MINISTRY OF AGRICULTURE, ANIMAL INDUSTRY AND FISHERIES

CLIMATE SMART MAIZE PRODUCTION MANUAL FOR EXTENSION WORKERS IN UGANDA

MAY 2025

FOREWORD AND ACKNOWLEDGEMENT

One of the key objectives of the agricultural extension policy is: "To develop a sustainable mechanism for packaging and disseminating appropriate technologies to all categories of farmers and other beneficiaries in the agricultural sector". This aims to address the problem of inconsistences in content delivery by extension workers.

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 remain high.The Ministry of Agriculture Animal Industry and Fisheries (MAAIF) has updated and customized the Maize Training manual, with a corresponding User's Guide.

This training manual has been designed for extension workers engaged in training farmers but can also 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. The manual will also enable farmers make informed decision regarding maize production.

The Permanent Secretary
Ministry of Agriculture, Animal Industry and Fisheries

LIST OF ACRONYMS AND ABBREVIATIONS

ABBREVIATION	FULL FORM
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 Tonnes
MTIC	Ministry of Trade Industry and Cooperatives
NGO	Non-Governmental Organization
PHH	Post-Harvest Handling
QDS	Quality Declared Seed
UCOP	Unit Cost of Production
UNBS	Uganda National Bureau of Standards
WFP	World Food Programme

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CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 PURPOSE OF THE MANUAL

This manual is to build the capacity of extension officers on Climate Smart Agriculture (CSA) Maize Technology, Innovations and Management Practices (TIMPs) to transfer the climate smart technologies and practices for resilient, adaptive and sustainable maize value chains.

1.2 OBJECTIVES OF THE MANUAL

i)To enhance knowledge and skills of extension workers on CSA TIMPs

ii)To provide reference materials for extension officers to support them in training farmers.

iii)To promote adoption of CSA TIMPs to build resilience of the farming community.

1.3 TARGET AUDIENCE

The manual will be used by both public and private extension officers.

1.4 OVERVIEW OF MAIZE PRODUCTION IN UGANDA

1.4.1 Importance of maize

- Production of maize has increased from 2.8 million MT (2015) to 4 million MT (2017).
- Maize is a source of food and provides income security as a result supports livelihood of millions of small-scale farmers in Uganda.
- Maize importance is associated with favorable climate and increasing demand
- Favorable climate enables two cropping seasons in a year
- Increased demand for maize as animal feed arising from increased demand for poultry products has due to rising income.
- This implies that there is a large local potential market for maize.

1.4.2 Food and nutrition aspects of maize

- Maize is also a staple food for majority of people in neighboring countries especially Kenya who are major importers of Ugandan maize grain. Example Kenya alone demands more average of 60,000 MT annually and is likely to go up to 1,000,000MT hence increasing demand on the regional market.

1.4.3 Market trends, challenges and opportunities of maize

- 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.

1.4.4 Maize value chain actors

- 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 and insurance providers.
- All these actors interact, either directly or indirectly, interact with maize products at various nodes of the chain.

1.5 CLIMATE CHANGE AND MAIZE PRODUCTION IN UGANDA

1.5.1 Definition of 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.

1.5.2 Characteristics of climate change

- Reduced weather predictability and cropping season planning.
- Overlapping seasons-impacts on harvest and post-harvest activities, reduced grain quality
- Increase in temperatures.
- Affects potential yields of commercial and farmer varieties.
- Increased frequency and intensity of prolonged dry spells, droughts and heat waves.
- Increases the frequency and intensity of floods, excessive rains, hailstorms and lightening.
- Increased water shortages resulting into poor quality and low maize yields.
- Increased pests and diseases build up.

1.5.3 Impacts of climate change on maize value chains

a. Effects on crop production

i) Unpredictable rainfall patterns affect planning for field activities such as sowing, weeding, applying inputs especially fertilizers and harvesting and this results into crop failure hence low yields and poor crop quality leading to food insecurity

ii) Prolonged dry spell causes water shortages resulting in low yields

iii) Prolonged dry spell cause crop pest outbreaks

iv) Floods destroy maize gardens, cause water logging, rotting and increase diseases.

v) In mountainous areas, excessive rain may cause landslide leading to destruction of bean gardens, homes and infrastructure

Figure 1:Effects of drought on maize field

b. Effects on environmental and socio-economic aspects

- Land degradation due to cutting down of trees.
- Water shortages and scarcity in communities.
- Increased incidence of wildfires.
- Silting of rivers, dams and destruction of riverbanks.
- Increased maize on-farm production costs
- Decreased household incomes and food security.
- Increased poverty levels
- Increased migration of the communities e.g. from flooded/landslide areas
- On-farm labour shortage due to migration
- Destruction of infrastructures, for instances roads and market structures
- Increase in human diseases, for instance, Cholera and Malaria

1.6 CLIMATE SMART MAIZE PRODUCTION IN UGANDA

1.6.1 Definition of climate smart agriculture

Climate-smart agriculture (CSA) is a holistic approach to farming that aims to sustainably increase productivity, enhance resilience to climate change, and reduce greenhouse gas emissions, while also contributing to food security and broader development goals. CSA is an integrated approach to managing landscapes—cropland, livestock, forests and fisheries--that address the interlinked challenges of food security and climate change.

1.6.2 Principles of Climate Smart Agriculture (CSA)

- Sustainably Increasing Agricultural Productivity and income
- Adapting and Enhancing Resilience to Climate Change
- Reducing and/or Removing Greenhouse Gas Emissions

SUSTAINABLY INCREASE AGRICULTURAL PRODUCTIVITY AND INCOMES

Enhance yields and incomes while conserving natural resources.

BUILD RESILIENCE AND ADAPTATION TO CLIMATE CHANGE

Strengthen capacity to withstand climate-related shocks

REDUCE AND/OR REMOVE GREENHOUSE GAS EMISSIONS

Lower or sequester emissions where possible

1.6.3 Benefits of climate smart agriculture

Improving food security and livelihoods by enhancing agricultural production in a way that is environmentally sound and socially equitable

Building the capacity of agricultural systems to withstand and adapt to the impacts of climate change, such as droughts, floods, and extreme temperatures.

Minimizing the agricultural sector's contribution to climate change by reducing greenhouse gas emissions and enhancing carbon sequestration.

1.6.4 Climate smart agriculture practices for maize production in Uganda

Table 1: Climate smart agriculture practices for maize production in Uganda

PRACTICE	PURPOSE
Soils testing	✓ To determine soil fertility levels so that in case of certain mineral deficiencies they can be added back.
Using climate smart varieties	✓ Plant certified, early maturing, drought tolerant and high yielding maize varieties better suited to weather conditions ✓ Drought-tolerant varieties have yield advantage >40% under stress

	✓ Certified for quality assurance, early maturing (90days) & high yielding to withstand drought & disease.
Using weather information services in crop planning	✓ Weather patterns should be known and are followed by farmers; because lack of early warning information results in untimely planting and harvesting leading to increased post-harvest losses.
Practicing minimum tillage	✓ e.g. basin conservation farming ✓ This reduces the cost of production, improves soil texture, conserve soil moisture especially in dry areas.
Appropriate use of agrochemicals	✓ Safety is emphasized to avoid harm on farmer, the plant and the consumer. ✓ Apply agro-chemicals at recommended rates. And buy from registered/Licensed agro-input dealers ✓ Follow the crop cycle to manage diseases & pests such that you realize optimum yield.
Use of appropriate cropping systems and practices	✓ To suppress weeds and also to conserve moisture, soil erosion management e.g. cover cropping, intercropping, proper spacing, crop rotation, mulching etc ✓ It is prudent to rotate (cereals -legumes -root crops then back to cereals) to break pests and diseases build-up, improve the soil texture.
Crop diversification innovations including sustainable land management	✓ To mitigate risks of crop failure ✓ To maintain soil productivity season after season
Harvest water for agricultural production.	✓ To irrigate crops during the dry spell
Plant boundary trees and hedge row	✓ To have wind breaks, control soil erosion, fix nitrogen, improve soil texture & fertility
Harvest of maize during dry weather conditions.	✓ To avoid losses in yield due to rotting, reduce contamination with aflatoxins

CHAPTER TWO: PRE-SEASON PLANNING

2.1 GOAL SETTING

Reflections on why you want to do maize farming.

- What are your goals?
- Are you part of a farmer group in your community?
- Are they short term, medium or long term?
- Have you made plans to achieve your goals?
- Are your plans climate smart?
- Have you written a maize farming business plan?

2.2 WRITING A BUSINESS PLAN FOR MAIZE FARMING

A business plan is written description of a business' future, what you plan to do and how you plan to do it and what you want to achieve.

2.2.1 Purpose of business plan

- Communication tool-attracts capital, loans, and partners.
- Management tool-tracks, monitors, evaluates business progress.
- Planning tool-guides you through various business phases).

2.2.2 Things to consider in making a simple maize farming business plan

- Budget of investment on the maize production
- Source of capital. Are you acquiring an agricultural loan or savings?
- Management plan of the farming & business operations.
- Type of maize products expected and access to markets.
- Plan of managing competitors in the market.
- Post-harvest handling, processing, value addition and quality assurance.

2.2.3 A cost benefit analysis (CBA) for maize production

One of the ways to determine the profitability of a given farming enterprise is to carry out a cost benefit analysis.

