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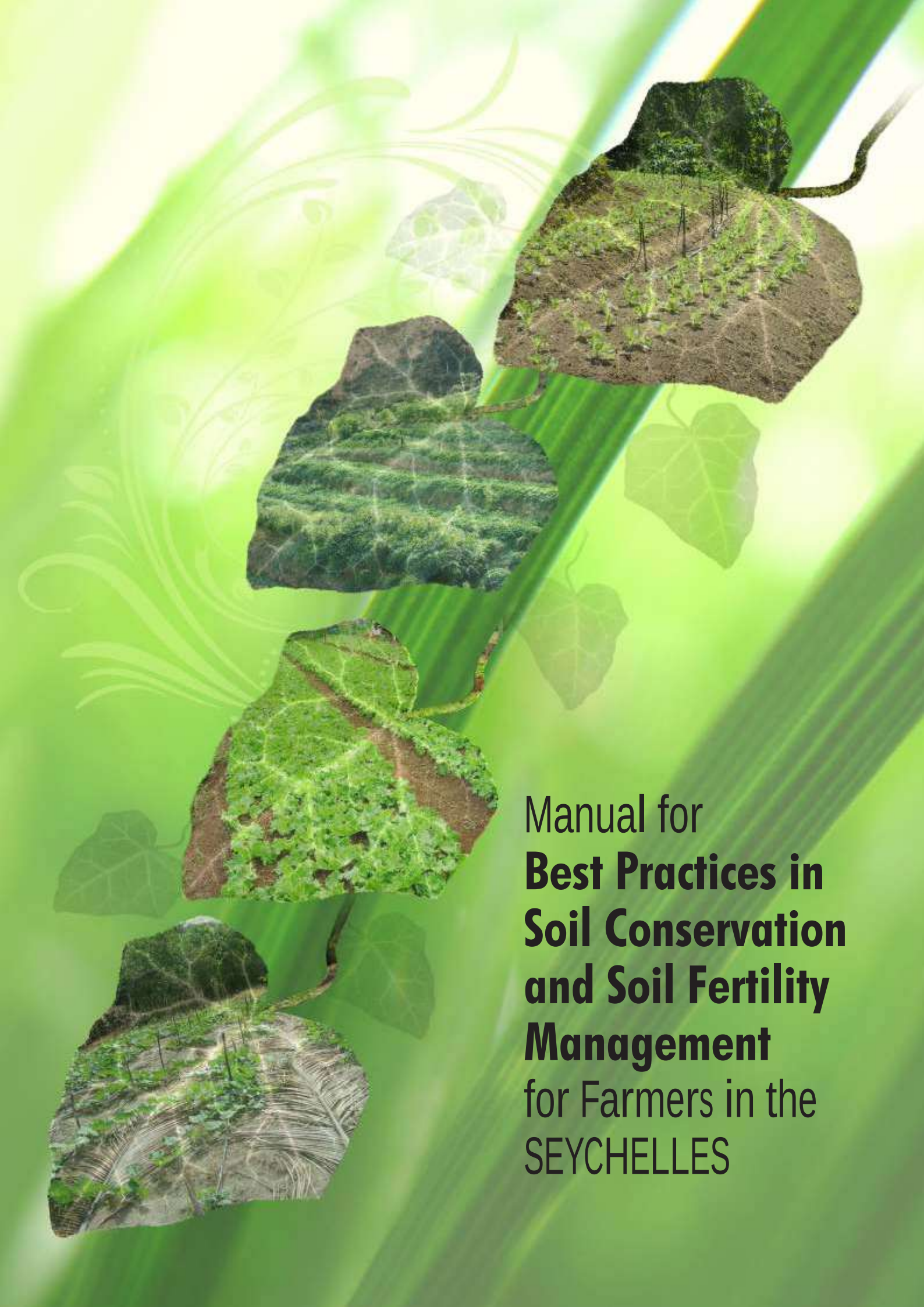

