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FiBL

African Organic Agriculture Training Manual
A Resource Manual for Trainers in Malawi

ORGANIC GROUNDNUT PRODUCTION

Version 1.0
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The manual is intended for use by trainers during the training of farmers in good practices for groundnut production.

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

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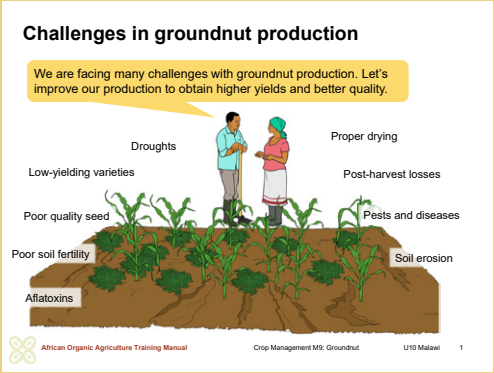
CONTENTS

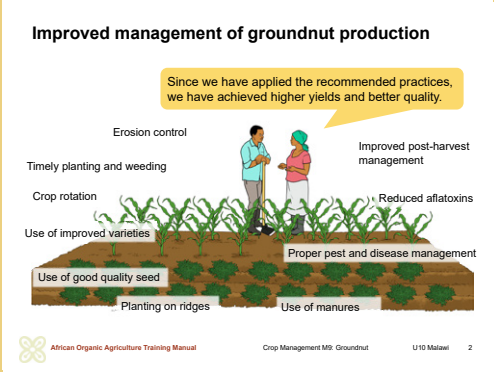
9-10 ORGANIC GROUNDNUT PRODUCTION

SET OF TRANSPARENCIES

CHALLENGES IN GROUNDNUT PRODUCTION



IMPROVED MANAGEMENT OF GROUNDNUT PRODUCTION



1. Introduction

Groundnut (*Arachis hypogaea* L.), also known as peanut, is one of the most important food and cash crops in Malawi. About one in every five farmers in Malawi grows groundnut. It is a principal source of digestible protein (25–34 %), cooking oil (44–56 %), and vitamins. It is therefore an important nutritional supplement to mainly cereal diets of many households in the country. In addition, as a legume, groundnut improves soil fertility by fixing nitrogen and thereby increasing productivity of other crops grown at the same time or in rotation on the same plot with groundnut. With a share of more than 25 % of agricultural income, groundnut is a significant source of income for most rural households in Malawi.

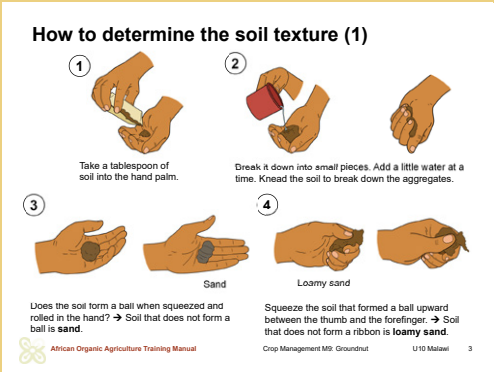
Despite its importance, groundnut production in Malawi is faced with numerous challenges, mainly:

- Use of low-yielding seed varieties;
- Low soil fertility and erosion leading to stunted growth;
- Low amounts and irregular distribution of rainfall, which leads to poor yields; prolonged drought periods, which affect yield and also enhance aflatoxin contamination; and limited access to irrigation;
- Poor insect pest and disease management;
- Poor postharvest handling and management;
- High aflatoxin contamination due to high exposure throughout the value chain.

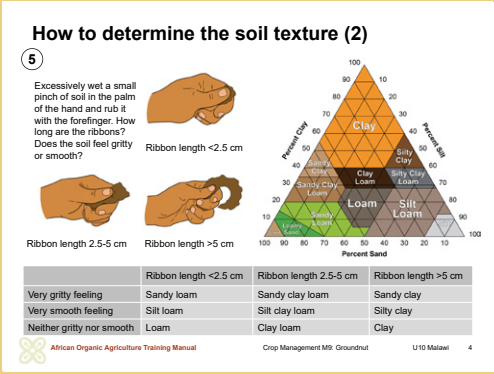
Groundnut is grown in nearly all of Malawi's 28 districts, but 70 % of the crop is grown in the Central Region. Yields are generally low at an average of 1000 kg per hectare for *CG7* and *Nsinjiro* varieties, and 600 kg per hectare for *Chalimbana*. However, there is potential for much higher yields with good management practices; for example, *CG7* can yield up to 2500 kilograms, *Nsinjiro* can yield 2000 kilograms, and *Chalimbana* can yield 1500 kilograms per hectare.

This training manual presents specific recommendations, which – when properly applied in their totality – can improve yields and income of groundnut farmers in Malawi.

DETERMINING SOIL TEXTURE (1)



DETERMINING SOIL TEXTURE (2)



	Ribbon length <2.5 cm	Ribbon length 2.5-5 cm	Ribbon length >5 cm
Very gritty feeling	Sandy loam	Sandy clay loam	Sandy clay
Very smooth feeling	Silt loam	Silt clay loam	Silty clay
Neither gritty nor smooth	Loam	Clay loam	Clay

2. Field establishment

2.1 Key growing requirements

a. **Rainfall/Water:** Groundnut is commonly cultivated as a rain-fed crop in Malawi with less than 1 percent under irrigation. Generally, groundnut requires evenly distributed rainfall between 450 mm and 1250 mm annually for effective growth, development and high yields. Although the crop is tolerant to droughts, insufficient water at the time of sowing, flowering and fruiting will significantly reduce yield. It is therefore important to strictly time the onset of the rainfall season for sowing of the crop, and where possible to use supplementary irrigation during prolonged drought periods (especially at flowering and fruiting stages). Early maturing small seeded varieties require 300 to 500 mm rainfall whilst the late maturing large-seeded varieties need 1000 to 1200 mm rainfall. With supplementary irrigation, the plant population per hectare can be increased, yields are guaranteed, and off-season production is possible. Groundnut is not suited to growing at high altitudes above 1500 m, as its optimum temperatures are 27–30 °C.

b. **Soil fertility:** A deep and well-drained sandy loam soil facilitates better pegging of the groundnut pods into the soil, and hence better yields. Groundnut will not grow well or fix nitrogen in acidic soils with pH below 5 or infertile soils. Therefore, on such soils application of good amounts of farm yard manure (10 t per ha depending on availability) at the time of sowing will not only help moderate the soil pH conditions, but will also support good establishment. In acidic soils, addition of lime (0.5 t per ha in the absence of a soil test) improves cell wall thickness and pod filling, and decreases fungal infection.

How to test for key soil properties for groundnut production

A soil test done at a reputable soil analysis laboratory is an ideal tool to determine whether the soil is acidic or alkaline, and meets the recommended soil fertility requirements for groundnut production, and to learn what corrective measures are required.

Instead of a soil test, a 'simple feel method' can be used to determine the soil texture – a key soil property for groundnut production.

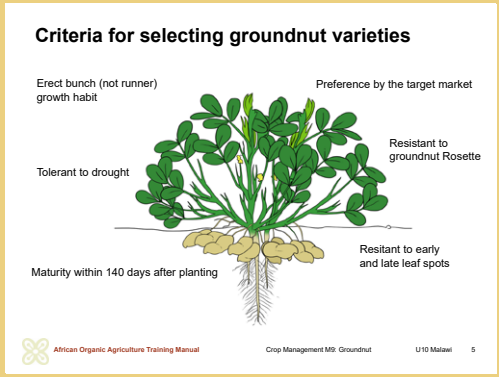
Participants' knowledge of groundnut production

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

- Have you experienced any decline in groundnut 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 groundnut yields?

Write down the answers. If possible, the answers can be reviewed later.

VARIETY SELECTION CRITERIA



2.2 Variety selection

The most common varieties of groundnut currently used in Malawi belong to two botanical or market types, namely: Virginia types that are commonly grown in mid altitude locations and Spanish types with either a bunch (erect) or spreading (runner) growth habit, and are grown in the lowlands.

The most popular varieties are *CG7* (red in colour) and *Chalimbana* (tan in colour). New varieties are continuously being introduced and promoted by the Ministry of Agriculture and other agents, recently *Nsinjiro*, *Baka*, *Kakoma*, and *Chalimbana* 2005. Table 1 shows the common groundnut varieties in Malawi and their specific attributes. Farmers are encouraged to inquire from the local Extension Officer about the most suitable groundnut varieties for their locations.

To achieve higher yields, it is advisable to use high-quality seed, preferably seed that is resistant to diseases (especially rosette and aflatoxin) and pests and is tolerant to drought. Drought tolerant varieties have been found to have reduced vulnerability to aflatoxin contamination.

The variety CG7, although well known for high yields, high oil content and marketability, is susceptible to the Groundnut Rosette Disease (GRD). The disease thrives in drought conditions and can lead to more than 50 % yield reduction. ICRISAT, together with the Department of Agricultural Research Services (DARS) in Malawi, released new groundnut varieties in more than four countries, including Malawi that have a high yield potential, are tolerant to abiotic stress, and well adapted to a wide range of environments. They also have better seed quality and weight, and therefore provide greater market opportunities. These varieties include:

1. Medium duration Virginia varieties maturing between 120–130 days and well adapted to mid-altitude growing conditions: CG 8 (ICGV-SM 08501), CG 9 (ICGV-SM 08503), CG 10 (ICGV-SM 01724), and CG 11 (ICGV-SM 01731).

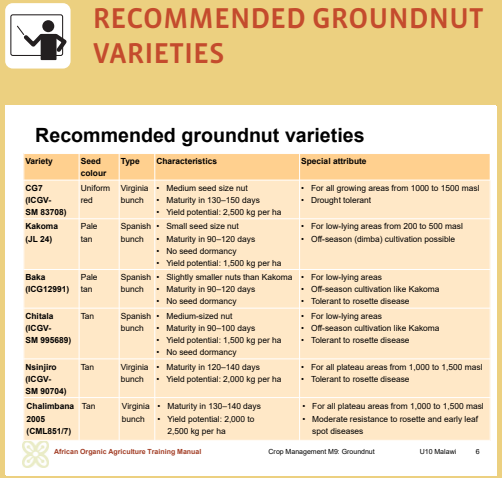
2. Short duration Spanish varieties, which mature within 90–110 days and are well adapted to low-altitude conditions: CG 12 (ICGV-SM 01514), CG 13 (ICGV-SM 99551), and CG 14 (ICGV-SM 99556).

