SUSTAINABLE LAND MANAGEMENT PROGRAM (SLMP)
TRAINING SERIES

14

FIELD GUIDE TECHNICAL IMPLEMENTATION

INTEGRATED SOIL FERTILITY MANAGEMENT



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INTRODUCTION AND PURPOSE OF THE GUIDE

Declining soil fertility is a threat to the livelihood of millions of African farmers. A lot of research has been undertaken on improving soil fertility, but in many countries there has been limited impact at farmers' level. What is needed is an effective extension strategy to help farmers understand their soils and, how to initiate a programme of integrated soil fertility management that will increase yields profitability and sustainably.

The Guide is designed to firstly raise awareness among farmers about soil fertility problems, secondly, how different measures can be used in an integrated approach, and thirdly, how to try, monitoring and evaluating different practices. Understanding the key physical and biological features of soils is essential for developing sustainable improvement strategies. Helping farmers to gain and improve their knowledge will enable them to make conscious choices for how to manage their soils, their crops and their livestock.

The Guide is a resource for use by extension workers in raising awareness, joint learning, planning, implementation, and monitoring and evaluation activities by farmers of integrated soil management practices suitable to their situation.

Those farmers participating in the activities will receive certificates and be encouraged to participate in farmer-to-farmer extension activities.

About ISFM+

The Integrated Soil Fertility Management Project (ISFM$^+$) is funded by the German Federal Ministry of Economic Cooperation and Development, through the Special Initiative 'One World - No Hunger (SEWOH)'. The key institutional partner of ISFM$^+$ is the 'Soil Fertility Improvement Directorate' of the Ethiopian Ministry of Agriculture and Natural Resources.

ISFM$^+$ is a component project of the GIZ contribution to the Sustainable Land Management Programme (GIZ-SLM). It is a three year initiative (Jan 2015 to Dec 2017) with the objective to 'promote integrated soil fertility management approaches in Tigray, Amhara and Oromia'.

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Ministry of Agriculture
Addis Ababa, Ethiopia

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HOW TO USE THIS GUIDE

This Integrated Soil Fertility Management Guide and Picture Series are based on the ISFM Technical Manual and designed as an extension tool for use with groups of 10–15 farmers. These could be groups of men, women and young people either on their own or as mixed groups. In all cases their active participation in discussion should be encouraged.

Extension workers should use the pictures and questions in the Guide, combined with others of their own, acting as *facilitators*, rather than *teachers*. In doing so, enough time should be given to allow the farmers to reflect, question and answer. In this way, farmers will be encouraged to learn, exchange their own experiences and try out different or experiment with practices that will enable them to determine their own way of improving the fertility of their soils.

The Guide uses a series of pictures, photos and illustrations as visual aids that are attractive, relatively low-cost, transportable, easy to reproduce, and can be adapted to local needs. The pictures can be attached to any suitable material, such as a board or a wall.

There are notes written on the back of each picture to help during discussions. However the information should be developed interactively, through questions and answers. Some technical understanding is essential but this may not always be mentioned by the farmers. Therefore, these items will have to be explained. This will require some preparation by extension staff, because only a short explanation is provided on the back of the pictures.

The Guide has a series of topics with pictures to be used during the discussions with farmers. These include those for awareness creation, soil improvement, trying preferred practices, as well as monitoring and evaluation activities.

Table 1: List of Pictures

Topic	Picture No	Total
SECTION 1: AWARENESS CREATION		
Soil health, crop health and human health	1	1
Healthy agriculture, healthy people	2-3	2
What is a healthy soil	4	1
Reasons for poor and healthy crops	5-6	2
Soil fertility problems (*erosion, organic matter, acidity and nutrients)*	7-12	6
Movement of nutrients around the farm	13	1
The need for integrated approaches	14	1

SECTION 2: SOIL IMPROVEMENT OPTIONS		
Improving soil organic matter	15-16	2
Making compost	17-18	2
Rapid composting	19-20	2
Vermi composting	21-23	3
Making manure	24-26	3
Applying compost and manure	27	1
Crop rotations and intercropping	28-33	6
Nitrogen fixing and seed inoculation	34-35	2
Green manures and cover crops	36-37	2
Push-pull	38	1
Agro-forestry practices	39-41	3
Mulching	42-43	2
Addressing soil acidity	44-45	2
Combining organic and inorganic fertilisers	46-47	2
Reduced and zero tillage	48-49	2
SECTION 3: PLANNING AND TESTING DIFFERENT PRACTICES		
Combining different practices	50	1
Agreeing options to test, monitor and evaluate	51-53	3
Benefits from integrated soil fertility management	54-56	3
Total	**-**	**56**

The three sections, i) awareness creation, ii) soil improvement options and, iii) planning and testing different practices, could be addressed on three separate days. Discussions on each day should not exceed 2-3 hours and be held at a time suitable for farmers.

As each section topic is introduced, the pictures relevant to that topic should be fixed onto a board or wall, ensuring that everybody can see them. Before starting a new topic, pictures from the previous topic should be removed.

Before starting the topic, ask a farmer to be your assistant to hold the pictures, attach them to the board and later remove them.

After a welcome, explain to the participants that the discussions are going to be based on:

- Awareness raising on soils, linking healthy soils with healthy crops and healthy people
- The main soil problems found in the area
- Methods by which soil fertility can be improved
- Planning for and testing farmer preferred options.

Please explain that the farmers' active participation is expected.

Several times during the discussions, ask questions to make sure that participants have understood. If necessary, any issue in doubt should be explained and discussed again.