Manual for **Best Practices in Soil Conservation and Soil Fertility Management** for Farmers in the SEYCHELLES

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TABLE OF CONTENTS

PREFACE

The best practice of soil conservation and soil fertility is the use of the land within the limits of economics practicability, taking into account its capabilities and needs to keep it permanently productive. Such practices aim at reducing the adverse effect of agricultural activities on the environment, including the cultivated slopes, the streams and rivers, the coastal plains and the marine environment Soil degradation is the loss in quality and productivity of the soil due to change in nutrient availability and soil organic matter. This is brought about by human activities such as farming. The different forms of soil degradation are:

- **SOIL EROSION;**
- **FERTILITY LOSS;**
- **LAND DEGRADATION.**

The soil conservation and fertility best practices are simple to manage as they do not require the use of hi-tech technology.

The Manual falls within the

Capacity Development for Sustainable Land Management (SLM);

Project funded by the
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Government of Seychelles (GOS);

and the
United Nations Development Programme (UNDP). ■

Fertile top soil being washed

Severe soil erosion on Praslin

INTRODUCTION

Soil conservation practices are a combination of approaches which influence the physical, chemical and bio-logical status of the soil. The practices conserve soil fertility and allow continuous soil regeneration for current and future cropping with the potential for achieving the highest agricultural yield through the most economic means.

Intercropping cabbage and maize

Contour planting on the hill

Mulch for soil moisture conservation

Manure to increase soil fertility

The different soil conservation and fertility management best practices, included in this manual such as terracing, mulching, crop rotation, ridges and beds, are addressed more in the technical and the practical aspects. The principal objective of this manual is to inform farmers, students and the public in general of the best practices in soil conservation and fertility management. ■

1 Major land sustainability Issues in the Seychelles

1.1 Land Degradation

Land Degradation can either be a natural or a man-made process which impairs the capacity of the land to function. Soils are affected in the process when acidification, sedimentation, contamination, erosion, or salinisation occurs. Land degra-dation lowers the soil fertility status due to the removal of change in the chemical and physical properties in the top soil and organic matter. ■

1.2 Soil Erosion

Soil Erosion is the downward transport-ation, displacement or movement along the slope of soil usually by water. Soil exposed by cultivation on hillsides succumbs to erosion during heavy rains. ■

1.3 Flooding of the Land

Flooding of the coastal plain is a result of deforestation and poor cultivation practices in the uplands as well as the inherent backward sloping of the coastal plain and a high water table Surface run-off in the upland region is when there is minimum soil cover which cause rain water to flow on the surface instead of moving down the soil profile. ■

Sedimentation of soil material

Soil erosion on Praslin

Flooding on the farm

Effect of surface run-off in the upland region

1.4 Soil Salinisation

Soil Salinity is common in the sandy soil found on the coastal plain. It is a condition where salts found in the soil affect plant growth. Salinity is the amount of dissolved salt in soil water or irrigation water. It is common in the sandy soil found on the coastal plain. It is a condition where salts found in soil water affect plant growth through salt toxicity. ■

The effect of soil salinisation after coastal flooding

2 Soil Conservation Practices

2.1 Terrace

Terracing is the construction of barriers or steps along the contours of the land with the purpose of preventing the rapid flow of water down the slope. Cultivation along steep slopes may cause severe soil erosion. The ideal way for cultivating shallow rooted crops on slopes such as vegetables is on terraces.

Terrace Construction

The most common type of terrace in the Seychelles is the bench type.

- The edge of the terrace is made along the contour line and a ply-wood sheet is used to retain the soil;
- Then the soil is removed from the front of this line and leveled;
- The ply-wood is then removed and the edge of the terrace is wetted and pressed.
- Grass is normally grown on the side of the terrace as a support to prevent erosion.