Discussion about groundnut varieties

To assess the suitability of groundnut varieties commonly used in the different areas of Malawi, ask the participants the following questions:

- Which groundnut varieties are suitable in the dry and wet or high and low areas of the central region of Malawi, etc.?
- What are the advantages and disadvantages of these varieties?
- Which criteria are considered in variety selection?

RECOMMENDED GROUNDNUT VARIETIES



Recommended groundnut varieties

Variety	Seed colour	Type	Characteristics	Special attribute
CG7 (ICGV-SM 83708)	Uniform red	Virginia bunch	• Medium seed size nut • Maturity in 130–150 days • Yield potential: 2,500 kg per ha	• For all growing areas from 1000 to 1500 masl • Drought tolerant
Kakoma (JL 24)	Pale tan	Spanish bunch	• Small seed size nut • Maturity in 90–120 days • No seed dormancy • Yield potential: 1,500 kg per ha	• For low-lying areas from 200 to 500 masl • Off-season (dimba) cultivation possible
Baka (ICG12991)	Pale tan	Spanish bunch	• Slightly smaller nuts than Kakoma • Maturity in 90–120 days • No seed dormancy	• For low-lying areas • Off-season cultivation like Kakoma • Tolerant to rosette disease
Chitala (ICGV-SM 995689)	Tan	Spanish bunch	• Medium-sized nut • Maturity in 90–100 days • Yield potential: 1,500 kg per ha • No seed dormancy	• For low-lying areas • Off-season cultivation like Kakoma • Tolerant to rosette disease
Nsinjiro (ICGV-SM 90704)	Tan	Virginia bunch	• Maturity in 120–140 days • Yield potential: 2,000 kg per ha	• For all plateau areas from 1,000 to 1,500 masl • Tolerant to rosette disease
Chalimbana 2005 (CML851/7)	Tan	Virginia bunch	• Maturity in 130–140 days • Yield potential: 2,000 to 2,500 kg per ha	• For all plateau areas from 1,000 to 1,500 masl • Moderate resistance to rosette and early leaf spot diseases

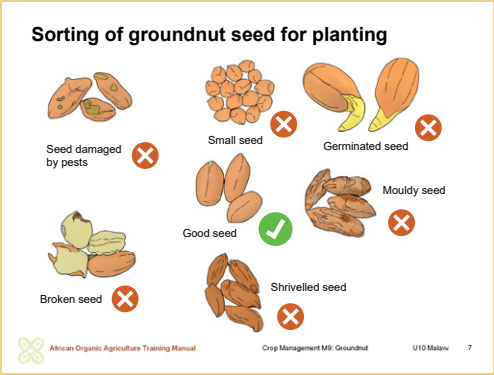
Table 1: Common groundnut varieties in Malawi and their specific attributes

Variety	Seed colour	Type	Characteristics	Special attribute
CG7 (or ICGV-SM 83708)	Uniform red	Virginia bunch	Medium seed size nut; tolerates drought; matures in 130–150 days; yield potential of 2,500 kg per ha; contains 48 % oil.	Suitable for all groundnut growing areas of the country. It is only suitable within an altitude of 1000 to 1500 m.a.s.l.
Kakoma (JL 24)	Pale tan	Spanish bunch	Small seed size nut; matures in 90–120 days after sowing; has no seed dormancy, so it should be harvested as soon as it matures; yield potential of 1,500 kg per ha; contains 48 % oil.	Suitable for low-lying areas at 200 to 500 m.a.s.l. such as Shire valley, lakeshore areas and for off-season (dimba) cultivation using residual moisture or irrigation.
Baka (or ICG12991)	Pale tan	Spanish bunch	Like Kakoma, though slightly smaller seeds; matures in 90–120 days after sowing; has no seed dormancy; contains 48 % oil.	Suitable for low-lying areas and off-season (dimba) cultivation like Kakoma, but tolerant to rosette disease.
Chitala (or ICGV-SM 995689)	Tan	Spanish bunch	Medium seed size nut (41 g per 100 seeds); matures in 90–100 days after sowing; yield potential of 1,500 kg per ha; no seed dormancy; contains 48 % oil.	Suitable for low-lying areas and off-season (dimba) cultivation like Kakoma, but tolerant to rosette disease.
Nsinjiro (or ICGV-SM 90704)	Tan	Virginia bunch	Matures between 120–140 days after sowing; yield potential close to CG 7 (2,000 kg per ha); contains 48 % oil.	Recommended for production in all plateau areas of Malawi within an altitude range of 1,000–1,500 m.a.s.l. It is tolerant to groundnut rosette disease.
Chalimbana 2005 (or CML851/7)	Tan	Virginia bunch	Matures in 130 to 140 days; yield potential of 2,000 to 2,500 kg per ha; contains 45 % oil.	Like Nsinjiro, but has moderate resistance to both rosette and early leaf spot diseases.

Source: Legumes Development Trust – African Institute of Corporate Citizenship (LDT-AICC), 2014: Harmonised Groundnut Production Manual for Malawi.

For further guidance regarding the groundnut varieties, contact the National Association of Smallholder Farmers in Malawi (NASFAM), www.nasfam.org.

SEED SELECTION



INDOOR SEED GERMINATION TEST

2.3 Seed selection and preparation

2.3.1 Selection and handling of seeds

Most small-scale groundnut farmers in Malawi use seeds saved from the previous harvest, while a few buy seeds from vendors, or receive them from the government or NGOs.

Groundnut's indeterminate growth habit results in seeds of varying sizes and maturity at harvest. Groundnut seed can be infested by seed-borne fungi (mainly *Aspergillus*) and viruses, bacteria and nematodes. As a result, seed quality and germination rate can vary strongly. Seeds that are taken from own crops also become weaker and progressively lose their good characteristics from one season to another, as they cross-pollinate with other varieties cultivated nearby.

If seeds are bought from an agro-dealer or seed agent, the seed should be checked, whether it is quality-certified or not. Quality-certified seed has a packet label with the following information: name of the seed producer, date of packaging, name of the variety, germination rate (percentage), seed purity (indicates how much free the seed is from debris), and net weight of the seed.

If in doubt, or as a matter of fact, the farmer should also inspect the seed visually to ensure that there are no seed quality problems. Careful seed selection is important to ensure good emergence of the crop. Immature, damaged, skinned, mouldy, small or shrivelled seeds should be sorted out. The selected seeds must also be free from contamination mainly of seed-borne fungi, irrespective of the sources of supply. It is recommended to purchase new seed stock every 2 to 3 seasons. Groundnut seed is very susceptible to physical damage and should be handled with care at all times. Generally, seed intended for sowing is hand-shelled 1 to 2 weeks before sowing by choosing only good quality ones.

Seed quality testing

The germination capacity of the seeds should be tested prior to planting. As a single test of seed germination of a single seed lot is not a reliable estimate of the quality, germination tests of different seed lots should be made.

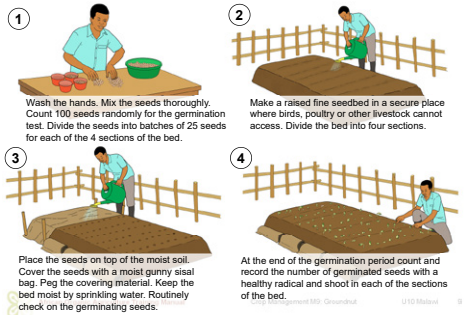
If a farmer has a very limited amount of seed, he or she can use 20 seeds only for the germination test instead of 50 or 100. For a good representation of the seed batch, the seeds should be taken randomly. Selecting the best or worst seeds only should be avoided. The soil / medium for the seed germination test must be kept moist, but not damp, otherwise the seeds will rot before they sprout.

Demonstration of the germination test

Show the participants, how to proceed for the germination test. Prepare a germination test in advance to show a possible result.

OUTDOOR SEED GERMINATION TEST

Outdoor seed germination test directly on the soil



ADJUSTING THE SEED RATE

Adaptation of sowing density

How to calculate the germination rate:

(B / A) x 100

B = number of successfully germinated seeds (after 7 days)
A = number of seeds sown for the test

Germination rate	Adjustments to seeding rate
0-50 %	**Discard the seed batch** and obtain good quality seeds
51-60 %	Discard the seed batch and obtain good quality seeds *or* **plant 3 seeds per hole/planting station** (tripple the amount of seed)
61-70 %	Discard the seed batch and obtain good quality seeds *or* **plant 2 seeds per hole/planting station** (double the amount of seed)
71-90 %	**Increase amount of seed by 20 %** (e.g. use 6 kg instead of 5 kg)
91-100 %	**Use the normal seed quantity** for sowing.

Seedling emergence in the field generally is about 20 % lower than in the germination test. A germination capacity of more than 85 % is recommended. If the germination in the test is lower than 90 %, then the number of seeds sown must be increased accordingly. A good field emergence is above 70 %.

2.3.2 Seed treatment

Conventionally, seeds are treated with a fungicide to control seedling blights caused by seed-borne bacteria and fungal diseases. Sometimes, the fungicide is mixed with an insecticide to protect the seeds from insect damage during germination. However, in organic production, seed treatment with synthetic chemicals is restricted.

The organic approach is to carefully select seeds from healthy and mature plants to minimise the transfer of infections from one field to another. This practice is complimented with proper hygiene during crop production avoiding the use of tools and materials from other farms.