Table 2: Cost benefit analysis for maize for different farming methods (an acre)

Activity	Traditional	Low input	High input	Conservation Tillage
Land clearing/slashing	60,000	60,000	60,000	60,000
1st Ploughing	150,000	150,000	100,000	
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 DAP (Basal)			185,000	185,000
Labour – digging holes	60,000	60,000	60,000	80,000
Applying fertilizers			20,000	20,000
planting	20,000	20,000	20,000	20,000
Labour for weeding	80,000	80,000	80,000	40,000
Herbicide			36,000	48,000
Herbicide Application			10,000	20,000
Top dressing fertilizer			185,000	50,000
Labour 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
Labour 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**	**1,391,000**	**1,028,000**
Yield (Kg/per Acre)	700	1000	2500	2500
Unit cost of Production	647	601	556	411
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**	**359,000**	**722,000**

As per the CBA presented in Table 2, the profit associated with the different farming methods was:

Conventional method (no inputs): 490,000 – 453,000 = Shs.37,000

Conventional method (low inputs) = 700,000 – 601,000= Shs. 99,000

Conventional method (high inputs) = 1,750,000 – 1,391,000= Shs. 359,000

Minimum tillage method (high inputs) = 1,750,000 – 1,028,000= Shs. 722,000

Based on the above it is very clear that the Profit and Return on Investment is highest when farmers practice conservation farming which is a form of climate smart agriculture.

NOTE:

- The gross margin is the total sales less total costs of production.
- Total cost of production is the sum of all costs incurred from production to marketing.
- Profit is the total sales less the total costs of production.

2.3 CROPPING CALENDAR

A cropping calendar is a schedule or tool that helps farmers plan what crops to plant, when to plant them, and when to harvest, based on local climate, soil conditions, and crop types. It usually shows sowing time, growing period, harvest time, fallow (rest) periods and sometimes even pest/disease management tips

2.3.1 Importance of cropping calendar

- Helps farmers maximize yield
- Avoids overlapping or conflicting crop cycles
- Ensures better use of resources like water, fertilizer, and labour
- Helps with crop rotation planning

Table 3: Generic crop production calendar

Category	Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Rain Season	Rains			R	R	R		R		R	R	R	R		
Peak Periods	Peaks				Pk	Pk					Pk	Pk			
Crop cycle	Planting			Pl	Pl				Pl	Pl					
Crop cycle	Growing				Gr	Gr	Gr	Gr		Gr	Gr	Gr	Gr		
Crop cycle	Harvest							HV	HV				HV	HV	
Pre-planting season	Seed sourcing	Sp	Sp					Sp	Sp						
Pre-planting season	Land preparation	Lp	Lp					Lp	Lp						
Crop Establishment	Planting			Pl	Pl				Pl	Pl					
Crop establishment	Weed management				W .mgt	W. mgt					W. mgt	W .mgt			
Crop establishment	Fertilizer application				W .mgt	W. mgt					W .mgt	W .mgt			
Crop establishment	Pest management				W .mgt	W. mgt					W. mgt	W. mgt			
Harvest	Harvest					HV	HV						HV	HV	
Post-Harvest management	Post-Harvest						PH	PH						PH	PH

2.4 AGRO-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 30°C – 34°C. Temperatures below 10°C and above 40°C 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

2.5 SITE SELECTION

Maize production requires a suitable site that will support optimal maize growth through the life cycle of the crop. Maize can be grown on a wide range of soils, but performs best on well-drained, well-aerated, deep warm loams and silt loams containing adequate organic matter and well supplied with available nutrients. The best pH range 6.0 - 7.0

Characteristics of a good site

- Well-drained
- Well-aerated,
- Deep warm loams and silt loams
- Contains adequate organic matte
- Well supplied with available nutrients.
- Has a pH range 6.0 - 7.0

Characteristics of a poor site

- Waterlogged
- Poorly aerated,
- Sandy loams
- Soil degradation

Figure 2: Site identification for maize growing

2.6 CLIMATE AND WEATHER INFORMATION

- Extension workers can effectively guide farmers in accessing weather information services, from the Department of Meteorology Services and various dissemination channels like: Mobile Phone, e-Extension Systems, sub county noticeboards, community radios.
- This helps the farmer in risk reduction, resource management and enhanced yield and income.

2.7 SOIL TESTING

- It is essential to assess soil health before any soil management operations are implemented.
- Determine acidity level (soil pH);
- Identify any soil nutrient deficiencies;
- Estimate fertilizer requirements for target yields;
- Estimate the cost of fertilizer needed and the returns

Figure 3: A farmer Taking a soil Sample

2.7.1 Where to test your soil

- 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.
- Always get advice on how to test soils from extension workers and the nearest ZARDI.

2.8 VARIETY SELECTION

There are two categories of maize varieties in Uganda; (i) Open Pollinated Varieties (OPVs) and (ii) Hybrids (see Annex 2). Variety selection is critical in climate smart maize production. The following are the aspects to consider for variety selection for climate smart agriculture.

- Adaptability and yield potential.

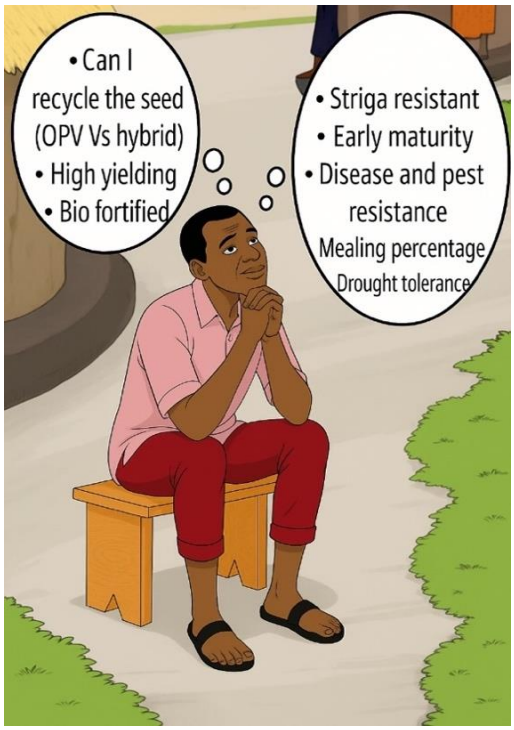
- Resistance to weeds, especially striga.
- Resistance to pests and diseases.
- Early maturity.
- Drought tolerant.
- Milling percentage.
- Nutrient content, for instance, bio-fortified, protein content etc.

NOTE:

- 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 must be bought every season. Recycling hybrid seed reduces yield potential.

Maize variety selection

- Consider selecting between OPV or hybrid maize varieties.
- Select your seed 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.



Characteristics of a good Maize Variety

- Adaptability to the prevailing production condition
- High yield potential.
- Tolerant to Pests and Diseases.
- Early maturity period and drought tolerant.
- Lists of climates smart Varieties-Refer to Annex3

2.9 ACQUISITION OF MAIZE SEED

- Maize seed acquisition refers to the process by which farmers obtain seeds for planting season after season.
- Extension officers should play a crucial role in linking farmers to genuine and quality maize seed dealers.
- Always read carefully the label on seed packages, taking note of source / origin, variety names, date packed, expiry dates and at times expected germination percentages.
- Quality verifications like QR codes and serial numbers using phones are now possible and recommended.

Figure 4: Acquisition of certified maize seeds and carefully read the labels.

NOTE

Seeds may be coated with bio stimulants and other natural based performance enhancing products aimed at improving germination, rooting and/or pest and disease protection.

2.9.1 Germination test

A germination test needs to be carried out on a given seed before planting by following the steps in the figure below.

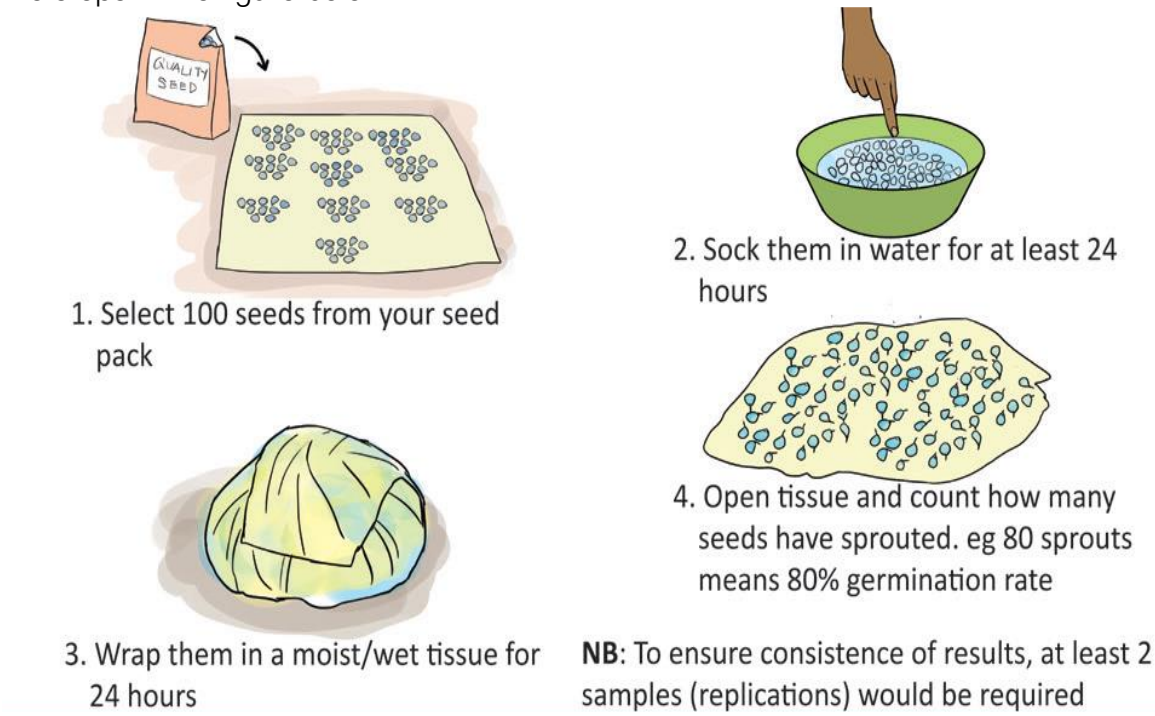


Figure 5: Conducting a germination test on maize seeds

Tabulate the results

Batch / Pack	Total seeds	Normal seedlings	Abnormal seedlings	Rotten, diseased, unavailable
1	100	X_1	Y_1	Z_1
2	100	X_2	Y_2	Z_2

Note:

- *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.

