SUSTAINABLE ORGANIC AGRICULTURE MANUAL

KCOA
Knowledge Centre for Organic Agriculture and Agroecology in Africa

KHSA
Knowledge Hub for Organic Agriculture and Agroecology in Southern Africa

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

In cooperation with

Kasisi Agricultural Training Centre

About the Sustainable Organic Agriculture Manual

Kasisi Agriculture Training Centre (KATC) is an in-country partner of the Knowledge Hub for Organic Agriculture and Agroecology in Southern Africa (KHSA). KHSA is part of the Knowledge Centre for Organic Agriculture in Africa (KCOA), a collaborative country-led partnership funded by the German Federal Ministry of Economic Cooperation and Development (BMZ) and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and non-governmental organisations across Africa. The KCOA aims to scale up the adoption of agroecological and organic farming practices through five knowledge hubs in Africa. The other hubs are implemented by GIZ with in-country partners in North, West, East and Central Africa.

The South African-based Sustainability Institute supports project implementation in southern Africa. Activities are focused in Zambia, led by Participatory Ecological Land Use Management (PELUM) Zambia and KATC; in Namibia led by the Namibia Nature Foundation in collaboration with the Namibian Organic Association; and in South Africa led by the South African Organic Sector Organisation and Participatory Guarantee System South Africa; and in Malawi by Soils, Food and Healthy Communities and the Kusamala Institute of Agriculture and Ecology.

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Acronyms

AE Agroecology
CM Centimetre
CO_2 Carbon dioxide
G Gram
KATC Kasisi Agricultural Training Centre
KCOA Knowledge Centre for Organic Agriculture and Agroecology in Africa
KG Kilogram
KHSA Knowledge Hub for Organic Agriculture and Agroecology in Africa
MSP Multiplier Support Programme
OA Organic agriculture
SI Sustainability Institute
SOA Sustainable organic agriculture

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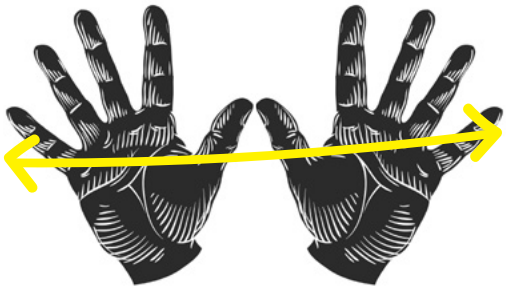
Approximate measures

5cm
Three fingers together

10cm
The full hand with fingers together from the thumb to the other side of the palm of the hand

20cm
Distance between the smallest finger (pinky finger) and thumb when they are fully splayed

30cm
One hand with fingers together next to one hand with pinky finger and thumb splayed



40cm
Two hands next to each fully splay from the pinky finger to the thumb

Glossary

Aerobic decomposition: This is when organic material is broken down in the presence of oxygen. This is a process in which living organisms that require oxygen to survive break down organic matter.

Agroecology: Agroecology is an approach to farming that considers ecological, social and economic factors. It uses farming practices that do not harm the environment, that save water, that build soil health and that produce a diversity of foods. The 10 elements of agroecology are diversity, co-creation and sharing of knowledge, synergies, efficiency, recycling, resilience, human and social values, culture and food traditions, responsible governance, and circular and solidarity economy (Sustainability Institute [SI], 2023:4).

Biodiversity: Biodiversity is all living things. It includes us, plants, trees, animals, insects, micro-organisms (see micro-organisms) and the places in which we live (ecosystems) (SI, 2023:5).

Biofertiliser: Biofertilisers are fertilisers made from natural formulations without any chemical input. They contain micro-organisms (living things in soil and plants that can't be seen with your eyes) that help to make the soil fertile by 'fixing' nitrogen in the soil. Plants access the nitrogen and use it to grow strong (SI, 2023:5).

Biomass: Biomass is any dead plant, tree and animal matter that can be burnt to cook food or provide warmth and to make compost. This material will break down over time to add to the soil. These 'dead' plants, trees and animal matter still have 'stored' energy that can be released through burning, composting or breaking down naturally into the soil (SI, 2023:5).

Climate change: Climate change refers to change over time (more than 20 years) in rainfall patterns (it rains less or more than in previous years or it rains at different times); change in average temperatures (it is hotter or colder or it becomes hotter or colder sooner or later than in previous years); and changes in how many and how severe extreme events are (droughts, floods, hailstorms, cyclones, etc.) (SI, 2023:5).

Climate change adaptation: Climate change adaption means changing the way that we do things to survive in a different climate. For example, in situations where there is less rainfall or it doesn't come at the right time, when the temperatures are higher for longer periods of time, or when there are more droughts and floods. For farmers, it means changing/adapting the methods used to farm, what crops are grown and eaten and what animals are raised and how they are fed to support ongoing food production (SI, 2023:4).

Climate change mitigation: Mitigation is the attempt to slow down and stop the volume of greenhouse gases being generated by people's activities. For example, the burning of coal for energy or of oil for transport generates greenhouse gases, as does the manufacturing of manmade fertilisers. There are parts of the Earth that store greenhouse gases naturally – the ocean, soils and forests. When these are polluted or degraded or destroyed, we lose the ability to store greenhouse gases. Mitigation therefore is about stopping the sources of greenhouse gases and it is about protecting the places that store them – these are called sinks (SI, 2023:9).

Ecology: Ecology is the study of how life on Earth interacts, including how we relate to our environment and to all life in it (plants, animals, insects, etc.) (SI, 2023:6).

Ecosystem: The ecosystem is all the living things around us (plants, trees, animals, insects, organisms, etc. and the relationships they have with each other and with the soil, water and air. An ecosystem contains many living things. It can be small like our gardens or very big like the ocean (SI, 2023:6).

Macro-nutrients: These are mineral elements that plants need in large quantities to be strong and healthy. These are nitrogen, phosphorus, potassium, calcium, magnesium and sulphur.

Micro-nutrients: These are the mineral elements that plants need in small quantities to be strong and healthy. These include boron, chlorine, cobalt, copper, iron, manganese, molybdenum, nickel and zinc. Plants get most of their macro and micro-nutrients from the soil.

Micro-organisms: Micro-organisms are tiny living things (like bacteria or viruses) that you can't see with your eyes, only with a microscope. They can be simple microbes with only one cell, or they can cluster together to make a more complex microbe (SI, 2023:6).

On-farm nutrient recycling: The use of on-farm resources to make natural fertilisers and pest and disease control products, among other soil health preparations.

Organic matter: Organic matter is all living or once-living things. Examples are plants and dead plants, animals and dead animals, leaves, plant roots, mulch, etc. When these things break down, they release nutrients back into the environment. Soil needs lots of organic matter for it to stay fertile and healthy (SI, 2023:10).

Organisms: Organisms are the small animals and insects that can be seen with the eyes (e.g., earthworms, spiders, mites, millipedes, spring tail, slater) and other living things (e.g., fungi and bacteria) in the soil that are too small to see with the eyes. They break down organic matter into humus and allow water to move through the soil (Namibian Organic Association & Namibia Nature Foundation, 2023)

Pest-predator balance: This refers to maintaining the population of creatures such as birds, frogs and insects, like spiders, lady birds, parasitic wasps, so that there are enough of them to manage pest problems by eating the pests.

Soil fertility: Fertile soil supports the growth of healthy, strong plants. For soil to be fertile, it needs nutrients (like calcium, nitrogen and potassium) and a 'safe' environment in which it is not over-exposed to wind and water or overly disturbed by tilling and human activity (SI, 2023:11).

Soil organic carbon: This is the carbon that remains in the soil after organic material has decomposed.

Sustainable organic agriculture: Is a term that refers to agricultural production systems that take a holistic approach to farming and that which to aim to benefit people and animals, while protecting the environment, water systems and biodiversity.

Transpiration: Evaporation of water from the plant, leaves and stem, into the air.

1. OVERVIEW

Kasisi Agricultural Training Center (KATC) in conjunction with the Knowledge Hub for Organic Agriculture and Agroecology in Southern Africa (KHSA) has been working with multipliers in Zambia's Eastern province to implement the GIZ-funded Multiplier Support Programme (MSP). A multiplier in the context of this project refers to any person, group, organisation or institution that shares/disseminates organic and agroecological agricultural knowledge and practices to others, including to farmers, consumers, policymakers and other relevant stakeholders. KATC's MSP works with selected multipliers from four institutions under the Ministry of Agriculture in Eastern Province, namely, Katopola Farming Institute in Chipata and the Farmer Training Centres in Katete, Chadiza and Lundazi. The target group of multipliers consists of a selection of staff from the four institutions including technocrats, camp extension officers and general workers.

Most of the MSP participants do not have a background in organic agriculture (OA) and agroecology (AE) or facilitation skills but they are expected to help farmers by offering various options and differentiated advice. For this reason, KATC has been working with these participants to build their capacity as OA and AE multipliers and to develop different tools or teaching aids (knowledge products) for disseminating OA and AE knowledge and practices. These have taken the form of posters, brochures and this manual.

