GUIDE FOR SUSTAINABLE MAIZE PRODUCTION IN GHANA

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GUIDE FOR SUSTAINABLE MAIZE PRODUCTION IN GHANA

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Contents

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- Xorla A.F., Ahiabor B.D.K, Fosu M. (2015). Community Extension Agent Handbook for Maize Production, Northern Ghana. Revised Edition, 2015. Innovations for Poverty Action (IPA); 131pp.
- Ministry of Food and Agriculture. (2019). Catalogue of crop varieties released and registered in Ghana. Directorate of Crop Services; 81pp.
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FOREWORD

Maize (*Zea mays* L.) is a major staple food crop, accounting for over 50% of the country's total cereal production. Maize grows well in almost every part of the country and its production is dominated by smallholder farmers. The average maize yield in Ghana is relatively low, around 2 t/ha, compared to the potential yield of 6.0 t/ha. Maize production in the country faces challenges, including reliance on rain-fed agriculture, poor soil fertility, limited access to inputs and credit, low adoption of improved technologies (varieties, natural resource management, etc.), pest and diseases, high cost of inputs (seeds, fertilizer and pesticides), and postharvest losses due to inadequate storage and transportation infrastructure. Inadequate extension services have been also identified as one of the main limiting factors to the growth of the agricultural sector and rural community development at large. Generally, achieving productivity growth in the agricultural sector can only be successful through the development and dissemination of improved agricultural technologies to smallholder farmers who dominate Ghana's agriculture.

It is in the light of these challenges that this Manual for Sustainable Maize Production was compiled to equip Agricultural Extension Agents (AEAs) and lead farmers with a comprehensive guide on sustainable maize production practices, such as improved agronomic practices, crop rotation, soil health management and postharvest practices, ensuring long-term productivity and environmental sustainability. By providing farmers with the knowledge and skills they need, extension officers empower them to make informed decisions about their maize production, leading to greater self-sufficiency and improved livelihoods. Improved maize production can contribute significantly to food security, as maize is a staple food crop in Ghana. Generally, lessons learnt in other projects indicate that enhancing the capacity of the extension staff and service providers has improved the uptake of new technologies for dry land farming.

Recognizing that the science of agriculture is always evolving and that all the related information on sustainable maize production herein is far from complete, this manual should not be regarded as a final product. Nonetheless, it has provided an excellent starting point that can, and should, be continually revised.

PURPOSE OF THIS MANUAL

Agricultural Extension Agents are the frontline workers who bridge the knowledge gap between researchers and farmers, ensuring farmers have access to the most effective technologies and practices, ultimately improving agricultural production, farmer livelihoods and food security.

Therefore, a manual on sustainable maize production is crucial for extension officers as it equips them with the necessary knowledge and practical skills to effectively guide farmers, leading to improved maize productivity, better resource management, and ultimately, increased food security and economic opportunities. This manual is intended for agricultural extension agents, lead farmers and others interested in dissemination information on sustainable maize production practices. Specifically, this manual has the following objectives:

- Knowledge transfer and skill development: This manual serves as a valuable resource for extension agents, providing them with the necessary knowledge and skills to effectively communicate and implement best practices in maize production.
- Improved maize production: By following the guidelines and recommendations outlined in the manual, extension officers can help farmers optimize their maize cultivation techniques, leading to higher yields and better-quality produce.
- Resource management: This manual can help extension officers educate farmers on efficient use of resources like water, fertilizers, and pesticides, promoting sustainable agricultural practices and reducing environmental impact.
- Pest and disease management: This manual provides extension officers with the knowledge to identify and manage common

maize pests and diseases, minimizing crop losses and ensuring a healthy harvest.

- Postharvest handling and storage: The manual also covers important aspects of postharvest handling and storage, helping extension officers educate farmers on proper techniques to minimize losses and maintain the quality of maize grains.
- Economic empowerment: By improving maize production and quality, extension officers can empower farmers to increase their incomes and improve their livelihoods, contributing to overall economic development.
- Food security: Increased maize production can contribute to food security, ensuring access to affordable and nutritious food for communities.
- Adaptation to climate change: The manual also includes information on how to adapt maize production to changing climate conditions, such as drought and heat stress, ensuring the long-term sustainability of maize farming.

Disclaimer The information presented in this manual is for advisory use only. Readers using the manual should verify details that relate to their agro-climatic zones from their area agricultural extension agents. The content of the manual is the views of the authors and does not necessarily represent the opinions of FAO, IITA and other implementing project partner organizations or institutions.

INTRODUCTION

Maize (*Zea mays* L.) is a major staple crop, produced and consumed by most farming households in Ghana. It can be used to prepare many local dishes such as kenkey, tuo-zaafi, koko (porridge), banku, akpele, baby weaning foods and is the major source of calories in many parts of the country. It is produced under rain-fed conditions mainly by smallholder resource poor farmers and is well adapted to all the agro-ecological zones of Ghana. It has practically replaced traditional staple crops like sorghum and pearl millet in northern Ghana, where these crops were previously a very important part of the diet of the people. This expansion is due to the availability of early maturing and drought tolerant varieties with higher productivity.

However, the average grain yield on farmers' fields is about 2 t/ha relative to an estimated achievable yield of about 6 t/ha (MoFA, 2021). This yield gap is caused by many factors and key among them include low soil fertility, in-season drought especially at critical stages of crop growth (e.g., tasseling, grain filling etc.), and pests and diseases. Other limiting factors include poor agronomic practices (low plant density, poor weed control, inappropriate timing of fertilizer application, inadequate use of fertilizer, etc.), limited use of inputs (high quality seeds, fertilizer etc.), poor land preparation and inadequate drying and storage facilities leading to high postharvest losses.

To address the above challenges and improve productivity of maize in Ghana, it is important to develop an extension training guide for agricultural extension agents and lead farmers on good agricultural practices (GAPs) for sustainable intensification of maize production in the country. This production guide, therefore, provides simplified GAPs for maize production in diverse areas of the country. This guide provides practical solutions to addressing the agronomic challenges of sustainable maize production from land selection through crop management practices to postharvest management.

MODULE I: MAIZE AGRONOMIC PRACTICES

Overview

The first module of this manual is maize agronomic practices. It aims to increase the participants' understanding and knowledge of good agronomic practices to optimize maize yield and quality through understanding suitable site selection, choice of maize varieties, use of quality seeds, proper land preparation, soil health, planting techniques (optimal planting time, proper planting depth, spacing, and seed rate), nutrient management and effective weed control methods. The module also highlights the characteristics of quality seed, recommended maize varieties, and the effects of poor site selection and use of poor-quality maize seed in maize production.