CHAPTER THREE: CLIMATE SMART PRACTICES FOR MAIZE PRODUCTION

3.1 CLIMATE SMART AGRICULTURE (CSA) MAIZE PLANTING PRACTICES

Traditionally, farmers in Uganda us hand hoes and other mechanical planting methods that require complete opening of the holes or furrows for seeding. However, some recommended climate smart planting practices that lead less disturbance of the soil include the followings..

3.2 TIMELY LAND PREPARATION

- Effective land preparation is a crucial component of CSA, as it sets the foundation for healthy crop growth
- Proper timing in land preparation is crucial for successful planting.
- It is recommended to begin land preparation either at the end of the harvesting period or at least three weeks (21 days) prior to planting.
- This timeframe allows for the breakdown of organic matter, which is essential for soil health.
- For optimal seedbed, plough land at least twice.

NOTE: *Farmers should be cautious to avoid excessive tillage, as it can damage soil structure by creating clods, which increases the risk of soil erosion*.

- In areas with dense vegetation, the first step is to clear the land by slashing all plants.
- Leave all the residues on the ground, and do not burn them.
- Incorporating crop residues into the soil, by ploughing them into the soil using appropriate equipment This process aids in moisture conservation and enhances the soil's water-retention capabilities.

3.3 CONSERVATION AGRICULTURE-BASED PRACTICES

Conservation agriculture (CA) is an approach that promotes sustainable and environmentally friendly maize production while enhancing soil health and crop resilience.

3.3.1 Minimum soil disturbance

Involves reducing or eliminating conventional tillage to preserve soil structure and prevent erosion

3.3.2 Zero tillage,

Here seeds are directly planted into untilled soil.

3.3.3 Cover cropping

Is also integral to CA in maize systems, where non-commercial crops are grown during fallow periods to protect the soil from erosion, suppress weeds, and improve nutrient cycling

3.3.4 Crop rotation

Is a key component of CA, as it breaks disease and pest cycles, improves soil structure, and enhances nutrient availability

3.3.5 Residue management,

Where crop residues are left on the soil surface instead of being removed or burned.

DO NOT BURN PLANT RESIDUES

3.4 TIMELY 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.
- Farmers should avoid late planting since it leads to increased incidences of pests and disease attacks hence reduced yields.
- Average optimum temperatures for temperate, highland tropical and lowland tropical maize lie between 20 and 30°C, 17 and 20°C, and 30 and 34°C, respectively
- Maximum temperatures currently exceed optimal temperature conditions for lowland tropical maize (34°C) in several maize production mega environments

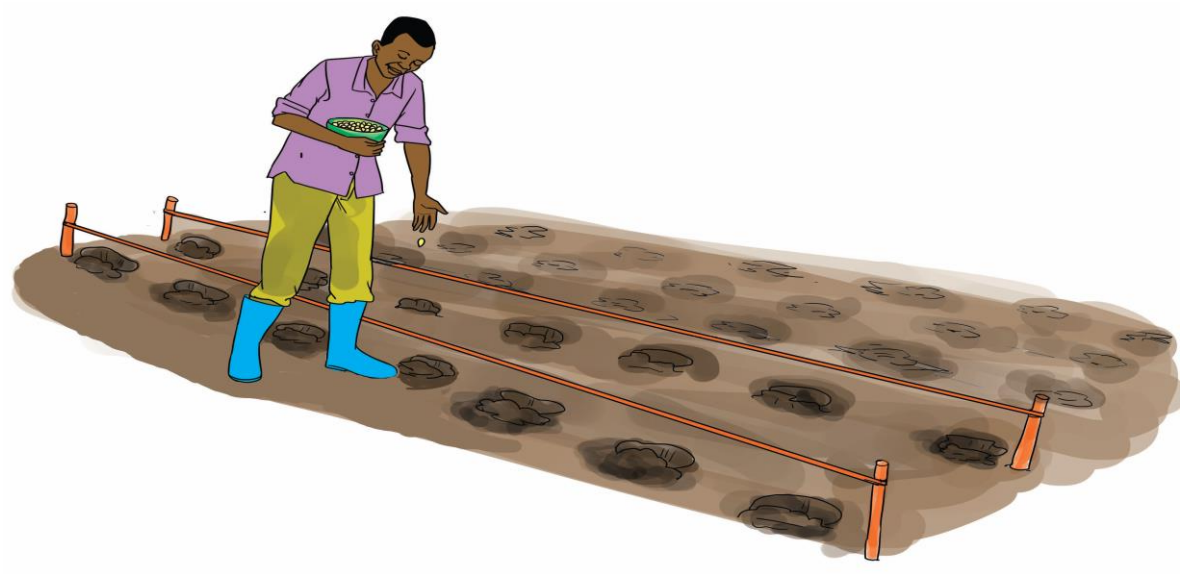


Figure 6: Row planting with well-marked holes

3.5 STRIP CROPPING AND INTERCROPPING

- ✓ Maize is planted in alternating strips with a legume to improve soil health, reduce pests, weeds, and increase yields by nitrogen fixation.
- ✓ Planting maize with legumes, for instance, beans, soybeans, peas or legume shrubs improves soil fertility by fixing nitrogen, potentially reducing on the usage of synthetic fertilizers, and enhances overall crop productivity.

Figure 7: A well-maintained intercropped field of maize and Soya Beans

The green manure cover crop is regularly slashed and left to cover the soil.

Legume shrubs are regularly pruned and the pruning's left to cover the soil and will improve organic matter content of the soil.

Figure 8: Pruning of Legumes

3.6 USE IMPROVED MAIZE VARIETIES

Utilizing drought-tolerant or high-yielding maize varieties can help farmers adapt to changing climate conditions and increase their overall maize production. Several drought-tolerant maize varieties are available, including:

Here's a more detailed look at some of the key drought-tolerant varieties:

- Longe 4: An early-maturing, drought-tolerant open-pollinated variety, also resistant to maize streak virus, grey leaf sport, and northern leaf blight.
- Longe 5 (Nnalongo): A quality protein maize with good tolerance to foliar diseases.
- Longe 7 H: One of the varieties that bring higher net returns in dry spell scenarios.
- MM3: A popular early-maturing variety.
- UH5051: A hybrid developed by NaCRRI, known for its drought tolerance and ability to yield up to 3 tons per acre.
- Longe 2H: A hybrid variety with quality protein maize traits.
- Longe 5H (Nnalongo): A hybrid variety with quality protein maize and good tolerance to foliar diseases.
- Bazooka: A drought and disease-tolerant hybrid and Some of these varieties, like Longe 4 and MM3, are also known for their early maturity.
- Longe 10H: A high-yielding, drought-tolerant hybrid. (Source: Online research gate)

3.7 FERTILIZER/PESTICIDE APPLICATION

CSA practices can optimize fertilizer and pesticide use, reducing environmental impact while maximizing crop yields. CSA methods like crop rotation with legumes reduce the need for nitrogen fertilizers, while precision farming and integrated pest management (IPM) minimize pesticide application.

3.8 PLANTING BASINS

These are shallow depressions in the soil that help to capture and retain rainwater, improving soil moisture availability for maize plants, especially in areas with limited rainfall.

They are about 15 cm wide, 30–35 cm long, and 15 cm deep.

Figure 9: Close-up of a planting basin.

The hand shows how deep the basin is: it should break through the hardpan

Making basins

- Stretch a rope across the field, perpendicular to the slope, securing both ends with pegs. Ensure the string is elevated to stay clear of vegetation.
- Starting at the first marker, dig a rectangular basin approximately 15 cm wide and 30–35 cm long (about the size of a man's foot), and 15 cm deep (as deep as your hand).
- Dig subsequent basins at each marker, working backwards to avoid stepping on the dug basins.
- Once at the row's end, measure the distance to the next row using sticks.
- Move the pegs to stretch the string again, staggering the holes for better rainwater catchment and to prevent runoff.
- About 2 weeks prior to planting, apply well-composted manure (1-2 drink cans per basin) or compound fertilizer (5-7 g per basin).
- If using fertilizer, it can be applied at planting. After application, partially fill the basins with soil, leaving about 5 cm (2 inches) below the original ground level to collect water.