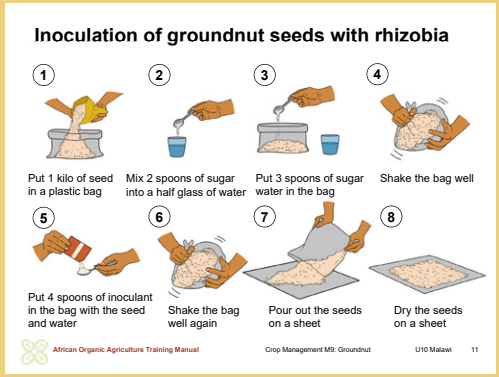
2.3.3 Seed inoculation with Rhizobia

The natural symbiosis of groundnut with nitrogen-fixing Rhizobia bacteria is essential for optimum plant growth, especially under low nitrogen input conditions. The root nodule building rhizobium *Bradyrhizobium* is in general present in soils that have been cultivated with groundnut before. However, fields where groundnut is planted for the first time may not contain this specific rhizobium. In this case, the rhizobium should be added to the soil at planting. Commercially sold rhizobia for groundnut inoculation consist of selected rhizobium strains with a higher nitrogen fixation rate than native strains. As native rhizobia compete with inoculated strains for root infection, some recommendations suggest to inoculate groundnut fields every season to maximise yields.

Research has shown that inoculation of *Bradyrhizobium* together with other rhizobia such as *Serratia marcescens* and / or the fungus *Trichoderma harzianum* can have a positive effect on root nodulation, and thus increase nitrogen fixation of the groundnut plants. Inoculation of soils with other beneficial soil-borne bacteria or fungi can result in better root growth, increased phosphorus uptake, or reduced pathogen incidences on the roots.

NOTE: To access the appropriate rhizobia, farmers should contact their agricultural extensionist, national organic agricultural movement (NOAM) or nearby agricultural research institute.

INOCULATION OF SEEDS WITH RHIZOBIA



The bacterial inoculum can be added by mixing it to the seeds before planting. Instead of direct seed inoculation, the rhizobium can be poured into the planting furrows in a suspension or applied in a granular form with the seed at planting to avoid damage to the seed. Alternatively, granular inoculum can be dispensed.

Procedure for inoculation of groundnut seeds:

- Soak the groundnut seeds tied in a gunny bag in water for 4 to 6 hours, or spread groundnut seeds on a gunny bag and cover them with another wet gunny bag for 12 to 14 hours.
- Prepare the inoculum as described in the product instructions.
- Then treat the seeds with rhizobium at a rate of 5 gms per kg of seeds (i.e. 600 gms for a full sack of 110 to 120 kg of seeds). Mix the seeds carefully with the rhizobial inoculum. Make sure not to bruise the seed coats.
- Let the seeds dry under shade for 30 minutes.
- Sow the seeds within 1 or 2 days.

2.4 Land preparation

Groundnuts grow well in soils that have been worked to a depth of 20 – 30 cm. This enables the roots to grow deep into the soil for good anchorage and better access to moisture, especially during dry spells. Good land preparation by hoe, oxen or tractors to loosen the soil provides suitable soil conditions for rapid and uniform germination, good root penetration and growth, and eventually steady pod formation, filling and seed development.

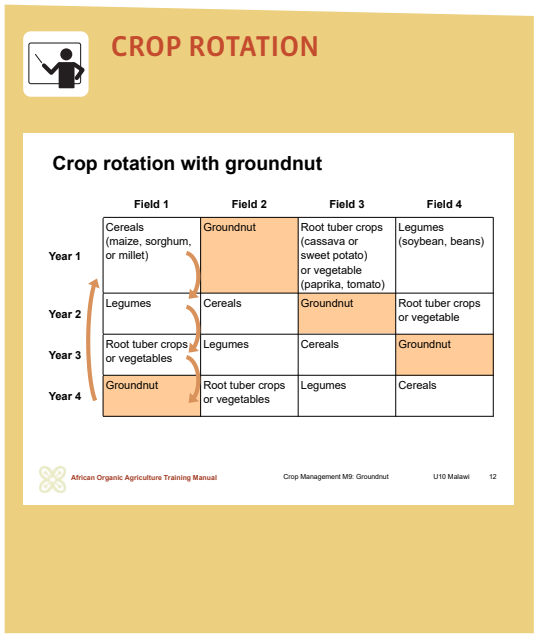
Land should be prepared early, before the rains start, so that planting can take place early in the rains. On slopy land, ploughing should be done along the contour lines to reduce the risk of soil erosion through runoff, when it rains.

At land preparation all previous crop residues and weeds should be completely removed or buried, and seedbeds should be smooth to provide good soil-to-seed contact after planting. Removed weeds can be used for composting or as mulch to control in-field soil erosion.

Commonly, farmers use ridges to plant groundnut, because the loose soil in ridges encourages pod development, improves weed control and harvesting, leading to higher yields. Ridges are especially required in wet, low-lying areas to prevent waterlogging.

Sharing experiences on crop rotation

Encourage participants to share experiences about crop rotation in groundnut production. Let them share and discuss possible advantages and inconveniences of the different options that are presented.



Ridges are normally 75 to 90 cm wide and flat-topped to allow double rows to be planted on the ridge. Planting double rows results in groundnut plants covering the soil quickly, which shades out weeds. An evenly prepared seedbed on the ridges helps to assure a uniform planting depth and facilitates better seed germination and emergence.

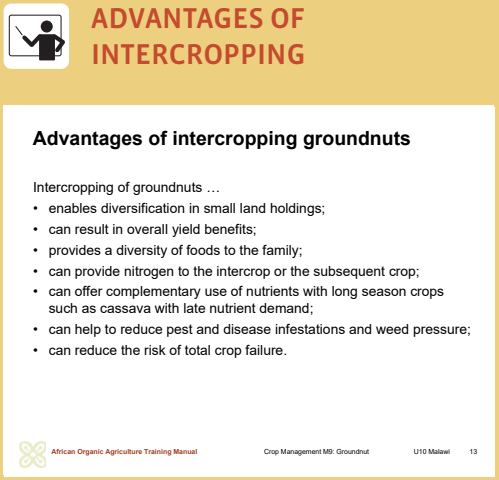
2.5 Crop rotation and intercropping

The continued cultivation of groundnut on the same plot of land leads to a build-up of high populations of aflatoxins in the soil, which will increase the probability of infection and aflatoxin contamination.

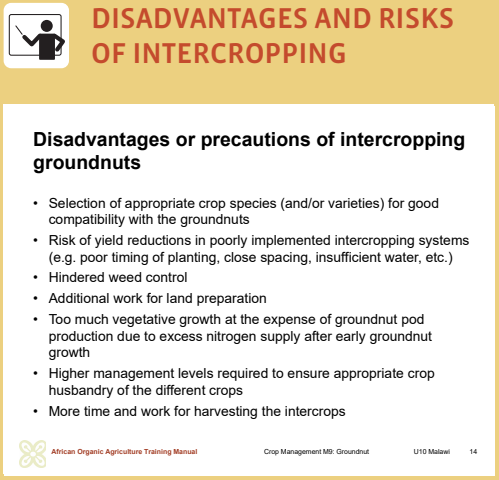
For best results, groundnut should not be grown in the same field for two consecutive seasons. It should be grown in rotation with cereals (maize, sorghum or millet), root tuber crops (cassava or sweet potato) or sunflower. However, to minimise diseases and pests, groundnut should not be sown after any legume crop, cotton or tobacco, as they cause build-up of nematodes and soil-borne diseases.
In Malawi, groundnut does well when it is grown in succession with a well-managed and fertilised maize crop. This is because groundnuts are good at utilising residual nutrients. Slide 12 shows, how groundnut can be grown in rotation with other crops.

Groundnut is mostly grown under monocropping. This is because it requires a lot of sunshine and the shading effect from intercrops reduces yields. However, under smallholder farming, groundnuts are commonly grown in mixtures with other crops on the same plot or land. Sometimes the crops are directly intercropped within the groundnuts with irregular spacing or as different patches without any distinct row patterns. In other cases, the crops are grown in alternating rows or strips.
The numbers of crops intercropped with a groundnut main crop by smallholders may vary. Some of the crops which are often found growing together with groundnuts on smallholder farms, include maize, sorghum, pigeon-pea, cotton, and cassava. There is not so much information on intercropping groundnuts in organic production compared to conventional systems. Research on conventional groundnut intercropping reflect some conflicting results on the performance of intercropped groundnuts compared to the sole or monocropping systems. For example, while some of the research in India showed up to 50 % groundnut yield

ADVANTAGES OF INTERCROPPING



DISADVANTAGES AND RISKS OF INTERCROPPING



increase in a sorghum-groundnut intercropped system, other research showed similar reduction levels compared to sole groundnut cropping. One of the reasons leading to the yield reduction include poor light interception and nodulation by groundnuts in the intercrop systems. When the yields of both crops are considered, the overall benefits of intercropping are sometimes greater than monocropping. Cotton-groundnut intercrops on alternate ridges (75 cm apart) gave higher cotton and groundnut yields in high rainfall areas with more than 1000 mm per year areas in Zambia, but no yield advantages were observed in lower rainfall areas with less than 800 mm per year.

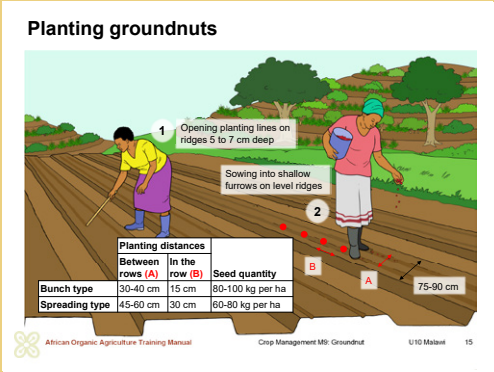
When intercropped, groundnuts will perform differently depending on a number of factors such as:

- **Rainfall** amount or availability of supplementary irrigation.
- **Spacing:** wider spacing is recommended, but spacing also depends on the type of intercrop. In Egypt, for example, some research showed that planting maize at 50 % of its monocropping density in the intercrop on a sandy soil led to the highest weight of seed per plant and pod yields while an intercrop with 100 % of the recommended sole maize planting density reduced groundnut seed weight and pod yields.
- **Type of groundnut planted:** some researchers report higher yields from groundnut varieties which have a longer growing season.
- **Type of intercrop:** species with less shading effect are more preferable, e.g:
  - A crop like cotton, which has a late-developing leaf canopy and can tolerate a wide range of population densities, may be better suited to intercropping with groundnuts.
  - Forage sorghums, for example, produce larger foliage and are likely to impart more shading to the groundnuts.
- **Timing of planting of the intercrop** is important. For example, delaying maize planting by about 4 weeks after sowing the groundnuts (relay cropping) provides a competitive advantage for the groundnuts compared to simultaneous sowing.
- Given the generally small landholdings in the Malawian smallholder context, some farmers may find it more appropriate to intercrop groundnuts with cereals and other crops rather than practicing crop rotations.