There are brochures for distribution to farmers that compliment this guide on each soil fertility practice

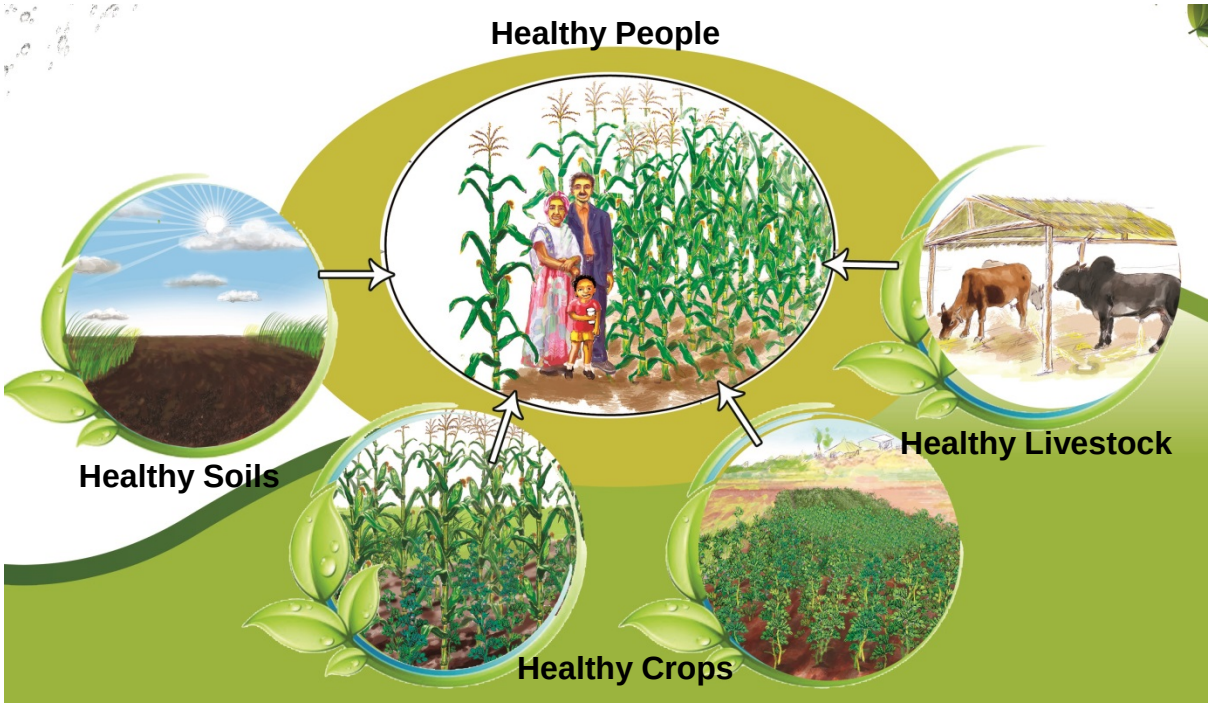
SECTION 1: AWARENESS CREATION

SOIL HEALTH, CROP HEALTH AND HUMAN HEALTH

Explain using Picture 1

Some farmers describe the health of the soil as “the power of the soil”. The concept is similar with animals. If a cow is healthy and fertile, it will produce many calves. The same applies to the soil. A healthy soil with will produce healthy crops and high yields. Healthy crops will produce healthy people.

Picture 1: Healthy people require healthy soil, crops and livestock



DISCUSSION BASED ON THESE QUESTIONS

i) <u>Do you think there is a connection between healthy people and healthy soils?</u>

EXPLAIN: People require a variable and nutritious diet to remain healthy, just as plants require different nutrients, moisture, sun and air to be healthy. The nutrients and moisture for healthy crops are derived from the soil.

ii) <u>Do you think there is a connection between healthy people and healthy crops?</u>

EXPLAIN: People require different types of food (nutrients) to grow. Different parts of the body require different nutrients and these come from the food we eat. All of these come from the plants and animals that we eat. If we eat an unbalanced diet, our children will be stunted and we will not be healthy. We need to eat a variety of crops, which need to be grown on healthy soils that are rich in nutrients.

iii) <u>Do you know what makes a plant healthy</u>

EXPLAIN: Apart from moisture, sun and air, plants need a balanced supply of nutrients which come from the soil. The main ones are Nitrogen, Phosphate and Potash, but other nutrients are also needed, such as Sulphur, Iron, Zinc and Boron. If the soil does not have these, plants will not be healthy and our bodies will not be healthy.

HEALTHY AGRICULTURE, HEALTHY PEOPLE

Explain using Pictures 2 and 3

People need a range of nutrients – the main ones are carbohydrates, proteins and fats and minerals and vitamins. We obtain these by eating a diverse diet because no one food supplies all the nutrients we need. The healthiest diets include a mix of cereals, legumes, fruits, vegetables, fats and animal foods.