3.9 MECHANIZED PLANTING

3.9.1 Rippers and rip lines

The use of rippers, particularly tractor/ox-plough-drawn rippers, can create rip lines in the soil, allowing for early planting and better water infiltration, especially in areas with sandy soils and irregular rainfall.

Figure 10: Animal traction and tractor drawn rippers

Animal traction and tractors mounted

- Special equipment for planting and used for digging of holes, placing of fertilizers, placing of seed and covering simultaneously.
- Always read the operator's manual and seek advice from the suppliers for effective usage
- The planter is manually operated, no. disturbance of the soil, just drill where to plant. and the advantage is that it digs the hole, places fertilizer, seed and covers it.

Figure 11:The planter has both the seed and fertilizer boxes

3.10 USE OF RECOMMENDED SPACING, SEED RATE AND OPTIMUM PLANT POPULATION

- Recommended spacing: 75cm x 60cm-2 seeds per hole
- 75cm x 25cm 1 seed per hole
- This takes 10kg of seed per acre and optimum plant population of 21,000 plants.
- Though nowadays there are varieties with specific recommended spacing
- Plant in lines (rows) to achieve optimum plant population and ease field operations like weeding, spraying and harvesting.
- 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 provides a favorable environment for crop growth and optimum yield output.
- reduces competition among the plants It reduces pests and disease pressure

3.11 INTEGRATED WEED MANAGEMENT (IWM)

Integrated weed management makes use of different forms of weed control tactics for the purpose of allowing producers the best chance of controlling weeds and also reducing the chances of the development of herbicide resistance.

3.11.1 Cultural Management

The cultural method of weed control comprises various agronomic practices like

Crop rotation (Legume-Cereal Rotation)

Examples:

- Intercropping maize with groundnut, bean, soybean, or pigeon pea can significantly improve maize yield.
- Use of organic based micronutrient fertilizer.

Mulching

- Mulching crop residues as a weed control strategy is extensively practiced in maize
- Applying organic materials like straw or wood chips to the soil surface can prevent weed seeds from germinating and reduce the need for herbicides.

Intercropping, cover Cropping and green manuring

- Planting cover crops before or between maize rows can smother weeds and improve soil health. Intercropping maize with groundnut, bean, soybean, or pigeon pea can significantly improve maize yield.
- Intercropping of maize and legume could decrease the available light for weed.
- Spraying postemergence herbicide on green manure, leads in the reduction of chlorophyll content, consequently guiding to browning, which is known to be brown manuring.

3.11.2 Mechanical weeding

This included land tillage, digging and sickling, flooding, clipping, and mowing of the weeds.

Deep tillage can aid in attaining weed management by burying the seeds of the weed deeper into the soil or by annihilating the roots of perennial weeds.

3.11.3 Chemical management

Chemical weed control involves the use of herbicides to eliminate or suppress weed growth in maize fields. This method is effective when properly timed and applied according to best practices. Herbicides can be classified based on their application timing (pre-emergence or post-emergence) and their mode of action (selective or non-selective).

Figure 12:Mechanical Weeding

Figure 13: Selective application of Pesticide

3.9.4 Biological Management.

Biological Weed Control involves using living organisms (like insects, nematodes, or fungi) to reduce weed populations however, the extent of their use still un clear in Uganda.

3.11. Weed-Suppressing Crop Varieties:

Some maize varieties have natural traits that suppress weeds, making them more competitive. # Integrated nutrient management

3.12. Integrated nutrient management (INM) involves the integration of various nutrient sources, including organic manures, inorganic fertilizers, , and crop residues, to enhance soil fertility and promote sustainable crop growth. Organic manures, such as farmyard manure (FYM) and compost, Inorganic fertilizers, such as nitrogen, phosphorus, and potassium fertilizers, are often used in combination with organic manures to supplement nutrient deficiencies and achieve balanced nutrition.

a. Manure and Compost:

Applying cattle manure or compost improves

- Soil structure,
- Nutrient availability,
- Water retention.

b. Making Compost Manure

Requirements include:

- Dry plant materials,
- Water, ash,
- Green plant materials,
- Animal droppings
- Top soil

c.Steps involved in making a three –pit compost

- Making the base: Find a shady area, dig a pit for the compost and make a bed with twigs or stalks
- 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,

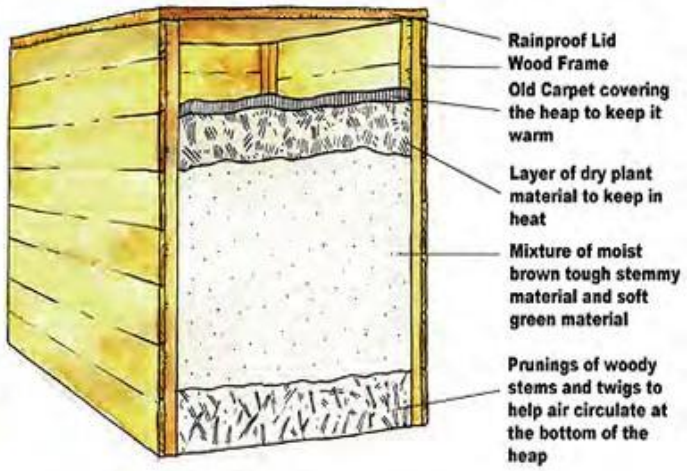


Figure 14:Three-Layer Compost Pit

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

- And water. Repeat the layers 3 or 4 times and cover with soil
- And dry grass to keep the compost moist.
- After 3 weeks, turn the heap layer by layer (this helps the rotting process).

After another 3 weeks, the compost will be ready.

d. Application of compost manure:

- In one acre of well ploughed, use 4 to 6 tons.
- Using a small container to a size of 3 spades, or a half basin,
- Apply during ploughing but should be well decomposed for two to three months,
- Distribute the well decomposed manure in the field evenly and hallow/dig it up, so that it mixes well with the soil.
- Planting is done after two to three weeks from the date of application.

3.12 USE OF NATURE BASED STIMULANTS, VERMICOMPOST, BIOCHAR.

Source: AgrTecno East Africa

3.13 USE OF MINERAL FERTILIZERS

Mineral fertilizers come in the form of powder, crystals, pills, supper granules and liquid fertilizer.

Figure 15:Urea application in Maize

Figure 16: forms of NPK fertilizer

3.14 MANAGEMENT OF STRIGA (WITCH WEED)

Striga is a parasitic weed that devastates maize, other cereals and grasses by attaching the root system and siphon nutrients hence causing stunting, and yield loss of up to100%.

Figure 17:Striga (Witch Weed)

Effective management of striga require an integrated approach including:

- Field surveillance and scouting to remove striga plant before flowering.
- This should be done collectively by all farmers in the area
- Deployment of host resistant maize varieties. These varieties are in two forms; natural resistance such as new maize variety, NARO maize 64-STR. While another type of resistant variety is herbicide resistance technology (IR varieties such as Kayongo-Go)
- Sustainable management of striga entails using push-pull method by intercropping/strip cropping maize and legumes to suppress seed banks (Triggers striga seeds to germinate but can feed on legumes and hence dies).

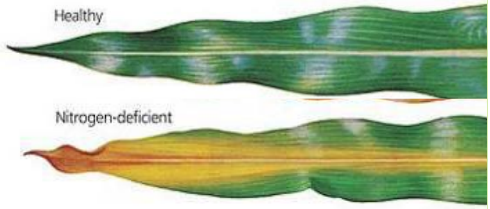
- Ensuring field hygiene and cleaning implements before moving from one field to the other.
- Practice crop rotation
- Boost plant health through manure/fertilizes application
- Awareness among farmers and other stakeholder on striga identification and management
- Refer to striga management manual in the hyper link annexed.

3.15 NUTRIENT DEFICIENCY IN MAIZE CROP

3.15.1 Common Nutrient Deficiencies and Symptoms in maize

Nutrient deficiencies in maize crops can manifest as stunted growth, leaf discoloration (yellowing, purpling), and necrosis (tissue death), impacting yield and overall plant health. This requires the farmer to routinely scout through the maize field to identify nutrient deficiency symptoms and take corrective actions to mitigate losses

Table 4: Common Nutrient Deficiencies and Symptoms in maize.

