SUSTAINABLE FARMING

Agroecological practices

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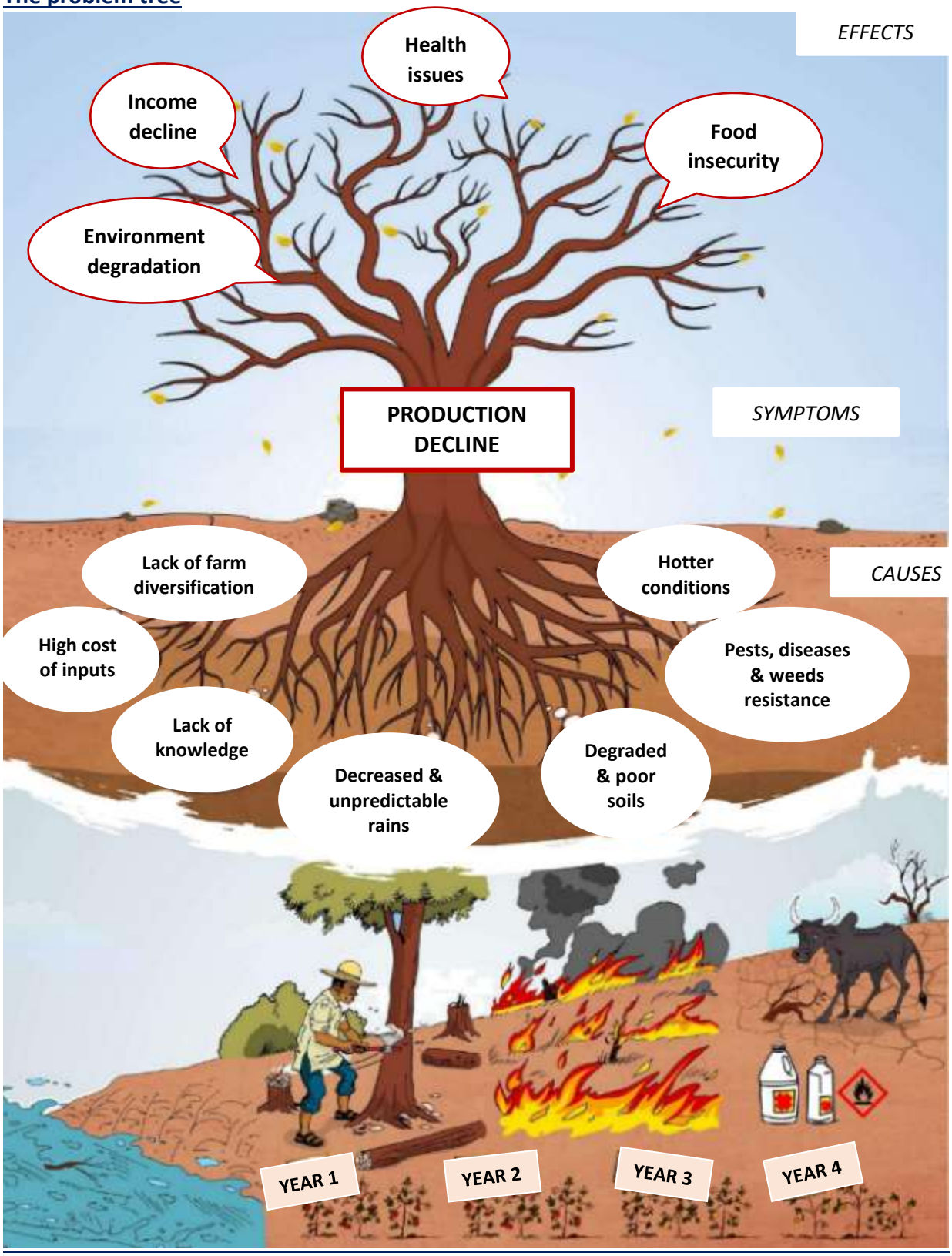
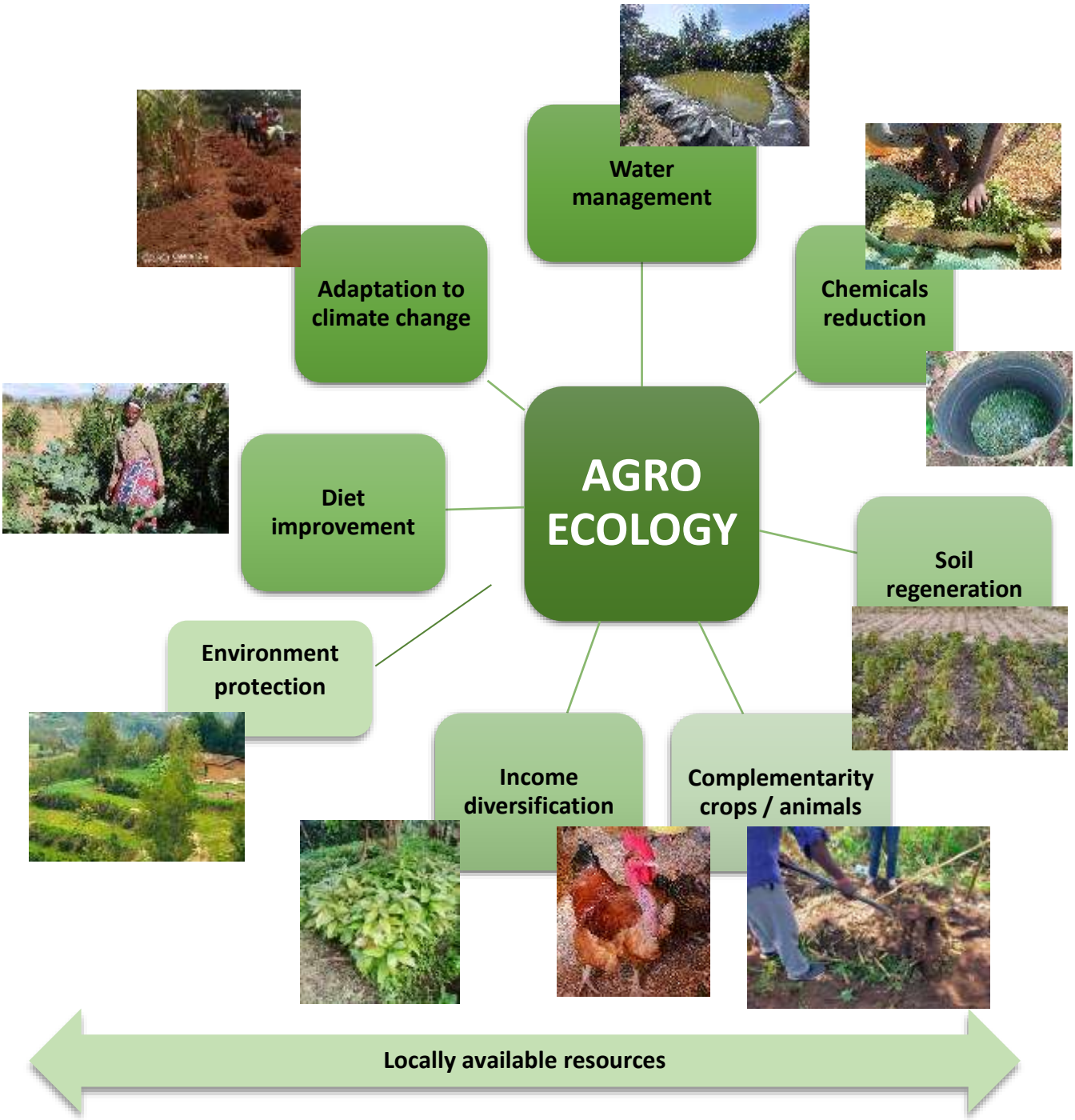
AGROECOLOGY : Principles and practices

1. GOING AGROECOLOGY: A NECESSITY AND AN OPPORTUNITY

The problem tree



The focus of CGA agroecology approach



Some agroecological practices

- Soil protection and water management: mulching, crop residues, terracing, basins
- Soil fertility improvement: manure/compost, mulching, legumes
- Crop rotation and/or mix-cropping
- Drought tolerant crops
- Production and use of organic inputs
- Planting of beneficial trees and hedge crops : Tithonia, Tephrosia, Leuceana, …

2. SOIL HEALTH SHOULD NOT BE NEGLECTED

A healthy soil is a fertile soil.
Soil fertility has 3 aspects :

Chemical health

- Nutrients content
- pH

- Soil flora
- Soil fauna

⇨ Nutrient release
⇨ OM decomposition
⇨ Aeration

Organic Matter

- Structure

⇨ Aeration
⇨ Water and roots penetration

Biological health

Physical health

Organic matter is at the centre through its impact on all aspects of soil health

Soil rich in organic matter:

⇨ Good structure
  => Good root development => good absorption of nutrients
  => Good water penetration and retention
⇨ Quick decomposition of crop residues, compost, … : nutrients are more available for crops
⇨ Strong crop

A soil pH less than 5,5 (acidic soil) affects organic matter and nutrients availability in the soil.
The efficiency of all types of fertilizers is reduced.
If your soil is acidic, it should be your priority to correct it!

How to assess soil health

- **Look** : colour, aspect
- **Touch** : sandy, aggregates, compaction, ….
- **Smell** : forest scent : rich in organic matter / bad smell : water-logging / little or no smell : poor in organic matter
- **Observe** water infiltration, roots development

In most cases:
•Dark brown to blackish soils=> rich in organic matter and microbial life. Healthiest
•Reddish soils => often infertile.
•Gray or pale soils => poor drainage, compaction. (chances of anaerobic reaction), limits root growth and water infiltration.
•Whitish soils=> High salinity issues, especially in dry regions. Also nutrient leaching

3. IMPROVING SOIL'S PROPERTIES

Biochar

Biochar is a soil amendment and improver resulting from the pyrolysis (= combustion without air) of raw materials such as maize cobs, sawdust, groundnuts shells, rice bran, …
Biochar's porous structure helps retain water and nutrients, making them more available to plants. It can also increase soil organic matter, improve soil texture, and boost microbial activity, all of which contribute to healthier and more productive crops.

<table>
<tr><th>Use of maize cobs (voluminous)</th><th>Use of rice bran, sawdust, …</th><th>Trench or pit biochar</th></tr>
<tr><td colspan="3">Building the pyrolizer and preparing the materials</td></tr>
<tr><td> 
1 barrel</td><td> 
1 barrel or ½ barrel</td><td> 
Dig a conic pit in the soil (0.5 to 1m deep and 1m wide)</td></tr>
<tr><td colspan="2">Chimney : 1.5m lenght / 15cm diameter</td><td></td></tr>
<tr><td>Maize cobs
Firewood
Liquid manure</td><td>150kg bran, sawdust, shells
Firewood
Liquid manure</td><td>Dry organic material such as grass, corn cobs, corn husks, wood scraps, branches, leaves, cow dung, … Cut the bigger ones</td></tr>
<tr><td colspan="3">Pyrolysis process</td></tr>
<tr><td colspan="2">1. Put the firewood in the bottom of the barrel and light the fire.
2. Add the raw materials :
○ Inside the barrel for maize cobs
○ Outside the barrel to cover it fully for sawdust, rice bran, ….
3. Close the barrel
4. Wait for the pyrolysis to be finished (can take up to 12h)
 
  </td><td>1. Put the materials in the pit, the easier to burn at the top
2. Light the fire from top. If the materials are very woody/heavy, add the biomass progressively as the burning progresses in it
3. Moderate the fire. The goal is to have a slow, smoldering burn. You can add an iron sheet to cover the pit
4. When the smoke thins out and the flames subside, it is time to stop the fire by adding water or a 10 cm thick layer of soil</td></tr>
</table>

Stabilization of the biochar

When the pyrolysis is finished:

5. Add a bit of water to put off the smoke and let the biochar cool down
6. Crush the biochar into small particles
7. Store the biochar in bags for 2 days then add liquid fertilizer to stabilize and enrich the biochar – outside of the bags, pour **1L of liquid fertilizer for 1kg of biochar**. You can use liquid manure, Tithonia or Tephrosia tea, vermiliquid, rabbit urine, etc
8. Store the final product in bags for at least 4 weeks to allow complete maturation

- The stabilization/charging of biochar with liquid manure is crucial – it is better not to use any biochar than to use an un-stabilized one since it will suck out nutrients from the soil (it acts as a sponge)
- By improving nutrient availability and water retention, biochar can potentially reduce the amount of fertilizer needed, especially at planting stage, but it depends on the soil nutrient content
- Biochar should be buried and mixed with soil for better efficacy, so better applied at land preparation stage or planting
- Biochar can be added to compost in the place of ash, it can help improving nutrient retention, and microbial activity within the compost pile, leading to a more stable and beneficial end product.

Rate of application

800kg to 2T/acre (once only for 10 to 15 years) – proceed portions by portions.
You can also bring smaller quantities over multiple years (ex: 200kg/acre on 4 to 5 years).

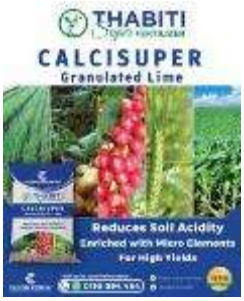
4. Liming

Agricultural lime neutralizes soil acidity and raises soil pH. It is made from limestone.
There are 2 types of lime : dolomitic and calcitic : both bring Calcium but dolomitic lime also brings magnesium. Dolomitic lime is recommended in magnesium deficient soils, but the pH adjustment is slower than with calcitic lime.

