2017

CAOF GAP GUIDELINES FOR PARTNER ORGANIZATIONS

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ABSTRACT

These guidelines are produced by CAOF to help member organizations to guide their farmers to transition from inorganic agriculture to organic agriculture. It will provide project officers with hands-on information to help the farmers in the transition process. It is also to assist them to help the already existing organic farmers in their business.

These guidelines serve as complimentary materials to those manuals developed by CAOF on other agricultural best practices such as composting, IPM and others.

This document is a living document and is subject to yearly revisions as CAOF continue to develope, research and practice organic agriculture.

1. INTRODUCTION TO ORGANIC AGRICULTURE

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).

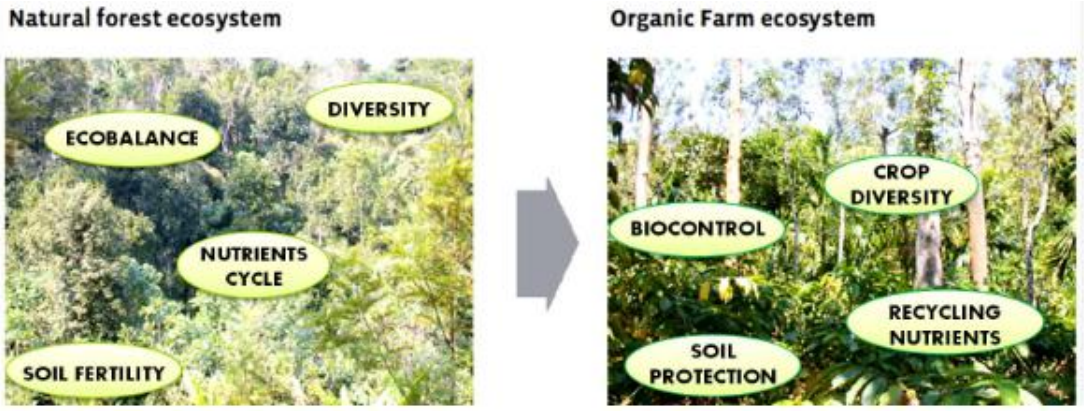


FIGURE 1-1 - USING NATURAL ECOSYSTEM AS A MODEL

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.

2. CONSIDERATIONS FOR CONVERSION TO ORGANIC AGRICULTURE

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. This will include farm characteristics, soil analysis, climate, organic matter sources, animal housing and limitations of factors of production.

B. **Farm related challenges to conversion:** Depending on the farm situation, different challenges are to be expected during conversion. Farms with high external input use, farms with low external input use, mixed farms and degraded lands all pose different challenges to conversion.
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.

3. STEP BY STEP CONVERSION TO ORGANIC AGRICULTURE

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.

A. **Step One: 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. 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 Two: Getting Familiar with organic practices:** - 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. Some of these practices include mulching, intercropping, composting, green manuring, organic pest management, appropriate seed and planting material, planting of leguminous crops, planting of farm-own animal feed, building of terraces and bounds, crop rotation and others.

C. **Step Three: Full conversion to organic Agriculture -** 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. Thus improving soil fertility, encouraging positive interactions and optimizing the balance between food production, feed production and livestock rearing.

NOTE: After becoming an organic farmer, the farmer needs to put in some mitigation measures to prevent contamination of the farm. Guard against pesticides and fertilizer spillage from neighbouring farms and avoid the use of GMOs especially seeds.

4. MULCHING IN ORGANIC AGRICULTURE

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.

Reasons for Mulching include the following:

- Protecting the soil from wind and water erosion
- Improving the infiltration of rain and irrigation water by maintaining a good soil structure
- Keeping the soil moist by reducing evaporation
- Feeding and protecting soil organisms
- Suppressing weed growth
- Preventing the soil from heating up too much
- Providing nutrients to the crops
- Increasing the content of soil organic matter

The kind of material used for mulching will greatly influence its effect. e. 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. 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.

The sources of mulch material can include; Weeds or cover crops, Crop residues, Grass, Pruning material from trees, Cuttings from hedges and Wastes from agricultural processing or from forestry

Recommendations while using mulch

- 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.

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. 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.

