

9-2 MAIZE



Draft Version 1.0
June 2011
Ready for field testing

IMPRINT

Publisher:

FiBL, Research Institute of Organic Agriculture, Switzerland, www.fibl.org

Collaboration:

- > IFOAM, International Federation of Organic Agriculture Movements, Germany, www.ifoam.org
- > NOGAMU, National Organic Agricultural Movement of Uganda, www.nogamu.org.ug
- > FENAB, Senegal
- > OPPAZ, Organic Producers and Processors Association of Zambia, www.oppaz.org.zm

Responsible authors of the unit:

Hervé Bouagnimbeck (IFOAM), Brian Ssebunya

Reviewer:

Olugbenga O. Ade Oluwa, Ofoso Budu

Illustrator:

Andrew Baingana

Draft version 1.0, September 2011.

This is an interim version. Comments and recommendations for improvement are welcome.

This manual chapter can be reproduced without permission.

All materials resulting from the Africa Organic Agriculture Training Manual project are available free of charge in the internet under www.organic-africa.net

The production of this manual was funded by the Bill and Melinda Gates Foundation and the Syngenta Foundation for Sustainable Agriculture with the goal to promote organic farming in Africa.

All the information contained in this manual has been compiled by the authors to the best of their knowledge. Reasonable efforts have been made by the Research Institute of Organic Agriculture and their partners to publish reliable data and information. The authors, the editors and the publishers cannot assume responsibility for the validity of the materials. Neither the authors, nor the publishers, nor anyone else associated with this publication, shall be liable for any loss, damage or liability directly or indirectly caused or alleged to be caused by the training manual and its tools.

The African Organic Agriculture Training Manual is based on research funded by the Bill & Melinda Gates Foundation and the Syngenta Foundation for Sustainable Agriculture. The manual's findings, conclusions and recommendations are those of the authors, and do not necessarily reflect positions or policies of either Foundation.

Please cite this publication as follows:

FiBL (2011): African Organic Agriculture Training Manual. Version 1.0 June 2011. Edited by Gilles Weidmann and Lukas Kilcher. Research Institute of Organic Agriculture FiBL, Frick

ISBN 978-3-03736-197-9

CONTENTS

1. Introduction	1
2. Improving crop husbandry of maize	2
3. Reducing postharvest losses	18
4. Marketing and certification of organic maize	20

9-2 MAIZE



FACTSHEET 2: MAIZE

Learning targets for farmers:

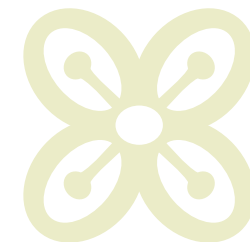
- › Learn proper selection and multiplication of maize seeds
- › Understand soil fertility and water management in maize production
- › Manage the maize stem borer and Striga weed
- › Manage maize weevils in stored maize grains
- › Receive guidance on marketing and organic certification of maize production

1 Introduction

Maize (*Zea mays* L.) is a major staple food in sub-Saharan Africa. It can be used as food, feed for animals and as a source of industrial raw material. In sub-Saharan Africa, maize is grown mostly by small-scale farmers under rainfed conditions mainly for human consumption. It is consumed as green maize fresh on the cob, or is baked, boiled or roasted. The grain can also be dried, ground and boiled into porridge or fermented into beer.

According to FAO's 2008 estimates, average national yields in sub-Saharan Africa are only about 1.4 tons per hectare as compared to the world average of 5.1 tons. Low yields in sub-Saharan Africa can be attributed to a variety of factors:

- › **Poor soil fertility** is one of the leading challenges for small-scale farmers in sub-Saharan Africa. The increasing population density has resulted in the intensification of land use and forced many farmers to shorten or abandon the previously well followed fallow periods. As a result, nutrients and organic matter in the soil have become heavily depleted and this has resulted in a reduced soil fertility and productivity.
- › **The use of low quality seeds** is another major cause of low maize productivity in sub-Saharan Africa. Poor seed selection and limited use of new improved commercial varieties are among the reasons why farmers are not able to cope with the productivity demand.
- › **Poor crop husbandry practices** such as late planting, poor weed management, pest and disease attacks (e.g. stem borers) and the Striga weed are important constraints that lower maize yields.





CHALLENGES



- › **High postharvest losses** especially due to improper drying and storage, lead to moulding and attack by the maize weevil during storage.
- › **Soil moisture stress** is a continuous problem for most farmers who cultivate maize under rainfed conditions. The erratic nature of rainfall, including distribution of the rain, sometimes predisposes the maize to severe soil moisture stress, reducing yields significantly.

These constraints call for a change in approaches to maize crop management in order to increase yields. Organic practices can help to address the above challenges and ensure increased productivity and sustainability of the current maize supply.

2. Improving crop husbandry of maize

Organic maize management begins by selecting suitable varieties and using high quality seeds. Crop management focuses on creating growing conditions that keep the maize plants healthy.



IMPROVED MANAGEMENT



2.1 Selection of suitable varieties

The choice of appropriate maize varieties for a given location is very important, as it makes a significant contribution to yield improvement. Varieties are selected according to specific factors such as climatic conditions, yield potential, resistance to infections or duration of growing period to maturity. This means that if a farmer plants the wrong cultivar for a given area, the maize plants may not have adequate soil moisture for proper growth, especially if the rainy period is much shorter than the growing period of the variety.

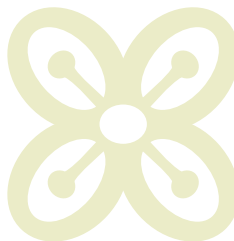
Furthermore, farmers must also consider the differences between modern varieties and traditional varieties. Wrong variety selection can lead to a poor harvest or total crop failure. It is, therefore, important to carefully select varieties that match with local growing conditions including climatic conditions, nutrient level of the farm and cooking habits and dietary requirements of the consumers.