Lime can be found in powder or as granulates. Here are the main differences:

Factor	Granulated Lime	Powdered Lime
Primary Goal	Short-term maintenance or localized (in-furrow/in-hole) correction.	Long-term, deep correction of total soil acidity.
Reaction Rate	Very fast (fine particles are quickly released upon contact with moisture).	Slow and sustained (contains coarse and fine particles; coarse particles work over many years).
Application Rate	Low rate is required to achieve a quick, but short-lived, pH spike.	High rate is typically required for full soil neutralization.
Cost	Expensive per ton (due to processing).	Least expensive per ton.
Duration	May require frequent applications (often yearly) as is it localized and as the fast-acting lime is quickly neutralized.	A single large application can correct pH for 4–8 years.
Ease of Use	Easy to apply, together with fertilizer, with little dust.	Specialized spreaders can be needed and may be dusty and hard to handle.

The rate of lime to be added on a plot depends on the acidity level, but generally the recommendation is round **2 tons/acre for powdered lime and 300kg/acre for granulated lime**.
If the lime application is split over multiple seasons, it is recommended to bring at least 1T/acre of powdered lime per application, until reaching the total lime requirement.
Agricultural **powdered lime** should be applied to soil **at least two months before planting** crops, ideally after harvesting and before tilling for the next planting season. It needs to be incorporated in soil to ensure maximum efficacy.
Granulated lime (ex: Amiran Calcipower, Thabiti Calcisuper, Chiromo Fertilizer Calcigrow…) can be applied **at planting**, mixed with fertilizers for a localized effect.



- Don't bring more than 3T/acre per season. Too much lime could create a temporary too alkaline soil and lock certain nutrients
- If applying the powdered lime requirement is too expensive at once, you can start by a small portion of your field or split the lime requirement provision over 2 or 3 years, but the minimum dose per season should be 1T/acre
- Clay soils require more lime than sandy soils to achieve the same pH change
- Generally, for most crops, a pH between 6 and 6.5 is recommended

ORGANIC FERTILIZERS PRODUCTION AND USE

- Increase organic matter in the soil
- Improve soil structure
- Reduce fertilizer costs

5. ANIMAL WASTE

The most accessible source of organic fertilizer and soil improver is Farm yard manure (FYM - *Thumu/Mbolea/Mboleo*).
But its management should not be neglected!
In most cases, it is comprised of a mix of cow/goat dung or chicken droppings, animal urine, waste from grass, bedding material (straws, hay), feedlot waste, crop residues or other dairy byproducts.

Ensuring the quality of FYM

Before Collection

1. Provide a mixed, nutrient-rich diet to animals, as the quality of their feed directly impacts the nutrient content of their manure.
2. Ensure animals are housed in a roofed structure with a floor that allows for easy collection of manure. The roofing ensures that the FYM is not rained on and is not soggy. This also ensures that the health of the Animals is assured.
3. Use absorbent litter materials to capture urine and create a balanced carbon-to-nitrogen (C:N) ratio, which is crucial for decomposition and nutrient availability. This includes among others wheat straw, maize stover, banana twigs and Tree leaves

During Collection & Maturation and storage

1. Collect manure regularly from the housing area.
2. If possible, incorporate the collected manure to compost to improve its quality and make it safer for handling and application (cf section 5).
3. Regularly aerate and mix the manure pile to promote decomposition and reduce odors.
4. Store manure on a waterproof surface, such as a concrete pad, to prevent nutrient leaching into the soil.

5. Protect the manure heap from direct sunlight and rain – ideally cover the manure heap with a roof or a plastic sheet. The covering should be placed at a height of 1ft to 2ft above the heap to allow for air exchange without heating up.
6. Keep the heap height manageable (around 1 meter) to allow for proper aeration and prevent compaction, which can hinder decomposition. The width can be maintained at 1.5 M to allow for heat generation during composting and easy management, especially when turning of the pile.

Application

1. Spread the manure evenly to avoid clumps and ensure consistent nutrient distribution across the field.
2. Once the manure is spread in the field, mix it into the soil as soon as possible to prevent nutrient loss from exposure to air and sunlight.

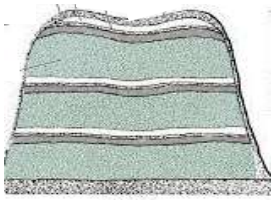
6. CLASSIC COMPOST

Many other materials can be added to animal waste to increase the quantity of organic fertilizer

Composting helps in killing weed seeds and germs responsible for diseases

2 ways of building the compost:

HEAP



HOLE

COMPARISON	HEAP	HOLE
ADVANTAGES	• Easier to manipulate • Requires little ground space	• Benefits from underground microbes
DISADVANTAGES	• Can easily be washed away if not well covered nor structured	• More effort to dig the hole and turn the compost (requires a 2nd hole next to the first one) • Risk of flooding of the compost

Compost making process

Materials:

- **Dry matter** : straw, molasses, grass, barks, branches …
  - ⇨ *Bring energy to the microbes*
  - ⇨ *Long-term decomposition => long-term effect*

Avoid pine and eucalyptus leaves, onions & citrus waste

- **Green matter** : leaves and stems of legumes: beans and peas, groundnut, tephrosia,..., azolla, sunflower, leaves of trees (banana leaves are rich in potassium), vegetables and fruit peels

  - ⇨ *Easily digestible*
  - ⇨ *Provide sugar and proteins for the growth of microbes*
  - ⇨ *But, they don't have a structure -> they block air and water flow => need for dry matter*
- **Nitrogen activators** : comfrey or tithonia moist leaves, raw cow or goat dung, chicken droppings
- **Enriching materials** : bone powder, crushed egg shells and ash (pH neutralization), urine
- **Accelerating ingredients** : rumen juice, yeast (cf Bokashi, p15)

The more materials rich in nitrogen (Tephrosia, Tithonia, comfrey, legumes, Sesbania, Calliandra, Leuceana leaves, …), the more efficient the compost

Hole/heap dimensions:

Length*width : 1.50 m*1.50/2m ; depth/height : 1.2 to 1.5m ideally

Layering:

1. Dry materials with some branches at the bottom of the pile to ensure infiltration of water and aeration of the compost (5cm)
2. Green materials (20-25cm – *4-5 times thicker than dry materials layer*)
3. Fresh manure mixed with sub-soil (5cm)
4. Ash (1cm)
5. Repeat these layers until filling the hole. For heap, repeat as many times as the materials are available

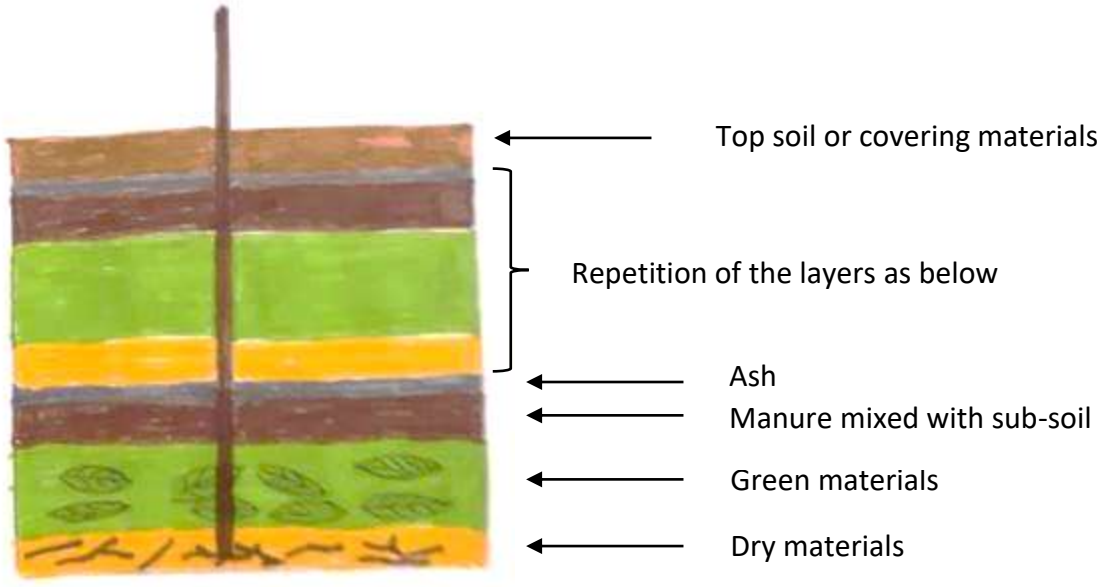
Add water to humidify the materials between each layer

Use a wood stick to appreciate the temperature during the process. If it is too hot, add water

Turn the compost after 15 days

The compost is ready in 90-150 days, which depends on the materials considered.

Cover the heap/hole with top-soil or covering materials (8cm) to limit evaporation and/or put it under tree shade or shelter.



Compost is mature and well done if:

- No bad smell - almost forest soil smell
- Shrunken pile
- It has a brown color
- Absence of coarse, humus-like materials

The richer the animal feed, the richer the nutrients content of compost

Nutrients content of different composts (literature and CGA analysis)

Type of compost	Nitrogen (N) kg/100kg compost	Phosphorus (P) kg/100kg compost	Potassium (K) kg/100kg compost
Matured goat droppings	0.3 to 2.9	0.05	1.5 to 2.1
Matured cow dung	0.6 to 3	0.2 to 2	0.5 to 1
Matured chicken dropping	~3	~2.6	~1.4
Mixed compost (green and dry matters, kitchen waste, animal dejections, etc)	1.4 to 2.5	0.18 to 0.3	0.49 to 1.05

7. BOKASHI

Bokashi is an accelerated compost.

Ingredients

- Crop residues, green leaves
- Fresh livestock dung
- Ash
- Yeast
- Rotten fruits

Steps

1. Mix **4 parts** of plant residues (mostly fresh materials, green leaves from fertilizer trees preferably) with **3 parts** of fresh livestock dung, **3 parts** of virgin soil and 0.5 parts of ash with small particles of charcoal to host micro-organisms
2. Mix all the ingredients and add water to form 1 mixture
3. Sprinkle the heap with a teaspoon full of yeast in 500ml of water and/or rotten fruits (or 0.5 parts of maize bran soaked in water over night, or local beer wastes)
4. Cover the heap with either banana leaves or a black plastic sheet to maintain temperature.

The heap is fully decomposed after **21 days**. If not used immediately, the compost should be stored under shade.

To enrich and/or accelerate compost or bokashi, many ingredients can be added: fresh milk, yeast, maize bran soaked in water, coffee grounds, rice water or cooked rice, animal or human urine, egg shells, …

8. 7-day compost

3 months to get compost is too long!!

You can get a compost ready in 7 days thanks to a natural activator

Materials required

- A rumen from a ruminant (preferably a cow).

Where to find this? In any slaughter house

The rumen juice pre-activator must be prepared within 2-3 hours after collection from the animal

- 5L rumen juice
- 3kg of rice/rice husk or 3.5kg of maize bran/flour
- 10L water
- 1kg of sugar
- Plastic buckets (2)

Preparation of the activator

1. Cook the rice/rice husks or maize bran/flour
2. Let it cool down until it is slightly warm
3. In a bucket, add 10L of warm water and the cooked rice/maize
4. Collect 5L of liquid from the rumen in another bucket (the rest can be put in a compost)
5. Add the 1kg of sugar in the rumen juice
6. Stir
7. Pour the rumen juice + sugar in the rice/maize + 10L water in the bucket containing the rice/maize and water
8. Stir for 5 minutes
9. Cover well (no air must enter) and let this pre-activator rest for 7 days

You can use the full content of the rumen, you will get a solid activator

Compost preparation and activation

1. Dilute 1L of activator in 10L water for a 2m3 of compost
2. Prepare the raw materials for compost as usual (cf p8)
3. Make the 1st layer of compost with the dry materials, the green materials and the animal dejections
4. Pour some activator
5. Repeat a second layer
6. Add activator between each layer
7. Cover the hip and let it rest for 7 days, mixing every 2 days

When the pre-activator is ready (after 7 days) 1L activator + 10L water for 2m3 compost

Preservation of the activator

If you remain with some activator, to keep it still alive, you can add more rice/maize + sugar + water every 3 weeks (expiry if no more feed). It can last up to 5-6 months when adding feed regularly.

“Good” activator: clear colour and yeast/bread smell // “expired”: black colour, bad smell.

9. VERMICOMPOST

Different sites for vermicompost



The worms will multiply better if they are in a temperate atmosphere
The site must be covered to be protected from animals and sun.
If it is on the ground, cover the ground with a tarpaulin or plastic cover so that the worms can't get into the soil.

Vermicompost fabrication and maintenance

1. Put feed for the worms at the bottom of the container, cut into small pieces (ex : raw manure, fruit and vegetable peels, straws, …) **Don't put tephrosia nor cow dung freshly dewormed, it could kill the worms. Also avoid pine, eucalyptus, citrus, pili-pili, …**
Having a right balance of dry matter and green/ fresh feed is very key.
2. Place the worms above the feed

3. Cover to protect the worms from potential predators such as chicken, birds, rats, … and add water to it

4. Add water in the compost when necessary. It must always be moist but not too wet (no water should leak if you squeeze the media). You can harvest the vermiliquid by piercing a hole at the bottom of the container but the concentration might not be very high.

If a bad smell develops, remove the feed provoking the bad smell.

