Upper Zambezi Ecological Organic Agriculture Development Project (EKONJIMO)

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ORGANIC FARMING GUIDE

VOLUME 2
Plant protection

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1 Integrated pest management

The main problem for most farmers is to protect their crops from pests.
In order to start planning your protection strategies we first need to determine what a pest is exactly.
A pest is an organism that harms and presents a threat to agricultural crops. A pest can be an insect, a fungus, a virus, a weed or an animal.

To help the farmers battle with pests, the agro-chemical industries produce numerous types of herbicides and pesticides. The problem is that this synthetic substances, besides polluting the soil and waters, are not a 100% effective and they cost a lot of money.
For this reason many farmers are moving toward a more sustainable approach, the integrated pest management, which relies on the natural relationships among different species of animals and plants.

The integrated pest management is a preventive approach that helps drastically reduce the use of chemicals.
The different strategies used in an integrated pest management can be grouped into the following categories:

- Cultural control
- Physical and mechanical control
- Biological control
- Natural remedies

2 Cultural control

Cultural control techniques refer to the way you grow your crops. The goal is to grow healthy crops that are more resistant to pests and diseases and to create an environment that is not suitable for pests.
In the previous guide "Volume 1 Crop Production" we described various techniques which can be considered as efficient cultural control strategies.

In this chapter we will describe some additional techniques that will help you keep pests out of your field and improve your crops health.

2.1 Companion planting

Companion planting consists in planting crops that are beneficial to each other in close proximity. The benefits can include pest control, higher yields, better pollination, better nutrient uptake, etc.
There are various types of companion planting; in this paragraph we will discuss companion planting for vegetables. Companion planting strategies for field crops (ex. corn) are described in the next two paragraphs.

In the table below you can find a list of the main vegetables and the plants you can and must not plant near them.

CROP	Plant near:	Keep away from:
Tomato	carrot, parsley, cucumber, onion, basil	fennel, cabbage family, potato, beet
Carrot	tomato, lettuce, onion, mint, radish, peas, beans	dill
Cabbage family	onion, beet, celery, aromatic herbs, spinach, lettuce, peas, potato	tomato, garlic, strawberry
Eggplant	beans, potato	
Potato	beans, beet, cabbage family, lettuce, peas	tomato, cucumber, celery, sunflower
Lettuce	carrot, radish, strawberry, cucumber, beans, beet, cabbage family, carrot, peas	parsley
Cucumber	bean, corn, peas, radish, cabbage family, lettuce	potato, aromatic herbs
Beans	most vegetables and herbs	onion, garlic

Table 1. Companion planting chart.

2.2 Trap cropping

Trap cropping is the planting of a trap crop to protect the main crop. The trap crop may or may not be harvestable. The trap crop can be from the same or different family group than that of the main crop as long as it is more attractive to the pest.
Trap cropping is a form of companion planting, in which one crop traps the pests and is "sacrificed" in order to maintain your main crop healthy.

There are 2 ways to plant the trap crops:

• perimeter trap cropping: the trap crops are placed all around the borders surrounding the main crop;
• within- row trap cropping: trap crops are placed in rows within the main crop.
The arrangement you are going to use depends upon the target pest so it is essential to have some knowledge of the target pest behavior.

An example of trap cropping is described in **Annex I**.

2.3 Intercropping

Intercropping is also a companion planting strategy. It consists in growing two or more crops simultaneously on the same field. The goal is to increase the yields in a plot by maximizing the use of space and resources that would be otherwise lost.
When growing together two crops each of them has to have enough space. In order to achieve that you must consider the following things:

• **spatial arrangement**: it refers to the way you will plant your crops. Crops can be planted in rows or they can be mixed together in no distinct row.

• **plant density**: when you grow together 2 crops, you will have to reduce the amount of seeds that you plant. The amount of seeds will depend on the yield you want to get. For example, if you plant corn and cowpea, and you want mostly peas, you will reduce the corn seeds for 80%. If you want the same amount of corn and peas you will plant 50% of the usual amount of seeds for each crop.