5. WATER MANAGEMENT IN ORGANIC AGRICULTURE

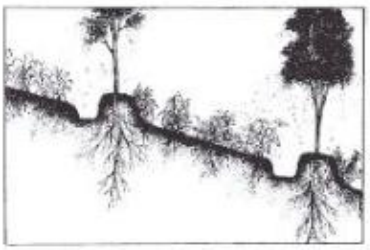
Scarcity of water for agriculture is a common phenomenon in many countries. In some regions it is almost impossible to grow crops without irrigation. Even in areas with large amounts of rainfall in the rainy season, crops may get short of water during dry periods. Organic farming aims at optimising the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

In other to keep the water in the soil, organic farmers should **keep soil moisture, reduce evaporation** and make **better use of the season's rainfall.**

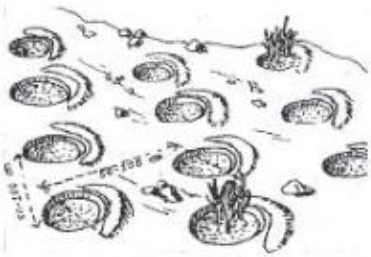
ATTENTION: A green manure or cover crop is not always a suitable way of reducing evaporation from the soil, due to the fact that they also use water.

A. Water Harvesting

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. In other to do this, rain water needs to be harvested. There are several ways of harvesting rain water, including planting pits, contour bunds and catchment trips, road catchments and half-moon micro catchments. The figure below illustrates some of these techniques.



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.

B. 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. Irrigation in Organic Farming

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. 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. The establishment of drip irrigation systems can be quite costly. However, some farmers have developed low cost drip irrigation systems from locally available materials.

6. CROP PLANNING AND MANAGEMENT IN ORGANIC AGRICULTURE

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. 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). Some of the benefits of crop rotation include;

- **It improves soil structure**
- **It increases soil fertility**
- **It helps control weeds, pests and diseases**
- **It produces different types of output**
- **In some ways, crop rotation takes the place of ploughing the soil**

Criteria for crop selection

Crop Selection: Before selecting the crops, it is necessary to answer the following questions?

What to produce? Crops produce many different things: food, fodder, firewood, fence poles, thatch and medicines.

Will it grow well? This depends on many factors: the amount of rain or moisture in the soil, the season, 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.

Does it improve the soil fertility? Legumes improve the soil fertility by fixing nitrogen from the air.

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.

Does it work with other crops? Try to find combinations of crops that complement each other well (Table 6-1)

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

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. 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.

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. 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 or 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). 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.
- **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.
- **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).
- **Mixed intercropping** - growing two or more crops together in no distinct row arrangement (for further details of possible combination, please see Table 6-1).

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.

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:

- 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

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*), and 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).

E. Designing a Cropping System

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.

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

Record Keeping

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.

7. NUTRIENT MANAGEMENT IN ORGANIC AGRICULTURE

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.

Improvement in agricultural sustainability requires, alongside effective water and crop management, the optimal use and management of soil fertility and soil physical properties. 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.

The main practices to enhance soil fertility include the use of organic fertilizers such as:

- Compost and vermicompost
- Green manures
- Animal manure
- Microbial fertilizers
- Mineral fertilizers

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 (Refer to CAOF composting Manual for More details.

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.

Animal Manures: 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.

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.

Mineral Fertilizers: 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).

8. PEST AND DISEASE MANAGEMENT IN ORGANIC AGRICULTURE

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). 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. 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.