Picture 2: Effects of soil and crops on nutrition and human health

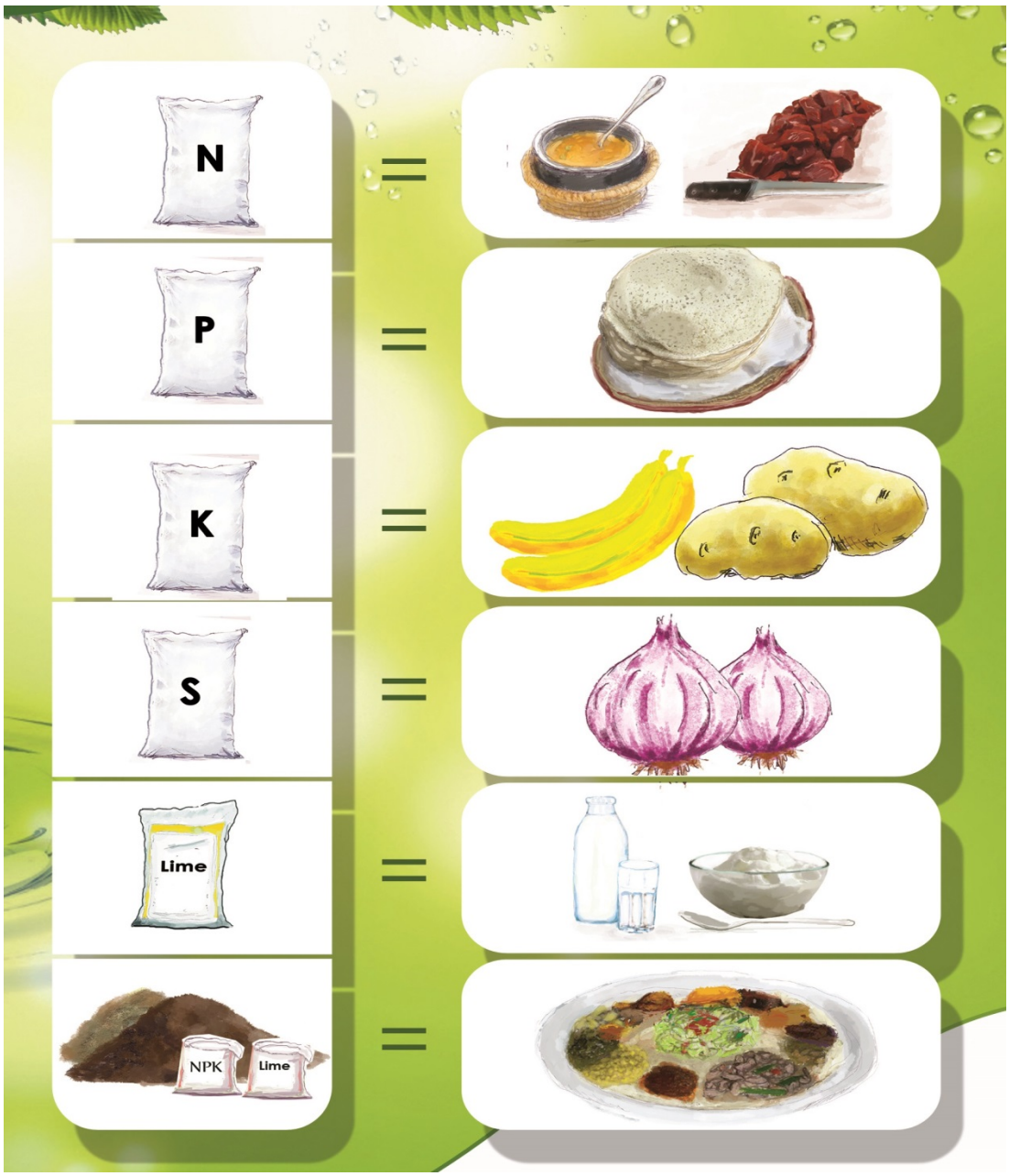
QUESTION

i) <u>Why do we need to grow a wide variety of crops?</u>

EXPLAIN: Eating a diverse diet makes sense for human nutrition and growing a diverse range of crops and maintaining a crop rotation helps to ensure healthy plants and healthy soils

- Growing a diverse range of crops also helps to build resilience against shocks such as drought, pests and diseases.

Picture 3: Basics of crop and human nutrition



QUESTION

ii) <u>What foods do people need to be healthy?</u>

EXPLAIN: To get good **quality protein** we need to combine a cereal with a legume, such as injera with shiro-wat, or consume animal foods.

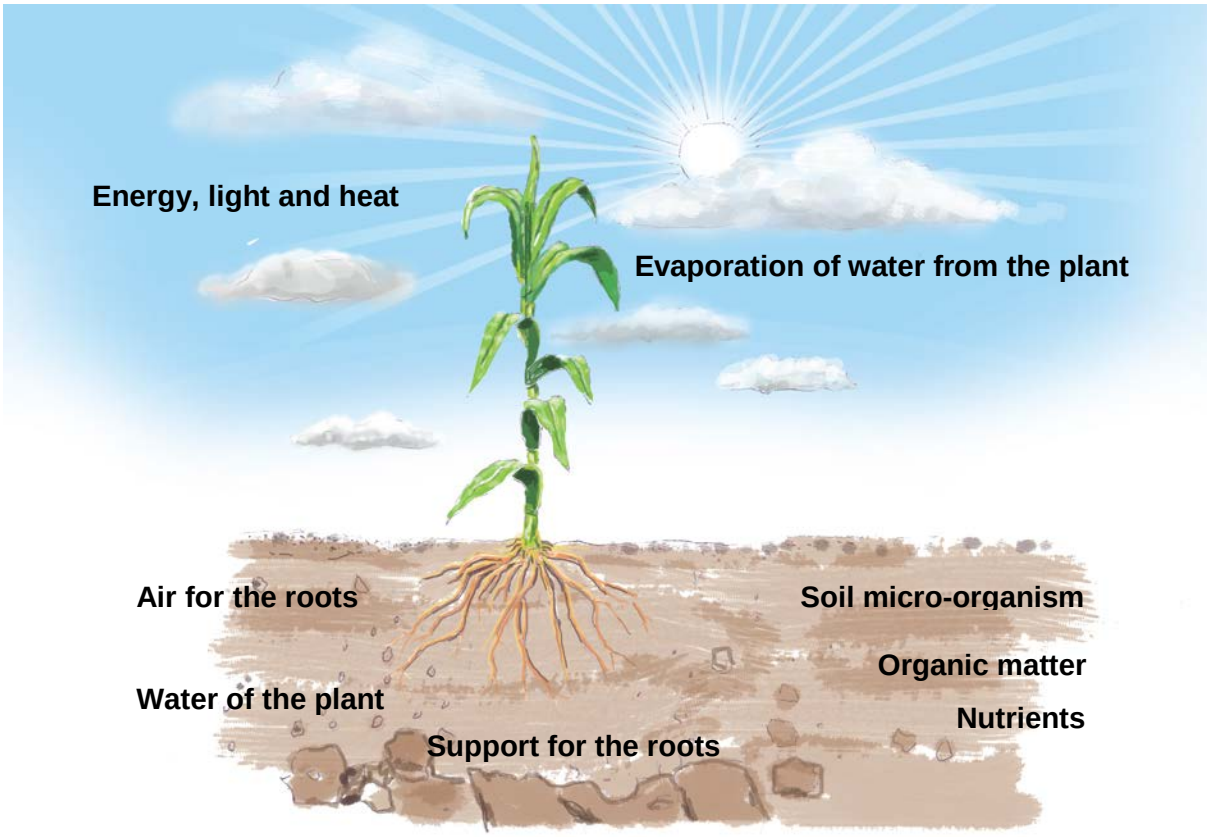
- **Vitamins** are produced by plants, such as vitamin C, vitamin A and vitamin B. So people need to eat vegetables, fruits and grains in a balanced combination to ensure adequate vitamins. Many vitamins are destroyed by cooking, so vegetables and fruits need to be lightly cooked.
- To absorb the **nutrients** from our food, we need to eat a combination of food, for example to absorb iron we need vitamin C from fruits and vegetables. To absorb vitamin A from fruits and vegetables, we also need some fat or oil.
- To obtain sufficient **minerals**, we need to make ensure that the soil is healthy, eat a range of foods and avoid over-processed foods.

WHAT IS A HEALTHY SOIL?

EXPLAIN using Picture 4

Soils are living systems in which activities of soil organisms create and improve the soil's health. This ensures production of healthy plants growing on the soil. If we do not look after our soils, the crops we plant will not be healthy.