Inquire about the farmers' knowledge of maize production

To find out about the farmers' perception of maize production, ask them the following questions:

- › Have you experienced any decline in maize yields over the years?
- › What do you think are the main causes of declining yields?
- › What do you think needs to be done to improve maize yields?



Traditional varieties

Many small-holder farmers in sub-Saharan Africa grow traditional maize varieties. Seeds are collected from the farmer's previous crop. These varieties have been developed based on specific farmers' criteria and have become, over the years, adapted to local growing conditions. Besides being well-adapted to local conditions, such varieties are adapted to low nutrient levels and farmer cooking habits. They may also withstand local pest and disease pressures well. In addition, traditional varieties are locally available and farmers can reproduce their own seeds for replanting. Nevertheless, yields of traditional varieties are generally low to moderate due to the poor methods of selecting seeds and to poor management.

Improved varieties

Besides traditional varieties, there are several improved open-pollinated and hybrid varieties of maize on the market in most places. They differ from one another with regard to characteristics such as yield potential, the time they take to reach maturity and their adaptability to specific growing conditions like drought, pests or diseases. Hybrids are generally higher yielding than open-pollinated varieties, if grown under suitable conditions. However, hybrid varieties are expensive because new seeds need to be bought for every planting season. On the other hand, improved open-pollinated varieties are often higher-yielding than traditional varieties and farmers can produce their own seed of open-pollinated maize varieties, thus reducing the costs for purchasing improved commercial varieties.

Another aspect farmers need to consider is the higher nutrient requirements of improved varieties. Most improved varieties will only perform well under improved soil fertility management conditions, for example after applying organic manure or using green manures.

Recommendations to farmers on selection of improved varieties:

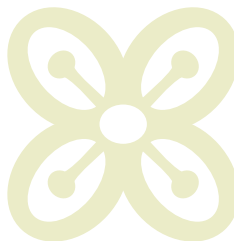
To select varieties that are most suitable to the local conditions, it is important to know the general characteristics of the area, including the length of the rainy season, prevalent diseases, pests and weeds, nutrient requirements of the crop and consumer requirements. Availability of such information helps to determine what characteristics a variety needs to perform well. The following recommendations are meant to guide farmers on selecting improved varieties.



Discussion assessing locally used varieties

To assess the strengths and weaknesses of locally varieties used, ask the farmers the following questions:

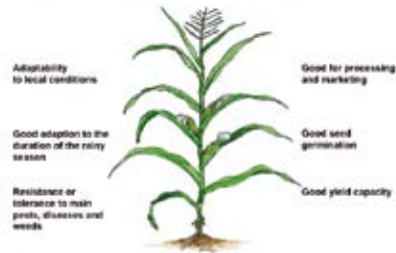
- > Which maize varieties are mostly used hybrid or open-pollinated?
- > What are the advantages and disadvantages of using these varieties compared to traditional varieties?





VARIETY SELECTION

Criteria for selecting maize varieties



a. Length of the rainy season

There are differences among maize varieties in the length of the growing period from planting to maturity. Late-maturing varieties mature in 110 to 120 days, medium-maturing in 90 to 100 days and early-maturing in 80 to 90 days. As a farmer, consider the average length of the rainy season in your area. This means that in areas with a short rainy season, you should select an early-maturing variety, as it is more adapted to less rain. If you instead plant a late-maturing variety in these areas, it may not grow to maturity. Such a variety grows well in areas with well-distributed rainfall during the growing season. Medium-maturing varieties can be planted in zones with two seasons of rainfall. Under suitable conditions, late-maturing varieties give the highest yields. Medium varieties tend to produce higher yields than early-maturing varieties.

b. Resistance to pests, diseases and weeds

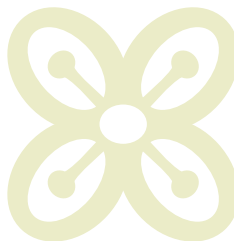
Select seed varieties with the best levels of resistance or tolerance to prevalent diseases, pests and weeds in the area. For example, if in your region the maize streak virus (MSV) is common, then choose varieties that have tolerance or resistance to this disease. Also, if the area is prone to the Striga weed, it is preferable to plant Striga resistant or tolerant varieties, if they are available.

c. Adaptability to processing and market requirements

The selected maize variety should correspond to the intended use and the market preference. Usually different varieties are preferred for processing and storage than for fresh consumption or any other purposes.

d. Testing new maize varieties

If you receive or acquire a new maize variety, then test it on small plots before scaling up the production to big plots. Observe and compare the performance of the new variety with the other varieties at every stage of growth under similar management conditions of planting time, weeding and soil fertility management. This will help you to choose the best performing variety under local prevailing conditions.





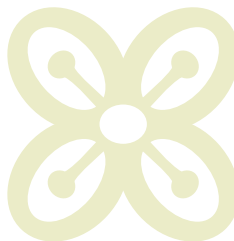
MULTIPLY YOUR OWN OPEN-POLLINATED MAIZE SEED VARIETIES



Recommendations to farmers regarding on-farm multiplication of maize seeds:

As already mentioned, farmers can produce and multiply seeds on the farm from open-pollinated maize varieties. The following recommendations are meant to guide farmers in proper seed production.