This manual is intended to offer additional information on key Sustainable Organic Agriculture (SOA) principles and practices so that the multipliers are better equipped to support farmers and others to implement OA and AE practices. This manual is developed for and at the request of the MSP multipliers to supplement the posters and brochures developed. It can also be used by anyone who would like to start practising OA and AE. This manual has been a joint effort of KATC, KHSA and the multipliers.

2. INTRODUCTION TO SUSTAINABLE ORGANIC AGRICULTURE

A SOA system can be characterised as environmentally friendly, economically viable and socially just.

- **Environmentally friendly:** The quality of natural resources is maintained through sustainable use of resources and avoiding the application of synthetic fertilisers and pesticides. This minimises loss of diversity, nutrients, energy and biomass and avoids pollution. It also means that the health of the entire ecosystem is enhanced and sustained.
- **Economically viable:** Farmers can produce enough for own consumption and a surplus for sale to gain sufficient cash to cover the cost of production and have enough money to cover their needs.
- **Socially just:** SOA is an equitable system for all people including future generations. A farmer is urged to think of how her/his farming system is affecting those around her/him, including those involved in the production process as well as consideration of the use of land/natural resources and of how the produce will affect consumers.

SOA strongly emphasises sustainability and good stewardship of the earth and all its inhabitants by using fair farming practices that produce safe food for all, while protecting biodiversity.

The concept of SOA encompasses different types of agriculture including OA, AE, biodynamic agriculture and agroforestry. Critically it refers to those forms of agriculture that do not use synthetic or chemical fertilisers and pesticides and that take a holistic approach to farming that aims to benefit people and animals as well as protect the environment, water systems and biodiversity. SOA requires us to consider agriculture as an integral part of the ecosystem meaning that agriculture affects and is also affected by the ecosystem. This calls for farming systems that focus on techniques that optimise the wellbeing and functioning of the ecosystem beyond production economics (a sole focus on yield and profit).

Zambia's small-scale farmers work in a context of degraded soils and relatively low productivity.

Table 1: Profit margin calculation per hectare maize, conventional systems

Input	Units (kilograms)	Unit cost	Total cost (kwacha)
Seed	25 kilogram (kg)	1	1 250
Fertiliser	6 x 50kg bags	1 000	6 000
Labour	50 man-days	40	2 000
Total cost			*9 250*
Yield	5 050kg	5.6	28 280
Profit			19 030

Table 2: Sustainable organic agriculture (first year)

Input	Units (kilograms)	Unit cost	Total cost (kwacha)
Seed	25kg	1	Free recycled
Fertiliser	8 x 50kg bags of organic fertiliser	150	1 200
Labour	50 man-days	40	2 000
Total cost			*3 200*
Yield	4 000kg	5.6	22 400
Profit			19 200

The use of synthetic inputs (chemical fertilisers, pesticides, herbicides, hybrid seeds, etc.) can result in high yields initially, but it has a negative impact on soil health and biodiversity over time. SOA promotes the use of natural biofertilisers and pesticides at the farm level, which improves soil health and thus soil fertility. This coupled with reduced use of external synthetic inputs (which are expensive) results in small-scale farmers having the opportunity to gain higher financial returns in the long term as the quality and quantity of their farm produce improves. Farmer-managed seed systems also help to ensure that seed is appropriate for farmers' needs and contexts, available when needed and easily accessible.

Subsequent years will require less organic fertiliser because of the lasting effect of biofertilisers on soil. Less volumes of fertiliser purchased means more profit.

2.1 Principles and practices of SOA

SOA is governed by three broad principles, which are soil fertility management, soil and water conservation, and natural pest and diseases management.

- **Principle 1:** Soil fertility management: The management of soil fertility in SOA is based on the underlying principles of on-farm nutrient recycling as opposed to a heavy reliance on external inputs. Practices for the management of soil fertility include the use of animal manure, compost, compost/manure extracts and teas, green manures, fertiliser trees, biofertilisers and cultural practices such as crop rotation, intercropping, mulching and residue retention.
- **Principle 2:** Soil and water conservation: Soil and water conservation in SOA is based on the understanding that natural resources should not be exploited just to satisfy immediate needs but that they need to be conserved to maintain productivity in the long term. There are three broad groups of practices for soil and water conservation, namely minimum soil disturbance (soil minimum tillage), maximum soil cover and crop diversification and rotation. There are also other measures promoted to prevent wind and water erosion, such as the use of hedgerows, contour techniques and terraces.
- **Principle 3:** Natural pest and disease management: A balanced agricultural ecosystem characterised by high diversity is key for the management of pests and diseases. There are a number of effective cultural practices including balanced crop nutrition, crop rotation, intercropping and crop diversification that are effective in the management of pests and diseases. There are also other deliberate pest management practices such as biological pest management, push pull, hedgerows and botanical pesticides.

This manual provides guidelines on how to implement pratical farming methodologies related to each of these three principles.

2.2 Benefits of SOA

Farmers gain the following economic, environmental and social benefits associated with SOA.

- **Prevention of land degradation:** Every year, huge areas of arable land are lost due to unsustainable chemical farming practices and cultivation is often shifted to new parcels of land (Neina et al., 2022). SOA addresses the issue of land degradation by emphasising production principles that protect the soil and manage the flow of water.
- **Sustainable intensification of limited farming land:** Zambia's population has grown quickly to reach about 21 million in 2023 (Worldometer, 2023). This growth in population is not accompanied by growth in available agricultural land and so there is a need for sustainable intensification of food production on existing land parcels. SOA focuses on the sustainable improvement and conservation of soil health, biodiversity and the environment, which, in turn, ensures sustainable and stable increases in productivity per unit land area.
- **Reduced need for external inputs:** External inputs – chemical fertilisers, pesticides, herbicides and seeds – are typically too expensive for rural households in Zambia. Their use also contributes to soil degradation and biodiversity loss. SOA emphasises the use of on-farm nutrient recycling (using on-farm resources to make natural fertilisers and pest and disease control products) and the use of own-saved seed, which is better for the environment and reduces the costs of production.
- **A balanced ecosystem:** The industrial agriculture model encourages monocropping (growing the same crop in the same soils year after year), accompanied by the use of chemical inputs. This can result in soils depleted of nutrients (European Union, 2021) and an ecosystem that is out of balance and unable to sustain production. SOA practices are carefully designed to focus on both increasing yields and maintaining ecosystem wellbeing.
- **Enhanced nutrition security at the household and national level:** Zambia has one of the highest

rates of malnutrition in the world (World Food Programme, 2021) – about 36% and 32% of children in rural and urban areas respectively are stunted (USAID, 2021). SOA focuses on building crop diversity and stable production, which helps ensure a more consistent and diverse food supply.

- **Climate change mitigation and adaptation:** SOA practices are tailored to ensure that the farmer is well equipped with the necessary tools and knowledge to mitigate the effects of climate change and to adapt and be resilient to climate change effects through maintaining ecosystem balance, building up soil organic matter, ensuring crop and enterprise diversity and encouraging reliance on readily available local resources.
- **Sustaining soils for long-term high and stable yields:** There are often high yields in the first few years of applying industrial agricultural approaches (monocropping, synthetic chemicals, hybrid seeds), but yields decline as the nutrient levels in the soil decline. SOA practices such as adding compost, bokashi, plant teas or fermented liquid biofertilisers helps ensure sustained high yields due to the increased availability of all necessary nutrients (Burke et al., 2019)
- **No toxic effect of chemicals:** The use of agricultural chemicals such as herbicides and pesticides can have negative effects on human and animal health, as well as on soil life; for example, contamination of the ground water with nitrates that when taken up are poisonous to people and animals (Jaga and Dhalami, 2003; Nicolopoulou-Stamati et al., 2016). SOA practices work with natural processes and resources, such as making compost and bokashi from local resources or encouraging predators that eat pests (frogs, parasitic wasps and ladybirds, for example) to thrive and manage pests. The intention is to protect people, animal, plants and the environment.