NUTRIENT DEFICIENCY AND SYMPTOMS	MANAGEMENT PRACTICES
Nitrogen symptoms Lower leaves have yellow mid-rib; Entire plant has a light green color 	Improving Soil health: ➢ Increase soil organic matter through practices like intercropping maize with legumes, which fix atmospheric nitrogen, or using cover crops. ➢ Minimize soil disturbance through no-till or reduced tillage practices, ➢ Mulching to suppress weeds
Potassium Symptoms appear on bottom or older leaves; yellow and brown margins beginning at leaf 	➢ Apply manure at the rate 1000 kg/Ha to improve water holding capacity and minimize leaching of nutrients from the soil ➢ Do not allow the ground to become waterlogged ➢ Keep fields free of weeds ➢ Avoid burning crop residue on the land after harvest so that nutrients from the residues can enter back into the soil ➢ Apply inorganic fertilizers at the rate of 100 kg/Ha using a bottle top of a 300 ml glass

Phosphorous Purple margins; symptoms appear on older/bottom leave 	➢ Focus on soil testing, ➢ Apply manure e.g. well decomposed compost manure made from plants. ➢ Apply 12.5 tonnes/Ha at least five weeks before planting maize. ➢ This can be achieved by applying an equivalent of 20 L tin of manure (16-18 Kg) by broadcasting every 8 metres/steps. ➢ Apply inorganic fertilizers at the rate of 100 kg/Ha using a bottle top of a 300 ml glass

Zinc

Description:

- 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

Remidies

- Test your soil for zinc levels 1-2 months before planting.
- Lime the soil at the recommended rates after soil testing to raise the pH to above 5.
- Use organic manures (e.g. farmyard manure, green manure etc.) to provide organic matter
- Apply compost or mulch to preserve microorganisms and other useful organisms that assist in zinc release.
- Avoid excessive application

Boron

Description

- 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

- Prioritize pre-plant applications or foliar sprays, especially during tasseling and silking.
- Consider soil amendments or foliar applications based on soil test results and
- crop nutrient requirements.
- Complementary practices like Integrated Soil Fertility Management (ISFM) and organic manure/compost
- use can enhance soil health and moisture availability, ultimately reducing reliance on synthetic fertilizers and improving yield.

Magnesium

Description

- 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

Test soil, if it indicates acidity

- Use neutral and basic fertilizers e.g. NPK, CAN (calcium ammonium nitrate)
- Apply lime at least 3 months before planting. Once lime has been applied, use of ammonium fertilizer can begin
- Apply FYM (farmyard manure)/compost manure during planting @ 2 handfuls per planting hole

(Source: Plant Wise fact sheet)

CHAPTER FOUR: PESTS & DISEASES OF MAIZE

4.1 FIELD PESTS OF MAIZE AND THEIR MANAGEMENT

Implementing Integrated Pest Management (IPM) practices can reduce stress on plants and improve their ability to utilize nutrients, according to Rogitex.

Maize 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**)

Table 5: Major Maize field Insect Pests and their Management

PEST	SYMPTOM	MANAGEMENT
Fall Army Worm (FAW) *Spodoptera frugiperda* 		Remove all crop residues right after harvesting Timely planting Deep plough the soils to bury the larvae and pupae
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
Cutworms 	Are greasy-looking, greyish caterpillars, which feed on green plant material. They grow up to 40 mm long and tend to curl into a 'C' shape when disturbed	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.
Aphids 		Early planting, healthy plants through proper fertilization, and weed control are key preventative strategies. Biological control using natural enemies like lady beetles and parasitoid wasps can also be effective.
Maize weevil  	Larvae bore into grain making small holes. Adults are shiny black	Larvae bore into grain making small holes. Adults are shiny black
Maize Smut 		Plough deep to bury surviving spores. ... Monitoring. When plant reaches knee height, check weekly for the presence of whitish-grey tumor-like galls/ swelling on: tassels, husks, ears/kernels, stalks, leaves, prop roots.

4.1.1 Storage pests of maize and their management

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.

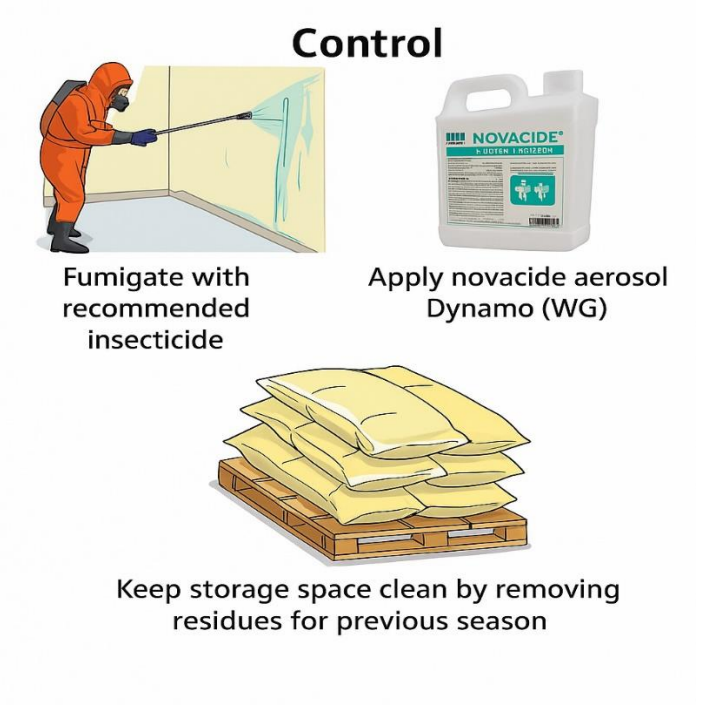
The main storage pests of maize include beetles and moths, with weevils, grain borers, and Angoumois grain moths being particularly common

4.2 PESTS, SYMPTOMS AND MANAGEMENT

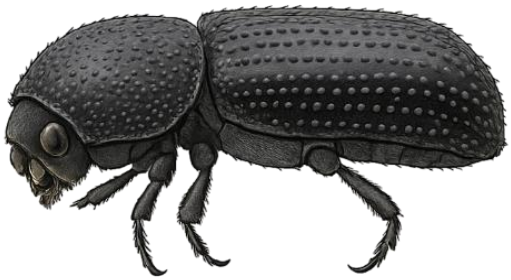
(a). Maize Weevil

Dry to less than 12-13% moisture content

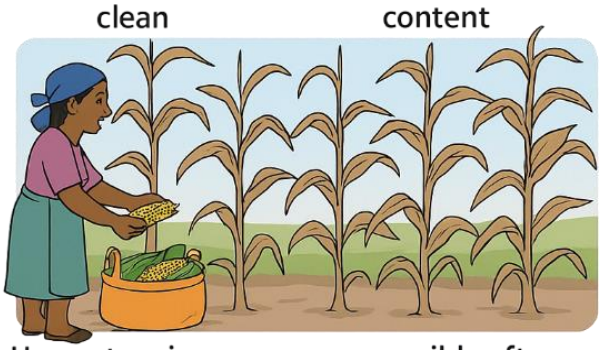
(b). Angoumois moth



(c) Large grain borer



Fumigate the store to eliminate residual infestations



Harvest maize as soon as possible after it has reached maturity

4.2.1 Impact of Storage Pests:

a) Reduced Quality:

Pests contaminate maize with their excrement, reducing its palatability and nutritional value.

b) Increased Moisture and Fungal Growth:

Pest activity increase humidity within the storage, creating conditions for fungal growth and spoilage.

c) Damage to Grains:

Pests can create holes in grains, rendering them unsuitable for consumption or seed.

d) Economic Losses:

Pest infestations can lead to significant economic losses due to reduced crop quality and yield, as well as storage costs.

4.2.2 Management Strategies of storage Pests:

a) Sanitation:

Maintaining clean storage facilities and removing residues from previous harvests can help prevent infestations.

b) Sun Drying:

Drying maize before storage can reduce moisture levels, which is crucial for preventing fungal growth and pest reproduction.

c) Storage Structures:

Using appropriate storage structures, such as airtight containers, can help protect maize from pests.

d) Natural Pest Control:

Using natural methods like storing maize with certain herbs or spices e.g. chili/red paper, neem powder

4.2.3 Maize diseases and their management

Table 6: Management of Common Maize Diseases and their Symptoms

DISEASE	SYMPTOMS	MANAGEMENT
Maize leaf blight		 Practice general field hygiene

Maize streak virus (MSV)		 Uproot and destroy infected plants Use resistant varieties
Maize smut		 Uproot and burn infected crops Plant resistant varieties
Gray leaf spot (GLS)		  Use resistant varieties Practice crop rotation Deep plough under the infested plant debris
Ear rot		

		Timely harvesting in very important
Maize common rust		 Timely planting & use of quality seed

CHAPTER FIVE: HARVESTING, POST-HARVEST HANDLING & MARKETING

5.1 HARVESTING AND POST-HARVEST HANDLING OF MAIZE

5.1.1 Harvesting of Maize Grain

- Harvesting 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.
- Timely harvesting is important to minimize yield losses, too early or late harvesting leads to pest infestation, fungal infection and ultimately yield loss
- For some varieties, the cobs may droop and face downwards as a sign of drying.
- Using clean mats, tarpaulins bags help to keep the cobs clean,
- and reduces fungal infection from the soil.
- It's better to dry maize cobs in well ventilated cribs.
- Treat storage bags with recommended pesticides
- Before bagging for storage ensure that the moisture is ≤ 13%
- Before harvesting, ensure to plan for what to be done.

Figure 18:Process before and after Harvesting maize

Figure 19: Maize Ready for harvesting

Figure 20: Structure for proper storage of maize

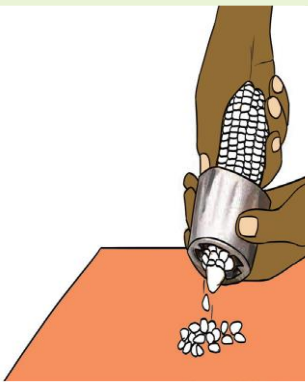
Figure 21: Use Of tarpaulins for covering and drying of maize cobs.