Discussion on intercropping

Discuss with the farmers about their experiences with rotations as well as intercropping (mixed, strip and relay intercropping).
Highlight the pros and cons of intercropping (as mixed, relay or strips) and the additional management requirements for intercropped systems.

PLANTING GROUNDNUTS



Given that many factors influence the performance of groundnuts in an intercrop, farmers should consult with local extension staff and try out various combinations of crops and management practices within their prevailing production conditions and make an informed choice. It is important, though, to keep in mind some of the key advantages and disadvantages of groundnut intercropping.

2.6 Planting

Groundnut is grown in all areas where tobacco and maize are grown, maize being the staple food and tobacco the main cash crop among smallholders in Malawi. Groundnut is frequently given the last priority in timing for planting.

Farmers in Malawi plant groundnut before the full rains, normally after the first 'effective rains' that are sufficient for planting.

Groundnut should be sown into moist soil; not immediately after heavy rains, because they will absorb too much water and rot. Planting after heavy rains can also result in excessive soil compaction, which may block germination and/or emergence.

The normal time of planting of groundnut is supposed to be mid-October to mid-November, but rains are increasingly becoming more erratic. Late planting may lead to crop failure and aflatoxin incidence due to drought effect, lower yields of up to 50 %, pests (especially aphids) and disease (rosette and leaf spot) incidences, and reduced quality of the nuts.

2.7 Plant spacing and planting depth

The recommended distance between rows in bunch types is 30 to 40 cm, and 15 cm between plants in the rows, resulting in a recommended seed quantity of 80 to 100 kg per hectare. For spreading groundnut varieties, 45 to 60 cm between rows and 30 cm between plants are recommended, resulting in 60 to 80 kg of seeds needed per hectare. Lower-limit row spacing allows earlier ground cover and helps prevent serious weed problems.

Groundnut should be planted at 5 to 7 cm depth. Deeper sowing will result in slow germination, whereas shallow planting should only be considered when enough moisture is available.

Discussion on establishment of groundnut fields

Inquire about the local process for establishing groundnut fields and discuss possibilities of improvement. Begin by asking the following questions:

- What time of the year do you start groundnut planting? Why?
- Do you know, how far to space groundnut plants to obtain appropriate plant density?
- What is special about seed handling, land preparation and planting of groundnut?

Other planting techniques used by farmers include:

1. **Hand hoe:** When farmers plant with the hoe, they simultaneously open a shallow planting hole using a small hand hoe held in one hand, and place the required number of seeds held in the other hand into the planting hole. Then, the sown seeds are covered with soil. This technique is mostly used when the sowing is done in a random manner.
2. **Mechanised sowing** involves sowing using a seeder mounted on a tractor or other equipment depending on availability and access to such machinery. The ridges can be pre-made, or they can be prepared in one operation by the machine when a more sophisticated machine is used. In the latter case, the machine performs ridging and sowing.

3. Field management

3.1 Weed management

Groundnut cannot compete effectively with weeds, particularly at the early stages of growth, from 3 to 6 weeks after sowing. Therefore, noxious weeds like couch grass or spear grass should be hand-sorted during land preparation to reduce competition with growing groundnut plants.

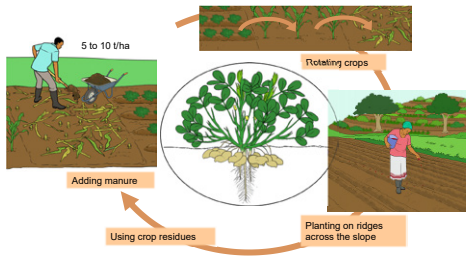
The use of herbicides is not allowed in organic production. Therefore, after groundnut establishment, organic farmers must weed at least twice during the growing season. The first weeding can be done mechanically, for example with a hoe. Once pegging begins, hand-weeding or light use of the hoe is recommended, so as not to interfere with the developing pods.

3.2 Soil fertility management

Groundnut is a legume and therefore has the natural ability to fix nitrogen from the air and soil with the help of bacteria, called *Bradyrhizobium*, in root nodules. This reduces its need for fertiliser. The amount of nitrogen that groundnut plants can accumulate in root nodules is higher than most other tropical legumes. Thanks to the nitrogen fixing bacteria, groundnut can cover about 3/4 of its nitrogen needs itself, if the bacteria is present in the soil.

SOIL FERTILITY MANAGEMENT

How to manage soil fertility in groundnuts



African Organic Agriculture Training Manual Crop Management M9: Groundnut U10 Malawi 16

NATURAL FERTILISERS

Natural fertilisers for use in organic farming

Fertiliser	Origin	Characteristics	Applications
Plant or wood ash	Burnt organic material	Rich in potassium (K) and calcium (Ca)	Add to compost (best) or around the base of the plants
Lime	Ground limestone	Buffers low pH	Apply every 2 to 3 years when soil pH is low, but avoid excessive use
Stone/ rock powder	Pulverised rock phosphate	P and trace elements (depending on the composition of the source)	Add to farmyard manure or organic waste material for composting. Mainly effective in acidic soils. For better P effectiveness, it is best to first dissolve the rock phosphate in an acidic solution such as juice from waste fruits before mixing it with the manure.

African Organic Agriculture Training Manual Crop Management M9: Groundnut U10 Malawi 17

The nitrogen does not only serve the groundnut, but also improves the yield of the crop grown after groundnut, e. g. maize. Groundnut hay or stover that remain on the field after harvest or are returned to the field after the peanut pods are harvested contains residual nitrogen in the vines, leaves and roots. These can be tilled back into the soil to decompose and naturally fertilise the field for the next crop.

The groundnut extensive root system allows the crop to effectively use fertiliser or manure applied to previous crops in the rotation. In organic production, the application of organic fertilisers is recommended not only to supply nutrients, but also to balance soil acidity, thus increasing groundnut yields, especially on infertile soils. However, it is not recommended to apply too much manure, because it promotes excessive vegetative growth of the groundnut due to the excessive N supply. It is recommended to apply between 5 to 10 t/ha of manure depending on the type and characteristics of the manure, the fertility of the soil. Additional plant needs for phosphorus can be met through use of rock phosphate products such as Minjingu phosphate rock (MPR) from northern Tanzania. To find out about possible sources of phosphate rock, farmers should contact their organic experts.

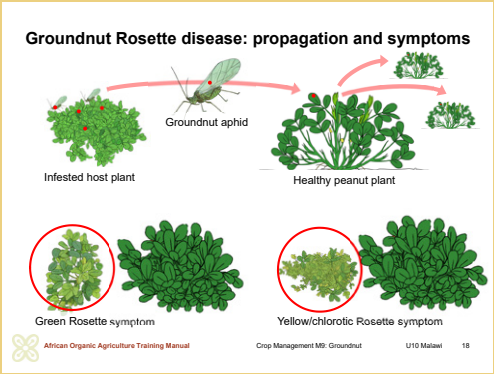
Addition of organic materials, such as compost – and to some extent also farmyard manure and crop residues – improves the water-holding capacity of the soil, thereby reducing the fungal colonisation and the accumulation of aflatoxin in the groundnut seeds. The common practice among Malawi farmers of burning crop residues exposes the soil to erosion and loss of organic matter. This practice is thus not allowed in organic production.

For further details on compost production, please see the poster and the guidance note on ' How to Make Good Quality Compost', and the Soil Fertility Module of the African Organic Agriculture Training Manual at www.organic-africa.net.

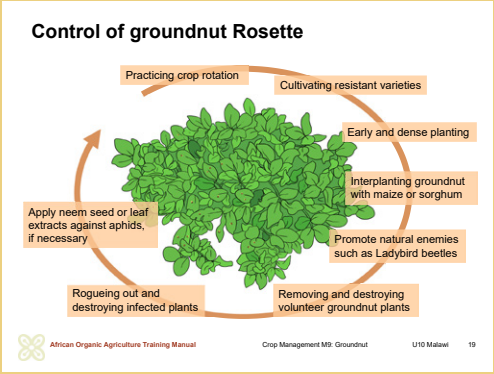
Discussion on soil fertility management in groundnut

Inquire about the participants' knowledge on soil fertility management, asking whether they have experienced or observed any decline in the fertility of their soils, and what they think are the main causes of this decline. Split the participants into small groups and invite them to discuss the availability of organic fertilisers for groundnut production. Ask the sub-groups to present their propositions, how soil fertility and nutrient supply to groundnut fields can be improved according to local conditions.

GROUNDNUT ROSETTE DISEASE



GROUNDNUT ROSETTE DISEASE MANAGEMENT



3.3 Pest and disease management during production

Several pests and diseases can cause major yield losses. Groundnut rosette and early and late leaf spot (diseases), and aphids and termites (pests) are of economic importance for groundnut production in Malawi.

3.3.1 Key groundnut diseases

Groundnut Rosette

Groundnut Rosette, also known as Kadukutu, Khate, in Chichewa and Kaligwiti, Khate in Tumbuka, is the most destructive disease of groundnut. It can cause 100 % loss of yield in severe cases, as plants affected when young may produce no nuts. If the disease occurs at flowering, yield losses are also very large.

Affected groundnut plants take on a bushy appearance due to stunting and distortion of the growing shoots. The leaves appear both as 'chlorotic' (yellow and stunted) and 'green' (green and stunted). Younger leaves may show mottling and flecking while older leaves may be small and very deep green and have inrolled margins.

The groundnut Rosette disease is common in Malawi. It is more serious during years with serious drought. The disease can spread rapidly through a crop. Groundnut Rosette is a viral disease transmitted by aphids such as the groundnut aphid (*Aphis craccivora*). The only way to control the virus once a plant is infected is to destroy the plant.

