Training manual for

ORGANIC AGRICULTURE

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TECA
Technologies and practices for smallholder farmers

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1. INTRODUCTION TO ORGANIC AGRICULTURE

SUMMARY

Organic agriculture is an integrated production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity (FAO/WHO Codex Alimentarius Commission, 2007). It emphasizes the use of natural inputs (i.e. mineral and products derived from plants) and the renunciation of synthetic fertilizers and pesticides.

Organic agriculture follows the principles and logic of a living organism, in which all elements (soil, plant, farm animals, insects, the farmer and local conditions) are closely linked to each other. This is accomplished by using, where possible, agronomic, biological and mechanical methods, following the principles of these interactions, using natural ecosystem as a model (Figure 1).

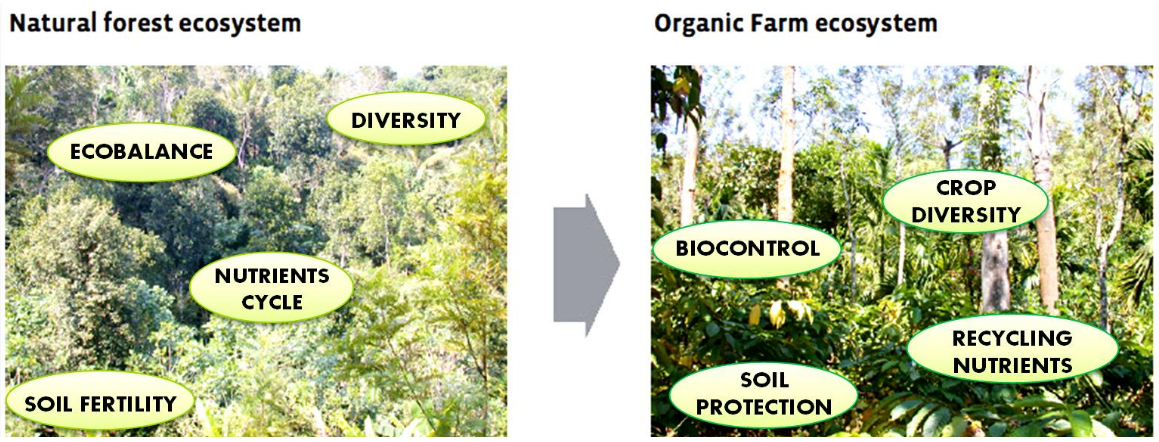

FIGURE 1-1 - USING NATURAL ECOSYSTEM AS A MODEL

Organic agriculture shares many techniques used by other sustainable agricultural approaches (e.g. intercropping, crop rotation, mulching, integration of crops and livestock). However, the use of natural inputs (non synthetic), the improvement of soil structure and fertility and the use of a crop rotation plan represent the basic rules that make organic agriculture a unique agricultural management system.

According with the Guidelines of Organically Food Produce of the Codex Alimentarius (2007), an organic production system is designed to:

- Enhance biological diversity within the whole system;
- Increase soil biological activity;
- Maintain long-term soil fertility;
- Recycle wastes of plant and animal origin in order to return nutrients to the soil, thus minimizing the use of non-renewable resources;
- Rely on renewable resources in locally organized agricultural systems;
- Promote the healthy use of soil, water and air as well as minimize all forms of pollution that may result from agricultural practices;
- Promote the careful processing methods agricultural products in order to maintain the organic integrity and vital qualities of the product at all stages;
- Become established on any existing farm through a period of conversion, the appropriate length of which is determined by site-specific factors such as the history of the land, and type of crops and livestock to be produced.

In addition, the International Federation of Organic Agriculture Movements (IFOAM), a non-governmental organization internationally networking and promoting organic agriculture, has established guidelines that have been widely adopted by the organic community for organic production and processing.

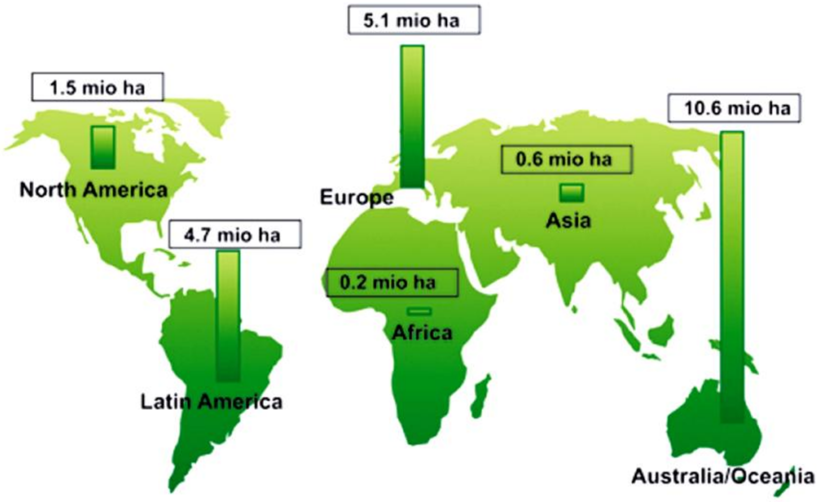

FIGURE 1-2 - OVERVIEW OF ORGANIC PRODUCTION IN 2003: HECTARES UNDER CERTIFIED ORGANIC MANAGEMENT IN THE DIFFERENT CONTINENT (SOURCE: SOEL STATISTIC, 2003)

According with IFOAM (2002), the organic agriculture practices are based on the following principles:

- **Principle of health**: the role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings. In view of this, it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

- **Principle of ecology**: organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustaining them. Organic management must be adapted to local conditions, ecology, culture and scale. The reduction of inputs by reuse, recycle and the efficient management of materials and energy will contribute to improve environmental quality and will conserve resources.

- **Principle of fairness**: This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties – farmers, workers, processors, distributors, traders and consumers. It also insists that animals should be provided with the conditions and opportunities of life according with their physiology, natural behaviour and well-being. Natural and environmental resources that are used for production and consumption should be managed in a socially and ecologically fair way and should be held in trust for future generations. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

- **Principle of Care**: This principle states that precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture. Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, it must consider valid solutions from practical experiences, accumulated traditional and indigenous knowledge and prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones, such as genetic engineering.

WHY ORGANIC AGRICULTURE?

The goal of organic agriculture is to contribute to the enhancement of sustainability. But what does sustainability mean? In the context of agriculture, sustainability refers to the successful management of agricultural resources to satisfy human needs while at the same time maintaining or enhancing the quality of the environment and conserving natural resources for future generations. Sustainability in organic farming must therefore be seen in a holistic sense, which includes ecological, economic and social aspects.

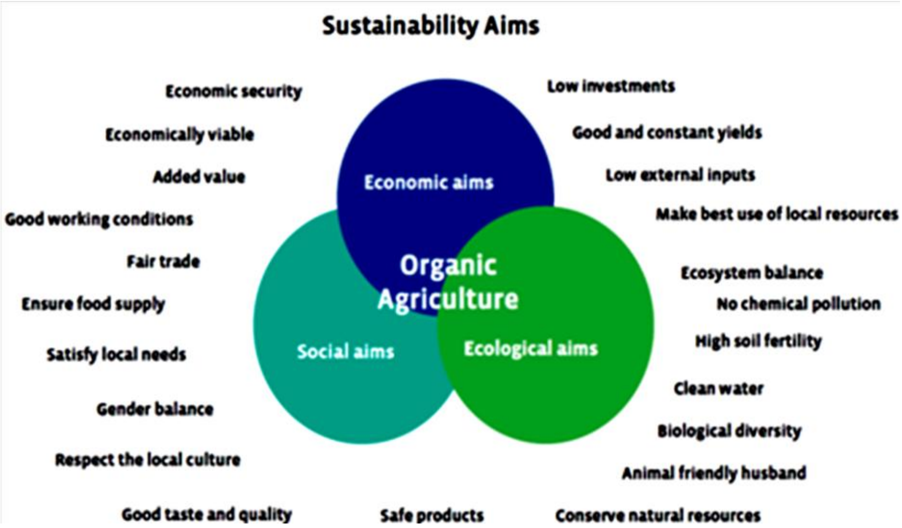

FIGURE 1-3 - THE THREE DIMENSIONS OF SUSTAINABILITY

Only if the three dimensions are fulfilled an agricultural system can be called sustainable.

The organic agriculture techniques are known to be **ECOLOGICALLY SUSTAINABLE** by:

- Improving soil structure and fertility through the use of crop rotations, organic manure, mulches and the use of fodder legumes for adding nitrogen to the soil fertility cycle.
- Prevention of soil erosion and compaction by protecting the soil planting mixed and relay crops.
- Promotion of biological diversity through the use of natural pest controls (e.g. biological control, plants with pest control properties) rather than synthetic pesticides which, when misused, are known to kill beneficial organisms (e.g. natural parasites of pests, bees, earthworms), cause pest resistance, and often pollute water and land.
- Performing crop rotations, which encourage a diversity of food crops, fodder and under-utilized plants; this, in addition to improving overall farm production and fertility, may assist the on-farm conservation of plant genetic resources.
- Recycling the nutrients by using crop residues (straws, stovers and other non-edible parts) either directly as compost and mulch or through livestock as farmyard manure.
- Using renewable energies, by integration of livestock, tree crops and on farm forestry into the system. This adds income through organic meat, eggs and dairy products, as well as draught animal power. Tree crops and on-farm forestry integrated into the system provide food, income, fuel and wood.

SOCIAL SUSTAINABILITY

Sustainability is also about equity among and between generations. Organic agriculture contributes to the social well-being by reducing the losses of arable soil, water contamination, biodiversity erosion, GHG emissions, food losses, and pesticide poisoning.

Organic agriculture is based on traditional knowledge and culture. Its farming methods evolve to match local environments, responding to unique biophysical and socio economics constraints and opportunities. By using local resources, local knowledge, connecting farmers, consumers and their markets, the economic conditions and the development of rural can be improved.

Organic agriculture stresses diversification and adaptive management to increase farm productivity, decrease vulnerability to weather vagaries, and consequently improves food security, either with the food the farmers produce or the income from the products they sell.

ECONOMIC SUSTAINABILITY

Organic farming appears to generate 30% more employment in rural areas and labor achieves higher returns per unit of labor input. By using local resources better, organic agriculture facilitates smallholders' access to markets and thus income generation; and relocalizes food production in market-marginalized areas.

Generally, organic yields are 20% less as compared to high-input systems in developed countries but could be up to 180% higher as compared to low-input systems in arid/semi-arid areas. In humid areas, rice paddy yields are equal, while the productivity of the main crop is reduced for perennials, though agroforestry provides additional goods.

Operating costs (seeds, rent, repairs and labor) in organic agriculture are significantly lower than conventional production, ranging from 50-60% for cereals and legumes, to 20-25% for dairy cows and 10-20% for horticulture products. This is due to lower input costs on synthetic inputs, lower irrigation costs, and labor cash costs that include both family labor and hired workers. Total costs are, however, only slightly lower than conventional, as fixed costs (such as land, buildings and machinery) increase due to new investments during conversion (e.g. new orchards, animal houses) and certification.

MARKET OPPORTUNITIES

The demand for organic products creates new export opportunities. Organic exports are sold at impressive premiums, often at prices 20% higher than the same products produced on non-organic farms. Under the right circumstances the market returns from organic agriculture can potentially contribute to local food security by increasing family incomes.

Entering this lucrative market is not easy. Farmers require hiring an organic certification organization to annually inspect and confirm that their farms and businesses adhere to the organic standards established by various trading partners. During the conversion period to organic management, which lasts 2 to 3 years, farmers cannot sell their produce as "organic" and thus, tap price premiums. This is because consumers expect organic produce to be free of residues. However, according to the Codex Guidelines on Organically Produced Food (2007), products produced on land under organic management for at least one year, but less than the two-three year requirement could be sold as "**transition to organic**"; but very few markets have developed for such products.

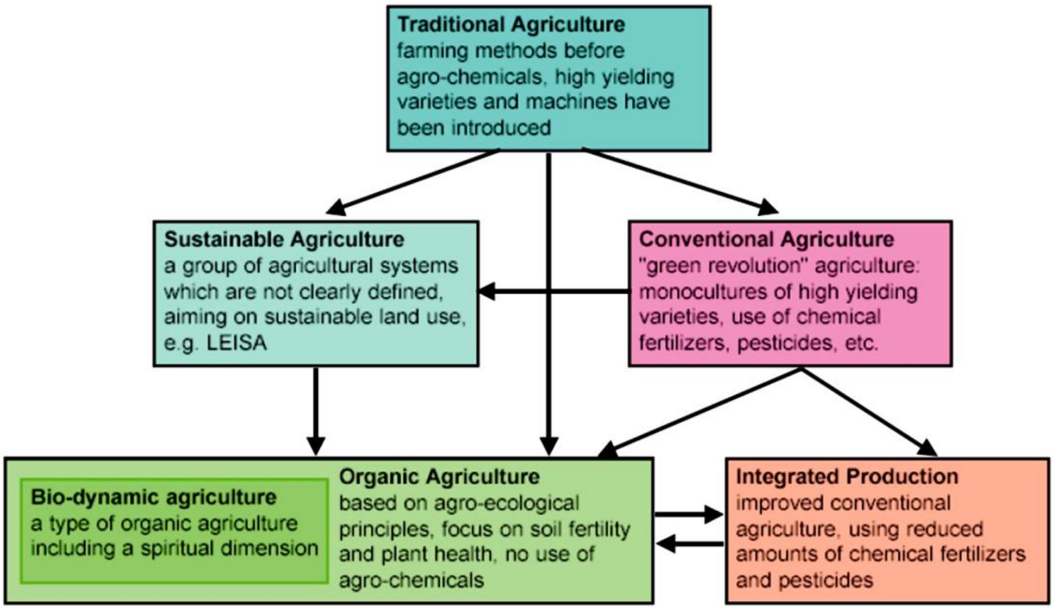

FIGURE 1-4 - DEFINITION OF SOME FARMING SYSTEMS: THIS SHOWS AN ATTEMPT TO DISTINGUISH BETWEEN SOME COMMONLY USED TERMS OF AGRICULTURAL SYSTEMS (ARROW SHOW HOW THEY CAN TRANSFORM FROM ONE TYPE INTO ANOTHER)

While most developing countries producers have historically targeted international export markets in the EU and North America, domestic market opportunities for organic food are emerging worldwide. Acknowledging the role of domestic organic markets in supporting a vibrant organic sector, alternative systems to certification have emerged worldwide. In developed countries, consumers and organic producers have built direct channels for home delivery of non-certified organic produce (e.g. Community Supported Agriculture). In the United States of America (USA), farmers marketing small quantities of organic products are formally exempt from certification. Increasingly in developing countries, Participatory Guarantee Systems (PGS) are recognized as substitute to third part certification (e.g. India, Brazil, Pacific islands).

More recently, organic agriculture has become an option to improve household food security, or to achieve a reduction of input costs. With the economic crisis, this phenomenon is seen also in developed countries. Produce is used by farmers for their own consumption or it is sold on the market without a price distinction as it is not certified.

Economic objectives are not the only motivation of organic farmers; the goals are often to optimize land, animal and plant interactions, preserve natural nutrient and energy flows and enhance biodiversity, while safeguarding human health of family farmers and contributing to the overall objective of sustainable agriculture.

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ON TECA

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2. CONSIDERATIONS FOR CONVERSION TO ORGANIC AGRICULTURE

SUMMARY

Conversion to organic agriculture describes the process of learning and implementation of changes on the farm towards a more sustainable and natural way of farming. The form the process takes depends on the local circumstances and the predisposition of the farmer or the community, and it varies from farm to farm. The more knowledge a farmer has about the concepts and practices of organic farming, the easier conversion process to organic farming will be. Even if organic farming does not depend on specific land conditions to start with, if soils are depleted for example, it may need greater efforts and require more patience to establish a sustainable production system and realize satisfying harvests. Here, you will find the factors to be considered during conversion to organic agriculture and some recommendations to succeed during the process.

A. ANALYSIS OF THE LOCATION

The conversion from a conventional to an organic system requires a transitory period, where the organic practices are applied progressively following an organized plan. During this period it is important to analyse carefully the actual situation of the farm and identify the actions to be taken (Florez, 2003).

The analysis of the farm must include (Figure 2-1):

1. Farm characteristics: size, plots and crops distribution, which kind of crops, trees, animals are integrated in the farm system.
2. Soil Analysis: an evaluation of the soil structure, nutrient levels, organic matter content, erosion level, and/or the soil have been contaminated.
3. Climate: rainfall distribution and quantity, temperatures, frost risks, humidity.
4. Organic matter sources and management (manures).
5. Presence of animal housing systems and/or machinery.
6. Limiting factors such as capital, labour, market access, among others.

This information will help you to have a clear picture of your farm and to take decisions.

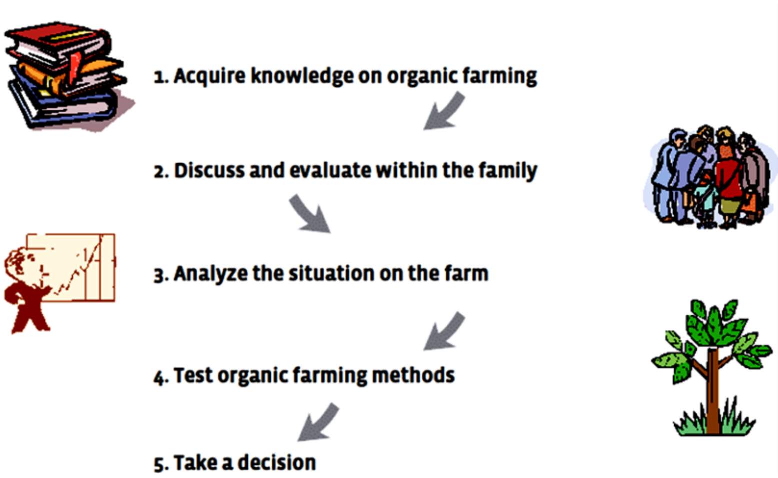


FIGURE 2-1 - PREPARING FOR THE CONVERSION

B. FARM-RELATED CHALLENGES TO CONVERSION

Depending on the farm situation, different challenges are to be expected during conversion:

1. FARMS WITH HIGH EXTERNAL INPUT USE

The majority of intensively managed farms in Africa, Latin America and Asia that strongly rely on external inputs are larger farms. Such farms mostly grow a few annual or perennial cash crops relying heavily on the use of fertilizers for plant nutrition and pesticides and herbicides for pest, disease and weed control. On such farms crops are often grown without a planned rotation and farm animals are not integrated into the nutrient cycle. Diversification is usually low on these farms. Trees and bushes are mostly removed to facilitate extensive mechanization, and crops are mostly grown alone. (Figure 2-2).

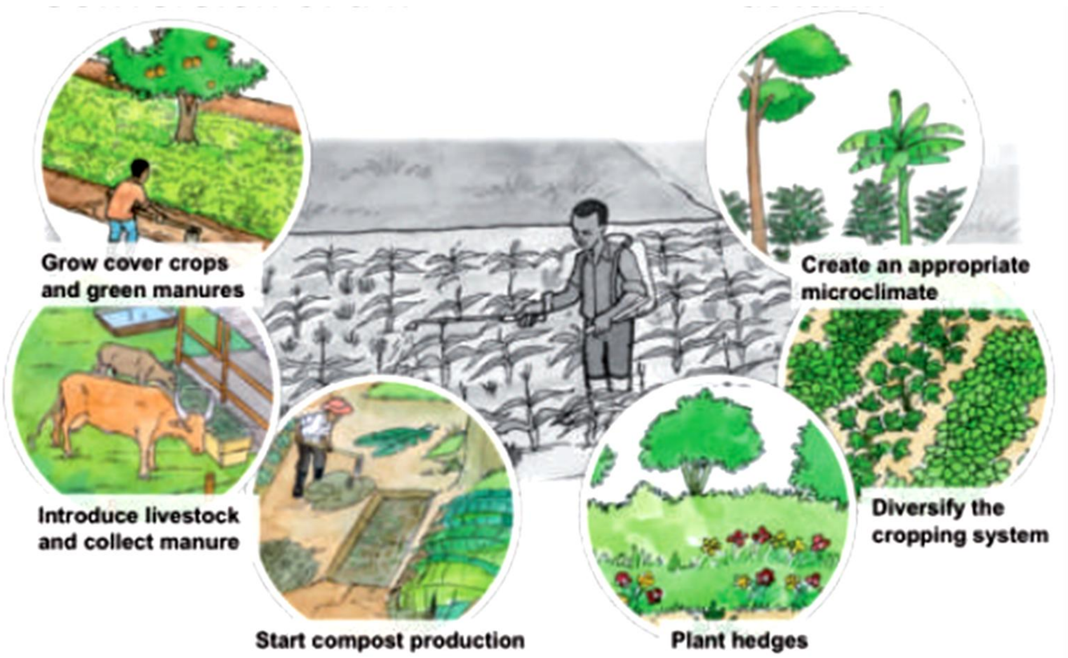


FIGURE 2-2 - CONVERSION OF A HIGH EXTERNAL INPUT FARM

Potential challenges in conversion of such farms (Figure 2-3):

- Establishing a diverse and balanced farming system with a natural ability to regulate itself usually takes several years.
- Major efforts may be necessary to restore natural soil fertility by providing a considerable amount of organic matter to the soil.
- Abandoning high input external fertilizers results in yield depression in the first years of conversion, before soil fertility is re-established and yields rise again.
- New approaches and practices usually involve a lot of learning and intensive observation of crop development, and dynamics of pests, diseases and natural enemies.

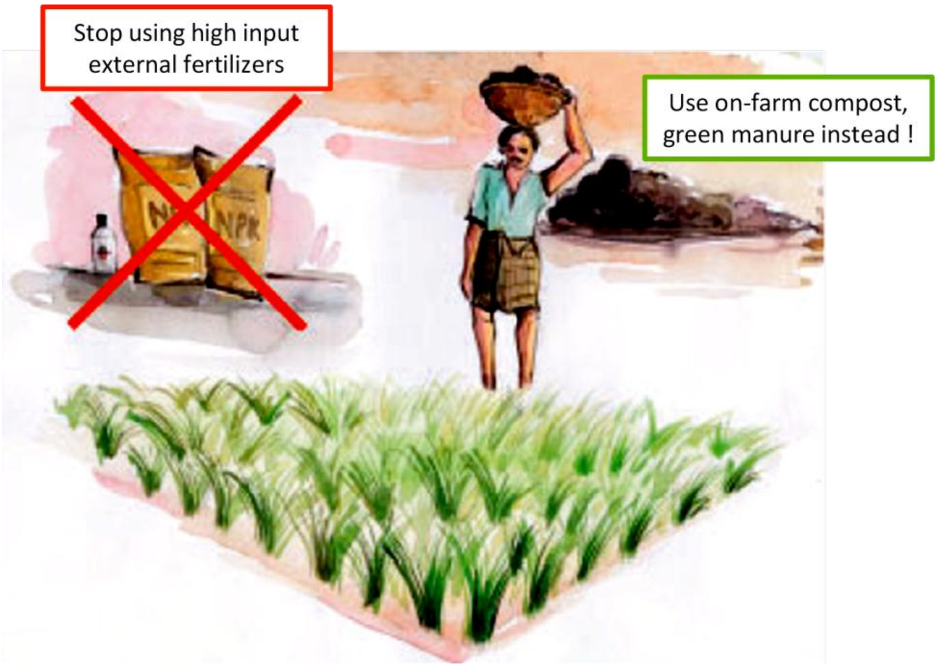


FIGURE 2-3 - MINIMIZING EXTERNAL INPUT

However, the conversion process can be achieved, if the following practices are implemented:

- **Diversify the farming system**: Select appropriate annual crops for the area and rotate them in a planned sequence. Include legume crops such as beans or leguminous feed crops in the rotation to provide nitrogen to the subsequent crops. Plant hedges and flower strips to encourage natural enemies and to control pests.
- **Start recycling valuable farm by-products**. Establish on-farm compost production based on harvest residues and manure, if available, and mix the compost with the topsoil. This will bring stable organic matter into the soil and improve its structure and its capacity to feed the plants and store water. Green manures can provide plenty of plant material to feed soil organisms and build up soil fertility (Figure 2-4).
- **Introduce farm animals into the system**. Farm animals provide valuable manure and diversify farm income through additional animal products.
- **Grow cover crops**. Cover crops or lay out mulches in perennial crops provide protection to the soil.

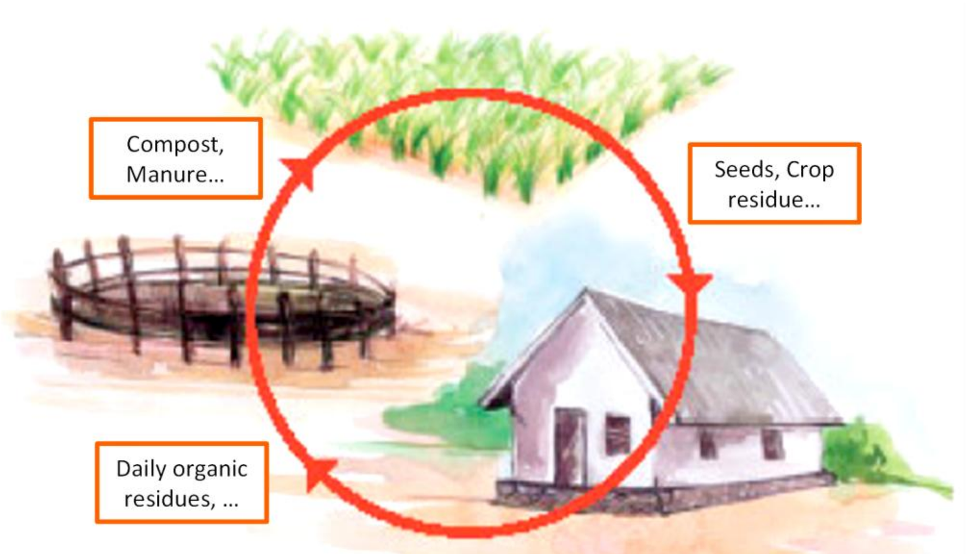


FIGURE 2-4 - RECYCLING VALUABLE FARM BY-PRODUCTS

2. FARM WITH LOW EXTERNAL INPUT USE

Farmers working with little external inputs based on traditional practices may grow many different crops in a densely mixed system on the same piece of land changing crops randomly. A few livestock such as chickens, pigs, cattle and/or goats may be kept, which scatter the manure in their feeding places, hence providing very little manure for the gardens. The trees may be extensively cut for firewood and charcoal burning. Bush and trash burning may be a common practise especially during land preparation. Harvests are probably low and increasingly becoming difficult due to unreliable and insufficient rains. The harvests may just be sufficient for feeding the family and little may be left to sell for income. (Figure 2-5).

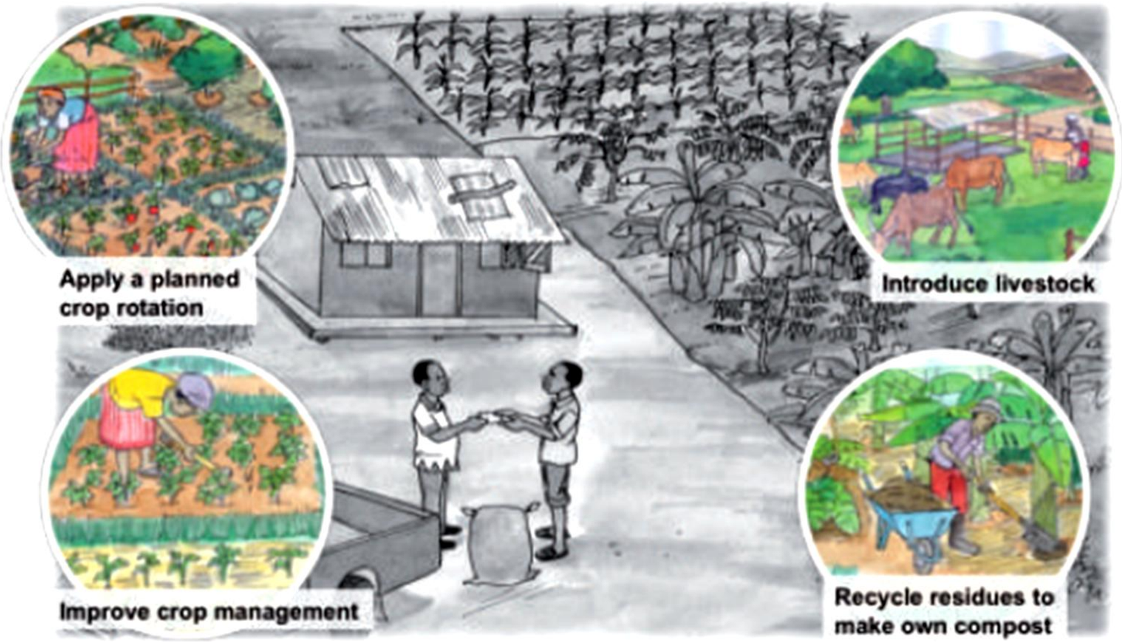


FIGURE 2-5 - CONVERSION OF A LOW EXTERNAL INPUT FARM

Traditional farmers fulfil some principles of organic farming already by relying on farm-own resources, growing different crops simultaneously and raising livestock. However, there are still practices, which clearly distinguish such farms from organic farms. The following challenges need to be addressed for conversion:

- Avoid burning of crop residues after harvest as this is, in most cases, not a viable solution, since it destroys valuable organic material and damages soil organisms.
- Establish a well organised diversification systems including a 'planned' crop rotation and intercropping systems.
- Accumulate knowledge and practice regarding efficient use of farm own resources, especially for compost production to manage and improve soil fertility.
- Avoid indiscriminate tree cutting for firewood and charcoal burning.
- Establish a system to collect the animal manure for composting.
- Apply measures to prevent loss of soil through erosion and protect it from drying out.
- Pay special attention to satisfy feed and health requirements of the farm animals.
- Avoid infection of seeds with diseases, gain knowledge on disease cycles and preventive measures.
- Avoid harvest and storage losses.

Some practices for conversion in this system are (Figure 2-6):

- Implement planned crop rotation and intercropping systems. A combination of annual and perennial crops including leguminous green manure cover crops is needed. Combined with properly selected or improved crop varieties with good resistance to plant pests and diseases, will facilitate the crop and soil management.

- Proper integration of animals into the farming system, as well as planting rows of nitrogen fixing trees between annual crops will improve the growing conditions for the crops and encourage better growth, while providing additional feed for the ruminant animals. Better housing is also needed to facilitate collection of animal manure for field use.
- Improving the fertility of the soils, for example, through the application of high quality compost. Compost is a highly valuable fertilizer in organic farming. Instead of burning the crop residues after harvest, collect them for compost production, or work them into the soil. The animal manures and plant materials should be regularly collected for compost making.
- Growing nitrogen fixing legumes between annual crops is another possibility to feed the soil and the crops.
- Additional measures to control soil erosion such as digging trenches and planting trees along the hillside, and covering the soil with living or dead plant material should be implemented.

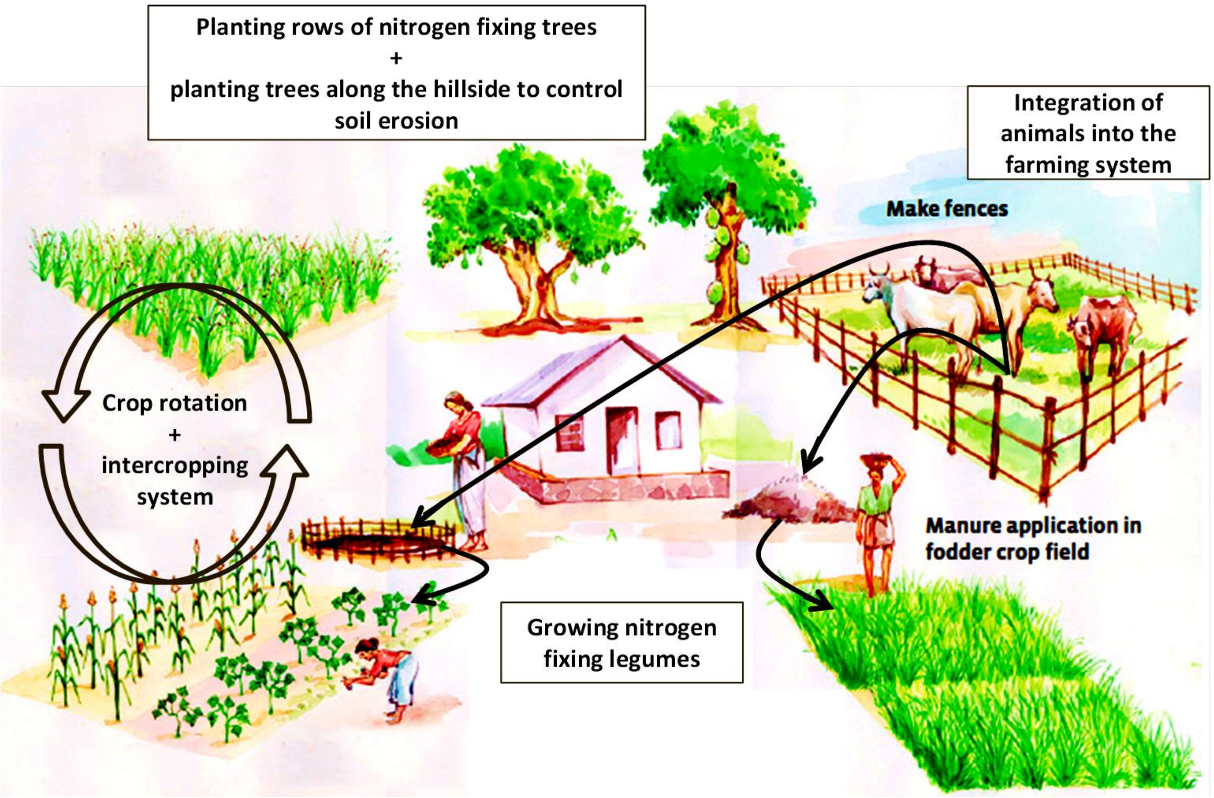


FIGURE 2-6 - SOME ORGANIC FARMING METHODS TO TEST IN YOUR OWN FARM

3. MIXED FARM

On mixed farms, crops and farm animals may be integrated, whereby the animal manure is collected and used in the gardens after having kept it for a few weeks to rot. Some soil conservation measures may be implemented, such as mulching in perennial crops and trenches to reduce erosion. Occasionally herbicides, pesticides and treated seeds may be used to control weeds in fruit and vegetable production. Farmers of such mixed farms are obviously familiar with some of the organic farming practices. Such farmers will find it easy to learn new methods from other farmers or from a trainer and to implement organic practices throughout the farm.

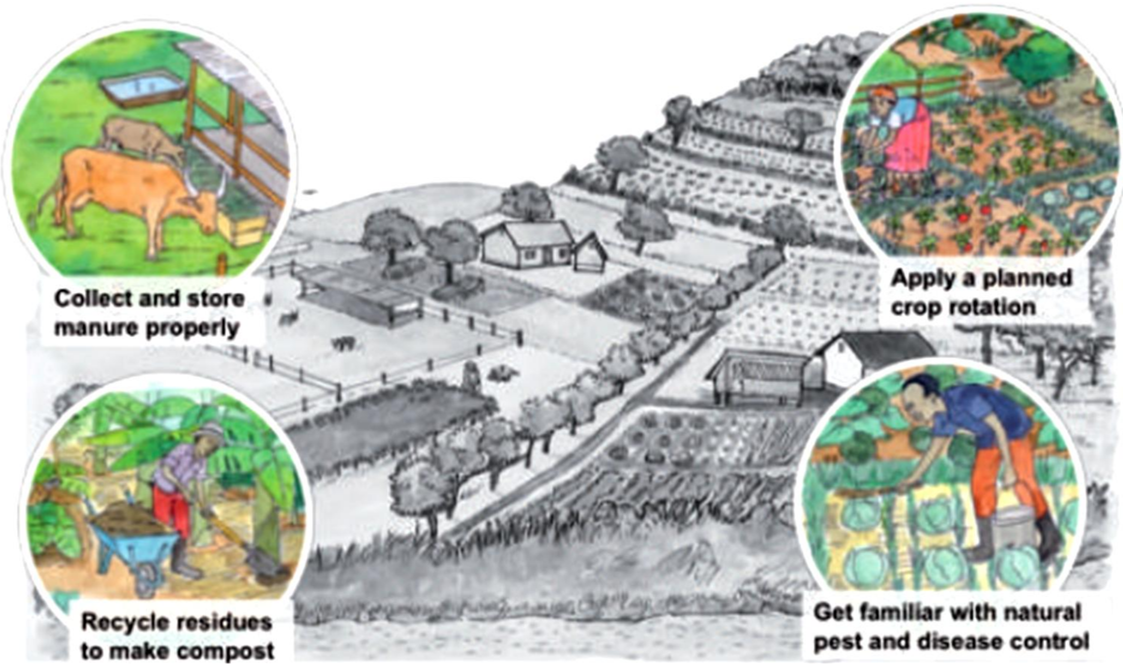


FIGURE 2-7 - CONVERSION OF A MIXED FARM

Recommendations for organic conversion (Figure 2-7):

- Implement organic practices to manage the soil and to control weeds instead of using herbicides. For example, in fruit orchards grow a leguminous cover crop to cover the soil. Or in vegetables and arable crops implement a planned crop rotation that includes weed suppressing green manure or feed crops.
- Further improve recycling of farm own nutrients from animals and crop residues to make best uses of them, for example by mixing them with crop residues for making compost. Improve storage of animal manures to avoid nutrient losses.
- Use seeds without pesticide-treatments, if available. Make sure to use healthy seeds only and get familiar with non-chemical ways of treating seeds.
- Get familiar with approaches and methods of natural pest and disease control.
- Learn about beneficial insects and observe population dynamics of pests through regular monitoring during crop growth.
- Further diversify the farming system to increase productivity of the land and provide habitats for beneficial insects and spiders.

4. DEGRADED LAND

Land may be degraded due to shifting cultivation, overgrazing, over-cultivation or deforestation, salinity after years of intensive irrigation with ground water, or water logging and flooding. Such land may take more effort and patience to establish good growing conditions. At the same time, organic practices are an excellent approach to recover such soils. It may require specific practices to stop soil degradation and to re-establish soil fertility. Such practices include digging of terraces or sowing an intensive fallow with a leguminous green manure crop that grows well on poor soils. (Figure 2-8).

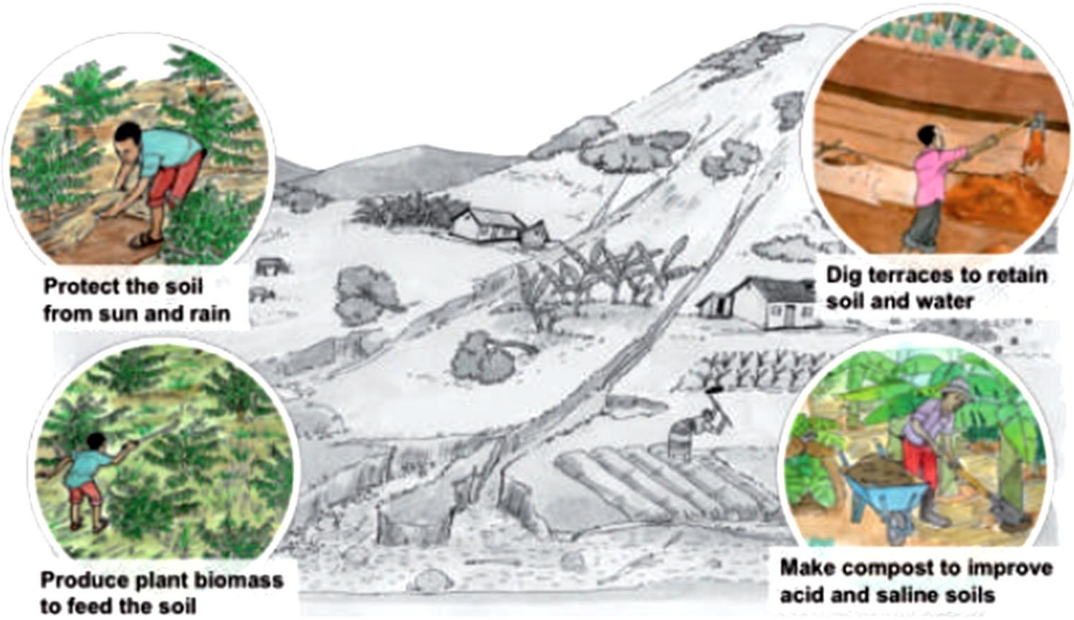


FIGURE 2-8 - CONVERSION OF DEGRADED LAND

Many experiences show that organic farming is a promising approach to improve degraded land and bring it back into production. In most cases, the increase of organic matter plays a key role to improve the quality of degraded soils.