Key questions

- What land and soil type are suitable for maize production?
- How do you prepare the land for maize production?
- Which varieties are suitable for each agro-ecological zone in Ghana based on climate and regional conditions?
- Distinguish between hybrid and open pollinated varieties?
- How to conduct germination test?
- What are the planting techniques of maize?
- Which fertilizers can you apply to maize, and what quantities, time and placement method?
- How to effectively control weeds in maize production?

Objectives

After completing this module, participants will be able to:

- Describe different soil types and their suitability for maize cultivation.
- Describe how to prepare the land adequately for maize production
- Identify high-quality maize seeds and understand the importance of seed viability, purity, and germination.
- Explain the difference between hybrid maize and open-pollinated varieties
- Explain how to conduct a germination test.

- Explain optimal planting time, proper planting depth, spacing, and seed rate for optimal plant establishment and growth.
- Explain the importance of soil fertility and how to assess nutrient deficiencies and apply appropriate fertilizers (organic and inorganic).
- Explain the role of organic matter in soil health and how to improve it through practices like cover cropping, manure application and composting.
- Apply fertilizers appropriately based on soil test results and crop needs.
- Describe effective weed control methods, including mechanical, chemical, and cultural practices, to minimize competition with maize plants.

1.1 Site selection

Land or site selection is key to ensuring successful production. The following factors should be considered when selecting a site for maize production:

1. **Cropping history and nature of land:**
    - Maize planted on newly cleared will usually yield more than maize planted on land which has been continuously cropped, especially to cereal crops. This is because soil fertility is high and weeds are less of a problem in newly cleared land.
    - Continuous cultivation of maize on the same piece of land in succession, without adequate addition of external nutrient inputs, leads to rapid decline in soil fertility and low crop yields.
    - Places with a long history of pests, especially the parasitic weed, *Striga hermonthica* and diseases, herding activities and high cost of labour should be avoided if possible.
    - Avoid sites on the slope of hills as water and nutrients will flow downhill away from your crops.
    - Accessibility of the land: You should also look out for areas close to a road for easy movement of your harvest from the field and tractors/equipment to your field. But be careful because being too close to a road may be a bad environment to grow crops. If

possible, choose sites that are close to a water source and have good drainage.

2. **Soil type**
   - Maize adapts well to different soil types with an optimum pH range of 5-7. Outside this pH range results in nutrient deficiencies because of unavailability of nutrients and mineral toxicity.
   - Preferably, soils that are deep, well aerated, well drained, fine structured and rich in organic matter give higher yields.
   - Shallow sandy or gravelly soils should be avoided whenever possible as they limit maize response to fertilizer application and increase the effect of drought on maize. However, if this is the only site or land, consider planting maize on ridges.
   - Waterlogged soils should also be avoided as maize is prone to waterlogged conditions. If such fields cannot be avoided, then create channels to drain excess water after soil moisture has reached field capacity. Proper drainage allows for better aeration, weed control and reduces the likelihood of nutrient leaching. Low lying areas usually have poor drainage and water logging will reduce yield.
   - Fertilizer recommendations for maize, depend on the agro-ecology, soil type, quantity and level of residual nutrients in the soil, cropping history of the field and the type of fertilizer materials available.
   - Take a composite soil sample from at least 20 core sub-samples per hectare of 0-20 cm or 0-30 cm depth across the diagonals of the entire field for laboratory analysis to determine the pH and fertility levels of your field. However, if laboratory testing of soil is not feasible, some visual features such as colour of the soil (dark black soil is an indicator of high organic matter), type, color, nature and distribution of weeds on land (dark green color, vigorous growth and uniform distribution of weeds across the field is an indicator of a fertile and good soil).

3. Climatic requirements

- You should also consider the rainfall pattern of the area. If this is a totally new area, you should ask people within the community to know about the amount of rain the area usually receives.
- Maize is sensitive to moisture stress during flowering, when a short spell of stress can reduce the crop yield significantly.
- If you realize that the area where you plan to site your farm does not receive enough rain for the selected crop, change to a different crop to avoid your crops suffering from drought or plant a drought-resistant variety of the selected crops.
- Shadiness of the area: Maize must be grown in full sunlight for efficient photosynthesis. Avoid planting maize in shady areas as maize yield decreases with reduction in the amount of sunlight that reaches the plant.
- Optimum temperature range for plant growth and development: 30-34°C. Although maize can tolerate higher temperatures, yields usually decrease if the high temperature coincides with pollen shedding.

1.2 Land preparation

- Land preparation is the process of loosening the soil to provide fine soil tilth to enhance good contact between the seed and soil for uniform seeding and germination. A uniform land preparation helps to control weeds, kill some insect pests, makes it easy to incorporate manure, apply fertilizer, sow seed, improve seedling emergence, crop establishment and fertilizer use efficiency. The land can be prepared manually (use of cutlass and hoe) or mechanically (animal plough or tractor) depending on the cropping history of the field. First clear any overgrown weeds, shrubs and stumps and spray with glyphosate herbicide to kill weeds seven days before ploughing. After that, wait for adequate moisture and depending on the history of the field, plough the field uniformly to a depth of 20 to 30 cm using any of the methods below.

1. Tractor plough: Get a tractor service to plough the land across the slope of the land to reduce water runoff on the soil surface (erosion). After ploughing, harrow the field to break large soil clod into fine tilth and incorporate the crop residue.
2. Animal plough: This involves the use of draught animals such as bullock, cow, donkey and horse to plough the land across the slope of the field to reduce water runoff on the soil surface (erosion).
3. Manual plough: This involves the use of hoe to turn and loosen the soil across the slope to reduce runoff and erosion.
4. Minimum tillage: Clear the area of weeds using a cutlass, allow the cleared weeds on the land surface to serve as mulch or spray the weeds with glyphosate to kill the weeds before sowing the maize seeds.

- **The following good land preparation practices must be observed for maize production**
  1. Plough across the slope of the field to reduce water runoff and erosion. Make ridges on shallow soil across the slope to improve the soil depth for the maize plants and also, to check erosion and run-off.
  2. Avoid burning of the slashed weeds as this kills beneficial microorganisms including those that can improve the quality of soil.
  3. Incorporate all dead weeds and crop residues from the previous crop into the soil to improve soil fertility, soil moisture retention and reduce soil erosion. Only burn the residues if the previous crop had evidence of pests and/or diseases. A ripper or a subsoiler can also be used across the slope to increase water percolation where there is compaction or hard pan within the root zone.