Preventive measures:

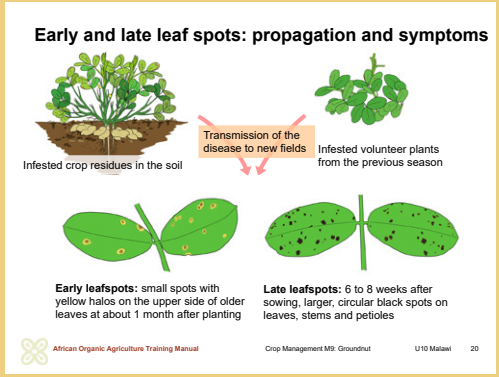
- Cultivating varieties that are resistant to the rosette disease such as *Baka*, *Chitala* and *Nsinjiro* is very effective. The *Chalimbana 2005* variety has moderate resistance.
- Early, dense planting with the first good rains helps to reduce infestations by aphids by covering the soil as quickly as possible and restricting the movement of the aphids. Late planted crops suffer heavy attacks by aphids that transmit the viral particle.
- Interplanting groundnut with other crops such as maize, beans or sorghum is effective in reducing the disease incidence as this confuses the aphids' movement.
- Rogueing and destroying infected plants by either burning or deep burying reduces further spreading of the disease.

Inquiry about common pests and diseases in groundnut production

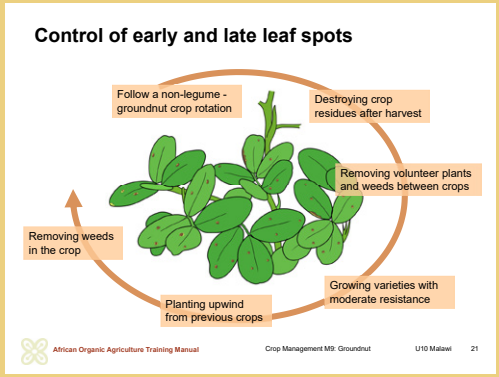
Ask the farmers the following questions to inquire about their challenges and approaches in pest and disease management:

- Which are the most important pests and diseases in your area?
- Which techniques do you use to manage these pests and diseases? Evaluate the advantages and disadvantages of different approaches.

EARLY AND LATE LEAF SPOT DISEASE



EARLY AND LATE LEAF SPOT MANAGEMENT



› Volunteer groundnut plants should be removed and burned, as they may contribute to the development of the disease in the next season.
› Neem seed or leaf extracts can be applied against aphids to limit the further spreading of the disease.

Early and late leaf spot

Late and early leaf spots are considered to be the most serious and widespread diseases of groundnut globally. In areas or situations where fungicides are not used, pod yield losses can be as high as 50 %.

At about one month after planting, small spots with yellow halos can appear on the upper side of older leaves. These are signs of early leaf spot. The spots are brown on the lower leaf surface. Between 6 to 8 weeks after sowing, larger, circular black spots appear, which are signs of late leaf spot. The spots also appear on the stems and petioles. Temperatures of 25 to 30 °C and 6 to 8 hours of high humidity are needed for infection and disease development.

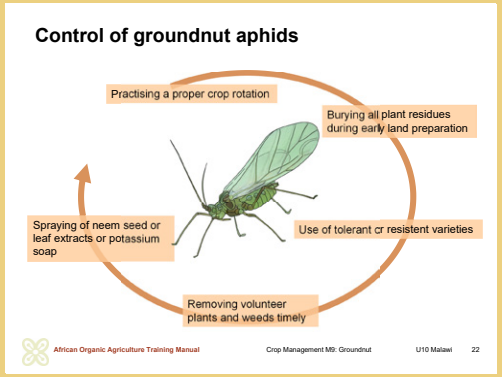
The diseases are due to largely soilborne fungi that survive mainly on crop residues in the soil and on volunteer crops that grow from the previous season.

There are a number of measures that can help prevent the disease:

› Rotation of groundnut with other crops is very important to create a distinct break in time between successive groundnut crops in a field. It reduces survival of the spores of the fungus in the soil.
› Deeply burying, burning or feeding of the residues of groundnut crops to animals after harvest reduces inoculum that may infect the new crop. Burning of crop residues in the field is though not allowed in organic farming unless necessitated by the control of serious pests or diseases.
› Volunteer groundnut plants and other host plants of the fungus should be eradicated between groundnut crops.
› Upwind planting of new groundnut crops as far away as possible from previous infected groundnut crops reduces infection of the new crop.
› Resistant or tolerant, early yielding varieties limit the negative impact of early leaf spot. *Chalimbana 2005* variety has moderate resistance to the disease.
› Removing volunteer plants and weeds reduces humidity in the crop stand and thus limits risks of infection.

Infected plants must be removed and buried deep in the soil or burned. They must not be composted, as the spores may survive in the compost and infect new crops.

APHID MANAGEMENT



Leaf rust

Leaf rust can easily be confused for leaf spot. The disease shows as orange-red pustules on the leaves, which later turn dark brown, and causes curling of leaves and defoliation. The disease is of little consequence, if it appears after the pegging and podding stage.

Like leaf spot, the fungus survives on crop residues, volunteer plants and host weeds. A proper crop rotation, removal of volunteer plants and weeds, and burying crop residues during early land preparation can significantly reduce leaf rust.

3.3.2 Key groundnut pests

Aphids

The groundnut aphid (*Aphis craccivora*) attacks and sucks sap from the tender parts of the growing groundnut plant, like leaf and flower shoots. The removal of sap by the aphids weakens the plants. This causes poor and stunted growth, leaf curling and distorted leaf growth, wilting and reduces resistance to drought conditions, all resulting in yield losses. In addition, the aphids are important vectors in the transmission of the Rosette disease virus.

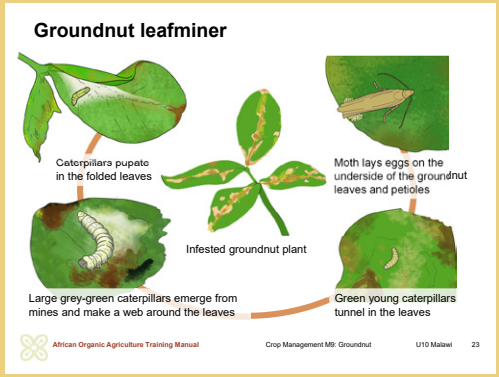
A proper crop rotation, removal of volunteer plants and weeds, intercropping, and burying crop residues during early land preparation can significantly reduce aphid infestations. Tolerant or resistent varieties can be used, if available. The promotion of natural enemies such as Ladybird beetles (*Coccinellidae*) and hoverflies (*Syrphidae*), and parasitic wasps and flies can (among others) contribute significantly to the control of aphids in groundnuts. Ladybird beetles, hoverflies, and parasitic wasps and flies can be promoted with selected flowering plants that provide pollen and nectar for the development of large populations of these natural enemies.

To limit damages on the crop by the aphids and infections with the Rosette disease in case of a heavy infestation by aphids, potassium soap, quassia extract or neem seed or leaf extracts can be sprayed. These natural pesticides have a limited negative impact on beneficial insects.

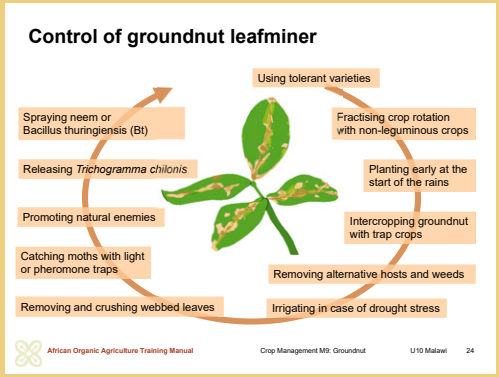
Termites

Termites can damage groundnut roots and stems, and bore holes in the pods, thereby damaging nuts. When termites damage pods, they also provide an entry point for the *Aspergillus* fungi that produce aflatoxin.

GROUNDNUT LEAFMINER



GROUNDNUT LEAFMINER CONTROL



To control termites, it is recommended to incorporate crop residues into the soil early enough. As they decompose, the residues produce a heat, which repels termites. Planting early can result in healthier and more vigorous plants, which can better tolerate termite attack. Harvesting promptly to 'escape' termite damage is another useful measure.

The use of synthetic termiticides is not allowed in organic production. In severe cases, destroying the termite mounds and removing the queen termites may be necessary. To remove the queen, it is important to seek for expert information from the local extension staff.

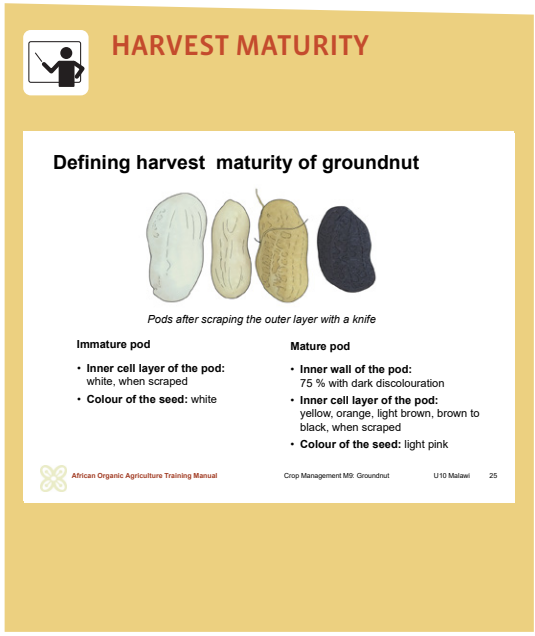
Groundnut leafminer

The groundnut leafminer moth (*Aproaerema modicella*) can reach epidemic densities and create severe yield losses in Malawi. The mottled moth lays eggs on the underside of the groundnut leaf and petioles. Yellowish green caterpillars hatch, tunnel into the leaves and feed between the upper and lower epidermis of the leaf. Mined leaves become distorted within a few days. When the grey-green caterpillars with a shiny black head emerge from their mines, they make a web around the leaves. Pupation takes place inside the webbed leaflets. Damaged leaves become brownish, rolled and dry. Severe cases of leafminer damage look like the crop has been burnt.