There is another form of terrace were the face of the terraces are not grassed. They are kept in place:

- Using support such as old galvanised tin sheets;
- Lengths of old planks or the rejected plank faces after sawing;
- All are kept in place using both live and dead stakes. ■

Terrace with old corrugated iron sheet support

Cultivation on terrace

2.2 Contour Cultivation

Contour Cultivation is when crops are planted along the contour lines. This helps to prevent soil erosion on sloping land.

Examples of crops cultivated in contour planting are sweet potato, cassava, pineapple, banana and fruit trees.

Advantages

- Contour planting helps to prevent soil erosion;
- It does not need high labour input compared to terracing.

Disadvantages

- Contour planting can be practiced only on gentle slope;
- Preferably vegetable crops should not be cultivated, because they cannot afford enough leaf cover to cover the ground and therefore prevent erosion. ■

Contour planting on the slope

Strip cropping using various crops

2.3 Strip Cropping

Strip Cropping is practiced on steep slopes involving two crops. One of the two crops is preferably a fruit tree with well developed root system and the other a shallow rooted crop such a vegetable. Crops are cultivated in alternate strips where the speed of flowing water is constantly reduced by the alternate strips of crops. ■

2.4 Vegetative Barrier

Vegetative Barrier made up of one or more rows of trees or shrubs planted so as to provide shelter from the wind and salt spray along the coast and it is also used to protect the soil from erosion.

Ideal plants for Vegetative barrier

Characteristics should be evaluated and the following are required:

- Act as a perfect wind break;
- Quick growing;
- Grow up to a desirable height of 1.5m - 2m hence providing maximum protection up to a certain distance;
- Not subject to predation by pests and are not vulnerable to diseases;
- Do not remove large amounts of nutrients from the soil;
- Can be used for other purposes apart from wind break such as fodder (ideal plants for wind break in Seychelles are elephant grass, *Pennisetum purpurium* and 'kasi', *Leucaena leucocephala*).

Spacing and Planting Distance

- Plant to be used as vegetative barriers must be planted at close spacing;
- The distance between the windbreaks should also be taken into consideration;
- A distance of 15 metres is reasonable for vegetable production. ■

Maize as a vegetative barrier in sweet pepper and cabbage

2.5 Cover Crop

A **Cover Crop** is a secondary crop grown to protect the soil against erosion and increase soil fertility while the main crop is growing.

Choice of cover crop

- Cover crop should not be planted in large numbers, or else it may compete with the main crop;
- Cover crop should be quick growing and provide enough cover to the soil in a short delay;
- It should not remove large amounts of nutrients from the soil;
- Preferably, a cover crop should be of some economic importance.

Some ideal cover crops for Seychelles are:

- Banana *(Musa spp.)*;
- Pigeon pea *(Cajanus cajan)*;
- Kasi *(Leuceana leucocephala)*;
- Elephant grass (Pennisetum purpurium);
- Cowpea *(Vigna spp.)*. ■

Pumpkin as a cover crop in banana

Banana as a cover crop in cassava

Cowpea and maize in multiple cropping

Maize and cabbage in multiple cropping

2.6 Intercropping

Intercropping is the cultivation of different crops in the same field. Through intercropping the rooting systems of the various crops use different elements in the soil profile, ensuring better nutrient uptake.

- Whilst practicing intercropping, vegetable of the same family, for example: eggplant, chilli, sweet pepper and tomato, should be avoided as they are affected by the same pests and diseases;
- There should be a mixture of leguminous plants such as beans combined with leafy and fruit vegetables. ■

2.7 Crop Rotation

Crop Rotation is the successive planting of different crops in the same field.

The advantages are:

- Crop rotation makes use of residual nutrients;
- Pests and diseases are also controlled;
- Help to reduce soil erosion as it provides soil cover;
- Improve soil fertility with the decomposition of leave litter;
- Increase crop yield due to increase in the soil fertility status;
- Use of nitrogenous fertiliser is reduced with the use of leguminous plants.