***Other option**:*
You can prepare a pre-compost by mixing the feed + 10L water.
After 3 days, add 10L of water again.
After 3 more days, you can give the pre-compost to the worms.
No need to add more water during the decomposition cycle

5. When the compost is ready
If the compost is in a *mtungi*

- Pour the compost + worms in a half mtungi with small holes at the bottom
- Add new feed in the 1st (empty) half-mtungi
- Place the half-mtungi containing the compost + worms above the half-mtungi with the new feed

Rapidly, the worms will migrate to the new feed through the holes

Other cases:

- Add new feed on a side of the container or in the adjoining container separated by a partition with holes
- The worms will migrate to the new feed
- Remove the mature compost

6. Remove the eggs from the mature compost by putting some new feed on a side of the mature compost. After 4-8 weeks, remove the newborn worms and put them in the raw compost, and remove the bait feed from the mature compost.

The worms are hermaphroditic, they can reproduce alone or with a partner. An adult can lay one egg capsule every 7-10 days which contains, on average, 2-12 worms.

7. Store the mature compost in bags or jericans

The compost is ready from 3 to 8 weeks.

- To prevent ants, put the feet of the unit in a cup of water or apply petroleum jelly pr old oil on the feet of the unit

- 1kg of feed -> 600-700g of compost
- Don't add new feed until the initial feed has become compost
- Don't put too much water, it must be humid but not wet
- You can use the juice from the vermicompost as a liquid fertilizer or an organic pesticide
  Dilution : 1L vermiliquid : 5-8L water
- Worms can be fed to chicken or fish.
- In winter, adding coffee grounds or comfrey can boost worms activity

Nutrients content of vermicompost or vermiliquid macerated 24h

This data comes from lab analysis of samples from different CGA farmers

Nitrogen (N) kg/100kg compost	**Phosphorus (P) kg/100kg compost**	**Potassium (K) kg/100kg compost**
2 to 2.5	0.25 to 1	0.09 to 1.5
Min quantity for maize 0.25 acre	**Qtity for cabbage, potato 0.25 acre**	**Qtity for spinash 0.25 acre**
450kg (up to 1600kg if soil very low in P)	900kg + TSP + MOP Or 2000kg	800kg + K supplement

10. TITHONIA TEA

When the crop is growing, it is not easy to use a solid form of organic fertilizer. That is when a liquid fertilizer is useful.

Tithonia Diversifolia (*Kiruru or Maruru in Kikuyu, Mang'ana in Kimeru, Mauat, Nengwan in Kalenjin*) is a very common shrub along roads, fields, …

Tithonia is very rich in (K) Potassium (3-5%) and (N) Nitrogen (2.5-3.5%).

Tithonia is very useful for vegetables and potatoes that need a lot of Potassium (spinach, cabbages, …)

The nutrient content can vary depending on the location and maturity stage.

Harvest the mature leaves preferably right before the flowering stage. If it has flowered, add more tithonia (it is less rich after flowering, but still usable)

Tithonia tea preparation

1. Chop **1 kg** of fresh leaves and twigs
2. Place them in a bucket
3. Add **3 litres** of water
4. Let it **macerate for 2 weeks**; make sure the lid is tightly sealed
5. **Stir** every 2 days to enhance the extraction process
6. When you're ready to use it:
   a. Dilute the **3 litres** Tithonia tea with **3 litres** of water
   b. Pour the diluted tea into the knapsack

Be careful to sieve the maceration or add a 2Nd layer of filter on the knapsack not to block its nasals

You can store the Tithonia tea in a sealed container, in a cool and shaded space.
It can be stored up to 6 months but the highest Nitrogen content is found after 2 weeks of maceration.

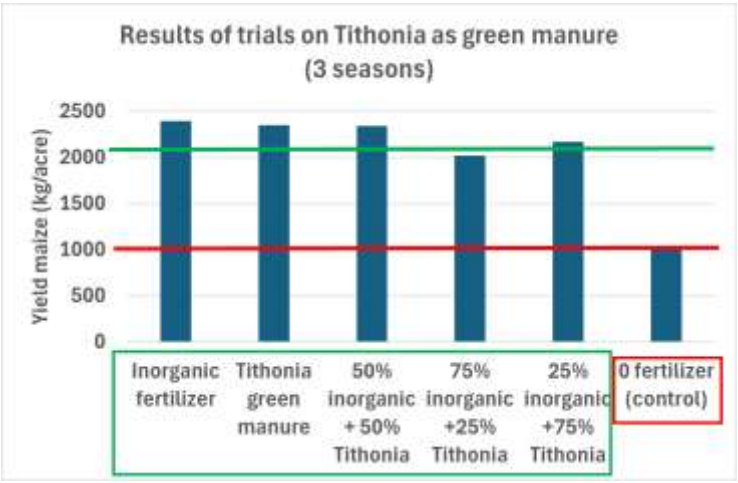
Maceration:
1 kg Tithonia : 3L water
Dilution for use :
1L Tithonia tea : 1L water

AVERAGE NUTRIENT REQUIREMENTS FOR MAIZE, VEGETABLES AND POTATO

	Nutrients requirements (kg/0.25 acres)			Kg of Tithonia needed per 0.25 acre
Crop	**N**	**P**	**K**	
Maize	10	4		**410 (planting + TD)**
Spinach	16	1.1	16.5	**500 - 625**
Cabbage	18	4	25	**500 - 750**
Potato	18	6	34	**900-1200**

From 200-250 kg fresh Tithonia leaves macerated, you can top-dress 0.25 acres of maize

Some fresh cow dung or comfrey can be added to Tithonia tea to enrich it even more
Tithonia can also be used as a green manure : put 1 handful of fresh chopped Tithonia per planting hole, better one month before planting.
Tithonia + neem can help controlling Tuta Absoluta on tomato.



CGA video on using Tithonia as an organic fertilizer: HERE

Variation: Tephrosia vogelli

Tephrosia vogelli appears to be a better organic fertilizer than Tithonia, go and multiply it!
And it is an organic pesticide (see page 32) and a legume. It can be added in the Tithonia tea or used as green manure or incorporated in compost.
Tephrosia Vogelli nutrients content (from a lab analysis): N: 5.27% / P: 0. 01% / K: 0.06%

Tephrosia should not be given to fish, it can kill them, nor to be put in the vermicompost

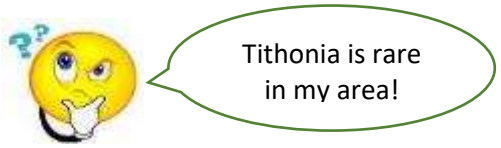
Multiplying Tithonia and Tephrosia:

	Tithonia	**Tephrosia**
Multiplication by	• Seeds – can be started in a nursery • Cuttings from ligneous branches – during rainy season	Seeds Soak the seeds 24h before planting them
Spacing	1m between plants	0.6 to 1m between plants

11. LIQUID MANURE

Tithonia is not available or in too little quantity?
There are other materials available for organic fertilizer?

⇨ You can make a liquid fertilizer!



Materials

- Solid elements:
  - Raw animal wastes and droppings
  - Stems and leaves from legumes (pigeon pea, beans, crotalaria, leuceana…), fertilizer plants (comfrey, tithonia, tephrosia, …)

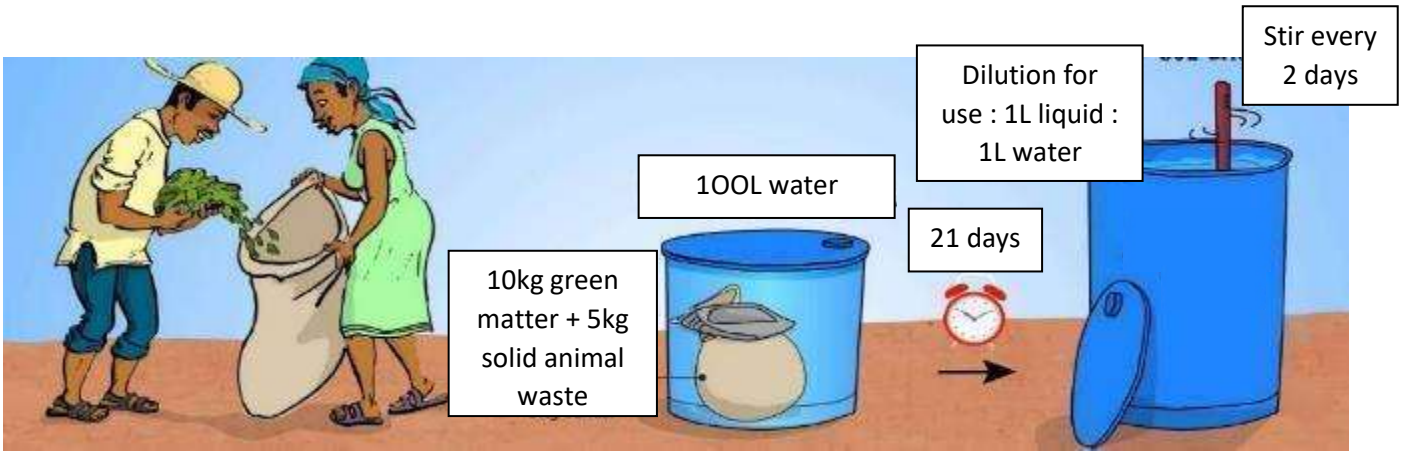
The liquid can be made from green materials only, animal wastes only or both mixed

- Water

Process

There are 2 ways :

- Directly putting the solid elements into the water. This will require to be sieved before use using cotton material at the opening of the knapsack sprayer
- Tying the solid elements into a bag and then soaking the bag in water



Apply 500 to 1000L of the diluted liquid in 0,25 acres of vegetables

12. RABBIT URINE

Rabbit urine nitrogen content varies according to what the rabbits are fed with, but here are some data from literature:

Nitrogen (N)	Phosphorus (P)	Potassium (K)
1.03 to 3%	0.01 to 2%	0.5 to 3%

Rabbit urine can be used as a liquid fertilizer with a dilution of **1L urine for 10L water for 10m²**.

It is said to be the most concentrated urine in Nitrogen because rabbits drink very little water.

The more proteins in their diet, the richer in nitrogen their urine.

- Beware of not burning the leaves when spraying as it is rich in nitrogen, thus importance of diluting it and **drenching** (rather than foliar spray)
- Rabbit urine is said to have a **pesticidal** effect, especially against Fall Army Worm (reduces the feeding of the larvae) and **antifungal** properties.
- Let the fresh urine ferment for 2 weeks in a sealed container. You can add 50g of sugar and 10mL of fermented milk for 1L of urine.
- For use, you can add soap for sticking effect and ash to maximize effect
    - Prevention : 1L of sieved fermented urine for 10L of water
    - Peak of infestation/infection: 1L for 5L water
    - Used as foliar spray
    - From 1L of raw rabbit urine, you can treat 10m² of land

13. BLACK SOLDIER FLY COMPOST

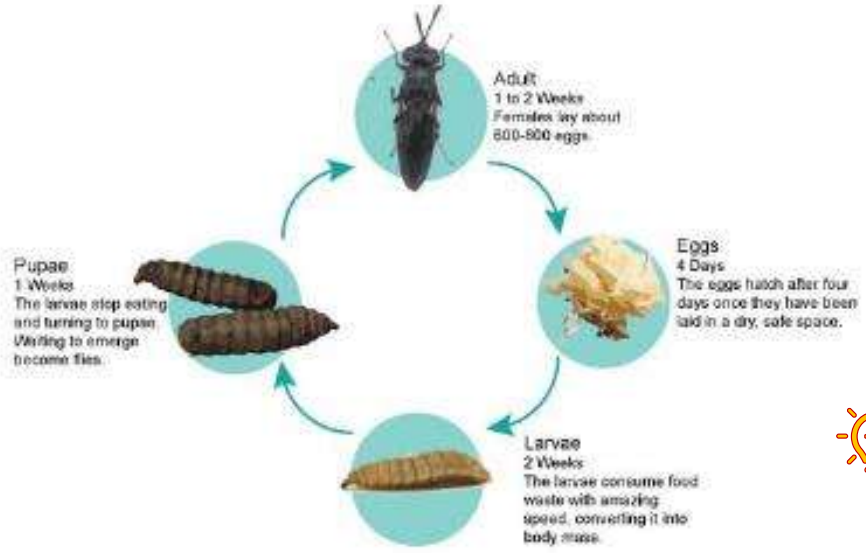
Advantages of BSF

- It is fast, efficient, and no hassle
- Soldier Flies are easily found
- You can feed them anything biodegradable
- Meat and fermented waste are some of their favorite feeds
- They dispose of all waste quicker than worms
- Maintenance is very little

Process

- Make a box closed with a net
- Enclose some flies in the box with some feed like vegetables peels, manure, …
- Inside this box, place some wood sticks, straws or rubber pieces, … where the flies can lay their eggs (they like to “hide”). A fly can lay from 400 to 800 eggs