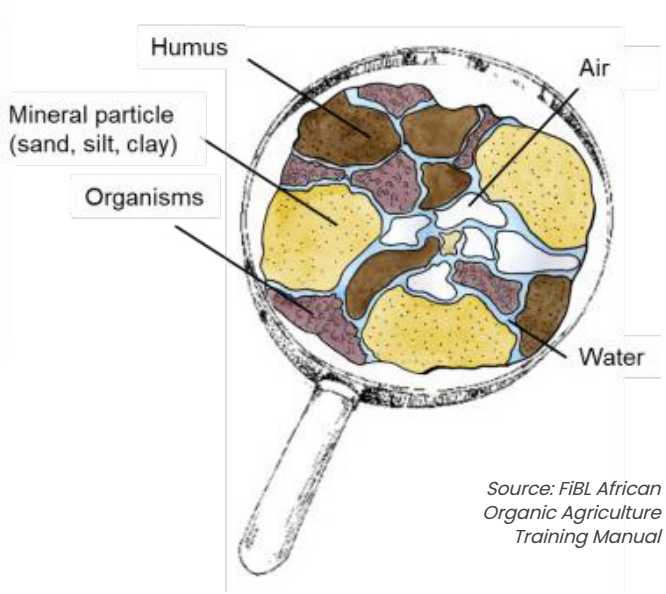
3. SOIL HEALTH AND FERTILITY

3.1 Soil structure

Soil is a natural active living body on the surface of the earth in which plants grow. Soil has three major components:

- **Solid particles:** These comprise minerals and organic matter and play a role in supplying plants with nutrients, anchoring them in the soil, retaining moisture and nutrients, and providing a habitat for soil organisms that keep the soil healthy and aerated (allow oxygen to flow through it). Soil organic matter, while only a small proportion of the soil (at most 5% of the total soil mass), is a key determinant of soil fertility and soil structure.
- **Soil water and air:** Water and air move in between the solid particles of the soil. The amount of water and air in the soil changes. For example, the soil may be completely filled with water after heavy rain with no air (water logging) and during the dry season, when there is no water going into the soil, most of the pores will be filled with air. Both are essential for maintaining the soil and plant health and it is important to have a balance between the two.
  - Soil water has a number of functions in crop production, significantly water carries nutrients, oxygen and hydrogen around the plant. Nutrients dissolve into water and are absorbed into the plant through the roots. Transpiration – the evaporation of water from the plant into the air resulting in the plant pulling up more water from the soil through its roots – maintains the flow of water and nutrients through the plant. It is also important for the life of soil organisms that need water to survive.
  - The air in soil (soil air) is essential for soil organisms and plant roots to breathe.
- **Soil organic matter:** Comprises all living soil organisms and all the remains of previous living organisms (animals, plants or macro/micro-organisms) in their various degrees of decomposition. It is the residues that are continuously broken down by living soil organisms and converted into humus, which is a fairly stable and indistinct brown to black material. The amount of humus in the soil is used as a way of telling how fertile the soil is. The more humus, the richer the soil is as humus helps to improve soil structure and holds water and nutrients in the soil well allowing them to be easily taken up by crops when needed.

Figure 1: What soil is made of



Source: FiBL African Organic Agriculture Training Manual

- **Physical, chemical and biological properties of soil:**
  - Physical properties include the soil bulk density, soil texture, soil moisture regimes, soil consistency, soil aggregate stability and soil drainage.
  - Chemical properties include soil acidity-alkalinity (pH), soil nutrient content and retention, which refers to the amount of a particular nutrient in a given quantity of soil over a specified period of time. Leaching refers to the loss of nutrients in a particular volume of soil over a specified period of time.
  - Biological properties are related to life in the soil, such as soil bacteria, fungi, actinomycetes and protozoa.

Soil organic matter effects all three soil properties and as such plays a critical role in determining the overall fertility of the soil. A farmer has control of the organic matter content of her/his soil and can change or improve it through various soil fertility management practices like adding compost, bokashi, manure, compost and manure extracts or teas.

3.2 Benefits of healthy soil

Soils that are rich in organic matter including humus have the following qualities:

- Ready source of nutrients for plants to grow strong and healthy.
- High amounts of organic matter help to improve soil structure so that water and air can flow through it easily but not too fast so that nutrients are leached away.
- Holds nutrients and water well: The addition of organic matter to clay and sandy soils over time can transform them to become loamier. This means the soil does not get too waterlogged and restrict air flow as is the case with clay, and it does not lose water and nutrients quickly as happens with sandy soils. In addition, organic matter, especially humus acts as a sponge that holds water and nutrients. The more organic matter the soil the better it is at holding water and nutrients.
- Full of life (rich biodiversity): Healthy soil can support many diverse lifeforms in and above the soil.

4. SOA PRACTICAL GUIDELINES

4.1 Managing soil health and fertility

This section provides step by step guidance on four key SOA techniques for managing and maintaining soil health and fertility. These are how to make and use compost, bokashi, manure and plant teas and fermented liquid biofertilisers.

4.1.1 Composting

Compost is a natural fertiliser. It is made by putting materials like crop residues, straw, vegetable waste (from the kitchen) and manure in layers in a particular order. The materials will start to heat up (cook) and decompose – this process is called composting in which organic matter is broken down by micro-organisms, nutrients are released and pathogens and weed seeds are destroyed. Adding compost to the soil improves its physical, chemical and biological properties (see pg 6). It is important to note that the composting method referred to in this manual is the 'HOT' composting process. Another method is 'COLD" composting process, which does not heat up in the same way and takes longer. Two common HOT composting methods are surface and pit composting. Surface composting is where a pile of organic materials is layered on the soil. Pit composting involves the digging of a hole in which the organic materials are layered. Surface composting is the easiest method as it does not require labour to dig a pit. The pit method does, however, provide a well-controlled environment in which materials on the sides have as much microbial activity as the inside materials and conditions are the same throughout. Both types of composting need turning when temperatures rise beyond 65°C.

How to make and use compost

There is no single fixed way of making a compost heap as it will depend on the materials available. Below are the basic guidelines:

What you will need:

- A hoe to clear the surface of any weeds and to loosen the surface of the soil so that water can infiltrate and that air passes easily through the heap.
- A machete to chop any large materials before layering them on the compost heap.
- A watering can to pour water onto the heap (in droplets).
- 4 x 1 metre (m)-long sticks (pegs) to mark the corners of the compost heap.
- 1 x 2m-long stick for inserting into the heap to measure temperature.
- 20 x bags of brown plant material: straw, hay, maize stover, rice husks, dried leaves, etc.
- 5 x bags of green plant material (as available): weeds, vegetable waste like peels, green grass and leaves of green manure crops, etc.
- 1 x bag of animal manure.
- 400 litres of water (moisture) to keep the micro-organisms alive and to moisten the brown materials so that they can easily be broken down.
- *Optional:* 1 bag of mature compost or local soil to introduce local micro-organisms to speed up the composting process.

Do NOT use these materials in your compost heap:

Diseased plants, poisonous plants (castor beans), plant materials which take too long to breakdown, acidic and toxic plants (acacia and eucalyptus), plants containing things that prevent/slow breakdown (pine needles). Cat and dog manure as it contains pathogens, animal bones and other animal food waste as they bring rats, inorganic materials e.g., plastics as they do not break down and prevent movement of water and micro-organisms, hazardous materials such as old batteries, razor blades, chemical wastes, etc.

Preparation of materials

Use a hoe or a machete (panga) to cut big material like maize stalks into pieces of about 10 centimetres (cm) so that they fully break down with the rest of the materials. Smaller/fresh green materials like grass, weeds, leaves or vegetable trimmings can be used without chopping.

Step-by-step guide for making compost (surface composting)

Step 1: Select and clear site for making a compost heap. Choose a place that is shady (under a tree), flat and near to the materials you need (animal manure, crop residues and water). If possible, choose a site close to the field where the compost will be used. This saves on time and labour. Clear the site.

How to make & use COMPOST

1

SELECT AND CLEAR SITE

2

MARK AND PEG SITE

3

ADD BASE LAYER

4

ADD BROWN LAYER

5

WATER HEAP

6

ADD GREEN LAYER

7

ADD MANURE LAYER

8

KEEP LAYERING MATERIALS

9

COVER HEAP

10

CHECK TEMPERATURE

11

TURN THE HEAP

12

FIXING THE HEAP

13

CHECKING COMPOST IS READY

14

USING COMPOST

Step 2: Measure and mark the site. Measure and mark the size of the heap. Put long pegs in the four corners of the heap. A good size for a heap is 1m wide and between 1m and 1.5m high. The available materials will determine the length of the heap.

Step 3: Add a base layer. Please a coarse/rough layer of material such as maize husks, twigs and maize stalks on the ground. This layer should be 20 centimetres (cm) high.

Step 4: Add first brown layer. Add a layer of brown material like straw, dry leaves or rice husks. The layer should be about 20cm high.

Step 5: Water the heap. Add water to the heap after every layer of brown material.

Step 6: Add first green layer. Add a layer of green material, preferably leaves from legumes like cowpeas, beans and velvet beans. You can include kitchen waste (vegetable peels or rotten vegetables)or weeds. The layer should be about 10cm high.

Step 7: Add first manure layer. Manure is a source of nitrogen for the compost heap. The manure layer should be between 2cm and 5cm high. Add some mature compost or soil to the heap if you have it. This adds micro-organisms to the compost heap and speeds up the process of decomposition. If using different manure sources, don't mix them but instead put them on different layers.

Step 8: Keep adding layers. Add another layer of brown material, sprinkle with water, add a layer of green material, then a layer of manure (adding some soil or old compost if you have it). Repeat this process.

Step 9: Cover the heap. Cover the whole heap with a layer of grass to protect it from direct sunlight and rain, if not made under a shade. This will also prevent animals destroying the heap. If a plastic is used instead of grass, make sure it has a lot of holes so that air can circulate in and out of the heap.

Step 10: Check the temperature. Take a long, sharp stick and drive it into the pile at an angle (diagonal) to help check on the conditions of the pile from time to time to see if the pile is hot, cold, wet or dry. After two to three days, decomposition should have started in the pile and the stick will be warm to hot when removed (40-60°C). If you have a thermometer, use it instead of a stick. Below 40°C, decomposition is too slow or not happening due to either using bad materials or not following the process well while above 65°C, burning of nutrients may occur.