- a. Select a suitable open-pollinated variety for your area. This can be sourced from the existing preferred maize crop on the farm, neighbours, the national maize program or a local seed company.
- b. Choose the best plot and prepare it well, removing all weeds. Maintain a distance of at least 300 meters from any nearby maize crop of a different variety. This is to avoid cross-pollination between the varieties and maintain the characteristics of the preferred variety. Alternatively, you can sow the preferred variety one month earlier or later than neighbouring maize fields.
- c. Plant your maize seed crop early and carefully. Examine and manage the maize plants as they grow to ensure a healthy growth and development.
- d. Select healthy looking maize plants, particularly those not infected with diseases or attacked by pests. The selected plants should have cobs of good size with well filled seeds. Label the cobs in the field and let them mature properly.
- e. Harvest the cobs when the plants start to dry, but making sure that they do not get mixed with cobs from other maize varieties. Allowing the cobs to over-dry will predispose them to infestation by weevils on the field.
- f. Dry the cobs further with their sheath cover, on a clean and dry surface in the sun.
- g. Remove the sheath cover and shell the dried cobs, being careful not to damage the seeds by taking the best seeds, which generally come from the middle of the cob. After shelling, dry the seeds further; well dried seeds crack when bitten. Clean the seed by removing all dirt and foreign matter and small and damaged seeds. Pack the seeds in a sack to stand on pallets in a clean, dry and well-ventilated store. Maintain a distance of about 0.5 m away from the wall of the room.



2.2 Proper field establishment

Maize can grow under diverse environments, and on a wide range of soils, but performs best on well-drained, deep, loamy soils containing sufficient plant nutrients and organic matter. Moreover, maize does not perform well under water-logging and drought conditions, particularly around the time of flowering. Lack of adequate soil moisture can significantly reduce crop quality and quantity.

2.2.1 Field preparation

In sub-Saharan Africa, land preparation for maize cultivation is dependent on the type of vegetation, but generally, field preparation is done using simple implements. In the forest regions where there are shrubs, a cutlass is used to slash the shrubs. However, in the savannah region, farmers instead use a hand hoe or animal traction with oxen. For organic maize production, it is recommended to minimize or reduce soil disturbance during the land preparation. Full tillage is thus restricted to situations where noxious weeds such as spear grass (*Imperata cylindrica*) or couch grass (*Digitaria scalarum*) must be removed.

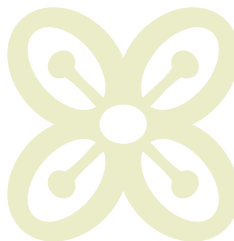
Under **zero tillage**, a dense legume cover crop, for example lablab (*Lablab purpureus*), velvet bean (*Mucuna pruriens*) or sunhemp (*Crotalaria juncea*) should be planted to suppress weeds and should only be cleared at the time of planting. The cover crop is cleared by slashing and strong weeds are pulled or dug out. Apart from suppressing these weeds, the legumes contribute to soil fertility when incorporated into the soil. Planting rows are then made directly using a hoe, oxen or tractor without ploughing the land in order to minimize moisture and organic matter loss. A short legume cover crop like beans, peas, soybean or mung beans is later planted as an intercrop at first weeding to cover the soil while the maize grows.

2.2.2 Germination test

Ideally, before sowing the seeds, a germination test is conducted to estimate the germination rate. This is helpful to establish the viability of the maize seeds in order to ensure ideal plant population.

Recommendations to farmers regarding testing of seed germination:

- › Count 100 seeds of the selected maize variety and put the seeds between moist newspaper sheets, keeping them moist. Place the paper with the seeds in a safe area where children or animals will not disturb it.



- › After four days of incubation, count the number of seeds that have germinated and express it as a percentage. For example, if out of the 100 seeds 85 seeds germinated, germination percentage is 85.

A germination percentage of between 85 and 100 is considered good for the maize crop. In case germination rate is lower, you may increase sowing density correspondingly to ensure appropriate plant density.

2.2.3 Planting

Generally, African small-scale farmers plant maize seeds by hand (dibbling) or using oxen-drawn planters, while a few large farms use tractor-drawn planters. Planting should preferably be done at the start of the rainy season to enable good seed germination and proper plant establishment. Delayed planting in relation to the onset of rains will affect yields, as the young plants will not receive enough rain for proper growth and development.

Usually, maize is sown in rows at a recommended spacing of 75 to 90 cm between rows and 25 to 50 cm within the row, with a seed rate of 2 seeds per hole. Where maize is to be intercropped with a legume, the legume should be planted in rows midway between maize rows.

The appropriate planting depth varies from 2 to 10 cm, depending on the weather conditions and the moisture status of the field. For example, in areas with adequate rainfall and well-drained sandy-loam soils, planting depth of 2 to 3 cm is optimal, as deep seed placement retards germination and emergence of maize seedlings. In dry areas where the soil is dry and sandy, maize seed may be planted more deeply (5 to 10 cm). This enables the development of a deep root system to obtain the needed water and nutrients. Deep roots penetrate far into the soil and use moisture and nutrients from the deeper depths of the soil.

2.2.4 Intercropping in maize

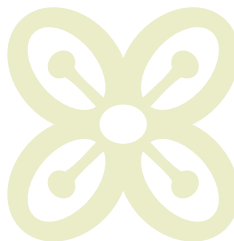
Intercropping helps to reduce the risk associated with the failure of a particular crop and reduces the risk of pest and disease attacks and shocks from drought. If one of the crops in a multiple cropped field is damaged, it is likely that the other crop can compensate for yield losses. This is partially due to the fact that the different crops use different growth resources in the environment and have different growth habits. Moreover, intercropping contributes to a more varied and balanced human diet and improves soil.



Discussion on establishment of maize fields

Inquire about local procedure for establishment of the maize crop and discuss possibilities of improvement. Begin by asking the following questions to farmers:

- › What time of the year do you start maize planting? Why?
- › Do you know how far to space your maize plant to obtain appropriate plant density? What are the criteria for how far to space your plants?



In sub-Saharan Africa, maize is commonly intercropped with beans or other legumes as well as with other food crops such as cassava and pumpkin.

a. Intercropping maize with legume crops

Intercropping of maize and legumes such as common beans, ground nuts or cow peas is a common practice in most small-scale farming systems in sub-Saharan Africa. Both crops are normally sown at the same time in the field in separate rows. Later on, the maize stems may serve as stakes for the climbing beans. In addition, other crops such as cassava may be grown.