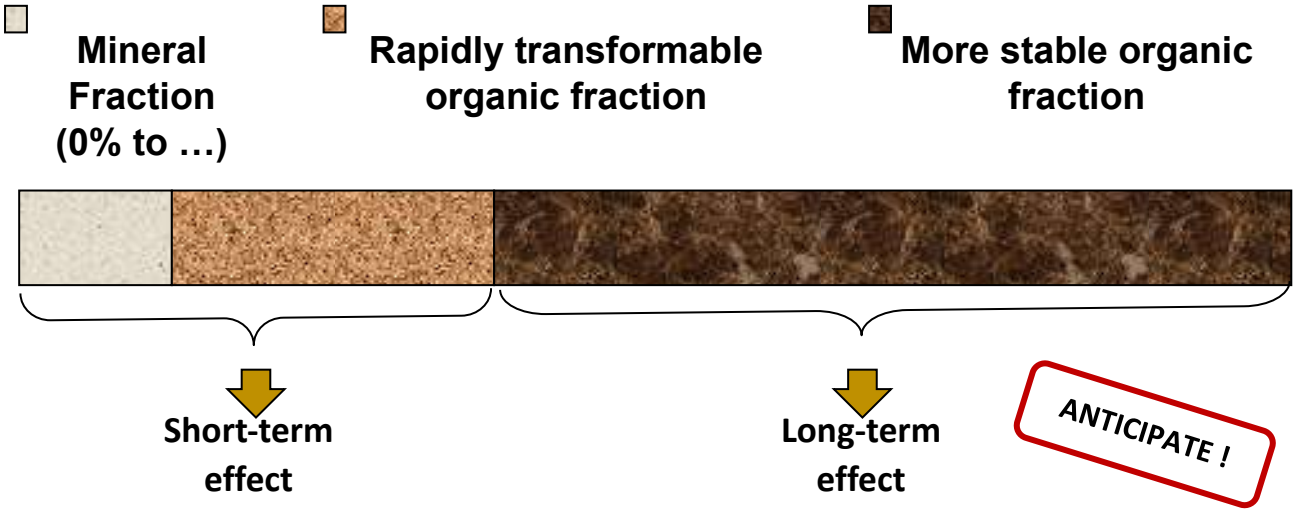
- When the flies have laid the eggs, take the eggs and put them in a half-mtungi with vegetable peels, meet, blood, carcasses (not from animal dead from a disease), manure, … Cover it because they like darkness
- The larvae (after the eggs hatch) will feed on them. When the feed is composted, sieve the larvae and place them in a mtungi with new feed
- The larvae last for roughly 18-22 days. When the larvae have turned black and they are very hard, put them back in the adults box for them to reproduce again. It takes about 2 weeks to pupate and emerge as a mature Soldier Fly
- Adult flies live for 1 to 2 weeks. The larvae and dead flies can be fed to chicken



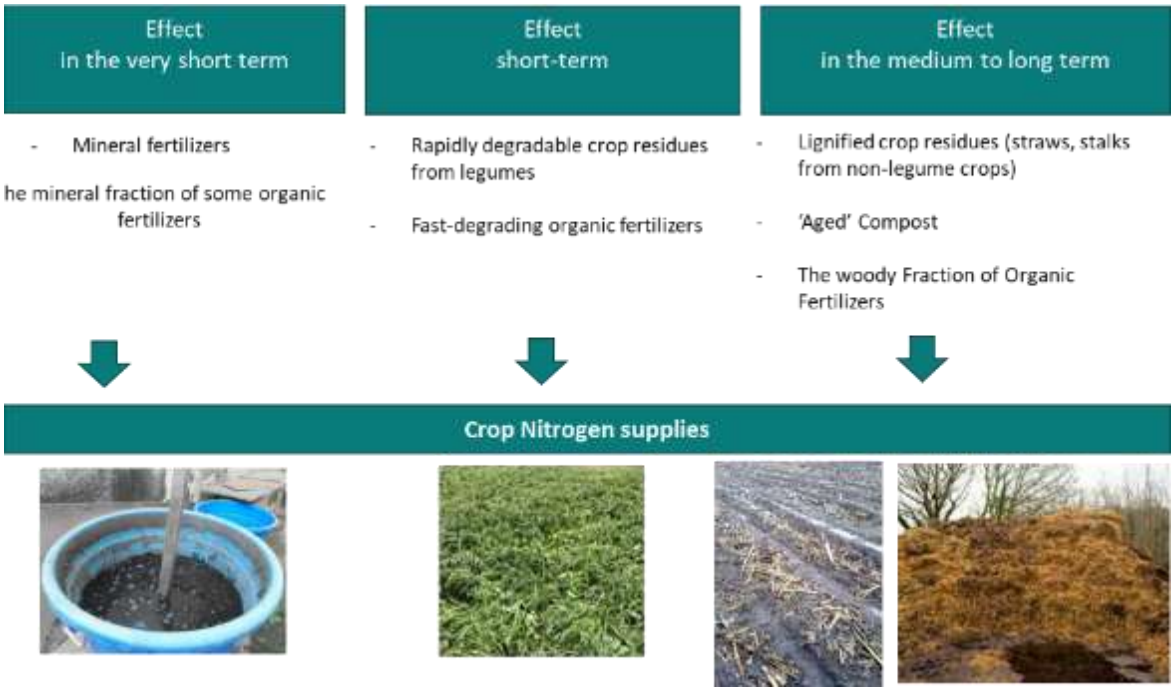
After 5 generations, you need to import new adults for reproduction (new genetics)

14. HOW AND WHEN TO APPLY ORGANIC FERTILIZERS

All organic fertilizers have 3 fractions :



The more lignified components in the compost/manure, the longer it will take for the Nitrogen to be available for the crops, so it is often recommended to put the compost/manure 2 weeks to 1 month before planting.



It is important to bury the manure, compost, green manure,… to maximize the decomposition and avoid losses by evaporation
The choice of the type of organic fertilizer depends on materials availability and your objective!

Concretely in the field:

All types of compost with or without fresh green manure (Tithonia,Tephrosia, Comfrey, … leaves) can be used at any stage of crop growth.
Solid forms are more appropriate for planting while liquid forms are more convenient when the crop (especially cereal and legumes) are already grown.

- In planting holes: 1 handful of compost or green manure per hole
- In Zaï-pits : 1kg per hole (2 handfuls) for the smaller zai-pit
- For seedlings in a nursery : ¼ compost mixed with ¾ soil
- Planting trees : 1 to 3kg of compost per planting hole
- Vermiliquid: dilution: 1L vermiliquid : 8-10L of water

Liquid fertilizers are more efficient when applied by drenching.

For those having an additional biopesticide effect, they can be sprayed as foliar.

15. EFFECTIVE MICROORGANISMS AND RHIZOBIUM PRODUCTION

Effective Microorganisms (EM) are a group of beneficial microorganisms, primarily bacteria and yeasts, used to improve soil health, plant growth, and overall environmental conditions.
Rhizobium is a bacteria naturally produced by legume plants roots in their nodules. It helps catching the nitrogen from the air, thus reducing the need for external input of fertilizer to these crops.
They can't be produced from scratch on the farm, but from a commercial primary source, they can be multiplied to reduce costs.

Production of effective microorganisms:

To develop microorganisms:

1. Cook 100g of rice or maize or wheat and let it cool down
2. Put the cooked cereal mixture in a container, dark/opaque preferably to be protected from light, well tight
3. Boil 100g of a legume (beans, pea grains) for 10min and crush them
4. Put the cooked legume mixture in a separate container, dark/opaque preferably to be protected from light, well tight
5. Store the 2 containers in the dark for 7 days but in a warm environment (prevent from decrease of temperature). You can place them in a hail bail for example.

To activate the microorganisms and prepare a usable solution:

1. Mix 2 glasses of sugar with 20 glasses of water (ideally non-chlorinated or rain water) and 2 glasses of the water used to wash rice before cooking it
2. Add 2 glasses of fresh milk or 1 plain yoghurt
3. Add 1 spoon of yeast
4. Mix all
5. Add 1 spoon of the microorganisms from the rice/maize preparation
6. Add 1 spoon of the microorganisms from the legume preparation
7. Mix everything and place it in a container well tight in the dark for another 7 days. Every 2 days, open slightly and briefly to release the gaz.

Use on the field:

5L of activated solution for 100L of non-chlorinated water – dose for 10m² area (= 50L of activated solution + 1000L of water for 0.25 acres)
Spray on the soil, preferably where you have just put manure or compost

Method n°2 to prepare EM:

Development of the microorganisms' substrate:

For a container of 110L of volume:
This is what you need:

- 4 kg of litter (from forest, bamboo lots) composed of leaves and plants decaying with white filaments (mycelia) that indicate the presence of many microorganisms. If a lot of litter is available, it is advisable to put more (for example 25 or 30 kg) and then put less cereal bran.
- 10kg of bran or cereal flour (sorghum, millet, maize, rice ...).
- 1.2 kg of brown sugar or sugar cane molasses. You can also use cane juice, bee honey, juice or fruit puree rich in sugar
- 1.2L of milk
- +/- 4L of non-chlorinated water (rain water) – the quantity may vary (see below)

Don't put green matter, it could rot

Process:

1. Spread the litter on a tarpaulin or concrete (to avoid contamination by soil) and remove if needed green matters, big woods or fruits
2. Add the cereal bran or flour
3. Mix well
4. In a bucket, mix the sugar + the milk + the water
5. Water little by little the pile of leaves and bran with the liquid mixture in the bucket while someone keeps on turning the pile to homogenize the wetness
6. Once the bucket is empty, add water if necessary by regularly checking the humidity with the fist test.

Fist test *to check the consistency: take a handful of the mixture and squeeze it very hard in one hand. No water must flow from the hand because otherwise it means that there is too much water and it is then necessary to add "dry" = bran.*
When you open your hand the ball formed must remain in place, otherwise it is that the mixture is too dry and you have to add water.

7. Put the mixture in containers. You need to pack/tamp the mixture to remove the air.
8. Close the container tightly and let it rest between 3 weeks and 1 month in a place in the shade, as cool as possible.

Shelf life: 1 year or more
You can use 20L of this mixture instead of litter when you want to produce more substrate
When opening, the mixture should smell very good, sweet smell. If possible, check the PH which should be between 3.5 and 3.8.
If the mixture has an unpleasant smell, a "rotten" smell or the PH is too low or too high, then discard the mixture

Preparing the microorganisms solution:

For a 100L container, you need:

- 5 kg of the solid substrate of EM made previously (5% by weight)
- 5L of milk or curdled whey (5% by weight)
- 5 kg sugar (5% by weight)
- Pure, non-chlorinated water

Process:

1. Put in the container the milk, sugar and add a little water, mixing well to dissolve the sugar.
2. Then place the 5kg of solid EM substrate in the container.
3. Finish filling the container with the water and then mix everything.
4. Finally, close the container tightly and leave it in the shade in a cool place
5. Soak 1 week in a tightly closed container before use.

You can reuse the EM solution to produce more: in a container of 100L, mix 10 of previously prepared liquid substrate and mix it with 5 kg of sugar, then fill the container with pure and non-chlorinated water.

Application:

- On vegetables and cereals, dilute 1L of the solution in a 16L knapsack and spray on the leaves. Apply 1 time/week.
- On the ground before planting, dilute 6.5 L for a 20L knapsack

You can replace the litter substrate or the rice and legumes mixtures (practice 1) by a commercial EM solution

Multiplying rhizobium

Rhizobium is a soil bacteria that fixes nitrogen. It creates a symbiosis with legume roots and catch the nitrogen from the air for the benefit of the legume growth.
You can buy rhizobium in an Agrovet, but you can also multiply it to cut on cost.

For a 100L container, you will need::

- 400g of legume roots : use plants from a disease-free soil, choose parts of roots with well-developed and active nodules (pink substance when you press the nodule)
- 1kg of sugar + 20L of water
- 10L of lactoserum or 2L of milk (not compulsory)
- Water to fill up to 80L of the container – rain water preferably

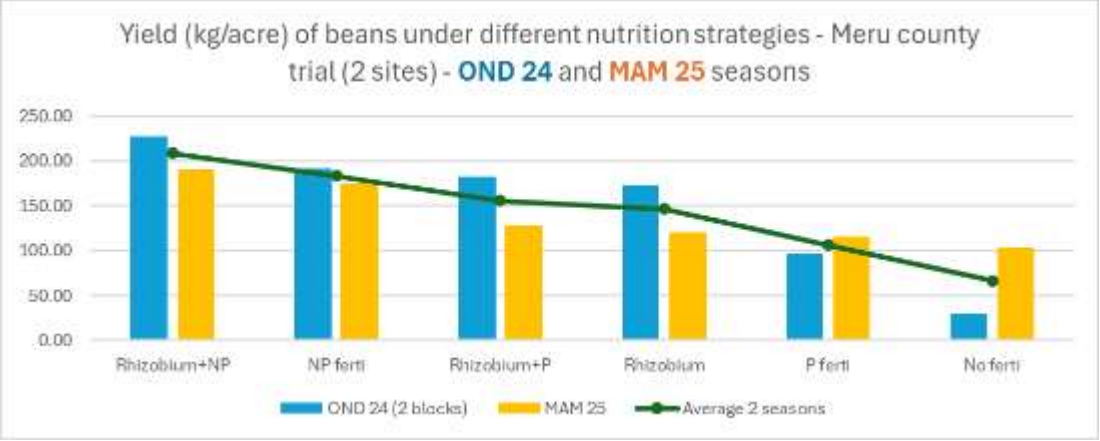
Process :

1. Dilute the sugar in the 20L water
2. Clean the collected roots with water
3. Cut the roots in small pieces and crush them
4. Put in the container and add the sugar water and mix
5. Pour the milk
6. Add enough water to fill the con tainer up to 80L
7. Close tightly the container and let it ferment for 14 hours

Application :

- Dilute 4L of rhizobium solution in a 20L knapsack
- To be applied at planting of legume crops

- You can replace the inoculant made from the nodules of the legumes roots by a commercial rhizobium.
- You can keep the rhizobium alive and multiplying by adding sugar + water. However, it is recommended to redo the whole process once per year.
- Each legume has its preferred strain of rhizobium -> use the nodules from the target crop to multiply the rhizobium.
- In theory, after an inoculation of rhizobium, it is able to remain in the soil for the coming seasons. So inoculation may be necessary only once