Step 11: Turn the heap. The compost heap needs to be turned regularly. When and how often to turn depends on the temperature inside the heap (see Step 12 Fixing the heap). Turning means bringing the inside of the heap to the surface and moving outside of the heap to the inside. Sprinkle the heap with water as it is being turned. This will help all the materials in the heap decompose faster. Check the temperature on a regular basis and if temperature is right, turn every 7-10 days until compost is ready. The compost will be ready after the fourth turning or after about six to eight weeks.

Optional step: Sprinkle some forest soil or mature compost to the heap to introduce beneficial microbes after step 7. Repeat the process (4 to 7) until the heap is about 1.5 m high.

Step 12: Fixing the heap: After about two to three days of making the heap, remove the stick and place it on the back of your hand. Based on how hot the stick feels, the following can be done:

- If the stick feels warm or hot and the smell is good, the temperature is normal for the compost and good decomposition has started. If the compost heap is heating up normally, turning should be done 10-14 days after building the heap. The best way to determine when to turn the heap is by constantly checking the stick and if the peak temperature of normally about 65 to 70 degrees Celsius is reached, then it is time to turn.
- If the stick feels too hot and can't be held continuously for a few seconds, it might mean there is too much nitrogen-rich material and the inner of the heap is burning or about to burn. Fix this by turning the compost and add more brown materials immediately.

- If the stick feels cool or cold and there is a foul smell, the temperature is too low for good decomposition. This might mean either that the materials are too dry or that there is insufficient nitrogen-rich material in the heap. Fix this by turning the compost and adding more nitrogen-rich materials and add water to the dry patches of the brown material only.
- If the stick is warm and wet but there is a bad smell like ammonia, this indicates that there is too little air and/or too much water in the compost thus the materials are rotting and not making a good compost. Add more dry plant materials and/or some old dry compost while turning the compost.

Step 13: Checking the compost heap is ready. The compost should be ready after the fourth turning or after 6 to 8 weeks. Hold the compost in your hand. If it is dark brown and fine like soil it is ready, if it is still rough, then turn the heap again and check after another week.

Using compost (Step 14)

Compost can be applied in different ways by adding a small amount in the hole where a seed is going to be planted; digging it into the bed where crops are going to be planted; or sprinkling it at the base of an already growing crop. If putting it into a hole or sprinkling at plant base, cover the compost with a little bit of soil. There are some considerations when using compost:

- Well decomposed compost adds organic matter to the soil, but it usually has a low nutrient content and might not provide the soil life with the food that is needed. Therefore, it would be useful on occasion to use partially decomposed compost that has a higher concentration of nutrients. This will help provide the microbes in the soil with food they need in form of decomposable organic matter. Care should be taken when applying partially decomposed compost as it can burn your crops due to heat being produced during the further decomposition process. Supply at half the recommended rate and put it away from the plant root/base to avoid burning the crop.
- Different crops need different amounts of compost. For example, heavy feeders like cassava need more compost than light feeders like maize. Less compost is needed for soils with already high fertility and when compost is used in combination with other fertility management techniques such as green manuring, plant teas, other bio-fertilisers and agroforestry.
- Guidelines for using compost with maize:
  - In rip lines: add 3 double handfuls every 1m in the rip line.
  - In basins: add 2 double handfuls.

4.1.2 Bokashi

Bokashi is a Japanese word for making a natural fertiliser by cooking organic matter through decomposition. It is used to rebuild and bring life into soils and provide plants with nutrients to support strong plant growth. Bokashi is ready after only 12 to 15 days and the materials used to make bokashi are easy to find and do not cost much. The benefits of bokashi are:

- It is quicker to prepare than compost.
- Bokashi improves the life (biodiversity) in the soil, which helps to improve the structure and nutritional content of the soil, i.e., there are more nutrients available in the soil for the plants.
- The slow release of nutrients ensures that nutrients are available to plants over a long period of time.
- It contains the macro-nutrients and micro-nutrients required by plants to grow strong and healthy.
- Bokashi improves the structure of the soil, improving the soils absorption and retention (holding) of water, in turn reducing surface run-off and resulting erosion.
- Plants in soil that has bokashi regularly added to it grow healthy and strong and do not easily succumb to pests and diseases.

How to make bokashi

What you will need

- A hoe to clear the soil surface of any weeds and to loosen the soil so that water and air can infiltrate.
- A machete (panga) to chop any large materials.
- A watering can to pour water onto the heap (in droplets).
- 7 bags of soil. It is best if it is clay or black soil or soil from termite mounds.
- 7 bags of manure from chickens, goats, sheep or cows or a mix of the different manures.
- 7 bags of brown materials like maize stover, dry leaves or even sawdust. Dry matter should be cut up or broken up into small pieces not longer than a hands width to make it easy to turn in the heap.
- 1 bag of crushed charcoal or biochar.
- 5 litres of molasses (the thicker the better) or 2kg of unrefined cane sugar, preferably brown sugar, made into a syrup by dissolving it in 5 litres of water.
- 500 grams (g) of yeast (instant clover or dried yeast).
- 1 bag of bran (maize, wheat, rice, oat) or straw. You can also use a mixture of bran and straw.
- 8kgs to 10kgs of fine rock dust or wood ash.
- Water. Use untreated water that has no chemicals (like chlorine) added. Note: tap water from the council is normally treated.

Note: Change the amount of ingredients depending on the availability of raw materials and the amount of bokashi one wishes to make.

Preparation of materials
Use a hoe or a panga to cut big material like maize stalks into pieces of about 10cm so that they fully break down with the rest of the materials. Smaller fresh green materials like grass, weeds, leaves or vegetable trimmings can be used without chopping.

Step-by-step guide for making bokashi
Step 1: Choose site. Choose a place to make your bokashi that is protected from the sun, wind and rain. These elements can disturb the fermenting process and reduce the quality of the bokashi. Make the bokashi on the ground, and never on a concrete floor. Collect the materials and bring to the site.

Step 2: Prepare molasses and yeast mix. Mix the molasses and yeast with 50 litres of water in a separate container. Sprinkle every layer with the molasses mix to moisten the material.

Step 3: Layer materials. Build the heap by layering the different materials on top of each other. Sprinkle every layer with the molasses mix. The layers can be placed in the following order: A layer of brown material, a layer of manure, a layer of soil, a layer of crushed charcoal and finally a layer of bran. All of the layers will eventually be mixed together, so no proper layer sizes are required, but avoid making the layers too thick. Repeat these layers until all the materials are used up. Make sure the heap is no taller than 1.5m.

Step 4: Turn the heap. When finished, turn the heap 4 times until all the layers are mixed together well. Add some more molasses mix if the heap is still too dry and dusty. Add it in small amounts. The right amount of moisture can be checked using the squeeze test.

Step 5: The squeeze test. Take a fistful of the mixed bokashi and squeeze it. It should form a sausage mixture that sticks together. If water leaks through your fingers, it means you have too much moisture. Turn heap again and add soil as you turn. If it doesn't form a sausage shape, you have too little water. Turn the heap again and add some more water. There should be no wet ground under or beside the bokashi heap.

Step 6: Check temperature. Check the temperature every day. Insert your hand deeply into the heap. The right temperature is about 60°C. You should feel a good amount of heat but be able to keep your hand inside the heap for a minimum of 10 seconds. If you need to pull your hand out before 10 seconds, the heap is too hot. If you feel only a little heat, the heap is too cold. If the heap has the right temperature, turn it 2 times a day (morning and evening) for the first 4 days. Otherwise fix the heap.

Step 7: Fixing the bokashi. If the heap is cold when you put your hand in, you need to add more molasses/sugar mixture and/or manure and turn the heap less frequently to start the process again. If your hand burns and you have to pull it out, the heap is too hot. Turn it more often every day or try spreading the materials out slightly to reduce the height of the heap. Keep checking the temperature until you get it right.

Step 8: Continue turning. From day 5 to day 10, turn the heap once a day until the temperature inside the heap is the same as the temperature outside. This can take longer in the cold season (up to 15 days) or if the fermentation has started slowly.

Using and storing bokashi (step 9)
It is recommended that farmers use bokashi immediately after it has been prepared as the material will be of high quality. The heap will, however, continue to break down and can be used. If bokashi needs to be storied, it should be covered to protect it from the sun, wind and rain.

Fresh bokashi can be acidic and should not make direct contact with roots or leaves. Place bokashi at the bottom of the planting hole and cover with some soil (later you can also bury it beside the plant).

- Use 1 handful per plant for field crops and leafy vegetables.
- 2 handfuls for vegetables with heads.
- 3 handfuls for plants that are continuously harvested (like tomatoes).