Intercropping of maize and pigeon pea is common in Malawi, Eastern Zambia and Northern Mozambique. Research has shown that in the long term, pigeon pea is one of the legumes with the highest positive effects on soil fertility and maize yields. Even though early growth of the pigeon pea is reduced when intercropped with maize, the pigeon peas compensate by continuing to grow after the maize is harvested. The pigeon pea also provides large quantities of biomass, and the seed is harvested for food. Due to its attraction to livestock, pigeon pea needs to be protected from grazing animals.

b. Intercropping maize with green manure crops

Different types of dense covering legumes can be intercropped with maize. They are sown at the same time as the maize and when they cover the ground, they are then cut and left as mulch cover. Sunhemp (*Crotalaria juncea*) has been successfully used in Zimbabwe for green manuring and as an intercrop with maize. Other dense legume covering crops such as lablab (*Lablab purpureus*) and velvet bean (*Mucuna pruriens*) are also commonly used.

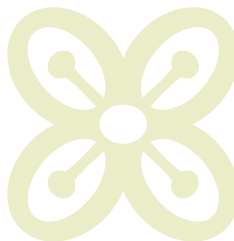
c. Maize in agroforestry

In addition to being intercropped with legumes and other crops, maize can also be grown with leguminous multi-purpose trees such as apple-ring acacia (*Faidherbia albida*), *Leucaena diversifolia*, *Calliandra calothyrsus*, *Sesbania sesban* or *Gliricidia sepium*. The maize is planted in-between alleys of legume tree hedge-rows planted either sparsely at 3 to 4 meters or densely at 1 to 2 meters. The trees fix additional nitrogen from the air and transfer it to the soil through their roots and leaf litter. Moreover, pruned material from trees can serve as mulch, animal feed or firewood. Furthermore, the trees play an important role in holding the topsoil and preventing soil erosion. *Faidherbia albida* is mostly preferred, be-



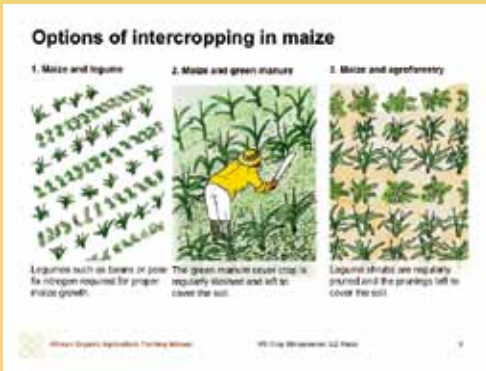
Sharing experiences on intercropping

Encourage the farmers to share experiences about intercropping maize with other plants. Let them share and discuss possible advantages and inconveniences of the different options that are presented.





OPTIONS OF INTERCROPPING IN MAIZE



cause it sheds its leaves at onset of the rains and retains them in the dry season. This makes it highly compatible with maize plants, as it does not compete with them for water, nutrients or light.

2.3 Improving soil fertility

In many parts of Africa, nitrogen and phosphorus are the most deficient nutrients in crop production. While phosphorus cannot be naturally replaced, legumes can fix nitrogen and provide all the needed nitrogen for proper maize growth.

In organic maize production, plant nutrition is satisfied through a balanced crop rotation including legumes and/or leguminous green manures, as well as timely application of compost and animal manures.

2.3.1 Crop rotation

Repeated planting of maize in the same field year after year leads to a decrease in the available nutrients necessary for plant growth and lowers yields. To avoid this, farmers should grow maize in rotation with legumes like groundnut, cowpea, pigeon peas and soybeans. Planting maize after a legume in rotation improves soil fertility and results in higher yields. In addition to fixation of nitrogen from the air, legumes interrupt the multiplication cycles of cereal diseases, provide food for humans and feed for animals and produce considerable amounts of organic materials that can be incorporated into the soil. Legumes are also known to solubilise phosphorus that is bound in the soil, and substantially increase microbial activity in the soil.

Growing green manure crops like cowpea, velvet beans or crotalaria can also generate sufficient nitrogen for a following maize crop. However, in many systems, cowpea has proved to have the shortest growing period providing sufficient nitrogen in only 8 to 10 weeks of growth.

2.3.2 Improved fallowing

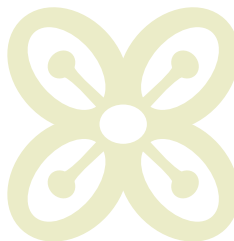
Traditionally, farmers would restore soil fertility after a period of cultivation by leaving part of their land uncultivated for up to 5 years in order for fertility to buildup, while new and more fertile land is cultivated for food production. The increasing population density has reduced the amount of land available to the farmers, and forced many farmers to shorten the fallow period or even to aban-



Discussion on soil fertility management in maize

Inquire about the participants' knowledge on soil fertility management, asking whether they have experienced any decline in the fertility of their soils, and what they think are the main causes of this decline.

Divide the farmers into small groups and invite them to discuss the availability of organic fertilizers for maize production. Ask the groups to present their propositions, how soil fertility and nutrient supply to maize can be implemented according to local conditions.



don the fallowing practice entirely in some areas. A natural short fallowing of overworked land will result in little or no improvement in soil fertility. It is therefore important to improve fallowing systems.

Experience has shown that the inclusion of improved short duration fallows of 1 to 3 years in rotations is important for significant improvement in soil fertility. Multi-purpose trees can be used to improve fallows. For example in Zambia, improved fallows using Sesbania (*Sesbania sesban*) have been found to be a good way of adding significant amounts of nitrogen and organic matter to soil. Green manure cover crops can also be used. For example in West and East Africa, maize is grown after a short lablab fallow to improve the productivity of maize, where lablab is incorporated into the soil before maize is planted. By planting lablab as green manure crop, soils are protected against erosion, nitrogen is fixed and weed infestation is controlled. As a result, soil fertility is significantly improved and the productivity of subsequent maize enhanced. For this purpose, it is recommended to establish improved fallows by planting different fallow species, as they make plant nutrients available for a longer period.

