Use recommended PHH practices
iii) When available use biological control agent e.g Aflasafe (Types of moulds that naturally prevent the mycotoxin producing moulds).

Use of mycotoxin binding agents and deactivators for production of animal feeds

Module Six:
Value Addition

Value addition can take a number of forms such as drying, shelling, cleaning, sorting, milling and fortification depending on the level of the value chain. Value addition is important because of the following:

- high market prices
- extended shelf life
- diversifies grain products hence alternative sources of incomes

6.1: *Cleaning and sorting of bean grain*

This normally done at farm level.

6.2: *Milling*

Milling is Process through which grains are broken into small pieces for flour. At a higher level, maize is processed to produce a number of value added products. The products include maize flour, cereals, snacks, grit, starch and byproducts such as maize bran, maize cob meal. The germ of maize can be extracted and used in in food and pharmaceutical industries

6.3: *Food Fortification*

Fortification is adding vitamins and minerals to foods to improve nutritional composition. The nutrients regularly used in grain fortification are meant to prevent micro nutrient malnutrition, strengthen immune systems, and improve cognitive development. Food fortification is required because current milling of maize grain in Uganda lead to loss of nutrients with the bran.

For millers with higher milling capacity producing over 20 tons per day, there is need to set up a more advanced system of Quality Assurance and Quality Control (QA/QC) that incorporates food fortification needs. Fortifying maize flour demands that the nutrients (Vitamin A, and Iron), are added in a manner consistent with national standards (US EAS 2) if it is to be safe and of benefit to the consumers.

Module Seven:
Marketing of Maize

A market is an arrangement which facilitates exchange of goods and services. It can also be a place or forum where buyers and sellers meet to perform their transactions.

Marketing consists of all activities involved in moving a product from the point of production to the point of consumption (Farm to the plate). In other words, marketing involves all those activities linking producers and consumers. Effective marketing should ensure that goods are supplied according to the demand i.e on time and of the quantity and quality that consumers want.

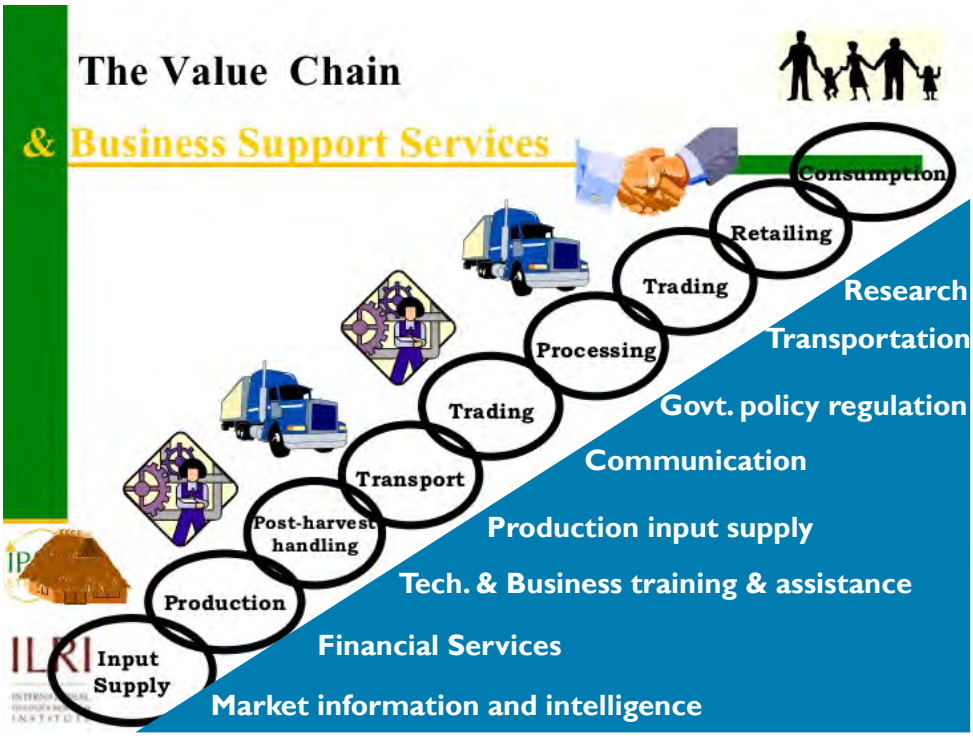
7.1: *Maize Products*

Maize is mainly marketed as, fresh cobs (green) grain, flour, cereals, snacks and bran (animal feeds). Maize in Uganda is sold to local, regional and international markets. Local market comprises individuals, institutions (schools hospitals, prisons, and army) relief organizations

7.2: *Access to markets*

Access to competitive markets requires establishment of both backward and forward linkages between organized farmers (suppliers) and buyers (customers). Farmers need to access other value chain support services such as market information, transport, warehousing, financing, and packaging to enable them produce good quality maize in big quantities as desired by the market.

An illustration of the Value Chain and the support services to show how marketing is interlinked



7.3: *Entrepreneurial skills and Marketing*

Entrepreneurship: Capacity and willingness to develop, organise and manage a business venture along with any of its risks in order to make profits. A maize farmer can become an entrepreneur if he/she comes up with technology innovations and adoptions that will help him increase on his net profits. It is important therefore that maize farmers acquire good entrepreneurship skills to enable them access better markets.

Marketing of maize follows the 7Ps model (Product, Price, Place, Promotion, Packaging, Positioning and People) and 2Cs (Customers and Competition). For maize to be sold to the market, there must be people who want to buy it (the customers), at the same time, sellers must be aware of the competition on the market.

The 7Ps

No.	The P	Relation to Beans
1	Product	Maize
2	Price	Price established by both parties
3	Place	The markets supported by distribution and transportation
4	Promotion	The way in which the target market is informed about the product and where it can be found.
5	Packaging	The way the product is presented to the customers. This creates impression that effects customers' decision to purchase.
6	Positioning	Product must be marketed in place where opportunities for purchasing it are high. Form of marketing that presents the benefits of your products to a particular audience.
7	People	Marketing of beans require people to purchase and to aid in marketing.

Farmers or stakeholder taking maize to market should first carry out market research to establish:

- the price being offered by buyers,
- players involved in the market
- other competitors that are willing to supply maize.

Sources of information include; district commercial offices, traders' information desk, NGOs, short message services (SMS) via phones, e-market apps, extension officers, media, traders and processors involved in grain trade etc.

7.4: *Group/collective marketing in maize business*

7.4.1 Group/collective marketing in maize business

Marketing as a group involves gathering products from individual entrepreneurs and selling collectively. In order for group marketing to be effective, entrepreneurs should synchronize their production operations (planting, inputs used eg seeds, fertilizers, harvesting) and postharvest operations (sorting and grading of the product).

For smallholder farmers to access competitive markets; they should enter into group marketing/collective marketing (horizontal linkages) to attain big volumes and have marketing contracts with big buyers or marketing facilities (vertical linkages) e.g WFP

7.4.2 Advantages of collective marketing

- Attracts large-scale buyers such as NGOs, relief agencies and cross-border customers (e.g. Rwanda, South Sudan) and export market
- Provides maize entrepreneurs with more bargaining power (in terms of prices, sales volume, time of delivery of the maize grain etc).
- Makes small scale farming competitive - small farmers can access technology, credit, marketing channels and information while lowering transaction costs
- Reduces costs if activities are carried out as a group (transporting, grading and packaging of the maize are costs that can be shared).
- Promotes access to better marketing information and marketing advisory services.
- Improves quality of products due to timely and sequenced production.
- Enables groups to purchase quality inputs and transport in bulk.
- Provides a link to get trainings from the off- takers, NGO, implementing partners and government extension.