4.1.3 Manure and plant teas
Manure and plant teas are a type of organic/natural liquid fertiliser. They are made by soaking compost, animal manure and/or nutrient-rich plant materials in water for a few days. Green plant materials for making teas include leaves from green manure crops (velvet beans, jack beans, lablab, etc.), leaves from agroforestry trees (moringa, Leucaena, sesbania, etc.) and non-leguminous plants that have lots of nutrients (like comfrey and tithonia). There are many benefits to these teas:

- Teas are easy to make and do not need much labour to prepare.
- They do not cost much money and can be made from locally available materials.
- The nutrients in the teas are easy for plants to take up.

How to make & use BOKASHI

1a

1b

CHOOSE SITE

2

PREPARE MOLASSES MIX

3a

3b

3c

LAYER MATERIALS

3d

LAYER MATERIALS

4

TURN HEAP

5a

'SQUEEZE' TEST

5b

'SQUEEZE' TEST

6

CHECK TEMPERATURE

7

CONTINUE TURNING

8

FIXING THE BOKASHI

9

APPLYING BOKASHI

- The teas help plants to grow strong and stay healthy.
- Extracts can also be used to overcome problems of leaching as nutrients are supplied in small but readily available amounts.

How to make and use manure and plant teas

What you will need

There is no single fixed way of making manure and plant teas, it depends on the materials available. Teas can be made from either compost, animal manure, plant materials or a combination of two or all of these materials. Below is a basic list:

- A 210 litre plastic drum to contain the water into which the nutrients will dissolve.
- 210 litres of water. The volume of water is adjusted if the amount of compost/manure is increased or decreased.
- A knapsack sprayer or watering can to pour water onto the heap (in droplets).
- 1 piece sack or bag that can hold solid material but also let water through easily (like a woven
- sack or an orange/onion bag).
- 1 piece of cloth/woven plastic bag that can cover the drum but let air flow easily.
- 1 piece of string (at least 2.5 metres).
- 1 piece of wire (optional).
- 1 stick.
- 20kg (1 bag) of compost/animal manure OR of green plant materials OR a combination of materials.
- A shovel to scoop the compost and manure into the bag.
- A panga to harvest and chop the larger materials into smaller pieces for easier handling and decomposition.

Preparation of materials

Use a panga to cut big material like agroforestry trees to smaller parts of about 10-20cm. Smaller fresh green materials like grass, weeds, leaves or vegetable trimmings can be used without chopping. Find a place in the shade to place the drum, so that direct sunlight and rain are cut off from the container where the compost and manure extracts are being made. Excess heat from the sun can evaporate the water and heat up the solution thus killing micro-organisms.

Step-by-step process of making manure and plant teas

Step 1: Gather materials: Gather all the materials (20kg of compost or animal manure or green plant materials or a combination of these materials). You will also need the drum and a sack or bag that can hold solid material. Fill the drum with water nearly to the top.

Step 2: Mix ingredients: Put the manure/compost/ leaves or a mixture of these materials in a 20kg bag that lets water flow through it easily.

Step 3: Soak ingredients: Tie the sack to a stick with the string or wire and lower the sack into the water. Make sure that the sack is fully covered by the water but does not touch the bottom of the drum. If it does touch the bottom of the drum, make the string or wire a bit shorter.

Step 4: Cover the drum: Make a small hole in the cloth that will cover the drum. Untie the string from the stick. Thread the string through the hole and retie it to the stick. Tie the cover firmly to the drum with another string. The cover should let air flow in easily but keep flies out.

Step 5: Mixing the tea: Mix the tea twice a day by lifting/ tilting the stick up and shaking the sack up and down 20 times.

Step 6: Diluting the tea: The tea is ready for use after 2-3 weeks. Dilute the tea with water before using it to avoid burning plant leaves or roots. To dilute, add water to the mixture until it is light brown or yellow in colour.

Applying manure and plant teas (step 7)

Apply diluted tea to the base of the crop by drenching using a knapsack sprayer with nozzle removed, or a bucket, a cup or watering can. The amount to be used is dependent on the fertility of the soil and farmers' experience. General recommendations are that heavy feeders like vegetables can receive 200 millilitres per plant, other crops 100 millilitres per plant. Recommendation application times:

- Field crops: For crops like cotton and maize, you can start applying as soon as your crops start germinating and continue until the crops are mature. In the dry season, apply once a week and make sure the soil is moist at application. Apply twice a week in the rainy season.
- Vegetables: Start applying immediately after transplanting to help plants recover from transplanting shock. Thereafter, you can continue applying your extract once a week until your vegetable crop matures.

How to make & use MANURE & PLANT TEAS

1a

1b

1c

GATHER MATERIALS

2

MIX INGREDIENTS

3a

3b

3c

SOAK INGREDIENTS

4

COVER DRUM

5

MIX THE TEA

6

DILUTE THE TEA

7

APPLY THE TEA

4.1.4 Fermented liquid bio-fertilisers using fresh cow dung

Bio-fertilisers are liquid super-fertilisers with a lot of balanced energy that supports and builds up soil fertility. Fermented bio-fertilisers are made from manure and other materials mixed into a liquid that contains nutrients and micro-organisms. They are good for supporting the life of soil organisms like bacteria, fungi and worms. Fermented liquid bio-fertilisers:

- Support life in the soil, making it more fertile and providing food for plants to grow.
- Help plants stay healthy and contribute to the establishment of helpful bacteria and fungi that keep in check harmful ones that could damage plants.
- Can be used instead of chemical fertilisers. This saves farmers money and is better for the soil.

What you need

- Airtight plastic drum of about 200 litres capacity.
- 1 small drum (minimum 20 litre) for mixing.
- Transparent (see-through) hosepipe (1 metre long and 1 centimetre to 1.25 centimetres in diameter) attached to the valve or nipple by a jubilee clip. Used to release gases.
- Irrigation coupling piece and rubber.
- Plastic glue to seal the air holes and ensure that the drum is airtight.
- A plastic bottle (1 or 2 litres) to be filled with water for the slow release of the gases without letting air into the drum.
- A wooden stick for stirring the ingredients.
- A plastic bag or an airtight lid is required for covering the drum.
- 1 x 50kg sack of fresh cow dung to provide micro-organisms (bacteria, yeast, fungi and protozoa) for the fermentation process.
- 4 litres of milk or whey to provides proteins, vitamins, fats and amino acids used to form other organic compounds.
- 500g yeast to add important microbes to quicken the fermentation process.
- 4 litres of molasses or sugar cane juice to provide energy used to activate the microbial metabolism and boost the fermentation process. This also provides other minerals like calcium, phosphorous etc.
- 4kg of wood ash to provide minerals and trace elements to the bio-fertiliser to activate and enrich the fermentation. The best ash is from cereals like maize, wheat and rice.
- 180 litres water (clean and with no chlorine) to provides the liquid medium in which biological and chemical reactions of fermentation with no air (anaerobic) occur. If using municipal water, you can put it in the sun for three days to kill the chlorine.
- 2kg of mineral salts (optional) to increase the amount of minerals already present in cow dung to strengthen the fermentation process and fertilise the soil.

Preparation of materials

Place the drum where the fermented bio-fertiliser is being made in the shade so that it is protected from direct sunlight and rain. Excess heat from the sun can increase the temperature of the solution killing important microbes. Best temperature in the drum should be about 38-40°C as in the cow's stomach.

Step-by-step guide of making fermented liquid biofertilisers using fresh cow dung

Step 1: Making an airtight drum: It is very important that no air can enter the drum once you have filled it with the bio-fertiliser. Follow these steps and use the guide on the images to identify where to make holes and join pieces together. Step 1: At point A, make a hole in the drum lid to fit the size of the pipe (B). Step 2: Insert the pipe in the hole and tightly seal the hole with plastic glue. Step 3: At point C, insert the other side of the pipe (B) into the plastic bottle. The size of the bottle to use depends on the size of the pipe. Step 4: Fill the bottle with water. Ensure that the other end of the pipe (D) ends inside the water in the bottle at all times as it prevents air to enter in the drum (if necessary, refill water in the bottle). Once the drum is full of the bio-fertilizer, you will see air bubbles appear in the water. This means that fermentation has started. Make a hole on the lid of the drum. Push in the valve or rubber into the hole and push in the nipple. Connect pipe on the outside.

Step 2: Mix manure and water: Pour 100 litres of clean water into the 200-litre drum and add 50kg of fresh cow manure and 4kg of ash. Stir until all ingredients are mixed well together.

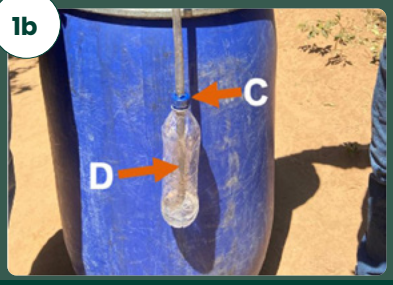
Step 3: Prepare second mixture (milk and sugar mixture): Pour 10 litres of clean water into a separate container and add 4 litres of whey or milk followed by 4 litres of molasses or sugarcane juice and mix properly. Add this mixture to the solution in the 200-litre drum and stir well.

