

# Sustainable Soil Management

Proper soil management can contribute to both water and land conservation. Soil management on agricultural land includes soil fertility management and soil cultivation practices. More direct soil and water conservation practices are discussed in the concept notes water systems and rangeland management.

## Soil fertility management

**Soil fertility** is defined as the soil's ability to provide all essential nutrients in adequate quantities and in the proper balance for plant growth – independently of the direct application of nutrients through fertilisers. This ability doesn't only depend on the content of nutrients in the soil, but also on the soil's efficiency at converting nutrients as part of the soil's nutrient cycle (FiBL, 2011). Sustainable agriculture promotes healthy soils by continuous "feeding" of the soil. This means applying organic material such as plant residues and animal manures, which decompose to form soil organic matter. A high soil organic matter content is to be encouraged because it has many advantages for agricultural production, such as those presented in Box 1. In turn, soil organic matter is mineralised to inorganic nutrients by the soil's food web before nutrients are taken up by the plants, thus re-entering the soils nutrient cycle (see Figure 1). Soil organic matter usually represents only a small proportion of the whole (5%) and is mainly present in the top layer. The quality of the soil organic matter has a fundamental impact on plant growth. **Humus** is well-decomposed soil organic matter, and a highly stable organic material (FiBL, 2011).

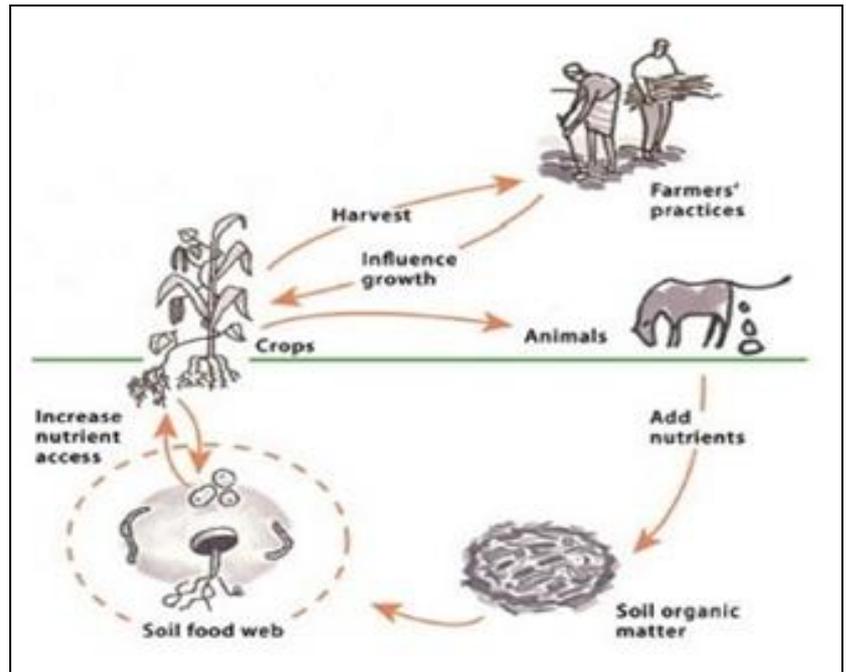


Figure 1: Soils nutrient cycle; plant material and animal manure are decomposed to soil organic matter (ILEIA, 2010)

### Box 1: Soil organic matter

- can **hold water** up to five times of its own weight;
- has a great capacity to **retain nutrients** and release them continuously to plants;
- gives the soil a **good structure**;
- provides food for soil organisms;
- prevents soils from becoming too acidic.

Source: FiBL, 2011

Soil pH is high in Afghanistan, whereas soil organic matter content tends to be low (between 0.2 and 2.5%), as is water-holding capacity. This demonstrates the importance of improving soil organic matter content, which will also increase the soil's water-retention capacity (USDA & UC Davis, 2013). Building soil organic matter content is a long-term process, and in general its results only become visible after a few years.

