A Guide for Trainers

Organic Agriculture

Principles and Practices

Uganda

EWA Empower Women Benefit for All

Women in Europe for a Common Future | WECF

Publication Data

Uganda

A Guide for Trainers

Organic Agriculture - Principles and Practices

Developed by: Jane Nalunga (NOGAMU)

Editor: Margriet Samwel, WECF

Project Partner: Appropriate Technology Uganda (AT Uganda)

This publication was realised with financial support of Netherlands Ministry of Foreign Affairs

Buitenlandse Zaken
Ontwikkelings samenwerking

WECF – Women in Europe for a Common Future

The Netherlands / France / Germany

www.wecf.eu

WECF The Netherlands	**WECF France**	**WECF e.V. Germany**
Korte Elisabethstraat 6, 3511 JG Utrecht Netherlands Tel.: +31 - 30 - 23 10 300 Fax: +31 - 30 - 23 40 878	BP 100 74103 Annemasse Cedex France Tel.: +33 - 450 - 49 97 38 Fax: +33 - 450 - 49 97 38	St. Jakobs-Platz 10 80331 Munich Germany Tel.: +49 - 89 - 23 23 938 – 0 Fax: +49 - 89 - 23 23 938 - 11

Content

List of acronyms

AT Uganda – Appropriate Technology Uganda

CA – Conservation Agriculture

EWA – Empowerment of Women – Benefit for All

NOGAMU- National Organic Agricultural Movement of Uganda

WECF – Women in Europe for a Common Future

The guide for trainers "Organic Farming – Principles and Practices"

This guide has been put together with the objective of assisting users to understand the basic principles and practices of Organic Agriculture and also to be able to put them in to practical use.

The guide is intended to support the Training of Trainers (TOT) trainees in the use of organic practices in the establishment of the conservation agriculture demonstration plots.

The guide is a simple guide for the freshly trained TOTs on Organic Agriculture Principles and Practices. As a trained TOT, your ultimate goal will be to translate all that you have learnt into practice but first create awareness among your target group and offer simplified training to the farmers with an aim of making them understand the conservation agriculture principles and practices using organic agriculture options.

The initial objective will be to convince them that it is indeed a good farming practice, which is capable of giving them better results compared to the normal farming practices they are used to. To do this successfully, you will first of all need to prepare yourself by revising your training notes and convincing yourself first about the benefits of the technology. *You have to be a convert before planning to convert others if you are to succeed.* The purpose of this guide therefore is only to highlight key issues and where necessary, you are advised to refer to any publication on Organic Agriculture.

1 Introduction

The project partner AT Uganda is implementing a by WECF coordinated project entitled: **Empower Women - Benefit for all** (EWA), funded by the Ministry of Foreign Affairs The Netherlands. The duration of the EWA Programme is from 06/2012 – 12/2015.

The overall goal of the EWA programme is to contribute to economic and political empowerment of women from low-income rural and peri-urban regions in six developing countries (Afghanistan, Georgia, Kyrgyzstan, South Africa, Tajikistan, Uganda).

In Uganda the major objective of this project is to improve local livelihoods of women and men through more environmentally friendly agricultural production, carried out in a profitable and business-like manner that empowers and respects the contribution of women, men and youth in the family. In implementation of this project AT Uganda works with local organizations to promote the adoption of environmentally friendly agricultural production in a gender inclusive manner. In Uganda the target districts are Kween and Kapchorwa.

In an effort to strengthen the capacity of the local organizations, AT Uganda signed a Memorandum of Understanding with the National Organic Agricultural Movement of Uganda (NOGAMU) to provide training services to local project trainers on organic production best practices in conservation agriculture and gender empowerment strategies.

This trainers guide on Organic Agriculture - Principles and Practices, was developed in cooperation with NOGAMU and was one of the outputs of the training on Conservation Agriculture (CA) held in Kapchorwa Uganda from 25th February to 1st March 2013. The training was organized by AT Uganda under the project **Empower Women - Benefit for all** (EWA)

2 Organic Agriculture

In Uganda and all around the world several types of farming are practiced and are based on different principles. For example:

Natural farming: What is the difference between organic farming and natural farming? Natural farming is a type of agriculture whereby the farmer does not put in much effort besides planting and weeding, but leaves the bulk of the care to nature.

Traditional farming: Generally refers to farming methods without agro-chemicals, high yielding varieties and machines. It involves low use of external inputs. It is based on wisdom, culture, tradition and practice handed down by our grandparents. In Uganda, traditional farming involves such practices as mulching, pruning and fallowing. Traditionally, farmers also select seed and breeding stock continuously, to come up with good yielding varieties and breeds.

Conventional agriculture: Conventional agriculture is the type of agriculture based on use of chemical fertilizers, pesticides, herbicides and growth regulators to increase yields. It involves practices of monoculture (only one crop at a time in each field) because the external inputs used are usually specific. The use of high yielding varieties, chemical fertilizers and pesticides usually leads to increased outputs in the short run.

Organic agriculture: Organic agriculture combines the use of traditional wisdom and science to provide sustainable solutions to area specific challenges in agriculture. Organic farmers must present a positive effort to conserve and improve natural resources during the course of attaining benefits from them. The soil is the major pillar in organic agriculture. Organic farming focuses on soil conservation, improvement of soil fertility, sustainable management of pests, diseases and weeds using methods that are not harmful to nature.

2.1 What is organic agriculture?

The word “organic” means "of plant or animal origin", but it also refers to the organizational aspect of an organism.

- kind of agriculture which is based on organic manures or other natural inputs
- no use of fertilizers and pesticides which are synthetic or chemical.

- follow the principles and logics of a living organism in which all elements (soil, plants, farm animals, insects, the farmer etc.) are closely linked with each other.

Definition of organic agriculture

- Organic farming is a production system that avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives.
- It is based on *minimizing external inputs*, *avoiding the use of synthetic fertilizers and pesticides*.
- Organic farming systems rely on crop rotations, crop residues, green manures, off-farm organic wastes and aspects of biological pest control to maintain soil productivity and health, support plant nutrients and control insects, weeds and other pests.

It is important to note however that, whether a system is certified organic or not depends on the condition of fulfilling all organic standards.

3 Basic principles and practices of Organic Agriculture

3.1 A System approach

Organic agriculture is a holistic way of farming; it is based on various systems. There is no single action that describes organic agriculture. It involves various systems that work together and complement each other to enable organic farmers attains a sustainable system. In addition to focusing on maximum yields and production of high quality goods, organic agriculture also focuses on:

- Conservation of the natural resources
- Maintaining fertile soils, clean water and rich biodiversity
- Best use of ecological principles and processes

Agroforestry systems

Complete ecosystems and modified microclimate

Organic Agriculture encourages the planting or maintaining of trees in cropping systems. Forests host a high diversity of plant varieties and animal species that make nutrients available to plants and contribute to pest management. Trees and other plants take up nutrients from the soil and incorporate them in their biomass (leaves, branches etc.). The nutrients go back to the soil when leaves fall or plants die. Part of the biomass is eaten by various animals (including insects) and their excrements return the nutrients to the soil. In the soil, a huge number of soil organisms are involved in the decomposition of organic material, which makes nutrients available to plant, roots again. The dense root system of the forest plants collects the released nutrients almost completely.

Recycling nutrients

Reduction in dependency on external inputs and investment costs

Organic nutrient management is based on biodegradable material i.e. plant and animal residues. Nutrient cycles are closed with the help of composting, mulching, green manure and crop rotation. Thus Farm animals play an important role in nutrient cycling.

Soil health and fertility

Maintain a healthy soil

Soil and its fertility constitute the centre of the natural ecosystem. Prevention of erosion and continuous supply of organic materials stimulate the activity of soil microorganisms and enhances fertility. This is very important in maintenance of yields and pest management. Organic farming methods should conserve and enhance soil fertility and biological activity.

Crop diversity

A very stable system and soil *fertility*

Organic farms grow several crops including trees either as mixed cropping or rotation. Trees and shrubs planted as windbreaks and hedges provide good habitats for beneficial insects. Animals form part of the farm system. Space, light, water and nutrients are used to the optimum. The main focus is on supporting the health and resistance of the crops and animals. Beneficial insects are promoted by offering them a habitat and food. If pests reach critical levels, natural enemies and herbal preparations are used for control to avoid losses.

3.2 Sustainability

Organic systems must be sustainable. Resources have to be managed successfully to satisfy human needs while at the same time maintaining or enhancing the quality of the environment and conserving natural resources. Sustainability in organic farming must therefore be seen in a holistic sense, which includes ecological, economical and social aspects. Only if the three dimensions are fulfilled, an agricultural system can be called sustainable.

Ecological sustainability

Some important aspects are:

- recycling the nutrients instead of applying external inputs
- no chemical pollution of soil and water
- promote biological diversity
- improve soil fertility and build up humus
- prevent soil erosion and compaction
- animal friendly husbandry
- using renewable energies

Social sustainability

Some important aspects are:

- sufficient production for subsistence and income
- a safe nutrition of the family with healthy food
- good working conditions for both men and women
- building on local knowledge and traditions

Economic sustainability

Some important aspects are:

- satisfactory and reliable yields
- low costs on external inputs and investments
- crop diversification to improve income safely
- value addition through quality improvement and on-farm processing
- high efficiency to improve competitiveness

Exercise: Based on the principles above, design a typical organic farm and describe all the processes taking place on that farm.

4 Organic production and management strategies

Types of organic production systems in Uganda

1. Small-scale
2. Mixed farming
3. Multiple cropping

There are various strategies that are used to ensure sustainable organic production. All strategies however, whether for crops or animals, are geared towards prevention, resistance and resilience. These strategies include:

- Plant nutrition based on soil and water conservation and soil fertility maintenance
- Animal nutrition based on fodder produced on the farm and clean water for the animals
- Disease and pest management based on preventive measures (both crops and animals)
- Use natural/organic remedies for cure
- Focus on optimum balance between profits, environment and food safety for sustainability

In following the various strategies will be presented.

4.1 Soil fertility management strategies

Key features in soil fertility management

- Soil Conservation
- Ensuring soil replenishment
- Sustainability of successful organic crop production

Issues of soil fertility management

Generally soil fertility in Uganda is low. There are only a few pockets of fertile soils scattered in different parts of the country, and originally it was believed that most soils in Uganda were very fertile and did not require addition of fertilizers for optimum crop production. Research and experience have shown however, that most soils have been heavily depleted of their original fertility by:

- Continuous cultivation without replenishment especially in densely populated areas
- Leaching due to the heavy rains and poor soil structure
- Erosion especially on the rolling and undulating slopes
- In sloping areas fertile top-soils are eroded and lost to lower valleys where farming activities are at a minimum.

Soil management strategies used by organic farmers

- Avoiding bush fires, which lead to destruction of plant residue, soil structure and nutrients
- Practicing conservation tillage
- Erecting barriers like trash lines, stone bunds, soil bunds, grass strips, bush hedges, terraces and ridges to control soil erosion and conserve landscapes
- Frequent application of organic manure to replenish nutrients required by crops and contribute to organic matter reserves in the soil
- Mulching to reduce the impact of rain, wind and evaporation, conserve moisture and replenish nutrient reserves
- Planting cover crops like jack beans, velvet beans and crotalaria that protect the soil and replenish it with nitrogen
- Fallowing where possible to allow natural regeneration of the land
- Intercropping to make use of different soil levels
- Crop rotation to make use of the various nutrients in the soil and control pests and diseases

4.2 Pest and disease management in organic systems

4.2.1 Key features concerning pest management

The climate in Uganda is favourable to vigorous plant growth and can support crop growth throughout the year. This fact however, does not apply to crops only, but to pests and diseases too. Being able to support crop production throughout the year, the Ugandan climate ensures an abundant supply of food to pests for most parts of the year. The constantly warm temperatures aggravate this situation.