Step 4: Add water and yeast: Fill the 200-litre drum with water up to the 180-litre mark, add 500g of

How to make & use FERMENTED LIQUID BIO-FERTILISERS

1a

1b



1c

PREPARE AIR-TIGHT DRUM

1d

PREPARE AIR-TIGHT DRUM

2

MIX MANURE AND WATER

3a

3b

3c

PREPARE SECOND MIXTURE

4

ADD WATER AND YEAST

5

COVER DRUM

6

CHECK BOTTLE

7

7

CHECK READINESS

8

APPLYING BIO-FERTILISERS

yeast and mix very well. Even though the fermented liquid bio-fertilisers can be made without yeast, adding yeast enhances the concentration of micro-organisms responsible for the fermentation process and speeds it up.

Step 5: Cover drum: Cover the drum with a plastic bag or lid (airtight) to start the process of fermenting the mixture and keep it in the shade to protect it from rain and heat. The best temperature for the mixture is 38-40°C (like the temperature in the stomach of a cow). Once the drum is full of the bio-fertiliser, you will see air bubbles appear in the water meaning that fermentation has started.

Step 6: Check the bottle: Keep drum sealed for 3-4 weeks to allow the fermentation to happen. In cold places it can take 8-12 weeks. Look at the bottle. If gas is no longer being released (there are no bubbles in the plastic bottle), fermentation has stopped. You can now open the drum.

Step 7: Check readiness: The bio-fertiliser is ready when it smells like alcohol, is foaming on top and the colour is reddish-brown and slightly transparent. It is not ready when the surface cream is green, and the colour of the liquid is cloudy. As air has already entered the drum when it was opened, it cannot be closed anymore. It can be used but is not of good quality and won't last long. Something has gone wrong if it smells rotten, is a very black colour on the surface and blue underneath or has mould on top. It should not be used because it might introduce the wrong bacteria in your soil.

Applying fermented liquid bio-fertilisers made with fresh cow dung

Pour 1 litre of the liquid into 20 litres of water. Use a knapsack sprayer to spray the bio-fertiliser on plant crops that are planted in rows at a rate of 1 metre a second. Use 1 cup of bio-fertiliser (300 millilitres) to apply on crops planted on stations. Use as a top dressing in intervals of 2-3 weeks.

4.2 Soil and water conservation

There are three primary principles of soil and water conservation: disturbing the soil as little as possible, covering the soil as much as possible and mixing and rotating crops. These three principles should be considered as the legs of a three-legged cooking pot meaning that if any of the legs is missing, then the pot will not stand. Thus, one cannot practice minimum soil disturbance only without maximising soil cover or rotating and mixing crops as it this will be a formula for failure.

There are many reasons for farmers to practice soil and water conservation, including to:

- **Maintain the productivity of land:** With population growth there is more pressure on the land and increasingly limited new land to which farmers can shift cultivation. Farmers must therefore ensure that their farmland remains productive.
- **Increase yields:** Soil and water conservation ensures that productivity per unit land area is high over a long period of time.
- **Adapt to and mitigate the effects of climate change:** Practising soil and water conservation can help to mitigate climate change by keeping carbon in the ground and preventing its release as a greenhouse gas. It also helps to build resilience to climate change – a cornerstone of adaptation – by boosting the ability of the ecosystem to weather external shocks, like droughts.
- **Reduce production costs:** Minimum soil disturbance helps reduce labour costs and practices and emphasises early land preparation immediately after harvesting helping farmers to spread labor evenly across the year.
- **Safeguard ecosystems from degradation:** Soil and water conservation protects our soils from erosion and our rivers from become silted from soils washing away.

There are instances where the three principles of soil and water conservation (i.e. minimum soil disturbance, maximum soil cover, mixing and rotating crops) may not be enough, such as when the field is on a slope or badly eroded and there is the need for special measures to prevent and stop soil erosion before implementing the soil and water conservation practices. The underlying principle of erosion control is based on maximum reduction of surface water run-off and increasing vertical water movement (infiltration) into the soil. To achieve this, techniques, all based on the contour principle, can be used.

Table 3: Description, rationale and practices associated with soil and water conservation

	Minimum soil disturbance	Maximum soil coverage	Mixing & rotating crops
Description	The farmer does not dig into the soil at scale, but rather directly sows or uses permanent planting basins or rip lines. Crop residues are not dug into the soil but rather left on top to provide the soil with cover; residues are gradually broken down by soil life – termites, worms, ants, etc.	The farmer always keeps soil covered, protecting it against the impact of rain and sun, providing soil life with a constant supply of food and providing a microclimate for optimal growth and development of soil organisms including plant roots.	The farmer practices crop rotation and interplanting to increase the amount, diversity and activity of soil life, supplying nutrients to the soil and to plants and to improve soil properties.
Benefits	• Less destruction of the soil structure. • Slower mineralisation of soil organic matter (as it is less exposed to the elements). • No disturbance to the habitats for soil life. • Improved circulation of air and water in the soil. • Reduced evaporation, soil erosion and water run-off and reduced nutrient leaching and thus improved nutrient retention, critical for plant growth.	• Improved infiltration and retention of soil moisture resulting in less severe and less prolonged crop water stress and increased availability of plant nutrients. • Source of food, habitat and energy for soil lifeforms. • Creates channels for air and water; enables biological tillage by soil organisms and provides a substrate for biological activity through the recycling of organic matter and plant nutrients. • Reduces the impact of rain on the soil, less incidences of crusting and surface sealing. • Reduces runoff and erosion, increases the formation of humus, reduces temperature variations and provides for better conditions for plant development.	• Breaks lifecycle of certain weeds, diseases and pests. • Provides for a more balanced diet and more types of produce to sell. • More efficient use of nutrients, water and sunlight. Combined yields of intercropped crops tend to be higher than crops grown on pure stands. • Reduces risk as a single crop may fail because of drought, flood or attack by pests and diseases or its market price may be low. • Different root structures perform different roles – plants with strong deep roots can break up hardpans, while others with fine shallow roots bind the soil. Roots also open up spaces for air and water to get into and move through the soil.
Key practices	• Zero tillage (direct planting, no till-farming): This involves slashing the weeds, previous crop residues or cover crops, and seeding directly through the mulch using a dibble stick or jab planter. A dibble stick is a strong stick that is used to make holes for the seeds in the ground. A jab planter is operated by hand and used to plant seeds in the soil. • Minimum tillage: Minimum tillage is the use of hand hoes or other less invasive tools that do not disturb the soil at scale.	• Retention of crop residues on the land. • Reducing competition with other uses such as livestock. • Use of cover crops, intercropping of upstanding crop such as maize, sorghum or sunflower with crops that have a tendency to cover the ground such as pumpkin, cowpea, velvet beans, etc. • Biomass transfer of mulching material. • Pruning of agroforestry species intercropped with main crop, no burning and use of crops with yield high biomass production.	• Systematic selection of crops from different families, with different nutrient requirements and root systems, as below: • Ensure that at least a third of the crops to be grown in a season are legumes. • Nitrogen-fixing crops should alternate with nitrogen-depleting crops. • Deep rooting crops should follow shallow rooting crops. • Alternate between crops with high and low root biomass. • Wherever possible, green manures/ cover crops and under-sowing techniques should be used to keep soil covered. • Crops that develop slowly and are thus susceptible to weeds should follow weed-suppressing crops. • Alternate between leaf and straw crops. • Do not grow crops that attract the same pest or type of pests in succession.

A contour is an imaginary line joining points of equal elevation (height). Practices under the contour principle include Contour ditches, Contour ridges and a Stone line and Grass strip.

In soil and water conservation, if a barrier such as a ditch is dug along a slope having points of different elevations (not along a contour line), there will be so much water concentrated in this ditch and because it is not on level ground, the huge volume of water will flow from higher points to lower points within the ditch causing erosion of a bigger extent than would have been the case if the ditch was not dug at all. A better way is to dig trenches along the contour lines of the land. The trenches allow rainwater to sink into the soil and any soil that is washed away down the slope will enter the trench. This stops the runoff and loss of fertile soil. There are three steps to the contour practice: building an A-frame, determining the contour line and making the contour design. A contour line is determined by use of an A-frame that can be made using simple materials that are readily available to the farmer.

4.2.1 How to make an A-frame

What you need

- 2 x 2m long poles.
- 1 x 1.5m pole.
- Wire/nails/rope/hammer/ruler or string.
- 3m of string onto which the stone will be tied to work as a pendulum determining uneven points.
- Wooden stakes or pegs (the number will depend on the size of land you are working with).
- Pen/marker/piece of charcoal (anything that can be used to draw/make a mark).
- An axe or panga for cutting the poles.
- A stone or heavy piece of wood to determine elevation (an equal height of ground points).
- Spade.

Step by step process of making and using the A-frame

Step 1: Make the A-frame. Take the two x 2m poles and nail or tie them together. Then connect the 1m pole to the other two poles at about halfway down making an 'A'. Tie the string around the stone and attach the other end of the string to the top (apex) of the 'A-frame.