In case of a **bare and eroded soil** on sloping land, organic farming calls for digging of terraces (e.g. fanya juu terraces, see the figure below). Fanya juu ('throw it upwards' in Kiswahili) terraces are made by digging trenches along the contours and throwing the soil uphill to form embankments (bunds), which are stabilized with fodder grass like Napier (Pennisentum purpureum) and multipurpose agroforestry trees (Figure 2-9). The space between the embankments is cultivated with crops and over time, the fanya juu develop into bench terraces. They are useful in semi-arid areas to harvest and conserve water. Additionally, green manures and compost can be used to further build the soil to support good crop growth and yields.

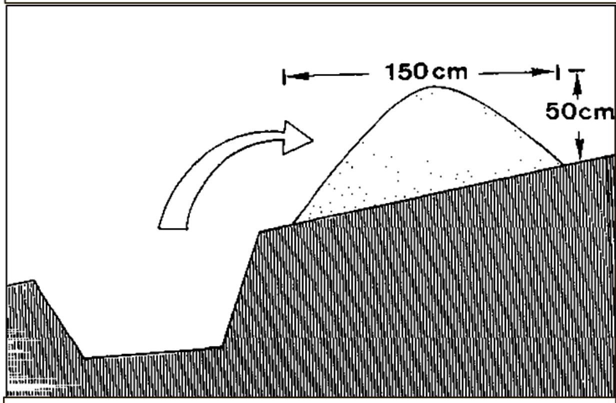
Saline soils contain large amounts of water soluble salts that inhibit seed germination and plant growth. These salts may have been accumulated through excessive use of irrigation water, especially in arid and semi-arid climates. These salts can be reduced slowly by ensuring proper irrigation and building up the structure of the soil with compost to allow natural drainage of the excess salts. In a first period salt tolerant crops may be grown.

Acid soils can be reclaimed by adding lime and well-made compost.

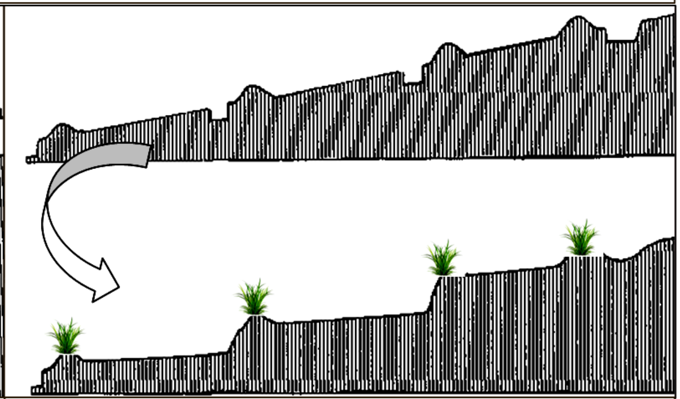
Flooded soils can be improved by creating drainage channels to drain off the excess water.

HOW A FARM IS CONSERVED USING FANYA-JUU TERRACES

1. The farm is surveyed by a technician to see if a cutoff drain is required above the fields.
2. A cutoff drain is laid out along the contour. All the runoff from outside the farm is held and infiltrates.
3. The soil dug out from the cutoff drain is heaped downslope.
4. Contours are then surveyed with a line level.
5. Soil is loosened with hoes or mattocks along the line of the contour and then thrown upslope to make the bund. A small step is left between the trench and the bund so that soil is not washed straight back in when it rains.
6. Grass is planted on top of the bund to stabilize it. "Bane grass" is one of the best varieties for Kenya. Bananas or other trees may be planted in the trench.
7. Ploughing, weeding and natural soil movement cause the land between the terrace banks to level off into benches after a few years.



Transversal view of Fanya-Juu terrace (details)



Transversal view of Fanya-Juu terraces through years

CUTOFF DRAIN Dimensions:
Ditch: 1,25 m wide at top and 1m wide at bottom
Depth: approx. 1m
Gradient: usually sited on contour, but sometimes sited on a slight gradient when it is joined to a natural waterway

Where fanya-juu terraces can be used
- in marginal/wetter zones (700 mm rainfall and above)
- soils should be deep
- suitable for slopes from less than 5% to 50%

FANYA-JUU TERRACE dimensions:
Spacing of terrace banks: usually between 5 and 20 m apart, (depends on the slope of the land - the steeper the land, the closer the terrace banks)
Trench: 60 cm wide and 60 cm deep
Bund: 50 cm high and 150 cm wide at base
Step: 20 cm between trench and bund
Gradient: sited on contour (in dry areas)
Labour: 150-350 person-days/hectare (for cutoff and terraces)

FIGURE 2-9 - FANYA-JUU TERRACES TECHNIQUES OF KENYA

C. CLIMATE RELATED CHALLENGES TO CONVERSION

Converting a farm to organic farming in an area with very little rainfall and high temperatures or strong winds will be more challenging than converting a farm located in an area with well distributed rainfall and favourable temperatures. At the same time, the improvements that follow implementation of organic practices will be more obvious under arid conditions than under ideal humid conditions. For example, compost application into topsoil or into planting holes will increase the soils water retention capacity and the crop's tolerance to water scarcity.

In very **warm and dry climate**, losses of water through transpiration from plants and evaporation from soils are high. These losses may be further encouraged by strong winds, enhancing soil erosion. The soils' organic matter content is generally low, as biomass production is low, implying that the availability of nutrients to the plants is highly reduced. (Figure 2-10).

Under such conditions, the key to increasing crop productivity lies in protecting the soil from strong sun and wind and increasing the supply of organic matter and water to the soil. Soil organic matter can either be increased through compost or through cultivation of green manure crops. In the case of compost production the challenge is to increase production of plant biomass, which is needed for compost production.

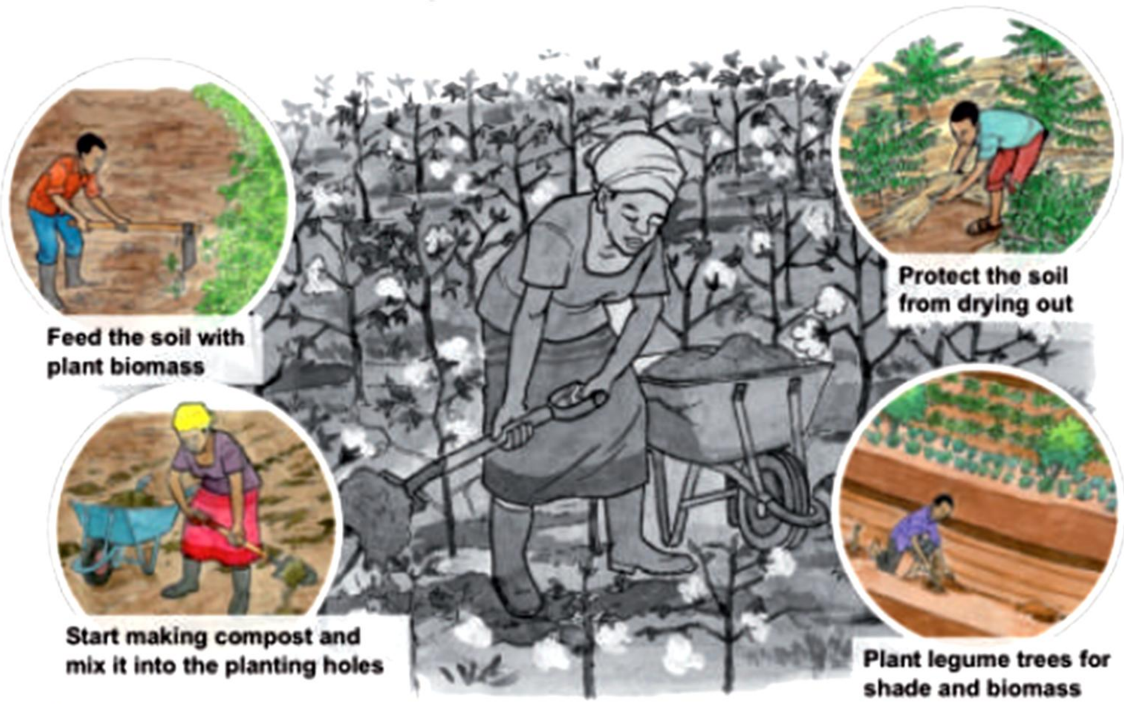


FIGURE 2-10 - CONVERSION IN DRY CLIMATE

In **warm and humid climate**, high aboveground biomass production and rapid decomposition of soil organic matter imply that the nutrients are easily made available to the plants. But it also involves a high risk that the nutrients are easily washed out and lost. Under such conditions a balance between production and decomposition of organic matter is important to avoid depletion of soil.

Combining different practices to protect the soil and feed it with organic matter proves to be the most effective approach to choose. These practices include creating a diverse and multi-layer cropping system ideally including trees, growing nitrogen-fixing cover crops in orchards and applying compost to enrich the soil with organic matter and in this way increase its capacity to retain water and nutrients.

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Agricultura Ecológica, Manual y Guía Didáctica. Javier Flórez Serrano, IRMA S.L. (Instituto de Restauración y Medio Ambiente, León-España)

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FiBL / IFOAM

ON TECA

Considerations for Conversion to Organic Agriculture: http://teca.fao.org/read/8363

3. Step by Step Conversion to Organic Agriculture

SUMMARY

The procedure of conversion of a farm commonly consists of three steps. In a first step, it is recommended to collect information on appropriate organic farming practices. In a second step, the most promising organic practices should be tried out on selected plots or fields to get familiar with. In a third step, only organic procedures should be implemented in the entire farm. Support from an experienced extension officer or a farmer is usually very helpful to give guidance in the process.

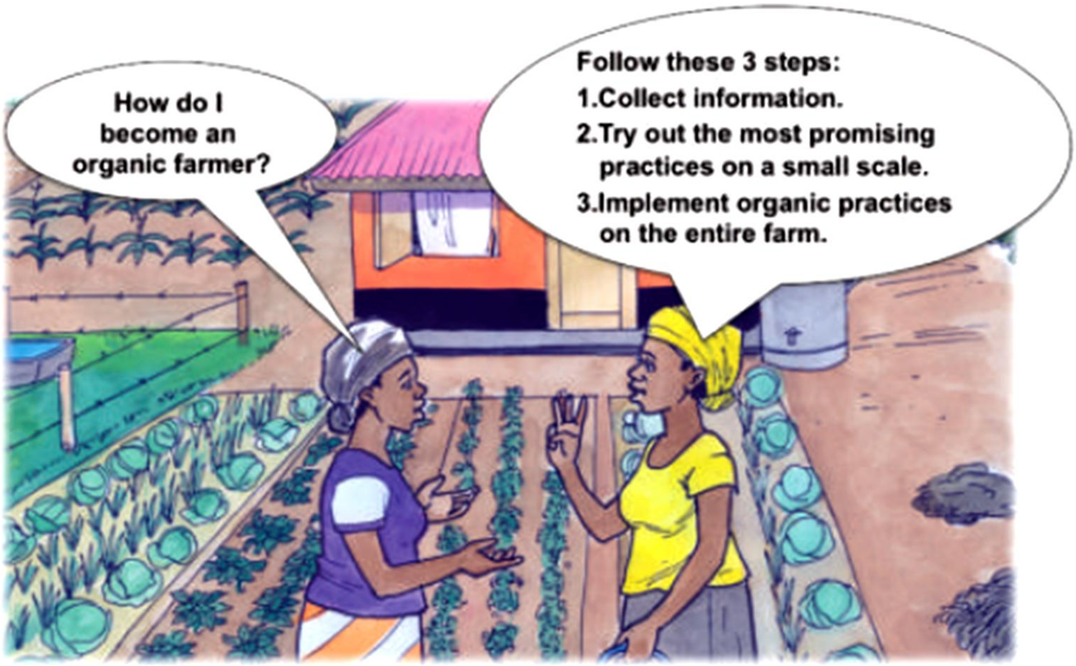

Figure 3-1 - How to become an organic farmer?

A. Step 1: Good information first

Successful organic farming requires considerable knowledge on the functioning and the possibilities of management of natural processes. Interest in learning about the possibilities to support natural processes to sustain and improve harvests is essential for successful organic farming. Farmers who are interested in adopting organic farming practices are recommended to get in contact with farmers in the area (Figure 3-1), who already practice organic farming to learn from them. Some farmers may be good at making compost, some at growing green manures, and some at making plant or manure tea. Learning from experienced farmers allows to get first-hand experience under local conditions, and thus to learn about the advantages and potential challenges related to implementing organic methods. (Figure 3-2).

FIGURE 3-2 - HOW TO GET INFORMATION ON ORGANIC AGRICULTURE?

Basically, farmers who are interested in converting their farm to organic agriculture need to know:

- How to improve soil fertility.
- How to keep crops healthy.
- How to best increase diversity in the farm.
- How to keep livestock healthy.
- How to give value to organic products and how to successfully sell them.

B. STEP 2: GETTING FAMILIAR WITH ORGANIC PRACTICES

After having collected information about the requirements, the potentials and the main practices related to conversion, farmers should start to learn from their own experience on their farms. To minimize risks of crop failure and losses of animals, and avoid frustrating overload, farmers are recommended to implement organic practices step-by-step to a limited extent, selecting specific practices at a time and testing them on selected plots or selected animals only. But which practices should one choose to start with? As would seem natural, farmers should start by applying practices that are of low risk and investment, require little specific knowledge, limited additional labour, and with high short term impact. Examples of recommended interventions include (Figure 3-3):

- **Mulching** - Covering the soil with dead plant material is an easy way to control weeds and protect the soil in annual crops. This practice can be implemented into most existing cropping systems. The main question may be, however, where to get appropriate plant material from.

- **Intercropping** - Growing two annual crops together, commonly a leguminous crop like beans or a green manure crop in alternating rows with maize or another cereal crop or vegetable is a common practice in organic farming to diversify production and maximize benefits from the land. In intercropping, special attention must be paid to avoid competition between the crops for light, nutrients and water. This requires knowledge on arrangements, which promote growth of at least one of the crops.

- **Composting** - Application of compost to the fields can have a major impact on crop growth and yields. To start compost production, farmers will need enough plant materials and animal manures, if such are available. In case such materials are scarce, farmers would first have to start producing plant materials on the farm by sowing fast growing leguminous plants that build a lot of biomass, and by introducing some livestock on the farm for manure production, if this proves appropriate. To get familiar with the process of making compost, farmers should be instructed by an experienced person. Proper compost production requires some knowledge and experience and additional labor, but is low in investments.

- **Green manuring -** The practice of growing a leguminous plant species for biomass production and incorporation into the soil may be new to most farmers. Nevertheless, this practice can greatly contribute to improvement of soil fertility. Green manures can be grown as improved fallows, as seasonal green manures in rotation with other crops, or in strips between crops. Proper green manuring first requires information on appropriate species.

- **Organic pest management** – Careful associations and management of plants and animals in order to prevent pest and disease outbreaks. Initially, bio-control agents may be applied but organic pest management is best achieved through ecological approaches that establish a pest/predator balance. While the choice of resistant varieties of crops is paramount, other prevention methods include: choosing sowing times that prevent pest outbreaks; improving soil health to resist soil pathogens; rotating crops; encouraging natural biological agents for control of disease, insects and weeds; using physical barriers for protection from insects, birds and animals; modifying habitat to encourage pollinators and natural enemies; and trapping pests in pheromone attractants.

- **Appropriate seeds and planting material -** Use of healthy seeds and planting materials, and robust and/or improved cultivars can make a big change in crop production. This practice may require some information on selection of seeds and planting materials including availability of improved varieties and seed treatments. Generally, locally-adapted seeds are preferred because of their resilience to local conditions.

- **Planting of leguminous trees -** In perennial crop plantations such as banana, coffee or cocoa, planting of leguminous trees such as *gliricidia, calliandra*, and *sesbania* may improve the growing conditions of the fruit crop by providing shade, mulching material and nitrogen through nitrogen fixation. In addition, some leguminous trees provide good fodder for livestock. This practice requires some knowledge on shade and space requirements of the tree crops and thus on ideal planting patterns for the leguminous trees.

- **Growing farm-own animal feeds -** To improve available feeds for the livestock, farmers may grow grasses and leguminous fodder crops around, between other crops or in rotation. As animal feed must be of organic origin, feed sources are best addressed by considering farm grown feed.

- **Terraces and soil bunds -** Construction of terraces and soil bunds along the curves of hills is a key measure for soil conservation. This practice builds the foundation of further improvement to soil fertility on slopes. It is of high relevance, but requires much labor and some specific knowledge for appropriate implementation.

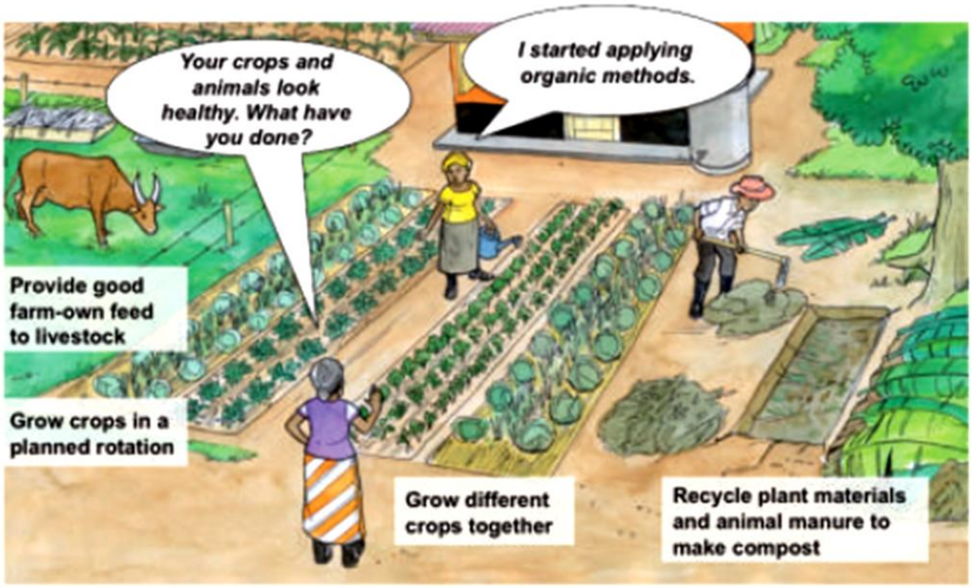

FIGURE 3-3 - HOW TO START IMPLEMENTING ORGANIC PRACTICES?

WHICH CROPS TO GROW DURING CONVERSION?

Looking at the organic farm as being 'one organism', the focus does not lie on cultivating specific crops only. Rather, the focus is on choosing crops that can easily be integrated into the existing farming system and will contribute to its improvement. But the choice also depends on the farmer's knowledge on the right management of the crops, their contribution to a diverse family diet or their demand in the market. Besides growing crops for food, farmers may need to grow leguminous cover crops to provide high-protein feed for livestock and to be used as green manures to feed the soil. Planting trees for shade, as windbreak, for firewood, feed, mulching material or for other uses, can be recommended in most situations.

Criteria for crop selection during conversion (Figure 3-4):

a. In the first place, organic farmers should grow enough food for the family. But they may also want to grow crops for the market to get money for other family needs. The farmers should also grow crops that contribute to improvement of soil fertility. Farmers who keep livestock need to grow pasture grass and legumes.

b. Basically, farmers should select crops with low risk of failure. **Cereals and legumes** such as **maize, sorghum, millet, beans and peas** are especially suitable for conversion, since they cost little to produce, generally have moderate nutrient demands and are robust against pests and diseases. In addition, many of the traditional crops can be stored and sold in domestic markets. **High-value short term crops**, such as most **vegetables**, are more delicate to grow and highly susceptible to pest and disease attack. Therefore, they should not be grown on a larger scale, unless the farmer can sustain some losses in harvest.

c. The crops to grow for sale should include crops that can be sold at the farm gate, at the roadside market or can be transported directly to nearby markets in urban centres. Choosing the right crop to sell on the market may require some market information. Decision making for crops for local or export markets requires detailed information from traders or exporters on the crops, requested varieties, quantities, qualities, regularity and season.

d. **High-value perennial** crops such as **fruit trees** take at least 3 years until the first harvest from the date of planting. This makes them appropriate crops for the conversion period. For new plantations, species and varieties must be carefully selected to suit the organic market and production requirements. For conversion of an existing orchard, it might be necessary to replace old existing varieties, if they are very susceptible to diseases and the product quality does not match with the market requirements.

e. The success of a crop will also depend on provision of favourable growing conditions. The better a crop variety matches local soil and climate conditions, and is tolerant or resistant to common pests and diseases, the better it will grow.

f. **Planting of hedges** other crops and/or agroforestry trees can be valuable to help establish a diverse farming system.

g. **Growing leguminous green manures** provides nutrients to the soil. Green manures do not provide immediate income, but in the long-term, they make the soil fertile and productive for the future.

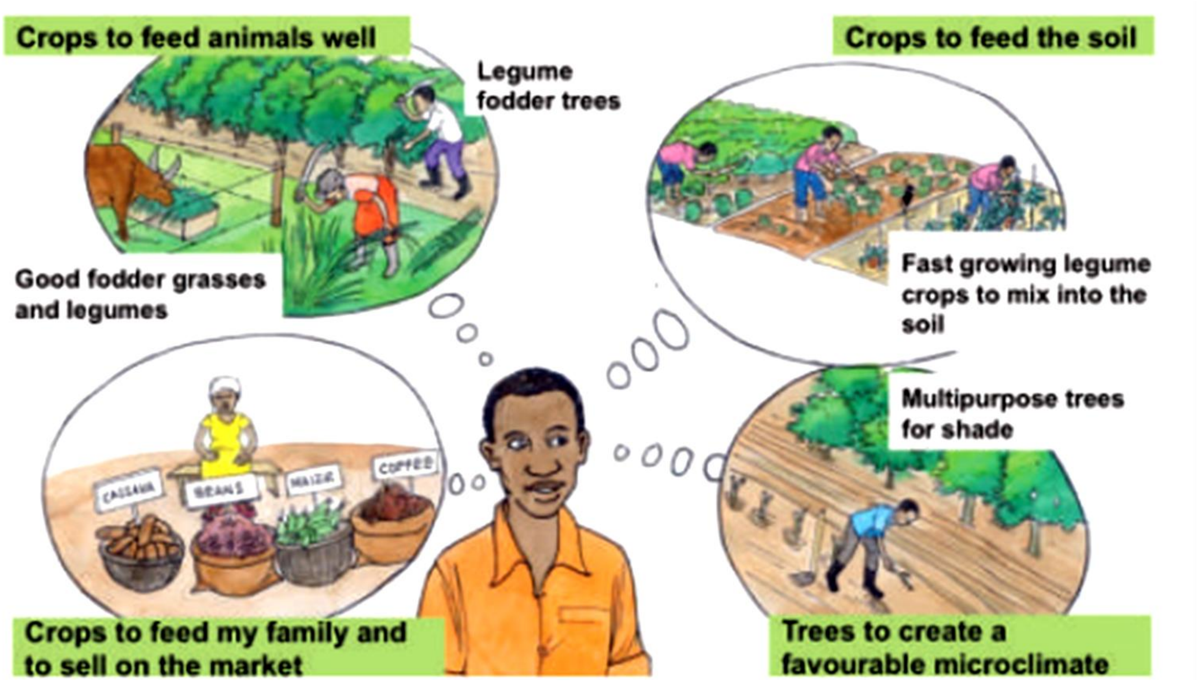

FIGURE 3-4 - WHICH CROPS SHOULD I GROW?

Many farmers want to see quick results and often ask how long it takes for organic crops to grow. Organic farming does not aim to make crops grow faster. Crops will grow faster and larger when they have better growing conditions than before. Although conventionally grown crops can be made to grow faster by intensive use of synthetic fertilizers and sprays. Organic crops are nurtured to grow at their normal, natural rate in order to be less susceptible to pests and diseases and build up good physical and nutritional structure. However, organic farmers do a lot to make their crops grow healthy and to produce good yields.

C. STEP 3: FULL CONVERSION TO ORGANIC FARMING

In a third step, implementation of organic practices throughout the entire farm should be considered, once sufficient experience with different practices has been gained. As soon as organic practices are implemented throughout the entire farm, a farmer can claim to be an organic farmer.

Commonly, consistent application of organic practices marks the beginning of a long process of improving the production system:

1. **Improving soil fertility** based on the recycling of farm own organic materials and enhancement of farm own biomass production.
2. **Encouraging positive interactions** between all parts of the production system (the farm ecosystem) to enhance self-regulation of pests and diseases.
3. **Optimizing the balance between feed production and livestock**.

Farming organically also means continuously learning from personal observation, from outside experiences, sharing experiences with other organic farmers and implementing new information on the your farm, making it increasingly more sustainable.

MITIGATING CONTAMINATION RISKS

a) Pesticides:

Organic farmers are responsible to protect the organic fields from being sprayed with synthetic pesticides (Figure 3-5). Even if the neighbour is not farming organically, an organic farmer can grow organic foods and fibres. To avoid pesticide drift from neighbouring fields onto the crops, organic farmers should safeguard the organic fields by using any of the following measures:

- Planting of **natural hedges** on the boundary to neighbouring fields can avoid the risk of pesticide spray drift through wind or run-off water. The wider the border area around the fields, the better.
- To avoid runoff from upstream fields, organic farmers should divert the water away or talk to the farmers upstream about how to work together to minimize the risk of contamination through water. Organic farmers, who are interested in saving nature, should share their knowledge and experiences with neighbours with the aim of helping them to either adopt organic farming practices or to minimize the risk of contaminating nature.

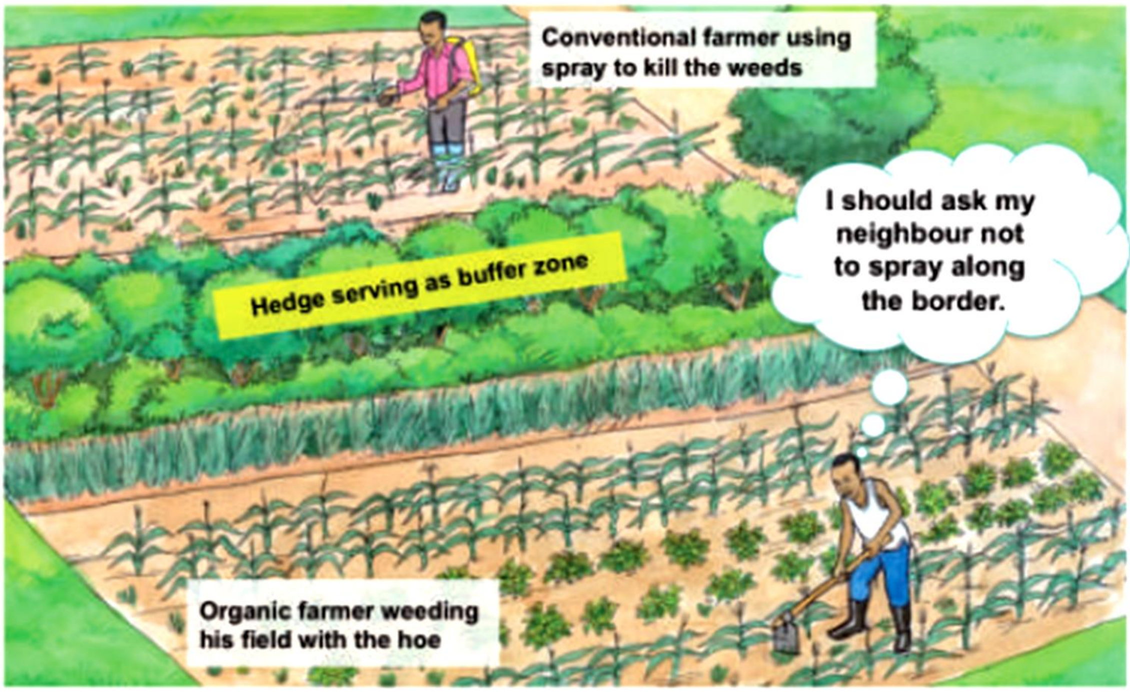

FIGURE 3-5 - HOW TO PROTECT CROPS FROM PESTICIDE DRIFT?

b) Genetically Modified Organisms (GMO):

Genetically modified seeds and planting materials are produced by transferring isolated genes from plants, animals or microorganisms into the crop genome, by using methods different from pollination and crossing natural barriers. **Genetically modified products should, therefore, not be used in organic farming, and organic farmers should protect their production against any GMO contamination** (Figure 3-6).

However, with the increased use of GM crops in the conventional farming systems, the risk of GMO contamination is expected to increase. Species which cross-pollinate, such as rapeseed or maize, or insect pollinated crops, such as soybean or cotton, are at a higher risk of being contaminated by a nearby genetically modified crop. Species that are mainly vegetative pollinated such as potatoes, cassava or banana are at lower risk of GMO contamination. Besides the genetic contamination, there is also a risk of physical contamination caused by GMO residues along the production and market chain, if GMO and organic products are not properly separated during storage and transportation.

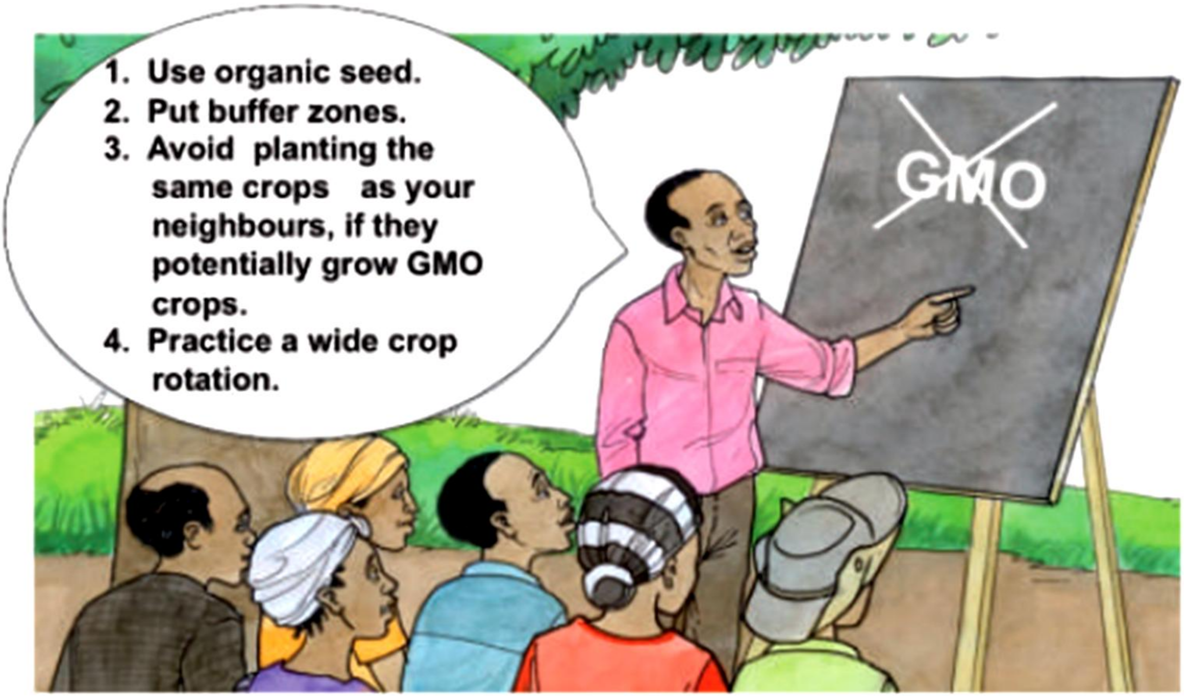

FIGURE 3-6 - HOW TO REDUCE THE RISK OF GMO CONTAMINATION?

Recommendations to farmers for reducing the GMO contamination risk:

- Use either personally selected seeds or get organic or untreated seeds. Verify the origin of the seeds, making sure that they do not come from neighbouring farmers where GM crops are grown, or from farms surrounded by GM crops (minimum distance of at least 1 km).
- If you use seeds from a trader, make sure that they are registered and can confirm where the seed is derived from. Check that he is not involved in GM production and multiplication. Ask your trader for a certificate confirming GM free seeds and inquire about the trader's involvement in the GM-seed market.
- Check for the breeding habits of the specific crops you are interested in. Most cross breeding species such as maize can disperse by wind or bees to distances of up to 1 to 3 km.
- Seeds of some crops can survive for 5 to 20 years in the soil. Therefore, precautions must be taken that no GM crops have been planted on land that shall be used for organic production.
- Create protective safety (buffer) zones around your fields to reduce the risk of GMO pollen dispersal, if GM crops are cultivated in this region. Isolation distances between GM crops and

organic fields should be established, about 2-3 times larger than those required for seed production for a given species. For dispersal of critical GM crops such as maize, the isolation distance should probably not be less than 2 to 3 km. This will reduce GMO dispersal by pollen to a great extent. For wind pollinated crops, like maize, borders or hedges with taller plant species, such as sugarcane or trees, can additionally prevent cross-pollination with GM crops.

- Avoid any physical GM contamination by using sowing and harvesting machines, transporters, processing and storage facilities not used by GM farmers. In case you have to use the same machines, thorough cleaning is necessary. Do not store organic products next to GM products.
- GMO free regions should be encouraged wherever possible, especially for own seed production.

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SOURCES

FiBL / IFOAM

ON TECA

Step by Step Conversion to Organic Agriculture: http://teca.fao.org/read/8364

4. MULCHING IN ORGANIC AGRICULTURE

SUMMARY

Mulching is the process of covering the topsoil with plant material such as leaves, grass, twigs, crop residues, straw etc. A mulch cover enhances the activity of soil organisms such as earthworms. They help to create a soil structure with plenty of smaller and larger pores through which rainwater can easily infiltrate into the soil, thus reducing surface runoff. As the mulch material decomposes, it increases the content of organic matter in the soil. Soil organic matter helps to create a good soil with stable crumb structure. Thus the soil particles will not be easily carried away by water. Therefore, mulching plays a crucial role in preventing soil erosion.

In some places, materials such as plastic sheets or even stones are used for covering the soil. However, in organic agriculture the term 'mulching' refers only to the use of organic, degradable plant materials.

WHY USING MULCH? (FIGURE 4-1)

- Protecting the soil from wind and water erosion: soil particles cannot be washed or blown away.
- Improving the infiltration of rain and irrigation water by maintaining a good soil structure: no crust is formed, the pores are kept open
- Keeping the soil moist by reducing evaporation: plants need less irrigation or can use the available rain more efficiently in dry areas or seasons
- Feeding and protecting soil organisms: organic mulch material is an excellent food for soil organisms and provides suitable conditions for their growth
- Suppressing weed growth: with a sufficient mulch layer, weeds will find it difficult to grow through it
- Preventing the soil from heating up too much: mulch provides shade to the soil and the retained moisture keeps it cool
- Providing nutrients to the crops: while decomposing, organic mulch material continuously releases its nutrients, thus fertilizing the soil
- Increasing the content of soil organic matter: part of the mulch material will be trans-formed to humus

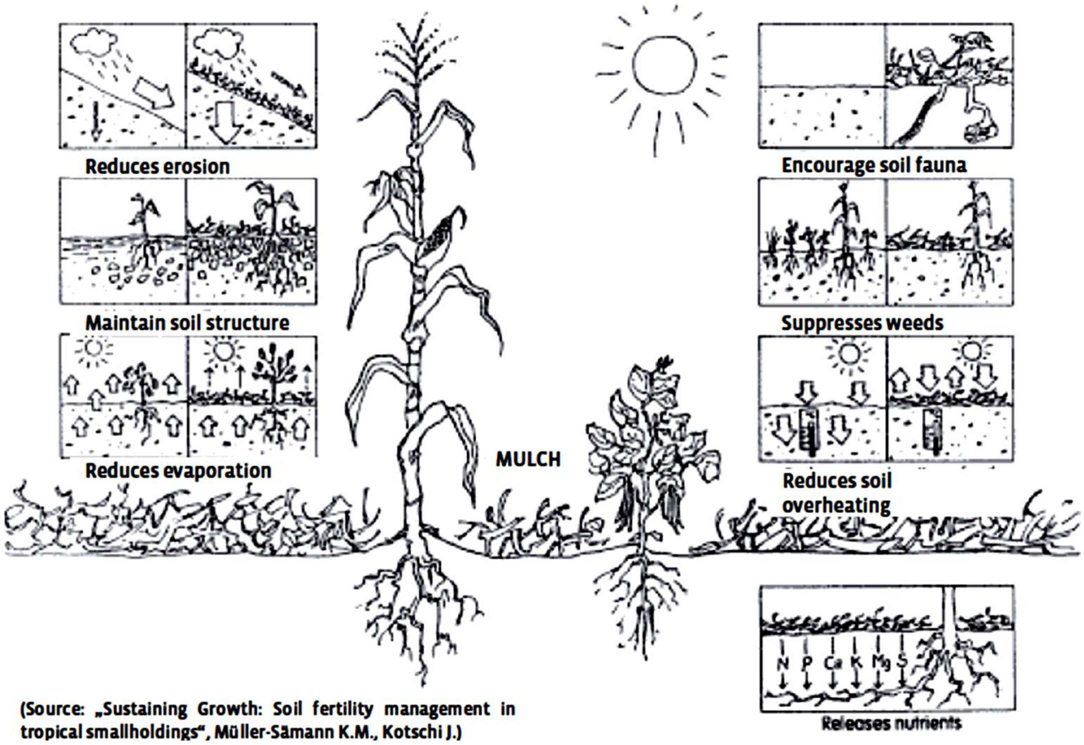

FIGURE 4-1 - SKETCH ON THE EFFECTS OF MULCHING

SELECTION OF MULCH MATERIALS

The kind of material used for mulching will greatly influence its effect. Material which easily decomposes will protect the soil only for a rather short time but will provide nutrients to the crops while decomposing. Hardy materials will decompose more slowly and therefore cover the soil for a longer time. If the decomposition of the mulch material should be accelerated, organic manures such as animal dung may be spread on top of the mulch, thus increasing the nitrogen content (Figure 4-2).