Issues in pest management

- Pests can breed more frequently due to the constant warmth and pest booms are common, especially towards the end of the rainy seasons.
- The high relative humidity also interacts with the warm temperatures leading to high incidences of humidity related diseases, especially fungal infections.
- With this scenario, organic farmers in Uganda have to start with thinking of preventive measures of pest and disease management, before thinking of control and curative measures.

4.3 Prevalent pests and diseases in Uganda

In following table an overview is given on the most common pests, their hosts and diseases

Pests	Host range	Diseases	Host range
Termites	Fruits and vegetables, young fruit trees	Bacterial blight	Vegetables, Potato, tomato
Cutworms	All young vegetables and fruit seedlings	Mosaic	Potato, tomato, cucurbits
Aphids	All vegetables, cucurbits, citrus	Rusts	Cereals, fruits, vegetables
Mealy bugs	Fruits, vegetables, pineapples,	Mildews	Fruits, vegetables, avocado
Scales	Fruits, vegetables, Pineapples, citrus	Wilts	Solanum spp., coffee, pineapples, ginger, banana
Boll worms	Cotton, fruits, vegetables	Leaf and fruit spots	Passion fruits, mango, vegetables
Moths (mainly leaf eating caterpillars)	Crucifers (cabbage, cauliflower, etc.), cucurbits	Rots	Fruits, vegetables, papaws, passion fruit
Leaf hoppers	Fruits, vegetables		
Leaf miners	Tomato, okra		
Thrips	Onions, tomato, collards, leeks, peas, avocado		
Whiteflies	Cucurbits, potato, egg plant, okra		
Fruit flies	Fruits		
Green bugs	All vegetables		
Mites	Cucurbits, citrus, tomato, passion fruit		
Nematodes	Fruits and vegetables		
Beetles/weevils	Vegetables, legumes		

5 Crop husbandry

5.1 Crop pest preventive measures

- Choice of resistant varieties
- Use of healthy (clean) seed so as to start with a disease-free and pest-free plant
- Appropriate spacing to avoid intraspecific competition that would weaken the crop, ensure good ventilation to avoid fungal diseases and avoid over shading to reduce hiding places for pests
- Use of organic manure (organic fertilizer) to be able to start with a strong plant and boost plant immunity
- Timely planting so that crops develop resistance before pests build up
- Timely weed control to reduce competition and remove alternative sources of pests and diseases
- Good water management to avoid water logging, stress and excess water on leaves
- Mulching for soil and water conservation and weed control
- Intercropping to control pests and diseases
- Crop rotation to reduce disease and pest build up
- Good hygiene/sanitation to remove disease and pest reserves
- Rouging to reduce sources of inoculum
- Promotion of the existence of natural enemies by leaving grass strips and controlled bush hedges which act as habitats to beneficial organisms

Among all the preventive measures, organic farmers in Uganda regard use of organic manure as a prerequisite to any successful organic venture as far as disease and pest management are concerned.

Organic manure is essential in soils to provide nutrients that help plants build resistance against soil pests and diseases. High microbial activity in the soil is required to counteract undesired fungal growth. With addition of organic manure, some farmers have been able to control nematode and fungal infections.

5.2 Crop Pest Curative measures

Organic farmers use various organic remedies to control and cure different pests and diseases. The major types of organic remedies include;

- Ashes like wood ash from charcoal stoves
- Herbal dusts prepared from herbs like Mexican marigold, Targetes spp., Lantana Camara,
- Cheap processed products like maize flour that are dusted on crops to control less mobile pests like aphids and mealy bugs
- Liquid herbal extracts (e.g. Tephrosia) that are sprayed to control both pests and diseases.

5.3 Push-Pull strategy

Push-Pull is a simple cropping strategy, whereby farmers use Napier grass and Desmodium legume (silverleaf and greenleaf Desmodium) as intercrops in maize.

Desmodium is planted in between the rows of maize. It produces a smell or odour that stem-borer moths do not like. The smell 'pushes' away the stem-borer moths from the maize crop.

On the other hand, Napier grass (Pennisetum Purpureum) is planted around the maize crop as a trap plant. Napier grass is more attractive to stem-borer moths than maize and it 'pulls' the moths to lay their eggs on it. But Napier grass does not allow stem-borer larvae to develop on it. When the eggs hatch and the small larvae bore into Napier grass stems, the plant produces a sticky substance like glue, which traps them, and they die. So, very few stem-borer larvae survive and the maize is saved because of the 'push-pull' strategy.

In addition, a ground cover of Desmodium (Desmodium Uncinatum or silverleaf), inter-planted among the maize, reduces Striga weed. Research has shown that chemicals produced by the roots of Desmodium are responsible for suppressing the Striga weed. Therefore, Striga does not grow where Desmodium is growing. Being a legume, Desmodium also fixes nitrogen in the soil and thus acts to enrich the soil.

Photo: Example of an effective intercropping strategy - push-pull. Push-pull plot during 2nd season, maize and desmodium with Striga border crop. The plot is bordered with Napier grass. © icipe

Desmodium is perennial and must only be planted once. As Desmodium seeds may not always be available, Desmodium can also be planted using vines. This can be an easy and cheap method to plant Desmodium vines.

How to plant a push-pull field?

1. Plant Napier grass (Bana variety is the best) in a border around the maize plot.
2. Plant at least 3 rows of Napier all around the maize field.
3. Apply 2 handfuls of well-decomposed farmyard manure in each hole.
4. In the first year, plant Napier grass before the rains so that is has a start on the maize. The stem-borer moths will like the larger Napier grass even more than the maize.
5. Get Desmodium seeds from seed companies ('Western Seed & Grain Co. Ltd.' in Kitale, Western Kenya) or your neighbour who has started growing it. For 1 acre of land 1 kg of Desmodium seed is needed.
6. Alternatively you may plant Desmodium vines. In this case plant the vines when there is enough rainfall and soil is moist.
7. Prepare the soil carefully so that it is as fine and clean as possible.
8. Using a strong pointed stick, make a furrow in the middle of the rows where the maize will be planted.
9. Mix the silverleaf desmodium seed with fine sand or fine soil (about 1 handful of seed and 2 handfuls of sand).
10. Plant Desmodium with the rains for maximum germination.
11. Plant your maize in the field surrounded by Napier grass.
12. After 3 and 6 weeks, trim the Desmodium so that it does not overgrow in between the maize plants.
13. Keep the field weed free so that the Napier has a start on the maize. The moths will like the larger Napier more than the maize.

Benefits of adopting a push-pull strategy

When you adopt a push-pull strategy you will:

- Increase maize yield by 25 - 30% in the areas where stem-borers are the only problem. Where both stem-borers and Striga are problems, you can double your maize yields.
- Increase the supply of cattle feed from harvesting Napier grass and Desmodium.
- Fix nitrogen into your farm soil by Desmodium legume, so you save on fertiliser costs.
- Protect your soil from erosion, as desmodium acts as a cover crop.
- Retain soil moisture, as Desmodium acts as mulch.

- Earn money from the sale of Desmodium seed at an attractive price of between Kshs 600 and 800 (US$ 8 to 10) per kg.
- Make more money from increased milk production and sales.
- Save on farm labour, as you do not have to manually remove Striga weed from the farm.
- Protect maize from strong winds, by surrounding it with Napier grass.

5.4 Animal husbandry

Livestock Preventive measures

- Choice of resistant breeds
- Use of healthy stock so as to start with a disease-free stock
- Appropriate space to avoid overcrowding
- Good hygiene/sanitation to eliminate disease and pest reserves
- Balanced nutrition to build immunity, encourage fast growth and efficient production

Livestock Curative measures

Liquid herbal extracts that are:

- Sprayed to control ecto-parasites like ticks and nuisance flies
- Force-fed to control diseases and endo-parasites
- Added to feed or drinking water especially for routine control of worms and fevers

6.0 Management of common pests in organic agriculture

Introduction

Pests cause a great loss in yield both quantitatively and qualitatively leading to loss of profit to a farmer. In organic Agriculture the aim is not to eradicate these pests but to keep them at a level where the damage caused is negligible. This involves a range of activities that support each other. Most management practices are long term activities that aim at preventing pests from affecting the crop. These management practices focus on keeping pest population low and keeping the plant healthy.

Photo (source: WECF, Samwel): Pest management practices focus on keeping pest population low and keeping the plant healthy

6.1 Definition of a pest

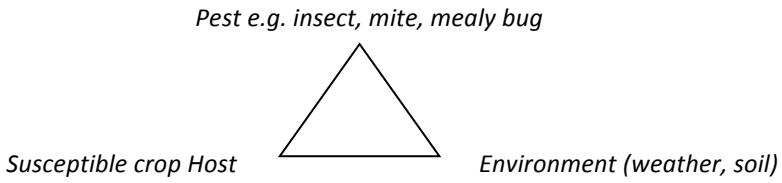
A pest is anything that affects a crop leading to loss in quality and quantity. It may also be used to include anything that cause annoyance to man. A pest may be "man", other animals (Domestic and wild), insects, weeds, diseases, rodents, birds (domestic and wild), etc. which reduce the quality and quantity of the crop yield. The main concern in this discussion will be on insect pests that attack our crops. Pests can be controlled by use of pesticides and these can be artificial or made naturally.

6.2 Insects

Insects are the most important group as pests on agricultural crops. Insects remain aware of their environment by means of compound eyes and antennae, which have a touching and smelling function. Insects have a head, thorax (which carries legs and wigs) and abdomen, which has the spiracles, colourless blood and for food circulation.

How do insects become pests?

As shown in the diagram below, there is a direct relationship between the insect, its host and the environment. Due to agriculture that provides unlimited food supply, the numbers of insects can increase easily: while the ecological change caused by agriculture, provides suitable food crops for development of pests.



Following some factors that influence the growing rate of insects.