Picture 4: Plant needs from the soil and air



QUESTIONS

i) <u>Do you know the differences between soil types?</u>

EXPLAIN: Every soil has its own potential with sandy soils being generally poorer than clay soils. Soil depth is also important. A deep soil and a soil that is rich in organic matter can store more moisture and more nutrients than a shallow or stony one. These differences are natural and cannot be easily changed by the farmer. However there are other factors which can be changed. These depend on how the farmer manages the soil.

ii) <u>Do you know what makes a soil healthy?</u>

EXPLAIN: A healthy soil has a good soil structure with a rich base of nutrients and organic matter, which can hold moisture. With energy from light and heat, a healthy soil will produce healthy crops with high yields.

The soil is a living system, whose health is determined by many factors including its structure, organic matter content, the nutrients it contains, the amount of micro-organisms and its pH (soil acidity or alkalinity):

CHARACTERISTICS OF A HEALTHY SOIL

- **A good soil structure**. This means the soil is soft and gaps between particles allows air and water to penetrate. This allows the plant roots to grow and extract nutrients and moisture from the soil.

- **High organic matter content.** This consists of decomposing plant and animal material comprised of crop residues, weeds, and compost or manure, which have been incorporated into the soil**.**

- **A rich base of nutrients**. This means that all the different nutrients, which plants need for healthy growth, are available in the soil. Healthy soils have the right quantity of nutrients, so that crop growth and yields can be good on a resilient and sustainable basis.

  The macro-nutrients required are nitrogen (N), phosphorus (P), potassium (K) and sulphur (S), with other minor-nutrients also being essential for healthy crop growth. These include zinc (Zn), iron (Fe), boron (B), and others. These are the same nutrients required to make people, especially growing children healthy.

- **Many soil micro-organisms**. These carry out biological processes in creating a healthy soil, through interaction between plant roots, soil nutrients and soil micro-organisms.

In addition the acidity or alkalinity of the soil is important to ensure that plants are able to absorb the nutrients in the soil.

WE WILL NOW DISCUSS THE REASONS WHY CROPS ARE POOR OR HEALTHY

WHAT ARE THE REASONS FOR POOR AND HEALTHY CROPS?

Compare poor maize crop with healthy maize crop (Picture 5 and 6)

In order to obtain a healthy crop that yields well, we require a healthy soil. Soil health can be regarded as the "energy or the power" of the soil to produce a good crop. It also means that the soil has the right nutrients. The concept is the same with humans. If children are healthy and happy, it means that they have been fed on healthy crops produced from healthy soils.

Picture 5: Poor maize crop

Picture 6: Healthy maize crop

QUESTIONS

i) <u>Can you describe what you see in these two pictures?</u>

EXPLAIN: Picture 5 shows a stunted maize crop. **Picture 6** shows a healthy tall maize crop. The reasons for the poor maize could be late planting, an unsuitable variety, drought, or if a good variety was planted at the right time and rainfall was reasonable, the soil was not healthy. The reasons for the good maize include planting at the right time, a suitable variety and good quality seed, a good plant population, a healthy soil and the crop was weeded and protected from pests.

ii) <u>What do you think are the reasons for the differences?</u>

EXPLAIN: In order to obtain a healthy crop that yields well, a healthy soil is required. It means that the soil has a good structure, and is able to supply moisture and the right nutrients to the plant. The plant is then healthy

The concept is the same with humans. If children are healthy and happy, it means that they have been fed on healthy crops produced from healthy soils.

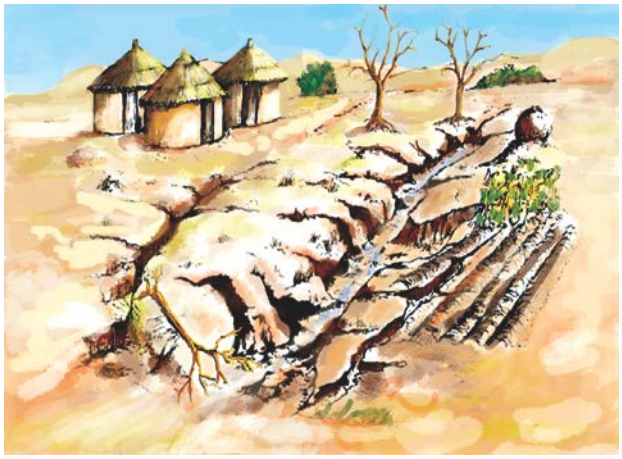
POOR SOIL HEALTH WITHOUT IMPROVING SOIL FERTILITY MANAGEMENT PRACTICES IS A MAJOR PROBLEM CONTRIBUTING TO LOW YIELDS, FOOD SHORTAGES AND MALNUTRITION.

WHAT ARE THE MAIN SOIL FERTILITY PROBLEMS?

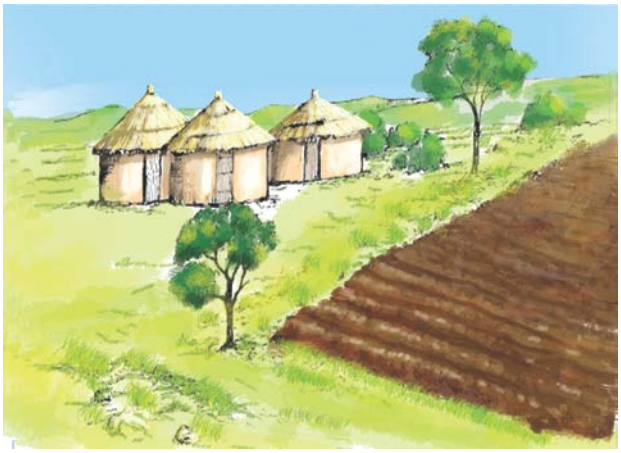
SOIL EROSION

Compare poorly and well conserved fields (Picture 7 and 8)

Picture 7: Poorly conserved field



Picture 8: Well conserved field



QUESTIONS

i) Can you describe what you see in these two pictures?

EXPLAIN: Picture 7 shows the soil washed away through soil erosion. Picture 8 shows a well prepared field ready for planting a crop

ii) What do you think are the reasons for the differences?

EXPLAIN: In Picture 7, no soil conservation measures have been used and ploughing has taken place up and down the slope, whereas in Picture 8 ploughing has been across the slope and the natural waterway has been protected and grassed.

I am showing you these pictures so that we can agree that land has to be protected against soil erosion. Although there are many methods to prevent soil from being washed away, in our discussions we will look primarily at the different methods of how to improve soil health and soil fertility.