Cultivation of one crop should not be followed by the planting of another one from the same family as for example eggplant, tomato and capsicum should not be planted one after the other so as to prevent the risk of pest and diseases.

One example of a rotation sequence is:

- 1st crop - leguminous crop such as beans;
- 2nd crop - a leafy crop, e.g. cabbage;
- 3rd crop – a fruit crop, e.g. tomato;
- 4th crop – a root crop, e.g. cassava.

The advantages of crop rotation over mono-cropping are:

- Prevent the excessive removal of one particular macro or micro- nutrient;
- Each crop or family of a certain crop is susceptible to a particular pest or disease. By crop rotation this will decrease the incidence of the pest or disease;
- Since many crops are cultivated, financial loss incurred on one particular crop may be compensated by the profit on another crop. ■

Crop rotation chilli, maize, spring onion and lettuce

2.8 Ridges and Beds

Ridges and Beds are raised soil structures for the cultivation of root crops and vegetables respectively.

The advantages of ridges and beds are to:

- Help in the drainage;
- Lower the risks of crops being damaged through excess surface water;
- Minimise the impacts of intense rainfall.

The cultivation of cassava and sweet potato is done on ridges to provide a better soil environment for tuber formation and growth.

- Ridges for cassava cultivation are normally 1m wide and 40 cm high;
- Ridges for sweet potato cultivation are 80 cm wide and 30 cm high.

Beds are used for the cultivation of leafy or fruit vegetable crops.

- They could be as wide as 1m to 2 m and 15 cm to 30 cm high. ■

Sweet potato being cultivated on ridges

Lettuce being cultivated on beds

Side of seed beds should always be inclined

2.9 Drains

Drains are dug-up structures for the disposal of excess surface water during and after rainfall.

Methods:

- The drains should be reticulated and be linked so as to dispose of the excess water from the entire cultivated area;
- The drains should be shallow from the high point and deeper towards the lower point to create a gradient;
- Drains should be at least 1m wide.

Storm drains are found at either end of the terraces.

- Their function is to remove excess surface flow from the terraces and to convey it down the slope. ■

Main drainage channel serving several farms

Secondary on-farm drainage system

3 Soil Fertility Management Practices

Compost heap

3.1 Organic Matter

Organic Matter is the un-decomposed, semi-decomposed or decomposed product or by-product of animals and plants that when applied to the soil is converted into the dark coloured complex known as humus.

The most common locally available organic fertilisers are cattle manure, poultry manure, compost, seaweed, pig manure, sawdust, grass and leaf litter, green manure and coconut coir.

Pile of chicken manure

The benefits provided by organic matter to the farmers are:

- Produces healthier plants;
- Reduces the water and fertiliser bills;
- Reduces environment pollution, through the minimum use of synthetic fertilisers. ■

Mulch material

Cattle manure

Application of cattle manure

Application of chicken manure

3.2 MANURE

Manure is obtained by the fermentation of feces and litter of animals. There are different types of manures used locally. Poultry manure is high in nitrogen and good for leafy vegetables.

Application of manure is done in two ways:

- In the hole or trench before planting at a rate of 0.5- 3.0 kg/m2;
- At the base of crop plant at a rate 20-30 t/ha (2-3 kg/m2). In this method the manure also acts as mulch (when applied as a side dressing).

3.3 COMPOST

Composting is the deliberate decomposition of organic refuse and residues for the purpose of producing humus. The process takes place under controlled conditions in heaps or pits.