## Sustainable practices

There are many ways to improve soil organic matter. The main idea is to add organic material to the soil, or in other words to feed the soil with plant residues and animal manure. The amount and quality of organic materials applied influences the content of the soil organic matter. A regular supply creates the best conditions for maintaining a good level of soil organic matter. The following measures, better known as **organic fertilisers**, contribute substantially to improving soil organic matter (composed from FiBL, 2011, ILEIA, 2010 and ICIMOD, 2008):

## Green manure

Green manure or cover crops are crops grown primarily to add soil organic matter (and nutrients) to the soil. Green manure predominately refers to the cultivation of **legumes** (see Box 2). Legumes fix atmospheric nitrogen through bacterial nodules on their roots, thus fertilise the soil. There are different ways of incorporating green manures into a farm:

- Winter cover: green manures are planted in late summer/fall to provide soil cover during the winter;
- Crop rotation: green manures are grown as part of a crop rotation, particularly before crops that need a lot of nutrients;
- Intercropping or relay cropping: green manures are planted between crop rows;
- Tree legumes: green manure trees are grown for long-term soil improvement;
- Mulching: green manures are grown as a living mulch to suppress weeds or used for mulching (see next page).

### Box 2: Examples of legumes to cultivate in Afghanistan

**Food:** Chickpea, common bean, cowpea, faba bean, groundnut, lentil, pigeonpea, soybean, etc.

**Fodder:** Alfalfa (Lucerne), clover, grass pea, sunn hemp, vetches, sainfoin, etc.

**Trees:** Black locust, Russian olive

**Table 1: Benefits and limitations of green manure**

| Benefits  | Limitations   |
|---|---|
| <ul style="list-style-type: none"> <li>• Increases soil organic matter</li> <li>• Enhances soil nutrients</li> <li>• Nitrogen fixation by legumes</li> <li>• Weed suppression</li> <li>• Covers the soil and reduces erosion</li> <li>• Very low cost</li> <li>• No transportation costs</li> <li>• Reduction in the use of chemical fertilisers</li> </ul> | <ul style="list-style-type: none"> <li>• Land use</li> <li>• Slow results</li> <li>• Dry-season problems</li> <li>• Right timing</li> <li>• Additional workload</li> <li>• Water requirements of green manure crops</li> <li>• Availability of appropriate ploughing tools</li> </ul> |

Green manure crops are not grown only for soil improvement, but can often be used for an additional purpose: as food, fodder, biomass, or to be directly incorporated into the soil as green manure. For optimal use of the fixed nitrogen, legumes should be harvested by cutting the emerged parts and leaving the roots in the soil. Legume cropping is inexpensive and provides an additional food or fodder crop. Despite the fact that legumes reduce the need for nitrogen fertiliser, legume seeds may not always be readily available to small-scale farmers in rural areas. Moreover, farmers in Afghanistan may also have too little

land to be able to cultivate green manures. Some benefits and limitations of green manure are summarised in Table 1.

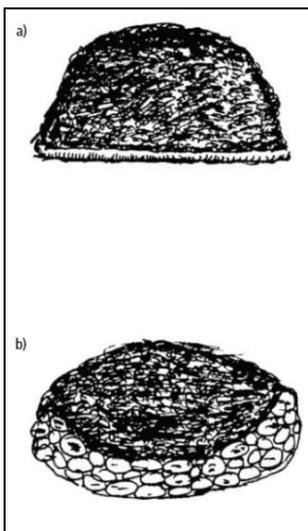


Figure 2: Making compost in a) heaps or b) pits (ICIMOD, 2008)

## Compost

Compost is made from plant residues and animal manure, which is usually available on farm. Biomass is collected for composting, a controlled decomposition of organic material. Composting takes less time than uncontrolled decomposition, reaches higher temperatures and results in a higher-quality product. Compost has proved itself to be the best type of organic fertiliser in dry climates, and it is a high value soil fertiliser for farmers without livestock. Its main value is its long-term effect on improving soil fertility. Moreover, compost increases the pool of nutrients in the soil and facilitates water retention by building the soil organic matter content. However, composting requires careful management and is labour-intensive; also, cold temperatures may slow down the composting process in Afghanistan. The biggest challenge to composting is the lack of biomass; every kind of crop residue, weed, litter and kitchen waste needs to be collected.

