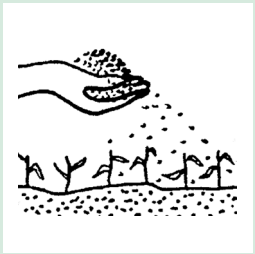
Agrodok-series No. 2

Soil fertility management



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Agrodok 2

Soil fertility management

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Foreword

Special thanks go first and foremost to Rob Leijder, Stephan Mantel, and Jan Vlaar for their invaluable comments. Further thanks go to the illustrators, Barbera van Oranje and Daniel van Buren.

This Agrodok is a revised edition, which incorporates two previously published Agrodoks (Agrodok 2: ‘Soil Fertility’, and Agrodok 28: ‘Green Manures’). These were combined because they can’t be dealt with separately: green manures offer the small-scale farmer extra opportunities to improve soil fertility. In addition to animal manure and chemical fertiliser, crop husbandry measures, such as the use of green manure, are important in combatting soil fertility problems.
Agromisa publishes a whole series of Agrodoks. In addition to ordering Agrodoks, you can correspond directly with Agromisa’s Question and Answer Service to get advice about specific problems relating to agriculture.

Rienke Nieuwenhuis
Laura van Schöll
October 1998

Contents

1 Introduction

Agromisa receives many questions about agricultural problems that directly or indirectly involve soil fertility problems. Often crop returns have decreased, so farmers want to know how to regain previous harvest levels. Lack of soil fertility causes decreased yields but many plant diseases are also related to poor soil fertility. If the soil fertility is not good, the crops are not in optimal condition, and are thus more susceptible to diseases and pests. The presence of diseases and pests lowers productivity levels, again threatening further the livelihoods of the rural communities. Such conditions can be avoided by improving the condition of the soil.

The presence of organic matter in the soil is fundamental in maintaining the soil fertility. Organic matter in the soil consists of fresh organic matter (leftover of dead plants and animals) and humus. The fresh organic matter is transformed into humus by soil organisms. Humus gives the soil a dark colour and can retain a lot of water and nutrients.

This means that the first step in maintaining soil fertility should be directed at maintaining the organic matter content of the soil. This can be done by using appropriate crop husbandry practices and by applying organic manure or compost. If the soil is very deteriorated, applying chemical fertilisers might be necessary. Chemical fertilisers can restore the soil fertility very quickly; because the nutrients are available to the plants as soon as the fertilisers are dissolved in the soil. It takes much longer before organic matter is transformed into humus and has released its nutrients.

This Agrodok will provide information about appropriate crop husbandry practices and the use of organic and chemical fertilisers, and it will give some background information and definitions of terms that are often used in soil science. Finally, it will outline a procedure to assess the condition of the soil.

This Agrodok is divided accordingly into three parts:
Part I describes the appropriate crop husbandry practices to maintain and/or improve the condition of the soil.
Part II describes fertilisers that can be applied to achieve quicker results but at a higher cost: both organic and chemical fertilisers will be considered.
Part III explains some scientific terms that are often used in texts about soil science to help those who want to read more about soils. A procedure to assess the condition of the soil is also given here.

Part I Soil fertility and crop husbandry

After an introduction about crop husbandry, organic matter, burning and the local conditions the crop husbandry systems are described in more detail:

- mulching is a method, in which a layer fresh organic matter is placed on top of the soil;
- green manuring consists in ploughing under fresh green material;
- intercropping means growing two or more crops together on the same field;
- during green fallow periods, species are sown or stimulated that have better qualities then the species that would grow spontaneously in the fallow period;
- agroforestry comprises all forms of land use in which woody species (trees and shrubs) are grown in combination with other crops.

Part II Soil fertility and fertilisers

The use of animal manure and compost contributes to retaining the level of organic matter in the soil. Chemical fertiliser can be needed to quickly supply a crop with required nutrients. In contrast to organic fertilisers, chemical fertilisers help the plants immediately; organic manures first have to be broken down into nutrients before they can be utilised by the plants. This means that organic material only has an effect in the long term, while chemical fertilisers contribute immediately (within a few days to weeks) to soil fertility. However, chemical fertilisers are depleted by the end of the season or seasons, while organic matter continues to enhance soil fertility as well as the soil

structure. Moreover, the presence of organic material ensures that the chemical fertiliser is more efficiently utilised by the crop because it prevents the fertiliser from being leached. It is in fact a waste of money to apply chemical fertiliser on soil that is poor in organic matter if it is not done in combination with measures to increase the level of organic matter in the soil.