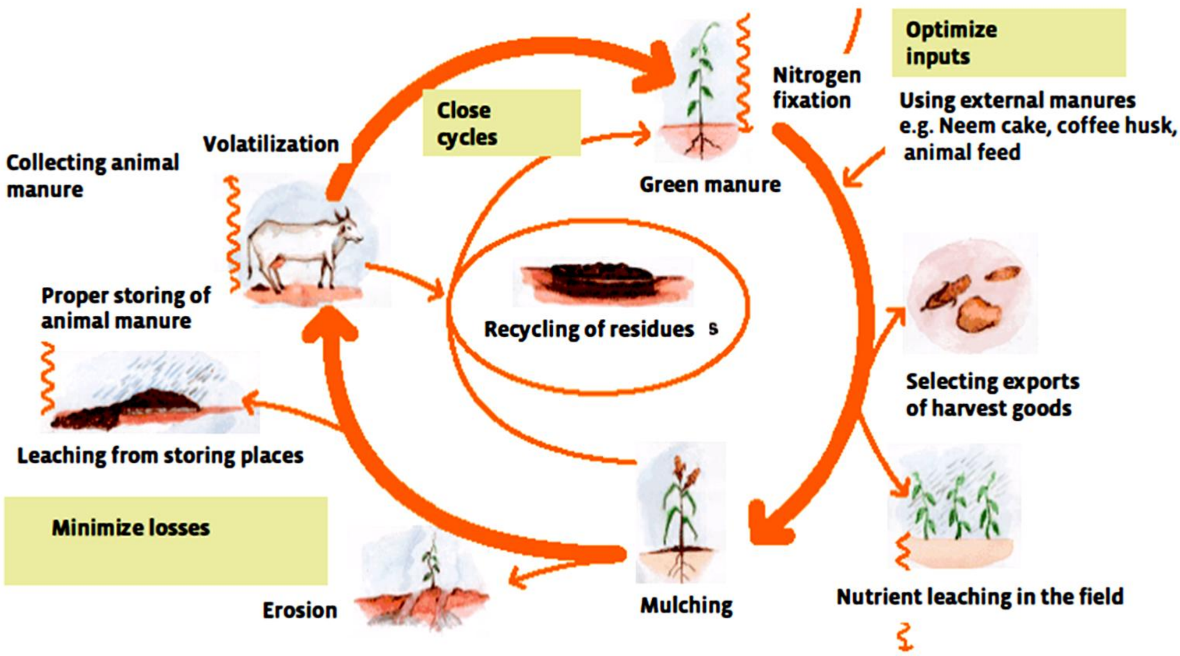

FIGURE 4-2 - OPTIMISING NITROGEN CYCLING IN THE FARM.
SCHEME OF A FARM WITH FIELDS AND ANIMALS SHOWING INPUTS, OUTPUTS AND LOSSES

Where **soil erosion is a problem**, slowly decomposing mulch material (low nitrogen content, high C/N) will provide a long-term protection compared to quickly decomposing material.

SOURCES OF MULCHING MATERIAL CAN BE THE FOLLOWING:

- Weeds or cover crops
- Crop residues
- Grass
- Pruning material from trees
- Cuttings from hedges
- Wastes from agricultural processing or from forestry

RECOMMENDATION WHILE USING MULCHES

While mulching has a lot of advantages, it can also cause problems in specific situations:

- Some organisms can proliferate too much in the moist and protected conditions of the mulch layer. Slugs and snails can multiply very quickly under a mulch layer. Ants or termites which may cause damage to the crops also may find ideal conditions for living.
- When crop residues are used for mulching, in some cases there is an increased risk of sustaining pests and diseases. Damaging organisms such as stem borers may survive in the stalks of crops like cotton, corn or sugar cane. Plant material infected with viral or fungal diseases should not be used if there is a risk that the disease might spread to the next crop. Crop rotation is very important to overcome these risks.
- When carbon rich materials such as straw or stalks are used for mulching, nitrogen from the soil may be used by microorganisms for decomposing the material. Thus, nitrogen may be temporary not available for plant growth.
- The major constraint for mulching usually is the availability of organic material. Its production or collection usually involves labour and may compete with the production of crops.

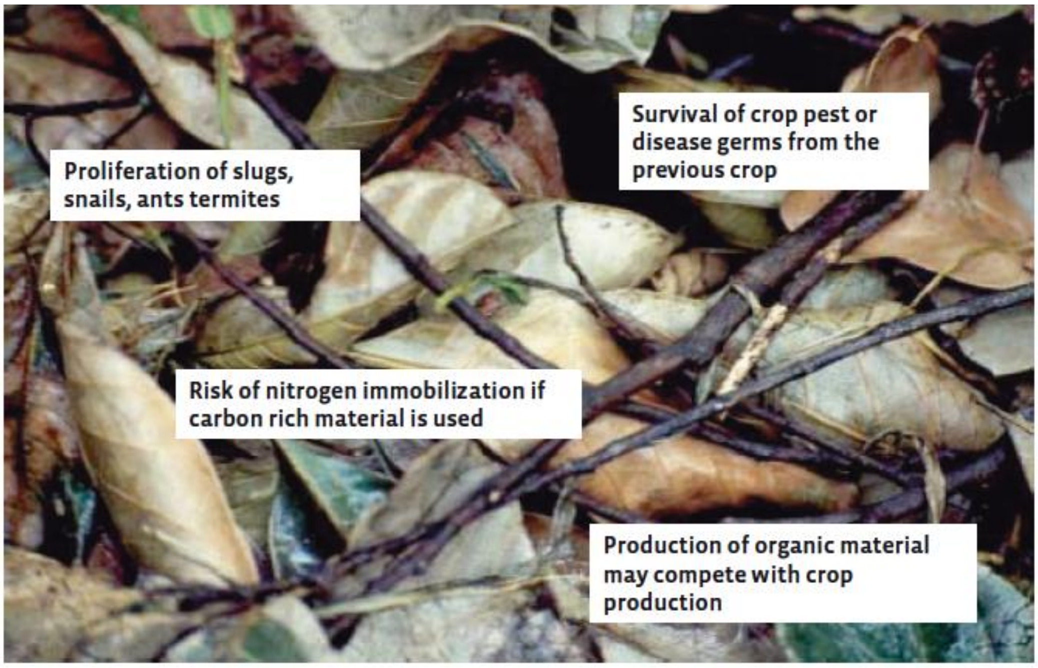

FIGURE 4-3 - POTENTIAL PROBLEMS RELATED TO MULCHING (PHOTO OF A MULCH LAYER)

APPLICATION OF MULCH

If possible, the mulch should be applied before or at the onset of the rainy season, as then the soil is most vulnerable.

If the layer of mulch is not too thick, seeds or seedlings can be directly sown or planted in between the mulching material. On vegetable plots it is best to apply mulch only **after** the young plants have become somewhat hardier, as they may be harmed by the products of decomposition from fresh mulch material.

- Apply before the rainy season.
- Not a too thick layer.
- Application in rows or around single plants.
- ... or evenly spread on the field.

FIGURE 4-4 - MULCH APPLIED IN VEGETABLE FIELDS IN THE PHILIPPINES, WITH RECOMMENDATIONS FOR THE APPLICATION OF MULCH IN KEY WORDS

If mulch is applied **prior** to sowing or planting, the mulch layer should not be too thick in order to allow seedlings to penetrate it. Mulch can also be applied in established crops, best directly after digging the soil. It can be applied between the rows, directly around single plants (especially for tree crops) or evenly spread on the field.

A PRACTICAL EXAMPLE: THE FUKUOKA SYSTEM OF MULCHING RICE FIELDS

The Japanese organic pioneer Fukuoka developed a system of growing rice which is based on mulching. White clover is sown among the rice one month before harvesting. Shortly thereafter, a winter crop of rye is sown. After threshing the harvested rice, the rice straw is brought back to the field where it is used as a loose mulch layer. Both the rye and the white clover spring up through the mulch which remains until the rye is harvested. If the straw decomposes too slowly, chicken manure is sprinkled over the mulch. This cropping system does not require any tillage of the soil, but achieves satisfying yields.

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IFOAM. 2003. Training Manual for Organic Agriculture in the Tropics. Edited by Frank Eyhorn, Marlene Heeb, Gilles Weidmann, p 108-113, http://www.ifoam.bio/

SOURCES

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ON TECA

Mulching in Organic Agriculture: http://teca.fao.org/read/8365

5. WATER MANAGEMENT IN ORGANIC AGRICULTURE

SUMMARY

Scarcity of water for agriculture is a common phenomenon in many countries. In some regions it is almost impossible to grow crops without irrigation. Even in areas with large amounts of rainfall in the rainy season, crops may get short of water during dry periods.

Organic farming aims at optimising the use of on-farm resources and at a sustainable use of natural resources. Active **water retention**, **water harvesting** and **storing of water** are important practices, especially for organic farmers. Organic farmers know that it is more important to first improve the water retention and the infiltration of water into the soil.

A. HOW TO KEEP THE WATER IN THE SOIL? (FIGURE 5-1)

- **Keep soil moisture:** During dry periods, some soils are more and some are less in a position to supply crops with water. The ability of a soil to absorb and store water largely depends on the soil composition and on the content of organic matter. Soils rich in clay can store up to three times more water than sandy soils. Soil organic matter acts as storage of water, just like a sponge. Therefore, crop residue or a cover crop protects the soil, prevents crusting on the surface, and slows runoff. Roots, earthworms and other soil life maintain cracks and pores in the soil. Less water runs off, and more sinks into the soil.
- **Reduce evaporation:** A thin layer of mulch can considerably reduce the evaporation of water from the soil. It shades the soil from direct sunlight and prevents the soil from getting too warm. Shallow digging of the dry top soil can help to reduce the drying up of the soil layers beneath (it breaks the capillary vessels). A better retention of water within the soil saves costs on irrigation.
- **Better use of season's rainfall:** Ripping during the dry season allows farmers to plant earlier – right at the start of the rains.

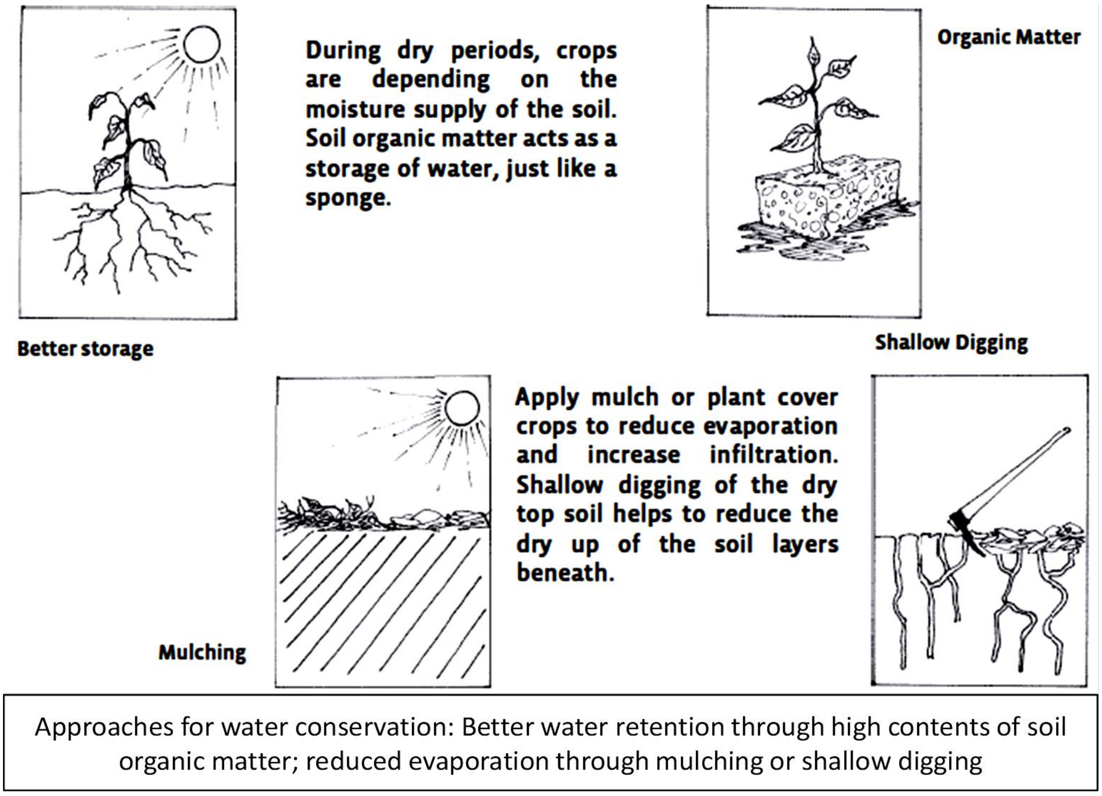


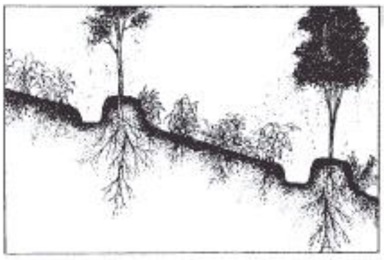
FIGURE 5-1 - APPROACHES FOR WATER CONSERVATION

ATTENTION: A green manure or cover crop is not always a suitable way of reducing evaporation from the soil, due that they also use water. In dry areas, you should consider using other types of mulch, such as crop residues or plant remains brought in from outside the field. That will help conserve moisture in the soil where it can be used by the crop.

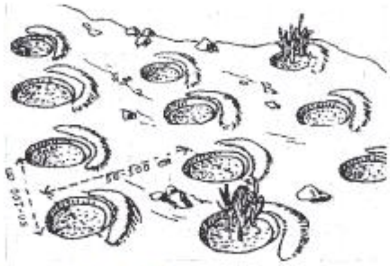
B. HARVESTING WATER

1. INCREASING INFILTRATION

During strong rains, only a part of the water infiltrates into the soil. A considerable part flows away as surface runoff, thus being lost for the crop. In order to get as much of the available rainwater into the soil, the infiltration of rainwater needs to be increased (Figure 5-2).



Contour trenches



Semi-circular bunds

Circular bunds

Plant pits with mulch

Sources drawings: «Introduction to Soil and Water Conservation Practices», World Neighbours; «Water harvesting and Soil moisture retention», Agromisa.

Upper: Sketches of trenches and semi-circular bunds, lower: photos of a circular bund around a coconut palm and beans with mulch in plant pits.

FIGURE 5-2 - INCREASING THE INFILTRATION

The most important for achieving a high infiltration is to maintain a topsoil with a good soil structure containing many cavities and pores (e.g. from earthworms). Cover crops and mulch application are suitable to create such a favourable top soil structure. Further, they help to slow down the flow of water, thus allowing more time for the infiltration.

➔Some techniques to harvest water include:

PLANTING PITS

Planting pits (known as *zai* in Burkina Faso and *tassa* in Niger, Figure 5-3) are hand-dug circular holes which collect water and store it for use by the crop. Each pit is about 20 cm across and 20 cm deep. After planting, the holes are left partly open so they collect water. Planting pits take a lot of work to dig when the soil is dry. But they produce good yields in areas where otherwise crops might die because of a lack of water. Once made, the pits can be used again, season after season. Leave the soil covered, and add compost or fertilizer to the pits to increase their fertility.

FIGURE 5-3 - ZAI HOLES WITH SORGHUM PLANTS - TYPICAL OF THE SAHEL
SOURCE: IIRR AND ACT. 2005. CONSERVATION AGRICULTURE: A MANUAL FOR FARMERS AND EXTENSION WORKERS IN AFRICA

CONTOUR BUNDS AND CATCHMENT STRIPS

In areas with low rainfall, there may not be enough water to grow a crop over the whole area. On gentle slopes (less than 3%), one possibility is to use contour bunds and catchment strips. Catchment strips are areas where no crops are planted. When rain falls on this ground, it runs downslope and is trapped by the contour bund. Plant rows of crops behind the bund to use this water. This can produce a good yield even with very little rain. Mulch the cultivated areas with crop residues to prevent erosion, help water sink in, and slow evaporation.

The picture below (Figure 5-4) shows an example of a farmer in Botswana, who makes his cropped strips 0,8–1 m wide a 3,3 m apart. He subsoils these strips using a tractor-powered subsoiler to a depth of 0,7 m. He shapes the land between the strips so it slopes towards the cropped strips, so rainwater will flow towards the crop. He plants two rows of maize in each strip, and sows a cover crop such as cowpea in between the strips. The strips are permanent: they can be used to grow crops season after season. The soil in the strips gradually improves in fertility as crop residues accumulate there. Rotating maize with a legume crop will improve the soil fertility further. The farmer has been able to grow up to 6 t/ha of maize with less than 400 mm/season of rain.

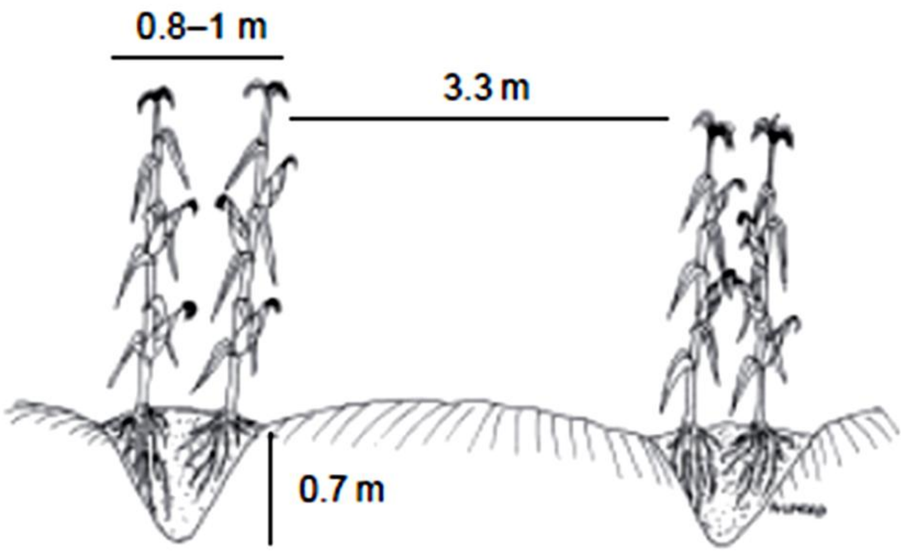


FIGURE 5-4 - MAIZE IN PERMANENT STRIPS
SOURCE: IIRR AND ACT. 2005. CONSERVATION AGRICULTURE: A MANUAL FOR FARMERS AND EXTENSION WORKERS IN AFRICA

ROAD CATCHMENTS

Water from roads – and from other unproductive areas such as paths and homestead compounds – can be channelled onto fields. It may be possible to divert water from structures that already exist, such as the ditches below *fanya juu* terraces. Or special bunds can be built around fields close to the road. Another possibility is to direct the water into a pond, which can be used to irrigate crops. (Figure 5-5 & 5-6).

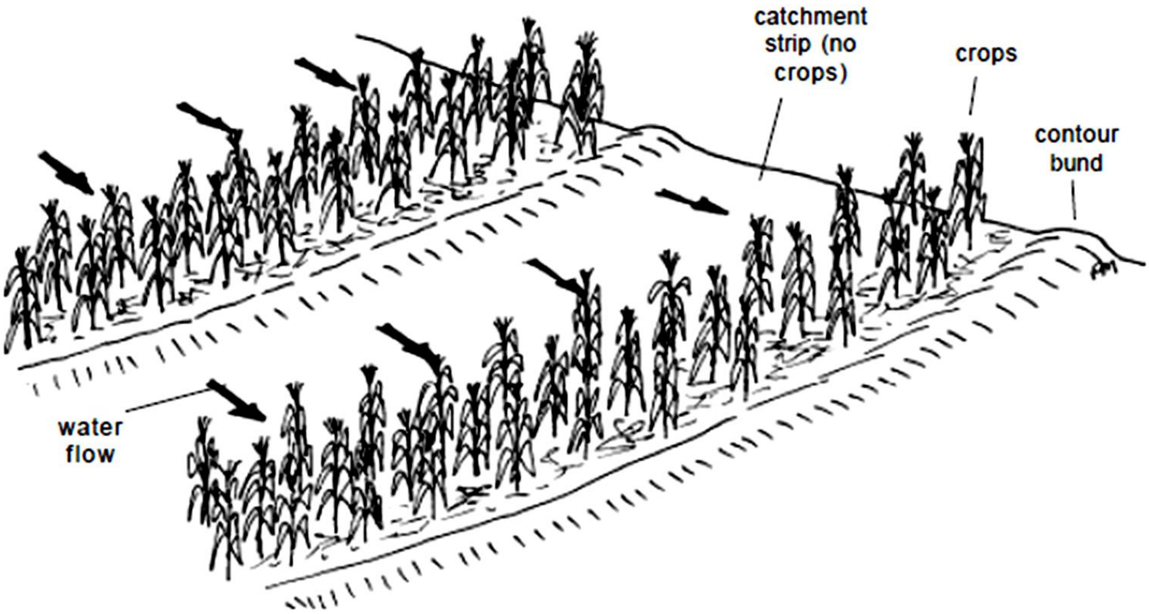


FIGURE 5-5 - CONTOUR BUNDS AND CATCHMENT STRIPS

SOURCE: IIRR AND ACT. 2005. CONSERVATION AGRICULTURE: A MANUAL FOR FARMERS AND EXTENSION WORKERS IN AFRICA.

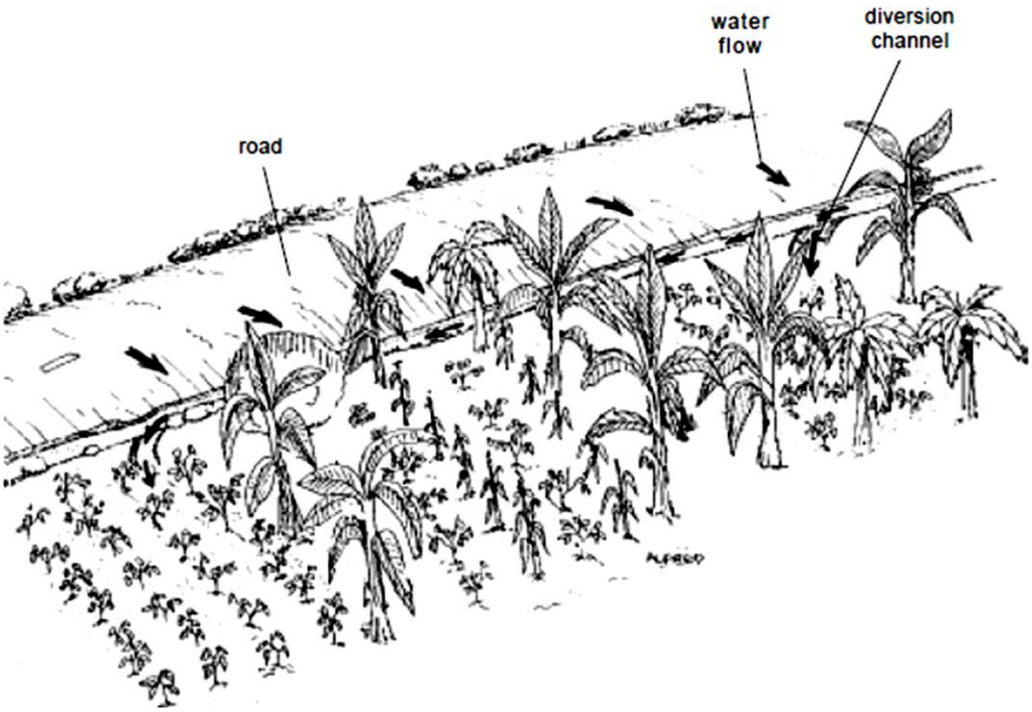


FIGURE 5-6 - RAINWATER HARVESTING USING A ROAD CATCHMENT

SOURCE: IIRR AND ACT. 2005. CONSERVATION AGRICULTURE: A MANUAL FOR FARMERS AND EXTENSION WORKERS IN AFRICA.

HALF-MOON MICROCATCHMENTS

Half-moon microcatchments are small, semicircular earth bunds. They are quite common on the desert margins of the Sahel, where they are called "demilunes". The half-moons catch water flowing down a slope. Crops such as sorghum, millet and cowpeas can be planted in the lower portion of the halfmoons. Half-moons are helpful to rehabilitate degraded land. (Figure 5-7).

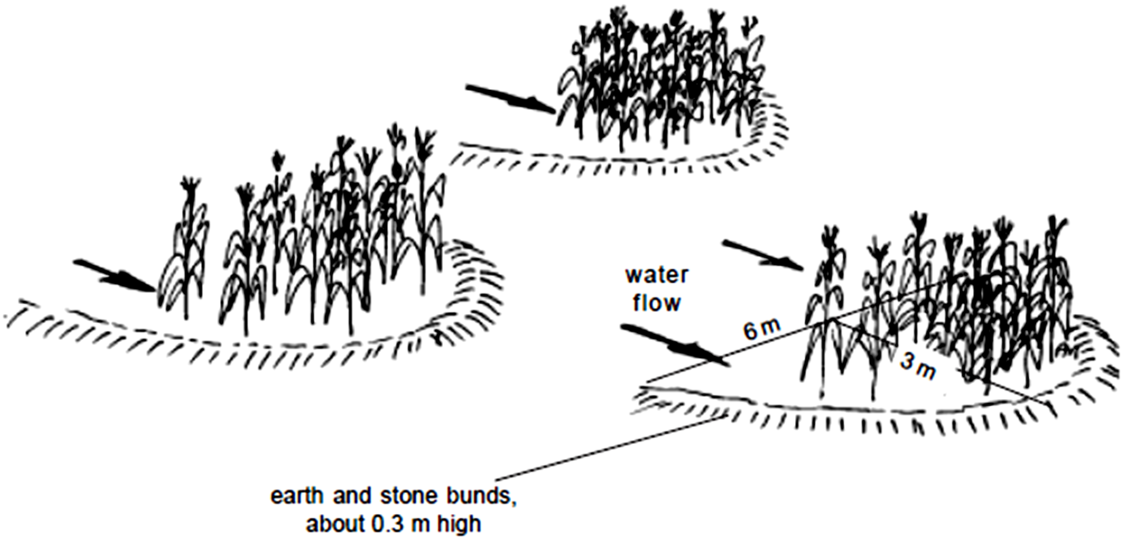


FIGURE 5-7 - HALF-MOON MICROCATCHMENTS

SOURCE: IIRR AND ACT. 2005. CONSERVATION AGRICULTURE: A MANUAL FOR FARMERS AND EXTENSION WORKERS IN AFRICA.

2. WATER STORAGE

Excess water in the rainy season may be made use of during dry periods. There are many possibilities of storing rainwater for irrigation, but most of them are labouring intensive or costly. Storing water in ponds has the advantage that fish may be grown, but water is likely to be lost through infiltration and evaporation. The construction of water tanks may avoid these losses, but needs appropriate construction materials. To decide whether or not to build water storage infrastructure, the benefits should be weighed against the costs, including the loss of arable land.

C. DRIP IRRIGATION SYSTEMS

The major factors that determine the necessity of irrigation are the selection of crops and an appropriate cropping system. Obviously, not all crops (and not even all varieties of the same crop) require the same amount of water, and not all need water over the same period of time.

Some crops are very resistant to drought while others are highly susceptible. Deep rooting crops can extract water from deeper layers of soil and hence they are less sensitive to temporary droughts.

With the help of irrigation, many crops can nowadays be grown outside their typical agro-climatic region. This may cause not only the above mentioned negative impacts, but also some advantages. It may make it possible to cultivate land which would otherwise be unsuitable for agriculture without irrigation. Or the cultivation of sensitive crops can be shifted into areas with less pest or disease pressure.

There are irrigation systems of higher or lower efficiency and with more or less negative impact. If irrigation is necessary, organic farmers should carefully select a system, which is does not overexploit the water source, does not harm the soil and has no negative impact on plant health.

One promising option are **drip irrigation** systems (Figure 5-8). From a central tank, water is distributed through thin perforated pipes directly to the single crop plants. There is a continuous but very light flow of water, thus allowing sufficient time to infiltrate in the root zone of the crops. In this way, a minimum of water is lost and the soil is not negatively affected.

Detail of the drip tubes (Thailand)

Drip irrigation system in vegetable cultivation

FIGURE 5-8 - DRIP IRRIGATION

The establishment of drip irrigation systems can be quite costly. However, some farmers have developed low cost drip irrigation systems from locally available materials. Whatever irrigation system the farmer chooses, he will reach higher efficiency if it is combined with accompanying measures for improving the soil structure and the water retention of the soil, as described above.

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NRC / IIRR

ON TECA

Water Management in Organic Agriculture: http://teca.fao.org/read/8366

6. Crop Planning and Management in Organic Agriculture

SUMMARY

In many traditional agricultural systems a diversity of crops in time or space can be found. Knowing that different plants have different requirements for nutrients, a good crop planning and management is required in order to optimise the use of nutrient in the soil. Crop rotation, intercropping, cover crops and green manures represent the main alternatives to the farmers to manage soil health and fertility. The first three practices will be described in this section.

A. Crop rotation

Crop rotation means changing the type of crops grown in the field each season or each year (IIRR and ACT 2005). It is a critical feature of all organic cropping system, because it provides the principal mechanisms for building healthy soils, a major way to control pests, weeds, and to maintain soil organic matter (Mohler and Johnson 2009). In more details, crop rotation brings the following benefits (IIRR and ACT 2005):

- **It improves soil structure**: some crops have strong, deep roots. They can break up hardpans, and tap moisture and nutrients from deep in the soil. Others have many fine, shallow roots. They tap nutrients near the surface and bind the soil. They form many tiny holes so that air and water can get into the soil. (Figure 6-1).

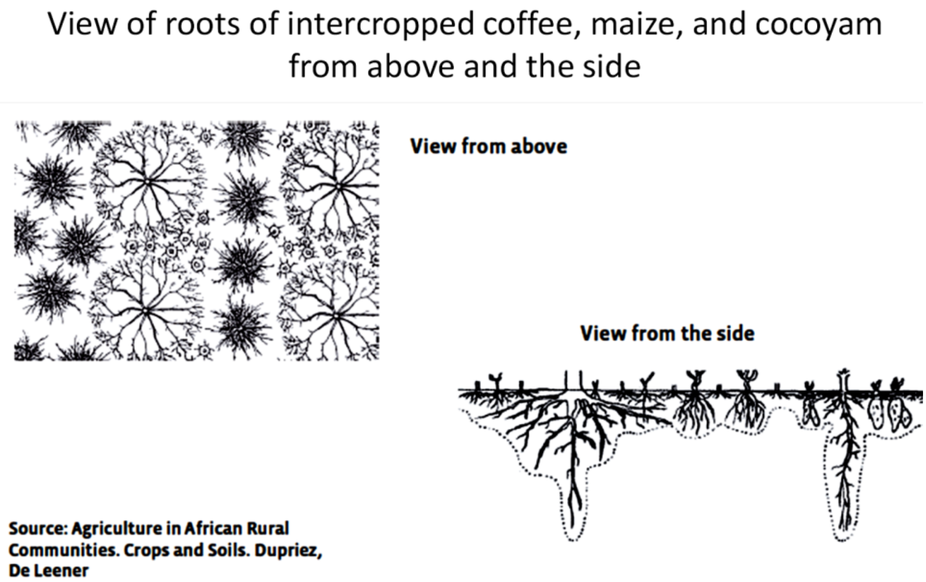

Figure 6-1 - Better use of root space in associated crops

- **It increases soil fertility**: legumes (such as groundnuts and beans) fix nitrogen in the soil. When their green parts and roots rot, this nitrogen can be used by other crops such as maize. The result is higher, more stable yields, without the need to apply expensive inorganic fertilizer.
- **It helps control weeds, pests and diseases**: planting the same crop season after season encourages certain weeds, insects and diseases. Planting different crops breaks their life cycle and prevents them from multiplying.
- **It produces different types of output**: growing a mix of grain, beans, vegetables and fodder means a more varied diet and more types of produce to sell.

- **In some ways, crop rotation takes the place of ploughing the soil**: it helps aerate the soil, recycles nutrients, and helps control weeds, pests and diseases. Intercropping, strip cropping and relay cropping bring many of the same advantages as rotation.

CRITERIA FOR CROP ROTATION:

a) Crop selection

Before selecting the crops, it is necessary to answer the following question:

- **What to produce?** Crops produce many different things: food, fodder, firewood, fence poles, thatch and medicines. Farmers grow some crops (such as cotton) only for cash. For other crops, such as cereals or vegetables, you may be able to sell what you do not use yourself. If your objective is marketing, make sure that there is a market of your main output or rotation crop.

- **Will it grow well?** This depends on many factors: the amount of rain or moisture in the soil, the season (some crops and varieties do not grow well at certain times of year), the soil fertility, among others.

- **What are the roots like?** Tall cereals (millet, maize, sorghum, etc.), finger millets and some legumes (e.g., pigeonpea and sunn hemp) have strong roots that penetrate deep into the soil – up to 1,2 m for tall cereals. Their roots improve the soil structure and porosity, so are a good choice if the soil is compacted. (Figure 6-2).

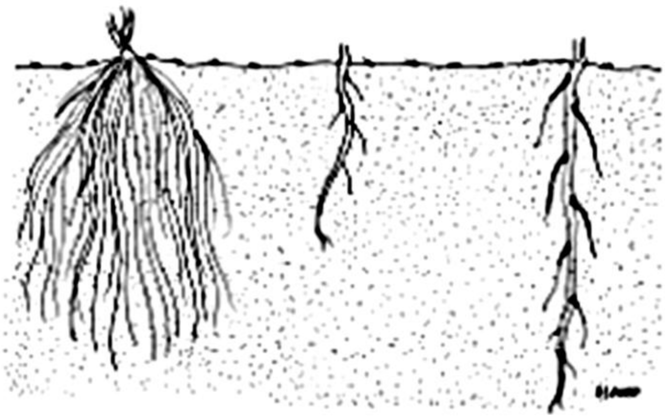

FIGURE 6-2 - DIFFERENT CROPS HAVE DIFFERENT TYPES OF ROOTS

- **Does it improve the soil fertility?** Legumes improve the soil fertility by fixing nitrogen from the air. They use part of it for their own needs, and leave the rest in the soil. Cereals and other plants can use this nitrogen if they are intercropped with the legume, or if they are grown as the next crop in the rotation.

- **Does it cover the soil well?** Tall cereals do not cover the soil well because they have upright leaves and they are planted far apart. Short grasses (Brachiaria, Cenchrus, Andropogon) and many legumes (lablab, groundnut, cowpea, beans) cover the ground very quickly after they are planted. When their main use is indeed to provide cover, we call them cover crops. If their main use is to provide food, we call them food legumes (beans, groundnuts).

- **Does it work with other crops?** Try to find combinations of crops that complement each other well (Table 6-1). For example, cereals grow well with legumes (either food legumes or cover crops): the cereals benefit from the nitrogen fixed by the legume. Two different legumes or two different cereals do not usually work well together. If you have problems with Striga in your field, you may want to grow trap crops such as Crotalaria or Tephrosia to encourage the Striga to germinate and die when they do not find any suitable plants (such as maize or sorghum) they can live off. It may be more difficult to find the right combination of crops for your situation. You and your neighbours can try out new combinations to see which ones work. Or you can check with extension workers, researchers or farmers in other villages to see what they suggest.

TABLE 6-1 - COMPANION PLANTING (KUEPPER AND DODSON 2001)

Family	Good companions	Bad companions (antagonists)
Asparagus	Tomato, parsley, basil	
Beans	Most vegetable and herbs	Onion, garlic, gladiolus
Beans, bush	Potatoes, cucumber, corn, strawberry, celery, summer savory	Onion
Beans, pole	Corn, summer savory, celery	Onion, beets, kohlrabi, sunflower
Beets	Cabbage and onion families, lettuce	Pole beans
Cabbage family	Aromatic herbs, celery, beets, onion family, chamomile, spinach, chard	Dill, strawberry, pole beans, tomatoes
Carrots	Peas, lettuce, rosemary, onion family, sage, tomato, leeks	Dill
Celery	Onion and cabbage families, tomato, bush beans, nasturtium, leeks	
Corn	Potatoes, beans, peas, cucumber, pumpkin, squash	Tomatoes
Cucumber	Beans, corn, peas, sunflower, radish	Potatoes and aromatic herbs
Eggplant	Beans, marigolds	
Leeks	Onions, celery and carrots	
Lettuce	Carrots, radish, strawberry, cucumber, onions	
Onion family	Beets, carrots, lettuce, cabbage family, summer savory, leeks	Beans and peas
Parsley	Tomato and asparagus	
Peas	Carrots, radish, turnip, cucumber, corn, beans	Onion Family, gladiolus, potatoes
Potatoes	Beans, corn, cabbage family, marigolds, horseradish	Pumpkin, squash, tomato, cucumber , sunflower
Pumpkin	Corn, marigold	Potato
Radish	Peas, nasturtium, lettuce, cucumber	Hyssop
Spinach	Strawberry, faba beans	
Squash	Nasturtium, corn, marigold	Potatoes
Strawberry	Bush beans, spinach, lettuce, onion family	Cabbage
Sunflower	Cucumber	Potatoes
Tomato	Onion family, nasturtium, marigold, asparagus, carrot, parsley, cucumber	Potatoes, fennel, cabbage family
Turnip	Peas	Potatoes

b) Choosing the right varieties

Farmers all know that not all sorghum is the same. Some varieties grow quickly and produce a yield in a short time. Others take longer until harvest. Some are taller than others, or produce more leaves. Some demand more or less nutrients, some are more tolerant to drought or Striga. The same is true for other crops. For example, some varieties of cowpeas can be harvested in 55 days; others take more than 100 days. Some climb, while others crawl on the ground. Choose a variety that has the characteristics you want. Make sure you get the right seed. If you find a variety that you like, consider producing your own seed to sow in the future.

c) Choosing a crop rotation

What crops should you plant next year, and the year after that? That depends on many factors, here are some considerations:

- Knowing the family where your crops belong to helps you to decide what to plant on the next cropping season, by planting a crop that belongs to a different family to the previous one. The table below provides various crop families and their common names (Table 6-2):

Table 6-2 - List of most used crop families and their common names

FAMILY	COMMON NAMES
Allium	Chive, garlic, leek, onion, shallot
Cucurbit (Gourd family)	Bitter gourd, bottle gourd, chayote, cucumber, ivy gourd, luffa gourd, melons pumpkins, snake gourd, squash, wax gourd
Crucifer (Brassica)	Bok choy (petchay), broccoli, Brussels sprouts, cabbage, Chinese cabbage, cauliflower, collard, kale, kohlrabi, mustard, radish, turnip, watercress
Legume	Common beans, black bean, broad bean (faba), clover, cowpea, garbanzo, hyacinth bean, kidney bean, Lima bean, lintel, mungbean, peanut, pigeon pea, pinto bean, runner bean, snap pea, snow pea, soybean, string bean, white bean
Aster	Lettuce, artichoke
Solanaceous (Nightshade family)	Potato, tomato, pepper, eggplant
Grains and cereals	Corn, rice, sorghum, wheat, oat, barley, millet
Carrot family	Carrot, celery, dill, parsnip, parsley
Root crops	Cassava, sweet potato, taro, yam, water chestnut
Mallow family	Cotton, okra

- Make a list of the crops you want to grow, considering the following recommendations (Mohler and Johnson 2009):

General recommendations:

- Grow winter cover crops **BEFORE** late-planted crops to accumulate organic matter and nitrogen.
- Grow winter-killed cover crops (oat-pea) **BEFORE** early season crops, so the seedbed will be easy to prepare.
- **NEVER** grow any crop after itself.
- Certain insect pests and diseases may spread easily from one crop to the next through the crop residues. Avoid crop combinations where this is a problem.
- Markets do not always exist for new crops; however you may want to plant some of them as part of your rotation. However. If your objective is marketing, ensure that there is a market for your main output and rotation crops.
- In addition it is important to check the source of seeds and price of the output before you decide which crops to plant.

Nightshades (tomatoes, potatoes, peppers, eggplants):

- Grow tomatoes **AFTER** peas, lettuce, or spinach, because tomatoes need a considerable amount of nutrients.
- Grow lettuce **BEFORE** potatoes, because it is a light feeder and an aboveground crop.
- Grow legume cover crops **BEFORE** potatoes or corn, so that they can feed the crops.
- Grow potatoes **BEFORE** crops that are poor competitors, because potato production involves aggressive cultivation and further working of the soil during harvest, both of which reduce weed pressure.
- **AVOID** growing potatoes before corn, because both are heavy feeders.
- **BE CAUTIOUS** when growing bell pepper before another vegetable crop, because of diseases.
- **AVOID** planting potatoes after corn, because of wireworm problems.