The compost needs to be turned repeatedly - every 30-50 days depending on the mix and the temperature. Compost should always be protected from direct sunlight and rainfall. Moreover, the material must remain moist at all times for the decomposing process to be efficient. Compost can be made in either heaps or pits (see Figure 2), which helps the compost reach temperatures of around 70°C and destroy pests and weed seeds. An earthy smell shows that the compost is well decomposed and can be applied - or stored for later use. Compost is applied directly to the soil, either along the crop rows or to individual plants.

**Vermi-compost** is the same as composting, but worms are used to decompose plant residues and animal manure to humus. A vermi-compost needs to be fed continuously; it does not reach high temperatures and therefore does not destroy pests and weed seeds.

**Small compost enterprises** can be established to tackle the lack of available labour for composting. A farmer produces compost to generate some income by selling the compost to other farmers. Small compost enterprises can prove sustainable, though there have to be sufficient sources of biomass to start a business.

### Mulching

Mulching is an alternative to cover crops. The topsoil is covered with a layer of organic material to create a favourable environment for plant growth. Mulching uses plant material such as leaves, grass, twigs, crop residues, pruning material from horticulture, hedge cuttings, weeds, straw, agricultural waste, etc.

If possible, mulch is applied before or at the onset of the rainy season. If mulch is applied prior to sowing or planting, the mulch layer must not be too thick, so that seedlings can penetrate it. Seeds or seedlings can be directly sown or planted in between the mulching material. Mulch can also be applied to established crops, preferably immediately after digging the soil.

| Benefits   | Limitations  |
|--|--|
| <ul style="list-style-type: none"> <li>Improves soil moisture</li> <li>Prevents soil erosion</li> <li>Suppresses weeds</li> <li>Controls soil temperature</li> <li>Improves soil structure</li> <li>Improves soil fertility</li> </ul> | <ul style="list-style-type: none"> <li>Labour-intensive</li> <li>Low availability of mulching material</li> <li>Provoques pests</li> <li>Introduction of diseases</li> </ul> |

Table 2 shows some benefits and limitations of mulching. Mulching is especially beneficial in vegetable production such as tomato cultivation, as it maintains soil moisture.

### Farmyard manure

Farmyard manure, and in particular composted farmyard manure, also helps greatly to improve soil organic matter. A full description of farmyard manure is available in module *AGR3B Organic Fertilisers*.

### Soil cultivation

With regard to soil cultivation practices, the main aim in sustainable agriculture is to maintain soil fertility and conserve soil water. One method with these two objectives is **conservation agriculture**. Conservation agriculture involves three basic principles:

1. Minimise soil disturbance (by reduced tillage);
2. Keep the soil covered as much as possible (by cover crops, green manure, mulching);
3. Mix and rotate crops.

#### Box 3: Conservation agriculture in semi-arid climates

- Retains water in the soil (soil moisture)
- Keeps the soil temperature constant
- Protects the land from erosion

Source: Biovision, 2012

Table 3: Advantages and disadvantages of reduced tillage (Biovision, 2012)

| Advantages   | Disadvantages   |
|--|---|
| <ul style="list-style-type: none"> <li>Less labour due to less operations</li> <li>Reduced erosion</li> <li>Conservation of soil moisture</li> <li>Improves soil organic matter</li> <li>Reduction in compacting; better rooting of plants</li> <li>Reduces CO2 emissions</li> </ul> | <ul style="list-style-type: none"> <li>Needs a long time to be well established</li> <li>Weed control is critical</li> <li>Lack of equipment for reduced tillage</li> </ul> |

### Reduced tillage

Tillage is the basic operation in crop production. Tillage operations include ploughing, harrowing, mechanical weeding, etc. However, every time land is tilled the land is exposed to erosion, water loss through evapotranspiration and the decomposition of soil organic matter. It is therefore best to reduce soil disturbance, for example through reduced tillage (Biovision, 2012). Table 3 summarises the advantages and disadvantages of reduced tillage. Reduced tillage is especially important for rain-fed cultivation

on rangelands in Afghanistan as it reduces soil erosion and conserves soil and water, making land use more sustainable.