The pest can be managed using resistant varieties. However, practicing crop rotation with non-leguminous crops such as maize and sorghum reduces the leaf miner population. Further preventive measures are planting early at the start of the rains to avoid the pest build-up, intercropping groundnut with trap crops such as pearl millet and cowpea, and practicing a proper crop rotation. Removal of the alternative hosts and weeds (i.e. amaranthus, hyacinth bean (lablab), mung beans, and *Indigofera hirsuta*) four weeks after planting and at least two times later when weeds are seen, reduces the leafminer population.

Drought stressed plants are much more susceptible to leafminer attack than plants that have adequate moisture. Therefore, avoiding drought stress by irrigating or early sowing the crop to take advantage of the full season rains reduces damages by the groundnut leafminer.

Removing and crushing webbed leaves, in which the green larvae hide, reduces damages on the crop and limits further multiplication of the pest. Light, sticky or pheromone traps can be used to attract and catch the adult moths and to monitor the pest populations.



The moth can be controlled biologically by promoting natural enemies like Ladybird beetles, releasing *Trichogramma chilonis* at 50'000 per ha twice in a 7 to 10 day interval, and spraying neem or *Bacillus thuringiensis* (Bt) to control the larvae.

4. Management at harvest and post-harvest

Farmers commonly invest a lot of effort in maize production and pay less attention to groundnut production. Groundnut requires a lot of labour especially during and after the time of harvesting. In order to minimise losses and avoid contamination from extraneous materials and agents, proper harvesting methods and appropriate storage are required.

4.1 Timely harvesting

Harvesting is a critical operation in groundnuts production. It is important to harvest groundnut at the right time, when the crop is mature (90 to 140 days after sowing depending on the variety). Premature or delayed harvest can result in great losses. The crop does not mature evenly, and the seeds on a plant will be at different stages of maturity. Therefore, it can be difficult to determine exactly when to harvest.

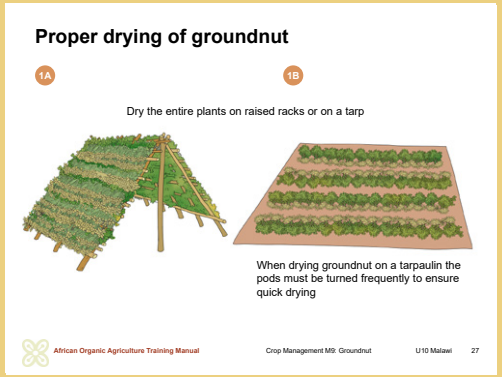
Diseases can have an influence on the determination of the harvest date. For example, groundnut plants that have been infested heavily by leaf spot diseases should be harvested early. In case of heavy drought, the groundnuts must be harvested immediately, when the plants wither and the seeds in the pods begin to shrivel. Prevailing or announced wet weather conditions can also result in an early harvest, as wet weather reduces seed quality.

In order to determine the best harvest date, the farmer must scout his/her groundnut crops regularly. As the number of days to maturity varies with cultivars, harvest maturity must be determined based on some characteristics that require special observation:

› Colour of the inner wall of the pod: When the inner tissue of 75 % of the pods of the sample plants have a dark-brown colour and the kernels are plump.

HARVESTING TECHNIQUE

DRYING



- **Colour of the outer wall of the pod**: 70 to 80 % of the outer wall of the pods should have an orange, light brown or black colour, when scraped with a knife. If the outer wall is white, the seed is still immature.
- **Seed colour**: Young, immature seed is usually white in colour. Mature seeds have a pink and dull pink colour.
- **Leaves**: The leaves of plants with mature seeds develop a yellow colour and are dry at the tips.

Groundnut seeds are protected by a shell, which acts as an excellent natural barrier against damage. However, when farmers wait too long before they start harvesting (usually until all leaves are dry), the pods are exposed to attack by rodents and insects, and aflatoxin contamination.

4.2 Harvesting technique

Groundnut is usually harvested with a hoe by digging out the pods from the ground rather than hand pulling. Harvesting is easier when groundnut is planted on ridges. The ridges are then levelled, and the pods are picked from the soil still attached to the plants. Care should be taken to maintain the pod shells intact during harvesting.

4.3 Proper drying

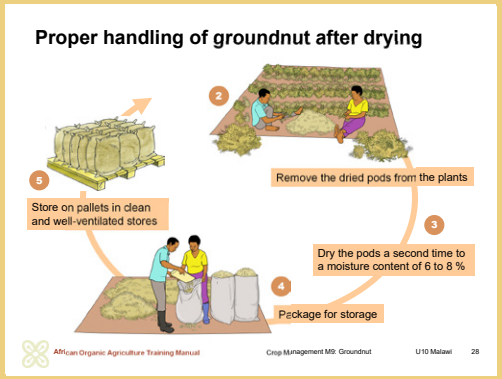
Immediately after harvest, the pods should be properly dried under the sun before being shelled. It is recommended to quickly expose the harvested groundnuts directly to the sun or a solar dryer in order to avoid moisture absorption, which supports fungal growth and ultimately aflatoxin contamination. However, lengthy exposure of pods to the sun can reduce both kernel quality and seed germination. Solar drying should not be carried out on the bare ground or rooftop to avoid absorption of moisture.

Ideally, drying should be done on a cemented floor, on mats or tarpaulins, on a raised structure like cribs or on specially constructed drying sheds (A-frame). A clean underlay prevents the drying pods from picking up dirt and insects also. The same places and materials (e.g. mats) may not be used to dry both conven-

Discussion on post-harvest handling of groundnuts

In a brainstorming session, write down the step-by-step groundnut handling process from the field to storage. Ask the participants to identify practical strategies for handling groundnuts to avoid wastage and damage at each step of the process.

HANDLING AFTER DRYING



tional and organic groundnuts. The use of the Mandela Corks for drying is preferred for its ability to minimise the exposure of the drying groundnuts to the direct sun. The Mandela Corks, to be staked on a raised platform, provide good ventilation to the drying groundnuts due to the good air circulation facilitated by the hollow space left in the middle of the staked Corks.

Drying should be continued until the moisture content is reduced to 6 to 8 %, that is when seeds rattle inside the pods and are brittle upon biting. Frequent turning of the pods ensures quicker drying. Rattling of seeds inside the pods and brittleness of seeds upon biting are good indicators of dry pods. If the pods are not well-dried, they will attract mould.

If available, an oilseeds grain moisture meter can be used to measure the moisture content of the groundnuts for best results. Farmers can ask their extension officers where to access a suitable moisture meter. The extension staff can also provide the farmers with tips on how to determine the proper dryness of the nuts.

4.4 Proper storage

After drying, groundnut pods should be plucked off the stems and roots, and stored in a clean and well-ventilated storage area, free from rodent attack. Traditionally, farmers store shelled groundnut seeds, because they are less bulky. It is, however, recommended to store groundnut in pods to minimise damage.

The dried pods can be stored in metallic silos or packed in sacks (bags with perforations) and stored well on pallets in clean and well ventilated stores (20 to 25 °C). Under such conditions, pods can be stored up to two years without any significant reduction in quantity and quality. Before any fumigants are used in the store for organic products, the certification body needs to approve it first.

4.5 Proper shelling

Shelling of the pods should be done immediately before selling, planting or preparation for household consumption. The storage life of groundnut seeds outside the shell is short and the quality reduces rapidly after shelling.

When shelling the pods for selling, minimise damage to the seeds as broken seeds are rejected by both local and export markets. Hand shelling is labour-intensive, but most recommended for small quantities or when shelling seed for planting, as it minimises damage to the seed. Mechanical shellers can be used for large quantities.

After shelling, the seeds should be cleaned by removing any dirt and foreign matter, and small, discoloured, shrivelled and damaged seeds. Depending on the market requirements, sorting into different sizes will be done before delivering the grains to the market.

The cleaned shelled grains are then packed in sacks (depending on customer requirements). When packed in sacks, the risk of damage is very high. Therefore, the packed groundnut grains should be immediately delivered to the market to avoid incurring losses.

4.6 Management of storage groundnut pests

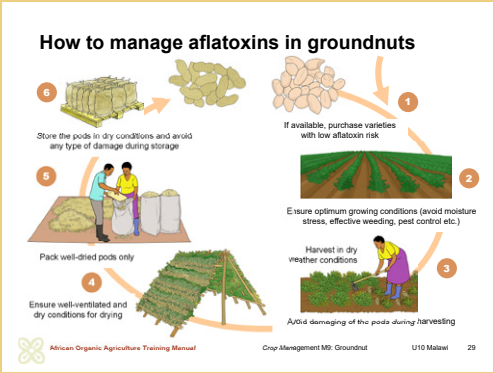
Post-harvest handling of groundnut (drying, threshing and cleaning) has significant influence on insect behaviour and establishment in the store. Immature and damaged pods are more susceptible to insect pests than mature and undamaged pods.

Groundnuts can be attacked by insect pests both as unshelled pods and as kernels (shelled). Though most of the insect pests attack kernels, as they are more susceptible than pods, groundnut bruchid (*Caryedon serratus*) infests unshelled nuts. However, the amount of damage depends on several factors such as moisture content in the nuts, the form in which the product is stored, level of maturity at harvest, sanitation of storage space and the quality of the material itself, as well as protective measures such as pest repellents applied to the stored groundnuts.

Groundnut bruchid

The adult female lays eggs on the pod shells. The hatched larvae burrow through the pods and start eating the kernels. No damage can be seen at this stage unless one searches carefully. The first sign of attack is the appearance of 'windows' (approximately 3 mm in diameter) made on the pod wall by the grub to allow the adult to leave the pod. Each larva feeds solely within a single kernel. Larval devel-

MANAGEMENT OF AFLATOXIN IN GROUNDNUTS



opment is completed in 40 to 45 days, and the pupal stage lasts for about 15 days. Sometimes, the grown-up larvae leave the pod and pupate at the bottom of the sacks. By this stage, the groundnut seeds are badly damaged and are unfit for use.

Regular monitoring is very important (like once in a fortnight) to determine pest infestation of harvested groundnut in the store so that remedial measures can be taken as soon as infestation is noticed. The presence of webbing represents the damage caused by larvae, while absence of webbing and the presence of powdery remnants represent damage by adult insects.