Grasses, corn, and grains:

- Grow beans **AFTER** corn to rebuild nitrogen.
- **AVOID** growing legumes before small grains to prevent lodging.

Alliums:

- Use a summer fallow **AFTER** onions, because usually there are many weeds.

LETTUCE AND CROPS IN THE BEET AND SPINACH FAMILY:

- Grow peas **BEFORE** fall greens, because there is time for double cropping, and fall greens benefit from the nitrogen fixed by the peas.
- Grow a root crop like beets **AFTER** lettuce or cabbage

B. INTERCROPPING:

Intercropping refers to the practice of growing two or more crops in close proximity: growing two or more cash crops together, growing a cash crop with a cover crop, or other non-cash crop that provide benefits to the primary crop (Mohler and Johnson 2009).

However, this practice requires additional management to keep competition between intercropped species in balance. When two or more crops are growing together, each must have adequate space to maximize cooperation and minimize competition between them. To accomplish this, four things need to be considered:

1) Spatial arrangement,
2) Plant density,
3) Maturity dates of the crops being grown,
4) Plant architecture.

There are at least four basic **spatial arrangements** used in intercropping. Most practical systems are variations of these:

- **Row intercropping**—growing two or more crops at the same time with at least one crop planted in rows. This can be beneficial in situations when using tall crops to reduce drought or heat stress of shorter crops, by providing shade and reducing wind speed. (Figure 6-3).

FIGURE 6-3 - ROW INTERCROPPING WITH ALTERNATE ROWS OF MAIZE AND BEANS (LEFT)
ROW INTERCROPPING WITH ALTERNATE ROWS OF A CEREAL AND A GRASS COVER CROP (RIGHT)

- **Strip intercropping**—growing two or more crops together in strips wide enough to permit separate crop production using machines but close enough for the crops to interact, for example, intercropping beans and maize. Legumes have a nitrogen-fixing bacteria associated with their roots. Consequently they compete slightly with non-legumes for nutrients, and in some cases even supply nitrogen to adjacent plants. (Figure 6-4).

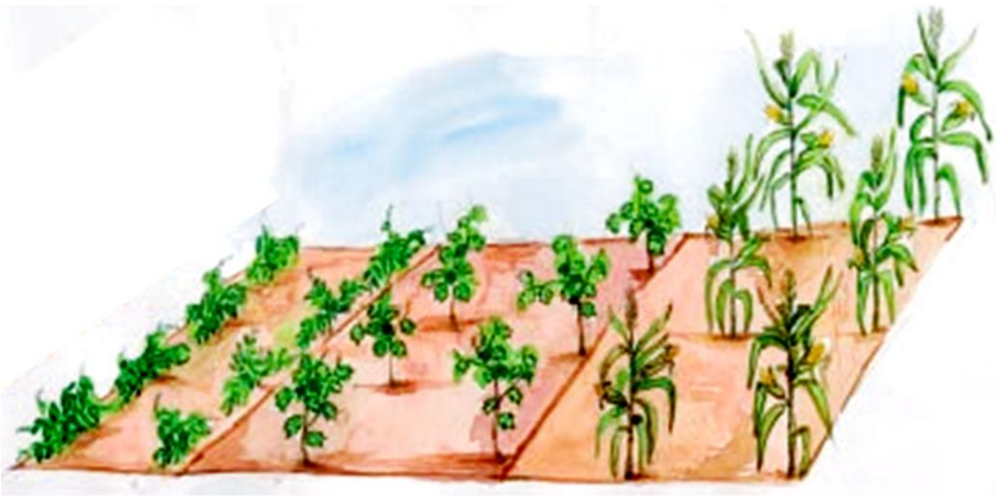

FIGURE 6-4 - STRIP INTERCROPPING

- **Relay intercropping**—planting a second crop into a standing crop at a time when the standing crop is at its reproductive stage but before harvesting (e.g transplanting lettuce next to tomatoes plants). The lettuce will use the space that is not yet occupied by the tomatoes and is harvested about the time the tomatoes are branching out to cover the width of the bed.
- **Mixed intercropping**—growing two or more crops together in no distinct row arrangement (for further details of possible combination, please see Table 6-1). Some crops may also be sown as a border crop or as a trap crops at the hedges of the main crop to reduce pests. The pest, arriving in the field from the edges, encounter the trap crop (which is strongly preferred than the main crop) and stops. The trap crop may be sprayed with natural insecticide to control the pest, before it moves to the main crop. (Figure 6-5).

FIGURE 6-5 - MIXED INTERCROPPING (NO ROWS)

A crop mixture with different **growth forms or development** may make cultivation and use of mulches more difficult and less effective. Therefore planting crop in alternate rows greatly simplifies management.

Intercropping may also represent a problem for crop rotation. Knowing that one fundamental principle of crop rotation is the separation of plant families in time, replanting two families mixed in the same field may be difficult. However, a good planning could maintain a viable crop rotation. For example, suppose that a farm grows an area with tomato, squash, broccoli and lettuce. A simple rotation would put each of the crops in a different year, with a three year interval before a crop is repeated on the same bed in order to keep some diseases and pest under control.

C. Cover crops

Every plant which covers the soil and improves soil fertility can be a cover crop. It could be a leguminous plant with other beneficial effects, or it could be a weed characterised by its rapid growth and enormous production of biomass. The most important property of cover crops is their fast growth and the capacity of maintaining the soil permanently covered.

The following characteristics make an ideal cover crop (Figure 6-6):

- The seeds are cheap, easy to get, to harvest, to store and to propagate
- Be of rapid rate of growth and be able to cover the soil in short time
- Be resistant against pests and diseases
- Produce large amounts of organic matter and dry material
- Fix nitrogen from the air and provide it to the soil
- Have a de-compacting root system and regenerate degraded soils
- Easy to sow and to manage as single crop or associated with other crops
- Can be used as fodder, grains as food grains

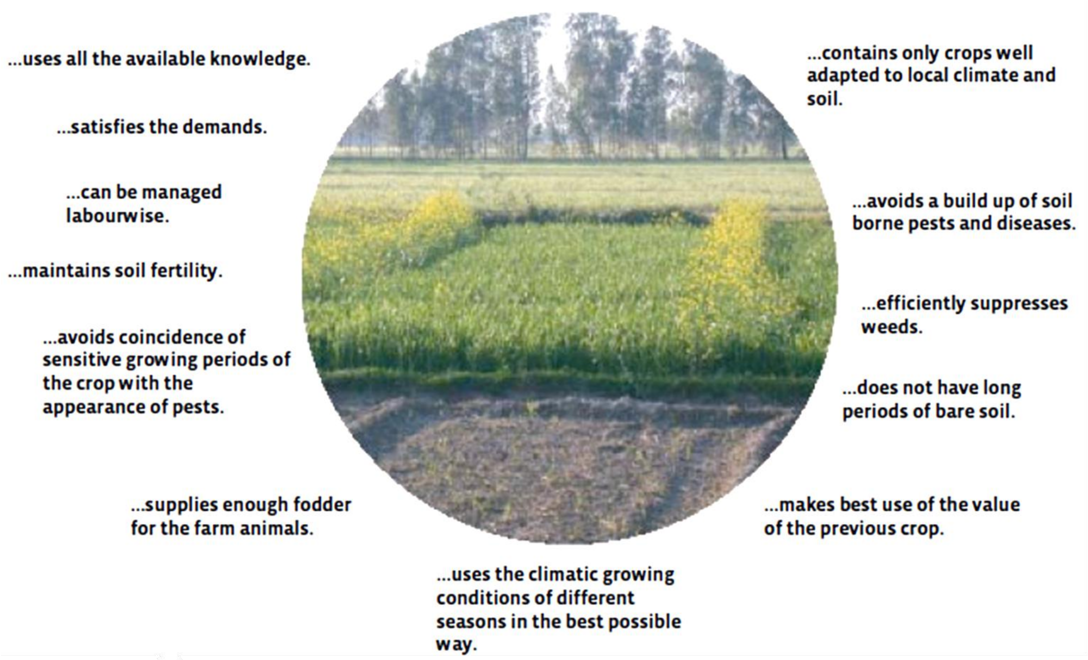

Figure 6-6 - Criteria for an "ideal" crop rotation

The example of cowpea as a cover crop:

Cowpea (*Vigna unguiculata*, French: Niébé) is an important grain legume throughout the tropics and subtropics. It has some properties which make it an ideal cover crop:

- It is drought tolerant and can grow with very little water
- It can fix nitrogen and grows even in very poor soils
- It is shade-tolerant and therefore compatible as an intercrop
- It yields eatable grains and can be used as an animal fodder rich in protein
- It is quite resistant to pest attack

Subsistence farmers in sub-Saharan Africa usually intercrop cowpea in maize, sorghum, millet and cassava.

Other legumes used as cover crops are alfalfa (*Medicago sativa*), crimson clover (*Trifolium incarnatum*), Faba beans (*Vicia faba*) and hairy vetch (*Vicia vellosa*).

Some cover crops are used to improve the soil structure and to add organic matter to the soil; examples of non-legumes crops used for this purpose include barley (*Hordeum vulgare*), buckwheat (*Fagopyron esculentum*), oats (*Avena sativa*), annual rye (*Lolium multiflorum*), winter wheat (*Triticum aestivum*).

D. Crop –Animal association

This practice integrates crop and livestock systems. In this case, cropping provides animals with fodder from grass and nitrogen-binding legumes, leys (improved fallow with sown legumes, grasses or trees), weeds and crop residues. Animals graze under trees or on stubble, they provide draught and manure for crops, while they also serve as a savings account (FAO, 2001).

An experimental farm in Thailand maintains pigs and chickens, as well as a vegetable garden and a fish pond. Animal wastes are used for fertilizer, fish feed and biogas generation. Crop and human wastes are also added to the biogas unit. Liquid effluent from the biogas generator is used in the fishpond and solid residues on the garden. Periodically, the locations of the garden and the pond are reversed, so residues from one serve as nutrients for the other (Based on BOSTID, 1981; FAO 2001).

E. Designing cropping systems

Cropping systems should be designed in such a way that the soil is almost permanently covered with plant canopy. In arable crops, careful timing of sowing and planting can help to avoid uncovered soil being washed away during the rainy season.

After the main crops are harvested, a green manure crop may be sown (Figure 6-7). On slopes, crops should be grown in lines across the slopes (along contour lines) rather than vertically. This can contribute enormously to reduce the speed of surface water, thus erosion. In crops which take some time to develop a protecting canopy, intercropping of fast growing species, such as beans or clover, can help to protect the soil in the initial stage of the main crop.

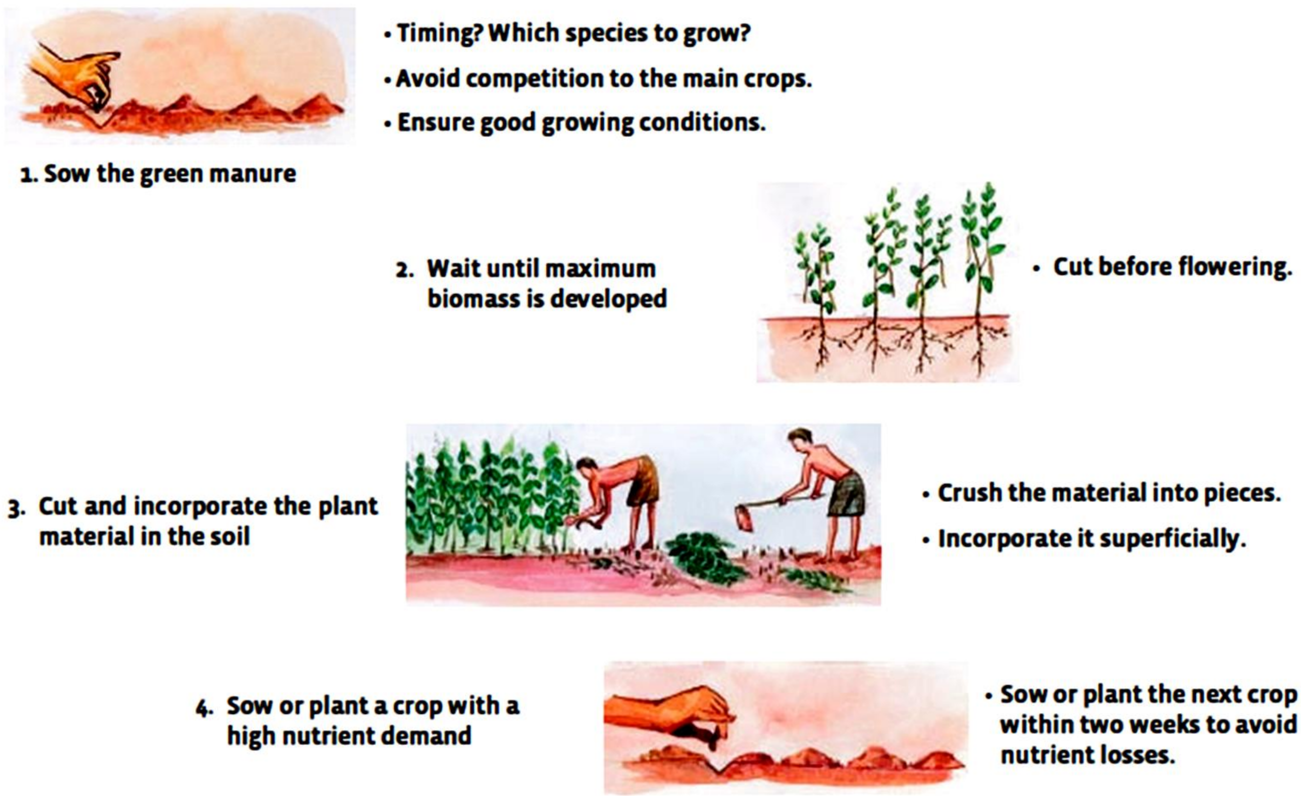

Figure 6-7 - Steps for using green manures, with some points to consider

In order to ensure a permanent plant cover it is important to consider the following aspects:

- Timing of soil cultivation
- Timing of planting or sowing
- Producing seedlings and transplanting them
- Mixed cultivation
- Intercropping
- Cover crops
- Mulching
- Timing of weeding
- Sowing of a green manure crop in the off-season (Figure 6-8)
- Expected effect on yields
- Availability of suitable species
- Costs of seeds
- Availability of water
- Availability of labour
- Additional use of side-crops
- Reduction of the risk
- Food security

Between two crops (for a short period)

As a cover crop into an annual crop

Between two crops (for a long period)

FIGURE 6-8 - 3 POSSIBILITIES OF INTEGRATING GREEN MANURES INTO THE CROP ROTATION

RECORD KEEPING IS IMPORTANT

A well-kept field record book is a great help in remembering which crop has in the past been grown in a particular plot within the field or farm. This is useful especially if the records also show past incidents of plant pests or diseases in each plot in the farm.

For example, soil diseases and pests can build up during the life of a susceptible crop. If the same crop or a similar type belonging to the same family is grown in the same field, it will suffer from the accumulated pests and diseases from the previous crop(s) and may not grow well. This can be avoided if the soil is left fallow (not cropped) for a while, or a different crop is planted which is tolerant or resistant to the particular pest or disease. Better still is to plant a crop from a different family which will not share a same complex of pests and diseases. This will result in decline of soil problems and the original crop can be grown successfully again.

These drawings show some conservation agriculture cropping systems in different parts of Africa. Each diagram shows the crops growing in each month over 2 or 3 years. Note that the soil is never bare!

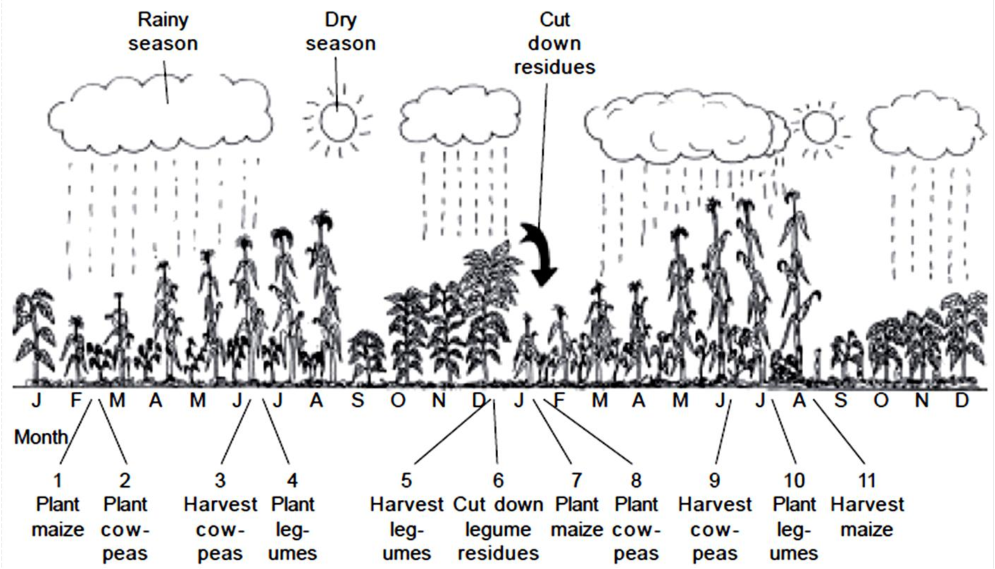

FIGURE 6-9 - 2-YEAR ROTATION OF CEREALS, COWPEAS AND LEGUMES IN KENYA

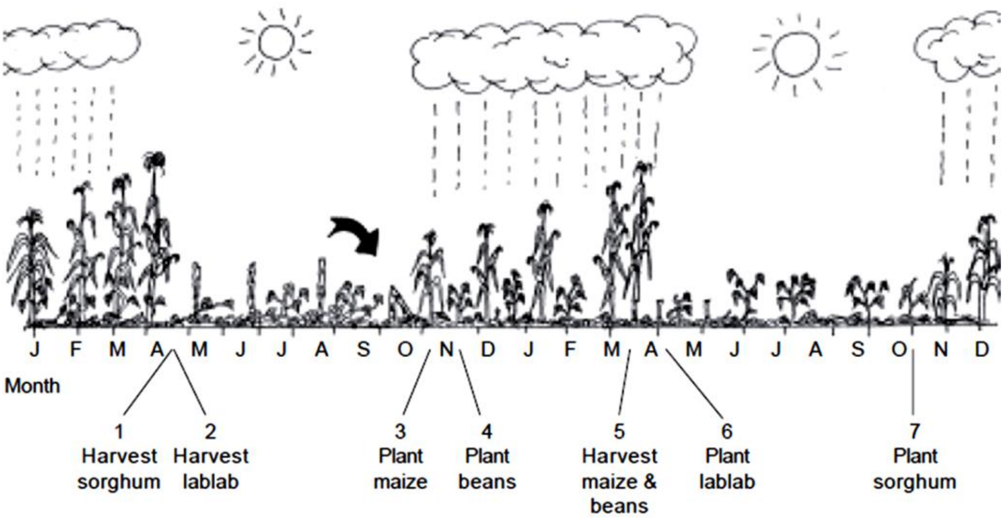

FIGURE 6-10 - 2-YEAR ROTATION OF MAIZE, BEANS, SORGHUM AND LABLAB IN SWAZILAND

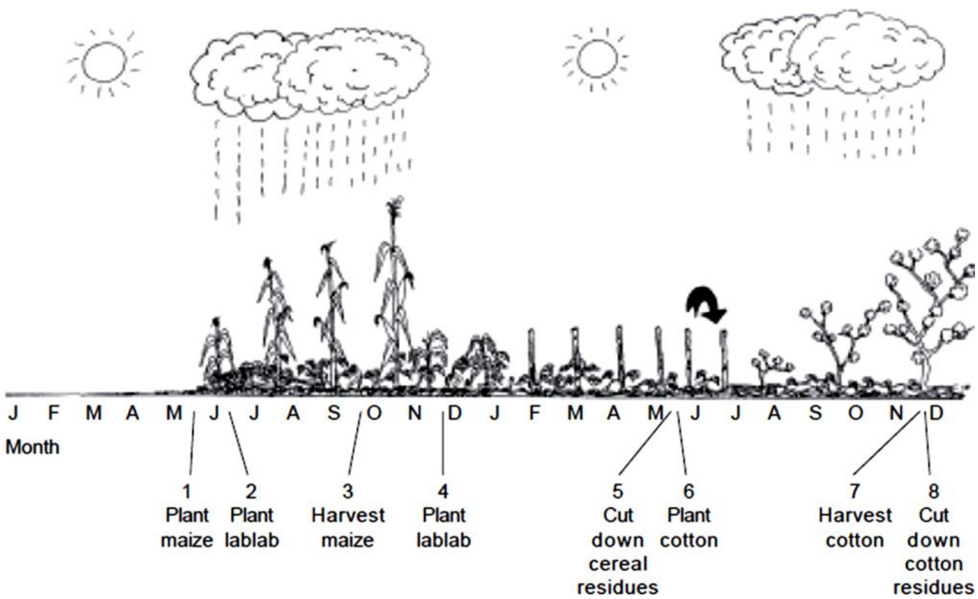

FIGURE 6-11 - 2-YEAR ROTATION OF CEREALS AND COTTON IN CAMEROON

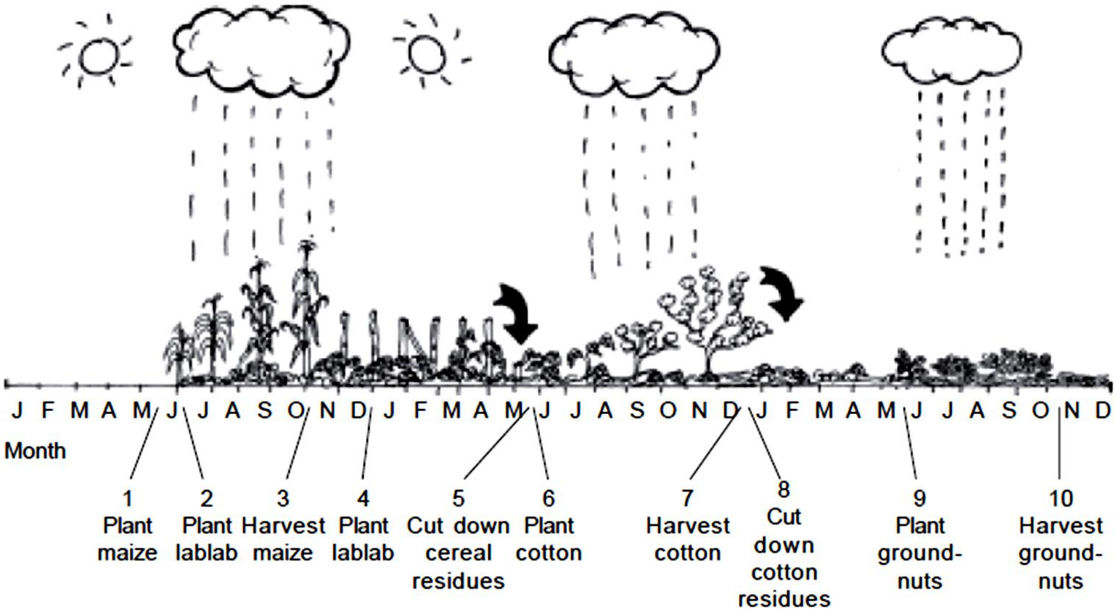

FIGURE 6-12 - 3-YEAR ROTATION OF CEREALS, COTTON AND GROUNDNUT IN NORTHERN CAMEROON

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7. NUTRIENT MANAGEMENT IN ORGANIC AGRICULTURE

SUMMARY

Soil is a living system and soil fertility is the key to agricultural productivity. The maintenance of the fertility of the soil is the primary step in any agricultural system. The plethora of microorganism inherent in any soil system ensures that nutrient cycle is in place and the large substrate is broken down to minute particles that can be easy assimilated by the plant's root system. Therefore farmers should maintain the inherent soil fertility by replacing the nutrients removed by the crops or livestock grazing by using green manures, animal manures (raw or composted) and other natural fertilizers (e.g. rock phosphate).

The input and output of plant nutrients must be monitored through a soil testing program, to ensure that nutrient depletion does not take place. Soils deficient in nutrient cannot support either crop production or active populations of beneficial microorganisms, which are essential for a productive soil. (Figure 7-1 & 7-2).

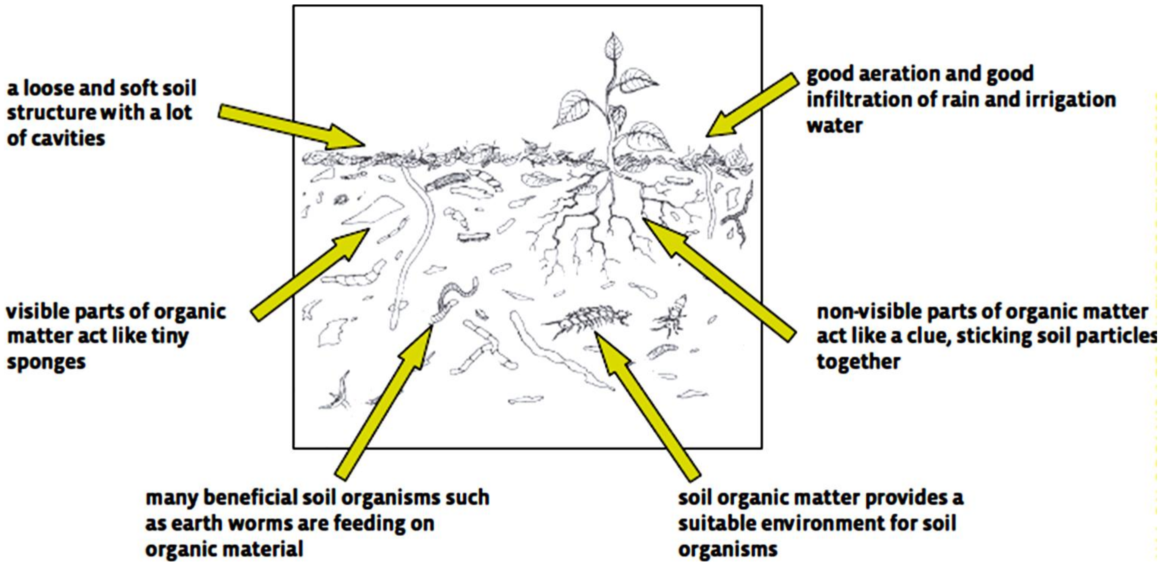

FIGURE 7-1 - WHY ORGANIC MATTER IS SO IMPORTANT

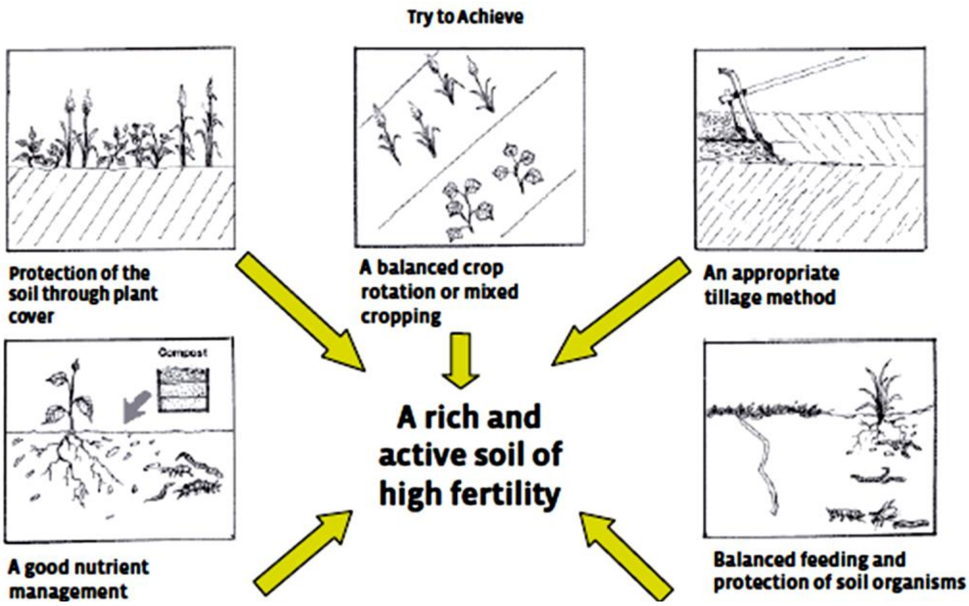

FIGURE 7-2 - HOW TO IMPROVE AND MAINTAIN SOIL FERTILITY

Improvement in agricultural sustainability requires, alongside effective water and crop management, the optimal use and management of soil fertility and soil physical properties (Figure 7-3). Both rely on soil biological process and soil biodiversity. This requires the adoption of management practices that enhance soil biological activity and build-up long term soil productivity and health.

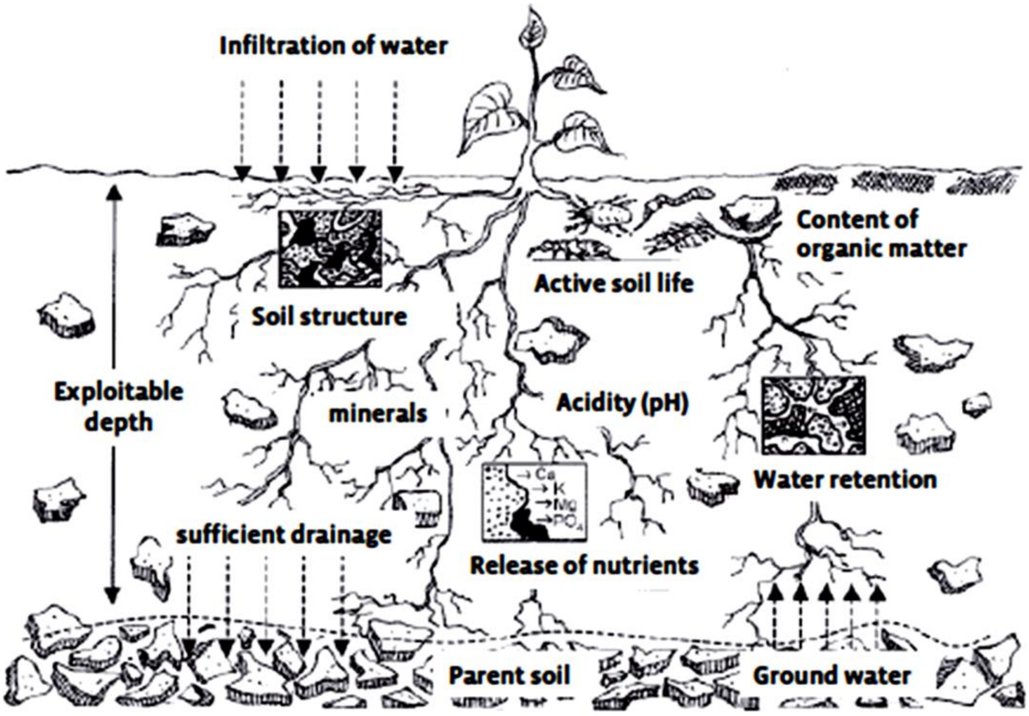

FIGURE 7-3 - FACTORS INFLUENCING SOIL FERTILITY

The main practices to enhance soil fertility include the use of organic fertilizers such as (Figure 7-4):

- **A.** Compost and vermicompost
- **B.** Green manures
- **C.** Animal manure
- **D.** Microbial fertilizers
- **E.** Mineral fertilizers

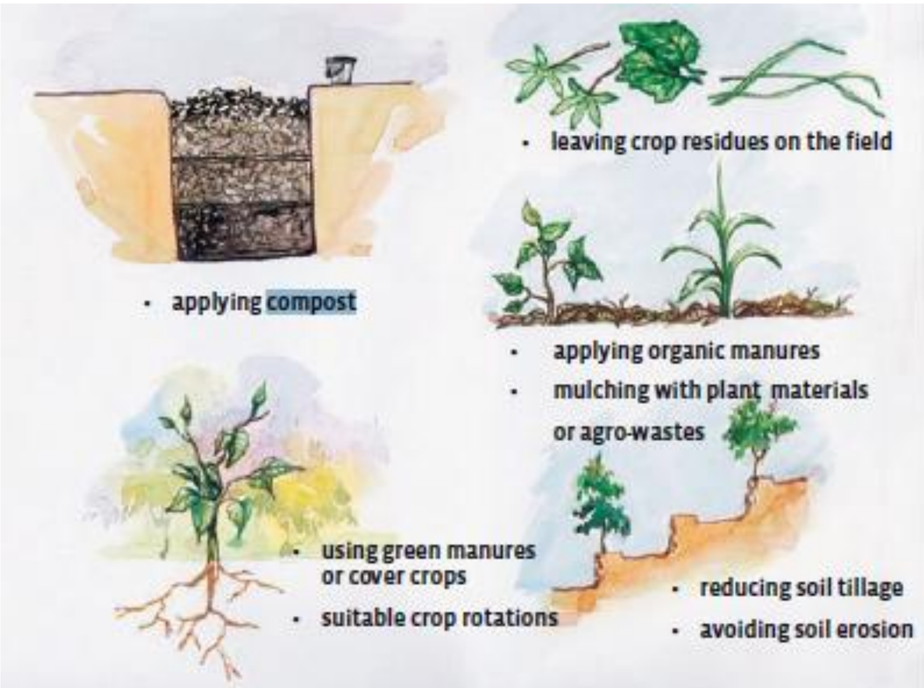

FIGURE 7-4 - HOW TO INCREASE THE CONTENT OF SOIL ORGANIC MATTER

A. Composting

Composting is the process of transforming organic materials of plant or animal origin into humus in heaps or pits. Compared with uncontrolled decomposition of organic material, decomposition in the composting process occurs at a faster rate, reaches higher temperatures and results in a product of higher quality.

Within the process of composting, three main phases can be distinguished: the heating phase, the cooling phase and the maturing phase. However, these phases cannot be clearly separated from one another. (Figure 7-5 & 7-6 and Table 7-1).

1. The heating phase:

- Within 3 days of setting up the compost heap, the temperature in the heap rises to 60 to 70 °C and usually stays at this level for 2–3 weeks. Most of the decomposition occurs during the heating phase.
- In this phase, it is mainly bacteria which are active. The high temperature is a result of energy released during conversion of easily decomposable material by the bacteria. The warm temperature is a typical and important part of the composting process. The heat destroys diseases pests, weed roots and seeds.
- During this first phase of the composting process, the bacteria have a very high oxygen demand due to the rapid development of their population. High temperatures in the heap signal that there is an adequate supply of oxygen for the bacteria. If there is not enough air in the heap, bacterial development will be hindered and the compost will develop an unpleasant odour.
- Humidity is also essential to the composting process, as bacteria require humid conditions for their work. The need for water is greatest during the heating phase because of high biological activity and strong evaporation occurring during this phase.
- As the heat increases, the pH of the compost heap rises (i.e. acidity decreases).

2. The cooling phase:

- Once the material which is easily digested by the bacteria has been converted, the temperature in the compost heap declines slowly and will remain at 25–45 °C.
- With the decline in temperature, fungi settle and start the decomposition of straw, fibres and wooden material. As this decomposition process is slower, the temperature of the heap does not rise.
- As the temperature drops, the pH of the composting material declines (i.e. acidity increases).

3. The maturing phase:

- During the maturing phase nutrients are mineralised and humic acids and antibiotics are built-up.
- Red compost worms and other soil organisms start to inhabit the heap during this phase.
- At the end of this phase the compost has lost about half of its original volume, has the colour of dark, fertile soil and is ready to use.
- The longer it is stored from now on, the more it loses its quality as a fertilizer, while its capacity to improve soil structure increases.
- In the maturing phase, the compost needs much less water than in the heating phase.