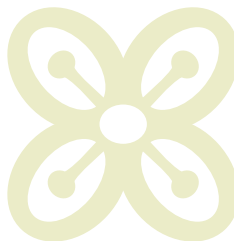
2.3.3 Application of organic materials

Although the content of essential nutrients in maize stovers is relatively low compared to that in the grain, stover can contribute to soil improvement. It is therefore important to avoid burning or removing maize stovers and other crop residues from the field. The practice of burning crop residues is also not allowed in organic farming. Organic farmers leave crop residues on the land as mulch to decompose and return their constituent nutrients.

The integration of farm animals can contribute to better recycling of nutrients within the farm if the animals are fed farm-own forage legumes, maize residues and the manure is returned to the field. Maize plants will benefit from the valuable manure from cattle, sheep, goats, pigs or chickens, especially when it is collected and composted with kitchen remains and crop residues.

2.3.4 Application of phosphate fertilizers

Low phosphorus availability is common in most soils of sub-Saharan Africa. Phosphorus is essential not only for crop production directly, but also to improve supply of nitrogen from the legumes. Legumes require adequate phosphorus supply for optimum biological nitrogen fixation. It is therefore important to develop appropriate management strategies to overcome phosphorus deficiency





SOIL FERTILITY MANAGEMENT IN MAIZE PRODUCTION



and increase maize production. Phosphorus can be supplied by organic farmers through farmyard manure, compost and in the form of locally available rock phosphate, a very slow acting fertilizer. It has a phosphorus content of 20 to 33 %, releases phosphorus very slowly and can last up to five years. Ideally, finely ground rock phosphate should be applied to composting material. This increases the solubilisation of the rock phosphate.

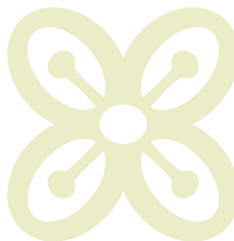
2.4 Proper water management

Maize is very susceptible to water stress. Lack of sufficient soil moisture will affect maize yields significantly. Since most maize production in sub-Saharan Africa is rainfed, there is a need to improve water use efficiency.

2.4.1 Improving water use efficiency

Efficient use of rainwater can be enhanced through the following practices:

- › Adopting minimum or zero tillage practices to minimize the exposure of soil to water loss.
- › Planting suitable varieties for the local conditions. Early maturing varieties are preferred for short rain season areas.
- › Early planting at the start of the rains to ensure that the plants get enough moisture, especially around flowering.
- › Proper weed control to reduce competition for water.
- › Using organic materials such as compost, mulch and organic manures to improve the soil's capacity to absorb and store rainwater.
- › Mulching with crop residues from previous harvest can be used as trashlines to reduce evaporation losses.
- › Reducing maize plant population is an important consideration in arid areas where irrigation is not available to increase the amount of water and nutrients available for each plant.
- › Water harvesting structures, for example, by diverting runoff from other areas (uphill or road runoff) onto a field. However, given the fact that maize does not tolerate waterlogging, water should not be allowed to stand in the maize field.



2.4.2 Irrigation

Maize is one of the most efficient grain crops in terms of water utilization, and thus can produce very high yields under irrigation. However, most maize production in sub-Saharan Africa is rainfed. Occasionally maize is grown under irrigation in areas with warm and dry periods (e.g. semi-arid areas) to ameliorate the effects of drought. In peri-urban areas, where maize is normally grown for the fresh market, irrigation is used for out-of season production.

Experience has shown that the most appropriate and suitable irrigation scheme for small-scale farmers is the drip system. In drip irrigation, water is applied only to the soil around the maize roots, so that they can easily access the water. This means less water is needed and the water is efficiently used.

Recommendations to farmers regarding irrigation in maize production:

- › When irrigation water is limited, irrigation scheduling should be based on ensuring the maize plants have enough water not to dry out during flowering. Drought stress during this period reduces yields considerably.
- › Irrigation will reach higher efficiency only if it is combined with good measures for improving the soil structure and water retention of the soil.

2.5 Weed management

Weeds can reduce maize yields by competing for moisture, nutrients, space and light. The most critical stage of weed competition in the life of a maize plant is during the first four to six weeks after emergence of the crop. Therefore, if weed infestation is minimized for the first 10 weeks, yields will not be significantly affected. If maize is heavily infested with weeds in these early stages, it may never fully recover, even if weeds are controlled afterwards. Late weeding mainly serves to prevent the weeds from producing seeds.

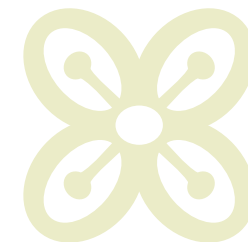
The parasitic weed *Striga* or 'Witchweed' is the most important weed of maize in Sub-Saharan Africa, causing yield losses ranging from 30 to 100 percent. Other important weeds in maize include spear grass (*Imperata cylindrica*), couch grass (*Digitaria scalarum*), nut grass (*Cyperus rotundus*) among others.



Discussion on water management in maize crops

Encourage sharing water management experiences in maize crops by asking the following questions:

- › How do you consider water supply of maize fields?
- › Is there a need for irrigation in your region?
- › What are the sources of irrigation water in your region?
- › Which strategies do you use to optimize water use?