5.2 METHODS OF DRYING MAIZE

- Use of maize cribs
- Dry the cobs on mats, tarpaulins or cemented floor so that they are not in contact with the ground and make sure farm animals are kept away
- Alternatively, use a maize drying crib for protected drying
- Don't let dry seed get wet, cover with a tarpaulin before it rains
- Dry the maize seed to the recommended moisture content of 13%
- Seed driers can be used to achieve this
- Use a moisture meter to measure the moisture content
- There are various methods of testing for moisture content, and these include, traditional biting, the salt bottle method, and moisture meter use

5.3 SHELLING MAIZE

Mechanical maize shelling



Hand maize Sheller

Hand Shelling

Do not beat while shelling

Figure 22: Different ways of Shelling Maize

- Shelling should be done at a moisture content of 16% and below
- Avoid beating the maize cobs to prevent breakage of the grains
- Broken grains will attract fungal infection (Aflatoxin) and insect infestation
- After shelling, dry maize grain up to recommended moisture content of less 13% to 14%.
- How to clean the grain?

Sieve to remove chaff and broken grain

Winnowing

Sorting (sieve (4.5mm mesh)

Remove mouldy and insect damaged grain

- Winnow grain or use a sieve to remove broken grain, chaff and foreign materials.
- Be careful to remove insect damaged grain, mouldy grain and chaff.

5.4 STORAGE

a) Storage methods and equipment

Use of Pic bags | Using pallets | Metallic silos | Use of Store

Figure 23:Different Ways of Storing Maize

- For long storage use hermetic bags,
- Avoid leaking roofs to reduce cases of mold growth which can lead to aflatoxins attack.
- Make sure the store is clean and fumigated before storage
- Ensure the batch of grain stored first is utilized first
- Use (first in – first out) principle

Figure 24:farmer displaying Hematic Storage facilities

5.4.1 Aflatoxin challenges and Dangers on Maize

a) What are Aflatoxins?

- These are poisons produced by fungi (moulds)
- which may attack maize in field, poorly dried and/or poorly stored maize grains.

- Aflatoxins can result into stunting of young children and cause cancer in human beings.
- When Aflatoxin levels exceed the acceptable level, it can lead to rejection of the grain on market.
- Infestation of maize grain by storage pests may favour growth of aflatoxin producing fungi.
- Aflatoxins are heat stable even after cooking/boiling they can still be poisonous
- Eating aflatoxin contaminated maize is not healthy both for food and feeds

b) Examples on dangers of Aflatoxin

- Aflatoxin contaminated maize rejected
- Maize molds
- Consuming aflatoxin can cause death of chicken

Figure 25: Dangers of Aflatoxin

5.4.2 Control of aflatoxins before storage

- Ensure the maize is well dried
- Receive produce with recommended moisture content for storage
- Check for/avoid:
- Chaff, Soil and stone-contaminated grain Check the store to ensure its clean.
- Check the levels of M.C%.
- Avoid broken grain.
- Avoid mouldy and discolored grains.
- Avoid insect and insect damaged grains.
- Avoid grain with bad smell, don't allow this in your store.

Figure 26: drying of maize

5.4.3 During Storage

- Winnow and remove all the damaged, shrivelled, diseased grains and any foreign materials.
- Store sorted, clean and graded grain only.
- Periodically re-dry produce to recommended moisture content.
- Allow spacing in the store for easy access during fumigation.
- Place and store dried produce in clean silos, hermetic bags.
- Store produce with recommended moisture content in clean and dry environment to avoid Insect and insect damaged grain, when you see insects in store, control them immediately.
- Use recommended storage pesticides to control insects and rodents.

Practice store hygiene: Management of rodents and avoid grain spillage in the store.

5.4.4 Good storage practices

- 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.

5.5 DURING TRANSPORTATION

Ensure that grain is well dried before transportation.

Proper transportation of maize grain is critical in maintaining quality, preventing contamination, and minimizing post-harvest losses. Many maize losses occur due to poor packaging, exposure to moisture, rough handling, and inadequate protection from contaminants such as dust, pests, or chemicals.

Figure 27: Proper Versus poor transportation of Maize Grain

5.6 PROCESSING AND VALUE ADDITION

Value addition takes 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
- How to add value on maize grain

5.7 CLEANING AND SORTING NORMALLY DONE AT FARM LEVEL.

a) Milling

Milling is the small 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.

b) Maize products include:

- Maize flour, cereals, snacks, grit, starch and by-products such as maize bran, maize cob meal and the germ of maize when extracted is used in food and pharmaceutical industries.

c) Food Fortification

- Fortification is adding vitamins and minerals to foods to improve nutritional composition.

Benefits

- 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.

CHAPTER SEVEN: MARKETING OF MAIZE

6.1 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 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.

6.2 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.

6.3 ACCESS TO MARKET

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.

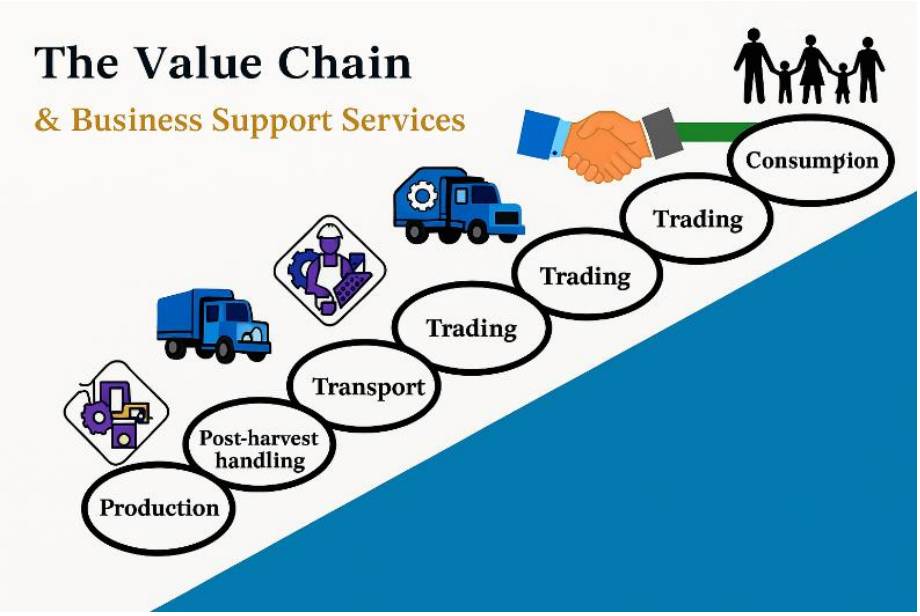


Figure 28: An illustration of the Value Chain and the support services to show how marketing is interlinked

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

6.4 MARKETING SKILLS

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.

6.4.1 The 7Ps Marketing Model

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.

Table 7:The 7Ps Marketing Model for maize

NO.	THE P	RELATION TO MAIZE
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 maize require people to purchase and to aid in marketing.

6.5 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 e.g. 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

6.5.1 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

6.5.2 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.

6.5.3 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.

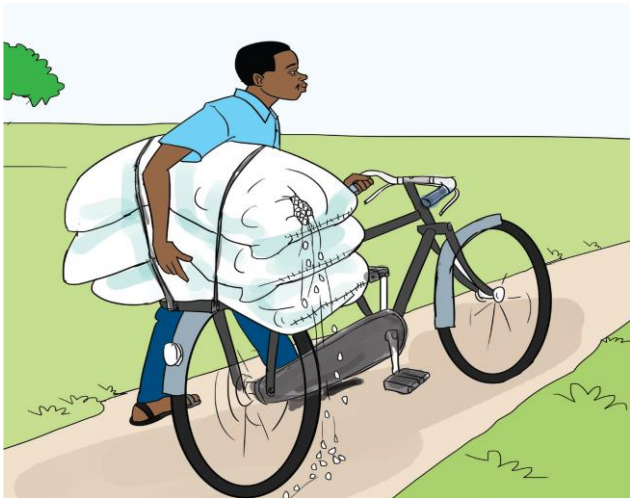


Figure 29: Group member taking produce for bulking

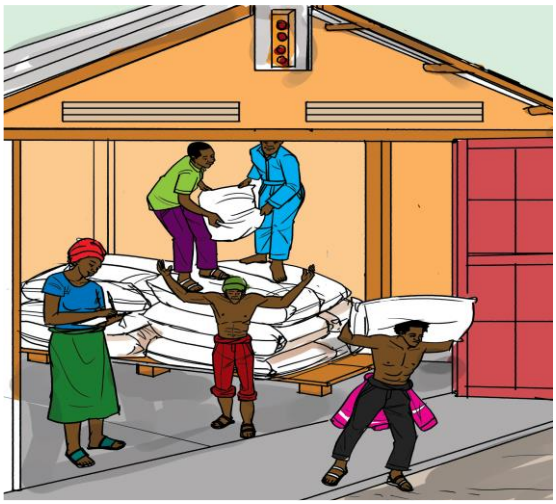


Figure 30: Secretary taking records of the sale of groups' produce

6.5.4 Other Marketing Channels

Maize producers may sell their grain through

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

a) 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

b) 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 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.

6.6 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.

- 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.

- Specification of maize gran standard

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/shrivelled maize, animal droppings and any other contaminants such heavy metal, chemical residues.

Table 8: Specific requirements for maize grain

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 total of the individual defects. It is limited to 70 % of the total of individual defects.