7.4.3 Challenges of collective marketing

Although collective marketing is beneficial to organized groups, the following challenges should be taken into consideration by group members:

- It may be difficult for the group to agree on crucial issues (decision making)
- Dishonesty/non-transparency among members especially the marketing committee may lead to conflicts.
- Poor record keeping may lead to losses.
- It requires safe collection and holding centers in accessible areas, which is not always possible in rural areas. thefts or losses can occur if the bulking facility is in a location that is poorly secured.
- Good road infrastructure is required to attract large scale buyers to remote/rural areas
- It may require heavy capital investments for assets such as, storage facilities and vehicles for transport.

7.4.4 Key success factors in group marketing

For group marketing to be successful, the following factors are critical:

- Members should be knowledgeable on business management.
- Members should attend group meetings regularly and participate actively in decision making.
- There should be mutual trust among members with emphasis on ethics and integrity.
- The group should have dedicated and committed leaders who are democratically elected.
- The group should have clear and enforceable bye-laws on corrupt and unaccountable leadership.
- There should be clearly defined roles and responsibilities especially in relation to promotion and marketing of group products.
- Existence of rural finance institutions from which to borrow additional capital funds to help finance the group's marketing operations.
- Conducting regular pre-production planning.
- Having access to marketing information through market research.
- Uniformity of group's product in terms of grain quality, packaging, grading etc.
- Having access to safe storage facilities with good road infrastructure.
- The group should have accurate record keeping.
- There should be transparent and equitable distribution of benefits.

7.5: *Other Marketing Channels*

Maize producers may sell their grain through

- The warehousing receipt system or commodity exchange
- Through contracting farming

Warehouse Receipting System (WRS): In this system, the farmer deposits his/her grain in a certified warehouse and is issued with a warehouse receipt document. The receipt provides proof of ownership that a specified **quantity** and **quality** of grain has been deposited at a particular certified warehouse by a named depositor.

Benefit of the WRS

- Provides storage services to the farmers/suppliers that have insufficient storage facilities hence reducing postharvest losses.
- Enables grain supplier to sell their grain when market conditions and prices are favourable
- Ensures quality grain to the market
- Offers quality assurance services to the grain handlers
- Enables farmers or depositors get access to cash faster against the warehouse receipt
- Eliminates issues of delayed payments to farmers
- Eliminates the need to use title deeds as security for financing grain growers

Commodity Exchange: A commodity exchange is a centralized location or trading platform on which buyers and sellers carry out transactions with or without physical commodities or physically meeting, under a set of clearly defined rules and regulations. Both parties are represented by brokers. The farmer becomes a price maker instead of a price taker. Commodity exchange creates a mechanism for price discovery (true market position price for a product at that particular point in time) to occur in an organized manner through a system of price bidding or an auction.

Advantages of commodity farming

- Commodity exchanges reduces transactions costs such as costs associated with identifying market outlets, physically inspecting product quality, and finding buyers or sellers
- Improves price discovery (true market position price) through a system of price bidding or an auction and increases transparency
- Reduces price risks.
- Stake holders are provided with vital information especially on commodity prices through regular publications and dissemination of the information.

Contract farming; In contract farming, agricultural production carried out according to an agreement between a buyer and farmers. It establishes conditions for production and marketing of maize for its products or a specific time. Typically, farmers agree to provide agreed quantities and quality of maize grain according to the set quality standards. In return the buyer commits to purchase the product and, in some cases, to support production through, for example, the supply of farm inputs, land preparation and the provision of technical advice.

Advantages of contract farming

- Makes small scale farming competitive - small farmers can access technology, credit, marketing channels and information while lowering transaction costs
- Assured market for their produce at their doorsteps, reducing marketing and transaction costs
- It reduces the risk of production, price and marketing costs.
- Contract farming can open up new markets which would otherwise be unavailable to small farmers.

- It also ensures higher production of better quality, financial support in cash and /or kind and technical guidance to the farmers.
- In case of agri-processing level, it ensures consistent supply of agricultural produce with quality, at right time and lesser cost.

7.6: *Support services in maize marketing*

These are activities or products required for successful execution of marketing of maize. Support services are a necessity but also come with added costs (marketing costs). Examples of marketing costs are cleaning, grading and packaging, handling, transport, storage, finance, insurance, etc.
Financing: It is a requirement for maize value chain actors and at time it involves huge financial resources requiring borrowing from financial institutions such as banks, microfinance institutions, SACCOs, external borrowing, leasing, hire purchase

Insurance: Importance of insurance is to hedge the maize value chain actors against agriculture risks/natural disasters over which they have limited or no control. Maize commodity for trade should be insured at all times whether in store or being transported. Warehouses should have full insurance cover against fire, burglary and other risks.

Transport: Transport is a major component of the maize trading and a well aligned transport logistics are necessary for the efficiency in the marketing effort. Transport costs vary depending on the distance between the farmer and the market, and the mode of transport used.

Market information: Market information is facts and figures that will help farmers, and other value chain actors involved in the marketing process to make informed decisions and minimize their risks. It may include current selling price of produce, potential buyers, quality and quantities needed; the price of inputs etc.

Benefits of access to market information to the farmer include:

- Farmers' bargaining power is increased.
- Farmers enabled to access more markets.
- farmers' decision making is improved in terms of; what to produce, how much to produce, price to charge, how to promote the product, when and where to sell the product.

Source of market information include buyers, farmers' organizations, fellow farmer, media (newspapers, magazines, TV, radio), exhibitions (shows, fairs and field days), extension workers, developmental agencies (NGOs, CBOs WFP) as well as use ICT – internet messages, short message services (SMS).

License and taxation

For proper trade, ensure that you pay the business license, local authority taxes (eccess taxes) and sales taxes.

Benefits of business license include:

- Legal Protection: A business license protects the owner against being shut down for having an illegal business.
- Credibility: A license helps reassure customers that they are dealing with a legitimate business. and not a scam
- Financial requisition. To qualify for funds, a business must possess a business license
- Business licenses are important because they provide a record of all businesses who may owe tax to the government.

Marketing is more than just sale. Try to find out what the customers want and then meet their demand (Know your Customers)

Module Eight:
Maize Grain Standards

A standard is a document that provides requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that products, materials, processes and services are fit for their purpose.

Standards are developed by national, regional and international standards institutions often to enforce legislation. These bodies issue specifications for commodities as well as methods of testing.

8.1: *Importance of grain standards*

- Complying with standards reduces post-harvest losses and ensures final product is of high quality.
- Farmers get better prices, traders and processors get reliable supply of grain that they can sell to their clients.
- Consumers get food that is safe and nutritious to eat.
- Facilitates both national and regional trade

8.2: *Specifications*

The maize standard requires that maize grain should be free from foreign smell, diseases (moulds), live insects and insect damage, weed seeds, other edible grains, discoloration, immature/shriveled maize, animal droppings and any other contaminants such heavy metal, chemical residues.

Specifically, maize grain shall comply with maximum limits given in table below when tested in accordance with the test methods specified therein.