1.3 Seed selection

Seed is an important resource in maize production. The source, type and quality of the seed is key for good germination, crop establishment, varietal purity and high productivity. The following factors should be considered when selecting a maize variety to plant:

1. Length of the growing season and amount of rainfall in your locality: These determine the type of maize variety to select in terms of maturity period and drought tolerance. For example, extra-early maturing maize varieties (70-85 days) are suitable for drought-prone areas and areas with a short season like the dry ecology of the Sudan and Guinea savannahs. Early maturing varieties (90-95 days) are suitable for all agro-ecological zones. Whilst medium maturing varieties (105 -110 days) are suitable for the Guinea savannah, transition, forest and coastal savannah zones. The pro-vitamin A or quality protein maize (QPM) maize varieties can be used to combat malnutrition. Farmers are advised to use the most common and adaptable open-pollinated varieties (OPVs) or hybrids recommended for their areas (Tables 1 and 2), or to contact the local Agricultural Extension Agent (AEA) or District Department of Agriculture for assistance.

2. Prevalence of maize pests and diseases in your locality: If your community is an area where maize is known to get infested with pests (insects, Striga, rats etc.) and diseases (streak virus, rust and smut etc.), it is recommended to choose varieties that are pest/disease tolerant, extra-early to early maturing so that they have less time on the field to be exposed to the pests/ diseases and targeting production period to escape peak incidence of the pests and diseases. Striga resistant varieties can be planted in Striga endemic areas.
3. The source type and quality of seed is among the key determinants of yield in crop production.

Sources of maize seeds

1. Local/ farmer own seeds (recycled seeds): This is farmer saved seeds preserved from varieties best adapted to the environment. It is the main source of seeds for most smallholder farmers in Ghana. The limitations of the recycled seeds are low yield, and lack of guaranteed seed quality after a short period of cultivation. To mitigate these limitations, smallholder farmers should select cobs from healthy plants in the center of the field to reduce contamination of pollen from neighboring fields and the plants should have desirable features such as deep-green leaves, tall, thick stems, big cobs, etc. The cobs of the potential seeds should be harvested separately from the other cobs. Examine the colour, size, signs of pest and disease or physical damage of the cobs or grains to select quality ones as seed for the next season. The seed should be cleaned of any physical impurities, dried and stored properly.

   It is highly recommended to use high quality certified seeds from reputable source each season or year for consistent and better maize yields. However, smallholder farmers who cannot afford to buy certified seeds every season can recycle the certified seed for not more than 2-3 years before buying new certified seed. This source of seed only works for open-pollinated maize varieties but does not work for hybrid maize varieties. Open-pollinated varieties are stabilized varieties in which farmers do not need new seed each season if farmers follow proper selection procedures. **Do not save hybrid seeds** for recycling as yield reduction is very high in the following year.

2. **Certified seeds:** These are seeds produced by registered certified seed companies under regulated and international standard protocols to ensure genetic purity and quality of seeds free from weeds, pests and disease. These seeds are subject to official control, production, certification and packaging requirements. The seed must be labeled with the information on the name of variety, seed purity, germination percentage, maturity period, yield potential and

expiry date. This is the best source of seeds for planting maize as the quality of seed in terms of germination and yield potential is assured, if properly managed. This source of seed can be obtained from reputable seed dealers across the country. Avoid using seeds from uncertified sources, as they are usually of poor quality, poor germination and might be a mixture of one or more different varieties. Certified maize seed will produce higher grain yields, if you take good care of them and follow best practices, such as planting in rows, weeding, and adding appropriate fertilizers on time. Without these management practices, even certified seed will not give higher yields

Types of maize

There are many types of maize depending on the method or criteria used for classification. The maturity period and pollination method are key among the criteria of classification in Ghana.

I. **Maturity period:** There are three types of maize under this classification which include extra-early, early and medium. The extra-early maturity type has 75-85 days physiological maturity, early has 90-95 days and medium-late has 105-110 days physiological maturity. See Tables 1 and 2 for examples of maize varieties with different maturity periods.

II. **Pollination methods:** There are two types of maize under this criterionf classification:

   a) Open pollinated (OPV): cross-pollinated or self-pollinated with two plants of the same variety. See Table 1 for recommended of OPV maize in Ghana.

   b) Hybrid: Cross-pollinated with two plants of different varieties. It is important to note that hybrid maize generally responds better to fertilizer application and gives higher yields compared with OPV of the same maturity group. See Table 2 for recommended hybrid maize in Ghana.

Table 1. Agronomic characteristics of selected open pollinated maize varieties recommended for cultivation in Ghana

Variety	Maturity type	Days to maturity	Kernel colour	Yield potential (Bag/acre)	Yield potential (t/ha)	Remarks	Suitable Agro-ecology
CSIR-Abontem	Extra-early	75-80	Yellow	16	4.0	Quality protein maize (QPM), drought and striga tolerant	Guinea savannah and Sudan savannah
CSIR-Aburohemaa	Early	90-95	White	18	4.5	Quality protein maize, drought and striga tolerant	Forest, Guinea savannah and Sudan savannah
CSIR-Omankwa	Early	90-95	White	18	4.5	Quality protein maize, drought and striga tolerant	Costal savannah, Guinea savannah and Sudan savannah
CSIR-Bihilifa	Early	90-95	Yellow	18	4.6	Drought tolerant	Forest, Transition, Guinea savannah and Sudan savannah
CSIR-Wang-Dataa	Early	90-95	White	19	4.7	Drought and striga tolerant	Forest, Transition, Guinea savannah and Sudan savannah
Obatanpa	Medium	105-110	White	18	4.6	Quality protein maize	All agro-ecological zones
CRI Ahoɔdzin	Medium	105-110	Orange	16	4.0	Source of Pro-vitamin A for improved nutrition and health	Forest and Transition
Ewul-Boyu	Medium	110	White	22	5.6	Drought tolerant	Forest, Transition, Guinea savannah and Sudan savannah
Sanzal-Sima	Medium	110	White	22	5.4	Drought tolerant	Forest, Transition, Guinea savannah and Sudan savannah

Table 2. Agronomic characteristics of selected hybrid maize recommended for cultivation in Ghana