BESIDES SOIL EROSION, OTHER SOIL FERTILITY PROBLEMS INCLUDE LOW ORGANIC MATTER CONTENT, INADEQUATE SOIL NUTRIENTS AND SOIL ACIDITY

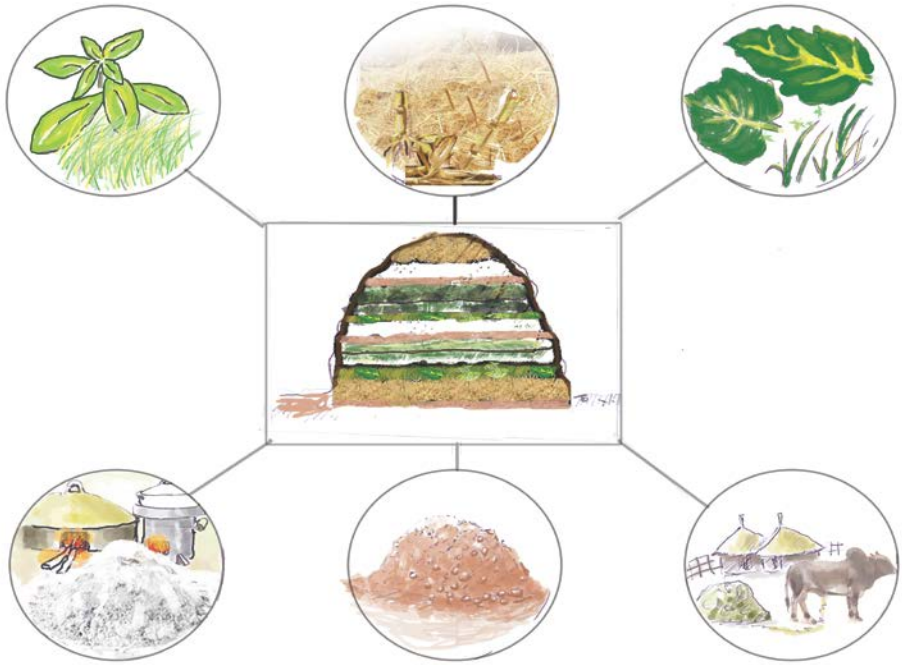
WHAT ARE THE MAIN SOIL FERTILITY PROBLEMS?

LOW SOIL ORGANIC MATTER

EXPLAIN Using Picture 9

EXPLAIN: Soil organic matter comprises decomposing plant and animal material in various stages of breakdown. It is important for increasing the moisture held in the soil, reducing surface crusting and ensuring nutrients can be taken up by the plant. Many soils have very low organic matter content.

Picture 9: Types of organic matter



QUESTIONS

i) What organic material is available on our farms?

EXPLAIN: Crop residues, grasses, weeds, household waste, manure and urine

ii) How is it presently used?

EXPLAIN: Organic material is used for many purposes, such as making compost, manure, feeding animals, building material, making fires and sometimes sold. This reduces that available for putting into the soil.

iii) How can we increase the amount going into our soils?

EXPLAIN: Organic material (or biomass) is essential for maintaining soil organic matter, but often insufficient is available in our soils. It is a good source of nutrients, especially as they can be produced locally and this is likely to be less costly than buying fertiliser.

WE WILL LOOK AT HOW TO INCREASE THE ORGANIC MATTER IN THE SOIL LATER

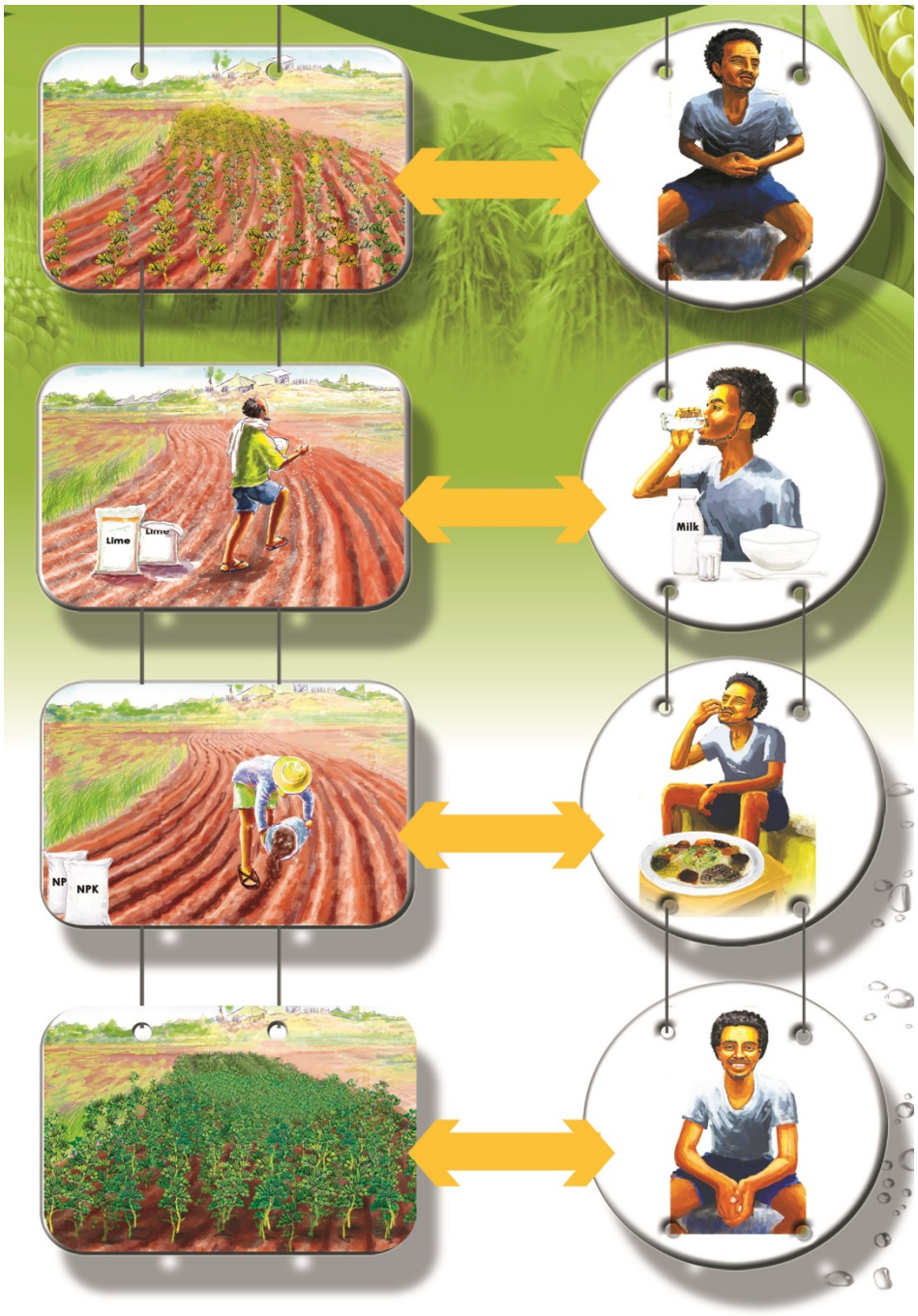
WHAT ARE THE MAIN SOIL FERTILITY PROBLEMS?