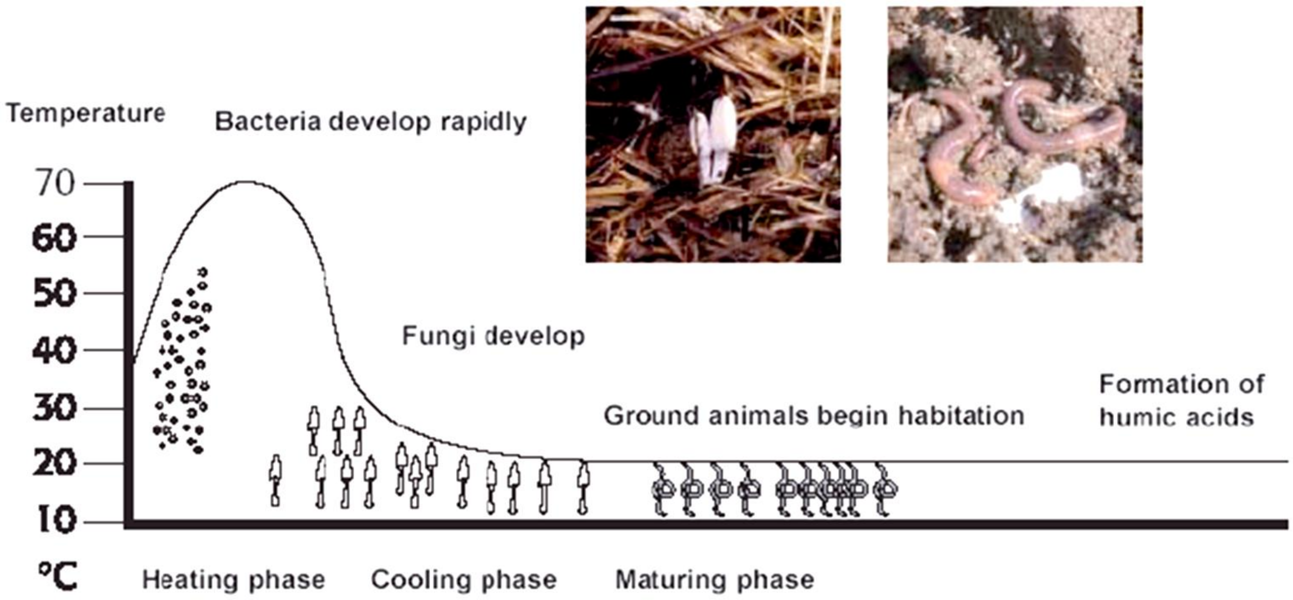

FIGURE 7-5 - THE PROCESS OF COMPOSTING – HOW WASTES BECOME HUMUS

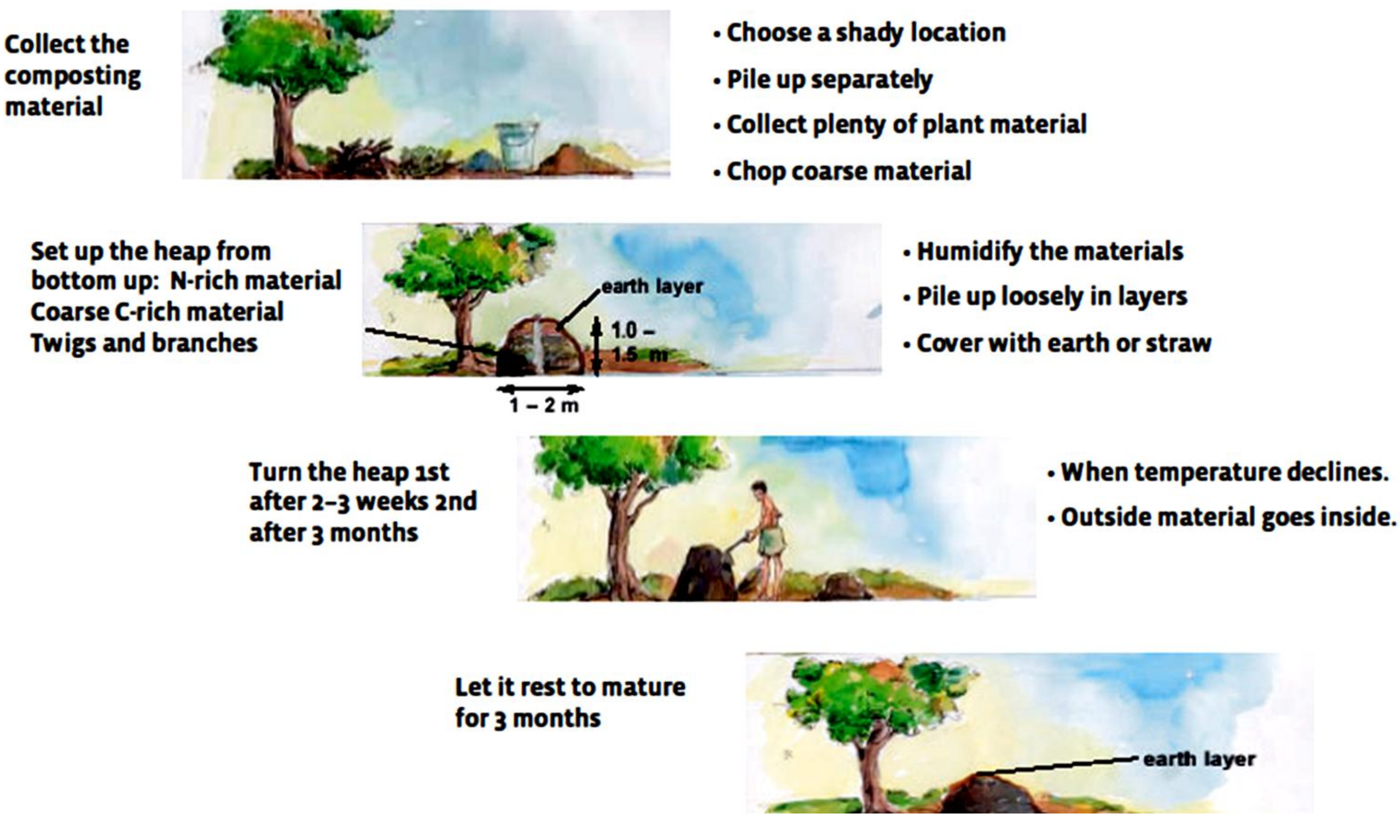

FIGURE 7-6 - HOW TO MAKE COMPOST

TABLE 7-1 - POSSIBLE PROBLEMS AND SOLUTIONS IN THE COMPOSTING PROCESS

Diagnosis	Problem	Possible Reasons	Solutions
Temperature does not rise	Microorganisms can not develop	• Material too dry or too wet • Lack of air or to much air • C/N-ratio is not correct • Too much earth	• Wetten with water or urine • Pile looser • Mix more fresh green material or dung to it
Sudden decrease of the temperature	Transformation process stops	• Material has become too dry • All available nitrogen used	• Wetten with water or urine • Add nitrogen rich material
Composting material gets dusty white	Too strong development of fungi	• Material too dry • Material not mixed for a longer time	• Mix and set up the pile again • Wetten with water or urine • Add nitrogen rich material
Material gets blackish-greenish, foul smeling	Composting material is fouling	• Lack of air and structure • C/N-ratio too low • Material toô wet • Material has not been mixed sufficiently	• Set up pile again adding bulky material with high C/N-ratio • Turn compost more often during heating phase

4. DIFFERENT SYSTEMS AND METHODS

Compost systems can be divided into «continuously» and «batch-fed» systems:

- **Continuously fed systems**: These systems do not heat-up during the composting process. They are handy if there is a continuous supply of wastes (e.g. kitchen waste). However, they lack the advantages of the heating phase.
- **Batch-fed systems** (all material is composted at once): These systems lead to a hot composting process. They offer the advantages of reduced nutrient loss death of weed seeds and diseases as a result of the high temperature of composting, the process is fast (within a few weeks) and it results in a compost of superior quality. If little water is available, composting in pits may be more appropriate since humidity is conserved better in pits than in heaps.
- **Vermi-composting**: is a method of composting using earthworms. Earthworms speed up the composting process, aerate the organic material and enhance the finished compost with nutrients and enzymes from their digestive tracts. Vermicomposting allows you to create compost round the year, indoor during the winter and outdoor during the summer (Figure 7-7).

FIGURE 7-7 - VERMI-COMPOSTING

B. GREEN MANURES

Green manures are plants grown to accumulate nutrients for the main crop. When they have built up maximum biomass, they are worked into the surface soil. As they are usually cut before flowering, growing a green manure is thus different from growing a legume crop in the rotation. Once worked into the soil the fresh plant material releases nutrients quickly and will be fully decomposed within a short period of time. Old or coarse material (e.g. straw, twigs, etc.) will decompose at a slower rate than fine material and will therefore contribute more to the build-up of soil organic matter than to fertilizing the crop.

An alternative to sowing a green manure crop in the field is to collect fresh plant material from elsewhere and work it into the soil. For example, trees and/or shrubs growing alongside crops in an agroforestry system may provide a large quantity of green material which can be used as green manure or for mulching (Figure 7-8).

FIGURE 7-8 - HOW TO PRODUCE MORE BIOMASS ON THE FARM

1. GREEN MANURES HAVE A NUMBER OF BENEFITS:

- They penetrate the soil with their roots, make it more friable and bind nutrients, which would otherwise be washed away.
- They suppress weeds and protect the soil from erosion and direct sunlight.
- If legume plants are used, nitrogen is fixed from the air into the soil.
- Some green manures can be used as fodder plants or even to provide food for human consumption (e.g. beans and peas).
- By decomposing, green manures release all kinds of nutrients in the correct mixture for the main crops to utilise thus improving their yield.
- The incorporated plant material encourages the activity of soil organisms, and builds up organic matter in the soil. This improves soil structure and water holding capacity.

Green manuring is thus an inexpensive way to improve soil fertility and the nutrition of the main crops grown.

2. Factors to consider before growing green manures:

- Labour is required for tillage, sowing, cutting and incorporation of plants into the soil, and is most intensive where the amount of helpful equipment available is small.
- If green manures are intercropped with the main crops, they compete for nutrients, water and light.
- When old or coarse plant material is incorporated into the soil, nitrogen may be temporarily immobilised and therefore unavailable for plant growth.
- If food and space are in short supply it may be more appropriate to grow a food crop rather than a green manure and recycle the crop residues, or to intercrop a green manure crop with the main crop.
- The benefits of green manures occur over the long term and are not always visible immediately.

3. How to use green manures

a) Sowing the green manure

- If grown within a crop rotation, the time of sowing must be chosen such that the green manure can be cut down and worked into the soil before the next crop is sown.
- Green manures need water for germination and growth.
- The ideal seed density must be tested for each individual situation. It depends on the species chosen.
- In general no additional fertilization is necessary. If legumes are grown in a field for the first time, inoculation of the seeds with the specific rhizobia may be necessary to profit from nitrogen fixation of the legume.

b) Working the green manure into the soil (Figure 7-9)

- **Timing**: The time gap between digging in the green manure and planting the next crop should not be longer than 2 to 3 weeks, so as to prevent nutrient losses from the decomposing green manure.
- **Crushing**: Green manures are worked in most easily when the plants are still young and fresh. If the green manure plants are tall or contain bulky and hard plant parts, it is preferable to chop the plants into pieces to allow easier decomposition. The older the plants, the longer decomposition will take. The best time to dig in green manure plants is just before flowering.
- **Depth of incorporation**: Green manures should not be ploughed deeply into the soil. Instead they should only be worked in to the surface soil (in heavy soils only 5 to 15 cm deep, in light soils 10 to maximum 20 cm deep). In warm and humid climates the material can also be left on the soil surface as a mulch layer.

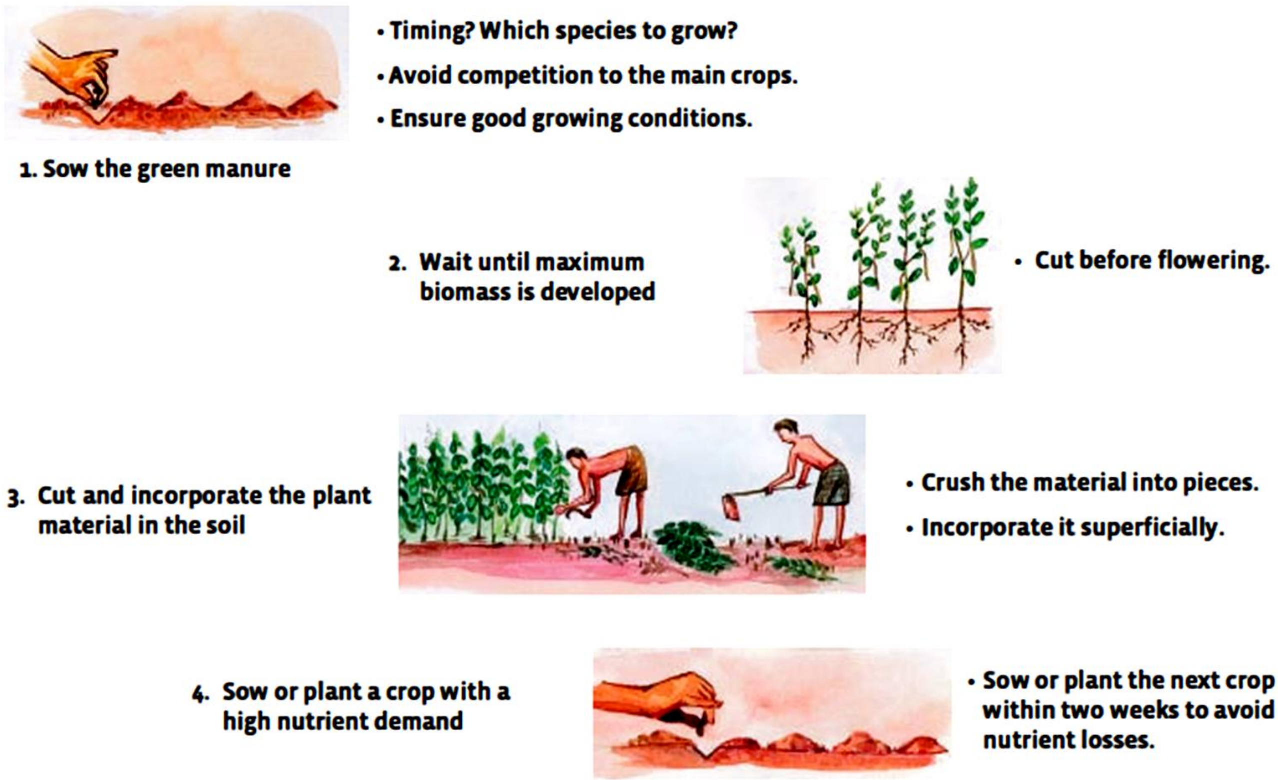

FIGURE 7-9 - STEPS FOR USING GREEN MANURES, WITH SOME POINTS TO CONSIDER

c) How to choose the right species?

There is a large variety of plants, especially legumes that can be used as green manure crops. It is important that appropriate species are chosen. Most importantly they should be adapted to the local growing conditions, especially rainfall and soil, fit into the crop rotation and not pose a risk of transmitting diseases and pests to other crops. (Figure 7-10).

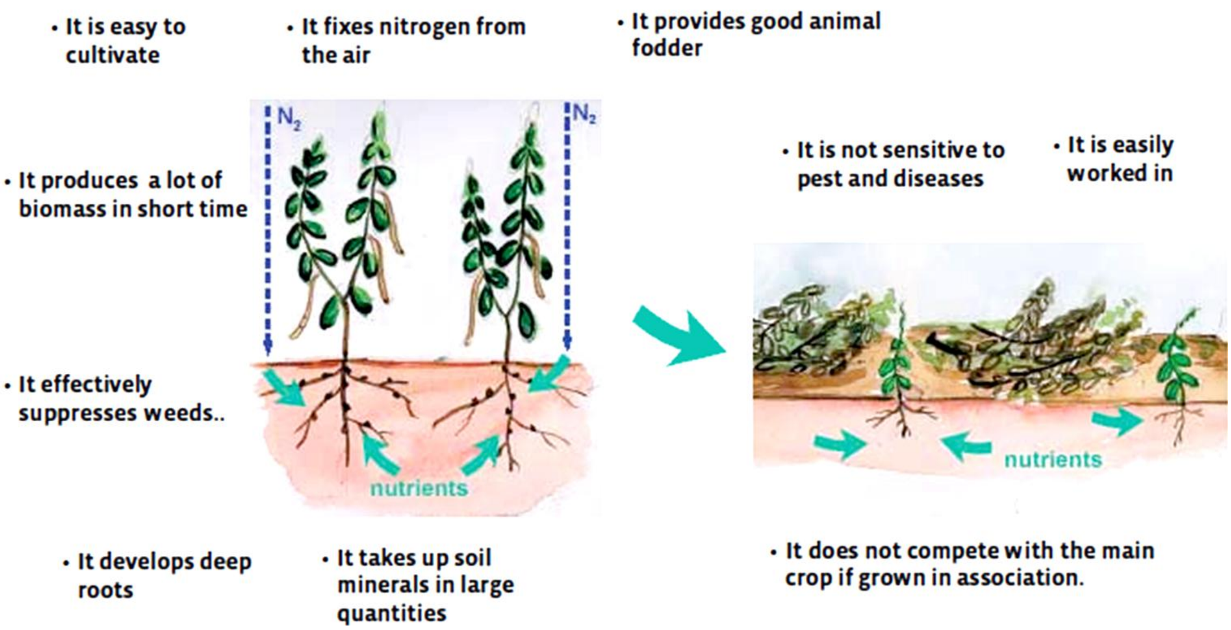

FIGURE 7-10 - CHARACTERISTICS OF THE ''IDEAL'' GREEN MANURE PLANT

C. Animal manure

Depending on whether animals are kept in stables or not (part or full time), farmyard manure consists of animal excreta and bedding material (usually straw or grass). Farmyard manure is extremely valuable organic manure.

Some characteristics and effects of farmyard manure:

- It contains large amounts of nutrients.
- Only part of the nitrogen content of manure is directly available to plants, while the remaining part is released as the manure decomposes. The nitrogen in animal urine is available in the short-term.
- When dung and urine are mixed, they form a well-balanced source of nutrients for plants. The availability of phosphorus and potassium from farmyard manure is similar to that from chemical fertilizers. Chicken manure is rich in phosphorus. However, it is important to be aware of the origin of the manure, as chicken manure from conventional farms is contaminated by heavy metals.
- Organic manures contribute to the build-up of soil organic matter and thus improve soil fertility.

How to store farmyard manure

Farmyard manure should ideally be collected and stored for a while so as to obtain a manure of high quality. The best result is achieved if the farmyard manure is composted. Manure stored under anaerobic conditions (e.g. in water logged pits) is of inferior quality.

Collection of farmyard manure is easiest if the animals are kept in stables. For storage, the manure should be mixed with dry plant material (straw, grass, crop residues, leaves etc.) to absorb the liquid. Straw that has been cut or mashed by spreading it out on a roadside can absorb more water than long straw.

Usually, the manure is stored next to the stable, either in heaps or in pits. It can also be stored within the stable as bedding, provided it is covered with fresh bedding material. In any case, the farmyard manure should be protected from sun, wind and rain. Water logging, as well as drying out should be avoided, so as to avoid nutrient losses. The storage site should be impermeable and have a slight slope. Ideally, a trench collects the liquid from the manure heap and the urine from the stable. A dam around the heap prevents uncontrolled in- and outflow of urine and water.

Storing manure in pits is particularly suitable for dry areas and dry seasons. Storage in pits reduces the risk of drying out and the need to water the pile. However, there is greater risk of waterlogging and more effort is required as the pit needs to be dug out. For this method, a 90 cm deep pit is dug with a slight slope at the bottom. The bottom is compressed and then first covered with straw. The pit is filled with layers about 30 cm thick and each layer compressed and covered with a thin layer of earth. The pit is filled up until it stands about 30 cm above ground and then covered with 10 cm of soil.

Humidity in the manure heap must be controlled. To avoid nutrient losses, it should neither be too wet nor too dry. Some indicators to monitor the humidity of the manure are (Figure 7-11):

- If white fungus appears (threads and white spots), the manure is too dry and should be dampened with water or urine.
- A yellow-green colour and/or bad smell are signs that the manure is too wet and not sufficiently aerated.
- If the manure shows a brown to black colour throughout the heap, the conditions are ideal.

FIGURE 7-11 - APPROPRIATE TREATMENT OF FARMYARD MANURE

D. MICROBIAL FERTILIZERS

The microbial fertilizers mostly consist of organic material and some source of sugar or starch, which are fermented together with specific species of microorganisms. The products are living organisms and need to be applied cautiously. They should not be used when expired, since the organisms may be dead.

Although some research has been done on the use of microorganisms and positive effects may be proven, there is still little experience with such products. To find out the effect of a certain product, it is recommended to test them in small scale and compare with an untreated plot. Remember though: microbial fertilizers cannot substitute an appropriate humus management in the farm.

Most of the bacteria and fungi present in the purchased products are generally present in soil. Microbial inocula, therefore, enhance the presence of the specific organisms. Some farmers make their own microbial fertilizers to save on costs (Figure 7-12).

FIGURE 7-12 - HOW TO PREPARE YOUR OWN BIOFERTILIZER (MICROBIAL FERTILIZER)

Some microbes add nutrients to the soil through mineralisation. Others add nitrogen by fixing it from the atmosphere. These include Rhizobium and Azotobacter. Other microbes, such as Mycorrhizal fungi, help to supply plants with phosphorus. Azospirillum and Azotobacter are bacteria that can fix nitrogen. Pseudomonas species are a diverse group of bacteria that can use a wide range of compounds that plants give off when their roots leak or die. They are able to solubilize phosphorus and may help to suppress soil borne plant diseases.

FIGURE 7-13 - SOME OF THE ACTIVE INGREDIENTS FOUND IN MICROBIAL FERTILIZERS

E. MINERAL FERTILIZER

The mineral fertilizers, which are allowed in organic agriculture, are based on ground natural rock. However, they may only be used as a supplement to organic manures. If they contain easily soluble nutrients, they can disturb soil life and result in unbalanced plant nutrition. In some cases, mineral fertilizers are ecologically questionable as their collection and transport is energy consuming and in some cases natural habitats are being destroyed.

TABLE 7-2 - MINERAL FERTILIZERS ALLOWED IN ORGANIC FARMING – A BASIC OVERVIEW

Fertilizer	Origin	Characteristics	Application
Plant Ashes	Burned organic material	• Mineral composition similar to plants • Easy uptake of the minerals • Wood ashes rich in K and Ca	• To compost (best) • Around the base of the plants
Lime	Ground limestone, algae	• Buffers low pH (content of Ca and Mg secondary) • Algae: rich in trace elements	• Every two to three years when soil-pH is low (avoid excessive use: reduction of availability of P, more deficiencies of micro-nutrients)
Stone Powder	Pulverised rock	• Trace elements (depending on the composition of the source) • The finer the grinding the better the adsorbance.	• To farmyard manure (reduces volatilisation of N and encourages the rotting process)
Rock Phosphate	Pulverised rock containing P	• Easily adsorbed to soil-minerals • Weakly adsorbed to organic matter • Slow reaction	• To compost • Not to reddish soils (irreversible adsorbtion)

You can find in further reading the list of approved substances for use in soil fertilizing and conditioning (from the CODEX 2013).

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8. PEST AND DISEASE MANAGEMENT IN ORGANIC AGRICULTURE

SUMMARY

Pest and disease management consists of a range of activities that support each other. Most management practices are long-term activities that aim at preventing pests and diseases from affecting a crop. Management focuses on keeping existing pest populations and diseases low. Control on the other and is a short-term activity and focuses on killing pest and disease. The general approach in organic agriculture to deal with the causes of a problem rather than treating the symptoms also applies for pest and diseases. Therefore, management is of a much higher priority than control. This document describes preventive practices, as well as control practices using biological, mechanical control and natural pesticides.

A healthy plant is less vulnerable to pest and disease infestation. Therefore, a major aim for the organic farmer is to create conditions which keep a plant healthy (Figure 8-1).

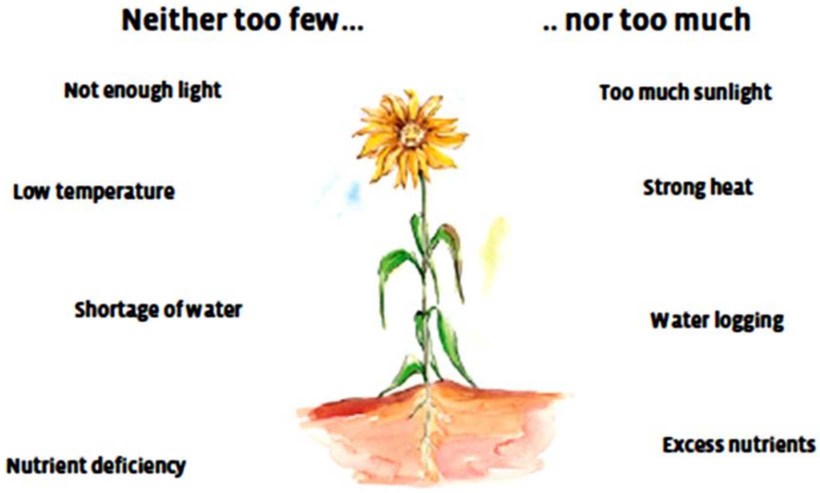


FIGURE 8-1 - FACTORS INFLUENCING PLANT HEALTH

The interaction between living organisms and their environment is crucial for a plant's health. Plant's health is more at risk in monocultures and on-farm diversification provide a balanced interaction between different plants and pests and predators. This is why a well-managed ecosystem can be a successful way of reducing the level of pest or disease population. Certain crop varieties have more effective mechanisms than others due to the adaptive nature to the environment and therefore have a lower infection risk.

The health condition of a plant depends to a large extent on the fertility of the soil. When nutrition and pH is well balanced, the plant becomes stronger and is therefore less vulnerable to infection. Climatic conditions, such as suitable temperatures and sufficient water supply, are further factors which are crucial for a healthy plant. If one of these conditions is not suitable, the plant can become stressed. Stress weakens the defence mechanisms of plants and makes them easy targets for pests and diseases. One of the most important points for an organic farmer is therefore to grow diverse and healthy plants. This avoids many pest and disease problems. (Figure 8-2).

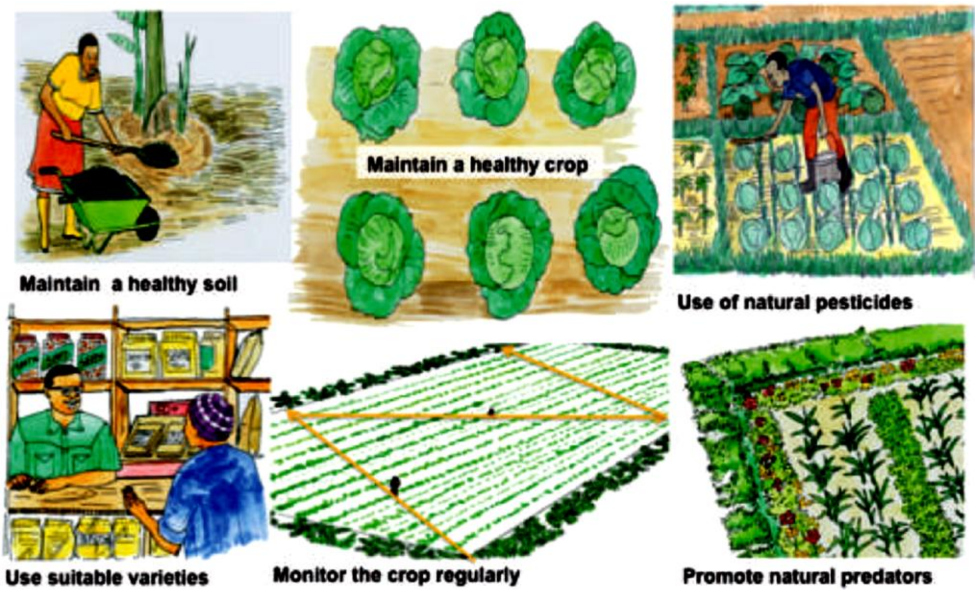


FIGURE 8-2 - BASICS OF ORGANIC PEST AND DISEASE MANAGEMENT

A. PREVENTION PRACTICES AND MONITORING

Knowledge about plant health and pest and disease ecology helps the farmer to choose effective preventive crop protection measures. As many factors influence the development of pest and disease, it's crucial to step in at the most sensitive points. This can be accomplished through the right timing of management practices, a suitable combination of different methods, or the choice of a selective method. Some important preventive crop protection measures are the following ones:

1) **Selection of adapted and resistant varieties:**

→ Choose varieties which are well adapted to the local environmental conditions (temperature, nutrient supply, pests and disease pressure), as it allows them to grow healthy and makes them stronger against infections of pests and diseases.

2) **Selection of clean seed and planting material:**

→ Use safe seeds which have been inspected for pathogens and weeds at all stages of production.
→ Use planting material from safe sources.

3) **Use of suitable cropping systems** (see 6. Crop Planning and Management):

→ Mixed cropping systems: can limit pest and disease pressure as the pest has less host plants to feed on and more beneficial insect life in a diverse system.
→ Crop rotation: reduces the chances of soil borne diseases and increases soil fertility.
→ Green manuring and cover crops: increases the biological activity in the soil and can enhance the presence of beneficial organisms (but also of pests; therefore a careful selection of the proper species is needed).

4) **Use of balanced nutrient management:**

→ Moderate fertilization: steady growth makes a plant less vulnerable to infection. Too much fertilization may result in salt damage to roots, opening the way for secondary infections.
→ Balanced potassium supply contributes to the prevention of fungi and bacterial infections

5) **Input of organic matter:**

→ Increases micro-organism density and activity in the soil, thus decreasing population densities of pathogenic and soil borne fungi.
→ Stabilises soil structure and thus improves aeration and infiltration of water.
→ Supplies substances which strengthen the plant's own protection mechanisms.

6) **Application of suitable soil cultivation methods:**

→ Facilitates the decomposition of infected plant parts.
→ Regulates weeds which serve as hosts for pests and diseases.
→ Protects the micro-organisms which regulate soil borne diseases.

7) **Use of good water management:**

→ No water logging: causes stress to the plant, which encourages pathogens infections.
→ Avoid water on the foliage, as water borne disease spread with droplets and fungal disease germinate in water.

8) **Conservation and promotion of natural enemies:**

→ Provide an ideal habitat for natural enemies to grow and reproduce.
→ Avoid using products which harm natural enemies.

9) **Selection of optimum planting time and spacing:**

→ Most pests or diseases attack the plant only in a certain life stage; therefore it's crucial that this vulnerable life stage doesn't correspond with the period of high pest density and thus that the optimal planting time is chosen.
→ Sufficient distance between the plants reduces the spread of a disease.
→ Good aeration of the plants allows leaves to dry off faster, which hinders pathogen development and infection.

10) **Use of proper sanitation measures:**

→ Remove infected plant parts (leaves, fruits) from the ground to prevent the disease from spreading.
→ Eliminate residues of infected plants after harvesting.

MONITORING

Regular monitoring of pests, diseases and weeds is the basis for effective management. To be able to manage pests, diseases and weeds, information is needed on the specific pests, diseases and weeds present in the region, village or crop fields and the associated damage they cause.

a) Typical signs of pest attacks on crop plants

Most crop pests belong to the insects, mites and nematodes. However, in Africa, mammals (like elephants, monkeys or voles), and birds (like sparrows, starlings and crows) can also damage crops.

Insect damage can be categorized by biting and chewing (e.g. caterpillars, weevils), piercing and sucking (e.g. aphids, psyllids) and boring (e.g. borer, leaf miner) species. Some are slow moving (e.g. caterpillars), fast moving (e.g. fruit flies), hidden (e.g. stem borer), or easy to observe (e.g. caterpillars, weevils).

- **Pest damage** is often species-specific: leaves with holes or missing parts is an indication of caterpillar or weevil damage; curled leaves is an indication of aphids; damaged or rotten fruits are often caused by larvae of fruit flies; withering plants can also be caused by larvae of noctuids or the stem borer; and branches or trunks with holes may be an attack by lignivorous insects.
- **Mites** are very small and cannot be seen with the naked eye. However, some mite species (spider mites) weave a typical tissue on attacked plant parts and can, therefore, easily be detected. If mites are present on plants, leaves and fruits become yellowish.
- **Nematodes** are also very small and therefore, they are not easy to observe with the naked eye. They mostly attack plant roots; plants become yellow, wither and die.

b) Typical signs of disease attacks on crop plants

Most crop diseases are caused by fungi, bacteria or viruses.

- **Fungi** cause the great majority, estimated at two-thirds, of infectious plant diseases. They include all white and true rusts, smuts, needle casts, leaf curls, mildew, sooty moulds and anthracnose. In addition, they are responsible for most leaf, fruit, and flower spots, cankers, blights, wilts, scabs, and root, stem, fruit, wood rots among many others. Parts of plants or the total crop plant can wither and die.
- **Bacteria** cause any of the four following main problems. Some bacteria produce enzymes that breakdown the cell walls of plants anywhere in the plant. This causes parts of the plant to start rotting (known as 'rot'). Some bacteria produce toxins that are generally damaging to plant tissues, usually causing early death of the plant. Others produce large amounts of very sticky sugars; as they travel through the plant, they block the narrow channels preventing water getting from the plant roots up to the shoots and leaves, again causing rapid death of the plant. Finally, other bacteria produce proteins that mimic plant hormones. These lead to overgrowth of plant tissue and form tumours.
- **Viruses** mostly cause systemic diseases. Generally, leaves show chlorosis or change in colour of leaves and other green parts. Light green or yellow patches of various shades, shapes and sizes appear in affected leaves. These patches may form characteristic mosaic patterns, resulting in general reduction in growth and vigour of the plant.

Careful and continuous monitoring of pest and disease levels during critical times of growth of a crop is the key to successful management. This can be done through regular scouting of the field by the farmer. It helps the farmer to intervene early enough before the pest and/or disease cause significant damage.

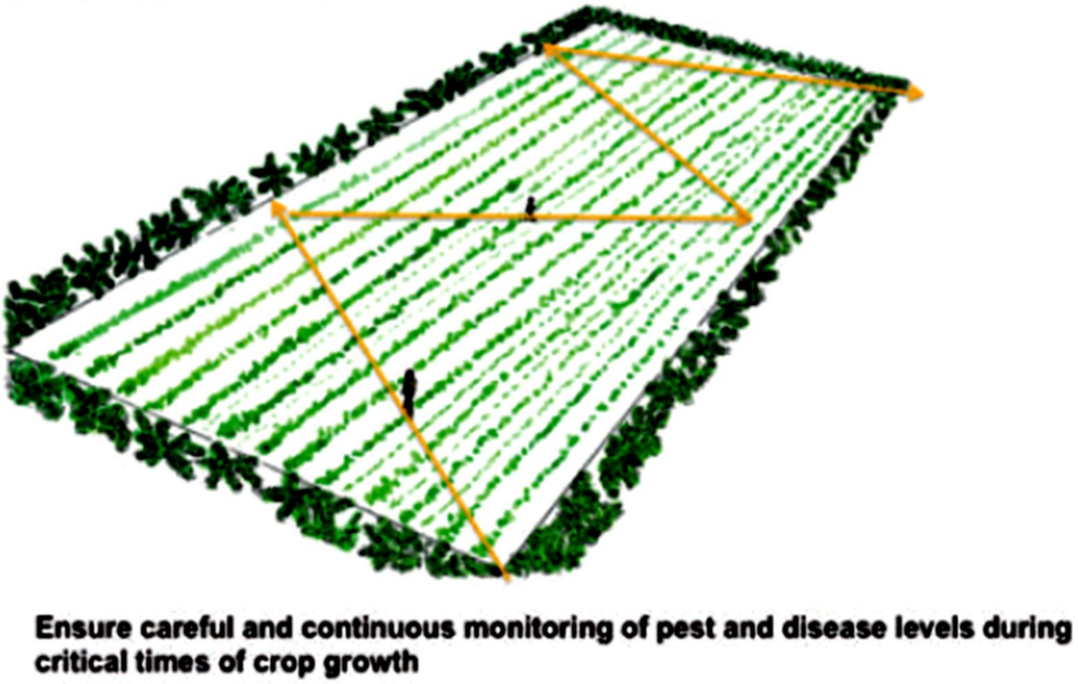


FIGURE 8-3 - SCOUTING PATTERN - ZIG-ZAG (OR M-SHAPPED) ROUTE THROUGH THE FIELD

Scouting (Figure 8-3) avoids unnecessary use of natural plant extracts. Limited use of these substances (e.g. pyrethrum, derris and tobacco) and oils is important as they also have negative effects on beneficial insects. If the application of these substances is not regulated, many pest predators and parasitoids may be killed as well. Over application of these substances may also lead to pests developing resistance. Therefore, scouting should be planned and done in an organised way. It is important to get a random sample that will be representative of the overall situation in the crop garden. Therefore, the scout (farmer) needs to observe and record any of the findings for better decision making.

The most common pattern in pest and disease scouting programs involves walking along a predetermined zigzag or M-shaped route through a field. This pattern is commonly used because it is easy to teach, convenient to use, and ensures that all regions of the field are visited. To monitor insect pests, different traps can also be used (Figure 8-4 & 8-5). The simple idea is to know more about the presence of the insect pests in the field especially the fast moving (mobile) insect pests (e.g. fruit flies, lepidopteran pests).

- Fruit flies can be captured using **bait traps**. For example, PE-bottles with small holes can be half-filled with water, some cattle urine, fruit flesh or a small dead fish and a drop of detergent or soapy water. These bottles are then hung in trees and checked every three days.

- Yellow plastic cards coated with **adhesive** are also good for trapping aphids and leafhopper. Yellow-orange plastic boards are appropriate for white flies, while blue cards are appropriate for thrips monitoring.

- **Light traps** are especially needed where noctuids (e.g. moths, cutworms, African armyworm, and cotton bollworm) are a problem. Within crops attacked by cutworms, visual checks of caterpillars have to be done by dawn.

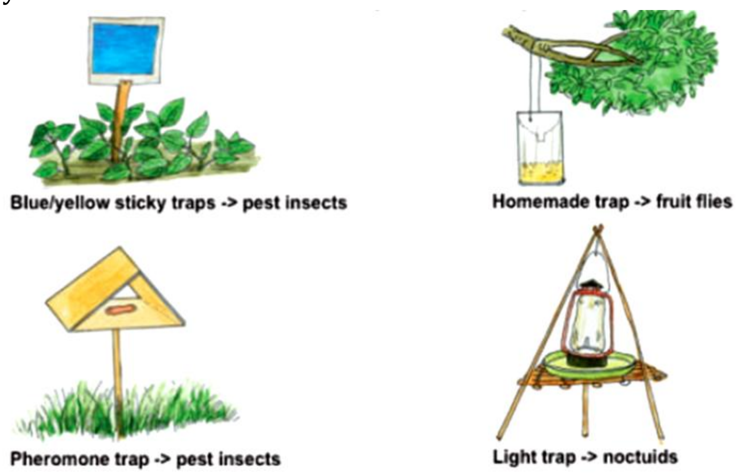


FIGURE 8-4 - TRAPS TO MONITOR INSECT PESTS

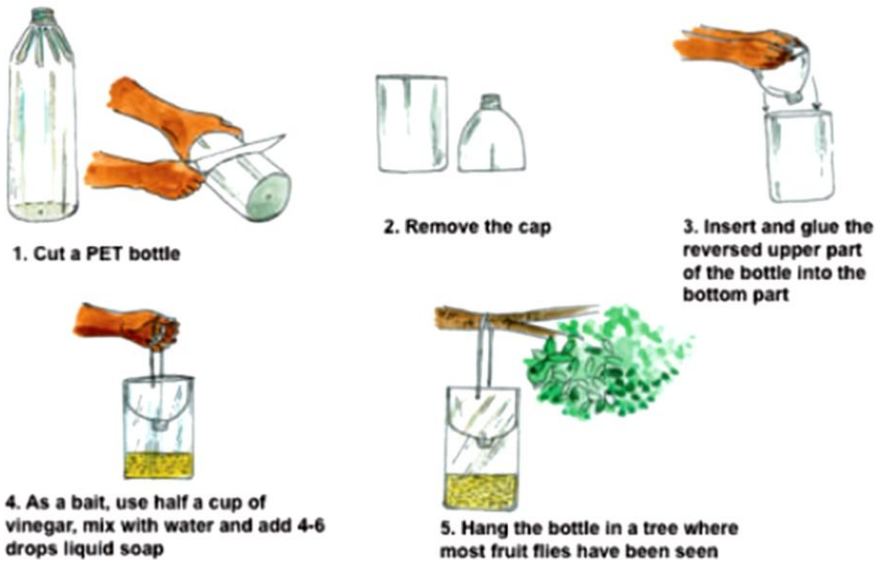


FIGURE 8-5 - HOW TO MAKE A FRUIT FLY TRAP

INDUCING PLANT RESISTANCE

Organic management and control of diseases is based strongly on strengthening the plant with the aim of enhancing its self-defence and thereby preventing the outbreak of the disease. One typical expression of induced resistance is the thickening of cell walls of the plant, which interferes with pathogen entering the cell. Another is the dying of the infested cell walls, which causes the pathogen to die also, and thus reduce its spread.

There are several resistance-inducing substances that can be prepared by the farmers themselves. Some are plant extracts made from efeu (*Hedera helix)*, rhubarb (*Rheum rhabarbarum)*, or giant knotweed (*Reynoutria sachalinensis).*

Compost teas and herbal teas are tools that can be made on the farm to enhance crop health and fertility, and to inoculate the leaves and roots with soluble nutrients, beneficial microorganisms, and beneficial metabolites (products that aid in the growth and development of plants).

Compost extract is a fertilizer, but it also can induce plant resistance. For its preparation, mature compost is mixed with water at a ratio of 1:5 to 1:8 (vol/vol: 1L of compost for every 5 to 8 L of water) and well stirred before it is left to ferment for 3-7 days. One spoonful of molasses can be added per litre of liquid, because this enhances the development of the microorganisms. The fermentation site should be shaded and safe from the rain. After the fermentation period and before the application, the extract is well stirred, then filtered and diluted at a ratio of 1:5 to 1:10.

Plant extracts can be obtained from stinging nettle, horsetail, comfrey, clover, seaweed and others, alone or mixed with marine by-products such as fish waste or fishmeal. Dilutions of 1:10 or 1:5 are used as foliar spray or soil drench.

As a general rule it is recommended to apply compost extracts or teas every 7 to 10 days to prevent diseases from developing and as a way to enhance soil microorganisms.

B. CURATIVE METHODS

PROMOTING AND MANAGING NATURAL ENEMIES

The natural enemies of pests are other organisms (fungi, bacteria, viruses, insect predators, and insect parasitoids) which kill pest. Therefore, the organic farmer should try to conserve natural enemies already present in the crop environment and enhance their impact. This can be achieved with the following methods:

- Minimize the application of natural pesticides (chemical pesticides anyway are not per-mitted in organic farming).
- Allow some pests to live in the field which will serve as food or host for natural enemies.
- Establish a diverse cropping system (e.g. mixed cropping).
- Include host plants providing food or shelter for natural enemies (e.g. flowers which adult beneficial insects feed on).