Step 2: Calibrate the A-frame. Place the A-frame on level ground and hammer a peg into the ground at the point where each of the A-frame poles meet the ground. Make a mark on the cross bar of the A-frame where the string with the rock tied to it settles. Turn the A-frame around so each leg touches the other peg (where the other leg was at first) and again mark where the string settles on the cross-bar. Following these 2 marks on the cross-bar, get a ruler or string and make a new mark in the middle of the first two marked points. The new mark in the middle is the center mark for the A-frame. Whenever, the A-frame string hangs on this middle mark, it means both legs are sitting on even ground (ground which is at the same level or contour line).

Step 3: Find the contour line. Using the A-frame, move across your slope step-by-step, each time swinging the A-frame slowly until the rope hangs over the central mark on the cross bar. Then bang a stick or peg into the ground next to the front leg of the A-frame. This will then be the start of the contour line.

Step 4: Map/mark the contour line. During this entire process, ensure that the A-frame is never completely lifted off the ground. Every time the string hangs on the middle mark, advance by turning the frame on one leg and place a peg until you reach the end of the field.

Step 5: Check the contour line. Once you reach the end of the field, ensure that the contour line is smooth and not in a wild zigzag by identifying any outlier pegs and eliminate them to smoothen the line but maintain the same level as much as possible.

Note: Depending on the steepness of the slope, there might be need for more contour lines. The actual number and spacing of the contour lines should be guided by the farmer's experience, the amount of run-off and the steepness of the slope. Generally, the spacing between contours can range from 5m to 20m. The steeper the slope the closer together the contours need to be as the water will runoff with higher speed and need more barriers to sink in.

Contour practices for soil & water conservation

1

MAKE AN A-FRAME

2a

2b

2c

CALIBRATE THE A-FRAME

3

FIND THE CONTOUR LINE

4

MAP THE CONTOUR LINE

5

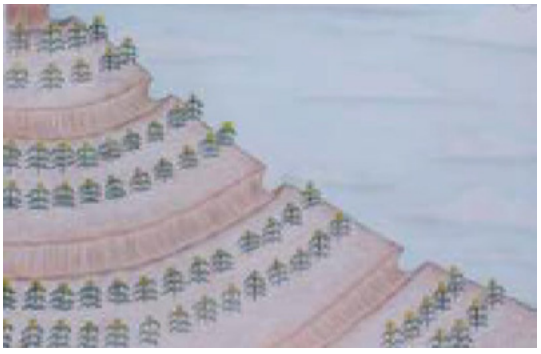
CHECK THE CONTOUR LINE

4.2.2 How to make contour barriers

Once the contour line has been mapped, different structures can be made along the contour line depending on the materials and labour available. Among these are:

- **Grass strip:** Fodder grasses such as vetiver grass (Vetiver zizanioides), Napier grass (Pennisetum purpureum) and guinea grass (Panicum maximum), Bahia grass (Paspulum notatum) can be planted in strips at intervals across the slope to slow down water runoff. In addition to reducing soil erosion, the grasses provide feed for the animals. The grass strips can be mixed or replaced with a hedge row of leguminous fodder trees such as Leucaena diversifolia, Calliandra calothyrsus, Sesbania sesban, Gliricidia sepium.

- **Contour ditch:** Ditches of 50cm or more in width and about 30cm deep are dug along the contour line. The soil from the ditch can be used to create an additional barrier to the movement of water. The soil can either be thrown up-ward (fanya-juu) so that the first barrier to the movement of water is a ridge. The challenge with this, however, is that if the ridge is not firm enough, the soil risks being washed back into the ditch. The other way is to throw the soil downward (fanya-chini). The ridge is stabilised by planting fodder grass such as Napier (Pennisentum purpureum) and/or multipurpose agroforestry trees on it.



- **Stone line:** Use of stone lines is most applicable when stones are easily accessible in the area. Here stones are piled across the slope along the contour line, breaking it into small sections where crops are grown. They slow down runoff and soil eventually builds up behind them, forming nearly levelled beds. In instances where the land is already badly eroded, planting banana plants in addition to contour structures will help fill up the gullies.

4.3 Organic pest and disease management

There is a balance in the natural ecosystem between insects, diseases, predators and pests. Pests and disease-causing organisms only become of concern when their activities affect the harvest, thus having consequences for food security and livelihoods (by destroying the economic opportunity provided by surplus produce). Pests and diseases tend to arise when there is an imbalance in the natural environmental system creating conditions for diseases to spread or for a 'pest' population to become dominant.

The aim of natural pest and disease management is to restore the balance between pests and predators and to maintain ecosystem balance to mitigate the risk of disease. Effective management of pests and diseases requires a full understanding of the proper functioning of the ecosystem. The benefits of natural pest and disease management are that:

- **It is affordable and cost-effective:** Using natural pest and disease control is often cheaper than using synthetic chemical pesticides because there is a focus on using locally sourced, and often free, materials and the farmer can undertake the activities and make the remedies.
- **There is little to no risk to human health:** There have been many reports of people suffering from a range of illnesses, including cancer, as a result of exposure to synthetic chemical pesticides. Farmers can be exposed when spraying without wearing the necessary personal protective gear (which can be expensive to buy), or through incorrect storage and disposal of these chemicals in their homes or on farmlands; or through pesticide residues that remain on and in the crop after harvest.
- **No risk to environmental health:** Chemical products that control pests and diseases have many detrimental effects on the environment because the non-selective nature of most chemical pesticides kills both pests and useful insects that eat or predate upon pests; most chemical pesticides have long residual effects in the environment and can stay in the bodies of humans and animals causing problems for many years; and the chemical compositions of most chemical products are very simple and insect pests can very quickly, over a few breeding cycles, become resistant to them, leading to pest resistance. SOA practices use natural ingredients, which do not have these effects.

The first step in preventing pests and diseases is to build healthy soils or to control them using living organisms, helpful insects, cultural practices or curative measures. Several options exist in SOA, such as mechanical, biological and botanical and cultural control practices. Cultural practices are mainly preventative in nature while the others are used as curative measures – this means controlling the pest or disease once it has infected the crop (see table 4).

4.3.1 Making botanical pesticides

Below are three recipes for botanical pesticides. They are easy to make, do not cost a lot and can be made from locally available material.

What you need

- 1 bucket (20 litres) of neem leaves or Tephrosia leaves or snake beans (depending on the recipe).
- 1 piece of cloth that can hold solid material but also let water through easily.
- 2 buckets (20 litres).
- 1 knapsack sprayer or watering can.
- A pestle and mortar.

Safety measures

- Wash your hands thoroughly after making or using.
- Avoid contact with your eyes.
- Cover and put out of reach with children.
- Wear protective gear like gloves and protective glasses.

Table 4: SOA measures to control pests and diseases

SOA measures to control pests and diseases	
Know the problem Before taking action to control pests and diseases, it is very important to make sure that the problem is correctly identified as there are many causes of an unhealthy crop. These can range from a lack of nutrients to environmental and biological factors like pests and diseases. Proper identification is therefore key in addressing the problem and preventing it from happening again. It will also determine what measures you would take.	
Preventative measures	**Curative measures**
• **Keep soils and plants healthy:** Plants that are fed well are much more resistant to pests and diseases. Crops grown using chemical fertilisers tend to only get 3 to 4 of the nutrients they need and cannot always get the balance from the soil, particularly when soils are degraded. As a result, the plant suffers from nutrient deficiencies and becomes vulnerable to pests and diseases. • **Maintain genetic diversity:** Crops that have been bred by modern breeding methods tend to be very similar to one another and as such have similar susceptibility to particular pests and diseases. It is important to grow different varieties of the same crop as this improves resistance and is an insurance against failure of one variety. It is also important to grow different crops in the same field, as this enables a diversity of insect populations, which helps to main the pest-predator balance. • **Rotate crops:** Crops should be rotated each year, and only returned to the original site after one or more seasons of growing different crops. This helps to break any disease cycle. Crop rotation also helps a variety of natural predators to survive. • **Practice good hygiene:** If infected plant material, live or dead, is left lying around, pests and diseases can be passed on to future crops. Infected debris should be cleared up and disposed of either by composting or burning if necessary. • **Use companion planting:** This means growing certain plants to protect other plants from pests or diseases as the pest is deterred by the companion plant, or because it is attracted to the companion plant rather than the crop. • **Use barriers, baits and traps:** Barriers are physical structures that prevent a pest from reaching a plant. Baits and traps are traditional methods of attracting and destroying pests. • **Work with others:** Sometimes it is necessary to work with other farmers to destroy a pest. For example, the variegated grasshopper (Zonocerus variegatus) usually has 1-2 nests per hectare. These can be destroyed by raking out the eggs and leaving them in the sun to dry and die. The nest could be on another farmer's field but affect your crops.	• **Mechanical control:** There are cases where it is possible to pick pests directly off the crops, like caterpillars, cutworms, snails and other large insects. Smaller pests such as aphids can be squashed on the plant. Parts of plants that are diseased can be cut or broken off to prevent the spread of the disease. Squashing can also be done during scouting; when a pest is found, do not just record its presence but squash it too. • **Release of natural predators:** Some commercial enterprises breed natural pest predators and sell them for release on farms in order to quickly reach the required balance of predators to pests. • **Antagonistic microbial sprays:** Natural microbial pesticides, like Bacillus thuringiensis (Bt), a bacteria that breaks open the stomachs of soft-bodied insects like caterpillars, are available at some commercial outlets. • **Botanical pesticides:** If pests and diseases cannot be prevented or controlled by microbial, cultural and physical means, it may be necessary to use botanical pesticides as a last resort. Although these botanical sprays do not stay long enough in the environment to do much damage, it must be remembered that they may also kill the beneficial insects and organisms.