SOIL ACIDITY

EXPLAIN Using Picture 10 and 11

EXPLAIN: Soil acidity is a term used to describe soils which are acid. Sometimes, if we have too much acid in our stomachs we become sick. If a soil is too acid, plants can become sick and fail to grow.

Picture 10: Treating acidity with lime



Picture 11: A poor faba bean crop

QUESTION

i) Do you think this faba bean crop will give a good yield?

EXPLAIN: Some soils develop from acidic parent material, but most soils become acidic as a result of leaching and of using urea fertilizer. Many of our soils are affected by acidity, which leads to deficiencies in some of the nutrients required by plants. Increased acidity, especially when the soil organic matter is low, can lead to purchased fertilisers, such as Di-Ammonium Phosphate (DAP) and Urea not being used properly by the plant.

i) Does anyone have experience of faba beans failing to grow even when they use fertiliser

EXPLAIN: In acid soils, poor plant growth is due to nutrient deficiency with yields being reduced by half or even to zero. Faba bean yields can be very low in acid soils

Poor plant nutrition also increases disease and signs of nutrient deficiencies such as black spots, yellowing and streaks on the leaves, can be seen.

WE WILL DISCUSS HOW TO ADDRESS SOIL ACIDITY LATER IN OUR DISCUSSIONS

WHAT ARE THE MAIN SOIL FERTILITY PROBLEMS?

INADEQUATE SOIL NUTRIENTS

EXPLAIN Using Picture 12

EXPLAIN: Healthy soils have the right quantity of nutrients, so that crop growth and yields can be good on a resilient and sustainable basis. Unfortunately many of these nutrients have become depleted as crops have been grown and harvested on our fields for many years.

Picture 12: A poor maize crop

QUESTIONS

i) Why is this maize crop looking poor?

EXPLAIN: This maize crop has not been able to absorb the correct nutrients to make it healthy. The reasons for this may be due to poor soil organic matter content or acid soils, both of which prevent the plant absorbing nutrients from the soil. Also, the soil may be poor in soil nutrients.

A soil is like a bank. You cannot keep taking money out of a bank, unless you put some funds into your account. The soil is the same. You cannot keep taking out nutrients year after year without putting something back. Investing in the soil means protecting it from soil erosion, increasing the organic matter content, ensuring the pH (acidity) is not too high and adding nutrients when high sustainable yields are required.

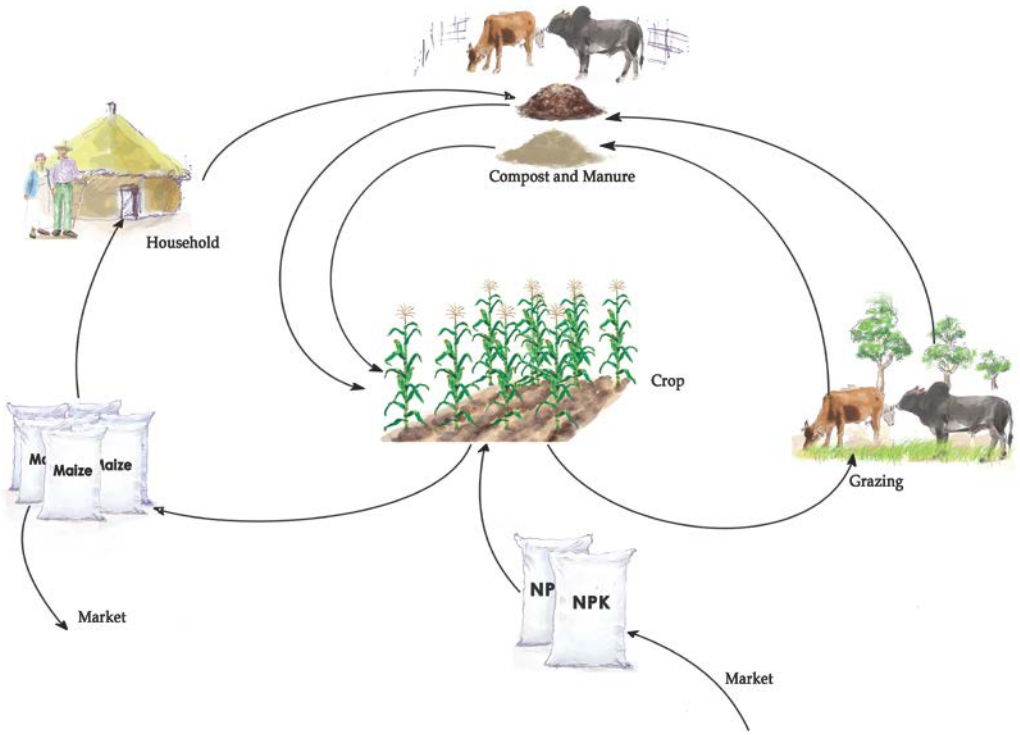
It also means using good seed and agronomic practices and ensuring there is a good market for the crops we grow,

MOVEMENT OF NUTRIENTS AROUND THE FARM

EXPLAIN Using Picture 13

EXPLAIN: Soil organic matter and soil nutrients are important determining factors for whether the soil is healthy or not. Although there are other factors, the ones the farmer can influence easily, are organic matter and the nutrient base. Nutrients move around our farms

Picture 13: Nutrient flows around the farm



QUESTIONS

i) Can you draw a sketch of how nutrients, organic matter and manure flow into and around your farm?