Variety	Maturity type	Days to maturity	Kernel colour	Yield potential (Bag/acre)	Yield potential (t/ha)	Remarks	Suitable Agro-ecology
CSIR-Denbea	Extra-early	80-85	Yellow	24	6.0	Extra-early maturing; fairly resistant to maize streak virus disease	All agro-ecological zones
CRI-Apraku	Extra-early	80-85	White	22	5.5	Extra-early maturing; low N and Striga tolerant;	All agro-ecological zones
CSIR-Wang-Basig	Extra-early	80-85	White	22	5.5	Extra-early maturing; tolerant to drought and Striga	All agro-ecological zones
CSIR-Puumaya	Early	90-85	White	30	7.4	Early maturing, stay green ability; 7.88% protein	All agro-ecological zones
CSIR-Kunjor Wari	Early	90-95	Yellow	23	5.7	Early maturity, drought and Striga tolerant	All agro-ecological zones
CSIR-Songda	Early	90-95	White	24	6.0	Early maturing; 8.76% protein	All agro-ecological zones
CSIR-Suhudoo	Early	90-96	White	23	5.8	Early maturity, drought and Striga tolerant	All agro-ecological zones
CSIR-Wumpini	Medium	110-115	White	33	8.3	Medium maturing; 9.59% protein	Forest, Transition, Guinea savannah and Costal savannah

CSIR-Tamabe	Medium	110-115	Weak yellow	34	8.5	Medium maturing, 10.09% protein	Forest, Transition, Guinea savannah and Costal savannah
CSIR-Dinani	Medium	115-120	White	38	9.52	Late maturing; good for animal feed; stay green ability. 7.77% protein	Forest, Guinea savannah and Sudan savannah
CSIR-Darizaa	Medium	115-120	White	33	8.32	Late maturing; 10.30% protein	Costal savannah. Forest, Transition, Guinea savannah
CRI-OpeƐburo	Medium	110-115	White	30	7.5	Moderately tolerant to drought	Forest and forest transition
CSIR-Kpari-faako	Medium	105-110	White	27	6.7	Drought and striga tolerant	Forest, Transition, Guinea savannah and Costal savannah
CRI-Abebe	Medium	110-115	Orange	25	6.3	Source of Pro-vitamin A for improved nutrition and health	Forest, Transition, Guinea savannah and Costal savannah
CRI Ahoɔfe	Medium	110-115	Orange	16	4.0	Source of Pro-vitamin A for improved nutrition and health	Forest, Transition, Guinea savannah and Costal savannah
RMG-Obaapa (Lake 601)	Medium	115-120	white	36	9.0	Drought tolerant, Hard grain for better weevil resistance; tolerant to pests and diseases	Forest, Transition, Guinea savannah and Costal savannah
Adikanfo (30Y87)	Medium	105-110	Yellow	48	12.0	High yield, excellent stay-green characteristics,	Forest, Transition, Guinea savannah and Costal savannah

Gyemedi (SC719)	Medium	115-120	White	51	12.8	Tolerant to rust, leaf blight and maize streak virus	Forest, Transition, Guinea savannah and Costal savannah
CSIR Sika Aburo (Pan 53)	Medium	105-110	White	32	8.0	Flint/Dent kernel;	Suitable for all agroecologies in Ghana
Tigli	Medium	105-110	Yellow	21	5.2	Tolerant to lodging and rust and blight	Forest, Transition and Guinea savannah
Aseda	Medium	110	White	26	6.5	Quality protein maize and drought tolerant	Forest and Transition
Tintim	Medium	110	White	30	7.5		Forest and Transition
RMG-Obaapa	Medium	110	White	36	9.0	Drought tolerant	Forest, Transition and Guinea savannah
SC649-Hw3fo) (SeedCo)	Medium	115	White	32	8,0	Tolerant to leaf blight and rust	Forest, Transition, Guinea savannah and Costal savannah

Quality of seed

Seed treatment: It involves the use of recommended chemicals (Marshal 2% dust, Apron star, Allstar, Dressforce etc.) to treat the maize seeds to protect them against soil-borne pests, diseases and bird attacks before and after germination. Care should be taken while mixing these chemicals, as they are poisonous. Use protective clothing and gloves before seed dressing. Wash hands with soap and water immediately after planting. Always read labels to follow instructions on how to use the chemical for seed dressing.

Germination test: It is conducted to determine the proportion of seeds that will germinate under favorable conditions, produce seedlings with roots and shoots and capable of developing into mature plants and reproduction. Conduct a germination test 2 weeks before planting to confirm the germination test results of the certified seed label or to ascertain the quality of recycled seed. This gives you enough time to get new seeds if your current seeds fail the germination test and possibly conduct another germination test on your newly acquired seeds too.

How to conduct germination test for certified seed (hybrid or OPV)

- Prepare a suitable land area or seed bed close to your house.
- Take a random sample of 100 seeds, plant them in shallow trenches of about 5 cm deep.
- Cover with light topsoil, water well for one week but do not wet the soil.
- Count the number of seedlings that emerge at the end of the week to confirm the germination test on the label.
- Alternatively, a suitable container filled with topsoil and placed under the sun can be used for the germination test in situations where land is not available.
- Table 3 shows the number of seeds to plant.

Table 3. Recommended seeding rate of maize after germination test of certified seeds

Number of plants counted	Number of seeds to plant
85 and above	2 seeds per hole
70-84	3 seeds per hole
50-69	Change for better seeds
Less than 50	Do not use seed for planting. Get different seed

Conducting germination test for recycled certified seed (OPV only)

It is highly recommended to use certified seeds for better maize yields but smallholder farmers who cannot afford to buy certified seeds every season can recycle the certified seed for not more than 3 years before buying new certified seed. The germination test for this type of seed should be done with a random sample of 100 seeds and follow the steps and recommended seeding rate in Table 3. This source of seed only works for open-pollinated maize varieties but does not work for hybrid maize varieties.

1.4 Planting

The best time to plant maize differs according to the agro-ecology, season and maturity period of the variety. Planting maize seeds at the right time of the season when the rainfall has stabilized is essential for good yields. Planting maize early is important for the crop to utilize the entire cropping season to maximize yield when the rainfall is normal. Early planting enables the crop to benefit from the early release of nitrates in the soil, as well as reduced incidence of insects and diseases. It is recommended to plant after three good rains within the planting window to ensure enough soil moisture to support germination and early growth. Use medium and early maturing varieties for early planting and extra-early maturing varieties for late planting window. Always ensure to do germination test, check for signs of weathering, disease or physical damage on seeds before planting. Table 4 shows the recommended planting windows for maize across the agro-ecological zones in Ghana.