Making botanical pesticides with neem (Azadirachta indica)
Neem is effective against pests like the fall armyworm and stalk borers. Neem can be used both to prevent pest and to fight infestations.

Step 1: Pound and soak leaves: Pound 1 bucket (20 litres) of fresh loosely packed healthy neem leaves into a powder. Mix the pounded leaves with 1 bucket (20 litres) of water and allow to sit for 12 hours.

Step 2: Strain through a cloth: Place a piece of cloth over the opening to the knapsack sprayer or watering can and pour the Neem mixture onto the cloth. The cloth will catch the leaves and ensure that only the liquid goes to the sprayer or watering can.

Step 3: Appy neem pesticide: Pour the neem pesticide into a knapsack sprayer or watering can. Spray the plant with the sprayer or water at the base of the plant using a watering can.

Making botanical pesticides with Snake beans (Ndale) (Swartsia madagascariensis)
Snake beans pesticide is effective against termites, jassids, and aphids.

Credit: Beatriz Moisset, CC BY-SA 4.0 via Wikimedia Commons

Step 1: Pound and soak beans: Pound 50 grams of dry snake bean pods (approximately two hands full). Mix with 1 litre of water and allow to sit for 24 hours.

Step 2: Strain through a cloth: Place a piece of cloth over the opening of the knapsack sprayer or watering can and pour the snake bean mixture onto the cloth. The cloth will catch the bean pieces and ensure that only the liquid goes to the sprayer or watering can.

Step 3: Apply snake bean pesticide: Pour around plant or spray on leaves. It is best to apply the snake bean pesticide early in the morning or late afternoon.

Making botanical pesticides with Tephrosia (Tephrosia vogelii)
Tephrosia is effective against aphids, cutworms and termites. It can also be applied once weekly as a preventative remedy.

TEPHROSIA
(Tephrosia vogelii)

Credit: Neil Phillips, CC BY 2.0 via Wikimedia Commons

Step 1: Pound and soak leaves: Pound 1 bucket (20 litres) of fresh loosely packed healthy Tephrosia leaves into a powder. Mix the pounded leaves with 20 litres of water and allow to sit for 12 hours.

Step 2: Strain through a cloth: Place a piece of cloth over the opening to the knapsack sprayer or watering can and pour the Tephrosia mixture onto the cloth. The cloth will catch the leaves and ensure that only the liquid goes to the sprayer or watering can.

Step 3: Apply Tephrosia pesticide: Apply Tephrosia by diluting 1 part Tephrosia pesticide to 4 parts water, e.g., 1 bucket of Tephrosia pesticide to 4 buckets of water. Spray the plant with a knapsack sprayer or water at the base of the plant using a watering can. It is best to apply early in the morning or late afternoon. To prevent pest build up, apply to crops once a week, even when there are no pests.

1

POUND AND SOAK LEAVES

2

STRAIN THROUGH A CLOTH

3

APPLY TEPHROSIA PESTICIDE

5. FACILITATION SKILLS

Good trainers require good facilitation skills. A facilitator is someone that provides an enabling environment/atmosphere that gives space and freedom for participants to be able to express themselves and actively take part in the acquisition and sharing of knowledge. Facilitation is the process of moving people through a process – that can be a learning journey, a training session, it can be coordination of a team to set and achieve set goals, etc. This chapter outlines the steps involved in facilitating training in SOA.

5.1 Role of a facilitator

- Assist participants to learn and leads discussions during proceedings.
- Guides learners to objectives and relevance of session.
- Prepares training materials well in advance.
- Selects and applies training methods according to the situation.
- Selects training materials and training aids that are appropriate to the lessons.
- Manage session and helps in dealing with conflicts.
- Processes ideas of participants and clarifies on issues that are not clear.
- Assists participants to evaluate the process.

5.2 Qualities of a good facilitator

Some of the qualities of a good facilitator are listed below.

- A good facilitator always starts from the simple to the complex or known to unknown when discussing a topic. This important because farmer/participants have a wealth of knowledge, and it is possible that the course content may not be new to them at all.
- Enough patience to let others learn and good listening skills.
- Confidence in knowledge of the subject matter without being arrogant.
- Knowledgeable, creative, innovative and full of enthusiasm when dealing with a given subject or topic.
- Has good presentation skills (see more below).
- Dresses appropriately and according to the occasion (dress code)
- Some skill in drawing and writing, this includes writing and drawing on flipchart.
- Knowledge of group development and ability to sense moods and is flexible in changing programmes to suit the mood.
- A good sense of arrangement of space and materials to create an attractive environment for participants.

5.3 Required facilitation skills

- **Effective listening:** This means understanding the message as the speaker intended it and also understanding the speaker's perceptions which are embedded in the message. Thus, it requires an open mind without assuming that you know what the speaker wants to say. Assumptions are dangerous because your mind/brain hears your assumptions instead of what the speaker is actually saying.
- **Impartiality:** It is a facilitator's job to be impartial and ensure that attention stays on the content and not on one's own opinions.
- **Respect:** It is important to show respect for the views of participants and any speakers you may have invited. Model the behaviour that you would like participants to have. For example:
  - Stop talking, stop thinking about one's views and what one wants to say next.
  - Put the speaker at ease and show them you want to listen by giving them your undivided attention concentrating on what is being said and not who is saying it.
  - Follow not only words but body language, which through the use of eyes or gestures often underlines meaning and gives life to the message
  - Be patient and avoid interrupting. Ask relevant questions, especially to ask for clarification if you don't understand and to give the opportunity to the speaker to rephrase or under line.
- **Clarity of speech:** To ensure that one's message is clear, it is important to know in one 'own mind precisely what one wants to communicate. Speaking it out loud to a friend or colleague can help clarify one's own thoughts and get the message into an understandable form. It helps one's own understanding too. Translation from English into local Zambian languages makes the message much longer and it will need more time to convey. It is also very difficult to find exact word for word translations of English terms used in facilitation.

Consequently, translations MUST be practised and tested on colleagues and knowledgeable bilingual members of target group to ensure that they correct and appropriate.

- **Probing:** Probing is a skill that is used simultaneously with good listening. It involves making appropriate comment and asking questions, as naturally and unobtrusively as possible, whilst listening to a speaker to ensure that the speaker clarifies his thinking and deepens the analysis he is engaged in.
- **Non-verbal communication:** Non-verbal communication is expressed through body language. Often times, we send different messages using different forms of body language about our level of interest, commitment, attitude etc. these can be expressed through facial expressions, gestures, stance, eye contact, etc. It is important to be aware of the messages being sent by body language and the consequences of inappropriate body language. For example, certain gestures are highly charged culturally, especially pointing and dismissive gestures and where one positions oneself in relation to others can indicate shyness, but it may also be interpreted as showing an assumed superiority.

A note on presentation skills

Facilitators must have good presentation skills, these include:

- **Good voice projection** (not too low or too high) just loud enough to be heard.
- **Confidence:** Relaxed when speaking, is not intimidated by the crowd and can hold eye contact.
- **Understanding of what tone to use** in the particular context and understanding of how to navigate power dynamics, particularly related to culture and gender aspects.

5.4 Materials needed when facilitating

- Markers.
- Flipcharts.
- Flip chart stand.
- Cards.
- Pens and exercise books.
- Microphone for big audiences
- Post-it notes, etc.

5.5 Basic steps in facilitation

- There is lots of preparation work that must be done before hand, setting the objectives of the workshop making sure they are SMART (Specific, Measurable, Accurate, Realistic and Timebound) and designing the programme, as examples,
- Start by greeting the audience and leading participants in self-introduction. An ice breaker helps both the facilitator and audience to become comfortable in the space.
- Once people are comfortable or are getting to know each other, introduce the topic of the event with a little bit of background to explain its relevance, followed by outlining the objectives of the workshop. This helps participants to understand why it is important to direct their focus on the topic at hand. It also helps them to be inquisitive.
- Find out what participants already know about the topic, this helps you as a trainer to build up on what is already known. This is particularly important because the aim of facilitation is to move people from the known to the unknown or from the familiar to the unfamiliar.
- Clarify the different contributions/responses given so that the discussion remains as clear as possible and focused.
- Process all responses from participants and make comments or any additions to cement participants' responses.
- Summarise the discussion and conclude by emphasising the main aspects relating to objectives. This can be done by writing them on the flipchart/board/book noting that these points will then be used to form the basis for your recap and action points.
- Feedback and evaluation [recap] should be done at the end of the session/training to get an overall feeling of the participants in relation to the topic or the course. This provides the basis for improvement.
- If action steps were committed to by participants, then a follow-up might need to be organised to check the impact of the training.

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