There are many possibilities to enhance floral diversity within and along the boundaries of crop fields (Figure 8-6):

- **Hedge**s - Use indigenous shrubs known to attract pest predators and parasitoids by offering nectar, pollen, alternative hosts and/or preys. Most flowering shrub species have this property. However, care should be taken to not use plant species known to be alternative hosts of pests or diseases.

- **Beetle banks -** Strips of grass in the neighbourhood of crop fields harbour different natural pest enemy groups like carabids, staphylinid beetles and spiders. In order to lower the risk of weeds and plants known as host plants of crop pests and diseases, one to three native grass species can be sown in strips of 1 to 3 m.
- **Flower strips -** Use indigenous flowering plant species known to attract predators and parasitoids by offering nectar, pollen, alternative hosts and/or preys. Most flowering plant species have this property. However, care should be taken not to use alternative hosts of pests or diseases. Three to five native flowering plant species can be sown in well-prepared seed beds, arranged in strips of 1 to 3 m on the boundary of the crop field. After flowering, seeds can be collected to renew the strip or create new ones.
- **Companion plants -** Natural pest enemies can also be attracted by companion plants within a crop. These companion plant species can be the same as used in the flower strips. A few (1 or 2 per 10 m^2) flowering companion plants within a crop serve as a 'service station' for natural pest enemies.

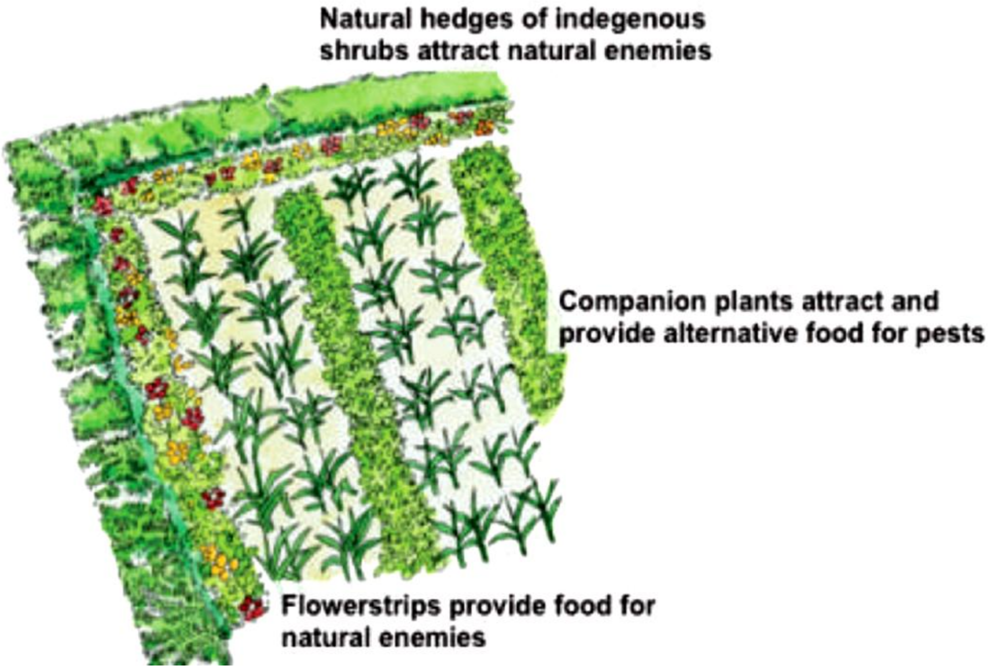


FIGURE 8-6 - ENHANCING BIOLOGICAL CONTROL

MECHANICAL CONTROL

Mass-trapping of pests is an additional control measure. They often can easily be built with cheap material. Some examples include:

- **Light traps** can be used to catch moths such as armyworms, cutworms, stem borers and other night flying insects. Light traps are more efficient when placed soon after the adult moths start to emerge but before they start laying eggs. However, light traps have the disadvantage of attracting a wide range of insect species. Most of the attracted insects are not pests. In addition, many insects that are attracted to the area around the light traps (sometimes from considerable distances) do not actually fly into the trap. Instead, they remain nearby, actually increasing the total number of insects in the immediate area.
- **Colour and water traps** can be used to monitor adult thrips. In some cases thrips can even be reduced by mass trapping with coloured (blue, yellow or white) sticky traps or water traps in the nursery or field. The colour spectrum of the boards is important for the efficacy of the sticky traps. Bright colours attract more thrips than darker ones. Sticky traps with cylindrical surfaces are more

efficient that flat surfaces. They are best placed within a meter of crop level. Traps should not be placed near the borders of fields or near shelter belts.

- **Water traps** should be at least 6 cm deep with a surface area of 250 to 500 cm^2, and preferably round, with the water level about 2 cm below the rim. A few drops of detergent added to the water ensure that thrips sink and do not drift to the edges and escape. Replace or add water regularly.
- **Yellow sticky traps** can be used to control whiteflies, aphids and leaf mining flies. Yellow plastic gallon containers mounted upside down on sticks coated with transparent car grease or used motor oil, is one such trap. These should be placed in and around the field at about 10 cm above the foliage. Clean and re-oil when traps are covered with flies. Yellow sticky boards have a similar effect. To use, place 2 to 5 yellow sticky cards per 500 m^2 field area. Replace traps at least once a week. To make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood (size 30 cm x 30 cm). Place traps near the plants but faraway enough to prevent the leaves from sticking to the board. Note that the yellow colour attracts many insect. Note that the yellow colour attracts many insect species, including beneficial insects, so use yellow traps only when necessary.
- **Fruit bagging** prevents fruit flies from laying eggs on the fruits (Figure 8-7). In addition, the bag provides physical protection from mechanical injuries (scars and scratches). Although laborious, it is cheap, safe and gives a more reliable estimate of the projected harvest. Bagging works well with melon, bitter gourd, mango, guava, star fruit, avocadoes and banana (plastic bags used).

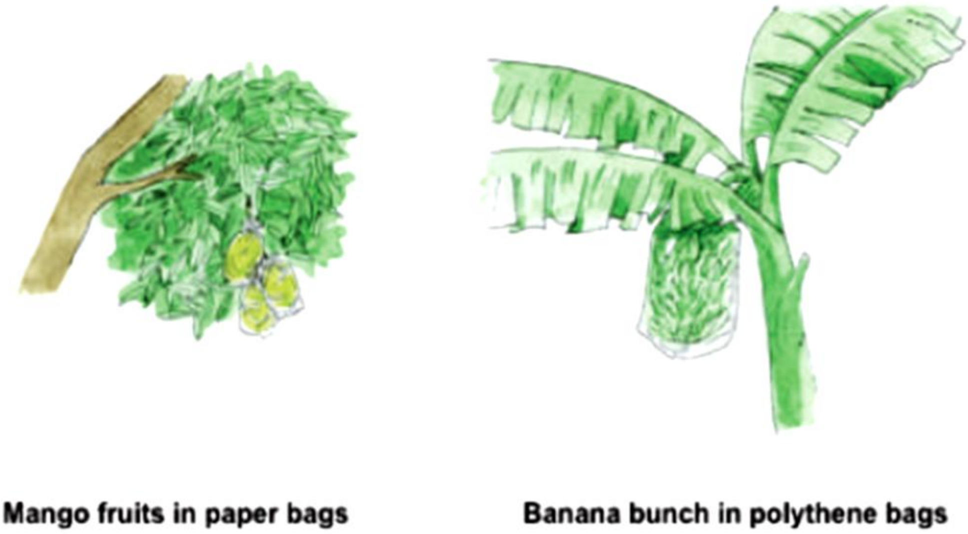
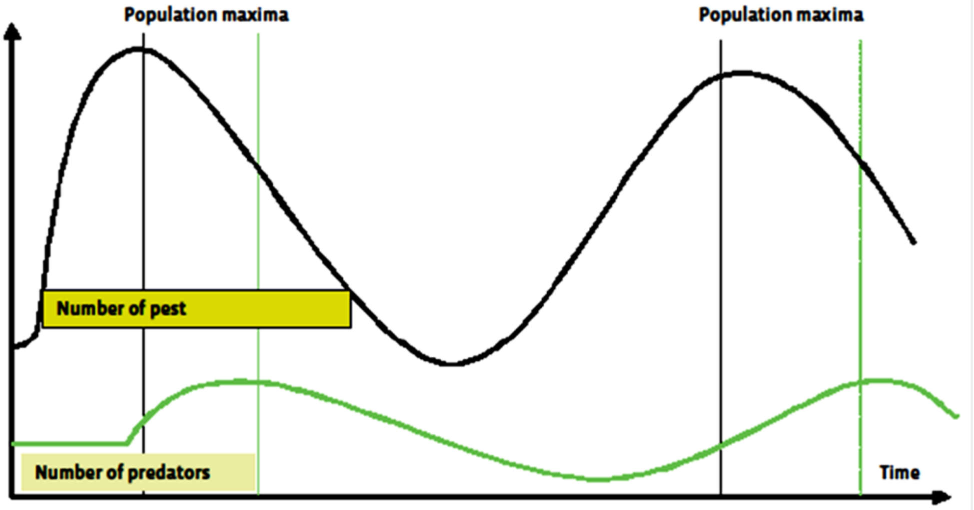


FIGURE 8-7 - FRUIT BAGGING

<u>**Recommendations to farmers regarding fruit bagging**</u>: Cut old newspapers to fruit size and double the layers, as single layers break apart easily. Fold and sew or staple the sides and bottom of the sheets to make a rectangular bag. Blow in the bag to inflate it. Insert one fruit per bag then close the bag and firmly tie the top end of the bag with sisal string, wire and banana fibre or coconut midrib. Push the bottom of the bag upwards to prevent fruit from touching the bag. For example, start bagging the mango fruit 55 to 60 days from flower bloom or when the fruits are about the size of a chicken egg. When using plastic bags (e.g. with bananas), open the bottom or cut a few small holes to allow moisture to dry up. Moisture trapped in the plastic bags damages and/or promotes fungal and bacterial growth that causes diseased fruits. Plastic also overheats the fruit. Bags made of dried plant leaves are good alternatives to plastic.

BIOLOGICAL CONTROL

Biological control is the use of natural enemies to manage populations of pests (such as ladybird beetles, predatory gallmidges, hoverfly larvae against aphids and psyllids) and diseases (Figure 8-8). This implies that we are dealing with living systems, which are complex and vary from place to place and from time to time.



Population dynamics of pests and predators: the y-axis shows the size of the pest and predator populations, the x-axis their development in time.

FIGURE 8-8 - POPULATION DYNAMICS OF PESTS AND PREDATORS

If populations of natural enemies present in the field are too small to sufficiently control pests, they can be reared in a laboratory or rearing unit. The reared natural enemies are released in the crop to boost field populations and keep pest populations down. There are two approaches to biological control through the release of natural enemies:

- Preventive release of the natural enemies at the beginning of each season. This is used when the natural enemies could not persist from one cropping season to another due to unfavourable climate or the absence of the pest. Populations of the natural enemy then establish and grow during the season.
- Releasing natural enemies when pest populations start to cause damage to crops (Figure 8-9). Pathogens are usually used in that way, because they cannot persist and spread in the crop environment without the presence of a host ("pest"). They are also often inexpensive to produce.

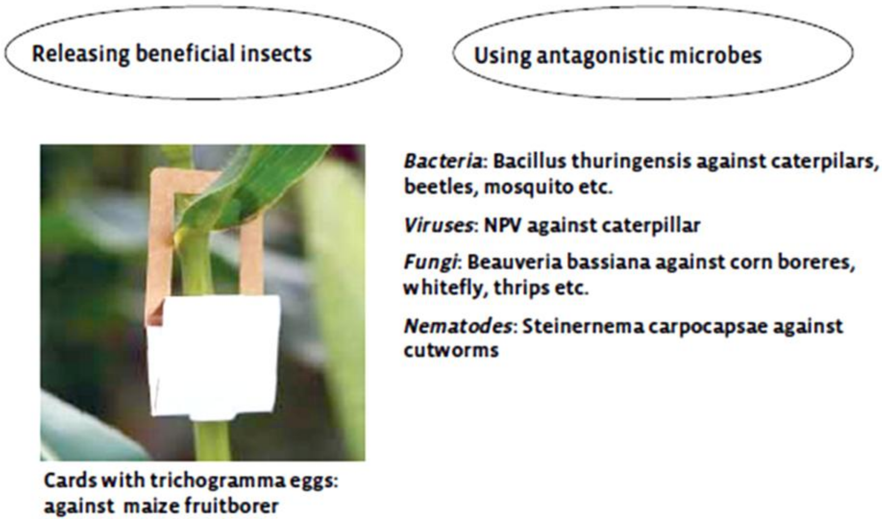


FIGURE 8-9 - RELEASING NATURAL ENEMIES

Natural enemies that kill or suppress pests or diseases are often fungi or bacteria. They are called antagonists or referred to as microbial insecticides or bio-pesticides. Some commonly used antagonistic microbes are:

- **Bacteria** such as *Bacillus thuringiensis* (Bt). Bt has been available as a commercial microbial insecticide since the 1960s. Different types of Bt are available for the control of caterpillars and beetles in vegetables and other agricultural crops, and for mosquito and black fly control. The best-known biocontrol agent used in field crops is the bacteria *Bacillus thuringiensis var. kurstaki and Bacillus thuringiensis. var. aizawai* against diverse lepidopteran pests, and the *Bacillus thuringiensis var israeliensis* against mosquitoes*. Bacillus thuringiensis var kurstaki* is produced in local factories in different African countries (e.g. South Africa, Kenya and Mozambique) and can be used against different pests (African armyworm, African bollworm, bean armyworm, beet armyworm, cabbage webworm, cabbage moth, cabbage looper, cotton leafworm, diamondback moth, giant looper, green looper, spiny bollworm, spotted bollworm, pod borers, tomato looper).
- **Viruses** such as NPV (nuclearpolyhedrosis virus), effective for control of several cater-pillar pest species. Every insect species, however, requires a specific NPV-species. An example: The armyworm *Spodoptera exigua* is a major problem in shallot production in Indonesia. Since experiments showed that SeNPV (NPV specific for *S. exigua)* provided better control than insecticides, farmers have adopted this control method. Many farmers in West-Sumatra are now producing NPV on-farm.
- **Fungi that kill insects**, such as *Beauveria bassiana*. Different strains of this fungus are commercially available. For example: strain Bb 147 is used for control of corn borers (*Ostrinia nubilalis* and *O. furnacaiis*) in maize, strain GHA is used against whitefly, thrips, aphids and mealybugs in vegetables and ornamentals. Several species of fungi can occur naturally in ecosystems. For example, aphids can be killed by a green or white coloured fungus during humid weather.
- **Fungi that work against plant-pathogens**. Some examples include: *Trichoderma sp*., widely used in Asia for prevention of soil-borne diseases such as damping-off and root rots in vegetables (Figure 8-10). Some Trichogramma species against the African bollworm are bred in some laboratories in Africa against lepidopteran pests and aphids. A successful introduction of the neotropical parasitoid *Apoanagyrus lopezi* against the cassava mealybug (*Phenacoccus manihoti*) caused a satisfactory reduction of P. manihoti in most farmers' fields in Africa. This is one of the success stories of classical biocontrol.

Biocontrol by *Trichoderma harzianum*

- The fungi species *Trichoderma harzianum* is known to parasite important plant diseases like damping off (*Rhizoctonia solani*)
- Trichoderma species can affect plant diseases by antibiosis and competition
- In addition, Trichoderma works as a growth stimulant and improves yields and product quality
- Some products are available in African countries

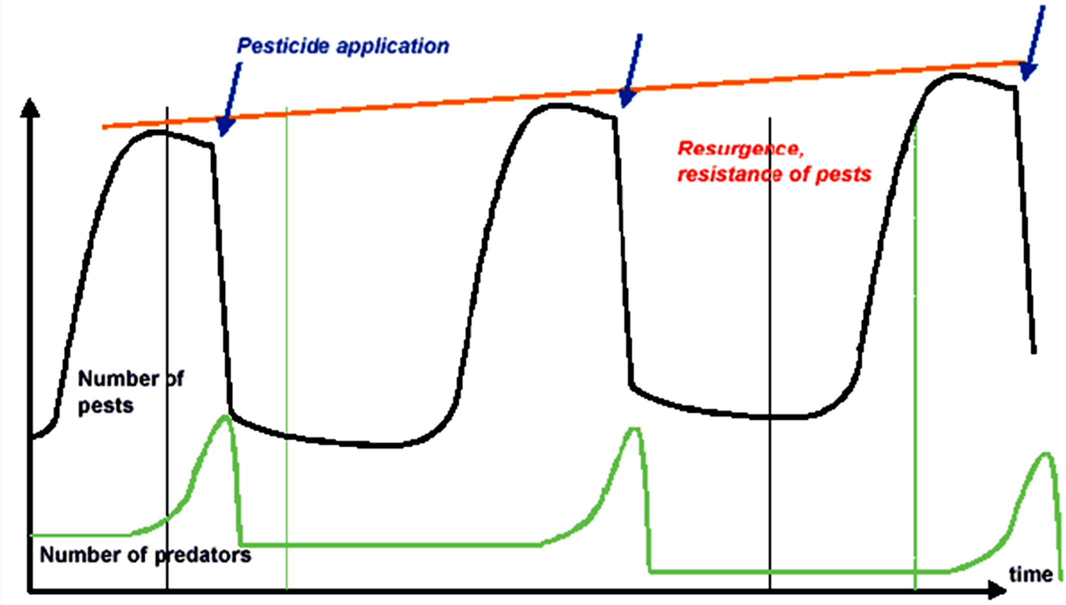
FIGURE 8-10 - BIOCONTROL OF PLANT DISEASES BY NON-PATHOGENIC FUNGI

- **Entomopathogenic nematodes** against different weevil species (e.g. *Steinernema carpocapsae, Heterorhabditis bacteriophora*) and to control soil insects like cutworms (*Agrotis spp*.) in vegetables.

NATURAL PESTICIDES

Some plants contain components that are toxic to insects. When extracted from the plants and applied on infested crops, these components are called botanical pesticides or botanicals. The use of plant extracts to control pests is not new. Rotenone (*Derris sp.*), nicotine (tobacco), and pyrethrins (*Chrysanthemum sp.*) have been used widely both in small-scale subsistence farming as well as in commercial agriculture.

Most botanical pesticides are contact, respiratory, or stomach poisons. Therefore, they are not very selective, but target a broad range of insects. This means that even beneficial organisms can be affected. Yet the toxicity of botanical pesticides is usually not very high and their negative effects on beneficial organisms can be significantly reduced by selective application. Furthermore, botanical pesticides are generally highly bio-degradable, so that they become inactive within hours or a few days. This reduces again the negative impact on beneficial organisms and they are relatively environmentally safe compared to chemical pesticides (Figure 8-11).



The impact of chemical pesticides on natural enemies: the y-axis shows the size of the pest and predator populations, the x-axis their development in time.

FIGURE 8-11 - THE IMPACT OF CHEMICAL PESTICIDES ON NATURAL ENEMIES

The preparation and use of botanicals requires some know-how, but not much material and infrastructures. It's a common practice under many traditional agricultural systems. Some commonly used botanicals are:

- **NEEM**: Neem derived from the neem tree (*Azadiracta indica*) of arid tropical regions, contains several insecticidal compounds. The main active ingredient is azadiractin, which both deters and kills many species of caterpillars, thrips and whitefly. Both seeds and leaves can be used to prepare the neem solution. Neem seeds contain a higher amount of neem oil, but leaves are available all year. A neem solution loses its effectiveness within about 8 hours after preparation, and when exposed to direct sunlight. It is most effective to apply neem in the evening, directly after preparation, under humid conditions or when the plants and insects are damp. There exist different recipes for the preparation of a neem solution.

  Recommendation to farmers about preparation of neem pesticides: In Ghana, Africa, neem seed kernel extract was tested on cabbage in Farmer trainings and had a very good repelling effect on diamondback moth (*Plutella xylostella*). Here is their recipe: Pound 30 g neem kernels (that is the seed of which the seed coat has been removed) and mix it in 1 L of water. Leave it overnight. The next morning, filter the solution through a fine cloth and use it immediately for spraying. It should not be further diluted.

Neem cake (ground neem seed or neem kernel powder) has also a considerable potential as a fertilizer and at the same time it will hinder nematode attacks of the crop roots (e.g. tomato). Put neem cake in the planting pit (200g per m2) and mix it with substrate. The neem cake will repel and even kill nematodes and other root pests. Insecticidal agents (azadirachtin) will be translocated to above-ground parts of the plant and help to get rid of pests there. (figure 8-12).

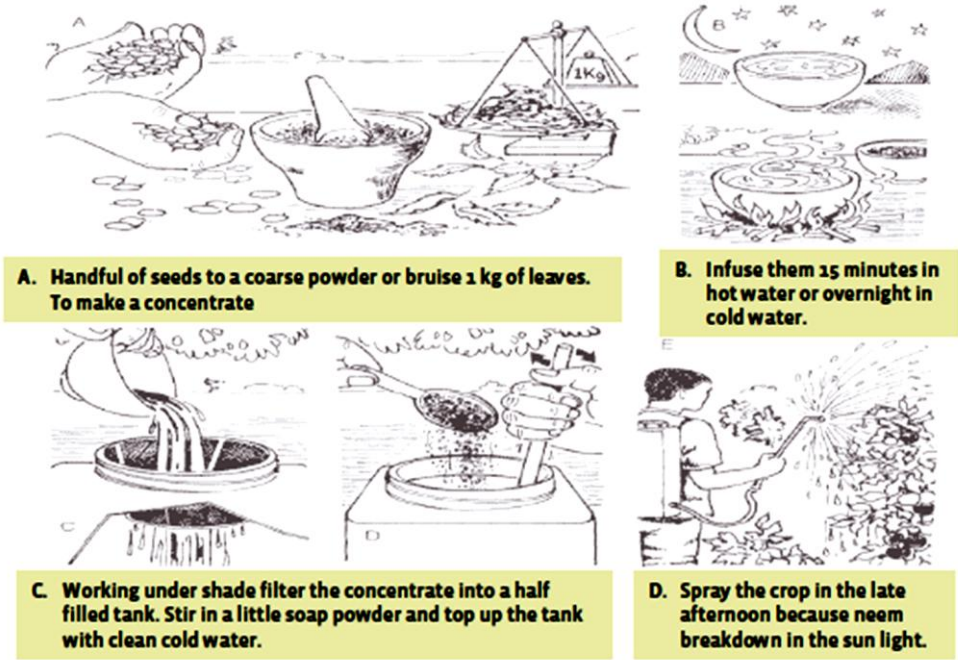


FIGURE 8-12 - PREPARATION OF A NEEM SOLUTION

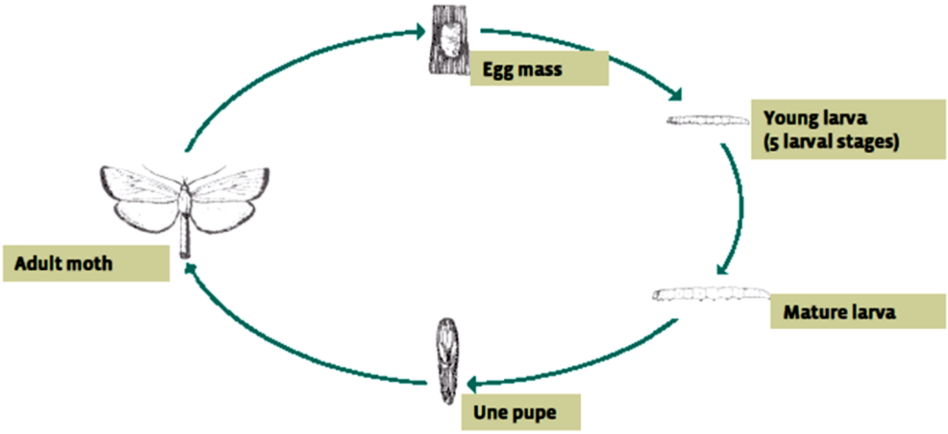
- **PYRETHRUM**: Pyrethrum is a daisy-like Chrysanthemum. In the tropics, pyrethrum is grown in mountain areas because it needs cool temperatures to develop its flowers. Pyrethrins are insecticidal chemicals extracted from the dried pyrethrum flower. The flower heads are processed into a powder to make a dust. This dust can be used directly or infused into water to make a spray. Pyrethrins cause immediate paralysis to most insects. Low doses do not kill but have a "knock down" effect. Stronger doses kill. Pyrethrins break down very quickly in sunlight so they should be stored in darkness. Both highly alkaline and highly acid conditions speed up degradation so pyrethrins should not be mixed with lime or soap solutions. Liquid formulations are stable in storage but powders may lose up to 20% of their effectiveness in one year.

  Recommendation to farmers about preparation of Pyrethrum pesticides: Pyrethrum powder is made with dried ground flowers. Use pure or mix with a carrier such as talc, lime or diatomaceous earth and sprinkle over infested plants. To make liquid pyrethrum extract (mix 20 g pyrethrum powder with 10 L of water), add soap to make the substance more effective. Strain and apply immediately as a spray. For best effects this should be applied in the evening. Pyrethrum can also be extracted by alcohol.

- **CHILLIPEPPER**: Chillies and capsicum pepper have both repellent and insecticidal effects.

  Recommendations to farmers on preparation of chilli pesticides: To make the chilli extract grind 200 g of chillies into a fine dust, boil it in 4 L water, add another 4 L of water and a few drops of liquid soap. This mixture can be sprayed against aphids, ants, small caterpillars and snails.

➢ **GARLIC**: Garlic has antifeedant (insect stop feeding), insecticidal, nematicidal and repellent properties. Garlic is reportedly effective against a wide range of insects at different stages in their life cycle (egg, larvae, adult) (Figure 8-13). This includes ants, aphids, armyworms, diamondback moth, whitefly, wireworm and termites. Garlic is non-selective, has a broad-spectrum effect and can kill beneficial insects as well. Therefore, it should be used with caution.



Life cycle of rice yellow stem borer (Scirpophaga incertulas): egg mass – young larva – mature larva – pupa – adult. (Source : IRRI, 1986)

FIGURE 8-13 - THE LIFE CYCLE OF THE RICE YELLOW STEM BORER

Recommendations to farmers on preparation of garlic pesticides: To make the garlic extract, grind or chop 100 g garlic into 0,5 L of water. Allow mixture to stand for 24 hours, add 0,5 L of water and stir in liquid soap. Dilute at 1:20 with water and spray in the evening. To improve efficacy, chilli extract can be added.

There are many other extracts of plants known to have insecticidal effects like tobacco (*Nicotiana tabacum*), yellow root (*Xanthorhiza simplicissima*), fish bean (*Tephrosia vogelii*), violet tree (*Securidaca longepedunculata*), and nasturtium (*Nasturtium trapaeolum*) which are traditionally used to control pests in Africa.

Anise, chillies, chives, garlic, coriander, nasturtium, spearmint and marigold are plants known to have a repellent effect on different pest insects (aphids, moths, root flies, etc.) and can be grown as intercrop or at the border of crop fields (Figure 8-14). Marigold is especially known to deter root nematodes, while neem cake is known to deter mice.

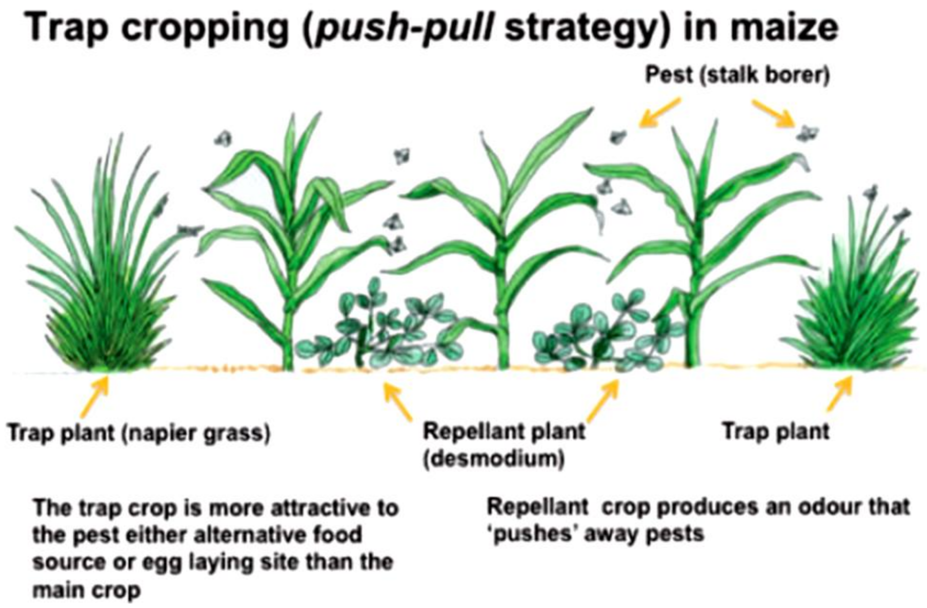


FIGURE 8-14 - TRAP CROPPING - TRAP INTERCROPPING

PRECAUTIONS TO FARMERS REGARDING USE OF PLANT EXTRACTS:

- Despite being "natural" and widely used in agricultural systems, some botanicals may be dangerous for humans and they can be very toxic to natural enemies. Nicotine for example, derived from the tobacco plant, is one of the most toxic organic poisons for humans and other warm-blooded animals. Pyrethrins are not poisonous for humans and warm-blooded animals. However, human allergic reactions are common. It can cause rash, and breathing the dust can cause headaches and sickness.
- Before a new botanical pesticide is applied in a large scale, its effect on the ecosystem should be tested in a small field experiment. Do not just use botanical pesticides as a default option! First understand the ecosystem and how botanicals influence it!
- Do not have direct skin contact with the crude extract during the process of preparation and application.
- Contact with plant extracts should be avoided in the eyes.
- Make sure that you place the plant extract out of reach of children during storage.
- Wear protective clothing (eyes, mouth, nose and skin) while applying the extract.
- Wash your hands after handling the plant extract.

Besides extractions of plants, there are some other natural pesticides, which are allowed in organic farming. Although some of these products have limited selectivity and are not fully biodegradable, there are situations, when their use is justified. However, in most cases, the desired effect is best reached in combination with preventive crop protection methods. Some examples are:

- **Soft soap solutions**: against aphids and other sucking insects.
- **Light mineral oil**: against various insect pests (harms natural enemies!).
- **Sulphur**: against spider mites (harms natural enemies!). The acaricidal effect of sulphur is best at temperatures above 12° C. However, sulphur has the potential to cause plant injury in dry hot weather (above 32° C). It's also incompatible with other pesticides. Sulphur should not be used together or after treatments with oil to avoid phytotoxicity.
- **Plant ashes**: wood ashes from fire places can be efficient against ants, leaf miners, stem borers, termites and potato moths. Ash should be dusted directly on pest colonies and infested plant parts. The ash will dehydrate the soft bodied pests. Wood ashes are often used when storing grains to deter storage pests such as weevils. In addition, ashes are used against soil borne diseases.

OTHER PRACTICES FOR DISEASE CONTROL INCLUDE THE USE OF:

- **Sulphur** is mostly used against plant diseases like powdery mildew, downy mildew and other diseases. The key to its efficacy is that it prevents spore germination. For this reason, it must be applied prior to disease development for effective results. Sulphur can be applied as a dust or in liquid form. It is not compatible with other pesticides. Lime-sulphur is formed when lime is added to sulphur to help it penetrate plant tissue. It is more effective than elemental sulphur at lower concentrations. However, the odour of rotten eggs usually discourages its use over extensive fields.

- **Bordeaux mixture** (Copper sulphate and lime) has been successfully used for over 150 years, on fruits, vegetables and ornamentals. Unlike sulphur, Bordeaux mixture is both fungicidal and bactericidal. As such, it can be effectively used against diseases such as leaf spots caused by bacteria or fungi, powdery mildew, downy mildew and various anthracnose pathogens. The ability of Bordeaux mixture to persist through rains and to adhere to plants is one reason it has been so effective. Bordeaux mixture contains copper sulphate, which is acidic, and neutralized by lime (calcium hydroxide), which is alkaline.

Recommendations to farmers on preparation of Bordeaux mixture: Bordeaux mixture comes in several formulations. One of the most popular, effective and least phytotoxic formulations for general use is the following formulation: Mix 90 g of blue copper sulphate with 4,5 L of water (in a non-metallic container). In another non-metallic container, mix 125 grams of slaked lime with 4.5 litres of water. Stir both, mix both solutions, and stir again. This formulation was developed in recognition of the fact that copper, like sulphur, is phytotoxic and that the level of toxicity is related to the age of plant tissue being treated. Application of Bordeaux during hot weather (above 85° F or 30° C) may cause yellowing and leaf drop. Additionally, leaf burn can occur if it rains soon after a Bordeaux application. Care should be taken when applying this fungicide to young, tender leaves of fruit trees. Do not apply Bordeaux mixture to corn or sorghum, which are described as copper-sensitive plants. There are other, very common and cheap copper formulations available: copper hydroxide and copper oxychloride. They are accepted in organic farming provided that the number of applications is strictly followed and a proper soil amendment is observed to prevent copper accumulation in the soil.

- **Acidic clays** have a fungicidal effect due to aluminium oxide or aluminium sulphate as active agents. They are used as an alternative to copper products but, are often less efficient.
- **Milk** has also been used against blights, mildew, mosaic viruses and other fungal and viral diseases. Spraying every 10 days with a mixture of 1 L of milk to 10 to 15 L of water is effective.
- **Baking soda** has been used to control mildew and rust diseases on plants. Spray with a mixture of 100 g of baking or washing soda with 50 g of soft soap. Dilute with 2 L of water. Spray only once and leave as long gaps as possible (several months). Do not use during hot weather and test the mixture on a few leaves because of possible phytotoxic effects.

Many plant extracts are known to have fungicidal effects. Onion and garlic are effective against many diseases such as mildew and fungal and bacterial diseases. Mexican and African marigold act as a crop “strengthener” to help potatoes, beans, tomatoes and peas resist fungal diseases such as mildew. The leaves of pawpaw (*Carica papaya*) and sweet basil have a general fungicidal effect. Many other plant species are known to have fungicidal effects. Traditional knowledge might be of help to amend the range of plant extracts in each region.

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9. Weed Management in Organic Agriculture

SUMMARY

Organic farmers give first priority to prevention of the introduction and multiplication of weeds. The management practices aim at keeping the weed population at a level that does not result in economic loss of the crop cultivation or harm its quality. The goal is not to completely eradicate all weeds, as they also have a role to play on the farm. For example, weeds provide cover that reduces soil erosion. In addition, most of the biological diversity in our crop fields comes from the presence of weeds. They provide habitat for both beneficial biocontrol insects and mycorrhiza fungi. Because weeds offer pollen and nectar they allow biocontrol insects to maintain their populations and, therefore, serve as a valuable instrument in controlling pests.

However, weeds may also alter the environment of the crop in a negative way. Light and air circulation, for example, are reduced between the crop plants. In this darker and more humid environment, diseases find ideal conditions in which to spread and infect plants.

As we have seen many times up to this point, a basic working principle in organic farming is to **prevent problems**, rather than to cure them. This applies equally to weed management. Good weed management in organic farming includes creating conditions which hinder weeds from growing at the wrong time and in the wrong place and then become a serious problem for the crop cultivation. Competition by weeds doesn't harm the crop throughout the whole cultivation period in the same way. The most sensitive phase of a crop to weed competition is in its early growth stage. A young plant is vulnerable and depends highly on an ideal nutrient, light, and water supply for a good development. If it has to compete with weeds at this stage, the crop may grow weak, which also makes it more vulnerable to pest and disease infections.

Weed competition later in the cultivation period is less harmful. However, some weeds may cause harvesting problems and reduce the crop yield in that way. Therefore, weeds should not be completely ignored after the most critical growth period of the crop, but in general, they become less important.

These considerations should influence the selection and timing of weed management measures. In general, such measures aim at keeping the weed population at a level which doesn't result in economic loss of the crop cultivation or harm its quality.

A. Preventive practices

Several preventive measures may be applied at the same time (Figure 9-2 & 9-4). The importance and effectiveness of the different methods depend to a large extent on the weed species and the environmental conditions. However, some methods are very effective for a wide range of weeds and are therefore regularly used:

- **Choice of crops and varieties**: tall crops and varieties with broader leaves will compete better with late occurring weeds than small varieties with narrow leaves. Some varieties will inhibit and suppress weeds while others will tolerate them. For example, there are witchweed (Striga) resistant maize and cowpea cultivars in many countries of Africa, which give better performance at the same level of weeds where other varieties are more affected (Figure 9-1).

FIGURE 9-1 - STRIGA ON A HOST PLANT WHICH SHOWS SIGNIFICANT DAMAGES

- **Mulching**: the weeds find it difficult to receive enough light to grow and may not be able to pass through the mulch layer. Dry, hardy material, that decomposes slowly, keeps its effect longer than fresh mulch material.
- **Living green cover**: The cover competes successfully against the weeds for light, nutrients, and water and therefore helps to prevent weed growth by winning the competition for resources. The cover crops usually used are legumes, which improves soil fertility on top of suppressing weeds. For example, a ground cover of desmodium (*Desmodium uncinatum*) or silver leaf, inter-seeded among maize, reduces striga weed and fixes nitrogen at the same time.
- **Crop rotation**: Rotation of crops is the most efficient measure to regulate seed and root weeds. Changing the conditions of the crop interrupts the living conditions of the weeds thus inhibiting their growth and spread.
- **Intercropping** (mixed cropping and under-sowing): Intercropping with fast growing weed-suppressive species ("smoother crop" or "living mulch") between rows of main crop species is effective in weed control. There are different examples known to work in Africa, for example, sowing cowpeas and egusi melons or pumpkins as intercrops in cassava to reduce weed occurrence.

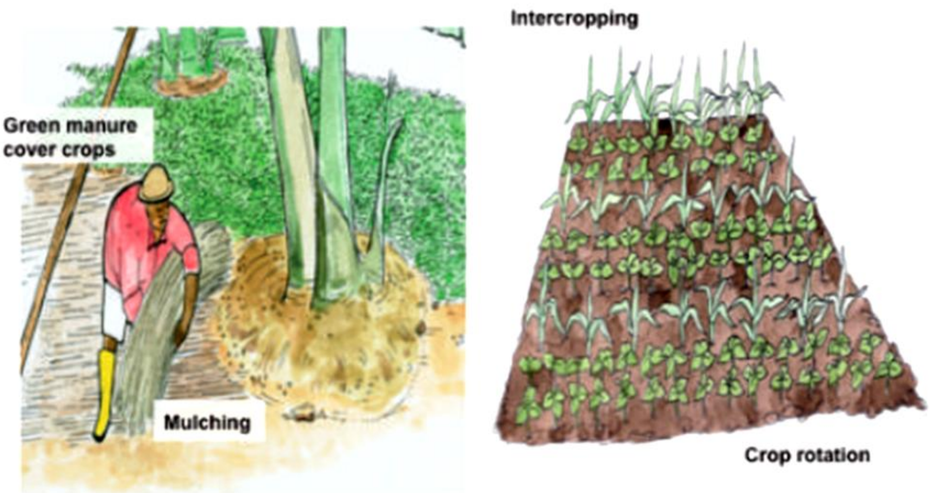

FIGURE 9-2 - CULTURAL PRACTICES OF MANAGING WEEDS

- **Sowing time and density**: Optimum growing conditions enhance the optimum crop plant development and their ability to compete against weeds. Proper crop spacing will ensure that minimum space is available for the growth of weeds and will minimize competition with weeds. This will effectively restrict weed development. In order to apply this approach, the limiting weeds must be known and the seasons in which they occur. A weed calendar of the area or region, if available, might be of help. It will be used to manage weeds in a targeted fashion with proper timing and effect.
- **Balanced fertilization**: it can support an ideal growth of the crop, which promotes the growth of the crop over the weeds.
- **Soil cultivation methods** can influence the total weed pressure as well as the composition of weeds. For example, minimum-tillage systems can increase the weed pressure. Because weed seeds can germinate between soil cultivation and sowing of the crop, weed cures before sowing can be effective at reducing weed pressure. Use of superficial stubble treatment works against persisting weeds. It should be done under dry weather conditions to allow the weed roots which have been brought to the surface to dry out.
- **Pasturing**: in perennial crops like coffee, mangoes, avocadoes or cocoa, the use of sheep and goats to reduce rampant weed growth is becoming common. In case of cattle, broadleaf weeds tend to predominate due to the cattle preference for grasses. Therefore, it is necessary to rotate with sheep and goats which prefer broadleaves to overcome this selective grazing (Figure 9-3).