Table 4. Recommended planting period for maize production in Ghana

Agro-ecology	Planting period
Major cropping season	
Sudan savannah	End of May - Mid of July
Guinea savannah	End of May - End of July
Costal savannah	End of March - End of April
Forest	End of March - End of April
Transition	End of March - End of April
Minor cropping season	
Forest	Mid of July - Early September
Transition	Mid of July - Early September

Planting can be done with a planter, machete or dibbler. Always plant maize seeds in rows at spacing of 75 cm between rows and either 40 cm within rows with 2 seeds per stand or 20 cm within rows with 1 seed per stand. Row planting can be done with the help of garden line at the recommended spacing above. Planting in rows helps to facilitate farm operations (weeding, fertilizer application, watering and harvesting), attain optimum plant density for better yields and reduce niches available for predatory pest. Ideally, plant the seeds at a depth of 2.5-5.0 cm and cover with light soil to ensure contact with seeds to facilitate germination and emergence. Planting deeper than 5.0 cm may cause poor seedling survival, vigour and reduction in the final seedling stand, whereas planting too shallow (<2.5 cm) may result in poor emergence due to drying of the soil surrounding the seed as well as poor rooting and therefore, lodging of the mature crop.

The recommended seed rate for good maize yields is about 8 to 10 kg per acre (20-25 kg/ha) depending on the size of the seeds. In 10-14 days after planting, observe the field to look out for seeds that did not germinate or have germinated but the seedlings look diseased and weak to replant (refill) those seedlings. There may be a need to thin out, refill, or do both after germination, to obtain optimum plant density. Thin-out or refill after it has rained and the ground is soft. It is recommended to soak seeds in water overnight and air dry under shade for a few hours before planting to reduce the number of days for germination.

1.5 Nutrient requirements

Ideally, it is good to conduct a soil test to know the fertility status of field before fertilizer application as this will help you make a good decision on the right type of fertilizer and right amount or quantity to apply. Generally, the soils in Ghana especially northern Ghana are very low in nitrogen (N) and phosphorus (P) nutrients and these are among the major nutrient required for maize production. Maize responds well to the application of organic manure and inorganic fertilizers.

Organic fertilizers

Organic inputs such as well decomposed farmyard manure and compost improve the physical condition of the soil and its water retention capacity. Also, they increase organic matter content, reduce the effect of salinity and acidity. Additionally, they have a longer lasting effect than chemical fertilizers. Well decomposed manure or compost should be applied at land preparation and work into the soil before planting. See Table 5 for more information on the types and rates of application. However, due to the inadequate availability of organic fertilizers, bulkiness for transportation and cost implications, integrated application of organic and inorganic fertilizer is ideal for sustainable maize. Nutrient management techniques for maize include crop rotation, compost, manure, crop residues, use of cover crops, biochar, matching nutrients with plant needs and slow-release fertilizers.

Table 5. Recommended quantity and rate of different organic fertilizer for maize production

Type of organic fertilizer	Quantity to apply (t/acre)	Number of bags/acre (50-kg bags/acre)
Compost	2.0	40
Cow dung	2.8	56
Chicken manure	1.6	32

Mineral fertilizers

They make nutrients readily available to plants after a few days of application to allow a quick start of the vegetative growth and supply nutritional needs during the active plant growth. Mineral fertilizers should be applied when there is adequate soil moisture to avoid scorching and the wilting of maize plants. There is no single fertilizer recommendation for maize which will fit all situations. Farmers should try and obtain fertilizer recommendations based on the analysis of soil samples. Where it is not possible to conduct a soil test, the following general recommendations should serve as a guide. When applied into the soil, mineral fertilizers become available to the plant immediately. If not taken up by the plant soon enough, it is easily lost. For this reason, it is recommended to apply mineral fertilizer in two parts as:

1. **Basal application:** This involves the application of fertilizers which contain NPK as the major nutrients with/without the addition to other nutrients. For better yield, it is recommended to apply this type of fertilizer with the maize seeds at planting in a different hole which is 5 cm apart from the maize seed, 5 cm deep and covered with soil to reduce losses from volatilization and erosion (Photo 1, left). Alternatively, the 2 operations (planting and basal fertilizer application) can be done with a simple hand push mechanized planter (Photo 1, right). However, in a situation where the fertilizer is not available at planting of the maize seed, the fertilizer should be applied 10-14 days after planting the maize following the same procedure above. See table 6 for details on type NPK fertilizer and recommended rate of application.

Photo 1. Planting maize seed and applying NPK basal fertilizer at planting left (manual method) and right (mechanized method).

2. **Top dressing:** This involves the application of N fertilizer to top up the N requirement for maize production. This application is done 35 days after planting and it should be applied 5 cm away from the maize plants, 5 cm deep and covered with soil to reduce losses through volatilization and erosion. See Table 6 for the common type of N fertilizers in Ghana and recommended rate of application.

Table 6. Recommended quantity and rate of selected inorganic fertilizers for maize production.

Type of inorganic fertilizer	Quantity/ acre (number of bags, 50 kg)
Basal application	
NPK 23-10-5+2MgO+3S+0.3Zn	2
NPK 25-10-10+3MgO+6S+0.3Zn	2
NPK 25-10-10+3S	2
Top dressing	
Ammonium Sulphate	1
Urea	½ - 1

1.6 Weed management

Weeds compete with the maize plant for water, nutrients, space and light. It also lead to increased production costs, resulting from the cost of controlling them and the insects and diseases they harbour. The early stage of maize plants, (first three weeks) is very sensitive to weed competition. Controlling weeds within the first 30 days after planting helps the maize plants to grow rapidly and become highly competitive. Depending on the growth of weeds in the field, it is recommended to do two weeding at 14-21 days after planting and 30-35 days after planting for better maize yields. Weeding in maize fields can be done by manual, mechanical, chemical and cultural practice methods.

Manual method: this weeding method involves the use of hoes and cutlasses.

Mechanical method: It is the use of mechanized farm tools for weeding.

Chemical method: It involves the use of recommended chemicals to control weeds. Much better weed control could be achieved through the

judicious use of herbicides. This method of weed control is faster, cheaper, less laborious and less tedious relative to the other methods of weed control. However, it also has a hazardous effect on human beings and the environment, if safety and disposal instructions are not followed. Generally, the type of herbicide used is determined by the type of weeds present (either broadleaved or grassy weeds). It is recommended to spray pre- and post- emergence herbicides within 24 hours after planting to control and delay the growth of weeds during the first 30 days after planting maize seeds. The second weeding at 30-35 days after planting is done with selective herbicide which controls the weeds leaving the maize plant. It is recommended to read the label of herbicide or consult the agricultural extension agent of the area to follow instructions on the safety and rate of application of the herbicide. It should be applied when the soil is moist and, in the morning, when the weather is clear of no sign of rainfall after application.

Cultural practice method: Cropping systems such as the use of weed-free seeds, weed-free field, cover cropping or live mulch can be used to reduce niches available for weed growth and suppress the growth of weeds in maize. The intercropping of spreading type of cowpea with maize at 1-2 weeks after planting maize has shown to reduce weed growth, improve soil moisture retention and soil fertility through biological nitrogen fixing activity of the legume for better yields of maize. Rotating maize with leguminous crops such as cowpea, soybean and ground nuts also reduce striga population, controls weeds and improves soil fertility. Avoid rotating maize with sorghum or millet, as they can be infected by Striga and may result in a build-up of the seed of this parasitic weed in the soil, which causes significant yield reduction.