NOTE 2 The parameter, Discolored grains are limited to at least 25 % discoloration on both sides of the kernel.

6.7 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.

CHAPTER SEVEN: SAFE HANDLING AND USE OF AGRO- CHEMICALS

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

7.1 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)

7.2 ADVANTAGES OF USING AGRO-CHEMICALS

- Increases food production
- Improves quality of produce
- Decrease costs of production e.g. use of herbicides
- Are labour saving
- 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

7.3 SAFE USE OF AGRO CHEMICALS

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

7.3.1 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.

Figure 31:Farmer purchasing agrochemicals from a licensed shop.

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

7.3.2 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.
- 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.

7.3.3 Application of Agro chemicals

- 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 Officer or the agro input dealer agent
- Put on the necessary protective clothing as recommended on the product label (cap, masks, overalls, gumboots, gloves, goggles)

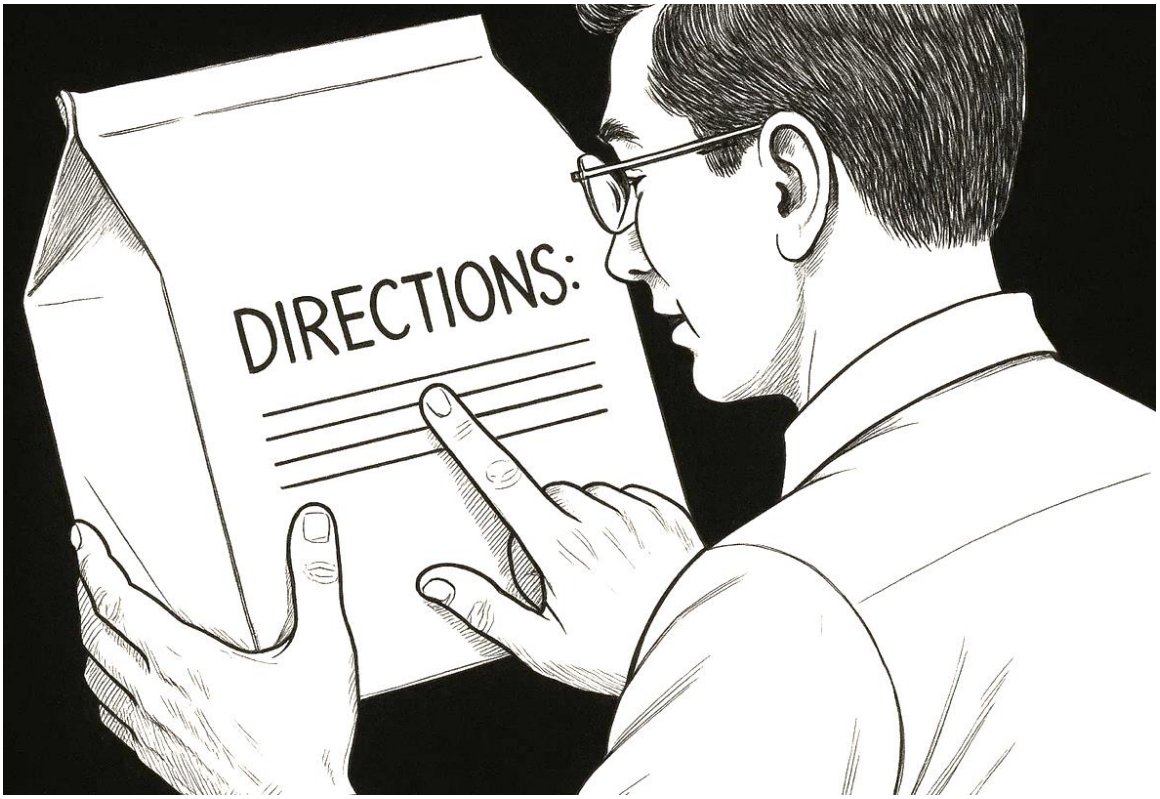


Figure 32: Reading the Product label and Put on the necessary protective clothing as recommended on the product label

- Look out for color 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

7.3.4 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.

7.3.5 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:
- Measure and mark out an area of 10m x 10m = 100sq.m
- Fill the knapsack with known volume of water e.g. 15 litres of water
- 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'.
- Spray the marked area.
- After spraying, measure the litres of water that has remained in the spray tank (e.g 10lts remained)
- Amount used to spray area of 100sq.m = 15lts -10lts = 5lts
- To work out how much pesticide to measure into the sprayer is now very easy.
- Look at the application rate on the product label.

E.G.: Roundup is 1.5L (=1500ml) per Acre and an acre = 4,000 sq. metres
To calculate how much to measure into your sprayer:
1.Calculate the volume of water needed to spray an acre. If 100sq.m took 5lts then 1 Sq.m will take 5/100 lts.
Therefore, An acre = (4000sq.m x 5lts)/100sqm = 200lts

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 needed to dilute 1.5 Liters of Round up.

Calculation:

- 200 lts of water needs 1.5 lts of chemical,
- 1 liter of water 1.5/200 lts of chemical
- Therefore, a knapsack of 20 lts of water (20x1.5) /200= 0.15lts of Roundup

Changing from liters to milliliters

- 1litre is equivalent to 1000ml then 0.15lts x 1000ml = 150mls

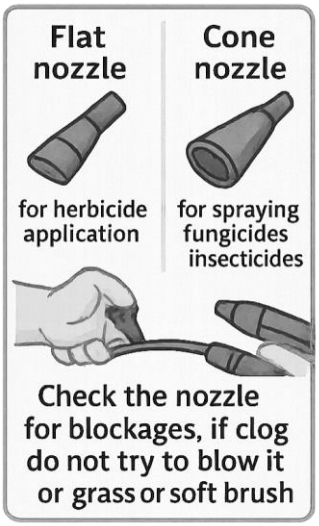
NOTE: Mixing and filling operations are the highest risk time for pesticide accidents.

7.4 SAFETY INSTRUCTIONS

- 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

a) Before Spraying

Before spraying, check the spraying pump for any leaks use the right nozzle for particular activity



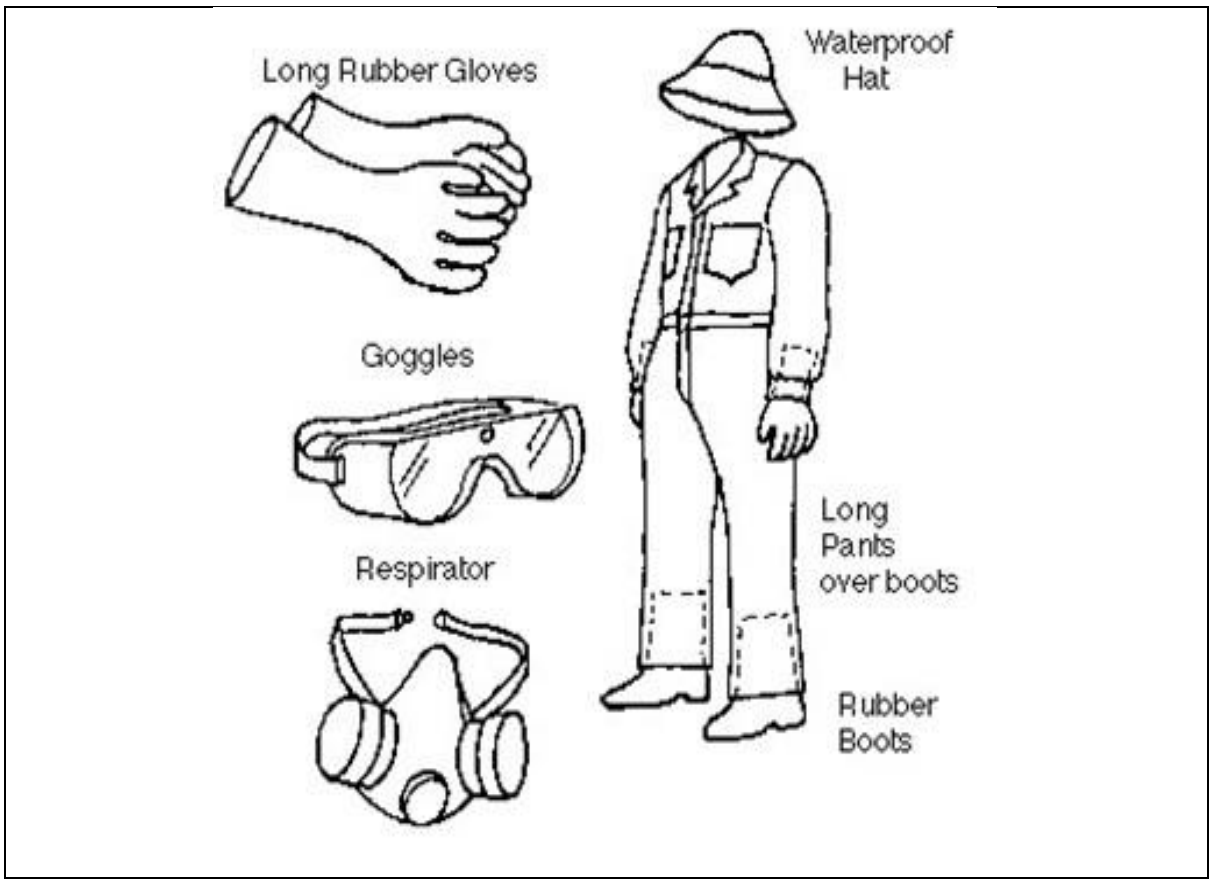
Check the nozzle for blockages, if clog do not try to blow it or grass or soft brush

Wear protective gear before spraying activities

7.4.1 Personal Protection:

- **Protective Clothing:**
  Wear appropriate clothing, including gloves, masks, and eye protection, depending on the type of agrochemical and the task being performed.