Part III Theoretical background

This section provides background information on technical terms, such as nutrients, and on important concepts in soil science, such as texture, structure, organic matter, soil organisms, aggregates, and chemical properties of the soil such as pH and CEC. These terms can also be found in the glossary (Appendix 2). In addition, Part III can be used as a preparatory resource for discussions with technicians or as an aid to understanding more technical literature.

A procedure to assess the condition of the soil is given: this includes assessing a number of important factors such as texture and structure of the soil, presence of impermeable layers, level of organic matter and soil life, the nutrient supply and the acidity of the soil.

A literature list is also included for those who seek more information on soil science problems.

Appendix 1 contains a list of a few important soil types in the tropics.
Appendix 2 contains a glossary.

Part I: Soil fertility and crop husbandry

2 Introduction

2.1 Crop husbandry measures

Crop husbandry measures refer to methods the farmer can use before, during and after the growing season that do not require the addition of a new component to his business nor the purchase of many extra inputs (just sowing or planting materials). These measures include mulching, green manuring, intercropping, green fallow periods, and agroforestry.

All of the above methods are intended to achieve and retain optimum conditions in the root zone, where the crop gets the nutrients and moisture it needs for good production. Also the soil must be penetrable for plant roots. Methods such as mulching, intercropping and agroforestry aim to keep the soil covered in order to prevent evaporation and dehydration. Intercropping and agroforestry also ensure that extensive root systems are present in the soil; planting different crops with different root systems that need different nutrients contributes to a better utilisation of the available nutrients and water. The trees that form a part of agroforestry systems also ensure that the nutrients in deeper soil layers are utilised.

Green manuring and green fallow periods contribute particularly to a higher level of organic matter and to greater availability of the nutrients that are released from the organic material worked into the soil. The latter function can be intensified if leguminous plants are used.

2.2 Organic matter

Organic matter is very important in soil fertility management because it has many properties that help increase soil fertility and improve the soil structure. Organic matter has a great capacity to retain nutrients; this is especially important in sandy soils, which retain very few nutrients. Organic matter can also retain a lot of water, which means that in dry periods more water is available for the plants for a longer time. This is especially important in sandy soils, which retain little water. Organic matter can improve the soil structure. This is important for both sandy and clay soils, because they have a poor structure. Finally, organic matter stimulates the growth of soil organisms, which help make the nutrients in the organic matter available to the plants.

The organic matter in the soil consists of fresh organic material and humus. Fresh organic material is plant and animal waste that has not yet decomposed, such as roots, crop residues, animal excrement and cadavers. The fresh material is transformed by soil organisms into humus, which is also called organic soil matter. In the process, nutrients are released; organic matter thus makes nutrients available to the plants. Humus, i.e. organic soil matter, is material that has been broken down so far that the original fresh material is no longer distinguishable. It gives the soil a dark colour. Humus itself is also broken down by the soil organisms, which releases even more nutrients, but this process takes much longer.

Crop husbandry that contributes to a positive balance of organic matter is the basis for good soil fertility in the long term. The balance of organic matter must be even or positive, that is, the amount of organic matter that is added must be equal to or greater than the amount that is broken down and thereby lost. However a positive balance of organic matter is difficult to achieve. This means that if a lot of organic matter is lost (by erosion for example) it is difficult to increase the level of organic matter in the soil. Even in favorable conditions and with good crop management, this can take a number of decades, especially if during that time crops are grown that are almost completely removed with the harvest.

The rate at which organic matter is broken down depends largely on the climate. In warm, damp conditions the organic matter is broken down faster than in cold or dry conditions.

2.3 Burning

Burning vegetation to prepare land for cultivating crops is a common practice. The advantages are great, because burning fallow vegetation or crop residues with weeds saves a lot of labour. The fallow or weed vegetation is largely gone and no felling or cutting has to be done. The ash contains many nutrients in a directly usable form. The first harvest after burning fallow vegetation is usually a good one.