Specific requirements for dry beans

S/N	Characteristic	Maximum Limit			Test Method
		Grade 1	Grade 2	Grade 3	
i.	Foreign matter, %, m/m	0.5	1.0	1.5	ISO 605
ii.	Inorganic matter, % m/m	0.25	0.5	0.75	
iii.	Pest damaged grains, % m/m	1.0	3.0	5.0	
iv.	Rotten and diseased grains, % m/m	1	2	3	
v.	Discoloured grains, % m/m	1.5	2.0	2.5	
vi.	Immature and shrivelled grains, % m/m	1.0	2.0	3.0	
vii.	Filth, % m/m	0.1			
viii.	Total defective grains, % m/m	5	9	14	
ix.	Broken kernels, % m/m	2.0	4.0	6.0	ISO 5223
x.	Moisture, % m/m	13.5			ISO 6540

NOTE 1 The parameter, Total defective grains is not the sum total of the individual defects. It is limited to 70 % of the sum total of individual defects.
NOTE 2 The parameter, Discoloured grains is limited to at least 25 % discolouration on both sides of the kernel.

Quality requirement

Current market trends and regulations require safe food to be availed to the market. Consumers of maize and its products expect to consume safe and good quality maize products. Maize and its products must meet quality standards.

Farmers should know that maize quality assurance involves prevention of defects from the earliest stages of cultivation. Therefore, quality of maize grain starts from proper land preparation up to when maize is sold. It is therefore, important to ensure good practices are followed at all levels

Contaminants (heavy metals, chemical residues)

Maize must be free of heavy metals in amounts stipulated by the Codex Alimentarius Commission. Heavy metal quantities can only be determined by testing in a laboratory using a special equipment. The contaminant limits are:

Arsenic	0.1 mg/Kg
Cadmium	0.1 mg/Kg
Lead	0.2 mg/Kg
Mercury	0.1 mg/Kg
Tin	0.1 mg/Kg

1Mg/Kg is equivalent to ppm (parts per million)

Aflatoxins

Aflatoxins are poisons released by certain moulds. They come from soil and air and grow when grain is handled poorly. Aflatoxins are not visible by eyes. Determination of presence and level of aflatoxin is done in analytical laboratories and the tests are very expensive. Aflatoxin contaminated maize with levels exceeding 10ppb should not be traded for food or feed. Consumption of high levels of aflatoxin can cause cancer and liver damage and may also lead to death. Always avoid growth of fungus at all stages of the maize value chain.

Maize grain shall comply with the maximum limits for mycotoxins given in the table below when tested in accordance with the test methods prescribed therein.

Mycotoxin limits for maize grain

S/N	Mycotoxin	Maximum limit	Test method
i.	Total aflatoxins (AFB1+AFB2+AFG1 +AFG2), µg/kg	15	ISO 16050
ii.	Aflatoxin B1, µg/kg	5	
iii.	Fumonisins, mg/kg	2	AOAC 2001.04

FDEAS 2:2017

Grain Grading

Grain grading is a process of categorizing grain based on certain quality parameters. This informs decisions such as storage of the grain, uses of the grain and the purchase price.

Method of Sampling

Sampling shall be carried out according to ISO 24333.

8.3: *Hygiene*

One of the ways of ensuring quality standards is to employ Good Hygienic Practices (GHPs) during handling. GHPs along the postproduction value chain ensure good quality and indirectly help in reduction of postharvest losses through reduction of cross contamination that leads to spoilage. Under the provision of the EAS 2 Standard, grain shall be prepared, packed, stored, transported and distributed under hygienic conditions. This implies that maximum care must be taken to ensure that maize is packaged in clean containers by clean people. The areas that the maize is stored should be clean and meet hygiene standards. These stores should be free from pests (e.g. rodents, cockroaches, weevils and other vermin). Modes of transport should also be clean.

8.4: *Packaging*

Maize, when not handled in bulk, shall be packed in clean bags (maximum 50 kg net weight) or similar acceptable protective containers which will safeguard the hygienic and other qualities of the maize. In East Africa it is common practice to package maize in second- hand bags. For a maize consignment to comply with the requirements of EAS 2, clean bags must be used.

The containers including packaging material shall be made only of substances which are safe and suitable for the intended use. These materials should be food grade and in the event of need for verification, a certificate from the supplier should be available to demonstrate that the materials have been declared for use in foods and foodstuff.

8.5: *Labelling*

The following information shall be provided in order to comply with the requirements of EAS 38 and EAS 46.

1. The name of the product should be declared as "White Maize Grain" on the bags. The grade of the maize grain should also be indicated.
2. The name, address and physical location of the producer/packer/importer/distributor should be indicated on the bags
3. The bags should have a lot/batch/code number for traceability
4. The net weight in kilograms should be shown on the package. The EAC partner states are signatories the International Labour Organization (ILO) for maximum package weight of 50 kg where human loading and offloading is involved.
5. The packages should have declaration that the "food is for human consumption"
6. The packages should also have storage instructions "Store in a cool dry place away from any contaminants".
7. The package should indicate the crop year and the packaging date.
8. The packages should have instructions of the disposal of used packages.
9. The country of origin should be indicated
10. A declaration on whether maize was genetically modified or not should be included.

Module Nine:
Farming as a Business

A business is a commercial activity designed to supply goods and/ or services that are demanded by the market with a major aim of making a profit. Farming as a business is built on the principles of improving farm production to increase profits and/or ensure sustainability of farm output. To make profit in business, the cost of production must not exceed the income. Farmers need to understand and update business practices as technology changes.

Farming as a business requires farmers to have entrepreneurship skills that can enable them carry out farming on a commercial scale.

9.1: *Commercial farming*

Farming as a business is based on the commitment of the farmer entrepreneur to carry out farming as an occupation, with a major aim of making profit. The farmer must ensure proper business planning; enterprise selection, business record keeping as well as farm enterprise budgeting.

For commercial farming to be a viable venture, farmers must accurately know their cost of production, margins, understand how to maximize profits by lowering costs of production while increasing yield.

Acreage:
This is the size of land used for agricultural purposes. It is measured in acres or hectares; however, different communities use different units of measurement for land area.

1 acre = 4,000 square meters; 1 hectare = 2.5 acres (10,000 square meters)

The size of a farm land- is very important for;

- Planning accurate input requirements
- Forecasting potential yield and income
- Evaluating performance (potential vs actual)

Land is the principle capital for a business enterprise therefore it must be optimally utilized.

Yield: The output per unit area usually expressed as kilograms per hectare (kg/ha however, in most farming communities, it expressed in terms or bags per acre or otherwise). Yield can only be known if one knows the land size and the weight of the harvest.
E.g Maize Longe 10H= 3600kg/acre

Yield potential should be the target at planning. Other value chain management practices will determine the deviation from the potential (100%)

Productivity

This is the yield per care (kg/acre). As a commercial farmer, it is important to aim at maximum productivity as this determines the total volume of produce supplied to the market. The bigger the volume, the higher the sales and the higher the profits assuming that other factors are held constant.