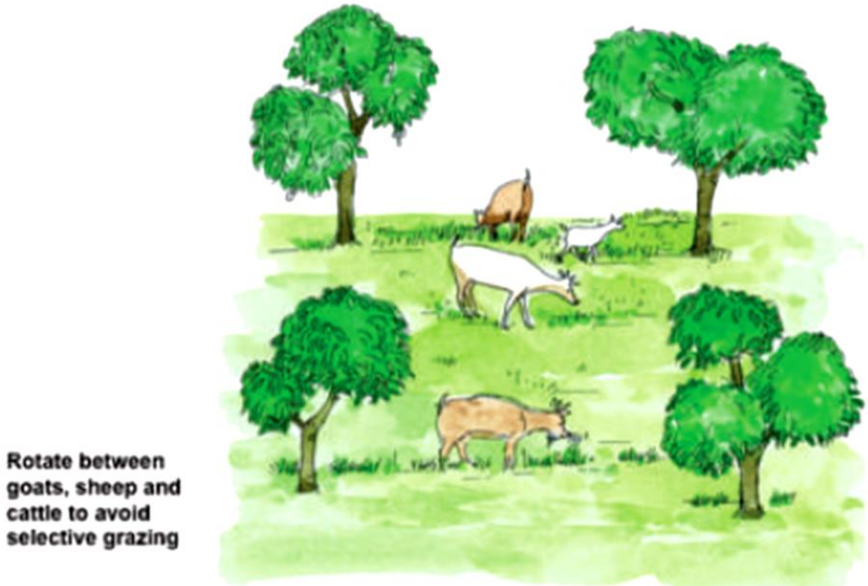

FIGURE 9-3 - PASTURING FOR WEED CONTROL

- Prevent dissemination of weeds by eliminating them before seed dispersal.
- Prevent insemination of crops by weeds by avoiding the introduction of weed seeds into the fields through tools or animals; and by using only weed free seed material.

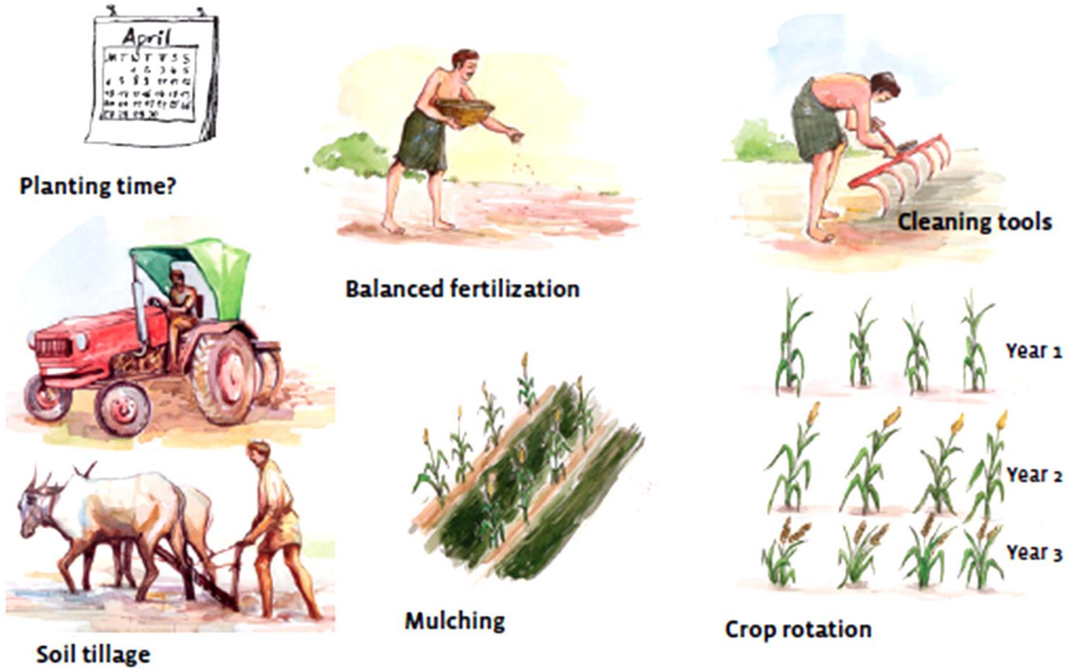

FIGURE 9-4 - HOW TO PREVENT WEEDS

B. BIOLOGICAL CONTROL OF WEEDS

The soil-borne fungus *Fusarium oxysporum* (different isolates from Burkina Faso, Mali and Niger) is very effective in reducing the witch weed *(Striga hermonthica* and *S. asiatica)* in different cereal crops, leading to yield increases in scientific trials. Other *Fusarium* species found in Sudan and Ghana are very effective, too *(Fusarium nygamai, F. oxysporum* and *F. solani)*. This mycoherbicide is on the way to being formulated and registered in different countries in Africa.

Rhizobacteria capable of suppressing germination of witch weed (*Striga* spp.) seeds or actually destroying the seeds are particularly promising biological control agents since they can be easily and cheaply formulated into seed inoculants. *Pseudomonas fluorescens putida* isolates significantly inhibited germination of *Striga hermonthica* seeds. However, currently no biocontrol product is available.

C. MECHANICAL CONTROL

With the necessary preventive measures, weed density can be reduced, but it will hardly be enough during the critical periods of the crop at the beginning of cultivation. Therefore, mechanical methods remain an important part of weed management (Figure 9-5).

Manual weeding is probably the most important one. As it's very labour intensive, reducing weed density as much as possible in the field will bring less work later on and should therefore be aimed at. There are different tools to dig, cut and uprooting the weeds; hand, ox-drawn and tractor-drawn tools. Using the right tool can increase work efficiency significantly.
Weeding should be done before the weeds flower and produce seeds.

Flame weeding is another option: Plants are heated briefly to 100°C and higher. This provokes coagulation of the proteins in the leaves and a bursting of their cell walls. Consequently, the weed dries out and dies. Although it is an effective method, it is quite expensive, as it consumes a large amount of fuel gas and needs machinery. It is not effective against root weeds.

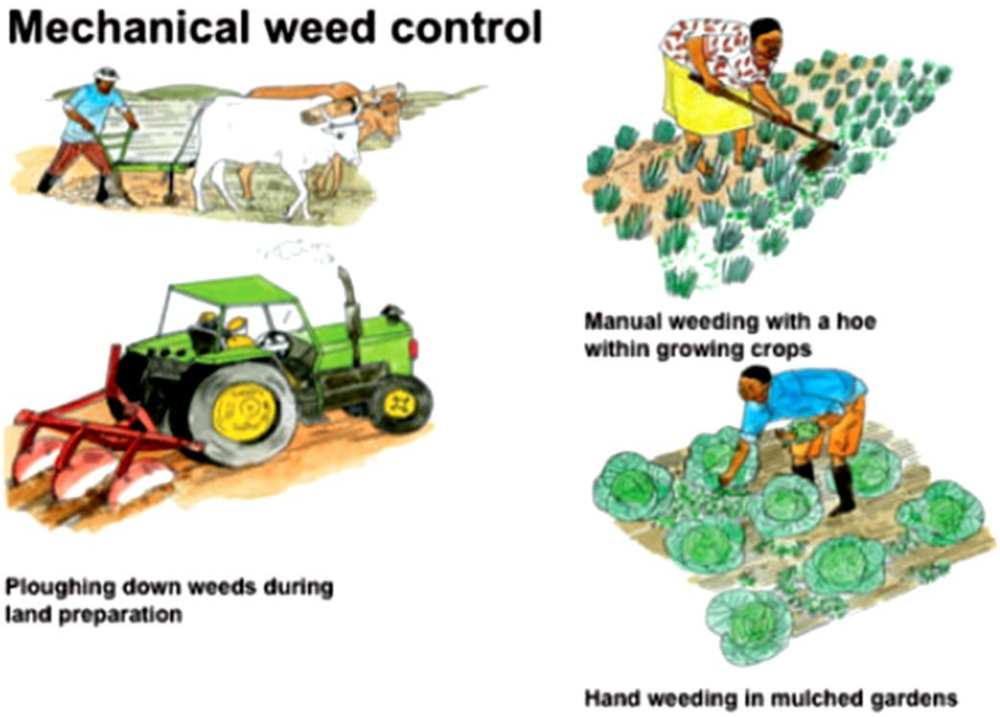

FIGURE 9-5 - MECHANICAL WEED CONTROL

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IFOAM

ON TECA

Weed Management in Organic Agriculture: http://teca.fao.org/read/8375

10. Soil Cultivation and Tillage in Organic Agriculture

SUMMARY

Soil cultivation includes all mechanical measures to loosen, turn or mix the soil, such as ploughing, tilling, digging, hoeing, harrowing etc. Careful soil cultivation can improve the soil's capacity to retain water, its aeration, capacity of infiltration, warming up, evaporation etc. But soil cultivation can also harm the soil fertility as it accelerates erosion and the decomposition of humus. There is not one right way to cultivate the soil, but a range of options. Depending on the cropping system and the soil type, appropriate soil cultivation patterns must be developed.

A. Creating good growing conditions for plants

There are many reasons for cultivating the soil. The most important ones are to (Figure 10-1):

- Loosen the soil to facilitate the penetration of plant roots
- Improve the aeration (nitrogen and oxygen from the air)
- Encourage the activity of the soil organisms
- Increase infiltration of water
- Reduce evaporation
- Destroy or control weeds and soil pests
- Incorporate crop residues and manures into the soil
- Prepare the site for seeds and seedlings
- Repair soil compaction caused by previous activities

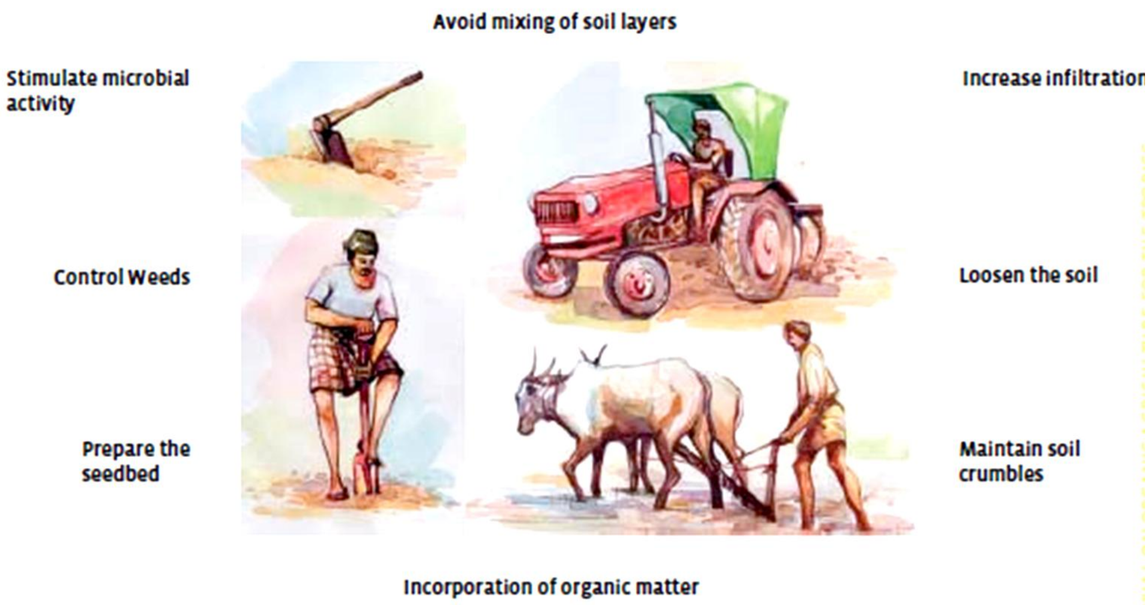
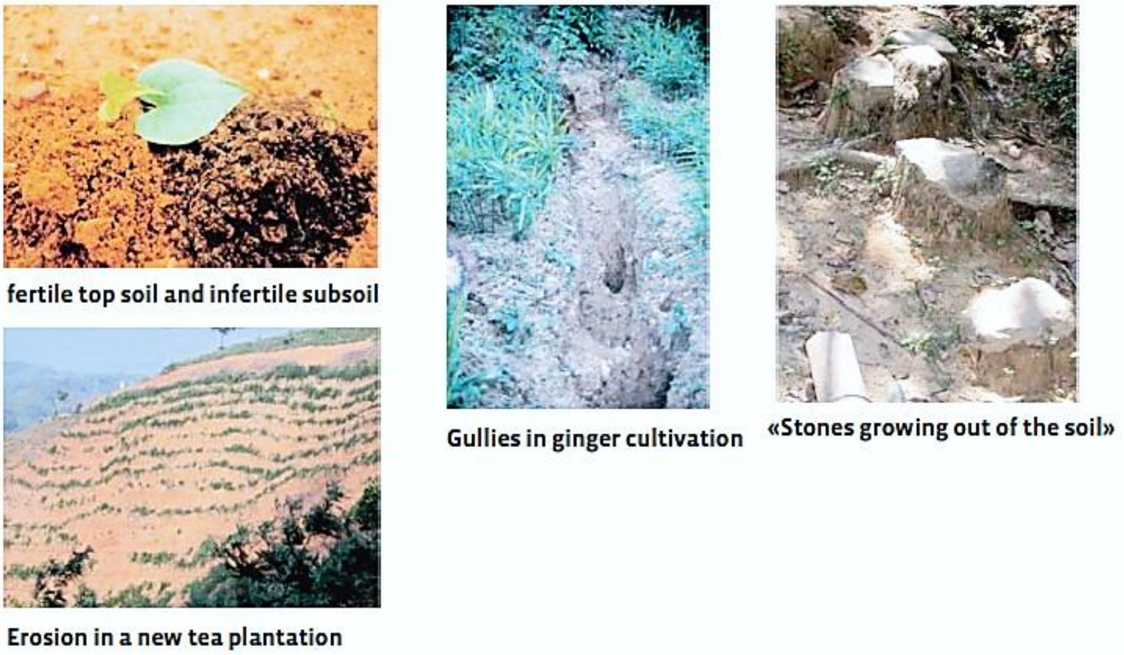


Figure 10-1 - Factors influencing soil fertility

B. Minimum disturbance

Any soil cultivation activity has a more or less destructive impact on soil structure. In tropical soils, regular tillage accelerates the decomposition of organic matter which can lead to nutrient losses. The mixing of soil layers can severely harm certain soil organisms. Soil after tillage is very prone to soil erosion if left uncovered before the onset of heavy rains (Figure 10-2).

Minimum tillage systems on the other side help to build up a natural soil structure with a crumbly top soil rich in organic matter and full of soil organisms. Nutrient losses are reduced to a minimum as there is no sudden decomposition of organic matter and nutrients are caught by a dense network of plant roots. Soil erosion won‘t be a problem as long as there is a permanent plant cover or sufficient input of organic material. Last but not least, farmers can save a lot of labour (Figure 10-3).



Upper left: subsoil of low fertility and dark fertile topsoil; upper right: stones elevated from the soil due to erosion; bottom left: severe erosion in a new tea plantation; bottom right: Gully erosion in ginger cultivation

FIGURE 10-2 - SIGNS FOR SOIL EROSION

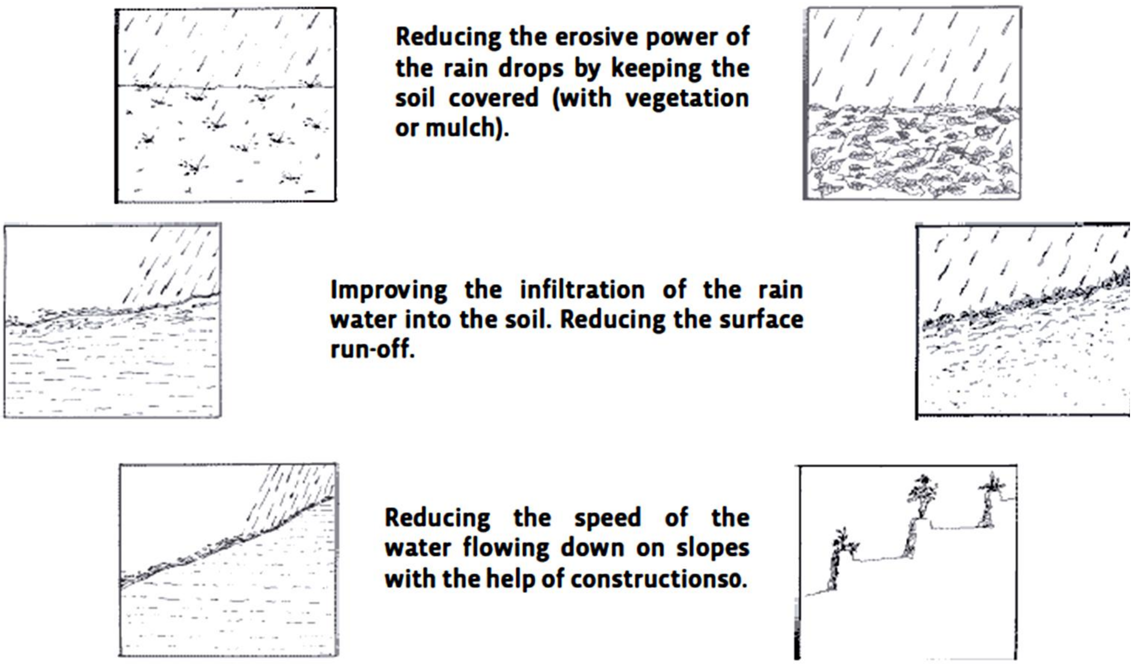


FIGURE 10-3 - HOW TO PREVENT SOIL EROSION

Thus, each organic farmer will have to assess the soil cultivation practice which is most suitable for his/her conditions. To minimize the negative impacts of soil cultivation while benefiting from its advantages, the organic farmer should aim on reducing the number of interventions to the minimum and choose methods that conserve the natural qualities of the soil.

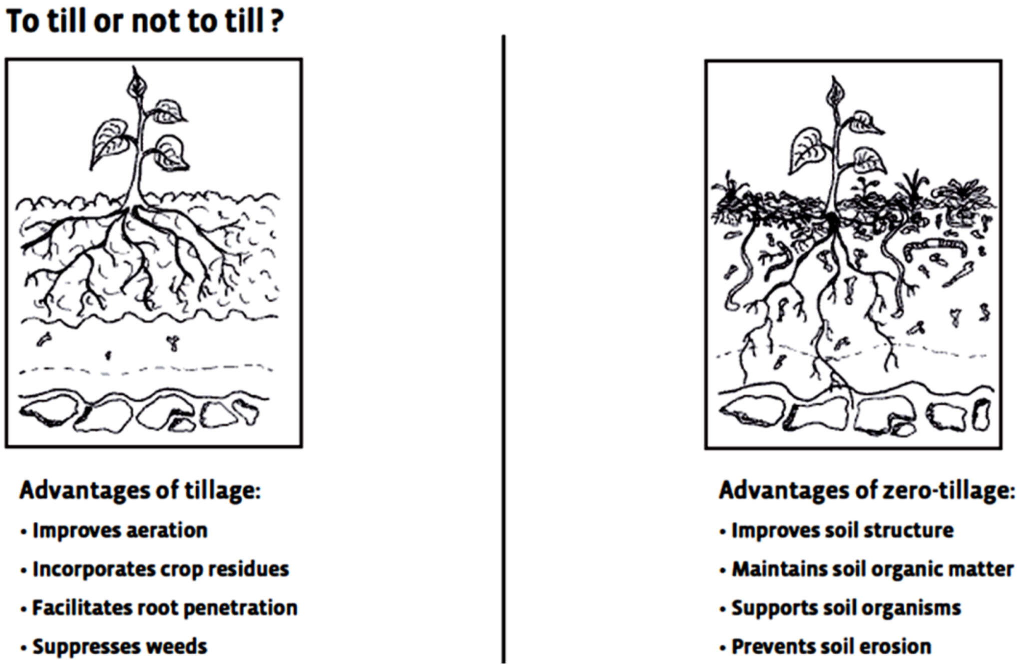


FIGURE 10-4 - ADVANTAGES OF SOIL CULTIVATION AND ZERO-TILLAGE SYSTEMS

C. SOIL COMPACTION

If soils are cultivated in wet conditions or burdened with heavy machinery, there is a risk of soil compaction which results in suppressed root growth, reduced aeration and water logging (Figure 10-5).

Where soil compaction is a potential problem, farmers should be aware of the following aspects:

- The risk of soil compaction is highest when the soil structure is disturbed in wet conditions
- Do not drive vehicles on your land soon after rains
- Ploughing of wet soils can lead to a smearing of the plough sole
- Soils rich in sand are less prone to soil compaction than soils rich in clay
- High content of soil organic matter reduce the risk of soil compaction
- It is very difficult to restore a good soil structure once soil compaction took place

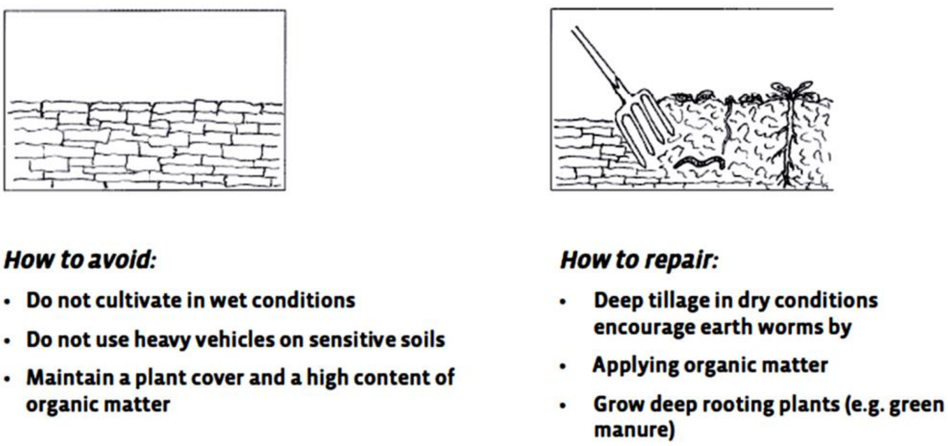


FIGURE 10-5 - SOIL COMPACTION

D. TYPES OF SOIL CULTIVATION

Depending on the aim of the soil cultivation, different cultivation practices are implemented during different stages of the cropping cycle: after harvesting, before sowing or planting or while the crop stands.

POST-HARVEST

In order to accelerate decomposition, the residues of the previous crop are incorporated into the soil before preparing the seedbed for the next crop. Crop residues, green manure crops and farmyard manure should be worked only into the topsoil layer (15 to 20 cm), as decomposition in deeper soil layers is incomplete, producing growth inhibiting substances which can harm the next crop.

PRIMARY TILLAGE

In annual crops or new plantations, primary tillage is usually done with a plough or a similar instrument. As a principle, soil cultivation should achieve a flat turning of the top soil and a loosening of the medium deep soil. Deep turning soil cultivation mixes the soil layers, harms soil organisms and disturbs the natural structure of the soil.

SEEDBED PREPARATION

Before sowing or planting, secondary soil cultivation is done to crush and smoothen the ploughed surface. Seedbed preparation has the purpose to provide enough loose soil of appropriate clod size. If weed pressure is high, seedbeds can be prepared early thus allowing weed seeds to germinate before the crop is sown. Shallow soil cultivation after some days is sufficient to eliminate the young weed seedlings. Where water logging is a problem, seedbeds can be established as mounds or ridges.

IN-BETWEEN THE CROP

Once the crop is established, shallow soil cultivation (e.g. by hoeing) helps to suppress weeds. It also enhances the aeration of the soil and at the same time reduces the evaporation of soil moisture from the deeper soil layers. When crops are temporarily lacking nutrients, shallow soil cultivation can stimulate the decomposition of organic matter, thus making nutrients available.

EXAMPLE: Minimum and zero-tillage in Honduras (Adapted from: “Manual de agricultura biológica”,1999. Kolmans, E. & Vasquez, D.)

→Farmers in the coastal region of Honduras are practising the following minimum tillage system:

- First, the vegetation is cut down to the soil level.
- Then the soil is opened along contour lines at plant row distance.
- Organic manure is applied into the rows.
- The crop is sown into these rows.
- The vegetation in between is cut regularly and used as a mulch.
- This system can be combined with leguminous plants which act as cover crops.

→In the same region, also a zero tillage system is practised by sowing maize and corn directly into the residues of the previous crop:

- Corn is sown into the mulch layer
- 1-2 months later the beans are sown.
- After the corn is harvested, the residues are left on the field and the beans grow over them.
- The beans offer suitable conditions for a direct sowing of the following corn crop.
- With this method, two corn crops and two bean crops per year are grown with satisfying yields

➔With both methods, farmers observe higher total yields, less soil erosion, less weeds and a great reduction of the work load.

THE TOOLS FOR SOIL CULTIVATION CAN BE GROUPED IN FOUR TYPES (Figure 10-6)

- Tools for primary cultivation: pole plough, mouldboard plough, digging fork, spade
- Tools for secondary cultivation: cultivators, harrows, rakes
- Tools for inter-row cultivation: inter-row cultivators, hoes
- Tools for land forming: ridgers, hoes

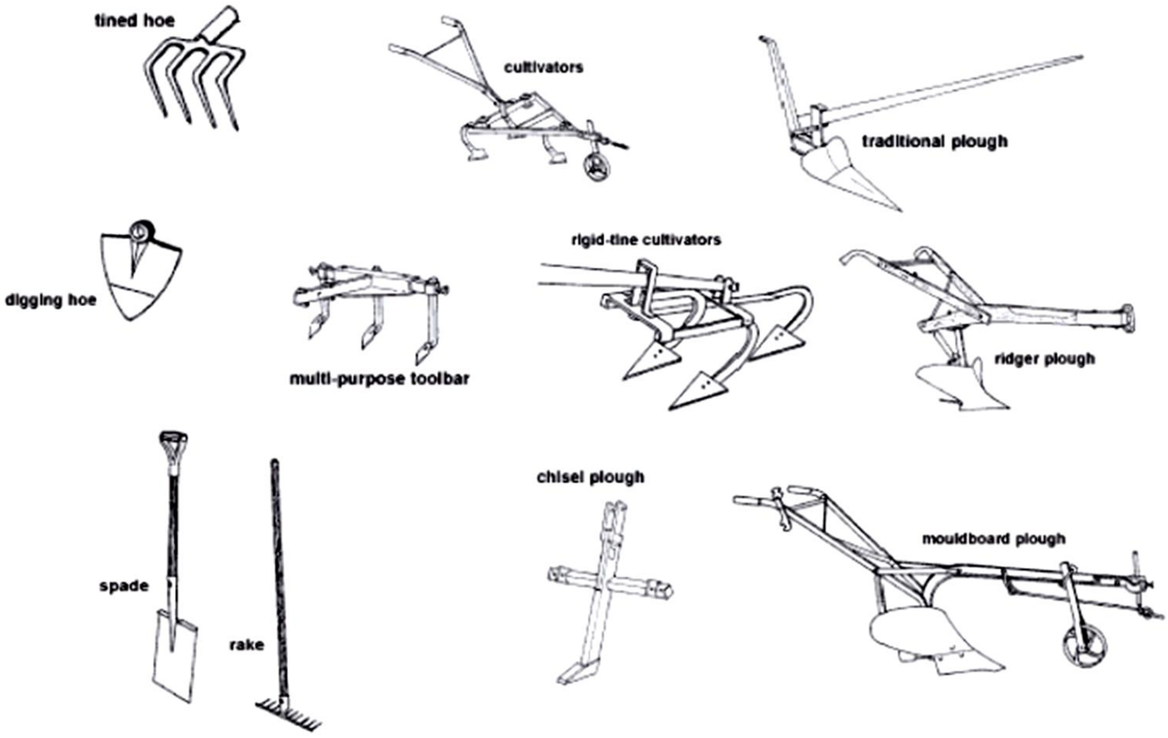


FIGURE 10-6 - SOME EXAMPLES OF SOIL CULTIVATION TOOLS (SOURCE. TOOLS FOR AGRICULTURE, CTA & GRET).

Tools should be chosen considering the soil cultivation purpose, the soil type, the crop and the available power source. Therefore, it is difficult to make general recommendations.

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11. PLANT PROPAGATION IN ORGANIC AGRICULTURE

SUMMARY

The choice of high quality organic seed and plant propagation material of suitable varieties is an important key to successful organic farming, allowing for improved yield and product quality, for crop resilience, considerate use of non-renewable resources and for increased genetic and species diversity. This practice describes the principles of plant propagation in organic farming, as well as the importance of the use of traditional varieties and their conservation.

Ideally, all plant production should be based on organically-bred and organically-propagated varieties. Where the number of organically bred varieties are very limited or non-existent for certain crops, conventionally bred varieties are allowed, except for varieties derived from genetic engineering (GMO crops, Figure 11-1), **which are not allowed in organic farming**. However, the seeds of conventionally bred varieties should be propagated under certified organic systems.

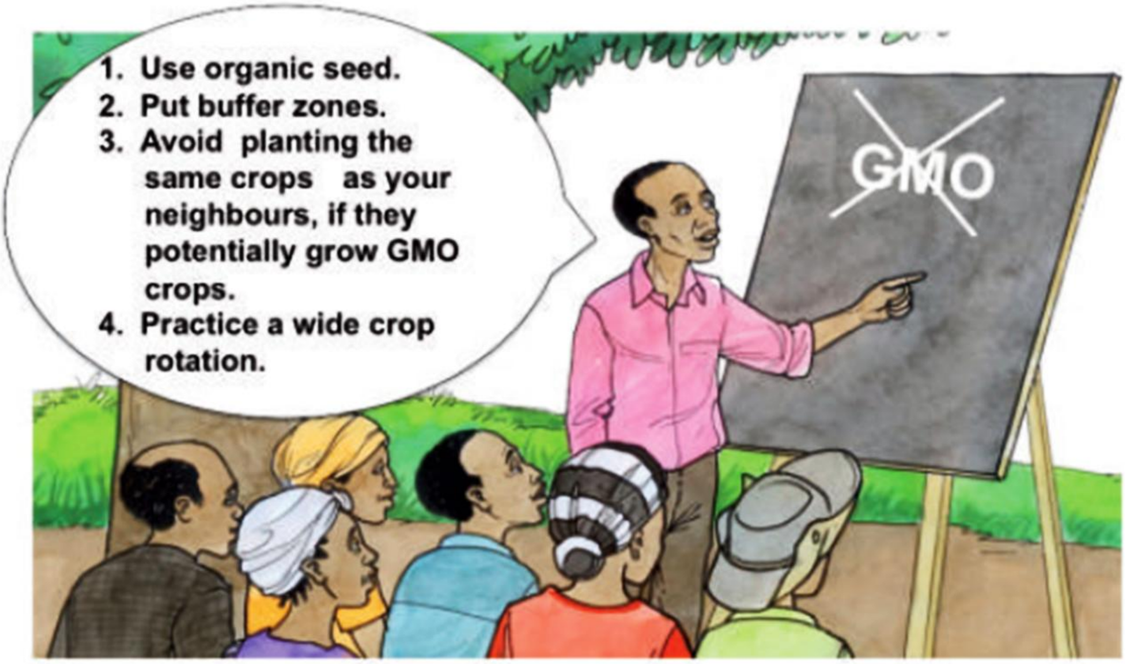

FIGURE 11-1 - HOW TO REDUCE THE RISK OF GMO CONTAMINATION

In order to improve the quality of organically propagated seed and plant material and to make the propagation less risky, training of farmers' groups that will specialize in this issue is required. Training is needed in all aspects of propagation: maintenance breeding, avoidance of unwanted cross-pollination, seed and plant health, phytosanitary issues of vegetative propagation, cleaning and processing of seeds, short and long term storage, as well as marketing strategies. Seed production should be combined with on-farm variety testing in order to provide as much information for farmers as possible.

A. PLANT PROPAGATION

First, the kind of propagation needs to be determined: either those based on generative propagation or sexual reproduction (seeds) such as lettuce, curly endive, pepper, eggplants, tomato, beans, etc.; or those vegetative propagated (asexual reproduction) through another part of the plant: potato tubers, sweet potato roots, bulbs in onion and garlic, cuttings in artichoke, stolons in strawberry, "spiders" or roots in asparagus, etc.

Despite the method of propagation to be used, all the seeds and plant material used should be free of pathogens and weeds, and obtained from safe sources. Certified seeds are normally clean, but if such seeds are not available to the farmers, the seeds should be treated before use to eliminate seed-borne diseases (with a hot water treatment for example, Figure 11-2).The health of the seeds (while storage period), seedlings, cuttings or other plant material used is crucial for preventing pests and diseases, and to keep crop productivity (Figure 11-3).

Hot water treatment of own seed to prevent seed-borne diseases such as black rot, black leg, black spot and ring spot of crucifers is very effective. It reduces the seed-borne pathogens such as *Alternaria* spp., *Colletotrichum* spp., *Phoma* spp., *Septoria* spp. and bacterial pathogens (*Pseudomonas* spp. and *Xanthomonas* spp). However, hot water treatments are delicate as seeds can rapidly be destroyed by too hot temperatures.
Therefore, specified temperature and time intervals must be strictly followed in order to maintain seed viability. **Use a good thermometer** or **ask for assistance** from an experienced person or from your local extension officer. To make sure that the seed is not damaged it is advisable to test the germination of 100 heat-treated and 100 untreated seeds. Hot water treatment can also be used for potato tubers (10 minutes in water at 55° C) to control blackleg infection, powdery scab and black scurf, and banana suckers to control nematodes and banana weevils.

Hot water treatment recommendations:

- **Potato tuber, banana suckers: 55°C for 10 minutes**
- **Spinach, Brussels sprouts, cabbage, pepper, tomato, eggplant: 50°C for 30 minutes**
- **Broccoli, cauliflower, carrot, collard, kale, kohlrabi, turnip:50°C for 20 minutes**
- **Mustard, cress, radish:50°C for 15 minutes**
- **Lettuce, celery, celeriac: 47°C for 30 minutes**

FIGURE 11-2 - HOT WATER TREATMENTS FOR SEEDS

FIGURE 11-3 - PREVENTIVE MEASURES AGAINST STORAGE PESTS AND DISEASES

In the following sections, the considerations for seed evaluation, characterization and multiplication will be discussed in details.

B. CRITERIA FOR SEED EVALUATION, CHARACTERIZATION AND MULTIPLICATION

Farmers select seeds with specific characteristics to meet their particular needs: yield; quality like colour, texture, flavour; adaptation to climate oscillations; resistance to pests and diseases; fodder value; soil enrichment by nitrogen fixation or extensive root system; among others (Shiva *et al.* 2004).

Good quality seed is the sum of its genetic, physiological, physical and health traits. Concerning **genetic quality**, the material should be of known origin, already tested in the region, and produced in an isolated environment (separated from other varieties to prevent intercrossing). The seeds can be bred by a plant breeder of by a farmer. When a farmer wants to select his own genetic material, he has to bear many details in mind:

- Choose the best plants on the farm: vigorous growth, high yielding plants, good quality fruits (shape, colour and flavour (when applicable)), best fruit covering, good health, etc.
- The selected plants should be looked after with the utmost care.
- Every plant not corresponding to the chosen type should be eliminated, and isolation distance strictly respected.
- Neighbouring plants having pest or diseases must be eliminated.
- Fruits must be picked at optimum maturity.
- Once picked, the seeds should be taken out at once.
- For storage, the procedure will depend on the plant family:
  →In case of fresh tomato cultivars for example, the juice, seeds and placenta should be put in a glass jar for fermentation for 24 to 48 hours fermentation, depending on ambient temperature, to prevent bacterial *cancrosis* problems transmitted by seeds. If the seeds get pressed together, the lumps should be taken apart by hand. The seeds is then stored in brown paper bags, with diatomaceous earth or wood ashes. In the latter case, the ratio is 50% seeds and 50% ash.
  →When storage of grain such rice is needed, the best strategy is to sundry the seeds before storage; sun dry should be carried-out at low air moisture. Before storage the grains should be soaked in neem oil, as this helps keep away storage pests.

Physical quality comes from **physical botanical purity**. In this context, the farmers must keep in mind that:

- Only pure seed of the selected species should be kept, free from foreign seeds. Great care must be taken while picking lettuce, onion, carrots, broccoli, cabbage, cauliflower, to keep out weeds with seeds, because separation later is very difficult.
- It should include the smallest possible amount of inert material (remains of flowers, fruits, etc.)
- It should have good weight and size, without mechanical damage (e.g. wild radish seeds are very sensitive, their seed cuticle being very brittle during the seed cleaning process).

Health quality should be achieved by working-up a healthy, organic soil, rich in organic matter, nutrients and microorganisms, so that plants grow healthy and without nutrient or physiological imbalances that make them susceptible to pests and diseases. Strict control of unhealthy plants should be established, so as not foster foci of infection and sources of inoculation brought from plant by insect vectors.

C. IMPORTANCE OF TRADITIONAL VARIETIES (SHIVA *ET AL.* 2004)

- Traditional seeds are locally available because farmers collect good seeds from their own plots and keep them for the next season.
- Farmers either buy or exchange their seed with other farmers or grow their own seeds. Therefore the cost of seeds is minimal.
- Native seeds are geared to a subsistence economy as the farmers first grow food for his subsistence and/or stock seed for the next season and market only the surplus.
- Native seeds embody indigenous knowledge. A farmer who uses native seeds use his/her traditional knowledge, skills and wisdom to grow them, promoting self-reliance.
- An outstanding feature of native seeds is diversity.
- Native seeds are hardy, as they have, over the years, developed resistance to the pests and diseases.
- Traditional seeds have high level of tolerance to conditions of stress and are adapted to local agro-climatic conditions.

D. SEED CONSERVATION

Farming communities have always implemented conservation methods known to the formal sector as *ex-situ* (off-field) and *in-situ* (in-field) conservation strategies. *In-situ* conservation provides farmers a valuable option for conserving crop biodiversity and helps to sustain evolutionary systems that are responsible for the generation of genetic variability. This is especially significant in many parts of the world subject to drought and other stresses, because it is under such environmental extremes that variations useful for stress-resistance breeding are generated. In the case of diseases or pests, this allows for continuing host-parasite co-evolution.

Also under these conditions, access to a wide diversity of local seeds probably provides the only reliable source of planting material. The ability of such material to survive under to survive under these stresses is conditioned by their inherent broad genetic base.

The seed system used in most traditional farming systems is based on the **local production of seeds by the farmers** themselves. Farmers consistently retain seed as security measure to provide back-up in case of crop failure.

Farmers practice seed selection, production and saving for informal distribution of planting material within and among the farming communities. **Community seed bank** represents one strategy for a collective maintenance of genetic diversity in crops/plant species. Low-cost community level seed bank or seed storage facilities can help to preserve climate mitigating characteristics of traditional varieties, while, at the same time, serving as a base material for farmers to select special lines to meet their changing needs. They also play a role in improving market outlets through enabling communities to produce crop of known quality and in stabilizing prices over changing situations. Thus, community seed bank development contributes toward promoting economic empowerment of farmers.