MODULE II: DISEASE AND PESTS OF MAIZE AND THEIR MANAGEMENT

Overview

The second module of this manual is disease and pests of maize and their management. It aims to increase the participants' understanding and knowledge of identifying and managing common maize pests and diseases, minimizing crop losses and ensuring a healthy harvest. The module also aims to understand identification, damage, life cycles, and control methods for key pests and diseases, including both biological and chemical approaches, and the importance of integrated pest management (IPM).

Key questions

- What are the differences between pests and diseases?
- What are the common diseases of maize and their symptoms?
- What are the control methods of the above maize diseases (Biological, cultural, chemical etc.)?
- What are the common pests of maize and their management?
- What are the control methods of pests and diseases (Biological, cultural, chemical etc.)?
- How do you minimize crop losses and ensure a healthy harvest?

Objectives

After completing this module, participants will be able to

- Distinguish between pests and diseases of maize.
- Identify and manage common diseases of maize.
- Identify and manage common pests of maize.
- Describe the effective control methods of the major pests and diseases of maize.
- Explain the importance of using maize varieties that are resistant to common pests and diseases.
- Explain the importance of combining various control methods to minimize pests and disease damage while protecting the environment.

Disease is any abnormal growth and development of a plant caused by biotic (living organism) and abiotic (environmental) conditions. Thus the plant is incapable of carrying out its normal physiological functions to the best of its genetic potential. A pest is any living organism that causes damage or harm to crops. Visit your maize farm regularly to scout for signs of pests and disease attack. Always remember to visit your district agricultural department for expert advice on the pests and diseases affecting your crop. Below are some selected key pests and diseases of maize and their managements.

2.1Biotic diseases and their management

2.1.1 Maize streak

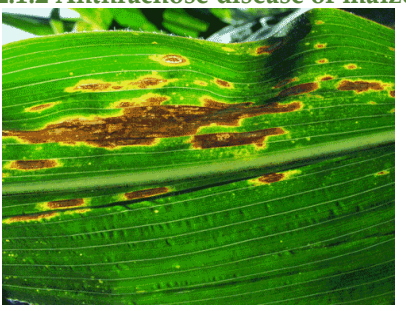
Maize streak is caused by a virus, and it is transmitted by leafhoppers.

Symptoms: Very small, round, scattered spots in youngest leaves which elongates to cause leaf chlorosis with broken yellow streaks along veins contrasting with dark green of normal leaf.

Management: Use resistant or tolerant maize hybrids and varieties such as Tigli, Sanzal-sima Dorke SR etc. Control population of transmitting pests such as leafhopper and aphids.

Symptoms: Very small, round, scattered spots in youngest leaves which elongates to cause leaf chlorosis with broken yellow streaks along veins contrasting with dark green of normal leaf.

2.1.2 Anthracnose disease of maize



Anthracnose is a fungal disease.

Symptoms: Irregular shaped lesions with dark brown centers starting with bottom leaves.

Management: Plant resistant maize varieties, practice crop rotation and spray with fungicides

2.1.3 Maize smut

This is a fungal disease favoured by dry conditions at 26-34 °C.

Symptoms: Galls on plant tissues which are initially green-white and turn into powdery dark brown or black spores. Galls are common on ears, tassels, shoots or midrib of leaves.

Management: Use resistant varieties; destruction of infected plants before the smut ruptures by burning or burying; bury infected materials outside the maize field.

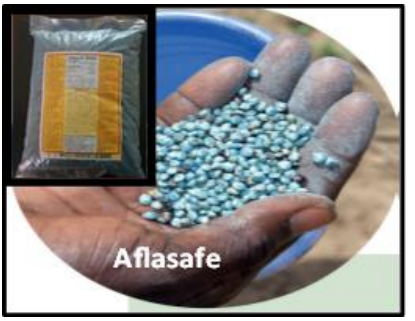
2.1.4 Common rusts of maize

Common rusts of maize are caused by the rust fungus.

Symptoms: Appearance of rust-colored to dark brown, elongated pustules on leaf surfaces (Fig 2.7). The pustules contain rust spores (urediniospores) that are cinnamon brown in color. Pustules darken as they age. Leaves, as well as sheaths, can be infected. Under severe conditions leaf chlorosis and death may occur.

Management: use resistant maize varieties such as Sansal-Sima, Wang-Daata, Blihilifa, etc. and spray with recommended fungicide; deep ploughing to bury crop residue after harvest as well as, using clean maize seed from a reliable source. Rotate maize crop with legumes

2.1.5 Aflatoxin

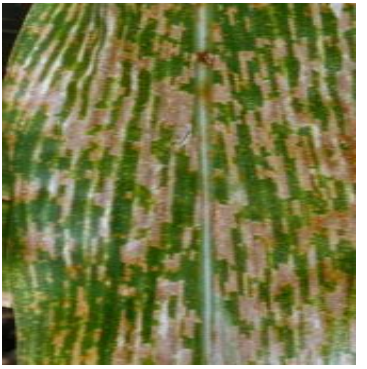


Aflatoxin contamination caused by a group of fungal, affects health, income and trade.

Symptoms: Moulds appearing on cobs and grains may indicate potential of aflatoxin contamination.

Management: Farmers should protect their crops from aflatoxin contamination by broadcasting biocontrol product Aflasafe GH02 at 4 kg per acre on maize when the crop is 35-40 days old and on moist soil. The active ingredients in Aflasafe inhibit aflatoxin formation and protect crops from contamination even in storage. Harvest and postharvest practices such as timely harvest, sorting out damaged and mouldy cobs, proper drying technique, moisture level of grains and storage conditions help in postharvest management of aflatoxin.

2.1.6 Gray leaf spot of maize



Gray leaf spot is a fungal disease

Symptoms: Long narrow lesions on leaves. Color of initial lesions range from tan to brown. Lesion expansion is limited by parallel leaf veins, resulting in the blocky shaped "spots". As sporulation commences, the lesions take on a grayer coloration.

2.2 Maize nutrient deficiencies (abiotic diseases) and their management

2.2.1 Nitrogen nutrient deficiency

Symptoms: Chlorosis (yellowing of leaves due to reduction in chlorophyll) and stunted growth. Nitrogen deficiency occurs on older leaves which turn pale or yellowish-green.

Corrective measure: Apply inorganic fertilizers such as ammonium sulphate, ammonium nitrate, urea. Organic fertilizers such as compost and manure can also be applied.