Profitability

A state of yielding profit or financial gain from a business activity and depends on how the farmer manages costs of production, yield and market price. It is expressed as;

Profit = Sales – Costs of Production

Benefits of farming as a business

Farmers that engage in Farming as a business enjoy the following benefits:

i. Growth in income due as a result of increased profit margins
ii. Improved standards of living due to increased income.
iii. Diversity of consumed products purchased using increased income.
iv. Improved nutrition and household food security.
v. Increased productivity and efficiency of the family farm

9.2: *Principles of business*

i) Invest resources with a profit motive
ii) Provide products or services of value to satisfy the market in exchange for a monetary return
iii) Legal and ethical activities with a defined purpose: Businesses undertake activities that conform to the laws and standards of the society in which they operate, and they clearly state what they exist to do for customers and stakeholders, including their core business
iv) Plan, analyse the environment, and manage risk: Businesses must undertake planning to continuously check what happens within and outside of the businesses, stay alert to uncertain events, and work to reduce potential loss.
v) Record keeping: Businesses out to keep up-to-date records for reference in planning and decision making
vi) Relationship management and continuity: Businesses should develop long-term relations with other stakeholders and continue to operate even beyond the life of the founder

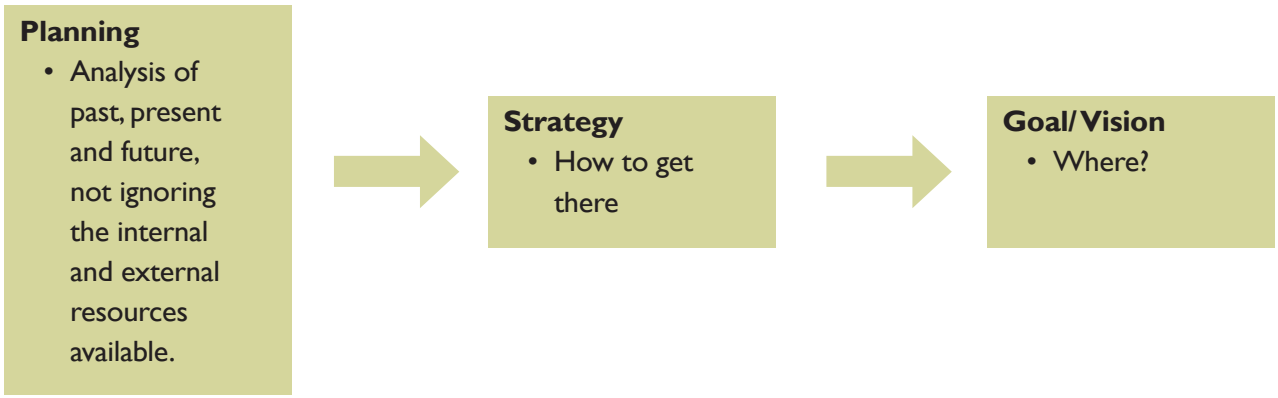
Farming as business = **Inputs** (seed, fertilizers, pesticides, herbicides, farm equipment) + **Processes** (land preparation, planting, weeding, fertilizer application, harvesting, and output marketing) = **Maize grain at a profit.**

9.3: *Farm planning and decision making*

Farm planning is an important aspect of farm business and it involves setting where the business is going **(goals)** and how to get there **(strategy)**. A successful farm is not the result of chance or luck - it is the result of good planning. **Planning** is the process of thinking through what is desired and how it will be achieved. Plans must be made before any other management activities can be performed. Assessment of past, present and expected future performance are integral to the planning process.

A poor plan is better than no plan, and not planning is planning to fail

It is important to take time to analyse past financial and production records to find out which production practices worked well which did not and identify weak spots and while planning for present consider internal (resource availability) and external (markets, economy, weather) forces on the decision-making process. There is need to emphasize joint family household planning and visioning to agree on tasks and roles.



9.4: *Risk Management*

Risk refers to the possibility of incurring a loss due to uncertain outcomes. These could be due to weather, diseases, pests, market, and price. Risk management are the measures put in place by the farmer to avoid or minimize the negative impact of hazards and shocks.

Managing risk is very important for the success of agricultural operations. While some risks can be managed through changes in farming and marketing practices, others cannot be avoided as they are natural (for example, droughts and floods). Therefore, managers of farm businesses need to focus on managing manageable risks and take measures to reduce the negative impact of those that are uncontrollable.

Maize farming like other businesses is supposed to generate income but this is not always certain. This is because businesses operate in a rapidly changing and unpredictable environment that impacts upon the outcomes of business activities. While the physical, political, economic, social, technological, and trading environment presents opportunities for business, it also offers threats that make business risky. However, this does not stop businesses from operating. Entrepreneurs have to expect, accept, and manage risks as they relate to business.

An identified risk is not a threat but a management problem

Risk and associated mitigations

Value Cain Level	Risk	Possible effects	Mitigations
Production	• Climate change/ droughts / floods • Input shortages /inaccessibility • High input costs • Poor quality inputs (counterfeits) • Pests and diseases • Ill health and labour shortages • Theft • Fire	• Total loss or reduction in beans yield	• Adoption of climate smart technologies (irrigation, green house etc) • Good business planning • Diversification of enterprises (crops and livestock) • Adoption of appropriate technologies • Staying up to date with disaster warnings • Collaboration with other farmers in acquiring funds and inputs • Crop Insurance

Market	• Price flactuation • An foreseen competition • Government intervention • Poor infrastructure	• Loss of income	• Insurance • Contract farming • Taking advantage of established market systems such as Warehouse receipt system and commodity market exchange • Collective marketing • Value addition • Proper planning

9.5: *Farm record keeping*

This is the documentation of all the farming activities Farm records facilitate quick reference to previous activities and this enables the farmer to make quick informed decision. Record keeping also provides useful information for assessing the performance of a business at any time. It is important for farmers to emphasize record keeping to enable them carry out financial analysis and budgeting as well as making informed business decisions. Farm records include; human resource, finance, production, operation, storage, and marketing (Annex 5).

Types of Farm records

i. Human Resource:

These include; details of the labor force, leave calendar and profiles of the workers for the farm

ii. Financial:

They include;

- Invoices: document issued by the seller to the buyer demanding payment for the goods and services offered. It indicates the quantity, unit price, taxes and details of the payee.
- Payment vouchers: A document prepared to pay service providers after invoices have been received and verified
- Receipts: It is a document issued acknowledging payment
- Pay in books: Documents indicating money you have paid in the bank
- Cash book: contains information of the money banked, received and spent

iii. Operation:

These are records that contain all farm activities as part of farming as a business. A farmer needs to design a simple comprehensive record entry/ report which can easily be understood by all the people on the farm. Records must be easy to understand and written in such a way that they can easily be accessed for analysis.

iv. Storage:

- Stock card: It is a document in form of a card hanged on a batch of food product or grain indicating the quantity of stock you have at that time. You can also have stock card for all inputs at your farm. Keeping track of stock helps with identifying theft, guarding against wastage and unnecessary purchases and planning for production
- Stack Card: Card fixed to a bag stack used to keep a tally of the number and weight of bags of grain either added or removed from the stack.
- Goods Received Note (GRN): Document issued out to acknowledge receipt of goods
- Received Stock ledger books: Records of the stock that has been received in the store/ware house
- Outgoing stock ledger books: Records of stock that has been removed from the store
- Quality control records: Records for quality status of the stored grain.
- Fumigation records: Records indicating fumigation activities carried out on the farm

v. Marketing:

- List of customers
- Price lists
- Details of buyers and quantities desired by the market
- Product types

Characteristics of good records

- It should be simple and easy to use. If your record keeping system is complicated, it is more likely to generate mistakes.
- The financial records maintained should have appropriate level of details depending upon the type of your business. A more complex farm operation requires a more detailed system.
- A good system provides essential information in a timely manner. Make sure that your records provide essential information on a timely basis.

9.6: *Resource mobilization and management*

Resource mobilization are activities involved in securing required inputs and products for the given program. It involves making better of, and maximizing existing resources such as land, capital and labour (human) that determine the day to day activities and accomplishments. For any given farm activity, it is important to know the resources required and how they can be acquired.