2.5.1 General approach to weed management in maize

Successful weed management in maize is best achieved by using a combination of measures including:

- › Prevention of introduction and spread of weed seeds, for example by using clean seeds and equipment.
- › Improved fallowing by using a dense covering legume that covers the soil well, such as lablab or mucuna, will suppress weed growth thus reducing its multiplication. This should be alternated with a cover crop within the maize crop in order to completely suppress the weed.
- › Manual or mechanical weeding to remove the weeds is also necessary. This is because maize is greatly affected by weeds during the first 10 weeks of growth.

2.5.2 Management of Striga weed

Two species of Striga are found in sub-Saharan Africa: *Striga hermonhica* in West and Central Africa and *Striga asiatica* in Eastern and Southern Africa. Striga is a parasitic weed that only grows by attaching itself to roots of a host plant like maize. It sucks nutrients from the maize plants, making them smaller and weaker. This leads to yield losses and complete crop failure. Once Striga becomes well established on a farm, it is difficult to control it, partly due to its high reproductive capacity. Striga also produces thousands of seeds, which can survive in the soil for many seasons and germinate only when a cereal crop is planted.

Successful Striga management is best achieved by using a combination of measures, which are also used for general weed management. They include:

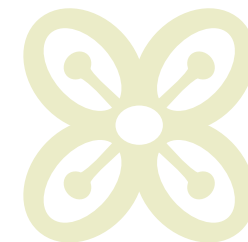
- › Prevention of its introduction and spread of weed seeds, for example by using clean seeds and equipment as well as Striga resistant or tolerant maize varieties, in case they are available.
- › Legumes that are grown in rotation or as intercrops with maize stimulate the germination of Striga, but inhibit post-germination growth of the weed because it cannot grow on the roots of legume crops. It is recommended to plant green manure and fodder crops such as desmodium, sesbania, croton or fodder grasses like Napier grass for at least two seasons and to plant maize or cereals only once every two to three seasons until all Striga is eliminated.



Discussion on weed management in maize production

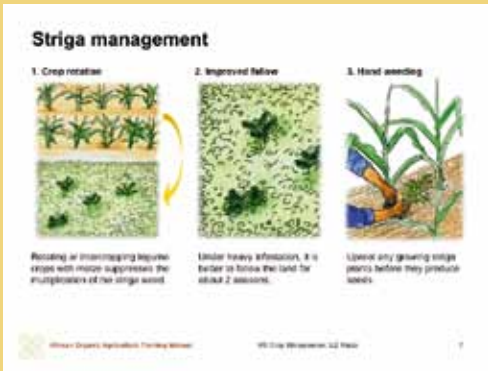
Discuss with the farmers challenges in weed management beginning with the following questions:

- › Is Striga or any other difficult-to-manage weed a problem in maize?
- › How have you tried to manage these weeds?





STRIGA MANAGEMENT



- › Intercropping maize with desmodium or other legumes such as mucuna between rows of maize has been shown to improve soil fertility and significantly suppress Striga weeds.
- › Farmers can also regularly walk through their fields and uproot any growing Striga plants. However, this should be done early enough before the Striga produces seeds and before it greatly affects the maize.

2.6 Pest and disease management

There are several pests and diseases that lower maize yields in sub-Saharan Africa, but the stem borer and the maize streak virus are the most destructive, as well as storage pests. Other important pests are cutworms (*Agrotis* spp.), armyworms (*Spodoptera exempta*) and leafhoppers (*Cicadulina* spp.). Important diseases of maize are maize leaf blights (*Exserohilum tureicum* and *Bipolaris maydis*), maize streak virus, ear and head smut (*Sphacelotheca reiliana*) and Grey leaf spot (*Cercospora zea-maydis*).

2.6.1 Management of stem borers

Two stem borer species cause significant yield losses in sub-Saharan Africa, namely the African maize stalk borer (*Busseola fusca*) and the spotted stem borer (*Chilo partellus*). The African maize stalk borer is present in most African countries, while the spotted stem borer is mainly found in Eastern and Southern Africa. Grain losses vary between 10 to 80 percent. Both stem borers also attack other cereal crops such as sorghum and millet. In addition, the spotted stem borers attack rice. The severity of infestation and damage depend upon several factors, such as the cropping system and soil fertility, which affect the growth vigour of the plant. Experience has shown that stem borer damage is stronger when nutrient supply of plants is poor.

Damage is caused by the larvae, which first feed on the surface of young leaves and then penetrate into the stems and feed inside the plant. During the early stage of crop growth, the larvae may kill the growing tip of the maize plant and also weaken the stem causing it to break. When the larvae are fully grown, they pupate in the stem. The adult moths emerge from the pupae and come out of the stem. Adult moths of stem borers are active in the night. They mate and lay eggs on the maize plants again and continue damaging the crop.

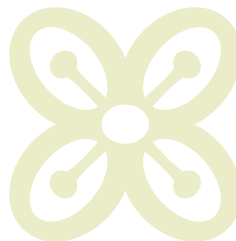


Inquiry about common pests and diseases in maize

Ask the farmers the following questions to inquire about their challenges and approaches in pest and disease management:

- › Which are the most important pests and diseases in your area?
- › Which techniques do you use to manage these pest and diseases?

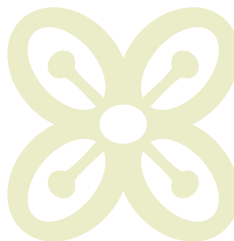
Evaluate the advantages and disadvantages of different approaches.



Infestations by stem borers have been reported to increase the incidence and severity of diseases like stalk rots and the contamination of the grains with toxin-producing fungi like *Aspergillus flavus*.