• **maturity dates of the crops**: it is advisable to plant together crops that have different maturity dates. This way you will reduce the competition between them for water, sunlight and nutrients. In addition, it will be easier for you to harvest them separately.

• **plant architecture**: it refers to mixing two crops of different height. This way the smaller crops below the taller crop will capture sunlight that would otherwise be lost.

Usually intercropping involves growing together crops of different heights. Examples of this kind of intercropping include:

- corn and peanut;
- corn and cassava;
- corn and sweet potato;
- sorghum and pigeonpeas.

Another pattern is to grow 2 tall crops with different growth rates. An example of this type of intercropping is growing together corn and sorghum.

2.4 Sanitation

To keep pests out of your field it is important to implement good sanitation practices.
When a plant is dying from a disease, or is infested, remove it from the field and place it far away from it so that the water and wind will not transport the pests back to your field.
Avoid working on the field while it is wet. Any activity in a wet field can spread fungi and bacteria throughout a field.
Handle your plants carefully. Any bruised, cut or broken part of a plant is an entrance spot for diseases.
Wash your hand tools regularly to avoid the spreading of soil- borne diseases.

3 Physical and mechanical control

Physical and mechanical control techniques directly remove pests or physically keep insect pests from reaching the crops by using traps.

Since insect pests are removed with traps and barriers that can be very expensive, we won't be mentioning them in this paragraph. Instead, we will focus only on the physical and mechanical strategies for the control of weeds.

3.1 Tillage

One of the main mechanical strategies for weed control is tillage. By turning over the soil, the weeds are buried beneath it. This way the sunlight doesn't reach the weeds and they die.
Although tillage was one of the first methods for weed control, it has also some negative effects. Continuous tilling leads to soil erosion and destruction of the soil structure. It is particularly not recommended on sandy soils.
A non- invasive tilling technique is described in "Volume 1 Crop production".

3.2 Hand pulling

Pulling weeds by hand is one of the oldest and most effective methods for the control of weeds.
It is especially effective for annual and biennial weeds.
The best time to pull the weeds is after irrigation or rain because it will be easier to remove them from the ground.
You should remove the weeds before the flowering stage to avoid the propagation of weed seeds.
If weeds are in flower, burn them to prevent seed spreading.
Although effective, this method is the most time consuming.

3.3 Solarization

Solarization is a simple technique that uses the sun heat and energy to destroy pathogens present in the soil such as fungi, bacteria and weed seeds.
The process consists in covering the soil with a clear plastic tarp for 4 to 6 weeks. The soil should be covered during a hot period of the year when the soil receives direct sunlight.
The top 15 cm (6 in) of the covered soil will heat up to as high as 52 ^{0}C (125 ^{0}F).
These high temperatures will destroy a wide range of soil pests. In addition, the heat will stimulate the release of nutrients from the organic matter present in the soil.

3.4 Summer fallow

This technique consists in ploughing the land after harvest and leaving it without any crop during the summer season. The roots of perennial weeds will be exposed to intense sunlight that will destroy them.

4 Biological control

Biological control consists in using an organism to regulate the population of insect pests. The natural enemies of insect pests can be divided in 3 groups:

• **Predators** kill and eat insect pests. Many species of amphibians, birds and mammals are useful predators of insect pests. Among the insects, predatory beetles, lacewings, flies and wasps are efficient predators. Spiders are also very useful since they feed entirely on insects. Predatory mites are also very efficient in reducing the population of pest spider mites.

• **Parasites** live and feed in or on a host. Insect parasites can develop inside or outside the body of the insect pest. Often only the immature stages of the parasite feed on the insect pest.
True parasites usually don't kill their host. Species useful in biological control kill their host and are commonly called parasitoids.
Most parasitic insects are either flies (order Diptera) or wasps (order Hymenoptera).

• **Pathogens** are microorganisms- bacteria, fungi, viruses, nematodes and protozoa- that infect and kill the insect pests.
Often the population of insect pests can be drastically reduced by naturally occurring pathogens. In addition there are commercially available pathogens under the form of biological and microbial pesticides.