- **Character of food supply**: Large seeds or fruits are more attractive food to pests than wild crucifers (caterpillars) or grasses (stalk borers).
- **Monoculture:** Minimum cultivation, which does not expose Coleoptera, Lepidoptera and Diptera, which increase habitats
- **Multiplication** of suitable habitants (especially in storage)
- **Loss of competing species**: e.g. in monoculture, continuous spraying of particular pesticides
- **Change of host** / **parasite relationships**: Use of chemicals e.g. in case of Red spider mite on fruits due to DDT use in orchards. Or due to lack of predators and parasites, and lack of serious competitors especially in case of Polyphagous insects there is a spread of unwished insects, caused by man

Types of damage caused by insect pest attack

- Boring insects e.g. American boll worms, fruit fly
- Scratching insects e.g. thrips, mites
- Biting and / or cutting insects e.g. Termites, cutworms, caterpillars, armyworms, beetles.
- Mining insects e.g. false codling moth
- Sucking insects e.g. Jassids, bugs, white fly, Aphids, leaf hoppers, scales

6.2.1 Direct effects of insect feeding

1) Biting insects

- Reduce amount of leaf assimilative tissue and plant growth (Nymphs and adults).
- Tunnel in the stem and interrupt sap flow, often destroying the apical part of the plant e.g. stem borers and shoot flies
- Ring – bark stems
- Destroy buds or growing points
- Premature fruit fall e.g. Mango fruit fly

- Attack flowers and reduce seed production
- Injure or destroy seeds completely or reduce germination due to loss of food reserves e.g. weevils and pod borers
- Attack roots and cause loss of water and nutrients absorbing tissue e.g. beetles
- Remove stored food from tubers and corms e.g. potato tuber moth

2) Piercing and sucking mouth parts

- Loss of plant vigour due to removal of excessive quantities of sap → wilting results and stunting e.g. White fly and Aphids.
- Damage floral organs and decrease seed production e.g. bugs
- Cause premature nut fall
- Premature leaf fall e.g. scales
- Inject toxins into plant body → distortion, proliferation (galls), necrosis, etc e.g. bugs
- Provide entry points for pathogenic fungi and bacteria

6.2.2 Indirect effects of pests

- Crop can become difficult to cultivate. The pest (e.g. insects) may distort the plant and also make it dwarf, and weeding becomes hard and delay's crop maturity.
- Infestation results in contamination and loss of quality i.e. loss in nutritional value or in marketability like in case of storage pests
- Transmission of disease organisms e.g. bugs
  (i) Mechanically (passive transmission)
  Through feeding lesions in the cuticle
  Sometimes pathogens carried on proboscis of the bug or body of insects
  (ii) Biological transmission
  Most viruses are transmitted by an insect vector (Cassava mosaic, Rosette, etc.)
  The vector is usually an intermediate host e.g. Aphids, white fly, etc.

7 Basics of organic pest management

In Organic pest control, a farmer should aim at reducing loss in a way that is economically viable, socially acceptable and environmentally friendly. The philosophy behind organic pest management is to first avoid pest build up and then protect the crop through encouraging control by natural organisms since other control methods may be short-term activities and focus on killing pests.
In a natural system, predators, pests and parasites are usually in balance and damage remains at a tolerable level and the general approach is to deal with the causes of a problem rather than treating the symptoms. If the situation goes out of hand, natural pesticides are an alternative to poisonous chemical products, which kill not only pests but also useful organisms in the farm (especially predators and parasites of these pests).

7.1 Pest management strategies in organic agriculture

- Crop rotation (break cycles)
- Organic cycle optimisation
- Intercropping (mixed cropping)
- Diversity (habitant diversification)
- Fallowing
- Trap crops (Okra, sorghum, maize, sunflower) before cotton.
- Closed season by laws
- Agro-forestry
- Sanitation / crop hygiene (weeding, clean tools, removal of volunteer crops, collection of fallen fruits, bury debris)
- Zero or minimum tillage (pests are exposed to the surface)
- Appropriate water management

- Deep ploughing (bury and exposes pests)
- Flooding (exposes army worms, cutworms, white grubs, etc to predators)
- Proper fertilisation (excessive Nitrogen weaken the plant)- use right quantities
- Mulching (excludes light, kills most weeds)
- Irrigation to avoid stress due to lack of moisture
- Use of resistant varieties
- Proper spacing
- Timely planting
- Use of plant strengtheners e.g. the Mexican and French marigold, the nettle tea and other plant teas such as from Comfrey, Leucaena and Tithonia.
- Transplant healthy and strong seedlings.

7.2 Principles of pest management

1. **Identify the problem**
   Study the plant and look for all possible symptoms e.g.
   - Water stress
   - Disease/pest
   - Competition with weeds
   - Physiological disorder due to poor soil fertility or nutrient imbalance
   - Other causes of damage like lightening, sun scorch or allelopathy
2. **Diagnosis**
   Try to discover the nature of the pest, disease or physiological problem by making a careful examination. Never assume, but always verify.
3. **Know the means of spread**
   This is necessary to determine when, where, what and how to control and manage pests and diseases
4. **Determine threshold levels**
   It is important to determine the optimum level at which commercial control measures should be implemented. On this aspect two factors are of much importance:
   - *Economic Injury Level* - refers to the lowest pest population density at which economic injury occurs, normally resulting into 5% loss of produce.
   - *Economic Threshold* – refers to the pest population density at which control measures should be started to prevent an increasing pest population from reaching an economic injury level. It is measured by the intensity of pest infestation and economic crop loss.
5. **Choose the right control method(s)**
   It is important to select the most appropriate combination of management and control in terms of cost, effectiveness, acceptance as well as sustainability.

7.3 Organic pest control methods

Biological control

Parasitic wasps and predatory mites can control pests such as the white fly and red spider mite, respectively. Hoverfly larvae consume green fly, black fly and other aphids in a big quantity.

Ladybird beetles are predators of aphids and parasitic wasps are effective in controlling bollworms. There are also parasitic spiders and deadly microbes, birds and animals. These are important partners in fighting pests.

Plant pest repellents

Among others, the Mexican marigold, hot peppers (pilipili), ordinary wood ash, onions and garlic, bar soap, lantana camara, tobacco, animal urine and dung.

Companion plants

- Celery goes well with onions and leeks.
- Lettuce goes well with carrots; both grow better if planted together.
- Tomatoes keep butterflies away form cabbage.
- Carrot and onions keep carrot flies and onion flies from each other.

- Cowpeas and maize do well together. Cowpeas help to minimize stalk borer attack in maize and maize obstructs American bollworm form getting to cowpeas.

Physical methods

Can be used in case of high value crops, and by observing your crop carefully all the time. For example
Remove and bury in time insect infested plants.
Control top borer by cutting off the top where pests shrive
Control malformations in mango by removing and destroying affected branches.

Hand-pick egg masses e.g. sweet potato moth, larvae, caterpillars and adult beetles from crops. Immerse them in water mixed with kerosene to destroy them.
Use of lethal temperatures (high or low)
High – e.g. hot water, grain drying using black polyethene
Low – e.g. No death but retardation in cell metabolism

Mechanical Methods

Use them in combination with the cultural and physical methods mentioned above to reduce pest population. Mechanical ways can be in form of traps to stop rodents, pulling weeds by hand, weeding. Light traps in the field can control a number of stem borers. Digging trenches around rice fields can prevent migration of the hairy caterpillar larvae. Barriers in form of smearing grease on trunks of fruit trees can prevent insects climbing up (caterpillars & ants).

Others can be:
a) Field sampling by hand
b) Use of drags on army worms
c) Hand picking

Use of Natural Pesticides

These can be referred to as plant pest killers e.g. Pyrethrum products, Phytolaca, Tehprosia, Neem tree, and hot pepper/chillies products. A combination of these is even more effective.

Natural pesticides are the solution to all the disadvantages encountered when using artificial pesticides and help in preserving the natural enemies on the farm.

- Natural pesticides come mainly from plants
- They break down quickly without leaving any harmful by products
- They are locally available
- Are cheap and within the means of smallholder farmers.
- Offer less or hardly any input from outside.

NB: Besides, some plant pesticides can be toxic to animals and human beings e.g. nicotine from tobacco, phytolaca, etc

Many plants have defensive or lethal effects on vertebrates, insects, mites, nematodes, fungi and bacteria. Active components can be extracted from various plant parts e.g. stems, leaves, roots, fruit and seeds. Because the lethal effect is due to a number/mixture of components/compounds, pests do not easily develop resistance against the pesticide. However, natural pesticides are not readily available when pest attack. They have a narrow range of insect control and take long to make.

7.4 Examples of natural pesticides and bi-rationals

Below some plant based pesticides are listed and how to prepare them:

1. Mexican Marigold (Kawunyira)

Procedure of preparing the
- Harvest leaves and flowers of marigold which fills a small basin (akatasa)
- Chop or pound it and place it in a basin
- Add 5 litres of water and cover
- Let it stand for 5 – 10 days while stirring everyday
- After the above days, they will be decomposed

- Sieve it and get out the liquid leaving out the remains which can be used as mulch in the vegetables
- Before using the liquid from this, add soap or soapy water (at a rate of 1:1 (1 part sieved liquid: 1 part soapy water). To a five litre solution, use 1/16 of a bar which is equivalent to the size of match box. If using powder soap, 1-2 bottle tops (soda or beer) to 5 litres.
- Spray on affected parts of the plant

2. Hot Peeper / Chilli (Kamulali)

- Get half kilogram of ready or ripe pepper and cut it into small pieces/pound (do not rub your eyes)
- Soak it in 3 litres of water
- Put it on fire and bring it to boil for 15 minutes or just soak them for 3-5 days
- Let it cool down and strain/sieve out the liquid
- Get a piece of soap to the size of a match box and dissolve it in water
- Then add 1:1 of this soapy water to the filtrate
- - Spray once a week if it is dry season and 2-3 times during rainy season

This natural pesticide is mainly used in vegetable gardens to kill caterpillars, flies, termites and other insects.

3. Wood Ash

- More effective if it is from eucalyptus, cedar (Christmas tree), brush bottle flower tree or rice husks.
- Should be fresh ash but cool
- Can be sprinkled on leaves or around the stem (collar level) – a handful is enough
- Gets rid of caterpillars/larvae of insect pests which cut seedlings or worms which affect roots and on snails
- If it rains, add more ash
- It is very useful in the first two or three weeks from transplanting

Photo source http://www.organeem.com/neem_tree.html)
Neem Tree: Almost every part of the tree is useful as an effective pesticide (insecticide)

4. Neem tree

- Alm ost every part of the tree is useful
- The effective ingredients are in all parts of the tree but most useful are the seeds
- Although the Neem extracts do not kill insect pests immediately, they change the insects feeding or life styles until it is no longer able to live or have young ones.
- The tree is used to control pests in the garden, and in storage of grains like beans, maize, soya beans, peas etc.
- If leaves are used, get one kilogram of leaves

- Add 10 litres of water
- Stir thoroughly every after 10 minutes for 1 hour
- Sieve/strain out the liquid
- Add a piece of soap as above and take to spray the affected crops

5. Animal urine

- Can be from any animal
- Collect 10 or more litres of urine
- Keep it for 14 days under shade while it is covered
- To 1 part of urine add 2 or 3 parts of water

NB: After adding baking powder, it should be used there and then. Hence mix only what you can use that day.

6. Cow dung

- Collect fresh cow dung in a basin
- Add water to make it watery
- Stir it well until it mixes well in water
- Filter out the green liquid
- Leave the solution to stand for seven days
- Can be sprayed on vegetables to control worms, aphids and other insect pests

7. Tephrosia (Muluku)

- Get leaves and small branches of Tephrosia
- To 1 part Tephrosia, add 5 parts water and 1 handful of pepper
- Add soap as above

8. Phytolaca (Oluwoko)

- In 10 litres of water add 2 kg of pounded phytolaca
- Boil for a few minutes
- Add a small piece of soap as above
- You can also add 3 spoons of sodium bi- carbonate before you spray
- Also 3 drops of paraffin can be added
- The mixture is effective on mainly aphids, caterpillars and other soft bodied insects
- The mixture is particularly useful on tomatoes in controlling early and late blight
- For banana weevils, one can mix Phytolaca and Tephrosia to come up with a bi-rational, which is more effective.