EXPLAIN: Food comes from our fields, we eat some, we sell some and we might throw away waste and inedible food. We can use this to make compost. Our animals graze crop residues, grass and leaves and we can incorporate their manure and urine on our crops. We might also buy fertiliser for use on our crops. If we do not return organic matter and the nutrients it contains to the fields, the soil organic matter and soil nutrients will decline. If our soils are fertile and we have enough manure we may not need to buy fertiliser, however, most farms do not have sufficient organic matter and need to buy fertilizer.

If we use manure or crop residues for making fires, this will reduce the amount of organic matter available for the fields and we may need to grow crops to help increase the organic matter and nutrients in the soil.

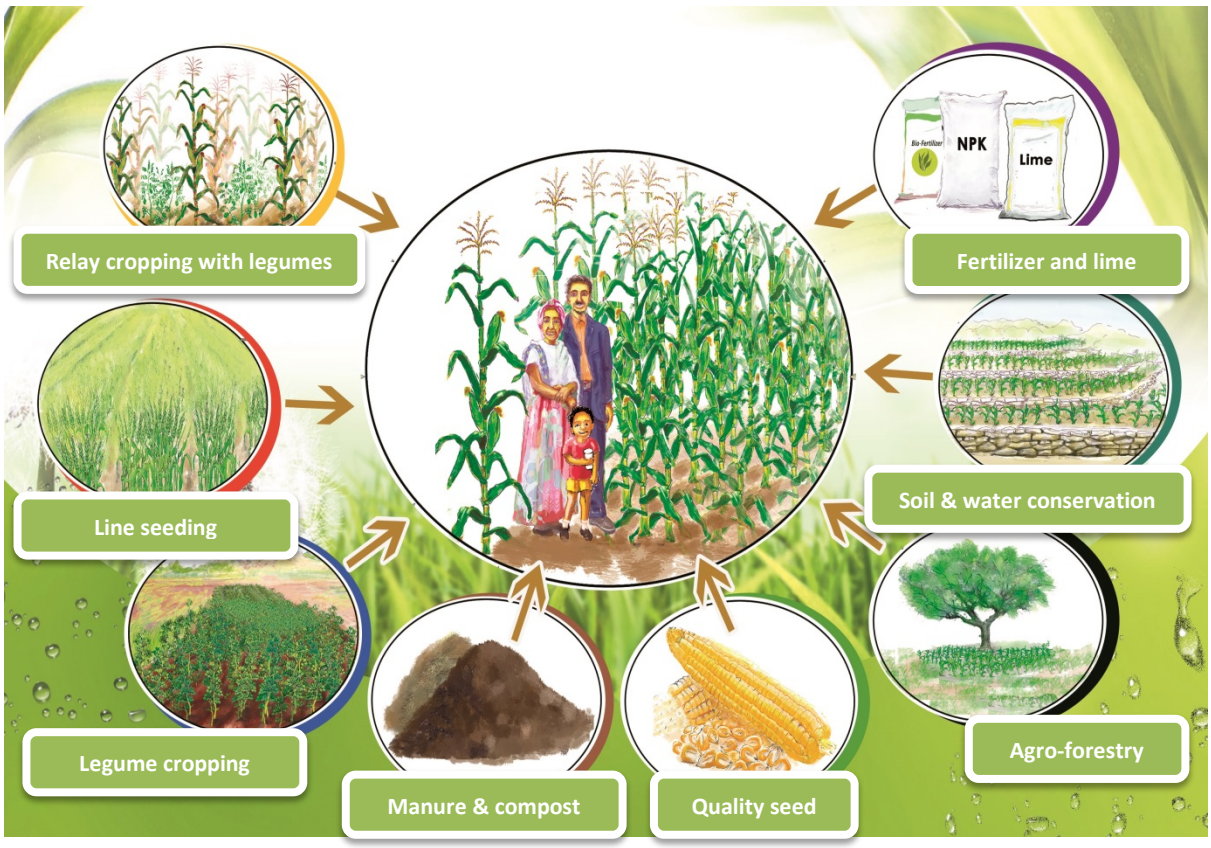
WE WILL DISCUSS HOW TO IMPROVE THE FLOW OF NUTRIENTS TO OUR FIELDS LATER

INTEGRATED APPROACHES FOR IMPROVING SOIL HEALTH

EXPLAIN Using Picture 14

EXPLAIN: Integrated soil fertility management is a combination of practices using both organic and inorganic fertilisers, as well as good seed and agronomic practices to improve soil fertility and crop yields. Because soils vary greatly, they respond to inputs in different ways.

Picture 14: Component practices for ISFM



QUESTIONS

i) Do you use or have you used any of the practices shown on the Picture. Have you heard of any of these practices? Are there any other practices you know about or use?

EXPLAIN: Maintaining or increasing soil organic matter is essential for healthy soils. Organic nutrient sources include composts and household waste, manure and urine, legumes, green manure cover crops, crop residues and mulches. However nutrients from organic sources may be insufficient for high crop yields.