How to maintain the population of natural enemies

1. Reduce or eliminate the use of broad- spectrum, persistent pesticides. If you must apply pesticides, apply them selectively: do not treat the entire plant but only the most infested areas.

2. Plant various plant species that flower in different times. By doing this you will provide a constant food resource (pollen, nectar) and shelter for natural enemies. Most natural enemies feed on pests only in the early stages; the adults feed on nectar and pollen so to maintain their population it is essential to provide them with enough food resources.

3. Control the ants' population. Ants are treated as pests because they feed on honeydew so they tend to protect honeydew producers from predators and parasites that might otherwise control them. Honeydew producers include pests such as aphids, mealybugs, soft scales, psyllids, and whiteflies.
By controlling the ant population, you will allow natural enemies to reduce the population of honeydew producers.

5 Natural remedies

Natural remedies can be used instead of chemical pesticides to control pests.
Natural remedies include various natural preparations that can help you reduce the pest population. In addition, these preparations are not toxic and thus do not pollute your crops, water and soil.
Below you can find a list of natural remedies recipes.

5.1 Tomato leaves

5.1.1 Tomato leaves recipe 1

Crush leaves from a tomato plant and soak in water for a couple of days. Strain then spray.

5.1.2 Tomato leaves recipe 2

Put tomato leaves in a pot, cover them with water and boil them. Let cool and seep for several hours at least. Strain and spray.

Tomato leaves spray is good for grasshoppers and white fly control.

Tomato leaves are poisonous. Be careful while handling the leaves and preparing the mixture. Do not spray on food bearing plants.

5.2 Rhubarb leaves

5.2.1 Rhubarb leaves recipe

1 cup rhubarb leaves
6.5 cups water
1/4 cup liquid dish detergent or soap flakes
Put the rhubarb leaves in a pot and cover them with water. Boil for 20 minutes then remove from heat and let it cool down. Strain and add the liquid detergent or soap flakes. Apply.
This mixture is good for controlling aphids, june beetles, spider mites and thrips population.

Rhubarb leaves are poisonous. Be careful while handling the leaves and preparing the mixture. Do not spray on food bearing plants.

5.3 Potato Leaves

5.3.1 Potato leaves receipe 1

1 cup potato plant leaves
2 cups water
Chop the potato leaves, put them in a container and cover them with hot water. Seal the container and put it in a sunny spot for 24 hours. Strain and apply.

Potato leaves are poisonous. Be careful while handling the leaves and preparing the mixture. Do not spray on food bearing plants.

5.4 Onion and garlic

5.4.1 Onion and garlic spray recipe

Mince 1 clove of garlic and 1 medium sized onion. Add to a quart of water. After one hour add one teaspoon of cayenne pepper and one tablespoon of liquid soap to the mix. Apply.

5.4.2 Garlic tea recipe

Boil 0, 6 L (1 pint) of water, then add chopped garlic and let it steep until the water cools. Remove the garlic and apply.

5.4.3 Onion peels and skin spray recipe

Put onion peels, skin and onion bits and ends in a pail and cover with warm water. Let it soak for a few days. You can keep the pail in the sun to steep. Use the onion water to spray your plants. Bury the onion bits and ends around plants to keep away pests.

Onion and garlic spray are effective in controlling aphids, spiders and other pests.

5.5 Pyrethrum

5.5.1 Pyrethrum spray recipe

Pick the flowers in full bloom when the 'pyrethrins' in the flower heads are at their peak. Pick enough stalk so you can hang the flowers to dry in an undercover and preferably cool, dark place. When dry, grind the flowers finely with a mortar or pestle. Use quickly as it loses its potency within 1-2 days.

To use, finely shake the pyrethrum power onto target pests or make a solution by mixing 2 teaspoons of powder with 3 liters of water. Let it steep for 3 hours; add a quick squirt of liquid soap, then use as a spray.

Since the powder attacks the nervous system of pests, it must touch each pest. After applying, wait for 2 days and then apply again. This is an effective method as some pests will be hiding during the first application.