Caution: Do not apply phytolaca towards harvesting. Observe a pre-harvest period of 3 days.

Birationals

A bi-rational is a mixture of different plant species and or animal by products that have insecticidal effect to come up with a compound natural pesticide. Hence, they are plants and plant combinations like those we have seen above. Generally, are effective and less toxic to mammals and birds than chemical pesticides.

Type 1

- Collect 20 litres of cow or goat urine.
- Add ¼ kg of ash.
- Keep and stir once in a while for 14 days
- Pound ½ kg of fresh marigold leaves.
- Pound ½ full 1 litre cup of chilli (pepper)
- Pound 5 garlic onion
- Pound ½ kg of *Phytolacca dodecandra*, (locally know as “oluwoko” in Luganda; “ruhoko” in Runyoro and Rutoro).
- Add and mix thoroughly all the above pounded materials to the mixture of urine and ash that has stayed for 14 days, allow the new mixture to stay for another 3 days.

At the end of the third day do the following:

- Filter well the mixture/infusion
- Dissolve a piece of soap comparable in size to a box of matches and pour to the filtrate depending on strength of the crop.
- Dilute the filtrate/mixture to a ration of 2 or 3 parts (cups) water and 1 of filtrate depending on strength of the crop and carry to the garden to spray.
- While in the field add 1 ½ tea spoon-full baking powder just before spraying.
- If you cannot get 20 litres of urine, work out proportions to match the urine you have.

It has been reported to be very good in repelling banana weevils and caterpillars on sweet potato

Note following for all plant based pesticides and bi-rationales:

- Dilute the plant-based pesticide based on the brittleness of the leaves of the crop to be sprayed.
- When preparing the pesticide keep it covered so that there is no direct radiation.
- Use the pesticide within the specified period

Type 2

- Pound ½ kg of tomato leaves.
- Pound ½ kg of tobacco leaves.
- Pound ½ kg of onions (small variety).
- Add to 20 litres of water.
- Stir well the mixture every after 10 minutes within the first hour.
- Filter well the mixture.
- Dissolve a piece of soap comparable in size to a box of matches in the filtrate.
- Carry the filtrate/mixture of plant based pesticide and go the field to spray.

Type 3

(Can be use in the place of Dithane M45, commonly sprayed on tomato)

- Pound ½ kg of ginger.
- Pound ½ kg of garlic.
- Pound ½ kg of onions (small variety).
- Add to 20 litres of water.
- Stir well the mixture every after 10 minutes within the first hour.
- Filter well the mixture.
- Dissolve a piece of soap comparable in size to a box of matches in the filtrate.
- Carry the filtrate/mixture of plant based pesticide and go the field to spray.
- Use of Tephrosia as a storage pesticide
- Pound fresh green leaves to a paste and dry.
- Crush the dried paste to powder.
- Mix this powder with cereals to be stored.
- It is best applied to those cereal seeds under storage for planting.
- It is not advisable to apply to cereals meant for food, especially if the powder is not well dried. Tephrosia smell might be left in the food.

Note:

Tephrosia can effectively be used to control root rats or mole rats that cause extensive root damage and yield loss in root crops like cassava and sweet potato. Plant Tephrosia plants throughout the field at a spacing of 3 x 3 metres while growing other crops in the same field. To prevent root rats from entering a field, plant Tephrosia around the field plants spaced at one metre apart. After one year the field should be free of root rats and Tephrosia shrubs can be removed. A combination of all the above methods can be used for sustainable organic pest management.

7.5 Benefits of organic pest management

Using a combination of various methods in the management of pest problems caused by diseases, pathogens, insects, nematodes, birds and rodents is more sustainable. Pest damage is kept at a level that does not cause economic yield loss. Measures taken are physical, biological, and cultural in nature. A combination of measures

is good in that it greatly reduces on the use of chemicals that cause environmental degradation, health risks to man, kill beneficial organisms (parasites and predators) and livestock.

You can achieve the following

- Promotes sustainable use of environmental resources.
- Maintains high yields and quality produce.
- Is feasible and economically affordable.
- Minimises use of chemical pesticides
- Keeps pest population below economic threshold.

7.6 Examples of common pests, damage caused, hosts and control

In the following table the most common pests the damage they cause, their hosts and possible control are presented.

Insect pest	Description and damage	Host range	Control
Termites	Both adults and young ones do destroy the plants by cutting the roots and at times eating up the stems.	Fruits, vegetable seedlings, cereals and all those woody crops.	• Use of hot pepper/ chillies • - Use of birationals
Aphids	These have sucking mouthparts. As it sucks it may inject a digestive juice into the plant phloem, which in young organs may cause severe distortion (e.g. curling). • Sucking up sugary phloem contents it excretes sticky substance (honey dew), which may block up leaf stomata and reduce photosynthesis. • Stylet may transmit viruses e.g. Y virus on potato, Rosette in groundnuts, etc.	All vegetables, cucurbits, citrus, legumes, etc.	• Use of predators and parasites e.g. Ladybird beetles, lacewings, hover flies, parasitic wasps and parasitic fungi. • Use of natural pesticides e.g. Derris, Pyrethrum, insecticidal soap, Spider weed, marigold, chillies/hot pepper, garlic and onions, phytolaca, cow dung, etc. (*See preparation*) • - Bi-rationals
Moth and butterflies (American boll worm and other Caterpillars)	• Adults have 4 large wings and curled feeding tubes • The larvae has six small legs and 8 false legs • Larvae is the only damaging stage • Feeding habits • Leaf eating habits • Others feed inside fruit (Codling moth in apples), under ground (cut worms), inside leaves (Leaf miners) and inside stem (stem borers).	Tomatoes, cabbages, cauliflower, crucifers, cucurbits, various vegetables, cereals and legumes.	• Weed control and use of ash (cutworms) • Parasites e.g. wasps • Predators e.g. birds • Mechanical • Use of Natural pesticides e.g. Derris, insecticidal soap, Marigold, chillies/hot pepper, garlic and onions, tobacco, Neem tree, Tephrosia, Phytolaca and wood ash. • Lantana camara • Bi-rationals • Cow dung
Leaf hoppers	• Are slender light green insects • Found on under surface of the leaves, causing mottling of the upper surface • It is a vector of diseases	Fruits and vegetables mainly potato and rose and other crops.	• Neem tree • Tobacco
Thrips	• Have modified mouth parts for	Onions, tomatoes,	• Use of predators and

	piercing and sucking • Have toxic salivary juice which cause silvering in onions and straw brown spots on cucurbit and streak in carnation blooms • It carries serious tomato spotted wilt virus	collards, leeks, garlic, peas, avocado, bananas, etc.	parasites • Neem
White fly		Cucurbits, potatoes, eggplants, okra, cassava, sweet potatoes, tobacco.	• Pyrethrum • Insecticidal soap • Marigold • - Parasitic wasps
Fruit fly	• Belong to Diptera • They have a single pair of clear fore wings • Larvae are legless, elongated and mouth parts are simple hooks (where present)	Mangoes, peaches, cucurbits, tomatoes, citrus, guava, papaya, banana, avocado, melons, passion fruits,	• Derris • Pyrethrum • Insecticidal soap • Marigolds • Neem • Birationals
Nematodes	Are normally referred to as eel worms They are very tiny and microscopic in nature Mainly attack the roots	All fruits and vegetables, Potatoes, tomatoes, cucumber, cassava, bananas and other crops.	• Steam sterilisation (Soil and planting materials e.g. bananas) • Use of resistant varieties (Tomatoes)
Beetles	• Belong to Coleoptera family • Adults have hard, horny fore wings • - Can also attack in the store	Vegetables and fruits e.g. potatoes, onions, brassicas and straw berries. Others like bananas, cereals and legumes.	• Derris • Chillies/hot pepper
Mites	Mites have 4 pairs of legs, fused body structure and no wings e.g. Red spider mite which has a piercing mouthparts that inject poisonous secretions which can cause localised death of leaf mesophyll cells although smaller than those of thrips	Tomatoes, cucumber, cassava, etc.	• Predators e.g. Predatory mite (*Phytoseilus persimilis*) • Derris • Pyrethrum
Mealy bugs	• All stages of insect development are pests and they do suck phloem juices by use of tubular mouthparts (stylet) and in dense mass • Produce honey dew and cause leaf drop	Orchids and Solanum, pineapples, sugar canes, etc.	• Hard to control due to thick cuticle
Scales	• Cause stunted growth and leaf defoliation	Fruit trees e.g. apples	Has a thick cuticle hence hard to control
Slugs	• Are mainly soil pests • Feed on seedlings, roots, tubers and bulbs. • Mainly cause above ground damage to leaves during moist and warm	-Vegetable and fruit seedlings, root crops, tubers and bulbs.	• Baits (Grape fruit skins and stale beer)

	weather but other times, they do damage below ground parts as soil pests.		
Mole rats	• Cause serious damage to stored products and those crops which have food stored under the ground	Sweet potatoes, cassava, ground nuts, etc.	• Tephrosia • Use of traps

8 Organic disease management

Organic disease management consists of a range of strategies done together to support and complement the efforts of each strategy. Most of these activities are long term and preventive in nature. Management aims at keeping disease prevalence low, while control is short term and focuses on killing disease causing organism.

Organic disease management deals with the causes rather than treatment of the symptoms. On that note, management is of much higher priority than control. Management begins with considering the heath of the plant.

8.1 Plant health

A healthy plant is less vulnerable to disease infestation. A plant growing in a favourable environment has sufficient mechanism to fight infections. Thus, an organic farmer should manage well his plant ecosystem. Some crop varieties however have better defense mechanisms and as a result have lower infection risk.

The health condition of the crop depends to a large extent on the fertility of the soil. A plant receiving the correct nutrition is strong and less vulnerable to infection. Equally important is the right climatic conditions like suitable temperature, sufficient water supply. If any of those conditions is not proper the plant is stressed, correspondingly the defense mechanism is weakened making it easy for diseases. Thus, as an organic farmer your first weapon in fighting diseases to ensure that your crops are healthy. Light temperature, water and nutrients should be sufficient for the plant to resist disease.

Vigorous plants that are well-fed and regularly watered can quickly replace the sap sucked up by aphids and are strong enough to develop new shoots and leaves. Weak plants will wilt when attacked by aphids and will not be able to compensate by rapid healthy growth.

Plant immune system

Plants have own mechanisms to fight against diseases. Only those not able to fight back are attacked. Resistance refers to ability of crop to prevent or restrict infection by one or several diseases. Many factors affect this resistance though some plants resist over whole vegetative season while other only in certain live stages.

What is required of an organic farmer is to select for resistant varieties. This requires good observation of infection process and period of plant in relation to environmental conditions. As mentioned above resistance can break down due to environmental stress. One good example has been the success achieved in fighting African cassava mosaic with resistant varieties.

Grafting

Very useful with perennial crops where a shoot of a high yield crop susceptible to disease(s) is combined to a rootstock of a variety with is resistant to soil borne diseases.

One achievement in this respect was grafting of the purple passion fruit to the yellow type. In the same respect a number of exotic perennial crops like fruit trees have been grafted onto indigenous plants tolerant to local soil conditions.

Compensatory growth

Some crops are seen to recover from relatively high disease incidence by producing many more leaves and increase in plant height. Hence, at times an organic farmer may not need to panic with initial disease attack.