Role: Nitrogen is important for amino acid, protein and chlorophyl production. It is key for good plant growth.

2.2.2 Phosphorus nutrient deficier

Symptoms: Stunted growth, reddish-purple discoloration in leaves and stem. Deficiency is observed in the older leaves. Any soil condition that limits root growth can induce the deficiency even with adequate P levels in the soil.

Corrective measure: Apply triple or single superphosphate fertilizer, manure, and compost.

Role: It enhances flowering, cob and grain development and development of roots production. It is key for good plant growth.

2.2.3 Potassium nutrient deficiency

Symptoms: Brown scorching and curling of leaf at the tips and edges as well as chlorosis (yellowing) between leaf veins starting from lower to upper leaves. Later in the season K deficiency can cause lodging of the crop because stalks are thin and weakened

Corrective measure: Apply fertilizers such as muriate of potassium (K_2O), potassium chloride (KCl), potassium nitrate (KNO_3).

Role: Regulate the opening and closing of stomata to improve tolerance to drought conditions, enhance root, cob and grain development.

2.3 Field pests of maize and their management

2.3.1 Striga infestation

Striga, a parasitic weed, is a major problem in maize fields, in northern Ghana, competing with the crop for nutrients and water.

Symptoms: They attach themselves to the root of maize plants to draw moisture and nutrients which inhibit maize growth.

Corrective measure: Uproot striga plants and destroy them before they flower and produce seeds. Practice crop rotation with crops like groundnut, soybean, cowpea etc. Use striga tolerant maize varieties. Use appropriate and recommended quantity of organic and inorganic fertilizer for maize cultivation. Aoid frequent cultivation of cereals, like maize, sorghum and millet, on the same land, as this often leads to a build-up of the parasitic weed, which may make further cultivation of

2.3.2 Worms (Cut and Army) and stem borers

Symptoms:

Cutworms: Cut young plants at the base near the soil surface, cut through stalks, notch stems of seedlings, irregular holes on young plants.

Fall armyworms: Small holes and "windowpane" feeding in the leaves emerging from the whorl, ragged appearance to the leaves and moist sawdust-like frass near the funnel as well as the upper leaves.

Stem borers: Destruction of the growing point in the whorl (dead heart); loss of leaves due to insect feeding; lodging due to burrowing in the stem and extensive damage of young kernels.

Management: Farmers should monitor and inspect maize fields immediately after germination to guard against damage caused by cutworms, fall armyworms and stem borers. They should monitor damage on 10 consecutive plants in 10 randomly selected sites. Take control measures if 20% of the plants are infested with larvae. They can be controlled with bio-pesticides or chemical pesticides.

Destroy maize residues after harvest by burning and use biological control with predators and parasites. Plough to expose cutworms to predators. If pests are identified, advice should be sought from agricultural extension officers or agro-input dealers.

Destroy maize residues after harvest by burning and use biological control with predators and parasites. Plough to expose cutworms to predators. If pests are identified, advice should be sought from agricultural extension officers or agro-input dealers.

2.4 Storage pests of maize and their management

2.4.1 Weevil

Damage: They chew into the kernels and lay eggs to cause holes in the kernel to make it hollow and reduce weight of grains.

Management: Clean storage facility between harvest to remove and burn infested materials. Use recommended insecticide or pesticide to eradicate weevils.

2.4.2 Moth

Damage: They eat grain's endosperm leading to weight loss and low nutritional quality of grain.

Management: Use recommended insecticides to protect the grain from moth. Fumigate storage facility to kill moths.

2.4.3 Rodents (Mouse and rat)

Damage: They eat grains, contaminate grains with urine and reduce nutritional quality of grains.

Management: Keep storage places clean and use traps to control them when their population is low.

2.4.4 Moulds

Damage: Moulds (also known as fungi) found on stored grains initially grow on the surfaces of grain and then slowly penetrate and consume them. They produce pigments or browning reaction. They also produce tasteless, odourless toxic chemicals which are also invisible to the naked eye called mycotoxins in the grains. Once these mytocoxins are produced on the grain, they cannot be destroyed by cooking or heating. The only way to prevent it from spreading is by drying maize grain quickly at harvest to desirable moisture levels of less than 13%.

Management: Dry maize grains to recommended moisture content of 13%. Store grains in recommended air-tight containers (PICS or ZeroFly bags, drums etc.) and keep in storage facility away from rain and direct sunlight. Control insects during storage.

MODULE III: HARVEST AND POSTHARVEST MANAGEMENT PRACTICES

Overview

The third module of this manual is harvest and postharvest management practices. It aims to cover important aspects of post-harvest handling and storage, helping extension officers educate farmers on proper techniques to minimize losses and maintain the quality of maize grains. This module encompasses understanding optimal timing, methods, and techniques to minimize losses and maximize quality, ensuring food security and economic benefits.

Key questions

- What are the harvest stages of maize and their signs of maturity?
- What are the consequences of not harvesting maize at the right time?
- How to shell maize?
- Why should maize be dried to a safe moisture level?
- What are the efficient and hygienic shelling and cleaning techniques to ensure quality and minimize contamination?
- What are the different methods of storing maize?
- How to store maize grains to minimize losses and maximize quality?

Objectives

After completing this module, participants will be able to

- Explain the proper timing and methods for harvesting maize, including shelling and drying.
- Describe the importance of proper storage to prevent spoilage and maintain grain quality.
- Explain different storage structures (bags, silos, etc.) and their suitability for various storage durations including pest management strategies during storage.
- Explain safe and efficient transportation methods to the storage location.
- Explain efficient and hygienic shelling and cleaning techniques to ensure quality and minimize contamination.

3.1 Harvest and harvest indicators

Harvesting of maize is done traditionally by hand (in most cases) or with a combine harvester. Depending on the purpose for harvesting maize, there are two stages to determine the signs of maturity in maize. Maize can either be harvested in a fresh state (green) or when dry. When maize is to be consumed fresh, harvesting should be done when the silk has turned brown.

Physiological maturity

At this stage, the "black layer" at tip of grain develops at the point of attachment to cob. To observe this harvest maturity index in the field, take random samples of the plants in the field, open the husk of a cob and detach a grain from the cob to observe the colour at the tip of the point of attachment of the grain to the cob. When a black layer colour is observed then the grain is physiologically matured. At this stage, the grains are well formed, tender, contain high moisture content of about 25 to 32% and it is good for fresh corn business. Further drying of the cobs for about 1-2 weeks is required to reduce the moisture content to facilitate shelling of the grains.