ORGANIC CONTROL OF PESTS AND DISEASES

- Reduce use of chemicals
- Reduce risks for human health
- Protect water and biodiversity
- Cut on cost

16. HOMEMADE BIOCONTROL SOLUTIONS

Interests of biocontrol solutions


- Use locally available materials
- Not harmful for health
- Reduce the expenses of buying inputs
- Not detrimental to the environment

How to use them :

- Chop raw materials as small as possible, it will facilitate the release of active ingredients
- Different materials can be mixed together (but it can increase the risk of developing resistance)
- Frequent use recommended for efficiency (preventive + curative)

⇨ Once per week for prevention / twice a week for cure

- During maceration, stir frequently
- Can add soap water for increased action
- Can be used solid at planting against underground pests. Chop them very fine and mix with soil
- The liquid products can be stored up to 6 months in a container free of air and in the shade in a cool atmosphere

Frequent scouting is very important to prevent pests infestation or diseases and adapt the best control strategy.
Prevention is also key (certified or treated seeds, crop rotation, use of resistant varieties).
It is important to identify the pest you want to control to choose the best product to use.
Many mobile-based apps exist to identify pests and/or diseases:
Plantix, Corteva FarmFundi, Tumaini, DiagPot…

KILLING AND/OR REPELLING INSECTS – All recipes are for an area of 10m². For prevention once a week – cure: twice a week

PILI-PILI

- Repels mostly small caterpillars
- 2 spoons of crushed pili-pili with 10L water
- Macerate for 1 night then use
- Pili-pili can be used in garlic or tagetes recipes
- Add 500g of fresh pounded pili-pili in 20L of neem tea before spraying (cf below)

TOBACCO

- Kills pests
- 1kg chopped leaves + 10L water + 1 soap
- Macerate for 1 day then use

GARLIC

- Kills pests such as worms, aphids, mites, caterpillars, tomato white moth + antifungi
- 1 whole mashed garlic (4-6 cloves)+ 250mL water
- Macerate 1 night, sieve, dilute with 2.5L water

TAGETES MINUTA / MEXICAN MARIGOLD

- Kills pests (nematodes) + antifungi
- 1kg of leaves for 10L water
- Macerate 5 days
- Caution when use : can be hitchy

NEEM

- Repels and diminishes the appetite of pests + antifungi
- Neem + Tithonia against Tuta Absoluta
- 3kg chopped leaves + 10L water
- Or 1kg crushed seeds + 5L water
- Macerate for 1 night then add soap
- Use by drenching or as a foliar spray
- Leaves can be chopped and mixed with soil

TEPHROSIA

<!> Not good for vermicompost nor fish

- Kills larvae, worms, and liquid fertilizer
- 1kg chopped leaves + 5L water
- Macerate for 5 days then use
- To preserve seeds from weevils, grain borers: 100g of dried leaves powder for 100kg of grain (storage and seed coating). Repeat every 3 months in store
- Can be used as mulch against termites

ASH

- Kills and repels underground pests + antifungi
- 1kg ashes mixed for 1m² soil
- Can be mixed with grains/leaves of neem to create a dough against beetles/scarab
- 1kg ash with 8L water for foliar spray
- Macerate 7 days

CASSAVA

- Kills the aerial and ground pests
- Grate 1kg cassava root + 10L water
- Macerate 1 night, filter and use

COMFREY

- Against bacterial diseases (scab) + powdery mildew
- Repels pests and organic fertilizer
- 1kg stems and leaves chopped + 10L water
- Macerate for 5 days then use

CROTALARIA, RADISH, ONION "SANITIZING CROPS"

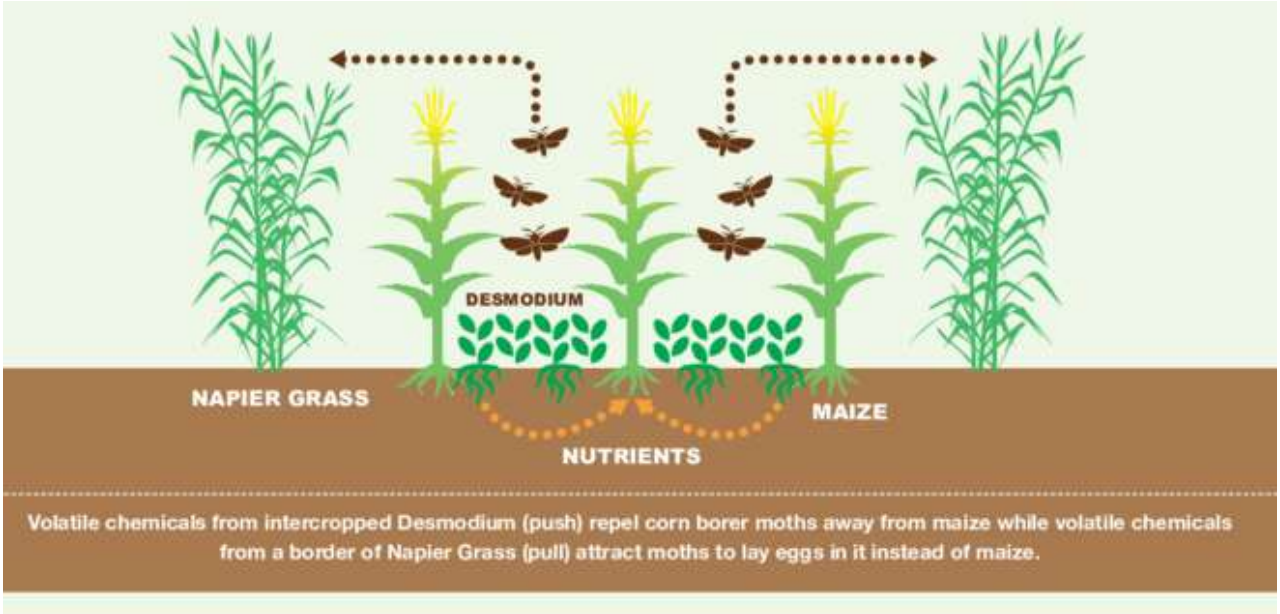
- Rotation or mix-cropping with onion or Crotalaria (spectabilis) or radish against bacterial wilt of tomatoes and nematodes

PROTECTION AGAINST DISEASES - **All recipes are for an area of 10m². For prevention once a week – cure: twice a week**			
 **VERMILIQUID**	• Pest repellent + fungicide • 1kg of mature vermicompost in 5L water • Macerate for 24h • Dilution: 1L macerated vermiliquid in 5L water • Or see recipe using direct vermiliquid p22	 **COW DUNG**	• Against bacterial and fungal diseases (scab, mildew, Candida, Fusarium wilt,…) • Organic fertilizer • 1kg cow dung + 8L water • Macerate for 7 days then use
 **PAWPAW**	• Against fungal diseases (oidium and rust) • 1kg leaves chopped + 5L water • Macerate for 5 days then use	 **FERN**	• Against bacterial disease (scab) • Repels pests • 1kg leaves chopped + 10L water • Macerate for 10 days then use
 **BAKING SODA (BICARBONATE)**	• Against fungal diseases (odium, mildew) • 200g + 20L water • Usable directly • To control blight : 3 tablespoons (TS) Bicarbonate + 1TS dish soap + 1TS vegetable oil + 3,5L water	 **GOAT OR COW MILK**	• Preventive fungicide • After milking, let the milk stand for 48h. • Dilute : 1L milk + 2L water

- For more efficacy, spray early morning or evening (pests can hide when it is too hot, or too cold).
- Thorough spray of the leaves, including the lower side, is crucial, especially for fungal diseases
- Add soap to make the foliar sprays more sticky on the leaves.
- Other organic pesticides: Maigoya (6kg leaves for 20L water – maceration 5 days), Aloe Vera, Tithonia, Sisal (Tuta absoluta), Sodom apple, Senna (Osenetoi, Senetwet, Muinu), Soap water (aphids, white fly, …), Lantana camara, …
- Even though there is no clear scientific information, it is recommended to observe at least a delay of 2 days between organic pesticide application on the crop and its consumption, and use PPEs when spraying

17. PUSH-PULL TECHNOLOGIES

Push–pull technology is an intercropping strategy for controlling agricultural pests by using repellent "push" plants and trap "pull" plants (Wikipedia).

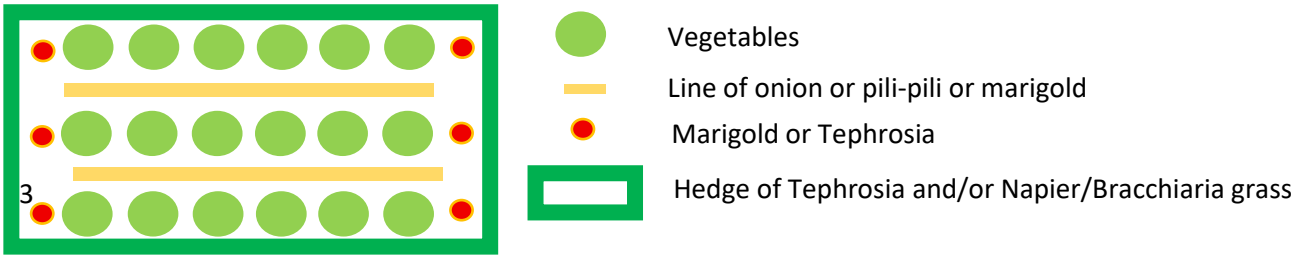


PULL : Napier grass, Brachiaria, Dania (coriander), Pigeon pea (beetles and other flying insects) … *They are planted around the plot*


PUSH : Desmodium, spring onion, garlic, pili-pili, pyrethrum, Mexican marigold, … *They are planted inside the plot*


Control the roots of Desmodium and all permanent cover crops to prevent them from taking all the space and hamper cereal roots development.

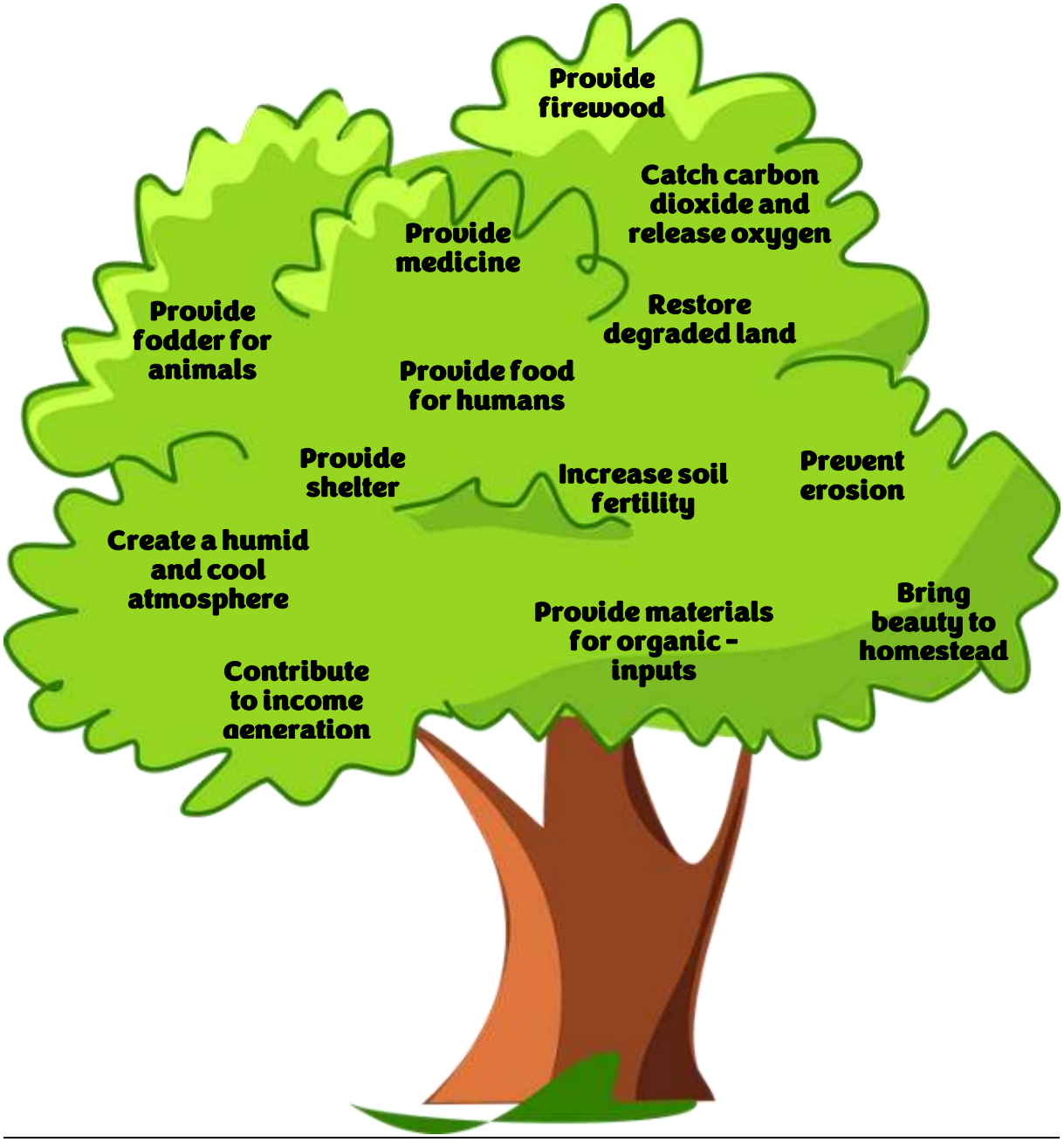
Example of an integrated pest management organization for a vegetable plot:



AGROFORESTRY

- Limit soil erosion
- Improve soil fertility
- Diversify diet and animal feed
- Contribute to carbon sequestration

Why planting trees and shrubs



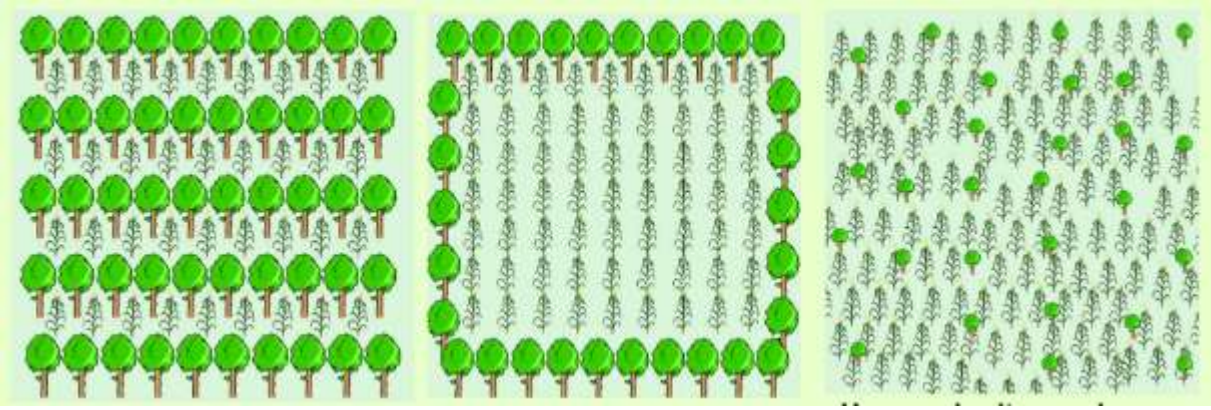
Which trees or shrubs

- Fruit tree : avocado, paw paw, mango,…
- Fodder tree or shrub : Grevillea, Moringa, Leucena, Sesbania
- Useful tree or shrub : Grevillea (firewood, mulching), Neem (organic pesticide), Castor tree (oil), Tephrosia (organic fertilizer and pesticide), …

Different options of layout on the farm

- In lines, alternated with crop lines (<!> cater for tractor path between the trees – where applicable)
- Live hedges (especially for organic fertilizer or pesticide species)
- Scattered in the plot
- Trees alone

Type of tree	Spacing between trees
Mango, avocado	10m x 10m
Orange, citrus, apple, plum	5m x 5m
Coffee	2m x 3m
Pawpaw	2m x 2m



How to plant and maintain a tree/shrub

Tree Type	Characteristics	Growing and Usage Tips	
 Sesbania (Mlndaziwa)	Shrubby tree, long narrow leaves, bean-like yellow flowers with brown and purple streaks, long and linear pods Legume Tree Tolerates saline, acidic or alkaline soils Elevation: up to 2300 m Rainfall: from 400 mm Tolerates water-logged soils Height: 1-3m. Can reach 2m in 60 day		- Multiplable by cuttings - For better growth, apply Rhizobium at planting. - Adding a lot of nitrogen reduces nodules formation
 Calliandra (Mkaliandra)	Trunk up to 30 cm in diameter and many branches, showy spike-like purplish-red flowers, broadly linear, flattened brown pods Legume Tree Not adapted to frost, waterlogged or alkaline areas Elevation: Up to 2200 m Rainfall: From 100 mm Height: 5-6m, Quick growth		- Better germination is achieved by immersion in hot water, then cooling and soaking for 12- 24h - Maintain a height of 1m for alley-cropping
 Leucaena (Mlusina)	Many branches, cream coloured globular flowers, flat brown pods Legume Tree Does not tolerate acidic soils Elevation: up to 1800m but best up to 1600m. Slow growth under 15° Rainfall: from 600 mm Height: 2m-20m		- To break dormancy: soak in warm water for 48 hours - Start harvesting after the second rain season by cutting back to 50 cm above ground level. - Grazing can start lightly when 1.5 m in height. - Can become a weed - Should not exceed 30% of the ration
 Moringa Oleifera	Limbrella shape crooked tree, corky and grey bark, sparse foliage, small dark green leaves, drooping flowers of five soft, thin, and white petals, pod looking like a drumstick Elevation: Up to 2000m but best up to 1300m. Slow growth under 15°. Can tolerate light frost and drought Rainfall: from 250mm Height: 8m-60m. Can reach 2.5m in 1-3 months		- Constant pruning at 1.5m height is recommended for best growth. - Establishment by cuttings or seeds
 Neem (Marubaini)	Toothed leaves, small white flowers, small smooth ellipsoidal green-yellow fruit Tolerates saline, acidic or alkaline but not waterlogged soils. Can neutralize acidic soils Elevation: Up to 1200m but better up to 700m Rainfall: From 150mm Height: 15-20m Slow Growth: 1st fruits after 3-5 years		- Low seed viability: must be planted within 3 months of harvesting
 Castor (Mbarika)	Palmate leaves (5 to 7 lobes), flowers in cluster, red spined fruits Elevation: 1200m to 2450m (better below 1600m) Rainfall: From 800mm Height: 6m-35m. Maturity attained in 4-6 months		- Low seed viability: must be planted within 3 months after harvesting -Better when grown from seedling
 Other forestry trees: Cordia africana (muringa), Dombeya torrida, Markhamia lutea , Grevillea robusta, ...	Elevation/Rainfall: variable	- Some species are promoted for apiculture - Often used for forest regeneration - Some are very efficient in carbon sequestration	- Germination rate of seeds can be low
 Fruit Trees: Avocado, Mango, Pawpaw, Banana, Apple, Orange, Citrus, Macadamia, ...	Elevation/Temperature: Temperate fruit trees (apple, grape) require chilly conditions for bud-break		- Some require pruning. - Grafting of improved varieties can add economic value. - Some require 2 trees: male and female (pawpaw, dragon fruit).

WATER MANAGEMENT

- Limit erosion
- Maximise the use of rain water
- Store water

18. WATER MANAGEMENT IN THE FIELD

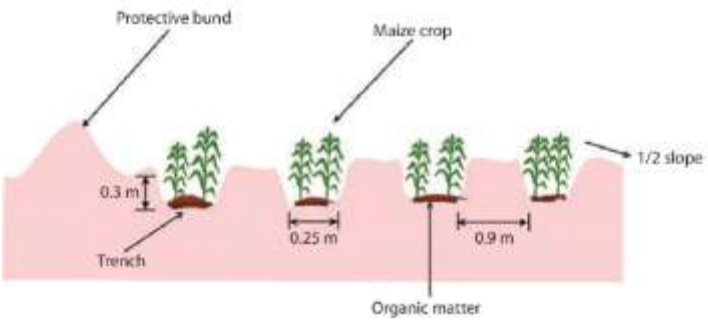
In a context of climate change and decreased and/or unpredictable rains, no drop of rain should be wasted. Moisture and water retention practices are then essential for crop production sustainability.

The 1st way to adapt to dryer conditions is to plant an adapted crop, like sorghum, cassava, pigeon pea, cowpea, groundnuts, …
Maize grows well if rains are >500mm per year, while cowpea can grow with only 200mm and sorghum with 250mm!

Zai pits

Zai pits are big and deep planting holes where the soil is mixed with manure/compost

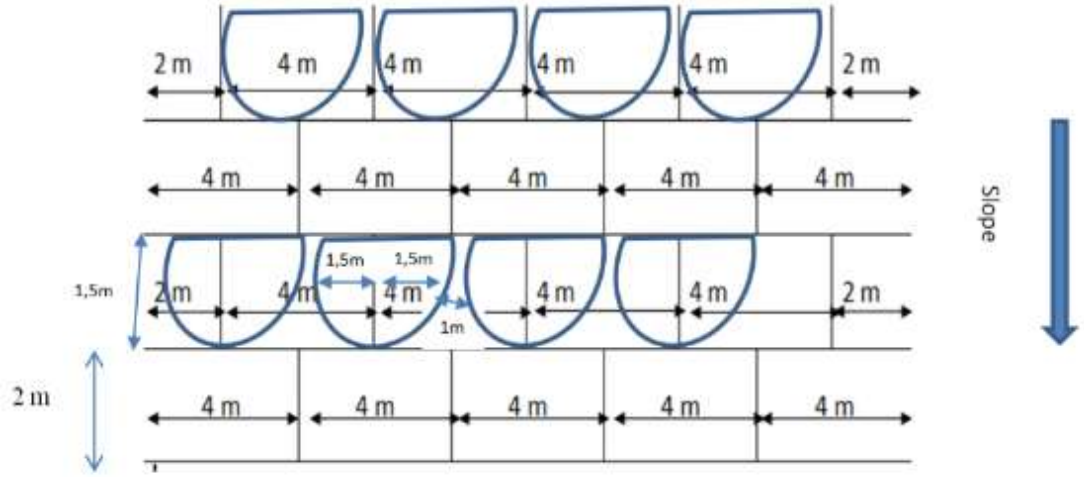
- The holes are dug against the direction of the slope (if there is), starting each time at the bottom of the slope and going up the slope backwards.
- The pockets of the zai are arranged staggered and in line.
- Zai dimensions :
  - Depth : 20 to 40cm
  - Width : can be adapted, minimum 25cm (diameter 40cm if round)
  - 3 seeds of maize per hole (more if bigger zai)
- Spacing between holes : between 60 to 90cm



Half-moons

The half-moon is a basin in the shape of a semicircle. The excavated soil is deposited on the semicircle in a semicircular bead/bank with a flattened top. They are adapted to bare land.

- Trace contour lines
- On a contour line, pivot using a compass of 1.5 m radius or a rope of 1.5 m.
- Commonly used dimensions are:
  - diameter: 3 m;
  - depth: 15 to 25 cm (deeper is better)
- Spacing:
  - From one line to the other : 2 m
  - The distance along the line is 4 m from center to center of half-moons or 1 m between 2 half-moons.
- 14 to 24 plants per half-moon depending on spacing requirements



- Bring a wheelbarrow of well-decomposed manure or compost (21 kg) per halfmoon and mix organic matter with topsoil

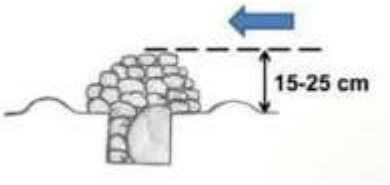
If possible, build a stone barrier or protective bund upstream of the half-moon field to curb flooding and thus protect the site from heavy runoff and erosion during heavy rains

Never cultivate inter-half-moon spaces (impluvium) which play the very important role of collectors of runoff for the benefit of half-moons

For zai-pits and half-moons, separate the top-soil from the sub-soil when digging. Mix the compost with the sub-soil, and then add the top-soil on the surface of the hole

Terracing and planting along contour lines

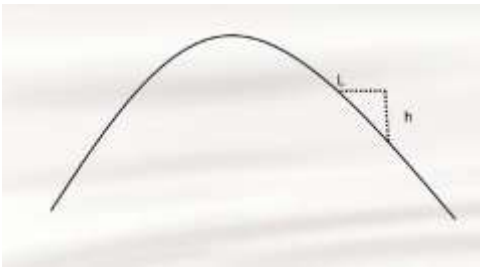
In a sloppy field, to prevent soil erosion, the water flow must be slowed down, it will also allow the water to penetrate into the soil.
different options to reduce erosion:



- Stone lines along contour lines : dig a furrow 10-15cm deep – 15-20cm wide. Place the soil on the downstream side of the hole. Put big stones on the upstream side of the furrow, and fill the hole and elevate the heap of stones by 15-25cm
- Planting trees at the top of the hill
- Planting along contour lines : use a A-frame
- Horizontal terraces following contour lines :
  - start from the top of the slope
  - the depth of the soil to excavate varies according to the slope (see table)
  - put the excavated soil towards the top of the slope

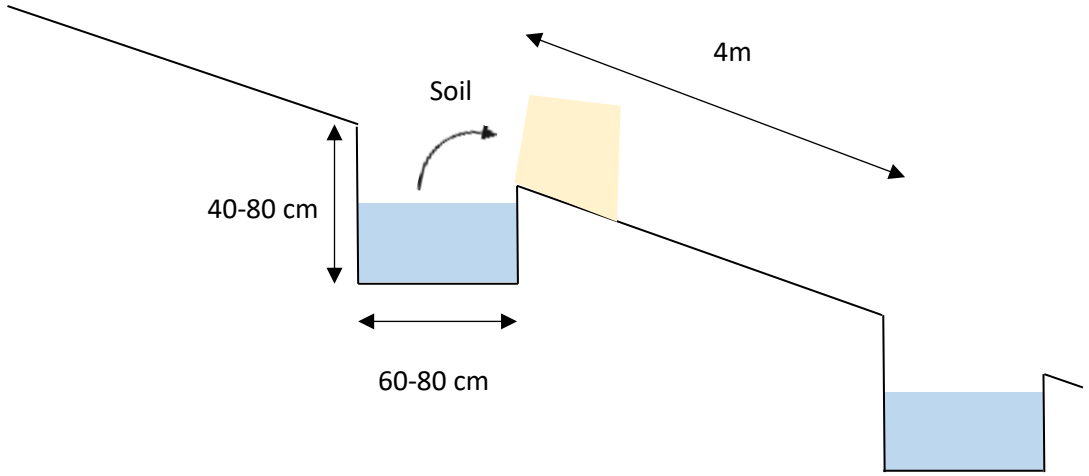
Creating terraces or contour lines is labour demanding. Do it collectively !