Likewise, the establishment of species adapted to extreme environments in **field gene banks** at strategic sites can provide a reserve for places where traditional crops may have completely failed. Germ-plasm materials maintained in such fields could be distributed to rural farming communities or for further investigation of their potential use in breeding programs to improve food security.

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Plant Propagation in Organic Agriculture: http://teca.fao.org/read/8377

12. ANIMAL HUSBANDRY IN ORGANIC AGRICULTURE

SUMMARY

Integrating animal husbandry into crop producing farms is one of the principles of organic farming. In temperate and arid zones, animal husbandry plays an important role in the recycling of nutrients, while it is less emphasised in the humid tropics. The caring, training, and nurturing of animals is considered an art in many farming communities.

Integrating animals into a farm help creating a closed or semi-closed system where energy and nutrients are recycled (Figure 12-1). Animals can convert non-edible biomass (e.g. grass, straw, kitchen waste) into food, while increasing soil fertility with their manure.

FIGURE 12-1 - ANIMALS INTEGRATED INTO THE FARM, SHOWING THE FLOW OF FODDER, DUNG AND PRODUCTS

Many farm animals have a multi-functional role, for example (Figure 12-2):

→ Produce dung which is of great importance for soil fertility.
→ Yield products such as milk or eggs for sale or own consumption continuously.
→ Recycle by-products such as straw or kitchen waste.
→ Serve as draught animals for tillage or transport.
→ Produce meat, hides, feathers, horns etc.
→ Serve as an investment or a bank.
→ Help in pest control (e.g. dugs) and weed management (e.g. grazing on barren fields).
→ Have cultural or religious significance (prestige, ceremonies etc.).
→ Produce young stock for breeding or sale.

FIGURE 12-2 - REASONS TO KEEP FARM ANIMALS - A COW IS NOT JUST A COW! FARM ANIMALS CAN HAVE MANY FUNCTIONS FOR A FARMER

The significance of each role will vary from animal to animal and from farm to farm. It will also depend on the individual objectives of the farmer.

A. MAKING A DECISION ON ANIMAL HUSBANDRY

There are several reasons for taking up animal husbandry as a part of your farming activities or even as the main one. There are also a number of critical aspects to be taken into consideration. In order to make a decision on whether and how to get involved in animal husbandry, you should ask yourself a number of questions:

IS MY FARM SUITABLE?

Do I have sufficient space for shedding and grazing, sufficient fodder or by-products to feed, sufficient know-how on keeping, feeding, and treating the specific kind of animals?

WILL THE ANIMALS BENEFIT MY FARM?

Can I use the dung in a suitable way? Will I get products for my own consumption or sales? Will the animals somehow affect my crops?

CAN I GET THE NECESSARY INPUTS?

Is sufficient labour available within or outside my farm? Is enough fodder and water of good quality available throughout the year? Will remedies and veterinary support be available, if needed? Can I get suitable breeds of animals?

WILL I FIND A MARKET FOR THE PRODUCTS?

Does anyone want to buy my milk, eggs, meat etc.? Is the price worth the effort? Am I able to compete with other farmers?

WHAT DO ANIMALS NEED?

Organic farmers try to achieve healthy farm animals which can produce satisfyingly over a long period of time (Figure 12-3). To achieve this goal, various needs of farm animals have to be considered:

- → Fodder in adequate quality and quantity; for non-ruminants: diversity in fodder is usually required.
- → Sufficient access to clean drinking water.
- → Clean sheds of sufficient size and with adequate light and fresh air.
- → Sufficient freedom to move around and perform their natural behaviour.
- → Healthy conditions and veterinary follow-up, when needed.
- → Sufficient contact with other animals, but no stress due to overcrowding.
- → For herd animals: an appropriate age and sex distribution within the herd.

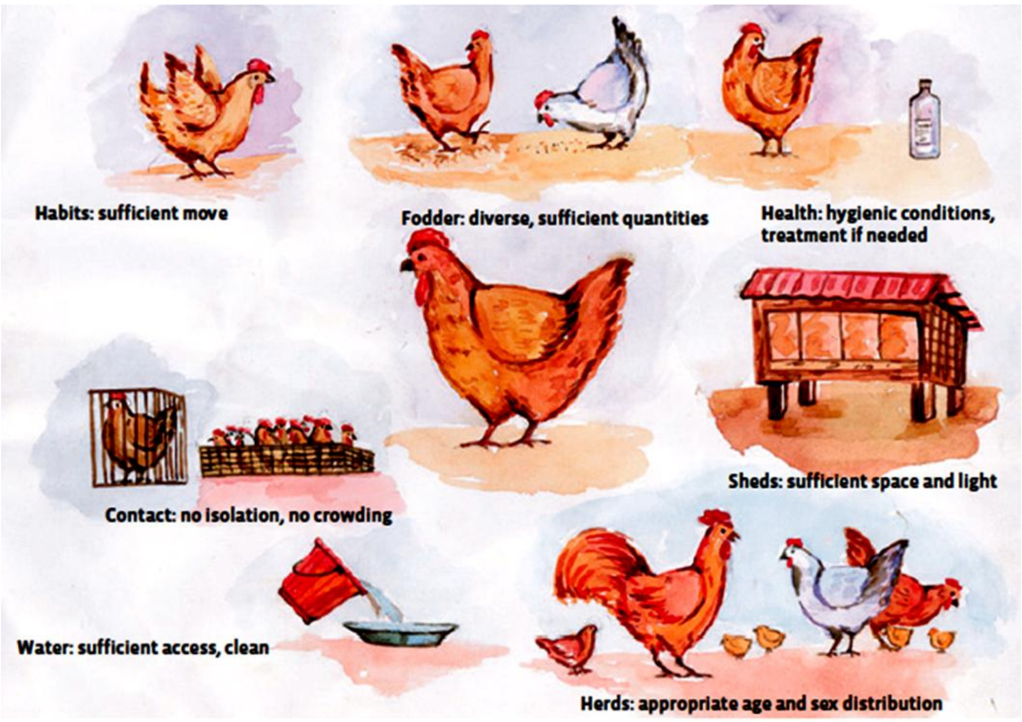


FIGURE 12-3 - WHAT FARM ANIMALS NEED - FOR EXAMPLE CHICKENS HAVE VARIOUS NEEDS WHICH SHOULD BE FULFILLED SIMULTANEOUSLY

Organic animal husbandry means not only feeding organic food and avoiding synthetic food additives and synthetic medicines (e.g. antibiotics, grow hormones), but also focusing on satisfying the various needs of the farm animals. Good health and welfare of the animals are among the main objectives. Suffering due to mutilations, permanent tethering or isolation of herd animals must be avoided as much as possible. For various reasons, landless animal husbandry (i.e. fodder purchased from outside the farm, no grazing land) is not permitted in organic farming.

HOW MANY ANIMALS TO KEEP?

In order to identify the appropriate number for a specific kind of animal on a farm, the following points should be considered:

- → Availability of fodder on the farm, especially in periods of scarcity (e.g. dry season).
- → Carrying capacity of pastures.
- → Size of existing or planned sheds.
- → Maximum amount of manure the fields can bear.
- → Availability of labour for looking after the animals.

In tropical countries, farm animals are frequently found to be underfed. When defining the number of farm animals, keep in mind that the economic benefit will be higher when fewer animals are kept, but fed well. Not only the amount, but also the quality of the available food must be taken into consideration.

B. Animal housing

The type of shed should be specific to the type of animals to be sheltered. Poultry, for instance, should be housed in sheds that do not get too hot. Contact of the animals with their faeces should be avoided as much as possible.

Planning sheds

With the exception of nomadic lifestyles, most farm animals are temporarily kept in sheds. The combination of animal husbandry and farm activities requires control of their movements so as to avoid damage to crops. For the welfare and health of the animals, sheds must be cool and aerated, and protect from rain (Figure 12-4).

They should be constructed in a way ensuring:

- → Sufficient space to lie down, stand up, move and express natural behaviour (e.g. licking, scratching etc.).
- → Sufficient light (as a rule, one should be able to read a newspaper in the shed).
- → Protection from sunlight, rain, and extreme temperatures.
- → Sufficient aeration, but no draught.
- → Appropriate beddings (see section below).
- → Elements to exercise natural behaviour (e.g. for poultry: perching rails, sand baths and secluded laying nests).
- → Sheltered pits or heaps to collect and store manure.

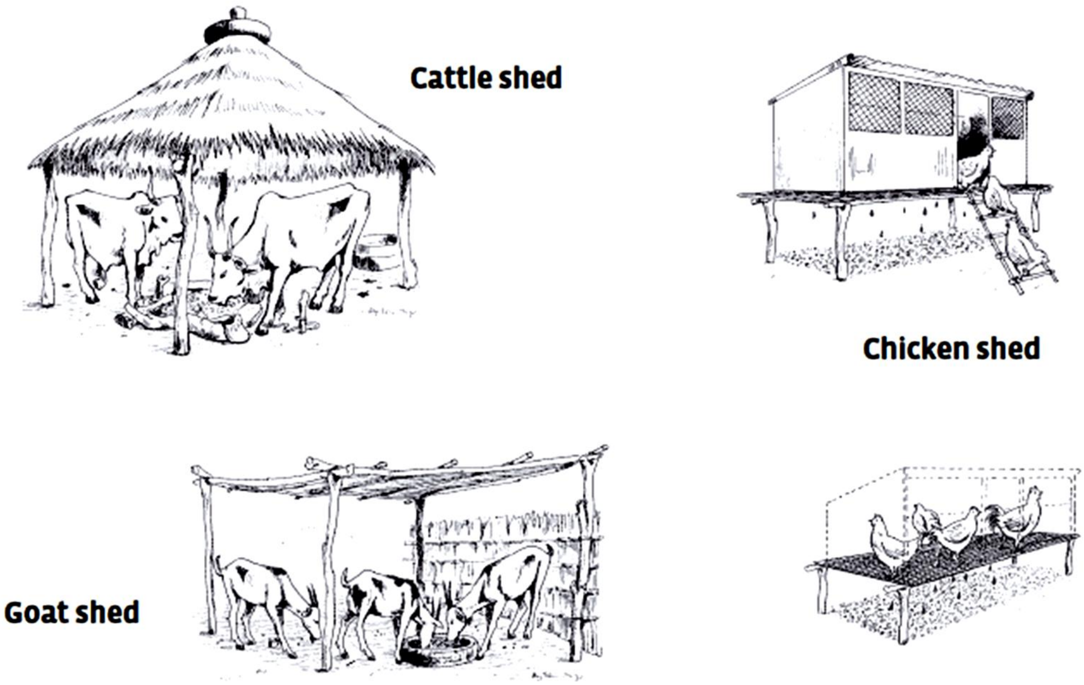


Figure 12-4 - Traditional simple sheds in Senegal (cattle shed, goat shed, chicken shed)

For economic reasons, sheds can be built with simple, locally available materials. Many countries have a rich tradition of shed constructions, and have developed the most efficient and appropriate shed systems for the conditions of the region. If techniques of this heritage are combined with the above principles, a locally adapted and at the same time animal friendly system may be obtained.

BEDDINGS

Beddings are materials used in sheds for keeping the floor soft, dry, and clean, which is important for animal health. They absorb the excrements of the animals and need to be re-placed from time to time. Beddings can be of straw, leaves, twigs, husks or other locally available material. They can be replaced daily or kept for several months while adding fresh material on top.

C. ANIMAL FEEDING

The availability of fodder is one of the limiting factors in animal husbandry. Unlike landless systems in conventional farming, organic husbandry should be mainly based on the fodder produced on the farm itself. As is the case with humans, there is a direct link between the quantity and composition of the food and the health status of the animals.

FOOD REQUIREMENTS OF ANIMALS

If farm animals are to be productive (milk, eggs, meat etc.), it is important that they get suitable food in sufficient quantities. If the fodder production of one's farm is limited (which usually is the case), it might be economically valid to keep less animals but supply them with sufficient food (Figure 12-5).

The appropriate quantity and the mix of feed items will of course depend on the type of animal, but also on its main use (e.g. chicken for meat or egg production, cattle for milk, meat or draft etc.). In milk production for example, cows producing milk should be given fresh grass and possibly other feed items of sufficient protein content. On the same diet, draught animals would rapidly become exhausted.

A balanced diet will keep an animal healthy and productive. Whether or not a farm animal receives the appropriate amount and kind of fodder usually can be seen by the shine of its hair or feathers. For ruminants, a majority of the fodder should consist of roughage (grass, leaves). If concentrates or supplements are used (e.g. agricultural by-products and wastes), they should not contain growth promoters and other synthetic substances. Instead of buying expensive concentrates, there are a variety of leguminous plants rich in protein which can be grown in the farm as cover crop, hedges or trees. If mineral content in the available fodder is not sufficient to satisfy the animal's requirements, mineral salt bricks or similar feed supplements can be used as long as they do not contain synthetic additives.

A variety of fodder grasses, both for shed feeding and pasturing

Leaves and twigs of leguminous trees are rich in protein and available also in the dry season

FIGURE 12-5 - VARIETIES OF FODDER GRASSES AND LEGUMINOUS TREE PLANTS USED AS FODDER FOR CATTLE AND GOATS

GRAZING VERSUS SHED FEEDING

In many regions of the tropics, favourable periods with abundant fodder alternate with less favourable periods when there is almost nothing to feed to the animals. However, keeping animals means providing fodder throughout the year. Fodder can be produced on the farm as grazing land or as grass or tree crops used for cutting.

While grazing requires less labour than shed feeding, more land is needed and appropriate measures to keep the animals away from other crops must be undertaken. Grazing may lead to a lower productivity (milk, meat) but usually is the more favourable option concerning health and welfare of the animals (Figure 12-6).

Shed keeping, however, has the advantage that the dung can be easily collected, stored, or composted and applied to the crops. Whether grazing or shed feeding is the more suitable option will mainly depend on the agro-climatic conditions, the cropping system, and the availability of land. A combination of shed feeding and grazing in a fenced area may be an ideal combination of high productivity and animal friendly husbandry. In extensive grass lands of semi-arid areas, however, grazing may be the only suitable option.

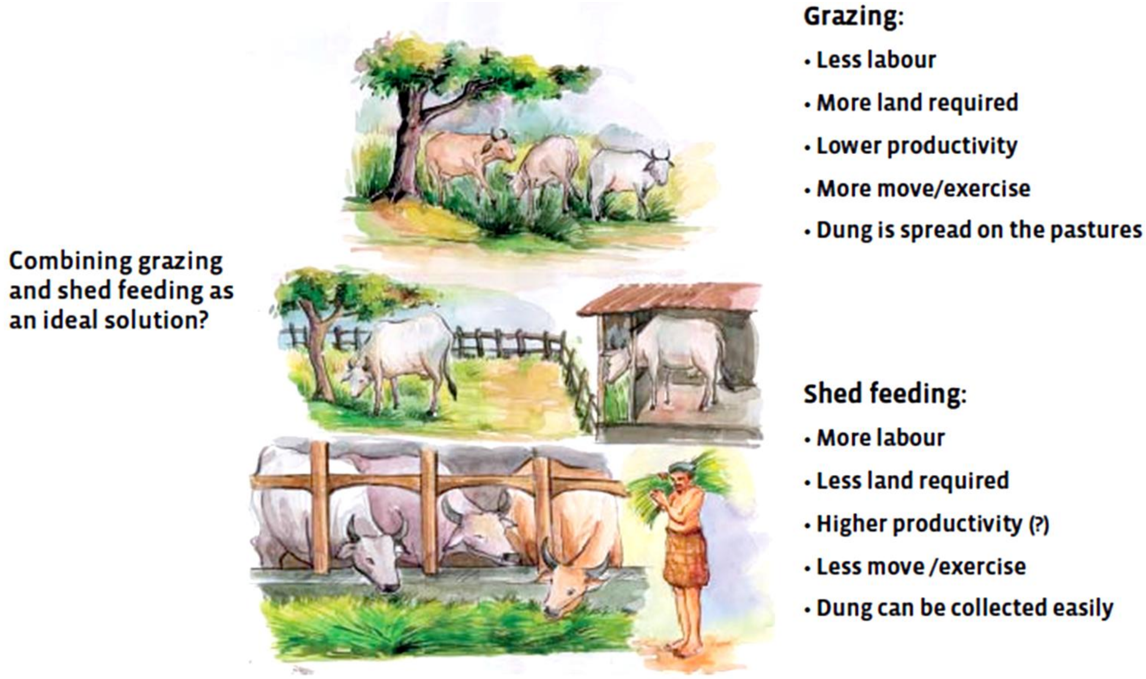


FIGURE 12-6 - THE PROS AND CONS OF GRAZING AND SHED FEEDING, AND THE COMBINATION OF BOTH SYSTEMS AS A PROMISING OPTION

INTEGRATING FODDER CULTIVATION IN THE FARM

In most smallholder farms, fodder cultivation will compete for space with the cultivation of crops. Whether fodder cultivation (and thus animal husbandry) is economically more beneficial compared with crop production must be assessed case by case. However, there are some options for integrating fodder crops in farms without sacrificing much land. Below are some examples:

→ Grass or leguminous cover crops in tree plantations
→ Hedges of suitable shrubs
→ Shade or support trees
→ Grass on bunds against soil erosion
→ Grass fallows or green manures in the crop rotation
→ Crops with by-products such as paddy straw or pea leaves

MANAGEMENT OF PASTURES

The management of pastures is crucial for a good herd management. It is also important to practice appropriate management throughout the year. There are many different types of grasses, and every climatic region has grasses which are specifically adapted to the conditions. In some cases it may be worth considering to till the grazing site and sow grass varieties that are more appropriate to the animal's needs.

Overgrazing is probably the most significant threat to grass land. Once the protective grass cover is destroyed, the top soil is prone to erosion. Degraded pastures or land with little plant cover is difficult to re-cultivate. Therefore, it is important that the use and intensity of grazing on a particular piece of land is appropriate to its production capacity. Sufficient time must be given to a pasture to recover after intensive grazing.

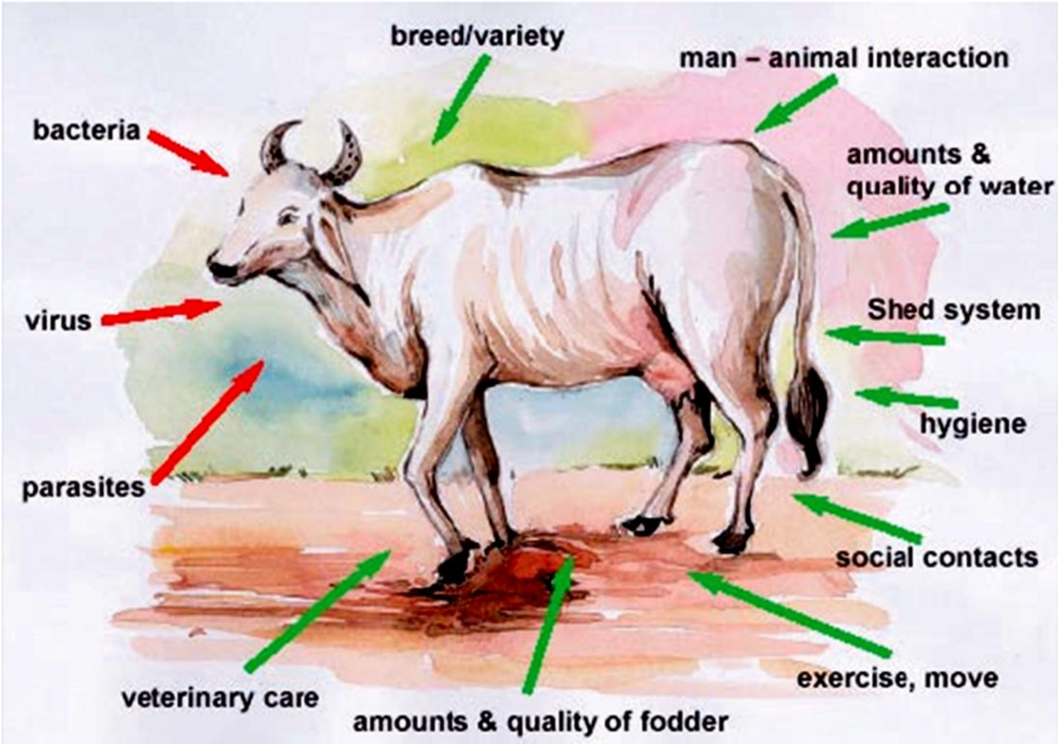
Fencing off of areas and rotation of the grazing animals on several pieces of land is the best option for managing the farm and the overall landscape. Creating "grazing cells" restores overgrazed pastures, reduce the incidence of intestinal parasites encountered while the animals graze, and increase land productivity. The intensity and timing of grazing, as well as the cutting of the grass, will influence the varieties of plants growing in the pasture (Figure 12-7).

FIGURE 12-7 - CATTLE GRAZING ON A PASTURE IN CUBA

D. ANIMAL HEALTH

Disease causing germs and parasites are present almost everywhere. Like humans, animals have an immune system which is usually able to cope with these germs. And as with humans, the efficiency of the immune system will be disturbed if animals are not properly fed, cannot practise their natural behaviour, or are under social stress.

Health is a balance between disease pressure (the presence of germs and parasites) and the resistance (immune system and self-healing forces) of the animal. The farmer can influence both sides of this balance: reduce the quantity of germs by maintaining good hygiene, and strengthen the animal's ability to cope with germs (Figure 12-8).



Bacteria, viruses and parasites attacking the farm animal which fights back with its immune system. The farmer can influence both sides of this balance.

FIGURE 12-8 - BACTERIA, VIRUSES AND PARASITES ATTACKING THE FARM ANIMAL WHICH FIGHTS BACK WITH ITS IMMUNE SYSTEM. THE FARMER CAN INFLUENCE BOTH SIDES OF THIS BALANCE

Organic animal husbandry puts its focus on improving the living conditions of animals and on strengthening their immune systems. Of course: if an animal gets sick it must be treated. But the farmer should also think about why the immune system of the animal was not able to fight the disease or the parasite attack. And the farmer should think of ways to improve the animals living conditions and hygiene in order to strengthen it.

PREVENTION BEFORE CURING

Similar as in crop health, organic animal husbandry puts the main emphasis on preventive measures in order to keep animals healthy, rather than on curative methods. This starts from keeping robust breeds rather than high performing but very susceptible ones. Next, the conditions in which the animals are kept should be optimal ones: sufficient space, light and air, dry and clean bedding, frequent exercise (e.g. grazing) and proper hygiene.

The quality and quantity of fodder is of crucial importance for the health of the animal. Instead of feeding commercial concentrates which make animals grow faster and produce more, a natural diet appropriate to the requirements of the animal should be achieved. Where all these preventive measures are taken, animals will rarely fall sick. Veterinary treatment thus should play only a secondary role in organic farming. If treatment is necessary, alternative medicine based on herbal and traditional remedies should be used. Only if these treatments fail or are not sufficient, synthetic medicines (e.g. antibiotics, parasiticides, anaesthetics) may be used; in these cases, the treated animals must be separated from non-treated organic stock and excluded for a period of time (e.g. at least 3 weeks) from organic certification..

The main principal for veterinary treatment in organic animal husbandry is: get to know the causes of (or factors that favour) diseases in order to enhance the natural defence mechanisms of the animal (and to prevent its manifestations in the future).

Unlike in crop production, synthetic means are allowed to cure sick animals if alternative treatment is not sufficient. Here, reducing the suffering of the animal is given priority over the renunciation of chemicals. However, the standards of organic agriculture clearly demand that priority is given to management practices which encourage the resistance of the animals thus preventing the outbreak of a disease. Therefore, an outbreak of a disease shall be considered as an indicator that the conditions under which the animal is kept are not ideal. The farmer should try to identify the cause (or causes) of the disease and prevent future outbreaks by changing management practices (Figure 12-9).

If conventional veterinary medication is applied, withholding periods must be adhered to before the animal products can be sold as “organic”. This shall ensure that organic animal products are free from residues of antibiotics etc. Synthetic growth promoters are not allowed in any case.

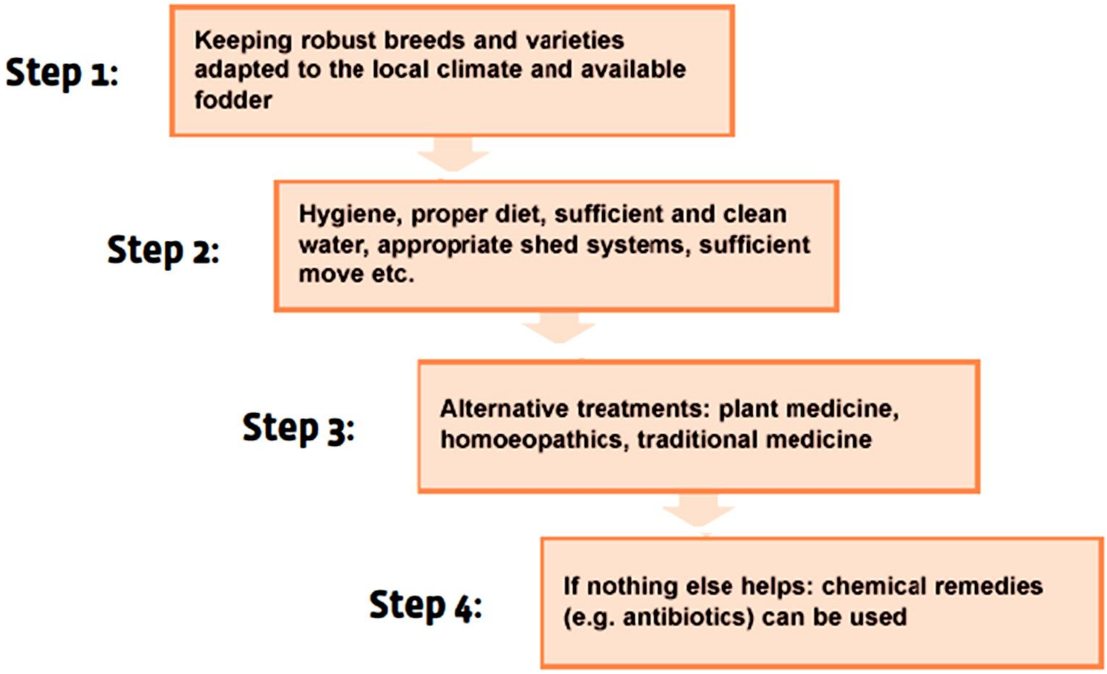


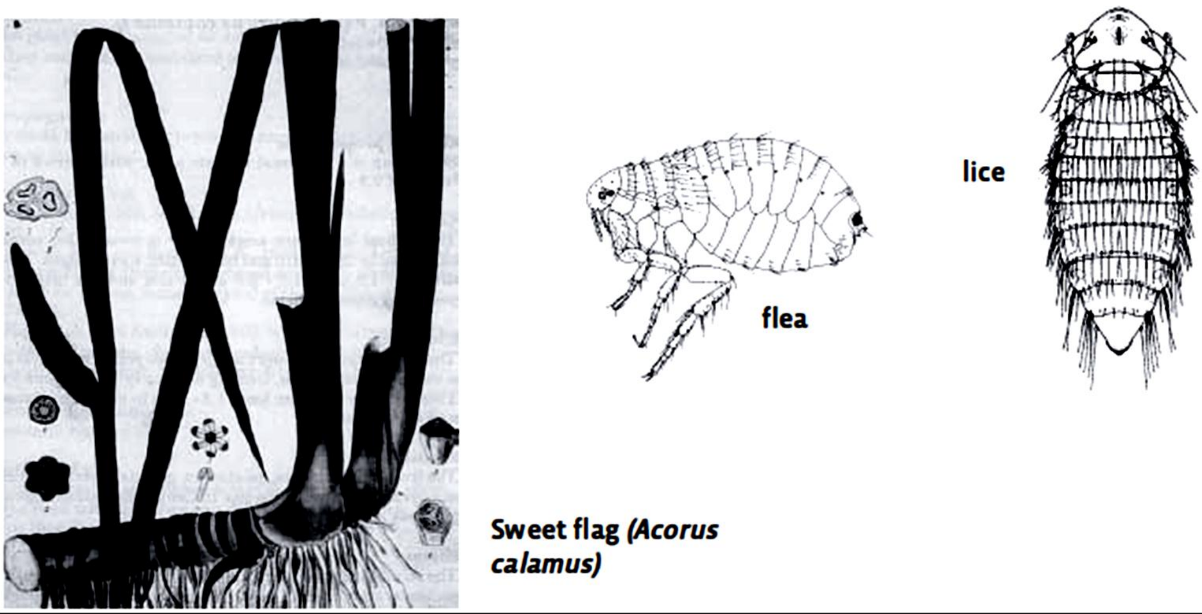
FIGURE 12-9 - PREVENTION BEFORE CURING -
ONLY WHEN ALL PREVENTIVE MEASURES FAIL ANIMALS SHOULD BE TREATED, PREFERABLY WITH ALTERNATIVE REMEDIES

CONTROLLING PARASITES WITH HERBAL REMEDIES

Herbal medicines are widely used in many countries. Some traditional farming communities have a vast knowledge of local plants and their healing properties. Plants can definitely support the healing process, even if they do not eliminate the germ of the disease directly. Still, farmers should not forget to identify the cause of the disease and also to re-think their management practises. For parasite problems, changing the living conditions or the management of pastures will be more effective in the long run than any treatment.

Example: Using Sweet Flag against parasites (Figure 12-10)

One example to use an herbal remedy against parasites is sweet flag (*Acorus calamus*). This plant grows both in tropical as well as subtropical regions and is found on the banks of rivers and lakes and in swampy ditches or marshes. The powdered dried rhizomes (thick root parts) act as an effective insecticide against fowl lice, fleas and house flies.



Sweet flag (Acorus calamus) can be used to treat fowls against lice, but also to reduce house fly populations. (Source: „Ectoparasites in the Tropics", Matzigkeit, 1990)

FIGURE 12-10 - USING SWEET FLAG AGAINST PARASITES

Treating fowls infested by lice: Use around 15 g of powdered rhizome for an adult bird. For dusting the bird with the powder, hold it by its feet upside down so that the feathers open and the dust will work its way to the skin. The treatment is reported as being safe to the birds. The sweet flag powder is also reported to be effective against house flies when dusted on fresh cow dung infested by fly maggots. It further shall protect new-born calves of vermin infection if washed with a water infusion.

Attention! Herbal remedies against parasites can also have a toxic effect on the farm animals! Therefore it is important to know the appropriate dose and application method!

PRINCIPLES AND METHODS

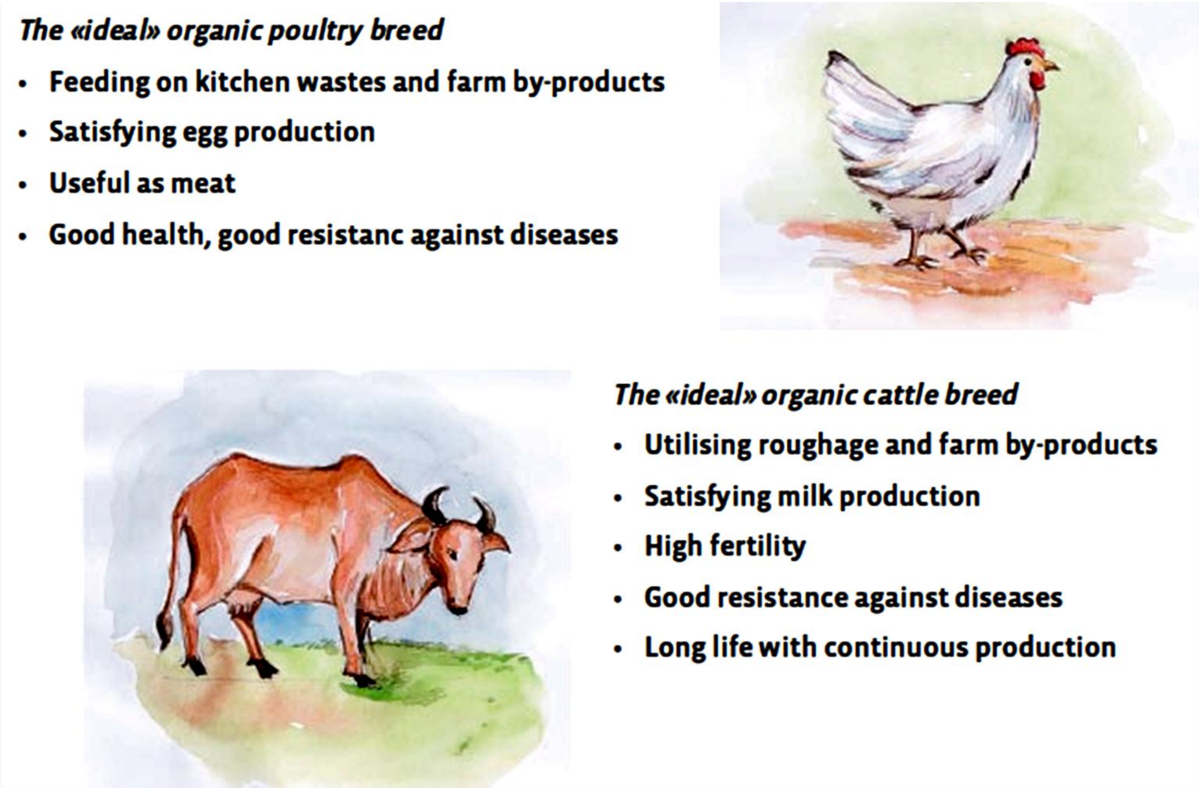
As preventive measures for maintaining good animal health are of high relevance in organic farming, the selection of breeds suitable to local conditions and to organic feeding is of crucial importance. This requires that suitable breeds are available. Traditional breeds of farm animals may be a good starting point for organic animal breeding. Animals can be improved by selection of individuals especially suitable for organic conditions. They can be crossbred with suitable new breeds, thus achieving an animal with the positive aspects of traditional breeds and the satisfying production of the new breeds.

For breeding, organic farming uses natural reproduction techniques. While artificial insemination is allowed, embryo transfer, genetic manipulation, and hormonal synchronisation are not permitted according to IFOAM standards.

E. BREEDING GOALS

Over the last decades, traditional breeds have been replaced by high performing ones in many regions. Similar to high yielding plant varieties, these new breeds usually depend on a rich diet (concentrates) and optimal living conditions. As high performing breeds in general are more susceptible to diseases than traditional varieties, they need frequent veterinary interventions. Thus, these new breeds might not be the right choice for small farmers, as the costs of food concentrates and veterinary treatment are too high compared with what can be earned by selling the products.

In addition, for organic farmers the main animal product (e.g. milk) is not the only reason to keep animals. Breeding activities therefore should try to optimise the overall performance of the animal, taking into consideration the different goals of an organic farmer. For example a poultry breed suitable for organic smallholder farms might not be the one with the highest egg production, but one in which meat production is good, and kitchen wastes and whatever is found on the farm yard can be used as feed. Suitable cattle breeds would produce sufficient milk and meat while feeding mainly on roughage and farm by-products (e.g. straw), be of high fertility and good resistance against diseases, if required, they can also be used for draught and transport.



Organic animal breeding should optimize the overall use of farm animals, with consideration given to the local conditions and available fodder: breeding goals for poultry and cattle breeding.

FIGURE 12-11 - BREEDING GOALS

MAXIMUM PERFORMANCE OR LIFE PRODUCTION?

When comparing the production of different breeds of cows, usually, only the production per day or year is taken into consideration. However, high performing breeds usually have a shorter life span than traditional ones with lower production. The life milk production of a cow giving, for example, 8 litres per day, but over 10 years, therefore would be greater than the one of a high-breed cow yielding 16 litres per day, but dies after 4 years.

As the investments to get a milk producing cow are quite high, i.e. the rearing and feeding of a calf or the purchase of an adult cow, continuous production over a long life span should be of high interest to the farmer. This should be reflected in the breeding goals, which so far mainly focus on the maximum short term production. (Figure 12-12).

Item	Breed A	Breed B
Investments: costs of a calf costs of a cow		
Maintenance: fodder purchases per year veterinary costs per year		
Milk production: litres per day litres per year productive years in life litres per life		
Other uses: meat draught dung		

FIGURE 12-12 - EXAMPLE - TABLE FOR COMPARING THE ECONOMIC PERFORMANCE OF TWO DIFFERENT BREEDS

REFERENCES

IFOAM. 2003. Training Manual for Organic Agriculture in the Tropics. Edited by Frank Eyhorn, Marlene Heeb, Gilles Weidmann, p 190-209, http://www.ifoam.bio/

SOURCES

IFOAM

ON TECA

Animal Husbandry in Organic Agriculture: http://teca.fao.org/read/8378

SOURCES

These techniques have been compiled by Ilka Gomez, from the TECA Team, with the collaboration of IFOAM, FiBL and Nadia Scialabba (Natural Resources Officer NRC - FAO).

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TECA stands for Technologies and Practices for Small Agricultural Producers and is an online interactive platform for sharing and exchanging innovative practices for small agricultural producers (http://teca.fao.org/). TECA was developed by FAO's Research and Extension Unit (DDNR) to facilitate access to practical agricultural information that can benefit small producers around the world. TECA comprises two basic features:

(a) A knowledge database of applied technologies and practices on various agricultural activities supplied by partner organizations and initiatives;

(b) Online forums – called Exchange Groups – where members can consult with a community of practitioners about a specific agricultural technology or practice, and at the same time share their experiences and challenges in the field with other members looking for support.

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IFOAM stands for **I**nternational **F**ederation of **O**rganic **A**griculture **M**ovements and has been leading, uniting and assisting the Organic Movement since 1972. As the only global organic umbrella organization, it is committed to advocating Organic Agriculture as a viable solution for many of the world's pressing problems. With around 815 affiliates in over 120 countries, it campaigns for the greater uptake of Organic Agriculture by proving its effectiveness in nourishing the world, preserving biodiversity, and fighting climate change. It also offers training courses, provides services to standard owners, certifiers, operators, and realizes organic programs.

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The Research Institute of Organic Agriculture (**FiBL**) was founded in 1973 and is situated in Frick (Switzerland) since 1997. It is one of the world's leading research and information centres for organic agriculture. The close links between different fields of research and the rapid transfer of knowledge from research to advisory work and agricultural practice are FiBL's strengths. Outside Switzerland the Institute's competence is also sought after, and FiBL is involved in numerous international projects - not only in research, consultancy and training but also in development cooperation.

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The **I**nternational **I**nstitute of **R**ural **R**econstruction (**IIRR**) is a non-profit, non-governmental organisation that aims to improve the quality of lives of the rural poor in developing countries through rural reconstruction; a sustainable, integrated, people-centered development strategy generated through practical field experiences.

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The Climate Impact, Adaptation and Environmental Sustainability team of the Climate, Energy and Tenure Division (**NRC**) develops the knowledge base on the impact of climate, climate change and climate variability on agriculture, and facilitates the use of this information and knowledge through field projects. The team also supports capacity development at national level by supporting governments to integrate disaster risk reduction in the agriculture sector as well as identifying, testing and validating in cooperation with various partners climate change adaptation and disaster risk reduction good practice options to build resilience of all actors in agriculture to the impact of climate change and extreme weather events.

The coordination of FAO's organic agriculture activities is housed in the NRC Division. Since 1999, the Organic Agriculture programme works along three main areas:

- Strengthening the ability to exchange information and to set-up organic agriculture networks, in order to ensure that producers, operators and governments have access to the reliable and quality information needed for informed decision-making, for directing research and extension, and for making investments;
- Developing and disseminating knowledge and tools that support organic plant protection, soil and nutrient management, animal husbandry and post-harvest operations, especially in developing countries and market-marginalized areas;
- Assisting governments in designing the types of legal and policy frameworks that provide support to farmers by facilitating the marketing and trade of certified organic products that meet international inspection and certification standards.

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