After a few seasons, however, a negative effect of burning can be seen in the level of nutrients and in the soil fertility. This has a number of causes. During the burn, large amounts of nitrogen (N) and sulphur (S) are released. These are thus no longer available for the plants (more information on the importance of these nutrients can be found in Part III, Chapter 12).

After burning, all the nutrients that were stored in the vegetation become available in the soil moisture, but they cannot be completely utilised all at once. In heavy rains, large amounts of N will be leached. Phosphate in mineral form becomes fixed to the soil particles and is then no longer available for the crop.

Regular burning of crop residues decreases the supply of fresh organic material and thus results in a decreased level of organic matter in the soil, which has negative long-term effects on soil fertility.

After the burns, the soil is unprotected and therefore susceptible to crust forming and to water and wind erosion. Ash is very light and is therefore easily carried away by wind and water. Along with the ash go the nutrients, leaving the soil without supplies for the next crop.

Since the soil is uncovered, the soil temperature during the day can become very high, which is unfavourable for soil organisms and for seed germination. The soil also dries out faster this way. As a result, the soil is hot, dry, and empty of soil organisms, rather than cool, humid, and rich in soil life, as the plants would like it to be.

2.4 Local conditions

In deciding which of the crop husbandry practices is the most effective, it is important to consider climate and possible slopes in the terrain. In humid areas that receive rain throughout the year, a living ground cover in the form of green manures is often better than mulch. A green manure takes in nutrients that the rain would otherwise wash away when no main crop is growing.

In sub-humid areas where it does not rain throughout the year and dry periods are clearly distinguishable, green manures can also be effective. However, in these areas competition with the main crop for water can become a problem. If the rainy season is so short that a green manure takes the place of a food or cash crop then the farmer will thereby lose food or income. A farmer will only do this if the green manure is so effective that it compensates for the loss by considerably increasing the yields of the following crops. The degree to which the yields are increased depends on the situation, so field trials must be done per region. It is important to remember that green manures save money by replacing chemical fertiliser, and they prevent the long-term loss of soil fertility (and thus income) by preventing erosion. These advantages are not always directly apparent. Mulch is a good alternative in sub-humid areas because it does not compete with the main crop. Intercropping is also often done because the water and nutrients are better utilised, it helps prevent erosion and it helps spread the risks of crop failure.

In semi-arid and dry savannah areas where the rainy season is very short, water is the most important limiting factor. Erosion by wind or water is a grave danger. Mulch is very important in these zones be-

cause it increases the moisture level in the soil by improving infiltration and preventing dehydration. The problem in these areas is how to obtain enough organic material to use as mulch. Intercropping is also used, especially as a way to spread risks. The yields of the various different crops together are not always higher than in a monoculture on the same area. This is because the plants in an intercropping system cannot be grown closer together than in a monoculture due to the shortage of water. Green manures are not suitable in dry areas because they require too much water.

In mountainous areas it is important to prevent erosion caused by water run-off. This is why it is so important to keep the soil covered as much as possible. In areas with enough rainfall, green manures and intercropping can be used, but in dryer areas mulching is a better alternative.

3 Mulching

Definition: Mulching means covering the ground with organic material, such as crop residues, straw or leaves, or with other materials such as plastic or gravel.

The goal of mulching is to:
- improve infiltration;
- protect the soil from water and wind erosion and from dehydration;
- prevent high ground temperatures;
- increase the moisture level in the soil;

and, when mulching with organic material, to:
- increase or retain the level of organic matter in the soil;
- better utilise the nutrients from chemical fertiliser;
- stimulate soil organisms.

3.1 Advantages of mulching

- Covering the ground with a mulch layer protects the soil from forming a crust. This allows the rainwater to infiltrate, and thus decreases water erosion. Moreover, the mulch layer protects the soil particles from being carried away by strong winds, i.e. it decreases wind erosion.
- The mulch layer protects the soil from becoming dehydrated. Together with increased infiltration, this ensures that the moisture content in the soil remains higher than in soil without a mulch layer. It will thus take longer in the dry season for crops with a mulch layer to be short of water.
- The temperature of exposed soil can become very high during the day. By applying a mulch layer, the sun is blocked and the daytime temperature is lower, which is favourable for seed germination, the crop's root growth, and for the growth of micro-organisms.
- The mulch layer prevents the phosphate in chemical fertilisers from getting into contact with the soil particles that fix the phosphate.