Dimensions of horizontal terraces

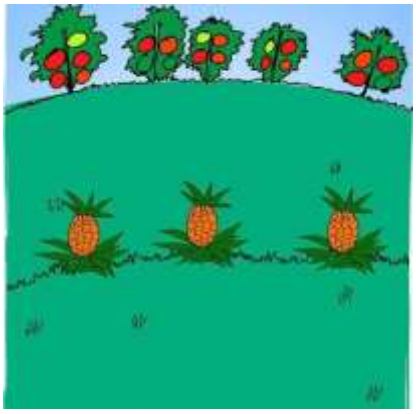


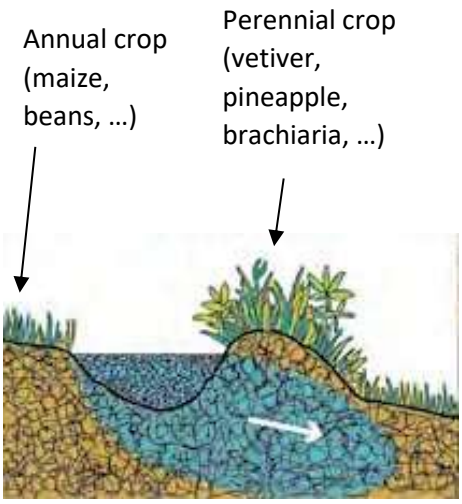
L value	Slope	h value	Minimum depth of soil
2,5 m	18° (32,5%)	1,17 m	59 cm
	25° (46,6%)	1,87 m	93 cm
3,4 m	11° (19,4%)	0,93 m	46 cm
	20° (36,4%)	1,84 m	92 cm

- Retention furrows (contour ditch) along contour lines :



Plant terrace hedges and retention furrows heaps with leafy and perennial plants (vetiver, brachiaria, pineapple, …) or shrubby legumes (cajanus, tephrosia, ...)





Use of spirit level to design contour lines

A spirit level (or bubble level), is a tool used to indicate whether a surface is horizontal (level) or vertical (plumb). It consists of a sealed vial (usually containing alcohol) with an air bubble inside, mounted in a frame. When the bubble is centered between the markings on the vial, the surface is level.

Spirit levels can be found in hardware shops.

You can also use a level line, composed of 2 sticks, a rope and a level.
For a low to moderate slope, the distance of the rope between the 2 sticks should be 10m, 5m if the slope is important.

Mark the middle distance of the rope with a pen. Always make sure the bubble is in the middle of the lines

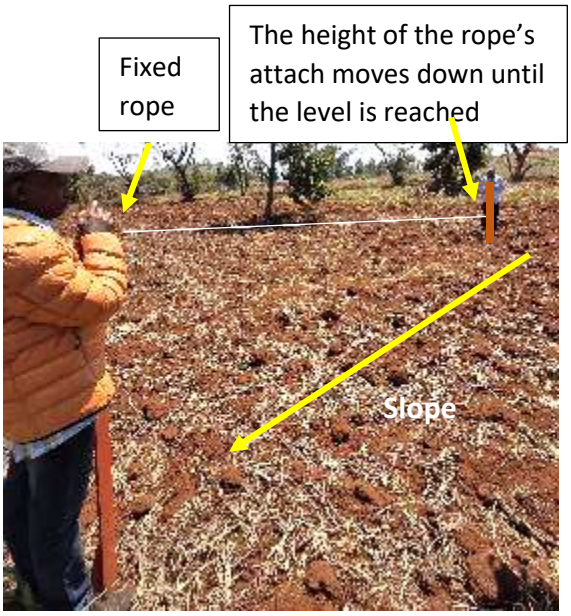
How to use the level line to draw the contour lines

1. Start at the highest point of the slope.

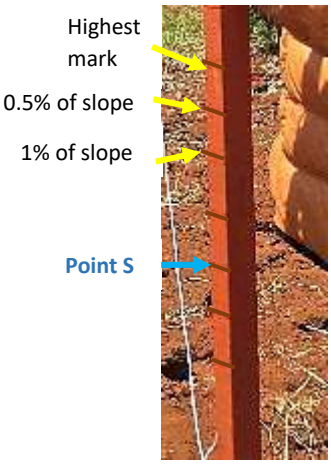
2. Place the leveling tool on the ground. One person remains still with one stick of the level, the other one with the 2nd stick stretches the line and moves up or down to adjust until the horizontal bubble shows level (the level being placed at the middle distance).
3. Mark this point with a stake.
4. As one person stays where the stake has been planted, the other one moves sideways along the slope, repeating the same procedure of stretching the line and then finding the spot where it is level.
5. Each time it's level, place another stake.
6. Continue until you reach the end of the slope at the hedge of your plot

How to move from one contour line to the next one

1. Establish the steepness of the land which is done using the level line. The stick of the level has 20 bars and each bar represents 0.5 % slope.
2. One stick is positioned on the just achieved contour line while the other stick moves
3. towards the downside of the slope, perpendicular to the contour you have just designed, until to have the rope tensed.
4. The person who holds the stick on the finished contour line (=the upper stick) adjusts the position of the rope on the stick moving it down until the bubble of the level stabilizes in the middle and shows level.



5. Read the percentage of slope indicated by the bar on the level (**S**)
6. Use the formula : Vertical Interval (**VI**) = **S**+4/10.
7. Then calculate the distance in meters with the next contour line = **VI**/**S** *100.
8. Put a stake at the 1st point of the next contour line and restart the process of drawing the contour line (make sure you bring the rope back to its initial position on the stick).



Example:

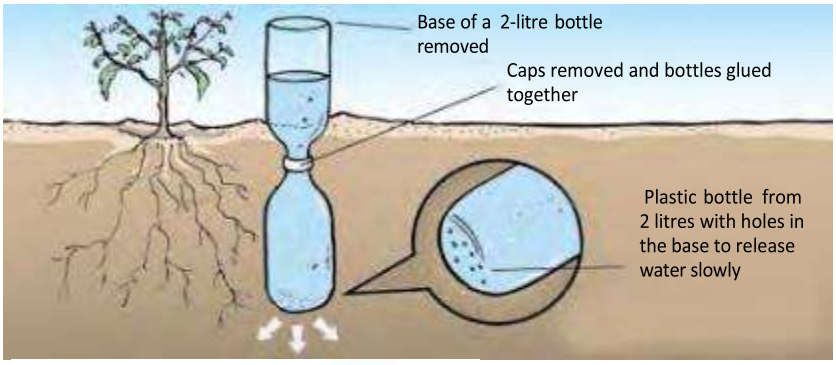
If the level is reached when the rope has reached point S, the percentage of the slope is 2% (because point S is the 4th mark from the top, so 4*0.5 = 2%). So vertical interval VI = (**2**+4)/10 = **0.6**

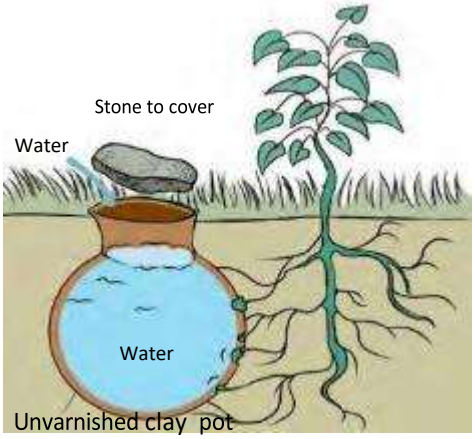
⇨ Distance between the 2 contour line = **0.6**/**2***100 = 30m

19. MINIMIZING IRRIGATION

To reduce the need for irrigation for vegetable gardening mostly, you can:

- Mulch the plot (cf p37)
- Use home-made micro-irrigation



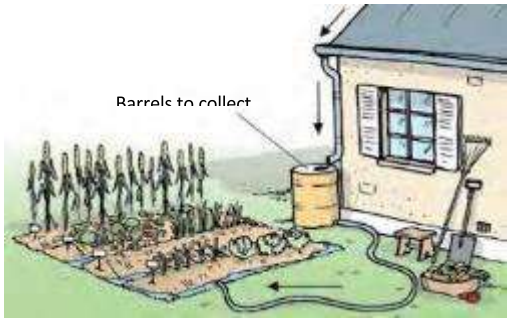


20. RAIN WATER HARVESTING

In areas where rains are depressed, collecting rain water can increase availability of water during dry periods.

It can be :

- Catching rain from the roofs
- Building water ponds
- "Storing" rainwater in the soil with minimum tillage, zai pits, …v



21. Case study for a farm pond

Dimensions of the pond:

Bottom Area	10 m x 8 m
Top Area	12 m X 10 m
Depth	2 m

Capacity = 200m3

Cost incurred to build the pond:

ITEM	COST (KES)
Land 1/8 acre	200 000
Excavation labour 500/= for 8 persons in 12 to 20 days	48 000 - 80 000
Dam Liner 1mm thick, 290m2	145 000
Dam liner transport	10 000
Dan liner installation	15 000
OPTIONAL	
Shade net 170m² + installation	35 200
Money maker pump	8 000
Conveyance piping (6m)	9 000
Hose pipe 50m (1)	8 000
TOTAL	**478 200 – 510 200**

Cost per m3 without the land ~1 500 KES/m3

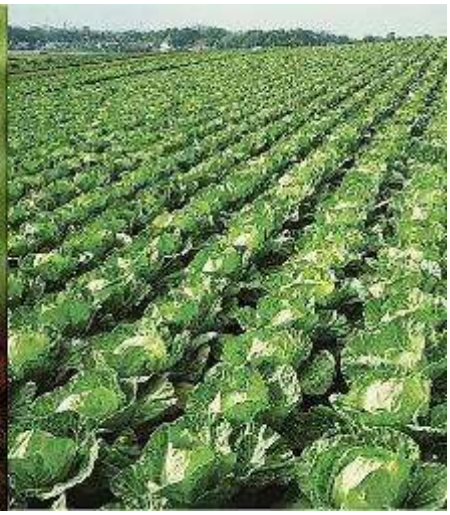
Source of the water:

- Run-off from slopes, roads
- Rain
- Overflow of rivers

CROP ROTATION

- Prevent diseases
- Limit soil depletion
- Improve soil structure





Example of good crop rotation

- For head of rotation : soil improver plant : legume (soybean, groundnuts, …)

⇨ provide nitrogen to the soil

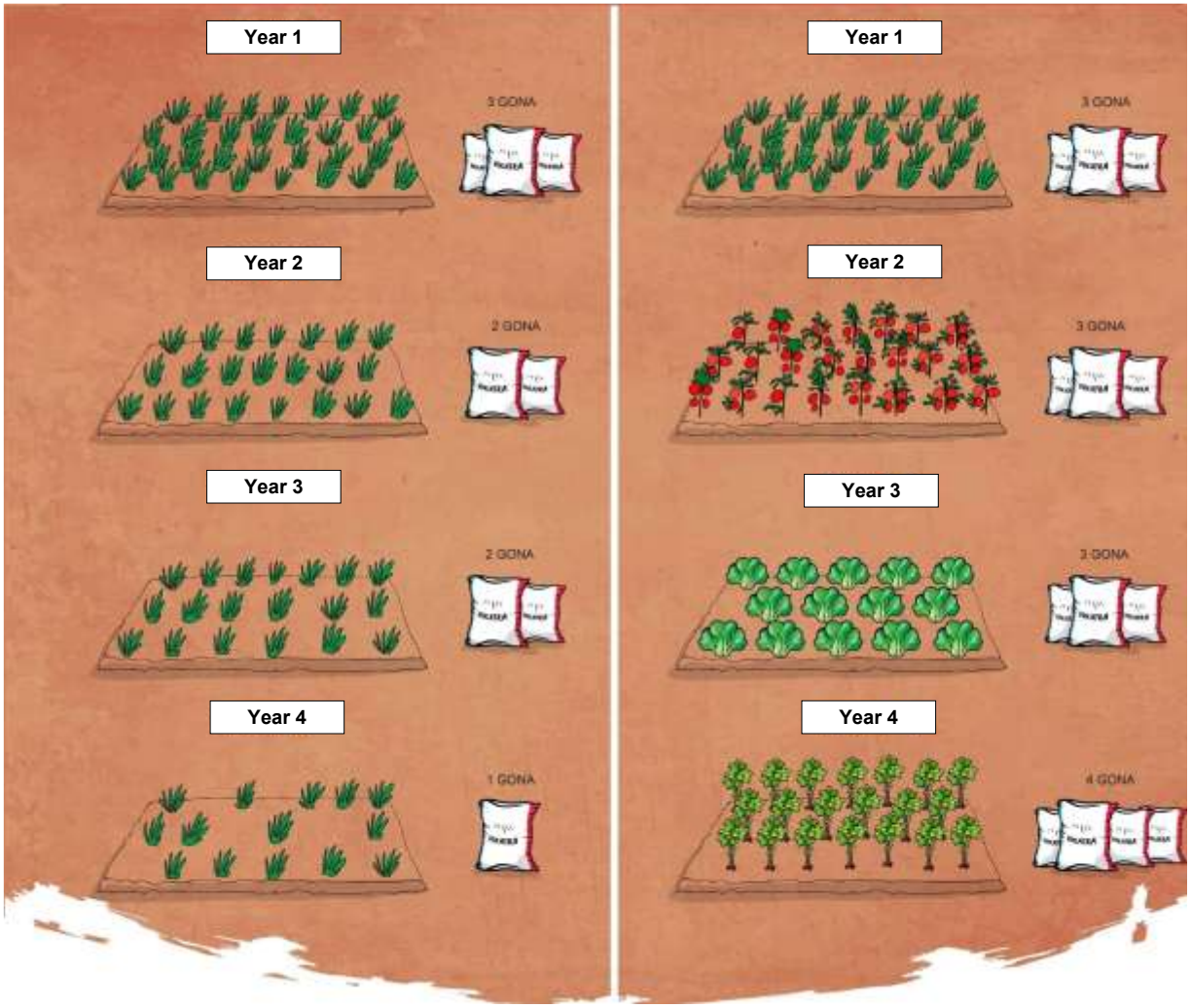
- For the second crop : can be greedy plants (tomato, maize, ...)
- At the third crop : tuber plants (carrots, cassava, potatoes ...)