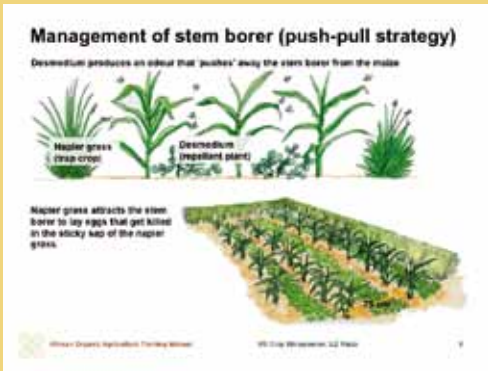
Proper management of the stem borers is best achieved by using a combination of crop husbandry practices. Such practices include:

- › Intercropping maize with crops that are not attacked by stem borers such as molasses grass (*Melinis minutiflora*) and desmodium (*Desmodium intortum*). Molasses grass produces volatile agents, which repel stem borers, but attract the parasitic wasp. In addition, the molasses grass is an effective cover crop and provides good fodder for livestock. Desmodium produces an odour that stem borers dislike, repelling egg-laying stem borer moths from the maize crop.
- › Growing maize in rotation with legumes to interrupt the life cycle of stem borers and add nutrients to the soil.
- › Conservation biocontrol by planting hedges or flower strips around and within the maize crop. These will encourage natural enemies such as parasitic small wasps and predatory ants that attack caterpillars of the stem borer.
- › Planting trap crops such as Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare sudanense*) around the maize fields. Napier grass has an odour that makes it more attractive to egg-laying adult moths. But most of the caterpillars are killed in the sticky sap of the Napier grass. Sudan grass also attracts moths and serves as a reservoir for its natural enemies.
- › Destroying stem borers by burning crop residues of infected plants to kill pupae in stems and stubble.
- › Implementing a push-pull strategy (see box).
- › Use of plant botanicals like neem products. The neem mixture should be applied into the folded leaves of the growing tip of the maize plant.





STEM BORER MANAGEMENT (PUSH-PULL STRATEGY)



Push-pull strategy

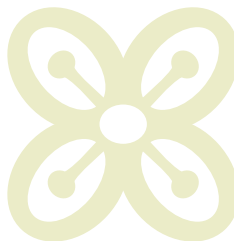
This intercropping technique involves planting the legume desmodium (*Desmodium uncinatum*, or *D. silverleaf*) between the rows of maize. Desmodium produces an odour that stem borers dislike. The odour ‘pushes’ away the stem borer moths from the maize crop. Desmodium also suppresses Striga weed and being a legume, fixes nitrogen in the soil and thus improves soil fertility. In addition, Napier grass is planted on the border around the intercropped maize field. Napier grass has an odour that ‘pulls’ or attracts the stem borer moths to lay their eggs on it. Most of the eggs are killed in the sticky sap of the Napier grass. Therefore very few stem borer larvae survive and the maize is saved because of the ‘push-pull’ strategy. Growing maize with desmodium and Napier grass can significantly reduce stem borer attack and improves soil fertility. It is also an effective method against Striga infestation. It is recommended to plant Napier grass before the rainy season, so that it begins growing before the maize, and desmodium and maize early, within the first rains.

Bt-maize is not allowed in organic farming

Bt-maize is genetically engineered to make it resistant to the stem borer. It is created by adding the genes from the soil bacterium *Bacillus thuringiensis* to the maize seeds. It produces a toxin that kills the stem borer. Bt-maize has been cultivated in some countries including South Africa and Kenya, mainly among large-scale farmers because of the high price of seeds. Apart from being expensive for small-scale farmers, farmers are not allowed to save or exchange seed of Bt-maize. Moreover, there is evidence that stem borers quickly develop resistance to Bt-maize and some fear that the pollen could transmit the Bt-gene to local maize varieties.

2.6.2 Management of the maize streak virus (MSV)

The maize streak virus is transmitted by several species of leaf hoppers (*Cicadulina* spp.) after feeding on infected plants, causing yield loss of 30 to 100 percent. Early disease symptoms begin within a week after infection and cause very small, round and scattered spots on the younger leaves. The number of spots increases with plant growth, enlarging parallel to the veins. The spots then become more profuse at the leaf base causing chlorosis with a broken yellow streak along the

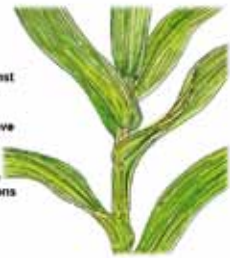




MAIZE STREAK VIRUS MANAGEMENT

Maize streak virus control measures

- › Use resistant varieties
- › Apply botanical pesticides against leaf hoppers
- › Ensure regular weeding to remove alternative hosts (grasses)
- › Ensure early planting before the buildup of leaf hopper populations



veins, contrasting with the dark green colour of normal foliage. Severe infection causes stunting and plants can die prematurely and will not develop cobs. The virus also infects a wide range of indigenous grasses and various cereal crops such as wheat, millet and rice.

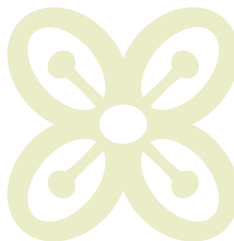
Integrated pest management is the best approach for combating maize streak virus. This includes the following measures:

- › Growing tolerant or resistant maize varieties offers the most economical and effective way of managing the disease.
- › Controlling leaf hoppers that transmit the disease can be done either by stimulating natural enemies of these insects or by the application of botanical pesticides.
- › Regular weeding of grasses that are also infected by MSV disease.
- › Planting early before the buildup of leaf hopper populations. Ideally, planting within a wider area is carried out at the same time to avoid migrating leaf hoppers landing on young plants.
- › Leaving a barrier of 10 meters of bare ground between maize fields and previously infested crops to reduce virus incidence, by restraining movement of leaf hoppers.