8.2 Prevention of plant diseases

This is attained through right timing an intervening at the most crucial point in plant's life through right management practices, suitable combination of different methods or choice of selective methods. Thus, here are some important disease preventive measures.

8.2.1 Sowing and planting

Select adapted and resistant varieties

These are varieties well adapted to local environmental conditions (temperature, nutrient supply, pest and disease pressure), which continue to grow healthy and strong despite disease incidence.

Select clean seed and planting material

Use safe seed inspected by reputable organic movement promoters at all stages of production. In addition, get planting materials from safe and trustworthy sources. Vegetative materials and seed must be mature, disease free, undamaged and have high germination capacity. Diseases transmitted in seed include common bacterial blight, fuscous blight, halo blight, wilt and anthracnose. All can be controlled if you have good healthy seeds.

Method and depth of sowing

Avoid damage to seeds during sowing this pre-disposes seed to fungi and bacteria especially those causing seed rots and damping off.

Avoid overcrowding especially to avoid damping off; this is important in groundnut against Sclerotium blight and Cercospora leaf spots. Deep sowing is sometimes bad as it prolongs the period between sowing and emergence and tends to increase period of pre-emergence damping-off. However, deep ploughing is important in preventing some fungus from reaching the soil surface to infect plants.

Selection of optimum planting time and spacing

Aim at ensuring that the vulnerable stage of the crop doesn't correspond with the period of high disease incidence. Most diseases attack a plant at a certain life stage. Therefore, the timing of planting should be such that it doesn't tally with the vulnerable stage of crop and high incidence of diseases.

Sufficient distance between plants reduces spread of diseases and allows the plant to dry faster preventing development of pathogens and infection.

Variation in sowing dates

Changing the planting time sometimes helps to confine disease outbreak. For example in region where watermelon tends to rot before ripening, late planting is sometimes advisable. Plants sown in middle rather than at the start of the wet season make the most of the rain to develop stem and foliage. Their fruits enlarge and ripen at the beginning of the dry season when microorganisms causing fruit rot are less active and therefore cause less damage.

Application of suitable soil cultivation methods

This can for instance promote faster decomposition of infested plant parts. Weeds will be regulated as host for pests and diseases.

Use of good water management

Avoid waterlogged conditions that stress the plant encouraging infections. Equally important is to avoid water on foliage as water borne diseases spread with droplet and fungal disease germinate in water.

Conservation and promotion of natural enemies

Provide an ideal environment for natural enemies to grow and produce as informed in insect pest management. For a number diseases arise as secondary infection as a result of injury caused by feeding insect pests.

8.2.2 Use suitable cropping system

Mixed cropping: Has been seen to limit spread of disease due to less plants and presence of more beneficial organisms that control or destroy the harmful ones. The bacterium Pseudomonas solanacearum causes bacterial ring spot or wilt in potato. Rapid spread is noted when the seed tubers are densely planted in pure stand, but spreads slowly when potato is intercropped.

Intercropping cassava with maize reduces cassava blight caused by a bacteria ((Xanthomonas manihotis). The bacterium is mainly transmitted by rainwater bouncing and splashing form plant to plant. The spread of the disease is hindered by the associated barrier created by the intercrop.

It is unwise however, to mix plants belonging to the same family because they are prone to attack by the same microorganisms. Therefore, it is not advisable to mix potato and eggplant, cabbage and cauliflower, cucumber and courgettes. It is safe to mix species from different families like tomato and pigeon pea, cabbage and onion and cucumber and maize. This holds for crop rotation. Plants from same family should not be grown in succession.

Crop rotation: Reduces soil borne diseases and increases soil fertility.

Green manuring and cover crops: Increase the biological activity of the soil enhancing the presence and population of beneficial organism. However, can as well increase diseases. Hence, need to select the proper plants.

8.2.3 Use balanced nutrient management

Moderate soil fertility ensures steady growth and makes plant less vulnerable to infection. Too much fertilization causes salt damage to roots, opening the way for secondary infection. Balance soil potassium has proved to prevent fungal and bacterial attack. Elephant grass has relatively higher levels of potassium. Thus, as organic manure can be used to increase the level of potassium in the soil.

Organic matter input

Soil is regarded as living body due to presence of microorganism. The diversity and population of microorganism is dependent on levels of soil organic matter. Adding organic matter increases microorganism density and activity in the soil in return decreasing the population density of pathogenic and soil borne fungi.
This is the basis of controlling a number of wilt diseases by ensuring that the soil in rich in organic matter. In addition, the soil structure is improved allowing for better aeration and water infiltration.
Organic matter is known to contain growth-promoting substance and substances which strengthen the plant's own protection mechanism.

8.2.4 Weeding and earthing up

Weeds encourage rapid increase in pests. Some pathogens harbour in them near crops. Weeds lower resistance of cultivated crops by competing for food and nutrients. Weeding unwanted plants therefore promotes the health of the plant. Earthing-up helps to control diseases especially if they attack the root-stem junction.

8.3 Plant density and disease control

A resistant and susceptible variety can be planted together. The resistant variety acts as a barrier preventing the spread of the disease from one host-plant to the next. By mixing resistant and susceptible strains, the resistance of the variety is maintained. If on the other hand, the resistant variety is grown in pure stand, the resistance may eventually breakdown because the pathogen deprived of weaker plants on which to feed, will adapt to the strong variety and finally overcome its resistance.

Another way of controlling diseases is to have a clear understanding of the way a disease develops and of its preference, you may then be able to alter the habitat to the pest's detriment. Take the example of controlling groundnut rosette virus. The aphid that transmits the disease attacks the underside of leaves but does not like deep shade. Thus, to reduce infestation a high planting density is good practice because it creates shade and humidity under the groundnut plants.

8.4 Use of proper sanitation measures

Sanitation aims at reducing or elimination of the source of primary infection at the beginning of the life of crop. Secondary infection occurs in the field; primary infection is what starts the infection. Sanitation involves the prevention on the inoculum (i.e. material with pathogen) of pathogen from reaching the crop

Nine sources of possible infection of a crop include:

1) Infected disease materials (trash) from the previous crop
2) Infected volunteers
3) Infected crop plant surviving intercrop season (between 2 crops e.g. early and late cotton). Here, survival is due to perennial habit of plant.
4) Infected seed and other planting materials.
5) Infected subsidiary hosts (this includes alternate, alternative hosts, alternate hosts are involved in the completion of life cycle). Alternative host are any other host apart form the primary that the parasite can live on.
6) Infected plant produce of commerce (e.g. fruits)
7) Infected soil.
8) Air-borne inoculum.
9) Infected or infested insects and other vectors.

As far as crop sanitation is concerned we are concerned with 1 to 7 above as we can hardly do anything in 8 and 9.

Remove infected plant parts (leaves, stems, fruits) from the ground (rouging) to prevent the disease from spreading. Rouging gives good control when applied on time and is useless when the disease has already spread, hence it works well with slow pathogen spread. Methods of sanitation include tillage aiming at inverting crop residues into soil to rot.

Eradication on the other hand, calls for systemic removal of infected plant material combined with all efforts to prevent re-introduction. At times it requires you to follow a closed season to prevent transmission of inoculum to next crop. For example in cotton all stalks are supposed to be collected and burnt and all farmers wait to plant together the next crop.

Contact between healthy and diseased plants must always be avoided. If there is any risk of infection the plants must be pruned or pulled up quickly. This may include diseased trees. If you dip up a tree because the roots are suffering from root rot, it is not enough to uproot the stump. You must remove the diseased roots right to the extremities using a pick axe or spade and burn them.

The soil is a reservoir of diseases; it harbours fungi, bacteria, insects, slugs and small rodents. Many of these pests are not able to reach leaves, stems and fruits above ground level because they cannot climb up the stem. If plants are staked, their aerial parts do not get into contact with the ground. If staking is not feasible, mulch with straw to avoid contact between fruit and soil.

8.5 Avoid practices and operations that transmit infection

Do not wound plants unnecessarily by slashing them with knives and machetes, or by breaking off branches. Clean or heat tools used for pruning and cutting to avoid transmitting the spores of microorganism clinging to the blades. This is particularly important for grafting and budding tools. Handle health plants as little as possible. Some diseases caused by microorganism are easily transmitted by contact. Fingers, clothes and tools can carry spores, which are then deposited on healthy plants. Be aware of irrigation water. Water is an important factor in the transmission of diseases in irrigated plants. Every effort must be made to prevent water flow, runoff and splash from infected plant parts to healthy ones. Use good soil cover to avoid splash (water hitting and bouncing off the ground) this is the most effective precaution. Also, try to irrigate at ground level rather than watering leaves above.

Avoid crop injury

Injury is often caused during spraying, weeding, harvesting, transportation of produce, in storage, in market and sowing. There is also damage by insects, nematodes, slugs (snails) and birds. Other damages difficult to

control include damage by hailstorms, wind, sunlight and frost. The damage creates wounds, which open avenue for infection particularly by secondary parasites.

Trap crops

Here you grow a plant whose root exudates will promote or stimulate the germination of propagules and before the propagules infect or multiply on the host you destroy the propagules off e.g. by cultivation. This method requires several crops for effective control.
One example is destroying root-knot nematode (Meloidogyne sp.) in pineapples by first growing several crops of tomatoes. Also Striga spp.a witch weed infecting and parasiting sorghum and maize is controlled by planting Sudan grass. Witch weed is stimulated to grow by Sudan grass but before the grass flowers it ploughed under and the germinating witch weed is starved. Later the main crop is planted.

8.6 Curative Crop Protection Methods

When a combination of disease management practices above has proved unsuccessful i.e. if it is forecasted disease infestation is going to cause 15% and above loss in yield (economic losses) then curative measures have to be resorted to. It then implies that curative measures are means of controlling the disease once it has already infested the crop.

See Herbal preparations chapter 7.4.

Photo source http://en.wikipedia.org/wiki/Tagetes_lucida
Mexican Marigold herbal preparations can be effective against caterpillars

9 Maintaining soil fertility in an organic cropping systems

Increased interest in organic crop production has been prompted by both consumer demand and the desire to sustain or improve the soil resource.

One of the many fundamental goals of organic farming is to produce a crop with minimal synthetic inputs. The main concept behind this approach is to conserve natural resources by relying more on biological processes within the soil system to recycle and release nutrients rather than provide high amounts of soluble nutrients from manufactured fertilizers.

9.1 Introduction

When any crop is sold, nutrients are lost from the farm. While many soils can supply nutrients for crop growth without fertilizer additions for many years, eventually the productivity of the farm will decrease unless the nutrients are replaced. A major challenge of managing soil fertility for organic food production is to integrate the input of nutrients from acceptable sources with the use of proper crop rotation. For animal farming

operations, this task is fairly straightforward. Farmers will grow and purchase feed for their operation, provide this feed to their animals, collect/compost the manure from the animals, and then apply the manure to appropriate crops. Legumes in association with nitrogen (N) fixing bacteria are used in the rotation to biologically fix Nitrogen from the atmosphere. These legumes can be used as feed for ruminant animals or as green manure. Deep-rooted legumes also can cycle nutrients from the subsoil to the soil surface. Grasses can also be used as forage and green manure crops to add organic matter and cycle nutrients from lower soil depths.