Harvest maturity

At this stage the leaves, tassel, cobs and the whole maize plant change color brown with the tips of the cobs dropping towards the ground. When these signs are noticed, it is recommended that the necessary steps should be taken to harvest the cobs to avoid harvest losses. Delay harvesting at this stage will lead to lodging of plants on the ground, pest (insect, termites, rodents) attack on cobs, development of moulds due to soil moisture, aflatoxin contamination and soiling of cobs which leads to

harvest losses. Harvesting should coincide with bright sunshine and dry weather, so that your maize will dry properly.

3.2 Postharvest practices

Shelling:

With the traditional method of harvesting maize, the cobs are gathered during or after harvesting for shelling. It is recommended to reduce the time interval from harvesting to shelling to minimize the postharvest losses through bad weather, pest damage and contamination of products. Maize cobs should not be heaped on the bare ground in the

field for long periods. This allows grains to imbibe moisture from the dew or rain, generation of heat in the inner portions of the heap, discoloration of the grains, destruction by termites and rodents as well as increase incidence of aflatoxin in the grains. It is important to sort out damaged or contaminated cobs from the good ones before shelling to ensure or maintain quality of harvest grains. Shelling is the process of separating the grains from the cob. It is done manually (by hand) or with a machine.

Manual shelling

Dehusk the maize after harvesting and sun-dry the cobs on a clean surface (tarpaulin or clean concrete floor) until they are sufficiently dry for shelling. Dehusking is the process of removing the husk from the maize cob. Protect the cobs from the rain, thieves and pests. Rain may cause the grains to begin to germinate, reducing the grain quality. Once the dehusked cobs are dry, shell on a clean surface (tarpaulin or clean concrete floor) by gently hitting the cobs with sticks until all grains fall

off. Shelling on a tarpaulin, mats, plastic sheets or a clean concrete floor, minimizes contamination from soil, gravel, grit, pebbles and other inert materials. Hand shelling is very difficult and takes a lot of time.

Machine shelling

You do not have to dehusk your maize if you plan to shell it with a maize sheller. Shelling of maize with machine is recommended as it reduces drudgery of farmers especially women, It is cost effect and saves time compared with the manual method. During shelling, it is important to minimize damage caused to the grain and bagged grains should be packed on tarpaulin to prevent direct contact with the soil.

3.3 Drying of maize grain to safe storage moisture content

The shelled grains should be further sun dried on raised platforms or tarpaulin or clean cemented floor for at least 2 days to ensure the right moisture content of 13% before storage. The grains should be spread out and turned/mixed at one-hour intervals or less using a rake during drying. The grains should be covered with tarpaulin at night and when it is about to rain to prevent wetting. Do not dry your grains on the bare ground as this will allow your grains to be contaminated by small stones, sand and other debris. Do not dry them on the roadside as your grains will become very dusty, making them look dirty and less appealing on the market. Solar driers can be used to dry grains during periods of rain (June – August) where there is inadequate sunlight. The grain moisture content can be measured with moisture meter or probes. Alternatively, in areas where moisture meters or probes are not available, farmers by listening to the chuckling sound produced when they bite the grain, dip the hand in the grain bag, etc. While this method may not be as accurate as a tightly calibrated moisture meter, it can be a quick way to decide if the crop is adequately dried.

3.4 Winnowing of maize grain

After shelling and drying the maize, the grain is cleaned using the wind for winnowing, or with screens of proper size and properly stored. It is important to winnow the shelled grains to keep them clean and free from

insect and mould attack during storage. Winnowing involves the removal of foreign matter such as stones, plant material from harvesting such as husks, cobs, etc. and broken grain and dust produced during shelling. After winnowing, use a sieve of 4.5 mm mesh or depending on the size of the grains to separate heavier impurities. At the same time, it is possible to remove insect damaged and mouldy grains by hand picking. **DO NOT** consume or sell grad-out grains or feed them to animals as they may be associated with high aflatoxin content and low-quality grains.

3.5 Bagging of maize grains for storage

Cleaned, healthy, properly dried maize grains of 13% moisture content can be bagged in hermetic storage bags (e.g. PICS or ZeroFly bags) or drums if grains are to be stored for more than 3 months. These bags or drums are airtight and provide an effective barrier against pests like insects, rodents, and other small animals that can cause damage to stored grains ensuring that the grains remain safe and free from contamination. Hermetic storage bag is an improved storage bag that is based on triple bagging. It is a convenient way of storing maize to keep it away from insect infestation and further mould proliferation. It is recommended to admix insecticide to grains that are to be stored for more than 3 months to prevent insect pest infestation and grain damage. Open weave sack can also be used to store grains if the grains are to be stored for less than 3 months.


PICS bag


ZeroFly bag


Drum

3.6 Storage facility and storage of grains

- The bagged grains should be stored in a well-ventilated storehouse, mud silo, crib or warehouse with strong walls and a good roof to protect grains against rain.
- Ensure the storage facilities, such as granaries, are dry and pest-free.
- For cribs, the floor should be at least 1 m above ground level to protect grains at the floor of the crib from rain splash and rodent from jumping into the crib. Additionally, the legs should be fitted with rodent guards to keep rodents out. The crib should be built across the prevailing wind to promote drying.
- Clean, fumigate to disinfect the structure before storing new harvests to control insects and rodents, prevent loss of crop quality and spoilage.
- In the case of a storehouse, bags of grains should be well arranged on pallets at least 1 m away from the walls. This allows for proper ventilation in the store and easy movement in the store. Proper sanitation should be maintained in and around the store during storage. Grain bags should not be placed directly on bare ground or against walls in the store.
- Routine cleaning and inspection of grains and storage structure is necessary to ensure that the quality of the grains is maintained.
- The new harvest should never be mixed with grain from the previous season as this will encourage the movement of pests from the old to the new harvest. The old harvest can be stored in a separate place for consumption.

3.7 Recommended practices for transporting grains

Farmers will have to move grains from the farm to the homestead, homestead to a farmer organization collection point, warehouse or market. This could be by means of hired motorized transport, tricycle, etc.

Farmers should ensure that carts and trucks are clean before loading the grain into them otherwise it might become infested. The transport container (truck, trailer, etc.) should be thoroughly cleaned and free from foreign matter, visible mould, insects, musty odors, or other contaminants that could contribute to mycotoxin production. Ensure the container is dry and airtight to prevent moisture buildup, which can lead to fungal growth and aflatoxin production. The grains should be well covered with waterproof material during transit to protect against rain, dew, or sun (Photo 3). Cover the vehicle with a tarpaulin to protect the grain from rain and wind, limiting moisture penetration from the external environment.

Photo 3. Means of transporting grains from one location to the other.

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