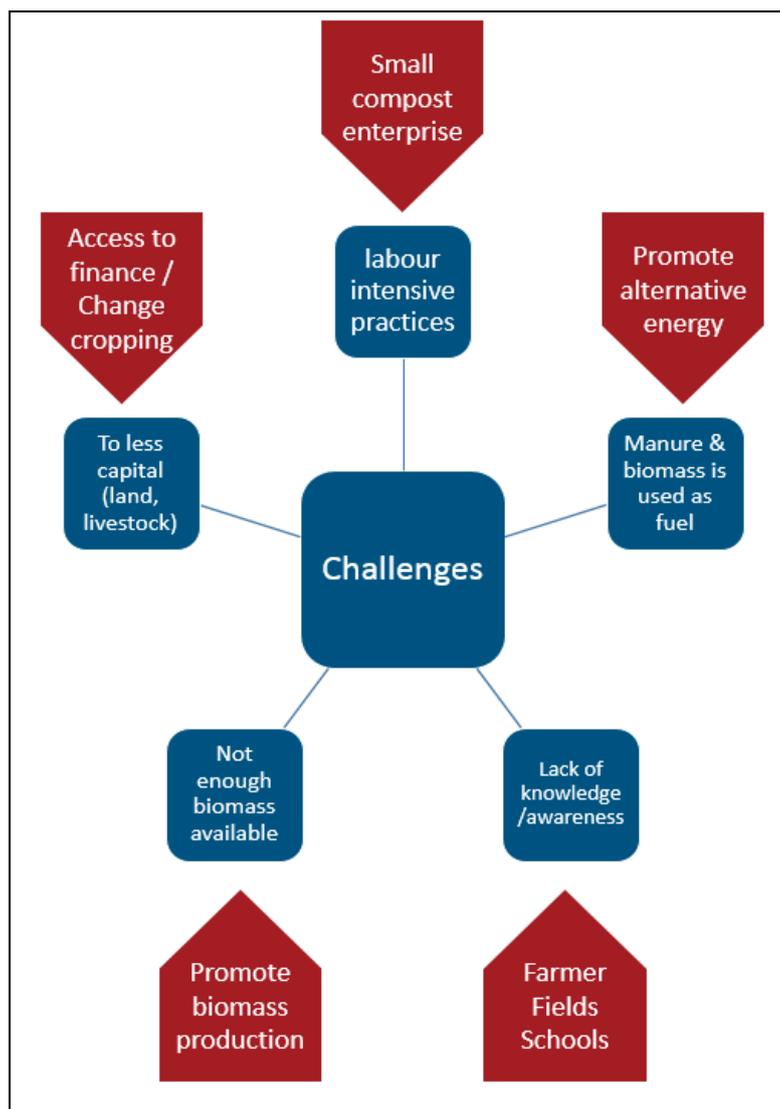


Figure 3: Challenges when applying organic fertilisers and strategies to overcome these challenges (Helvetas Swiss Intercooperation, 2014)

### Promoting sustainable practices

Figure 3 shows the challenges involved in promoting sustainable soil management and organic fertilisers. Some challenges - e.g. too little capital (land for green manure, livestock for farmyard manure) - are difficult to overcome, whereas others need special attention and management.

The use of manure and biomass as fuel can only be tackled if **alternative energy** is promoted as a new source of fuel. Module *SYS5B Alternative Energy* presents the different strategies available.

The large amount of labour required for composting can be addressed by promoting **small compost enterprises**. The labour of composting is given a monetary value by a farmer selling the compost for an appropriate price.

Available biomass is critical for composting and mulching. Biomass is scarce in semi-arid climates, but its availability can be increased. On the one hand, more existing biomass should be collected by pruning trees and collecting weeds and other plants; on the other, biomass production can also be increased, by planting winter crops, intercrops and fodder trees, and by cultivating waste land.

Finally, Farmer Field Schools are a good way to raise awareness and share knowledge about soil management and organic fertilisers. Farmers need to learn about the best organic soil management.

### Further reading and references

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