Advantage of compost

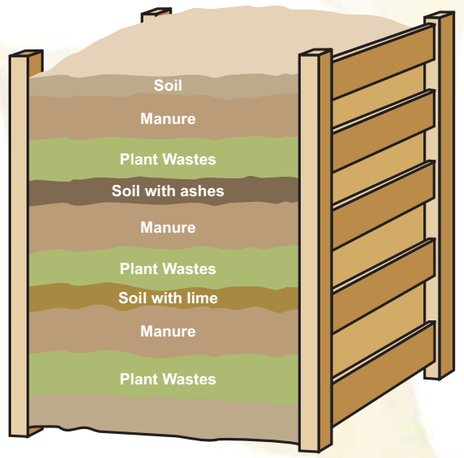
- Compost increases the level of organic matter in the soil which brings about the benefits mentioned in the chapter on organic matter.

The disadvantage is that

- Composting is labour intensive;
- A compost heap can attract vermin.

Method:

- Materials to be used should rot easily;
- The composting materials should not be derived from diseased crops;
- Composting materials could include grass clippings, woodchips/shavings, dry leaves, seaweeds, pen manure, food scraps, household refuse.



A Compost heap. Organic materials are added in layers and kept moist.

The quantity of compost required depends on the soil type and the crop being grown.

- On average, 1 tonne of compost provides 4.3-9.1 kg of nitrogen, about 5.6 kg of phosphorus and 4.2-27 kg of potassium;
- Micro-elements are also supplied to the plant when compost is applied;
- The compost recommendation rate for most vegetables is 5 kg/m2. ■

Application on planting beds

Compost application in planting holes

3.4 Green Manure

Green Manure is any crop grown to increase soil fertility. They are plants that can provide nitrogen to the soil through their ability to fix nitrogen.

When growing a crop for green manure the following needs to be considered:

- The green manure crop should be grown at a time when the land is not used for another crop or it can be grown as an undercover crop;
- Crop grown in rotation or mixed cropping practices;
- Plant used as green manure should not need fertiliser treatment;
- In the case of leguminous plants, they should be able to produce nitrogen;
- When incorporating the plants into the soil, they should be young, being either in the vegetative or flowering stage in order to allow for easy decomposition by micro-organisms;
- The crop should have some economic advantage, e.g. forages for animals, or the by-product of which can be used for human consumption.

The advantages of green manure are:

- Increases the level of soil organism;
- Acts like a live mulch;
- Increases the humus content of the soil thus improves its physical properties;
- Reduces nutrient loss by preventing erosion and leaching;
- Reduces the rate of evaporation from soil surfaces by acting as a cover;
- When legumes are used, they improve the nitrogen content of the soil.

'Tripsedonn' bean as green manure

Cowpea used as green manure

Some examples of locally available green manure are:

- Cowpea;
- Peanut;
- Beans;
- Soya bean. ■

3.5 Inorganic Fertiliser

Inorganic or Chemical Fertilisers are salt containing one or several nutrients required by plants.

- The correct timing and quantity of fertilisers is important so that the crop grows at the normal rate;
- The correct type of fertiliser should be used depending on the soil;
- Alkaline forming fertiliser should be used in red soils and acidic fertiliser in sandy soils.

Inorganic fertiliser is the most important source of plant nutrients being used by farmers.

- They are concentrated, low in bulk and affordable;
- Different fertilisers are used to provide all nutrients required by plants;
- Fertiliser can be applied at various stages of the plant growth;
- It can be introduced at the time of soil preparation, at the time of planting or several times during the crop growth period.

Bags of inorganic fertiliser

Fertiliser application:

- **Basal dressing** – before planting, operation is carried out;
- **Top dressing** – during the life cycle of the crop;
- **Ring application** – in a ring pattern around the plant;
- **Band application**;
- **Pocket application**;
- **Application by broadcasting**. ■

Broadcasting application

Ring method application

Pocket dressing

Row method application

A soil sample analysis is required prior to fertiliser application so that the optimum amount can be recommended.