If livestock are not raised on a farm, nutrients from manure or other organic amendments/fertilizers need to be obtained externally. These organic fertilizers usually have a higher cost per unit of nutrient than synthetic fertilizer sources, which in turn will necessitate obtaining a higher price for the crop unless costs can be cut from other sectors of the operation. Legumes and other green manure crops can still be grown, although it may be more difficult to find room in the rotation if you do not have animals to feed. Forages can be grown as cash crops, but when sold off the farm large amounts of nutrients are exported and must be replaced. Organic crop producers must be creative in finding opportunities in their rotations to grow soil-building legumes and other green manure/cover crops. They need to carefully evaluate the cost of purchasing organic nutrient sources vs. the lost income from growing a non-cash crop.

9.2 Nutrient forms taken up by plants

The majority of nutrients must be dissolved in the soil solution before plant roots can take them up. If a fertilizer is applied to the soil, it must first be broken down to its simplest inorganic forms to be efficiently used by plants. Plant roots can absorb some larger organic molecules, but their rate of absorption is slow. From a plant root perspective, it makes little difference if the nutrient originally came from an organic or inorganic fertilizer.

Deciding required amendments

For any crop production operation (conventional or organic), decisions on what amendments to apply should be based on a soil test. A soil test should include pH, organic matter content, plant-available phosphorus (P), and available potassium (K) at a minimum. After a soil test is taken, adjust nutrient inputs based on test results and the crop to be grown. General recommendations for the amount of nutrients to apply based on the crop grown are provided with a soil test.

9.3 Nitrogen management

Of all the essential nutrients, N is the one that is usually most limiting for non-legume crop production and N is often the most difficult nutrient to manage in an organic system. The most common source of N for organic crop production is manure. Many different types of manure are available. The nutrient content of these manures will vary with the animal, bedding, storage, and handling. Although tables are available that have general analyses of manure nutrient content, the recommended method for determining how much manure to apply is to have it tested for nutrient content. Composted manure is the preferred manure source for organic production. Some restrictions apply to use of non-composted manure for organic certification.

9.3.1 Fresh versus composted manure

Fresh, non-composted manure will generally have a higher N content than composted manure. However, the use of composted manure will contribute more to the organic matter content of the soil. Fresh manure is high in soluble forms of N, which can lead to salt build-up and leaching losses if over applied. Fresh manure may contain high amounts of viable weed seeds, which can lead to weed problems. In addition, various pathogens such as *E. coli* may be present in fresh manure and can cause illness to individuals eating fresh produce unless proper precautions are taken.

The use of non-composted manure is prohibited in organic production. Composted plant or animal materials must be produced through a process that establishes an initial carbon-to-nitrogen (C:N) ratio of between 25:1 and 40:1 and achieves a temperature between 131°F and 170°F. Heat generated during the composting process will kill most weed seeds and pathogens. The microbially mediated composting process will lower the amount of soluble N forms by stabilizing the N in larger organic, humus-like compounds. A disadvantage of composting is that some of the ammonia-N will be lost as a gas. Compost alone also may not be able to supply

adequate available nutrients, particularly N, during rapid growth phases of crops with high nutrient demands. The decision on what form of manure to use will ultimately depend on certification requirements, availability, and cost. Composted manure is usually more expensive than fresh or partially aged manure.

9.3.2 Green manures/cover crops

Crops that are incorporated into the soil while still green are referred to as green manures. Cover crops are similar to green manures, but are usually grown to protect soil from erosion during the non-growing season. Because topsoil is higher in organic matter and nutrient content than subsoil, controlling erosion is an important method of conserving soil nutrients. Green manures and cover crops are both used to supply N and increase soil organic matter. Legumes such as Mucuna, jack bean and alfalfa can fix between 100 and 200 kg of N per acre in one year. The use of grasses without a legume will not increase the N content of the soil. These crops are used for increasing soil organic matter content. They can also scavenge residual N from the previous crop and keep it from being lost by leaching. A mixture of both grasses and legumes can be used to obtain the advantages of each. Improved soil tilth from added organic matter improves root growth, which increases the capacity of a crop to take up available soil nutrients. The decision to plant a green manure should take into account the cost of cultural practices (planting, cultivation) and seed, as well as the lost opportunity cost if the green manure is grown instead of a cash crop.

Some green manure crops accumulate high levels of Phosphorous (P) and are thought to increase P availability to subsequent crops by returning it to the soil in organic form. The benefit of these P accumulating crops will depend on the following crop and to what extent recycling of organic P increases P availability to them compared to inorganic soil Phosphorous.

9.4 Tropical green manures/cover crops

What are green manures/cover crops?

The terms "green manure" and "cover crops" originated from practices of using primarily leguminous plants and ploughing them under to fertilize soils. However, as the practice has spread to the tropics, different conditions have generated different uses, and the practice has changed.

The terms remain although many tropical farmers do not use the vegetation green, nor do they normally plough it under as one would a manure.

The terms now refer to a series of plants, mostly leguminous, which are used by farmers for a whole range of purposes, one of which is the fertilization and improvement of the soil by applying the vegetation to the soil surface. In the following, the term green manure is used to cover both green manure and cover crops.

Advantages of green manures

The proven advantages of green manures are numerous. The first six of those listed below would apply to virtually all leguminous green manures, while the last two would apply only to selected ones:

Accumulation of Organic matter

Green manures are capable of contributing up to (and occasionally more than) 50 tons/Ha (green weight) of organic matter to the soil during each application. This organic matter has a whole series of positive effects on the soil, such as improving its water-holding capacity, nutrient content, nutrient balance, friability and pH.

Addition of Nitrogen

This organic matter also adds significant quantities of nitrogen (N) to the farming systems. Common levels of fixed N reported are about 150 kg/Ha, with some species yielding even more. This means that farmers can, even allowing for significant loss of N to the air, add to their systems quantities of N that would cost them at least US $75/Ha if they were to use different forms of chemical fertilizer.

Reduced costs

These additions of organic matter and N are achieved with no transportation costs; they are produced right in the field. Green manures require no capital outlay once the farmer has purchased his/her first handful of seed.

Weed control

Green manures can also be an important factor in reducing weed control costs, especially when used as mulch. Thus, the use of green manures does not only reduce the use of chemical fertilizer, it can also reduce or

eliminate the use of herbicides. Farmers using mucuna species have successfully controlled spear grass (Imperata cylindrica) from their fields.

Soil Cover

The soil cover provided by many green manures can be very important for soil conservation. A careful study has shown that farmers cultivating mono-cropped maize on 35% slopes with 2000+ mm rainfall in northern Honduras are actually INCREASING the productivity of their soil year by year, with no conservation practices except for the fact that the soil is covered by velvet bean ten months of the year.

9.5 Transition to zero-till

The use of green manures allows farmers to switch to zero-till systems while maintaining productivity on land. Since plowing and weeding are two heavy operations that have always provided a major advantage to those farmers capable of mechanizing their agriculture, and since green manures are often capable of eliminating both of these operations, it is quite possible that non-mechanized and/or hill-side farmers once again have the chance of competing with their wealthier, mechanized competitors.

Each of these advantages should be analysed and weighed when we choose green manures. It is quite infrequent that farmers are primarily attracted by the green manure's ability to increase soil fertility. Much more commonly, farmers are motivated by the green manure's multiple uses, for human food, weed-control capabilities, or the possibility of no longer having to till the soil.

The Disadvantages

***Opportunity cost**:* Farmers will not plant green manure where they could plant either subsistence or cash crops. This means that the land they use to grow green manure must have no known opportunity cost.

***Long term results**:* The improvement of the soil is a long-term factor which is not immediately noticeable to the farmer. Usually, significant improvement in productivity does not occur until after incorporation, which means visible results are not apparent until well into the second cropping cycle or second year. This slow appearance of a result, that is difficult to believe any way, complicates the adoption of green manures.

***Potential destruction**:* Often green manures must either continue to grow or form mulch during the dry season. Grazing animals, agricultural burning, termites and a host of other problems may prevent their lasting very long during this period.

Susceptibility to environmental conditions

Conditions such as extreme drought, extreme infertility, extremes in pH, severe drainage problems, and other problems common on poorer village farms, will affect green manures almost as much as traditional crops, thereby reducing the impact of green manures. Often solutions to these problems are achieved at the cost of reduced biomass production, reduced N fixation, and/or reduced number of niches in which the green manures can fit.

9.6 Promising cover crop/ Green manure species

Although these species are the best known to date, we should all be constantly looking for alternatives.
For low elevations (0-1500 meters) or warm weather:

1) Velvet bean (Mucuna pruriens) This is by far the most popular of the green manures used by development programs worldwide and for good reasons. Of the legumes, it is one of the best N-fixers (150 kgs/Ha), and one of the best weed suppressors. It grows well in very poor soil and resists both drought and heavy rains quite well. Its biggest problems are that it is an aggressive climber (must be pruned often, or associated with maize, and cannot be grown at all among shorter-stature crops); it is not advisable for human consumption; and the seed must be boiled for most animal consumption.

2) Lablab bean (Dolichos lablab, or Lablab purpureum, also widely known in Asia as "hyacinth bean"). The lablab bean has a whole series of advantages over the velvet bean. It is edible and good tasting without any special processing; it grows just as well as the velvet bean and produces nearly as much biomass. It is the palatable for animals of all the green manures we use, with a 23% protein content. It is perennial; often staying green and producing seeds through four or five months of drought. It is significantly more drought-tolerant

than the velvet bean. Nevertheless, in some cases (perhaps in the absence of rhizobia bacteria) the lablab bean has been fairly demanding of good soil fertility, and in others has suffered insect attacks that have significantly retarded biomass production.

3) Jack beans (Canavalia ensiformis) or Sword beans (C. gladiata). By far the jack bean is the most hardy of the known green manures. It will grow where either the climate is so dry or the soils so poor that virtually nothing else will grow. For either of these conditions, it is an excellent beginning green manure. It also fixes more N than the velvet bean (230 kgs/ha) and is perennial. And the tender pods can be eaten like string beans. Furthermore, there are both bushy and climbing varieties, although all the bushy varieties we know of do some climbing when grown under shade. However, jack beans produce about 10% less biomass than velvet bean and do not control weeds as well, unless very closely planted. Jack beans plants and seeds are not palatable for animals, nor is it advisable to use jack beans for human consumption.

10 Conservation Agriculture

Conservation Agriculture (CA) can be defined as a resource-saving agricultural production system that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. Conservation agriculture is based on the principles of rebuilding the soil, optimizing crop production inputs, including labour and optimizing profits.

Unlike conventional agriculture, which is based on maximizing yields while exploiting the soil and agro-ecosystem resources, CA is based on optimizing yields and profits, to achieve a balance of agricultural, economic and environmental benefits. Conservation agriculture is the integration of ecological management with modern, scientific, agricultural production. This holistic embrace of knowledge, as well as the capacity of farmers to apply this knowledge and innovate and adjust to evolving conditions, ensures the sustainability of those who practice CA.

CA emerged as an alternative to conventional agriculture as a result of losses in soil productivity due to soil degradation (e.g. erosion and compaction). CA aims to reduce soil degradation through several practices that minimize the alteration of soil composition and structure and any effects upon natural biodiversity. A major strength of CA is the step-wise implementation by farmers of complementary, synergetic soil husbandry practices that build to a robust, cheaper, more productive and environmentally friendly farming system. These practices coalesce into a system that is more sustainable than conventional agriculture because of the focus of producing with healthy soils.