Resource management refers to decision making process (setting goal) whereby limited resources (information, land, labour and capital) are allocated to a number of production, marketing, and financing alternatives

Sources of finance

Savings:

Saving is an act and a habit of putting money away to use at a future date. This can be in the form of cash or material goods whose value appreciates over time. It entails discipline and sacrifice, as one postpones consumption from now to a future date. It leads to capital accumulation over time, which can be invested in profitable enterprises.

Group saving through Village SACCOS

Why saving is important

- Source of capital for farm investment
- Easy source of soft loan for the farmer
- It helps in meeting household needs like paying school fees, hospital bills and buying food
- Money can be used to expand a business.
- Many organizations that provide loan will want to see that a farmer has the ability to save before giving him/her a loan.
- Saving can be used to meet urgent unforeseen emergencies.
- Saving allows a farmer to keep their money safe.

Loan or credit

A loan or credit is money borrowed by an individual from relatives, friends, groups, moneylenders, micro-finance institutions (MFIs) or banks in order to meet either social or economic obligations. A loan is usually paid back over a specified period of time with or without interest depending on the source and purpose. Where the loan is acquired for agricultural development, it is referred to as agricultural credit.

Pre-requisites of accessing agricultural credit

- Must be a commercial farmer
- Have production records.
- Has understanding of credit facilities.
- Willingness to pay back
- Must have a business plan

It is advisable that agricultural credit be used to finance;

- Yield -enhancing inputs and technologies e.g. inputs (fertilizers, pesticides, opening up land)
- Cost reducing inputs such as herbicides

A loan has a cost(interest) that will increase total cost, therefore your yield must increase significantly to both cover this cost and make more profits than a non-borrower.

9.7: *Formalisation of business*

Registration of small-holder farmers is through farmer groups, associations and cooperatives, Large scale farmers can register as companies and this will require a business name, physical location, Article of Association and other relevant documents as required by the law.

9.8: *Writing a business plan*

A business plan is written description of a business' future. It is a road map that describes what you plan to do and how you plan to do it. It is an important first step for any size of business- no matter how simple a business is. It helps to get organized and make sure all necessary steps are taken and acts as a guide to help you think carefully about what you want to farm and what to achieve in future. It is one the documents always required by funders and finance institutions when applying for loan or seeking credit.

A simple but good business plan should include:

- The goal- the direction of the business
- Plans to make your farm more efficient or more profitable.
- What crops are being planted and what acreage (how much maize s planted).
- The stages of planting to marketing of maize and what activities need to done at each of this stage.
- Yield and prices used to estimate income.
- How to market your products.
- Business expenses to be incurred.
- Additional resource needed (source of funds e.g saving, loans etc)
- How to measure success of your business
- Cash flow of the business

9.9: *Cost Benefit Anaylsis (CBA)*

During enterprise selection, profitability of the enterprise should be taken as key. One of the ways for determining the profitability is by carrying out Cost Benefit Analysis of the enterprise.

Gross Margin = Sales – Costs of production

Note: Costs of production involves total costs from production to marketing.

COST BENEFIT ANALYSIS FOR MAIZE USING 4 METHODS OF FARMING				
			High Input	
Activity	**Traditional Farmer A**	**Low input Farmer A**	**Conventional Farmer C**	**Conventional Tillage Farmer D**
Land clearing/slashing	60,000	60,000	60,000	60,000
1st Ploughing	150,000	150,000	140,000	
2nd ploughing			100,000	
Herbicides				30,000
Labour herbicide application				15,000
Seed(OPV), Hybrid	Own seed	30,000 (OPV)	60,000 (Hybrid)	60,000 (Hybrid)
Fertilizers (Basal)			150,000	150,000
Labour – digging holes	60,000	60,000	60,000	80,000
Applying fertilizers			20,000	20,000
planting	20,000	20,000	20,000	20000
Labor for weeding	80,000	80,000	80,000	40,000
Herbicide			36,000	48,000
Herbicide Application			10,000	20,000
Top dressing fertilizer			120,000	120,000
Labor for top dressing			40,000	40,000
Foliar fertilizers		40,000	40,000	40,000
Insecticide			40,000	40,000
Insecticide application		15,000	15,000	15,000
Labor for harvesting	16,000	24,000	60000	60,000
Bags	12,000	15,000	35000	35000
Shelling	20,000	30,000	75,000	75,000
Transportation	5,000	10,000	30,000	30,000
Drying		12000	45,000	45,000
Cleaning and sealing	10,000	15,000	40,000	40,000
Tarpaulins	20,000	40,000	80,000	80,000
Total Production Costs (UGX)	453,000	601,000	**1,356,000**	**1,163000**
Yield (Kg/per Acre)	700	1000	**2500**	2500
Unit cost of Production	647	601	542	465

Farm gate price per kg	700	700	700	700
Total sales @ 700/-per kg	**490,000**	**700,000**	**1,750,000**	**1,750,000**
Profit	**37,000**	**99,000**	**394,000**	**587,000**

NB: When conducting training on CBA, the table should include all the realistic activities carried during the selected enterprise from production up to marketing.

Profit = Sales – Costs of production

1. Tradition Farmer A Profit = 490,000 – 453,000 = Shs.37,000
2. Low input Farmer B Profit = 700,000 – 601,000 = Shs. 99,000
3. High input Conventional Farmer C Profit = 1,750,000 – 1,356,000 = Shs. 394,000
4. High input Minimum Tillage Farmer DProfit = 1,750,000 – 1,163,000 = Shs. 587,000

Based on the calculation above, it is clear that the conservation tillage method generates high profits and therefore high income. The farmer can use the information to make informed investment decisions.

High profitability leads to quick return on investment (ROI)

$$\text{RoI} = \frac{\text{Gain – Investment costs}}{\text{Investment Cost}} \times 100 \text{ or } \frac{\text{Benefit}}{\text{Cost}} \times 100$$

1. Traditional (A) : $\frac{490{,}000 - 453{,}000}{453{,}000} \times 100 = 8\%$

2. Low input (B) : $\frac{700{,}000 - 601{,}000}{601{,}000} \times 100 = 16.5\%$

3. High input (C) : $\frac{1{,}750{,}000 - 1{,}356{,}000}{1{,}356{,}000} \times 100 = 29\ \%$

4. Conservation Tillage (D) : $\frac{1{,}750{,}000 - 1{,}163{,}000}{1{,}163{,}000} \times 100 = 50\ \%$

Module Ten:
Climate Change

Climate change is the shift in the average weather conditions of an area observed over a long period (30 years and above) of time. Climate Change effects are accelerated by human activities such as deforestation, burning of fossil fuels among others. This is mostly evidenced by the overall trend in raising maximum and falling minimum global temperatures. Climate change may affect the maize value chain in various ways depending on the agro ecological zones. It reduces the prediction predictability of seasonal weather patterns and increases the frequency and intensity of severe weather events e.g. floods, drought and hailstorms.

10.1: *Climate Change risks*

Climate Change risks include negative impacts on, crop production, and farmers' livelihoods mainly resulting from prolonged dry spells, erratic and excessive rains, storms and lightening. Some regions experience floods while others have prolonged dry spell, pest and disease build up and water shortages which may result into poor quality and low beans yields. Climate variation, also contributes to the destruction of infrastructure e.g. road network and market. All these factors threaten the overall agricultural production value chain.