- **Gloves:**
  Gloves, especially those made of materials like nitrile or latex, should be worn to protect the skin from absorption and irritation.
- **Masks/Respirators:**
  Use masks or respirators when handling dusts, powders, or spraying chemicals that can be inhaled.
- **Eye Protection:**
  Goggles or face shields are essential to prevent chemicals from splashing into the eyes.
- **Long Sleeves and Pants:**
  Cover exposed skin with long sleeves and pants to minimize contact with agrochemicals.
- **Footwear:**
  Wear closed-toe shoes or boots to protect feet.



b) 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.

Figure 33: A farmer spraying a maize field

c) 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)

d) Disposal of empty containers
- Make sure to properly dispose of empty pesticide containers
- Use all the product in the container according to the instructions.
- Triple-rinse the container and use the solution like the full-strength pesticide.

- Punch multiple holes in the empty container so it won't be used again.
- Recycle the container.

1. Wearing gloves, empty contents of container into sprayer.

2. Fill container ¼ full of water

3. Replace cap and shake container for 30 seconds.

4. Drain rinse water into sprayer.

5. Repeat two more times, shaking container in different directions.

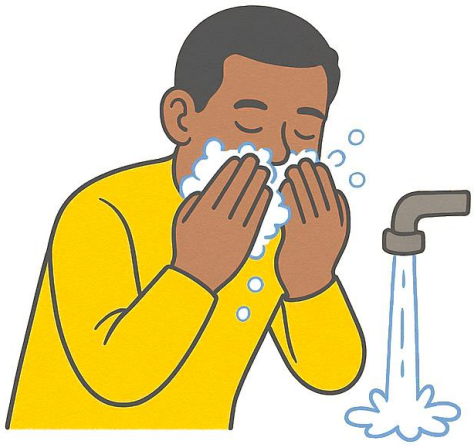
6. Rinse the outside of the container

7. Remove foil seal and label booklet

8. Render unusable. Never reuse a pesticide container for any purpose.

a) Cleaning the spray pump and yourself

b). Bathing after spraying



PERSONAL HYGIENE:
Immediately wash hands, face, and exposed skin with soap and clean water.

SHOWER AND CHANGE CLOTHES:
Take a full shower as soon as possible and change into clean clothes. Wash contaminated clothing

CHAPTER EIGHT: MONITORING AND RECORD KEEPING

8.1 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 several production, marketing, and financing alternatives. Finacing farm activities can be from savings or loans as explained below.

8.2 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.

8.2.1 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.

8.3 LOAN OR CREDIT

A loan or credit is money borrowed by an individual from relatives, friends, groups, moneylenders, micro-finance institutions (MFIs) or banks to meet either social or economic obligations.

A loan is usually Chain and the support services to show how marketing is interlinked Marketing

8.4 TYPES OF FARM 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.

b. Production records

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

c. Human Resource / Labour records

This type of record details the labour used for the various tasks on the farm, including details of the labour force, leave calendar and profiles of the workers for the farm.

d. 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.

8.4.1 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.

8.4.2 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/warehouse
- Outgoing stock ledger books: Records of stock that has been removed from the store

8.4.3 Marketing records / 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.

LIST OF COMMON AGRO-CHEMICALS FOR MAIZE PRODUCTION

Table 9:Common Agro-Chemicals Used during Maize Production

Period of Registration	The registration number	Trade name / Commercial name	Name of the active ingredient(s) and Concentration
INSECTICIDES			
27/02/2018	UgC/2018/001776/In /RRRRR	ROCKETT 44EC	Profenofos 400g/l +Cypermethrin 40g/l
29/08/2016	Ugc/2016/001468/In /R	STRIKER 247SC	Lambda-cyhalothrin 106g/l + Thio- methoxam 141g/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
21/09/2017	UgC/2017/001696/In /RR	CYPERMETHRIN 5EC	Cypermethrin 50g/l
HERBICIDES			
15/01/2018	UgC/2018/001749/H e/RRRR	WEEDMASTER 50SL	Glyphosate 500g/lP
19/01/2018	UgC/2018/001757/H e/RR	OXFEN 24EC	Oxfluorfen 240g/l
22/12/2017	UgC/2017/001726/H e/RRR	WEED END 41SL	Glyphosate 410g/l
2/10/2017	UgC/2017/001701/H e/R	WEEDROUND TURBO 75.7 SG	Glyphosate ammonium salt 757g/l
08/01/2018	UgC/2018/001728/H e/R	MAIZE PLUS 40 OD	Nicosulfuron400g/l
24/08/2017	UgC/2017/001658/H e/RRR	WEED KILL 360 SL	Glyphosate 360g/l
14/06/2017	UgC/2017/001609/H e/RRRRRR	KALACH 360SL	Glyphosate 360g/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
NATURE BASED / BIOSTIMULANTS			

EXAMPLES OF TYPES OF RECORDS

Table 10:Example of Farm planning schedule

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	

Table 11: 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				

Table 12: Example of Input record for 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 plantingholes					
Pegs for marking planting holes.					
Total expenditure on inputs					

Table 13: Example of sales record for a maize 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.

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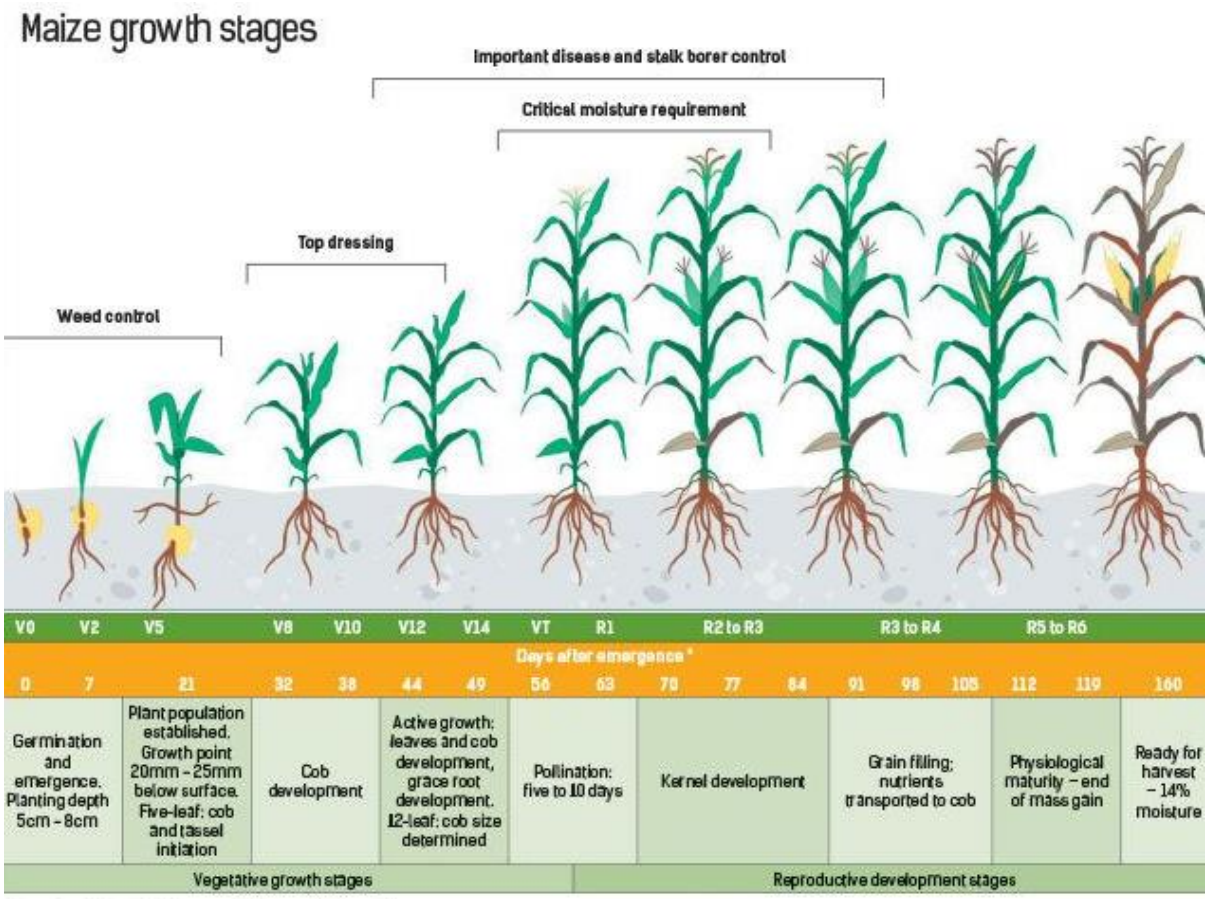
ANNEXES: MAIZE GROWTH STAGES AND CRITICAL MANAGEMENT FOR EACH STAGE



* The number of days varies between growth classes and environments.