5. Management of aflatoxins in the field and in post-harvest

5.1 Aflatoxins, a key problem in groundnut production

Aflatoxin contamination is considered as one of the most widespread groundnut quality challenges in Malawi as in many other groundnut producing countries. Aflatoxin is a poison produced by the *Aspergillus flavus* fungus. In Malawi, it is commonly called 'Chuku'. Chronic exposure to aflatoxins, even at low doses, leads to malnutrition, child stunting, and damage to the liver and suppression to the immune system. Continuous exposure to or consumption of high quantities of contaminated groundnut can cause can cause liver cancer or death to humans and animals.

Aflatoxin is of particular concern, as it can not only contaminate groundnuts, but also other oilseed crops such as soybean and sunflower, cereals such as maize, sorghum, pearl millet, rice and wheat, and other crops like spices and tree nuts. Milk from livestock, which have been fed with or eaten aflatoxin contaminated feeds, is also affected.

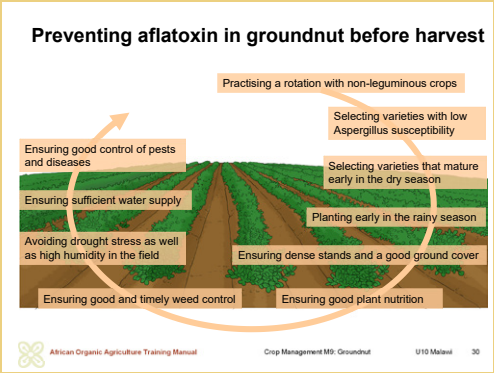
Economically, aflatoxins reduce the quantities of marketable and edible groundnuts (or other affected crops). Contaminated groundnuts and other food and feed products cannot be exported for human safety reasons. Malawi loses up to 40 % of its export groundnuts due to aflatoxins every year causing significant incomes losses to farmers.

The maximum permissible limit for aflatoxin in foods for human consumption of the European Commission is at 4 to 30 parts per billion (ppb), dependent on the country. As aflatoxins cannot be destroyed by cooking the groundnuts, prevention of contamination is of highest importance.

Discussion on management of aflatoxins in groundnuts

In a brainstorming session, write down the causes of aflatoxins from the field to storage. Ask the participants to identify practical strategies for avoiding aflatoxin infections at each step of the process.

PRE-HARVEST MANAGEMENT FOR AFLATOXIN PREVENTION



Groundnut can be infected by the aflatoxin causing fungi at different stages of production. The contamination can start during plant growth (pre-harvest stage), or during harvest or after harvest and during processing (post-harvest). Both biological (biotic) and environmental (abiotic) factors contribute to aflatoxin contamination. Prolonged dry spells during initial crop growth stages in addition to poor harvesting and drying procedures can lead to severe aflatoxin contamination. When the following factors are effectively managed, mould growth and aflatoxin production in groundnut can be substantially reduced:

5.2 Factors contributing to pre-harvest groundnut infection and recommended management practices

Infection before harvest is largely influenced by the farming practices.

Cultivar / variety

Different groundnut varieties have different susceptibilities to contamination by Aflatoxin. The greater the stress of the plants in the field due to exposure to heat, dryness or infestation with insects, the more susceptible to aflatoxin contamination they are. Therefore, groundnut varieties that are drought tolerant are more resistant to the fungal infestation. The length of the growing period of the selected cultivar is also an important property, when it comes to Aflatoxin-resistance. With rains from October to the end of April in Malawi, long-duration groundnut cultivars are harvested under dry conditions. These dry conditions favour rapid post-harvest drying of the pods, thus reducing the opportunity for seed invasion by Aflatoxin producing fungi. In addition, breeding for aflatoxin-resistance is on-going. For example, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is developing breeding lines that are high yielding and having low susceptibility to aflatoxin.

Weather conditions and supplementary irrigation

High temperatures and drought stress are common factors that contribute to aflatoxin contamination.

› Typically, the optimum conditions for aflatoxin production are between 25 °C and 30 °C at 85 % relative humidity. Excessive moisture weakens the pods and testas providing entry points for fungal infections.

- On the other hand, drought stress in the field has the same effect as high humidity, as it damages the pods and testas. Irrigated crops have been reported to have less Aflatoxin infected kernels than crops grown without irrigation. Early maturing varieties are desirable to reduce aflatoxin contamination in drought-prone areas.

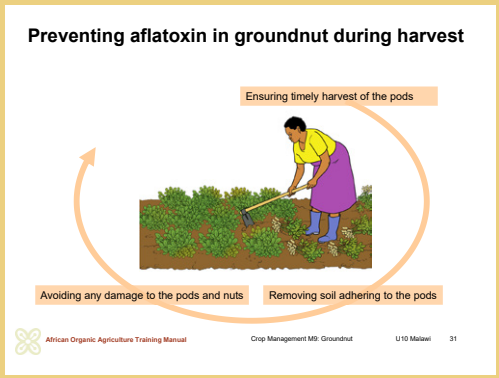
Agricultural practices during growth

Improper agricultural practices can also increase the incidence of the aflatoxin producing fungi and aflatoxin contamination in groundnut.

- **Timing of planting:** Early planting is recommended to avoid end-of-season droughts, which can cause stress and cracking to the groundnuts and expose the pods and kernels to infection and contamination. However, planting too early can expose the crops to contamination due to possible erratic rains at the beginning of the season. On the other hand, late planted groundnuts are usually more susceptible as they are affected by termites or other pests and the end-of season droughts. Any damage to the pods or nuts provides an easy entry point to the Aflatoxin-causing fungi.
- **Poor plant density:** A good ground cover helps to protect the soil from erosion, evaporation and destruction of the soil structure. Poor ground cover and low plant densities promote increased contamination.
- **Lack of, or poor crop rotation:** The repeated cultivation of groundnuts or susceptible (host) plants/crops on the same field promotes the rapid increase in the populations of the aflatoxin producing types of *Aspergillus*. The high populations can ultimately lead to pre-harvest contamination. A good crop rotation may lower the rate of between-season survival of different species/strains of the fungus, especially if it involves crops that are non-host to the *Aspergillus* species. However, other management practices have to be favourable too, to reduce stress on the crop and reduce aflatoxin production.
- **Poor moisture/water management and irrigation practices:** During crop growth, conditions of moisture stress will favour fungal infection and subsequent aflatoxin contamination. When exposed to stressful drought conditions, the groundnut pods crack thereby providing easy access by the fungus to the enclosed grains.

  As the majority of smallholder farmers have no access to supplementary irrigation and produce their groundnuts under rain-fed conditions, techniques of infield water harvesting and soil moisture retention and conservation can

AFLATOXIN PREVENTION AT HARVEST



help to reduce the risk of aflatoxin contamination. Farmers can plant on ridges, especially in sloping areas, to improve water retention and infiltration into the soil. The ridges must be constructed early in the season in order to retain as much rainwater as possible in their fields and reduce any run-off.
If available, and if the risk of termites is low, mulching can also be used to reduce water evaporation from the soil.

- **Poor weeding, field sanitation and termite attack:** A field with poor hygiene attracts termites, which in turn cause damage to the pods and hence increases contamination of the nuts in the ground. Good and timely weed control is therefore crucial in limiting the activities of termites. Timely weeding also helps to retain soil moisture, which promotes proper plant growth and reduces the risk of dry conditions that predisposes developing pods to cracking. In addition, fields which are known to host termites should be avoided, as the chances of damage and subsequent aflatoxin contamination are high.
- **Soil amendments and fertilisation practices:** Good plant growth leads to strong pod shells, which resist infection and offer protection to the kernels. Groundnut shells require good amounts of minerals such as calcium. For example, if farmyard manure is applied in groundnut production and lime is added, then fungus infestation can be reduced by around 80 per cent. On the other side, any growth characteristics which weaken the pod shells increase vulnerability of the pods and kernels to infection and thus contamination.

5.3 Factors contributing to aflatoxin contamination during harvest and recommended management practices

Harvest operations and conditions have implications on aflatoxin predisposition and contamination in groundnut. Factors, which favour infection by the Aflatoxin-causing fungus, include:

- **Premature harvesting of the pods:** When pods are harvested prematurely, they are more susceptible to fungal infections. The high moisture content of prematurely harvested pods and nuts promotes fungal development after harvest and poor drying (for more information see section on harvest timing).
- **Improper harvesting techniques:** Soil adhering to the pods contains *Aspergillus* fungi and is a source of infection. Any damage caused to the pods and nuts during harvest favours fungal infection and contamination by aflatoxins.

POST-HARVEST MANAGEMENT FOR AFLATOXIN PREVENTION

Smallholder farmers usually harvest groundnuts by pulling the plants or by digging out the plants with hoes. Some pods and nuts can become damaged with these methods, hence providing easy access by the *Aspergillus* fungi. Infection occurring at harvest will aggravate contamination during the post-harvest stage of groundnut.

5.4 Factors contributing to post-harvest groundnut infection and contamination and recommended management practices

Mechanical damage to groundnut pods renders them easily vulnerable to storage moulds. Cracks and breaks in grains are caused mainly during harvesting and shelling, but insect, bird or rodent damage also cause the same effect. Typically, farmers leave the harvested pods and haulms on the field for a longer period to dry while others directly dry the pods on the ground. Especially when rains persist during the harvesting season, the drying process will be slow, making it difficult to achieve the recommended moisture level for safe storage.

Instead of stripping pods from the plant, which can easily lead to contamination by aflatoxin causing fungi during drying, groundnuts should be slow-dried in the field in ventilated stacks, which allow for air movement in the interior of the stack. Care should be taken to prevent or minimise infection and contamination during the post-harvest stage.

The key conditions that promote infection by *Aspergillus* and contamination by aflatoxins during the post-harvest stage include the following:

- **Unsuitable curing and drying practices:** The practice of drying the pods on exposed ground, floors and rooftops renders the pods and grains liable to rains and moisture, a favourable factor for fungal growth. Over-dried pods can crack easily and expose the grains to mold infection. The groundnuts should be protected from rain and/or moisture during drying. Furthermore, over-dried grains/kernels crack easily and expose the grains to infection and contamination.
- **Poor pod stripping:** During separation of the pods from the haulms, any adhering soil will continue to be a source of fungal infection, and hence should be removed from the pods to minimise risks during subsequent storage.
- **Improper shelling of the pods:** Threshing of the groundnuts in a sack will render damage to the pods and grains. Some farmers sprinkle water on the pods

to soften the shells as a way of making shelling easier. However, this water will provide a conduce environment to the fungus and promotes its growth. Similarly, when farmers sprinkle some water on the dried kernels to improve their weight for marketing purposes also leads to infection and contamination. Shelling practices, which render wounds or other forms of damage and increase exposure of the pods and kernels to fungal infections, should be avoided.