Some of the locally available fertilisers

Fertiliser	Chemical symbol	Percentage nutrient
Ammonium sulphate	$(NH_4)_2\ SO_4$	21% N; 23% S
Urea	$CO\ (NH_2)_2$	46% N
Potassium Chloride	KCl	60% K; 46% Cl
Potassium Nitrate	KNO_3	13% N; 36% K
Triple Super Phosphate (TSP)	$Ca\ (H_2PO_4)_2$	26% P_2O_5
Nitrophoska (NPK, brown)	N,P,K	13% N; 13% P; 20% K
Nitrophoska (NPK, blue special)	N,P,K	12% N; 12% P; 17% K; 2% MgO
Limestone ammonium nitrate (LAN)	$NH_4\ NO_3$, $CaCO_3$, $Ca\ (NO_3)_2$	28% N

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3.6 Diseases Controlled Practices

Diseases Controlled Practices are the management of pests and diseases using organic and chemical methods.

Surface and sub-soil diseases have negatives impacts on soil fertility which may lead to:

- Soil degradation;
- Poor crop performance;
- Low agricultural yield;
- The soil is exposed due to poor crop density.

Soil being sterilised in drums

Soil solarisation to control soil-borne pathogens.

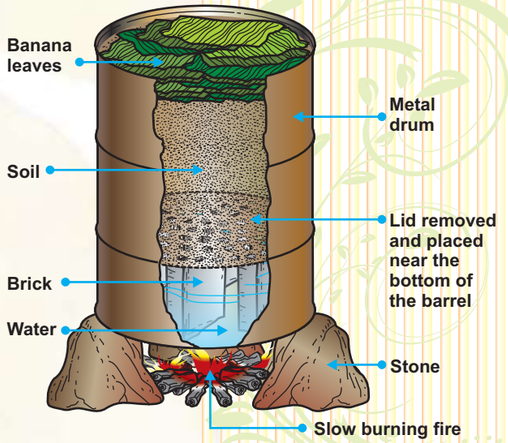
Pesticide application on crops.

Soil Sterilisation

Soil sterilisation through steaming is a recommended practice for protection of the seedlings against all soil-borne pathogens.

- The soil mixture containing the added farm organic resources is boiled in a used half of an oil drum over an open fire for about an hour;
- Then it is allowed to cool overnight and subsequently used for potting seedlings pots.

Disease controlled practices increase the yield and support sustainable land management. ■



A simple Soil Sterilizer from a used drum. ►

Source: Rice, R.P and Rice L.W. (1990). Soil fertility management.

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3.7 Mulch

Mulch is an organic or inorganic cover on the surface of the soil to protect the plant and the soil.

The use of mulch offers several benefits:

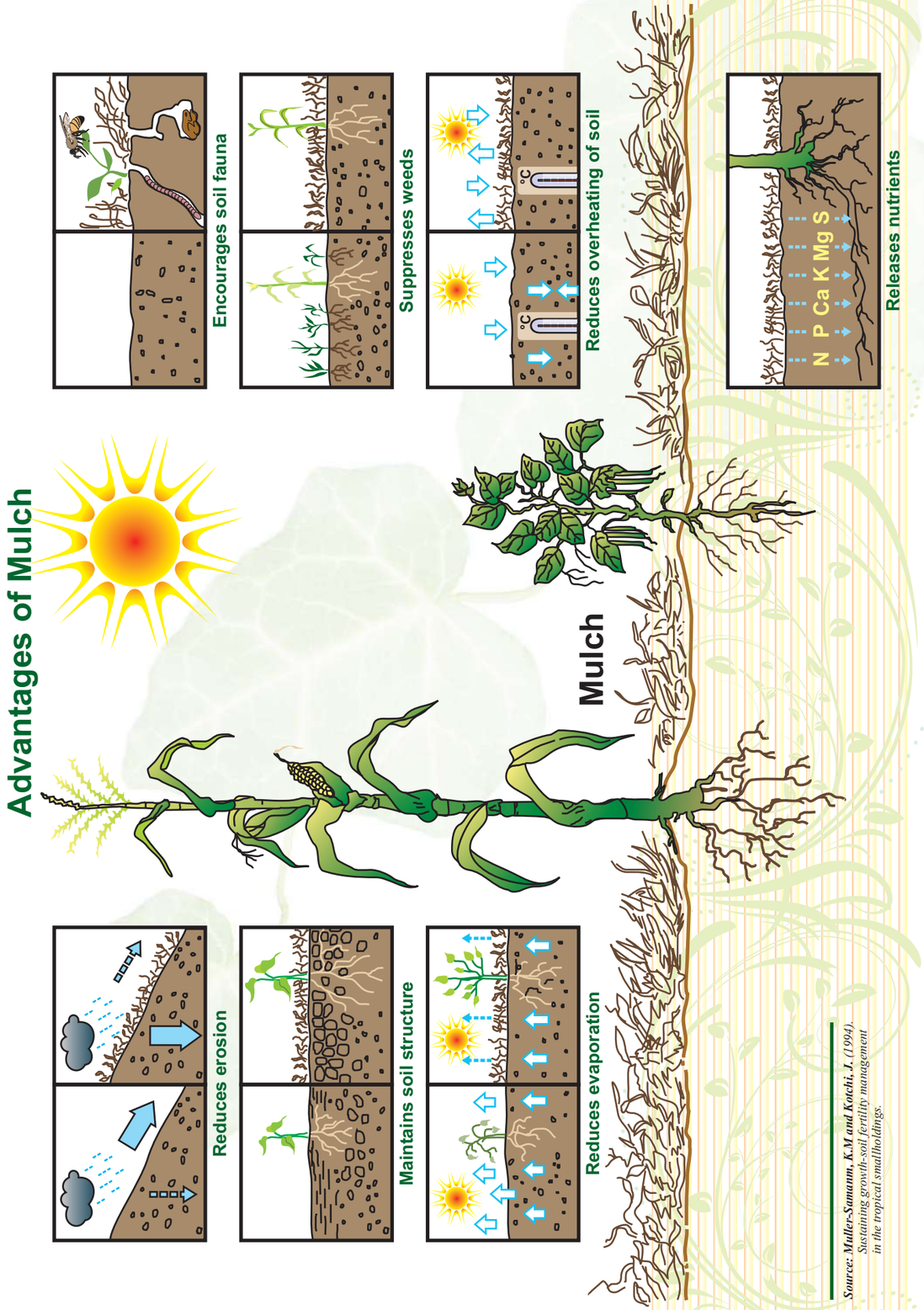
- Provides a source of plant important nutrients;
- Acts as a weed suppression agent;
- Maintains the optimal soil moisture level;
- Reduces soil evaporation and protects (plant root) from extreme temperature.

Application:

- In the case of the tree crops, it is recommended that the mulch is placed about 30cm away from the base of the trunk;
- Mulch is also commonly used in crops such as pumpkin and melon as an organic carpet to keep the final product free from soil hence increasing the market value;
- Mulch has to be applied before the rainy season;
- The mulch layer should not be too thick as it will be difficult for the germinating plant to reach the surface. ■

Mulch of coconut leaves

Mulch application at the base of fruit tree



Source: Muller-Samann, K.M and Kotchi, J. (1994). Sustaining growth-soil fertility management in the tropical smallholdings.

3.8 Irrigation

Irrigation is the act of delivering and applying water necessary for plant life and growth. The aim is to maintain an adequate soil moisture level around the seedlings of vegetable and fruit vegetable plants.

Irrigation can be carried out using:

- Open ended hose;
- Watering can;
- Overhead sprinklers;
- Mini-sprinklers;
- Drip irrigation system.

The drip and the mini-sprinkler irrigation systems with fertigation are commonly used by farmers.