The best time for spraying is in the evening since high temperatures degrade the pyrethrum quickly.

6 Protecting crops from monkeys

Wildlife damage causes severe economic loss to communities, affecting the livelihood and well-being of locals.
While there are numerous studies regarding the quantification of crop damage problems the means used for crop protection are very limited.
What follows is a list of methods used by farmers around the world to protect their crops.

6.1 Sunn hemp

Sunn hemp is receiving widespread acceptance as a green manure in East Africa. The species they grow is *Crotalaria ochroleuca*.
It has been observed that monkeys are afraid to move across a belt of sunn hemp. So putting a row of sunn hemp around the field protects the crops.
Why does sunn hemp protect the crops from monkeys? First of all the sunn hemp forms a dense barrier. Secondly, the sunn hemp produces a clattering sound that might disturb the monkeys. Thirdly, if they are discovered stealing corn, it is almost impossible for them to run away across the sunn hemp border as the branches form a rather strong network like wire.

6.2 Molasses grass

Farmers in Bhutan (Asia) have discovered that planting molasses grass around the field is very effective in protecting the crops from monkeys.
Molasses grass is a sticky, tufted, stoloniferous, perennial grass that grows up to a height of 180 cm. It has a strong characteristic odor of molasses or cumin due to the secretion of a volatile oil through the leaf hairs. It grows in thick carpets because of its pioneering growth habit, which together with the secretion makes animal's movement in it difficult. Monkeys get stuck in the sticky molasses grass and find it very difficult to move across it. For this reason, they do not come to the field anymore.

6.3 Pitched bell

Putting a sharp pitched bell in the field, which is rung at intervals of about 30 minutes, can help in preventing monkey to come to the field. This need not be a complicated bell. A small metallic object struck against a hanging piece of rail or old plough disc is adequate. Monkeys are frightened at the sound of the bell.

6.4 Chili powder

Put chili powder on the paths that the monkeys always use in coming to the garden. Monkeys always rub their eyes when they sit down, getting the powder into their eyes. This frightens them away.

6.5 Dry fish

Make sealed small packets with boneless dry fish pieces kept around the field. After opening the packets, the monkeys will rub the fish with both hands. After smelling and getting irritated by the smell they will rub the hands on the rocks. The leader of the monkey gang that faced the bad experience will never enter the same field with his team.

6.6 Plastic snakes

Hang some colorful rubber snakes in polythene bags. Monkeys will see the snake and run away. It helps for only a short period until an intelligent monkey finds out the snakes are not real.

ANNEX I

Example of a trap cropping strategy: The push- pull strategy

The push- pull strategy is widely used for the control of stem borers and suppression of striga weeds in maize.
For this strategy farmer use Napier grass (synonyms: elephant grass, Ugandan grass) and desmodium legume (silverleaf and greenleaf desmodium).
Desmodium is planted between the rows of maize (Figure 1.). It produces an odor that repels stem borers thus "pushing" them away from the maize crop.
Napier grass is planted around the maize field. Napier is more attractive to stem borers than maize so it "pulls" the stem borer to lay its eggs on it. Once the eggs hatch the Napier grass produces a sticky substance that kills the larvae.
In addition, the desmodium suppresses the proliferation of striga weeds.