- **Lack of or poor sorting of nuts:** Farmers should remember that any damaged kernels can be a source of infection to other nuts and should be removed before storage. Only the healthy grains should be selected for storage. All broken, cracked and shrivelled grains ought to be removed before storage.
- **High moisture content:** The moisture level of the groundnuts at any stage during the value chain strongly determines, whether aflatoxins will develop in groundnuts after harvest. The *Aspergillus* fungus will only grow when the moisture content of the nuts exceeds 9 % and 80 to 85 % relative humidity of the air. Exposure of the kernels to winter rains and high humidity during the night will promote fungal growth. High temperatures should also be avoided by promoting good air circulation in the storage structures.
- **Use of unsuitable storage containers:** The storage containers should protect the pods and/or kernels from moisture and pests. Nylon bags offer better protection compared to e.g. hessian bags. Airtight storage containers also reduce exposure to moisture and pests.
- **Poor pest control during storage:** Insects and mites may damage stored grain, but they also carry fungal spores. Insects can attack growing crops. Because of the insect damage, fungus infect the grains prior to harvest or during harvesting and storage. During storage, insects, due to their metabolic heat and water, can increase the water activity and temperature of grain to levels suitable for fungal growth.
- **Poor storage structures:** Storage structures commonly used by most small-scale farmers in Malawi are traditional. They may not maintain an even, cool and dry internal atmosphere, not provide adequate protection from insects and rodents, not be easy to clean and above all, not be waterproof. All these conditions favour mould growth and aflatoxin production.
- **Poor transportation conditions:** Contaminated vehicles, wheelbarrows, scotch-carts, etc. can transfer the contamination to the grains during transportation from the field or to the markets. Good hygiene must be observed at

all times. If open transport types (e.g. open trucks) are to be used, care should be taken to ensure that the grains are transported when there is no risk of rains.

6. Organic certification and marketing

Although a large quantity of groundnut is produced for household consumption and domestic markets, there is growing interest in organic certified groundnut on export markets, especially in the EU and the USA. For marketing and labelling groundnuts and other agricultural products as organic, the products must be certified.

6.1 Organic certification

Certification is the process by which the inspection and certification body (CB) gives a written and reliably confirmed assurance that the products have been manufactured in accordance with a specific organic standard. Certification is crucial to building confidence among processors, distributors and consumers.

In Europe, the legal basis of organic agriculture are the EC Council Regulations 834/2007 and 899/2008, in the USA organic agriculture is regulated in the National Organic Program Regulation (NOP). These regulations define the rules for organic production, processing and labelling of agricultural products. Farmers in Malawi that wish to export organic products to the EU must comply with the European Regulation. For Export to the USA the NOP Standard must be respected.

In some cases markets ask for additional certification against private organic standards such as Naturland, Demeter or Bio Suisse. The standards from private label organisations are stricter than the EU or NOP regulations. Whereas the EU regulation permits organic farming of individual farm units, most private organic label organisations require that the entire farm must be managed organically. Organic production on part of a farm only, while the rest of the farm is still managed conventionally, involves risks of chemical residues on organic products and commingling of organically and conventionally produced products. Most private label organisations prohibit partial conversion of a farm. In the EU regulation partial conversion is subject to special restrictions and constraints.

Generally, for small farms, only conversion of the entire farm is recommended, as the farm unit would become too small to enable establishment of a diverse production system, allow proper crop rotation and introduction of livestock. Parallel production, i.e. the production of the same crop under organic and non-organic management, is not allowed even under the EU Regulation.

The certification process starts with signing a contract with an organic certification body operating in the country. The conversion begins once the farmer renounces the use of synthetic pesticides, fertilisers and GMO or treated seeds. The conversion period is accomplished after 2 years for annual crops and after 3 years for deciduous crops. Land that has not been treated with forbidden substances for at least 3 years can be certified with a reduced conversion period. Once the conversion period is finished, the products can be certified and sold as organic. A stepwise reduction of agrochemical use is not considered part of the conversion period.

Farmers in Malawi should first consult the national organic movement and then sign a certification contract with an accredited organic certification body operating within the country. Producers should work with a certification organisation that has the necessary accreditations for the required standard and target markets.

Organic certification commonly happens through inspection and certification of an individual farm by an accredited certification body. Also farmers can be certified as a group. Internal inspection for each farm in the group is then carried out by members of the group with the help of an Internal Control System (ICS). In the case of group certification, the certification body does not inspect all individual farmers of the group, but assesses the performance of the ICS and inspects only a small, but representative number of the farms. To determine the minimum number of farms to be inspected by the certification body, the square root of the total number of farms in a group is calculated, e. g. if the total number of farms is 100, then only 10 farms will be selected for inspection by the certification body. The selection of actual farms to be visited for the inspection takes into consideration the prevailing situation, e.g. proximity to contamination sites, physical location, and the potential influence from other external factors. For the inspection, the certification body assesses the functionality of the ICS and checks each selected farm using an existing inspection checklist.

Like all other organic products, organic certification for groundnut is worthwhile only if the groundnut can be marketed with an organic price premium over the regular price. The premium must at least cover the certification costs and the major costs caused by organic management. Ideally, most or all the crops from the certified farms are marketed with an organic premium. In the case of exporting a crop such as groundnut, the farmers need to work together in a group to produce enough volume and to ensure the quality and quantity requirements of the target market.

Having completed the formal conversion period and received organic certification does not mean that the development of the farm is finished. It usually takes several years to establish a well-balanced farm ecosystem and restore natural soil fertility in the sense of organic farming.

Aflasafe – biocontrol of Aflatoxins

Aflasafe is a biofungicide reported to significantly reduce pre-harvest aflatoxin contamination in groundnuts, maize and other crops by 80 to 90 per cent. Aflasafe was developed by the International Institute of Tropical Agriculture (IITA). Protection lasts beyond harvesting, which means that the crop will also be safe when stored. Following its successful commercial application in many sub-saharan countries, the Aflasafe MWMZ01 and Aflasafe MW02 have been tested and now cleared for release by the Agricultural Technical Clearing Committee (ATCC) in Malawi.

Aflasafe is listed as a permitted organic product in the Organic Materials Review Institute (OMRI) as «Organic *Aspergillus flavus* AF36 Prevail» for use as a pest lure, repellent, or as part of a trap, or as a disease control. It may be used for other pesticidal purposes, if the requirements of 205.206(e) are met, which requires the use of preventive, mechanical, physical, and other pest, weed, and disease management practices.

The current listing from 28 May 2018 expires on 01 June 2020. The details of the listing can be found at: https://www.omri.org/acj-12443. Before using Aflasafe in organic management, producers should always check/consult their certification body or advisors, if the product can be used under the national and/or the importing country's legislation whichever maybe applicable based on the target markets. Like any other organic inputs, the producers should also check, if such a product is still holding a valid and not expired listing or registration.

How does Aflasafe work?

The active ingredients of Aflasafe are native strains of *Aspergillus flavus* that do not produce aflatoxins, but out-compete the aflatoxin-producing strains so that crops become less contaminated. Spores of these strains are coated on to a grain carrier (e. g. sorghum) using a polymer sticker. When applied, Aflasafe non-poisonous strains grow rapidly on the grain carrier, which serves as their food. They produce spores and colonise organic matter in the field before moving to the target crops. This will prevent the aflatoxin-producing strains from colonising the groundnuts.

How to use Aflasafe

Apply Aflasafe in groundnut fields 30 to 45 days after planting, regardless of whether groundnuts are cultivated as monocrop or are intercropped with other crops. Application of Aflasafe when groundnut plants have already flowered will not be effective in reducing aflatoxin accumulation. Before Aflasafe application, ensure that all agronomic practices (weeding, last fertiliser application, etc.) have been completed.

Ensure that Aflasafe is distributed uniformly in the field during application: broadcast the grains at the rate of 4 kg per acre. The beneficial strains of Aflasafe require moisture to grow, therefore apply Aflasafe after rains, when rains are expected or when the soil is wet.

Note: For certified organic production of groundnut, farmers need specific approval by the applicable certification body. It is therefore advisable that organic farmers inform their respective certification bodies before Aflasafe is applied to their fields.

More information about the product can be obtained from www.aflasafe.com

6.2 Marketing

One of the key motivations driving farmers to convert to organic farming is the ability to access niche markets for their produce or products. Even under subsistence farming, with adequate quantities of groundnut production, farmers should consider exploring market opportunities to sell the excess production to improve their incomes to meet other household needs. Before deciding on the market to target, if not already provided by the agents promoting organic farming, it is important to understand the requirements of that market in terms of the following aspects:

- The type of customers and their product requirements,
- The key actors, especially existing and potential competitors,
- Information about delivery channels and cost of delivery,
- Information about price offers and any premiums,
- Bulking, storage and packaging requirements,
- The required quantities, timeliness and consistence in delivery,
- Quality requirements (varieties, etc.), particularly aflatoxin contamination limits,
- Whether organic certification is required and for which standards,
- Any value addition required to the products.

For more information on marketing of organic products, for example...

- where to find relevant information about market opportunities, prices and quality requirements,
- how the organic market chain is organised,
- how to identify and take advantage of organic market opportunities,
- how to identify market expectations in terms of quality, standards and know-how to cope with these standards,
- how to assess the market potential of organic products,
- how to develop a marketing concept, define a marketing strategy and apply marketing techniques,
- how to promote organic market development beyond individual businesses,
- how to determine usefulness of organic certification, and how to get access to it,

see the training materials related to marketing at www.organic-africa.net, including a trainer's module, a booklet and a video.

Group discussion on marketing of groundnut

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

- Which markets demand organic groundnuts?
- What are the requirements of those markets?
- How can interested farmers be supported to join those markets?

Recommended literature for further reading

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