⇨ These plants can fetch the nutrients deep

- At the fourth crop : leafy vegetables or greedy plants (onion, garlic, peas, ...) or short-cycle crops

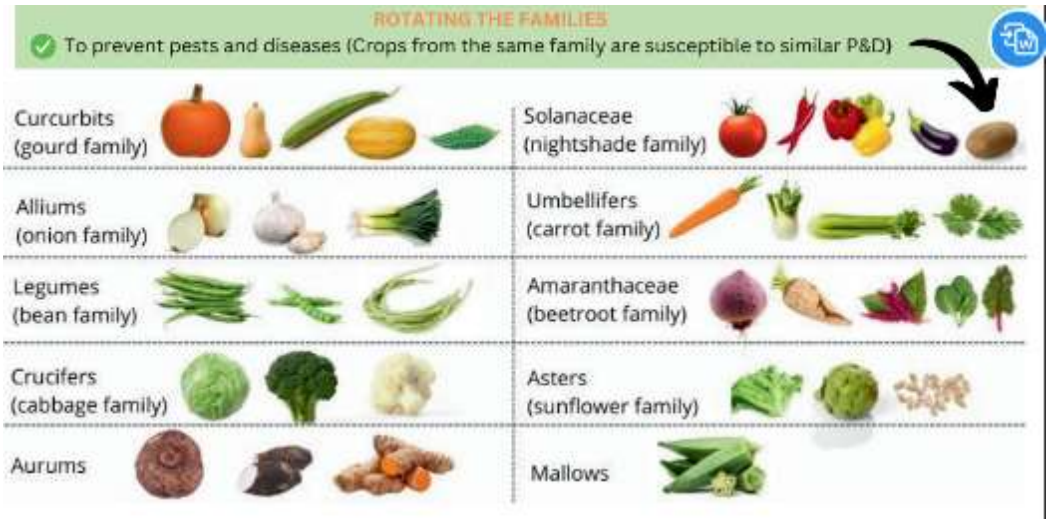
The succession of same family and same species plants is not recommended in a plot because :

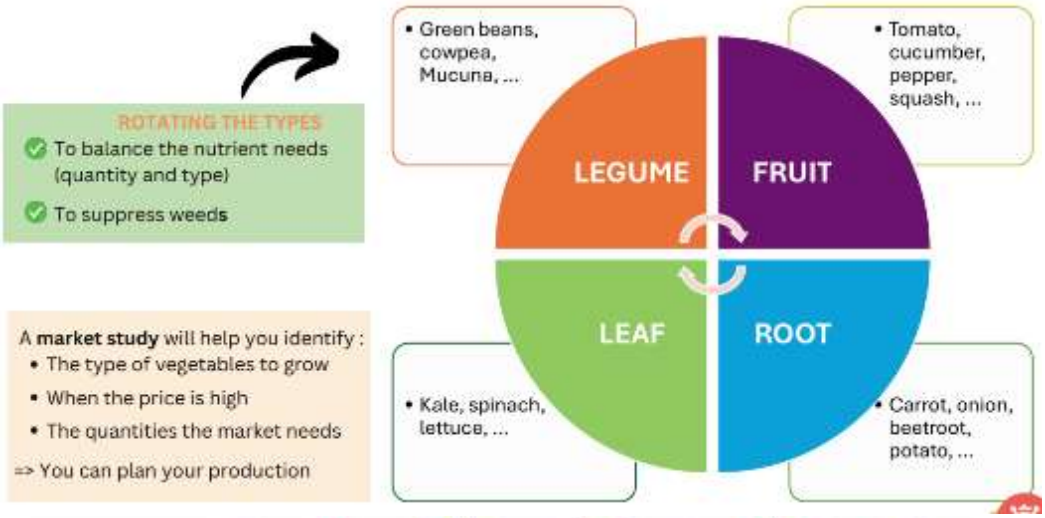
- They have the same needs (type of nutrients, depth at which nutrients are fetched, …), so they deplete the soil and need more external inputs
- They are affected by the same pests and disease – rotating cuts the contamination cycle

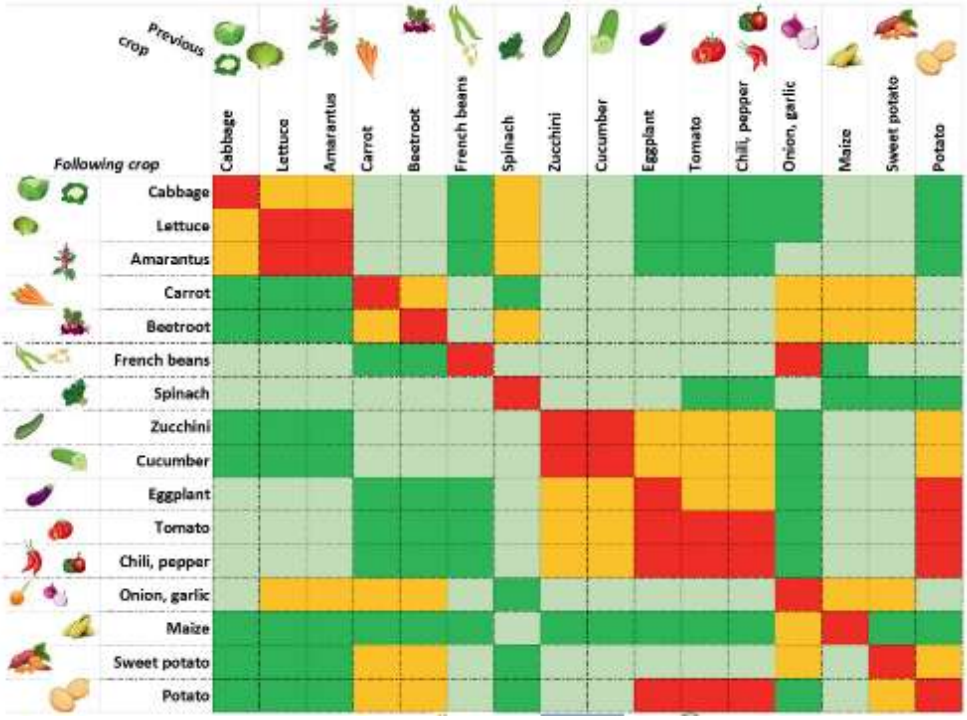


If your field is invaded by Striga weed, don't plant maize, millet or sorghum. Rotate with a non-host plant such as onion, sunflower, a legume. Desmodium and certain varieties of cowpea contribute in killing striga.
Only long rotation and good management practices can suppress Batcerial wilt

Examples of rotations in vegetables farming:







SOIL COVER

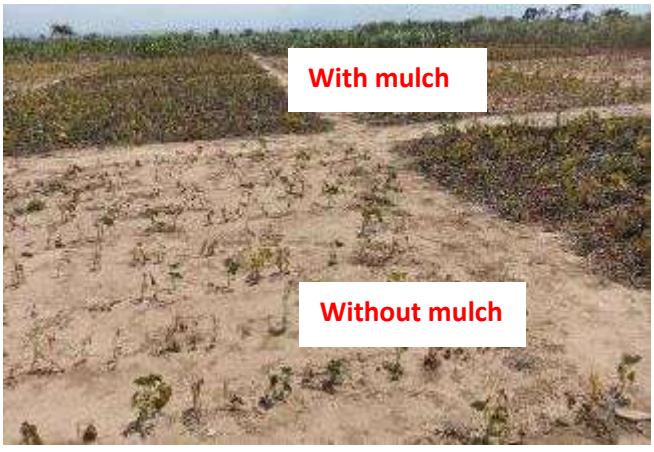
- Prevent moisture loss
- Limit soil erosion
- Bring organic matter to the soil
- Limit weed growth
- Protect from frost

What to use for soil cover

3 ways exist to cover the soil :

Type of cover	Advantages	Cautions/disadvantages
Crop residues	• No extra effort (they are on-site)	• Can propagate diseases to the next crop, especially if too much rain • Competition with animal feed • Quantity limited according to the crop and its production level • Can be carried away by water if flood
External mulching materials	• Can use various materials : grass, Grevillea, Leuceana, Tithonia, etc leaves, except from eucalyptus and pine • Can adapt the thickness as wished	• Effort (and cost?) to procure them • Beware of introducing weed seeds • Can be carried away by water if flood • Negative impact on carbon sequestration if use of tree leaves
Cover crop	• Can be source of organic matter and/or fodder • Some are perennial : no need of replanting every year	• In dry conditions, can create competition for water (and nutrients) with the main crop • Cost to install it with no financial return • If permanent cover, roots can become invasive

If the mulch is thick, you may need to create space in the mulch for the emergence of the seed.
If rainfall is high at the start of the cycle, you can put the mulch when the rains start reducing, to prevent the development of fungal diseases or rot.



Benefits of cover crops:

Common Benefits

- Breakage of hardpan thanks to deep and strong roots.
- Soil decompaction and aeration.
- Better root development for next or mixed crop.
- Ability to catch nutrients and water deep.
- Prevention of soil erosion.
- Prevention of evaporation of soil moisture.
- Weeds suppression.
- Source of biomass & nutrients for incorporation in compost or use as green manure, mulch.

Species-Specific Benefits

Legume Plants:

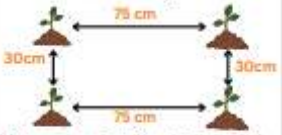
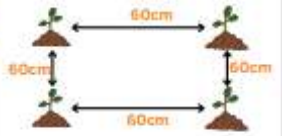
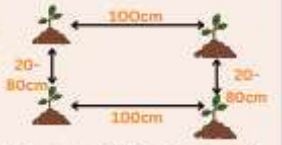
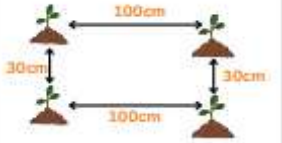
I. No competition for nutrients when mix-cropping.

II. If residues and roots are left on the field, they provide nutrients for the next crop.

Usable as animal feed or fodder.

Usable for human food.

Help in controlling pests and/or diseases.

Crop	Agroecological Conditions	Benefits	Planting Conditions
 Canavalia	Elevation: up to 1800 m above sea level Rainfall: from 600 mm Tolerates acidic and saline soils Cycle: 180- 300 days		Broadcasting or:  If inter-cropping: Plant Canavalia 4 weeks after planting maize. 50cm between Canavalia seeds.
 Crotalaria	Does not tolerate long frost nor too long water-logging Elevation: up to 2000 m Rainfall: > 200 mm Cycle: 105-120 days	 **NOTE:** Can become a weed.	Broadcasting or: 
 Desmodium Silverleaf or Greenleaf	Tolerates acidic soils Susceptible to frost Elevation: up to 2500 m Rainfall: >700 mm Cycle: 75-85 days	 Perennial Crop Multiplication through seeds or cuttings.	
 Mucuna pruriens (Upupu)	Elevation: up to 2100 m; <1500 m best for grain production Rainfall: >400 mm but prefers areas > 1000 mm Cycle: 120 days	 **NOTE:** Risk for health if grain is not well treated before consumption.	 If inter-cropping: Plant mucuna 45 days after planting maize.
 Sweet Potato	Sensitive to alkaline or saline soils Elevation: up to 2400 m (better <2100 m) Growth slowed below 10°C Rainfall : best from 750 mm Cycle: 3-6 months	 Can be propagated through vine cuttings.	

⚠ IN ARID OR SEMI-ARID AREAS, RISK OF COMPETITION FOR WATER BETWEEN THE COVER CROP AND THE MAIN CROP

MINIMUM TILLAGE

- Prevent wind and water erosion
- Soil moisture retention
- Improvement of soil structure
- Decrease in land preparation cost

Minimum tillage is not only for dry areas! It helps improving soil structure, which can favor better water penetration and evacuation in case of fields prone to waterlogging

Equipment

- Ripper, chisel, jembe
- Manual ripping, ox-ripper, walking tractor, tractor pulled
- Combined planter and ripper

How to do minimum tillage

1. Clear the land from weeds but leave the weeds to decay on the field
2. Draw the planting lines with the ripper/chisel.

The 1st season, the hardpan has to be broken so it requires a deep ripping (below the hardpan), but the following seasons, the ripping depth should be between 5 and 15 cm

3. You may need to use a non-selective herbicide or shallow weeder to control the weeds
4. Plant along the created lines
5. At the end of the season, if possible leave the crop residues on the plot
6. The following seasons, if the same lines are used, the planting can be done directly, for example with a jab-planter or a strip-till

How to fabricate a direct-planter :
https://www.youtube.com/watch?v=hZ7j8t4I5-g
https://www.youtube.com/watch?v=Fnm8Om0K2ic

Before engaging in minimum tillage, make sure you have solved the weed issues

This guide has been produced by

And

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