2.6.3 Management of storage pests and diseases of maize

The most common storage pests of maize are the Angoumois grain moth (*Sitotroga cerealella*), the larger grain borer (*Prostephanus truncatus*), grain weevils (*Sitophilus* spp.) and rodents (mostly mice). They can be managed by a combination of measures:

- › Early harvest of the maize to prevent or reduce infestation of the maize cobs in the field.
- › Growing suitable varieties that have the husk covering all of the grains.
- › Proper drying of the maize grain is an important procedure in storage pest prevention. In order to be stored safely, the produce must be dried quickly after harvest and only be stored after it has been thoroughly dried.
- › Good hygiene in the storage area by cleaning out all residual pockets of infestation at the end of the storage season minimizes reinfestation of the new harvest. Removing all dark corners, sealing off all potential entry points and clearing the surrounding spots where rodents are likely to hide, is helpful to control rodents.



- › Periodic inspection and removal of all infested maize cobs or grain.
- › Use of plant extracts, for example, crushed, ripe, dry chilli pepper pods and mixed with wood ashes, and mixed with dried maize ready for storage to repel and kill maize weevils.
- › Use of natural enemies, for example, the predatory beetle *Teretrius nigrens* has been used in many African countries in an attempt to control the larger grain borer.

3. Reducing postharvest losses

Farmers invest a lot of effort in maize production. However, these efforts can be wasted during and after the time of harvesting due to inconsistent harvesting methods, damage caused by storage pests and diseases or inappropriate storage.

3.1 Timely harvesting

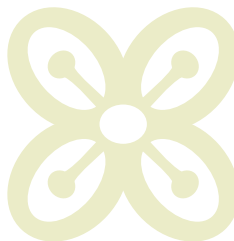
Maize is usually harvested by hand on the cob in small-holder maize farming. Maize that is to be eaten green is ready for harvest when the grain hardens or when the silky flowering at the top of the maize cob turns black. At this full maturity stage the crop has a moisture content of about 30 percent.

However, maize to be dried is left to partly dry in the field until all the leaves of the plants have turned brown. This bears the considerable risk of the grains spoiling by feeding birds. Many small-scale farmers wait too long to start harvesting because they lack suitable drying facilities. Delayed harvesting can lead to rotting of the cobs, and attacks by rodents, birds and weevils. It also allows fungal pathogens such as aflatoxins to spread, especially if the drying crop is rained on while still in the field. At harvest the husks are removed from the cobs.



Group work on postharvest management

Ask the participants to formulate practical strategies to avoid damage by storage pests and diseases, and to avoid contamination of the maize. Invite a member of each group to present the results in the plenum.





PROPER POSTHARVEST HANDLING PROCEDURES



3.2 Proper drying

Quickly after harvest, the cobs should be properly dried under the sun before being shelled. If the grains are not well-dried, they will attract insect pests and mildew. When a handful of grains and half a handful of salt are shaken in a dry soda bottle for 2 or 3 minutes, and after the grains were allowed to settle, the salt sticks on the walls of the bottle, this means the grains still contain moisture. These grains should be dried again and tested repeatedly until no salt sticks to the bottle, before being stored.

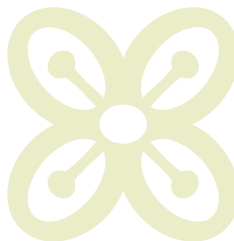
Drying should not be carried out on the bare ground, but on a cemented floor, on mats or tarpaulins on a raised structure like cribs or specially constructed drying sheds. This is to avoid the grains picking up moisture, dirt and insects. In case of open air drying, the grain should be protected from rain, night dew, domestic animals and birds.

3.3. Proper storage

After drying, maize should be stored in a clean and well-ventilated storage area, separating old from new grain stocks. There are different ways of storing maize.

- › Traditionally maize is stored by hanging cobs, before shelling, on kitchen fire rafters to prevent insect damage. It is, however, recommended to shell cobs immediately after drying to reduce weevil damage.
- › Shelling of the grains should be done carefully, so that the grains do not get damaged.
- › After shelling, the grains should be cleaned by removing any dirt and foreign matter, small and damaged seeds.
- › The cleaned shelled grains are then stored in small household storage metallic silos or packed in sacks (bags with perforations) and stored well on pallets in clean and well ventilated stores. Under such conditions, grain can be stored up to two years without any significant reduction in quantity and quality.

For farmers who do not have adequate storage capacity, it is advisable to sell off the grain immediately to avoid incurring losses. Well-dried and shelled grain is ready for milling into flour and further processing into other products.



4. Marketing and certification of organic maize

The great majority of maize produced in Africa is consumed locally, as maize is an important staple food in most areas. Average per capita maize consumption in sub-Saharan Africa is expected to increase from 44 kg in 1993 to 50 kg in 2020.

In recent years, maize has also become a cash crop with local industries (for the livestock sector and breweries) due to economic growth, urbanization and rising incomes.

As a result, there are growing domestic and continental market opportunities for maize throughout sub-Saharan Africa. This potential can be positively used by organic farmers to position organic maize at the national and continental levels.

However, the market for certified organic maize is still very small, or does not exist. But given the fact that many small-scale farmers are already using some organic practices such as intercropping, they can easily learn and make use of full organic practices to establish sustainable and productive production systems for their families and take advantage of the local market opportunities without organic certification.

Recommended literature for further reading

- > Infonet-Biovision. www.infonet-biovision.org
- > Maize Production and Improvement in Sub-Saharan Africa. www.absfafrica.org
- > Cornell University: Soil Fertility Management In The Smallholder Maize-Based Cropping Systems Of Africa
- > Control of Striga and stem borer in maize. www.anancy.net
- > FAO. A guide to maize marketing for extension officers. www.fao.org



Group discussion on marketing and organic certification of maize production

Invite the farmers to discuss in groups the various options for selling maize to different markets and to share the results in the plenum.

- > Are there markets that are demanding organic maize?
- > If yes, how can the farmers tap into those markets?
- > If no, then how can the organic markets be developed?