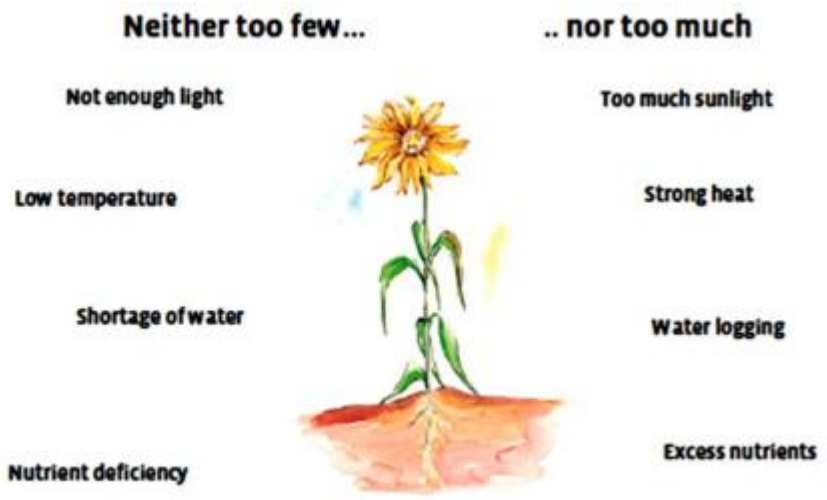


FIGURE 8-1 - FACTORS INFLUENCING PLANT HEALTH

A. Preventive Practices and Monitoring

Knowledge about plant health and pest and disease ecology helps the farmer to choose effective preventive crop protection measures. Some important preventive crop protection measures are the following ones:

- **Selection of adapted and resistant varieties**
- **Selection of clean seed and planting material**
- **Use of suitable cropping systems**
- **Use of balanced nutrient management**
- **Input of organic matter**
- **Application of suitable soil cultivation methods**
- **Use of good water management**
- **Conservation and promotion of natural enemies**
- **Selection of optimum planting time and spacing**
- **Use of proper sanitation measures**

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.

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.

- **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.

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.

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.

Please refer to the CAOF material on IPM for more information on pest management.

B. Curative Measures

If the pesticide threshold levels demand curative measures after monitoring then the following should be used.

- Promoting and management of natural enemies - The natural enemies of pests are other organisms (fungi, bacteria, viruses, insect predators, and insect parasitoids) which kill pest. There are many possibilities to enhance floral diversity within and along the boundaries of crop fields. This can be done by **Hedge**s, **Beetle banks, Flower strips** and **Companion plants.**
- Mechanical Traps - Mass-trapping of pests is an additional control measure. They often can easily be built with cheap material. Some examples include **Light traps, Colour and water traps,** Water **traps, Yellow sticky traps** and **Fruit bagging.**
- **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. This is done by releasing natural enemies of pest. Examples include **Bacteria** such as *Bacillus thuringiensis* (Bt), **Viruses** such as NPV (nuclearpolyhedrosis virus), **Fungi that kill insects**, such as *Beauveria bassiana,* **Fungi that work against plant-pathogens** and **Entomopathogenic nematodes** against different weevil species.
- **Natural Methods** - 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. Some of these include **NEEM, PYRETHRUM, CHILLIPEPPER** and **GARLIC.**
- **Other methods - Soft soap solutions, Light mineral oil, Sulphur, Plant ashes, Bordeaux mixture (Copper sulphate and lime), Acidic clays, Milk** and **Baking soda.**

9. WEED MANAGEMENT IN ORGANIC AGRICULTURE

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.

A. Preventive Measures

Several preventive measures may be applied at the same time.). 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.
- **Mulching:** the weeds find it difficult to receive enough light to grow and may not be able to pass through the mulch layer.
- **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.
- **Crop rotation:** Rotation of crops is the most efficient measure to regulate seed and root weeds.
- **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.
- **Sowing time and density**: Optimum growing conditions enhance the optimum crop plant development and their ability to compete against weeds.
- **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.
- **Pasturing:** in perennial crops like coffee, mangoes, avocadoes or cocoa, the use of sheep and goats to reduce rampant weed growth is becoming common.

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 of weeds

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.

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.

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.

10. SOIL CULTIVATION AND TILLAGE IN ORGANIC AGRICULTURE

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 conditions growing conditions for plants

There are many reasons for cultivating the soil. The most important ones are to:

- 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

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. 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.

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.

C. Soil Compactation

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. 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

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.

11. PLANT PROPAGATION IN ORGANIC AGRICULTURE

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 numbers 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, **which are not allowed in organic farming**. However, the seeds of conventionally bred varieties should be propagated under certified organic systems.

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 crosspollination, 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).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.

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

- 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.

12. ANIMAL HUSBANDRY IN ORGANIC AGRICULTURE

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. Animals can convert non-edible biomass (e.g. grass, straw, kitchen waste) into food, while increasing soil fertility with their manure.

Many farm animals have a multi-functional role:

- 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.

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?
- Will the animals benefit my farm?
- Can I get the necessary inputs?
- Will I find market for the products?
- What do animals need?
- How many animals to keep?

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.

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.

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.

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.

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.