10.1 Conservation tillage

Conservation tillage should not be confused with conservation agriculture. Conservation tillage refers to a set of practices that leave crop residues on the surface, which increases water infiltration and reduces erosion. It is a practice used in conventional agriculture to reduce the effects of tillage on soil erosion. It still depends however on tillage as the structure forming element in the soil. Conservation tillage practices such as zero tillage can be good transition steps towards Conservation Agriculture.

Tillage and current agricultural practices result in the decline of soil organic matter due to increased oxidation over time, leading to soil degradation, loss of soil biological fertility and resilience. Although soil organic matter (SOM) mineralization resulting from tillage liberates nitrogen and can lead to improved yields over the short term, there is always some mineralization of nutrients and loss by leaching into deeper soil layers. This is particularly significant in the tropics where organic matter reduction is processed more quickly, with low soil carbon levels resulting only after one or two decades of intensive soil tillage. Zero-tillage, on the other hand, combined with permanent soil cover, has been shown to result in a build-up of organic carbon in the surface

Conservation agriculture promotes a series of principles to achieve conservation objectives, rather than a particular technology. This is in recognition of the fact that global agriculture is practiced in many different ecosystems, and technologies have to be carefully tailored suit particular situations in order to be successful.

10.2 Principles of conservation agriculture

The three basic principles of Conservation Agriculture (CA) are:

1. Practicing minimum mechanical soil disturbance

This is essential to maintaining minerals within the soil, stopping erosion, and preventing water loss from occurring within the soil. Continuous tilling of soil can cause severe erosion and crusting of soils, which will lead to a decrease in soil fertility. Soil organic matter can be destroyed by exposure to the sun. Although ploughing increases the amount of oxygen in the soil and increases the aerobic processes, hastening the breakdown of organic material, at the same time, the soil is depleted more quickly of its nutrient reserves.

2- Protecting the soil with a permanent soil cover

This principle concerns managing the topsoil to create a permanent organic soil cover that supports sustainable organic matter accumulation and growth of organisms within the soil structure. These are the soil organisms, which break down the mulch that is left on the soil surface. The breaking down of this mulch produces a high organic matter level, which rejuvenates soil fertility within the soil surface. Implementation of this principle has a cumulative effect if practiced for many years, generating good amounts of organic matter built up at the surface. The accumulated organic matter helps in preventing soil erosion.

3. Practice of crop rotation with more than two crop species

The foundation for crop rotation lies in the fact that as crops grow; they each demand and draw different sets of nutrients from the soil, and in different quantities. This means that when a particular crop species is grown on the same piece of land for several consecutive seasons, chances are that with time production of the crop is significantly reduced as depletion of the nutrients necessary for the expected or potential yield occurs. Whereas cereals are heavy phosphorus and nitrogen feeders, some crops like legumes have the capacity to enhance soil nitrogen content through natural capture of atmospheric nitrogen and fixing it the soil. The fixed nitrogen may become available for the proceeding crop, thus increasing its productivity.

Crop rotation also plays a major role in breaking pest cycles and reducing the prevalence of soil borne disease-causing organisms by breaking their feeding and reproductive cycles. This significantly influences the rate of growth of pests and pathogens, and their potential challenge to crops. The basis of this is the fact that in the absence of a host plant, disease-causing organisms either hibernate or die of starvation. Crop rotation can also help build up a soil's infrastructure. Establishing crops in a rotation allows for an extensive build up of rooting zones, which will allow for better water infiltration.

10.3 Practical implementation of conservation agriculture

Conservation agriculture emphasizes that the soil is a living body, essential to sustain quality of life on the planet. In particular, it recognizes the importance of the upper 0-20 cm of soil as the most active zone, but also the zone most vulnerable to erosion and degradation. Most environmental functions and services that are essential to support terrestrial life on the planet are concentrated in this zone. It is also the zone where human activities of land management have the most immediate, and potentially the greatest impact. By protecting this critical zone, we ensure the health, vitality, and sustainability of life on this planet.

10.3.1 Maintaining permanent soil cover

CA maintains a permanent or semi-permanent organic soil cover consisting of a growing crop or dead mulch. Surface mulch helps reduce water losses from the soil by evaporation and also helps moderate soil temperature. This promotes biological activity and enhances nitrogen mineralization, especially in the surface layers. Research has shown that bacteria, fungi, earthworms and nematodes are higher in residue-mulched fields than those where the residues were incorporated into the soil. Another function of the organic cover is to physically protect the soil from impact of the sun, rain and wind and to feed soil microorganisms. The soil cover also helps to enhance soil and water conservation and control soil erosion. Keeping a permanent soil cover improves soil aggregation, soil biological activity and soil biodiversity, water quality, and increases soil carbon sequestration. Ground cover promotes an increase in biological diversity not only below ground but

also above ground. The number of beneficial insects has been noted to be higher where there is ground cover and mulch, a condition that helps keep insect pests in check.

Maintaining a permanent soil cover also enhances water infiltration, improves soil water use efficiency, and provides for increased insurance against drought. Permanent soil cover can be maintained during crop growth phases as well as during fallow periods, using cover crops and maintaining residues on the surface. Examples of cover crops include the velvet bean, Jack beans, sunn hemp.

Photo (source WECF, Samwel). CA maintains a permanent or semi-permanent organic soil cover consisting of a growing crop or dead mulch

Under conservation agriculture, a healthy, living soil should be maintained through crop rotations, cover crops, and the use of integrated pest management technologies. These practices reduce requirements for pesticides and herbicides, control off-site pollution, and enhance biodiversity. The objective is to complement natural soil biodiversity and to create a healthy soil microenvironment that is naturally aerated. Such a soil is in a better position to receive, hold and supply soil water and nutrients and support enhanced nutrient cycling as well as decomposition and mitigation of pollutants. Crop rotation can be in the form of crop sequences, relay cropping, and mixed cropping.

10.3.3 Balancing inputs with crop requirements

Conservation agriculture promotes application of fertilizers, pesticides, herbicides, and fungicides in balance with crop requirements. Feed the soil rather than fertilize the crop. This will reduce chemical pollution, improve water quality, and maintain the natural ecological integrity of the soil, while optimizing crop productivity and economic returns.

10.3.4 Precision placement of inputs

Conservation Agriculture promotes precision placement of inputs to reduce costs, optimize efficiency of operations, and prevent environmental damage. Treat problems at the field location where they occur, rather than blanket treatment of the field, as with conventional systems.

10.3.5 Promoting legume fallows and organic soil amendments

Promoting legume fallows (including herbaceous and tree fallows where suitable), composting and the use of manures and other organic soil amendments, forms a part of practical conservation implementation. This improves soil structure and biodiversity, and reduces the need for inorganic fertilizers.

10.3.6 Promoting agroforestry for timber, fruit and medicinal purposes

Agroforestry (trees on farms) provides many opportunities for value added production, particularly in tropical regions, but these technologies are also used as living contour hedges for erosion control, to conserve and enhance biodiversity, and to promote soil carbon sequestration, as well as on farm fuel wood resources.

10.4 Benefits of conservation agriculture

Most of the agricultural benefits of zero tillage relate to increased organic matter in the soil. This results from the combination of eliminating soil disturbance in conventional tillage, increased biomass from improved crop yields, greater diversity of types of organic matter from increased rotation and cover crops, reduced erosion and differences in the assimilation and decomposition of soil organic matter from reduced surface soil temperatures and increased biodiversity.

There are many benefits of CA that can be reaped, but farmers should understand that these benefits are long term. They may not be evident during the first season, but they build up continuously following the second year. CA is shown to have even higher yields and higher outputs than conventional agriculture once CA has been establish over long periods of time. As long as good soil management is observed then the soil will continue to renew itself. This could be very beneficial to a farmer who is practicing CA and intends to keep his soil at a productive level for an extended period of time.

Benefits of Conservation Agriculture (CA) include:

- Reduced soil erosion
- Increase in organic matter
- Better water conservation
- Improved biodiversity in a given area
- Conserving, improving and making more efficient use of natural resources
- Improvement in air quality due to less emission being produced
- Improved soil structure and rooting
- Reduced production costs for a certain crop, as well as farm labour requirement
- Reduced use of fossil fuels, pesticides, and other pollutants

10.5 Examples of conservation tillage techniques

In Conservation Agriculture there are many examples that can be emulated. Residue-based zero tillage with direct seeding is perhaps the best example of CA, since it avoids the disturbance caused by mechanical tillage. A varied crop rotation is also important to avoid disease and pest problems.

Some examples of CA techniques include the ones listed below.

1. Direct sowing/direct drilling/no-tillage

The soil remains undisturbed from harvest to planting except for nutrient injection. Planting or drilling takes place in a narrow seedbed. Weed control is primarily by herbicides with little environmental impact. Cultivation is a possibility for emergency weed control. This strategy is the best option for annual crops.

2. Ridge-till

The soil remains undisturbed from harvest to planting except for nutrient injection. Planting takes place in a seedbed prepared on ridges. Residue is left on the surface between ridges. Weed control is by herbicides and/or cultivation. Ridges are rebuilt during cultivation.

3. Mulch till/reduced tillage/minimum tillage

The soil is disturbed prior to planting. Tillage tools such as chisels, field cultivators, disks, sweeps or blades are used. Weed control is by herbicides and/or cultivation. In non-inversion tillage, soil is disturbed (but not inverted) immediately after harvest to partially incorporate crop residues and promote weed seed germination to provide soil cover during the intercrop period. These weeds are later chemically destroyed (using herbicides) and incorporated at sowing, in one pass, with non-inversion drills.

4. Cover crops

Sowing of appropriate species, or growing spontaneous vegetation, in between rows of crops, trees, or in the period of time in between successive annual crops, as a measure to prevent soil erosion and to control weeds. A cover crop and the resulting mulch or previous crop residue help reduce weed infestation through competition and not allowing weed seeds the light often needed for germination.

Zero tillage in Argentina

11 Gender in agriculture

Introduction

Both women and men play critical roles in agriculture throughout the world, producing, processing and providing food that is consumed domestically and internationally. In many parts of the world today, there is an increasing trend towards what has been termed the 'feminization of agriculture'. War, sickness, death from HIV/AIDS and migration of men from rural areas to towns and cities in search of paid employment have reduced the male populations that are engaged in agriculture.

Gender inequalities are a major explanatory factor for the poor performance that is observed in the agricultural sector and consequently the high poverty levels in some parts of the country and among certain socio-economic groups.

11.1 Definition of gender

What is gender?

Gender (as defined by FAO1997) refers to the relations between men and women, both perceptual and material. Gender is not determined biologically, as a result of sexual characteristics of either women or men, but is constructed socially. Gender is a central organizing principle of societies, and often governs the processes of production and reproduction, consumption and distribution. Gender issues focus on the relationship between men and women, their roles, access to and control over resources, division of labour, interests and needs. Gender relations affect household security, family well-being, planning, production and many other aspects of life

Gender awareness

Gender awareness is the ability to view society from the perspective of gender roles and how this has affected women's needs in comparison to the needs of men. Gender sensitivity is translating this awareness into action in the design of development policies, programs and budgets.