10.2: *Climate Change Impacts on:*

Crop production

- Unpredictable rainfall patterns affect planning for field activities such as sowing, weeding, applying inputs especially fertilizers and harvesting, this results into crop failure hence low yields and poor crop quality leading to food insecurity
- Prolonged dry spell causes water shortages resulting in low yields
- Prolonged dry spell cause crop pest outbreaks
- Floods destroy maize gardens, cause water logging, rotting and increase diseases build up.
- In mountainous areas, excessive rain may cause landslide leading to destruction of bean gardens, homes and infrastructure

Effect of drought on maize production

Socio-economics

- Land degradation due to cutting down of trees, bush burning, silting of rivers, destruction of river banks
- Decreased crop yield
- Decreased income
- Increased production costs
- Food insecurity
- Increased poverty levels
- Increased migration of the communities e.g. from flooded/landslide areas.
- Labour shortage due to migration
- Destruction of the infrastructures (road & markets)
- Increase in human diseases e.g. Cholera and Malaria
- Water shortage.

10.3: *Adaptation and Mitigation of Climate Change effects on Maize value chain*

There are two approaches to responding to climate change impacts. These include climate change adaptation and mitigation measures.

Climate Change adaptation refers to the making of anticipatory or reactive adjustments to prepare for expected climate variability and changing average climate conditions, to moderate harm and exploit beneficial opportunities in agriculture such as climate smart agricultural practices.

Climate change mitigation refers to efforts taken to reduce or prevent emission of Green House Gases that warm the planet. These include planting trees, use of environment friendly technologies, -renewable energies (such as solar, biogas etc.)

10.4: *Why Adapt to Climate Change in the Beans Value Chain?*

There is a need to address effects of Climate Change on production, processing, storage, and packaging of agricultural products such as maize.

10.5: *Climate Smart Agriculture Practices on the farm*

Practice	Why the practice
1. Soil testing	To determine soil fertility levels so that in case of certain mineral deficiencies they can be added back.
2.Pay attention to seasonal weather forecast	So that expected weather patterns are known and are followed by farmers; Because lack of early warning information perpetuates untimely planting and harvesting leading to increased post-harvest losses.
3. Practice minimum tillage e.g. basin conservation farming.	Reduces the cost of production, improves soil texture, conserve soil moisture especially in dry areas.
4. Plant certified, early maturing, drought tolerant and high yielding maize varieties better suited to weather conditions.	Certified for quality assurance, early maturing (90days) & high yielding to withstand drought & disease.
5. Safely use recommended agrochemicals to control weeds, pests, and diseases.	Safety is emphasized to avoid harm on farmer, the plant and the consumer. Apply agro-chemicals at recommended rates. Buy from registered/Licensed agro-input dealers and follow the crop cycle to manage diseases & pests such that you realize optimum yield.
Plant cover crop as intercrop	To suppress weeds and also to conserve moisture
6. Practice crop rotation.	It is prudent to rotate (cereals -legumes -root crops then back to cereals) to break pests and diseases build-up, improve the soil texture.
7. Harvest water for agricultural production.	To irrigate crops during the dry spell
8.Plant boundary trees and hedge row	To have wind breaks, control soil erosion, fix nitrogen, improve soil texture & fertility

Practice	Why the practice
9. Harvest of maize during dry weather conditions.	To avoid losses in yield due to rotting, reduce contamination with aflatoxins

While most of the Climate Change adaptation strategies such as conservation agriculture focus on effects of climate change on production, there is little consideration on appropriate climate smart interventions to cater for post-harvest value chain issues such as storage, processing and packaging. Below are the recommended climate smart agricultural practices for on farm, postharvest handling, storage and marketing.

10.6: *Climate smart practices for post-harvest handling and storage*

Practice	Why the practice
10. Shell maize when it is dry	Shell using appropriate shellers and on tarpaulins to maintain good maize grain quality and minimize losses
11.Dry maize using tarpaulins, concrete floors and mats or in cribs	To maintain good quality, minimize losses and aflatoxin contamination. Ensure that grain is dried to 13%mc,
12. Dry maize grain using recommended driers e.g. solar driers	To maintain good quality, minimize losses and aflatoxin contamination
13. Dry maize to the recommended moisture content (13%) before storage.	To maintain good quality, minimize losses and aflatoxin contamination.
14. Store maize in dry safe places and on pallets, and air tight containers (hermetic storage)	To maintain good quality, minimize losses and aflatoxin contamination.

10.7: *Climate smart marketing*

Practice	Why the practice
Sell off dried grain when they are of good quality, good mc and well sorted	to minimize losses, attract competitive prices and builds good farmer's reputation for quality.

10.8: *Mitigation practices on the farm*

Practice	Why the practice
Agroforestry (fruit trees, shade trees)	Trees are carbon sinks which reduces on the accumulation of Green House Gases in the atmosphere. Fruit trees provide food while leguminous shade trees fix nitrogen in the soil.
Use of renewable energies	To prevent emission of Greenhouse gases

Annexes

Annex 1: Maize Grain

Variety name/ code	Optimal production altitude range	Duration to Maturity (days)	Grain yield (T/Ha)	Special attributes
Longe 1	1000 - 1600	115	6	OPV, Resistant to MSV, drought tolerant, early maturity
Longe 2H	1000 - 1600	125	8	Resistant to MSV, NLB, GLS and to storage pests, resistant to lodging
Longe 3H	1000 - 1600	125	8	Resistant to MSV, NLB, GLS and to storage pests, tendency to produce 2 cobs/plant
Longe 4	1000 - 1600	100-105	4 - 6	OPV, early maturity, drought tolerant, resistant to MSV, NLB and GLS,
Longe 5 (QPM), S	1000 - 1600	115	6	Quality Protein maize, early maturity, drought tolerant, high protein content, OPV, resistant to MSV, GLS, susceptible to NLB,
Longe 6H	1000 - 1600	125	8	Higher yields than OPVs, Resistant to MSV, NLB, GLS
Longe 7H	1000 - 1600	125	8	Resistant to MSV, NLB, GLS, drought tolerant
Longe 8H	1000 - 1600	125	8	Resistant to MSV, NLB, GLS
DK 8051	1000 - 1600	145-150	8	Resistant to MSV, NLB, GLS
DK 8071	1000 - 1600	145-150	8	Resistant to MSV, NLB, GLS
DK 8031	1000 - 1600	145-150	8	Resistant to MSV, NLB, GLS
H 517	1400 - 2400	200-210	11	Highland hybrids
H 628	1400 - 2400	200-210	11	Highland hybrids
H 629	1400 - 2400	200-210	12	Highland hybrids
UH 6303	1400 - 1800	150-180	10	Transitional zone hybrid
UH 615	1400 - 1800	150-180	9	Transitional zone hybrid
WH 403	1000- 1500	125	8	Mid- altitude hybrids
29.YARA 41	1000- 1600		8	Mid- altitude

Variety name/ code	Optimal production altitude range	Duration to Maturity (days)	Grain yield (T/Ha)	Special attributes
YARA 42	1000 - 1600		8	Mid-altitude
H QPM(Salongo)	1000 - 1600	120	7	Resistant to MSV, NLB, GLS diseases. Quality Protein Maize (QPM)
Longe 9 H	1000 – 1600	120	8	Resistant to MSV, NLB, GLS, drought tolerant
Longe 10 H	1000 – 1600	120	9	Resistant to MSV, NLB, GLS, drought tolerant
Longe 11 H	1000 – 1600	120	8	Resistant to MSV, NLB, GLS, drought tolerant
WE 114		125	7.5	Drought tolerant, resistant to MSV, NLB and GLS
WE 106		125	8.25	Drought tolerant, resistant to MSV, NLB and GLS
PAN 7M - 89	1000 - 1600	140 - 150	9.0	Resistant to MSV. Good semi dent grain type
PAN 63	1000 - 1600	120 - 135	8.7	Resistant to MSV. Good Stand ability, flint grain type