- The drip system uses dripper heads perforated into the hose with different drip rates ranging from 2 to 8 litres per hour;
- The drip system is most suited in the cultivation of fruit, vegetables and fruit trees, while the mini-sprinkler is ideal in the cultivation of leafy vegetables. ■

Drip irrigation

Micro-sprinkler irrigation

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Bags of liming agent at the agricultural store

3.9 Soil Limimg

Liming is the application of calcium and magnesium rich materials to the soil to increase the soil pH. Liming an acidic soil means that the farmer can grow a wider range of crops.

Lime application

- Dolomite is applied as a liming agent and a soil ameliorant at a rate of 1.12 kg/m2 (11.2 t/ha) for strongly acidic soil. ■

3.10 Zero Tillage

Zero Tillage is one of a set of techniques used in conservation agriculture, which aims to enhance and to sustain farm production by conserving and improving soil, water and biological resources.

Zero tillage involves maintaining a permanent or semi-permanent organic soil cover (e.g. a growing crop or dead mulch):

- Protects the soil from sun, rain and wind and allows soil micro-organisms and fauna to take on the task of "tilling" and soil nutrient balancing;
- Soil moisture remains in the soil and is available to the plant.

This type of cultivation requires certain skills and equipment so as to be successful, as with any cultivation system if it is not carried out correctly it will have adverse effect on the environment. ■

Uncultivated/virgin plot with the accumulated ground surface organic matter.

Cultivated plot with minimum tillage.

Cropping between the stubble of the previous crop

3.11 Integrated Nutrient Management (INM)

Integrated Nutrient Management (INM) is one of the modern approaches of farming in which inorganic fertiliser is used to a minimum.

The practice involves using organic fertilisers instead of synthetic fertilisers. The main principle of INM is achieving the balance between the conservation of nutrients in the soil and the uptake of nutrients by the crop.

Use of mulch

Use of Manure

INM promotes:

- Agricultural productivity and safeguards the environment;
- Consists of both organic and inorganic plant nutrients for increase in crop productivity and reduces soil degradation. ■

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3.12 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) is one of the modern approaches of farming in which traditional pesticide is used to a minimum.

It is an effective and environmental approach to manage pests and diseases and uses the available information on the life cycles of pests and how they interact with the environment.

The practice involves using cultural and natural approaches of controlling pests and diseases by:

- Keeping a threshold level of pests before pesticide application;
- Using selective and bio-pesticides so as to protect the beneficial insects and organisms.

Threshold level of pest

While practicing IPM, farmers follow the four steps below:

- **1-** Eliminate the natural habitat for the pests;
- **2-** Set Action Thresholds;
- **3-** Monitor and Identify Pests;
- **4-** Use of pest control.

When the monitoring and identification indicate that pest control is necessary and preventative methods are no longer effective, IPM control method is used which combines lower risk pest control measures such as:

Application of pest specific control

- Pest-specific chemicals that affect growth, reproduction etc.;
- Natural predators like lady bugs and praying mantises;
- Mechanical control including trapping and weeding. ■

4 Sustainable Land Management in the Livestock Sector

Poultry farm

Cattle in shed

Land Utilisation in the Livestock Sector is related to farm infrastructure and waste management, mainly in the rearing of pigs and poultry.

- Seychelles being small with limited land resources there is not enough pasture for grazing;
- Grasses and fodder are harvested for the penned cattle.

Harvest of grass and fodder does not pose a threat to soil conservation and fertility as the fodders are fast growing and have an extensive rooting system.

There is not much grazing taking place, therefore there is minimum impact on the environment. ■

CONCLUSION

To enhance the national food and nutrition security, to achieve the goals as stated in the Agricultural Development Strategy 2007-2011, more land must be put under agricultural production and must be used intensively. Intensive cultivation might render the land susceptible to soil erosion, and might lead to loss of soil fertility and land degradation. Therefore soil conservation and fertility management through sustainable land use is of paramount importance for continued crop production, sustainable agriculture, and sustainable land management.

More research work is required on some of these practices such as green manuring, INM and IPM so as to create a package which will convince farmers to use the techniques for their own benefits. ■

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