Gender Equality

The term gender equality has been defined in a variety of ways in the context of development, which means gender equality in terms of equality under the law, equality of opportunity (including equality of rewards for work and equality in access to human capital and other productive resources that enable opportunity), and equality of voice (the ability to influence and contribute to the development process). It stops short of defining gender equality as equality of outcomes for two reasons. First, different cultures and societies can follow different paths in their pursuit of gender equality. Second, equality implies that women and men are free to choose different (or similar) roles and different (or similar) outcomes in accordance with their preferences and goals.

Gender inequalities exert high human costs and constrain the development of countries. These consequences provide a compelling case for public and private action to promote gender equality. The state has a critical role in improving the well-being of both women and men and, by so doing, in capturing the substantial social benefits associated with improving the absolute and relative status of women and girls. Public action is particularly important, because social and legal institutions that perpetuate and are responsible for gender inequalities are extremely difficult, if not impossible, for individuals alone to change. Market failures, too, mean insufficient information about women's productivity in the labour market (because they spend a greater part of their work hours in non-market activities or because labour markets are absent or undeveloped) and are clear obstacles.

Improving the effectiveness of societal institutions and achieving economic growth are widely accepted as key elements of any long-term development strategy. However successful implementation of this strategy does not guarantee gender equality. To promote gender equality, policies for institutional change and economic development need to consider and address prevailing gender inequalities in rights, resources, and voice. And active policies and programs are needed to redress longstanding disparities between women and men. The evidence argues for a three-part strategy for promoting gender equality (**Rights**, **Resources** and **Voice**).

11.2 Women empowerment

This is defined as women's level of control in decision-making positions, for control over the allocation of resources, the determination of policy, regulations and laws. At the level of the society or the nation, women's empowerment is here measured in terms of the level of women's representation in higher level decision making positions in public institutions.

This is a rather rough measure of women's empowerment: firstly it is concerned only with national level decision-making, and secondly it overlooks the problem that some women may occupy public office without actually exercising power ('token women'). By the same token it overlooks the likelihood that some women are actually in background positions, which might actually be very important in determining public policy. These limitations are typical of the price paid by using simple 'surface' quantitative indicators of gender gaps, without looking more deeply into the underlying structure.

11.2.1 Women empowerment versus women self-reliance

There is need to distinguish between women's empowerment and women's self-reliance. Women's self-reliance may be defined in terms of the individual woman's ability to gain access to resources, and to take decisions affecting her own personal life. This is often, by mistake, termed 'empowerment' or 'personal empowerment'. The level of women's self-reliance, relative to men, may be measured by such indicators as levels of literacy and education, skills training, ownership of land and capital, and access to credit.

Women's level of self-reliance is a measure of the extent to which women are in a position to maximise their well-being, and control over their lives, within the existing structure of gender inequality. By comparison, women's level of collective empowerment is a measure of the extent to which women occupy higher levels of decision making in society, so that they are in a position to challenge and change present structures of gender inequality. The common failure to distinguish between empowerment and self-reliance, and the consequent

inter-changeable use of these terms, leads to a failure to distinguish between two quite different forms of women's advancement.

GROUP WORK (4 groups):

Create an informative poster that reflects and graphically explains a gender case, responding to the following questions:

- Identify a gender case that uplifts the status of women as far as decision making is concerned/ Identify a gender case that undermines the status of women/men as far as decision making is concerned
- State its area of location (district/sub-county)
- What are the most interesting aspects of this case in terms of gender and/or women?
- What are the roles or positions of women and men in the case?
- What are the benefits/challenges for women and men in the case?
- What is the objective of the case vis a vis gender?
- What are the most interesting factors?

11.3 Gender inequality in agriculture

Land ownership and use rights

Land in Uganda is highly concentrated and unequally distributed across the regions, between income groups and by gender. There are deeply rooted gender biases in land ownership rights: male-headed households hold and control 80% to 90% of the ownership rights of the land available in Uganda.

Involvement in agricultural activity

Women carry out the bulk of farming activities on farms. In most districts, the male-headed households act as employers within the agricultural sector while female-headed households work on their own farms or are employees.

Crop Production Bias

More male-headed households tend to grow high value commodities such as rice, pineapples, oranges, cabbages and tomatoes, compared to female-headed households. Female-headed households tend to grow food crops. In some regions high value crops (cash crops) have been unanimously assigned to men (male crops), while low value crops (sweet potato, cassava) have been assigned to women (low value crops).

Use of agricultural inputs

The use of improved agricultural inputs is generally limited among all households in Uganda. The main reasons for non-use of improved agricultural inputs were presented as lack of knowledge about the inputs, being too expensive and non-availability. Gender aspects indicate however, that more men farmers have access to agricultural inputs than women farmers.

Livestock ownership

About half of the farming households in Uganda are involved in animal husbandry. Both male and female-headed households are engaged in animal husbandry, but the proportion of male-headed households owning livestock far exceeds that of female-headed households with livestock in all districts.

Access to Agricultural extension services

The 2005/06 Uganda National Housing Survey (UNHS) indicated that the majority of households in Uganda lacked access to extension services. The proportion of households that had never received crop agricultural services however, was higher for female-headed households. In some regions (North and eastern), there are glaring differences where male-headed households have higher access to agricultural extension services than female-headed households. Even within one household, men are more likely to receive direct extension messages or training than women.

Market availability

Although there is no purposive gender discrimination by buyers, women face more challenges in marketing their agricultural produce, compared to men. (Discuss)

11.4 Gender roles within the household

In every community there are defined roles for men and women. Research findings show that women have the prime responsibility for domestic duties and food production while men spend more time on productive activities or at leisure. Both women and men contribute to agricultural production, with the women playing a larger role and in most cases entirely responsible for food production. Women were found to be responsible for small-scale livestock rearing while men cared for the larger livestock, particularly cattle.

Group work (4 groups): Create an informative poster that reflects roles and responsibilities of men and women in a farming household. What do you think should be changed and why?

11.5 Gender mainstreaming

Mainstreaming gender is the process of assessing the implications for women and men of any planned action, including legislation, policies or programs, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programs in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is to achieve gender equality. Gender mainstreaming involves bringing the contribution, perspectives and priorities of both women and men to the centre of attention in the development arena in order to inform the design, implementation and outcomes of policies and programs. It is a critical strategy not only in the pursuit of gender equality – a development goal in its own right – but also in the achievement of other development goals, including economic ones. Indeed, overlooking relevant gender factors in macroeconomic policies and institutions can undermine the successful outcome of those very same policies and institutions".

"Mainstreaming" is a process rather than a goal that consists in bringing what can be seen as marginal into the core business and main decision-making process of an organization. It involves incorporating equal opportunities for women and men into all Community policies and activities. Efforts to integrate gender concerns into existing institutions of the mainstream have little value for their own sake. A gender perspective is being mainstreamed to achieve gender equality and improve the relevance and effectiveness of development agendas as a whole, for the benefit of all women and men.

Mainstreaming includes gender-specific activities and affirmative action, whenever women or men are in a particularly disadvantageous position. Gender-specific interventions can target women exclusively, men and women together, or only men, to enable them to participate in and benefit equally from development efforts. These are necessary temporary measures designed to combat the direct and indirect consequences of past discrimination.

Transformation by Mainstreaming

Mainstreaming is not about adding a "woman's component" or even a "gender equality component" into an existing activity. It goes beyond increasing women's participation; it means bringing the experience, knowledge, and interests of women and men to bear on the development agenda.

It may entail identifying the need for changes in that agenda. It may require changes in goals, strategies, and actions so that both women and men can influence, participate in, and benefit from development processes. The goal of mainstreaming gender equality is thus the transformation of unequal social and institutional structures into equal and just structures for both men and women.

The basic feature of the principle of 'mainstreaming' is the systematic consideration of the differences between the conditions, situations and needs of women and men in all Community policies and actions. This does not mean simply making community programmes or resources more accessible to women, but rather mobilizing concerted efforts to build balanced relationships between women and men.

Basic Principles of Gender Mainstreaming

The responsibility for implementing the mainstreaming strategy is system-wide, and rests at the highest levels within agencies. These principles include:

- Establish adequate accountability mechanisms for monitoring progress Initial identification of issues and problems across all area(s) of activity such that gender differences and disparities can be diagnosed.
- Assumptions that issues or problems are neutral from a gender-equality perspective should never be made.

- Gender analysis should always be carried out.
- Clear political will and allocation of adequate resources for mainstreaming, including additional financial and human resources if necessary
- Gender mainstreaming with efforts to broaden women's equitable participation at all levels of decision-making
- Mainstreaming does not replace the need for targeted, women-specific policies and programmes, and positive legislation; nor does it do away with the need for gender units or focal points.

Gender mainstreaming involves a number of activities

- Forging and strengthening the political will to achieve gender equality and equity, at the local, national, regional and global levels;
- Incorporating a gender perspective into the planning processes of all ministries and departments of government, particularly those concerned with macroeconomic and development planning, personnel policies and management, and legal affairs;
- Integrating a gender perspective into all phases of sectorial planning cycles, including the analysis, development, appraisal, implementation, monitoring and evaluation of policies, programmes and projects;
- Using sex-disaggregated data in statistical analysis to reveal how policies impact differently on women and men;
- Increasing the numbers of women in decision-making positions in government and the private and public sectors;
- Providing tools and training in gender awareness, gender analysis and gender planning to decision-makers, senior managers and other key personnel; and
- Forging linkages between governments, the private sector, civil society and other stakeholders to ensure a co-ordination of efforts and resources.

Because gender mainstreaming is a broad-spectrum strategy that cuts across government sectors and other social partners, it requires strong leadership and coordination.

The four important elements in transforming gender blind organizations into gender responsive ones are:

1. Political Will – evidence when top-level leadership publicly support gender integration, effectively communicate the organization's commitment to gender equity, commit staff time and financial resources, and institute needed policies and procedures.
2. Technical Capacity – evidenced in increased staff skills in gender analysis, adoption of new systems for gender disaggregated data, and the development of gender-sensitive tools and procedures
3. Accountability – evidenced in institutional incentive and requirement systems that encourage and reinforce behaviours within individuals and within organization as a whole
4. Organizational Culture – evidenced in a gender-balanced staff, a gender sensitive governance structure, and the equal valuing of women and men's working styles.

12 Further readings

IFOA*M* Training manual for Organic Agriculture in the Tropics. Downloadable at http://www.s-ge.com/sites/default/files/IFOAM%20Training%20Manual%20for%20Organic%20Agriculture%20in%20the%20Tropics.pdf

Organic Africa website: http://www.fibl.org/en/media/media-archive/media-archive11/media-release11/article/african-organic-agriculture-training-manual-implementation-in-africa-begins.html

FAO . Conservation Agriculture, a manual for Farmers and Extension Workers in Africa http://www.fao.org/ag/ca/AfricaTrainingManual.html

WECF Netherlands

Korte Elisabethstraat 6
NL - 3511 JG Utrecht
Phone: +31-30-2310300
Fax: +31-30-2340878

WECF Germany

St.-Jakobs-Platz 10
D - 80331 Munich
Phone: +49-89-23239380
Fax: +49-89-232393811

WECF France

Cité de la Solidarité Internationale
13 avenue Emile Zola
F - 74100 Annemasse
Phone: + 33 (0) 450 834 810