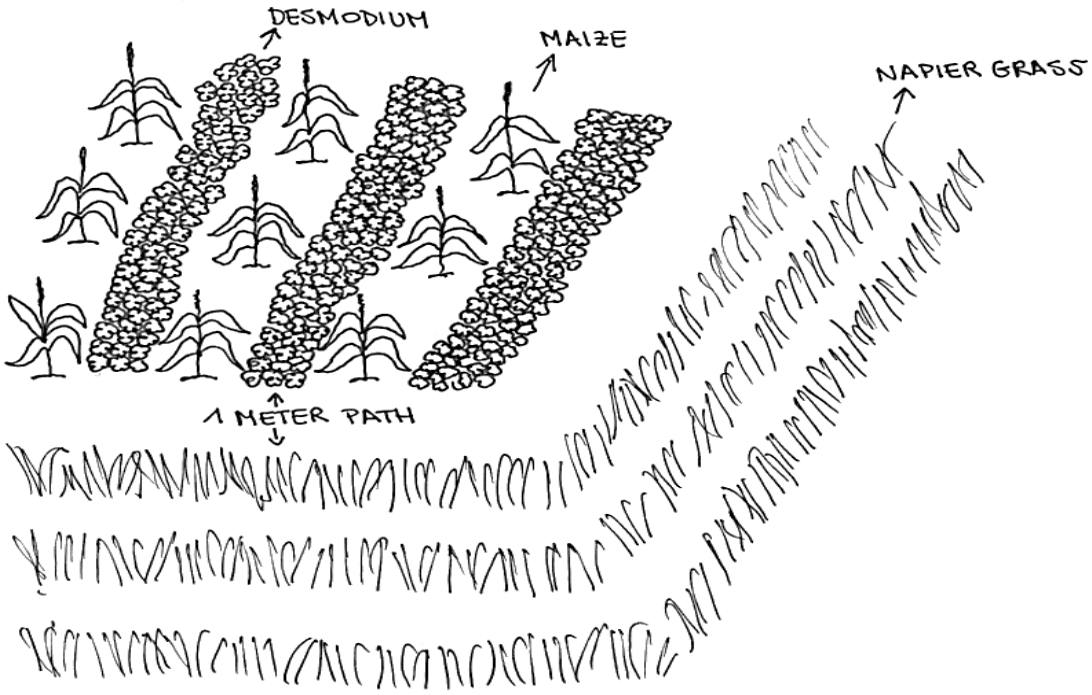

Figure 1. How to plant Napier grass, Desmodium and maize.

1. Clear your land during the dry season. Plough and harrow your land to a fine tilth. Be careful about the size of your plot; if it is less than 10 x 10 m the push- pull strategy will not work because the Napier grass will block the sunrays to reach the maize.
In the first year, plant Napier grass before the rainy season.
Plant the Napier grass around the maize plot.

2. Plant Napier grass.

- dig a hole;
- put in 1 tablespoonful of fertilizer or 2 handfuls of farmyard manure;
- plant splits or plant cane;
- cover with soil.

The spacing should be 75 cm between rows and 50 cm between Napier grass plants within a row.

Figure 2. How to plant napier grass

3. Plant maize

Plant maize in the plot already surrounded by napier grass. The first row of maize must be 1 meter away from the inner row of Napier grass (Figure 2).

The spacing between maize plants should be of 75 cm between rows and 30 cm within the same row.

4. Plant desmodium

You will need 1 kg of desmodium seed for 1 acre (0.4 ha) of land.

The distance between desmodium and maize rows should be of 75 cm. Use a stick to make 1-2 cm deep holes and fill them with a mixture of desmodium seeds and sand (1 part of seed and 3 parts of sand).

Plant the desmodium during the rainy season for maximum germination.

ANNEX II

SUNN HEMP *Crotalaria juncea* L.

Sunn hemp is a rapidly growing crop that is used for fiber production in India and Pakistan. Sunn hemp is an annual plant, generally 1 to 4 m in height.
It is used as a green manure and as an organic nitrogen source.

Sunn hemp suppresses weeds, slows soil erosion, and reduces root-knot nematode populations. Sunn hemp is drought resistant and is adapted to hot, semi-arid and arid areas, yet can tolerate light frosts. It is not tolerant of salt, nor of sustained waterlogging.

Sunn hemp is established by seed. Sowing rates of 40-45 kg/ha are used when it is sown as a forage crop or as green manure, but when it is sown for fiber, rates of 100-240 kg/ha are used. Sunn hemp is fast growing. Seedlings emerge 3 days after sowing, and rapidly produce a thick ground cover that smothers weeds. Extensive cross-pollination occurs in Sunn hemp and self-pollination takes place after the stigmatic surface has been insect or mechanically stimulated.

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