MSV= Maize streak virus
NLB = Northern Leaf Blight
GLS = Gray Leaf Spot

Annex 2: FAO crop calendar for Maize

Information from collected literature for Uganda to be used for crop modelling for Uganda

Agro-ecology	Planting - onset	Planting - end	Sowing rate (kg/ ha)	Growth duration	Harvesting - onset	Harvesting end
Districts of Kamuli, Kaliro, Iganga, Jinja, Mayuge, Kayunga and Bugiri (Busoga farming system)	25/02	15/08	25	110-120 days	15/06	15/12
Districts of Kaberamaido, Katakwi, Amuria, Soroti, Kumi, Bukedea, Pallisa, Budaka, Butaleja, Tororo and Busia (Eastern Savannah)	15/03	15/08	25	110-120 days	05/07	20/12
District of Abim, plus parts of Kaabong, Moroto and Nakapiriprit districts (Karamoja Wet zone)	20/03	20/04	25	100-120 days	30/06	20/08
Districts of Kibaale, Mubende, Kiboga, Bundibugyo, Kyenjojo, Kabarole, Kamwenge, Buliisa, Masindi and Hoima (Lake Albert Crescent)	20/03	31/08	25	110-120 days	10/07	31/12

Districts of Wakiso, Luweero, Nakaseke, Mityana, Mpigi, Mukono, Masaka, Kampala, Kalangala and Rakai (Lake Victoria Crescent)	25/01	31/08	25	110-120 days	15/05	31/12
Districts of Kitgum, Pader, Lira, Dokolo, Amolatar, Apac, Oyam, Gulu and Amuru (Northern Farming system)	15/03	20/07	25	110-120 days	05/07	20/11
Districts of Kisoro, Rukungiri, Kanungu, Kabale. (South western Highlands)	15/08	15/09	25	150-180 days	15/01	15/02
Districts of Moyo, Adjumani, Yumbe, Koboko, Arua, Nyadri and Nebbi (West Nile Farming system)	20/03	20/07	25	110-120 days	10/07	20/11
Districts of Sembabule, Lyantonde, Kiruhura, Mbarara, Isingiro, Ntungamo, Bushenyi, Nakasongola, Ibanda and Kasese (Western Range lands)	15/08	15/09	25	110-120 days	05/12	15/01

Annex 3: List of Common agro-chemicals for maize production

Period of Registration	The registration number	Trade name / Commercial name	Name of the active ingredient(s) and Concentration
INSECTICIDES			
16/03/2018	UgC/2018/001779/In/RRRR	JACKPOT 50 EC	Lambda cyhalothrin 50g EC
27/02/2018	UgC/2018/001776/In/RRRRR	ROCKETT 44EC	Profenofos 400g/l +Cypermethrin 40g/l
27/02/2018	UgC/2018/001774/In/RRRRRRR	CYPERLACER 5EC	Cypermethrin 50g/l
12/02/2018	UgC/2018/001771/In/R	LARVET 44EC	Profenofos 400g/l + Cypermethrin 40g/l
24/01/2018	UgC/2018/001763/In/RR	SICOTHOATE 40EC	Dimethoate 400g/l
29/08/2016	Ugc/2016/001468/In/R	STRIKER 247SC	Lambda-cyhalothrin 106g/l + Thio-methoxam 141g/l
19/01/2018	UgC/2018/001762/In/RRRR	HANGTHOATE 40EC	Dimethoate 400g/l
19/01/2018	UgC/2018/001761/In/RRRR	DUDU ALL 45EC	Cypermethrin 100g/l + Chlorpyrifos 350g/l
21/09/2016	Ugc/2016/001484/In/RRRRR	TAFGOR 40EC	Dimethoate 400g/l
15/01/2018	UgC/2018/001746/In/RRRR	DUDU CYPER 5EC	Cypermethrin 50g/l
12/01/2018	UgC/2018/001744/In/R	EXTREME 44EC	Profenofos 400g/l + Cypermethrin 40g/l

21/09/2017	UgC/2017/001695/In/RR	CHLOROFET 48EC	Chlorpyrifos 480g/l
21/09/2017	UgC/2017/001696/In/RR	CYPERMETHRIN 5EC	Cypermethrin 50g/l
13/09/2017	UgC/2017/001663/In/R	MISILE 44EC	Profenofos 400g/l + Cypermethrin 40g/l
19/06/2017	UgC/2017/001619/In/RRR	NIMBECIDINE 0.03EC	Azadirachtin 30g/l
HERBICIDES			
24/01/2018	UgC/2018/001764/He/RRR	ASCOMINE 72SL	2,4-D Amine 720g/l
180/1/2018	UgC/2018/001751/He/R	R CHOICE 2,4-D AMINE 720SL	2,4-D Amine 720g/l
15/01/2018	UgC/2018/001749/He/RRRR	WEEDMASTER 50SL	Glyphosate 500g/lP
15/01/2018	UgC/2018/001748/He/RRRR	BUTANIL 70EC	Propanil 350g/l + Butachlor 350g/l
19/01/2018	UgC/2018/001757/He/RR	OXFEN 24EC	Oxfluorfen 240g/l
22/12/2017	UgC/2017/001726/He/RRR	WEED END 41SL	Glyphosate 410g/l
2/10/2017	UgC/2017/001701/He/R	WEED ROUND TURBO 75.7 SG	Glyphosate ammonium salt 757g/l
18/09/2017	UgC/2017/001665/He/R	RISCOPE 2,4-D 72SL	2,4-D Amine 720g/l
18/09/2017	UgC/2017/001664/He/R	FALCON 720 SL	2,4-D Amine 720g/l
08/01/2018	UgC/2018/001728/He/R	MAIZE PLUS 40 OD	Nicosulfuron400g/l
28/08/2017	UgC/2017/001660/He/RRR	ROUND UP 360 SL	Glyphosate 360g/l
24/08/2017	UgC/2017/001658/He/RRR	WEED KILL 360 SL	Glyphosate 360g/l
14/06/2017	UgC/2017/001609/He/RRRRRR	KALACH 360SL	Glyphosate 360g/l
08/05/2017	UgC/2017/001598/He/R	MAIZE SUCCEED 26% OD	Mesotrione 4% + Nicosulfuron 2% + Atrazine 20%
11/07/2016	Ugc/2016/001448/He/RRRRRRR	PRIMAGRAM GOLD 660SC	Atrazine 370g/l + S-Metolachlor 290g/l
FOLIAR FERTILIZER			
11/01/2018	UgC/2018/001737/Fe/R	AGROFEED	NPK 12:10:8 + TE
11/01/2018	UgC/2018/001736/Fe/R	EASYGRO CALCIUM	NPK14: 0:2 + TE
07/04/2017	UgC/2017/001589/Fe/R	MAXIFORCE	NPK 20-20-20 + TE
12/12/2017	UgC/2017/001725/AD/RR	SUPER GRO	Wetting agent & Adjuvant

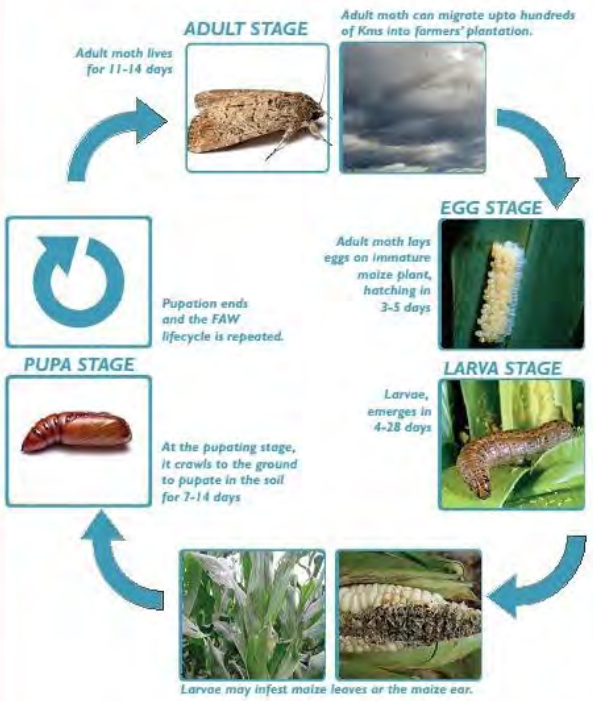
Annex 4: Prevention and Management of Fall Army Warm

FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Feed the Future Uganda Commodity Production and Marketing Activity

Prevention and Management of the Fall Army Worm(FAW)

Life Cycle and Identification



Prevention


Remove all crop residues right after harvest

Deep plough the soil to bury the larvae and pupae


Plant early to avoid infestation which is usually at peak of adult moth migration.


Keep monitoring crops right from 2-3 weeks of planting for any presence of pests or symptoms of infestation

Remedial and Control Actions


For small holder farms, handpick and destroy the egg masses and larvae


If affected area is less than three worms per square foot, put a handful of sand (mixed with lime or ash) sawdust, or soil in the affected area.


For large scale farms, insecticide control is warranted when an average of three or more worms per square foot occurs. Ensure that you use recommended insectcide by designated agricutural authorities.

USAID FROM THE AMERICAN PEOPLE

MAAIF

NARO

Annex 5: Examples of types of records

A. Farm planning schedule:

These are details of the planned farm activities and the tentative dates for carrying them out. The planning schedule should be among the first records a farm manager produces.

An example of a farm planning activity schedule for starting maize production

Activity	Timeframe
• Buying tools and equipment	1st Month
• Preparing land including clearing and ploughing	
• Marking the field	
• Digging planting holes	
• Buying bean seeds and staking materials	
• Gap filling	2nd- 4th Month
•Routine management (weeding, etc.)	
• Looking for markets	
• Harvesting	

B. Production records:

These include input records, labor records and records of all other inputs that are used in the production of maize.

(i) Input records

An example of an input record for starting a maize farm

Input	Date of purchase	Expected useful life	Unit cost	Quantity	Total cost
Land					
Implements (hoes, pangas, etc.)					
Seed					
Fertilizers					
Pesticides					
Gumboots (pairs)					
Sisal rolls for marking planting holes					
Pegs for marking planting holes.					
Total expenditure on inputs					

(ii) Labour records:

This type of record details the labour used for the various tasks on the farm.

An example of labour records for a maize business

Input	Timing (e.g. March)	Duration of the activity (e.g. days)	Amount of labour (e.g. person-hours)	Total Cost of the labour (UGX)
Land clearing				
Ploughing and harrowing				
Field marking				
Digging holes				
Planting				
Weeding				
Thinning				
Harvesting				
Transport				
Marketing				

C. Marketing records :

(i)Sales record:

The sales record is used to capture information on the sales made. It should include the volumes of the produce sold, the date of sale, the average selling price, the type of buyers and mode payment.

An example of sales record for a bean farm

Date of sale	Type of product	Quantity sold	Average. Price per unit sold	Type of buyer, e.g. bicycle traders, wholesaler, etc	Mode of payment, e.g. cash, cheque, credit etc.

Important financial statements

(i) Expected start up Budget:

This helps in projecting the required capital for a business. It can include the capital required for land hire, production, costs of fixed assets and other variable costs required to start your maize business. Can be developed at the start of the business or when planning for some activities. It therefore gives resource requirements for the business.

Format below for preparing a startup budget.

Required resource	Amount planned	Unit cost	Total cost
Land			
Labor			
Equipment			
Planting materials			
.....			

(ii) Cash flow

The cash flow is an educated guess about when and how much money will come into and go out of your business. The cash flow and sales forecast will enable you to decide what you can afford, when you can afford it and how you will keep your business operating on a month-to month basis. As part of the business plan, a cash flow and sales projection will give you a much better idea of how much capital investment your business idea needs.

Sample of a cash flow statement

Cash Inflows	**Amount**
Sell of maize grains	
Sell of fresh maize cobs	
Total Cash Inflows	
Cash outflows	
Payment for land	
Purchase of equipment	
Labor expenses	
Purchase of stationery	
Total cash outflows	

(iii) Balance Sheet

The balance sheet describes the assets, liabilities, and equity of a business at a particular point in time. It is a widely used accounting statement that indicates the economic resources of your organization and the claim on those resources by creditors. It shows the assets of the business and the debts/liabilities of the business

Assets	UGX
Cash	8,000,000
Oxen	1,850,000
Ox ploughs	850,000
Stores	850,000
Total Assets	5,550,000
Liabilities	
Bank Loan	1,500,000
Money from money lender	400,000
Money from a friend	400,000
Total Liabilities	2,800,000
Net assets/Owners Equity	8,250,000

Annex 6: Definitions

Goods – Are tangible things or items that are consumable example food, feeds, tools, agro-chemicals

Services – Are activities people perform such as transportation, cleaning, shelling, storage etc

Value Chain - is a set of linked activities that work to add value to a product. It consists of actors and actions that improve a product while linking commodity producers to processors and markets

Supply – refers to the total amount of goods or services that are produced

Demand- Refers to the total amount that consumers will consume

Pest- is any unwanted organism (animal, plant, insect, bacteria, virus, fungus)

Annex 7: References and Resource Guides

- Sasakawa- Global 2000, 2016. Good Agronomic and Post-Harvest Handling Practices for Maize
- Sasakawa- Global 2000. Crop Production Handbook.
- MAAIF 2016. The Maize Handbook for Extension Workers.
- ACDI/VOCA. Maize Handbook
- MAAIF 2013. Maize Handbook for Extension Workers
- Godfrey Asea et al 2014. Quality Protein Maize Production and Post-Harvest Handling Handbook for East and Central Africa
- WFP 2012. Training Manual for Improving Grain Postharvest Handling and Storage
- East African Community. Trainers Guide 2014. Maize Grain Quality Specification (EAS2:2013)
- Understanding the Warehouse and Warehousing Standard for bagged Storage of Cereals and Pulses, 2017
- A Trainer's Manual on Regional Maize Standard for COMESA & EAC Member States
- Guide for the Dissemination of EAC Maize Grain Standard Posters and Brochures to Farmers and Traders in Uganda
- Guide for Dissemination of Posters and Brochures Concerning Climate Smart Agricultural and Storage Practices for Maize and Beans.
- CIAT. Enabling Rural Innovation in Africa. A Market Facilitator's Guide to Participatory Agro-enterprise Development
- USAID/APEP. Farming as a Business and Production Credit Training Guide

MINISTRY OF AGRICULTURE, ANIMAL INDUSTRY AND FISHERIES
P.O Box 102, Entebbe Plot 16-18, Lugard Avenue, Entebbe-Uganda
Email: www.agriculture.go.ug
Website: info@agriculture.go.ug
Tel: +256 41 4320004