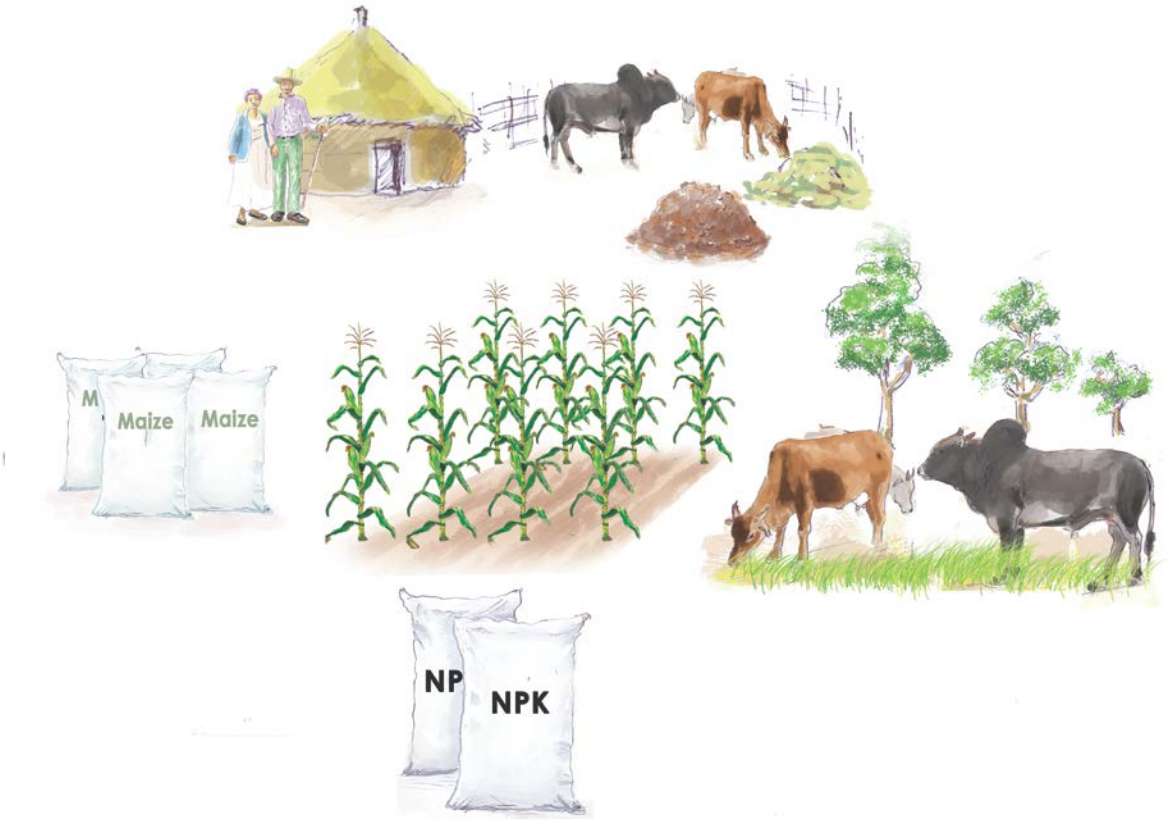
Nutrients are removed from the soil at harvest and must be replaced and inorganic fertilizers may be essential to ensure good yields.

Integrating different practices is the basis of ISFM allowing farmers to obtain good grain and residue yields on a regular basis. Crop residue yields such as straw are very important to increase the on-farm production of animal manure and compost or to provide material for mulching.

In deciding the best options, farmers need to take into account the existing soil fertility status, the availability of organic inputs and also the farmer's ability to access and pay for inputs.

THE REST OF OUR DISCUSSIONS WILL BE ABOUT WHAT WE CAN DO TO IMPROVE THE HEALTH OF OUR SOILS.

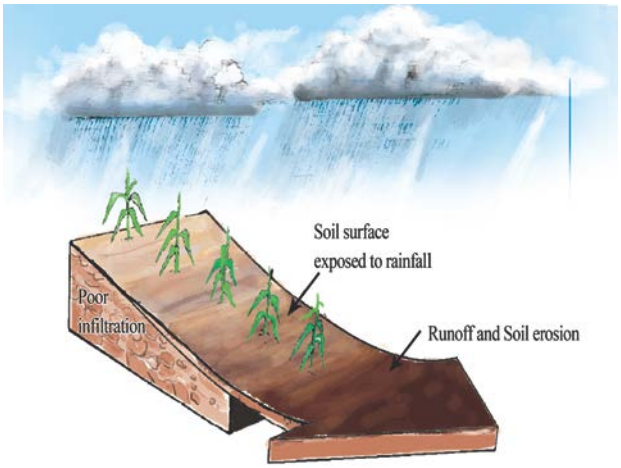
SECTION 2: SOIL HEALTH IMPROVEMENT OPTIONS



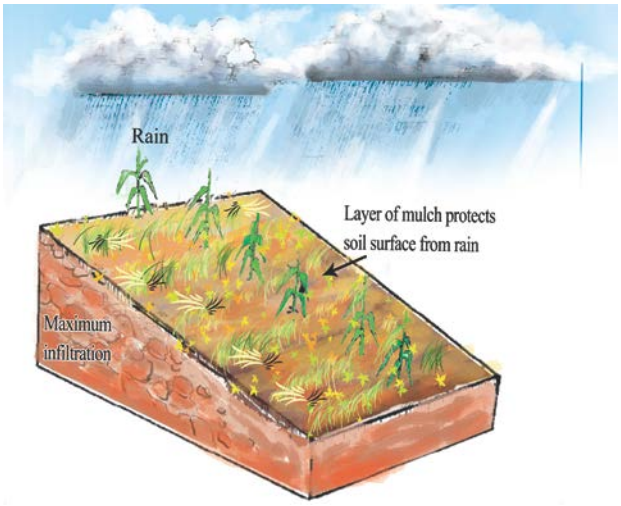
IMPROVING SOIL ORGANIC MATTER

Compare two situations (Picture 15 and 16)

Picture 15: Bare soil exposed to rainfall and sun



Picture 16: Mulch will reduce organic matter breakdown and return organic matter to the soil



DISCUSSION BASED ON THESE QUESTIONS

i) Can you describe what you see in these two pictures?

EXPLAIN: Picture 15 shows a stunted maize crop with the soil exposed to both rainfall and sun resulting in run-off and soil erosion. **Picture 16** shows a better maize crop with a layer of mulch protecting the soil from rain and sun, which helps to reduce run-off.

ii) What do you think are the reasons for the differences?

EXPLAIN: When a soil is bare and exposed after ploughing, organic matter breaks down rapidly, the soil degrades and infiltration decreases. A mulch cover will protect the soil surface from sun, wind and rain as well as reducing the breakdown of organic matter, returning some organic matter to the soil and improving infiltration.

THE ORGANIC CONTENT OF THE SOIL CAN BE IMPROVED BY

- Adding compost or manure
- Using green manures or cover crops or agro-forestry options
- Using crop residues for mulching as shown in picture 16

IMPROVING SOIL ORGANIC MATTER

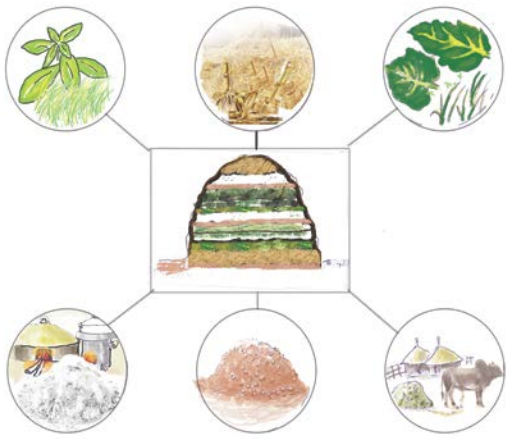
MAKING COMPOST

EXPLAIN Using Pictures 17 and 18

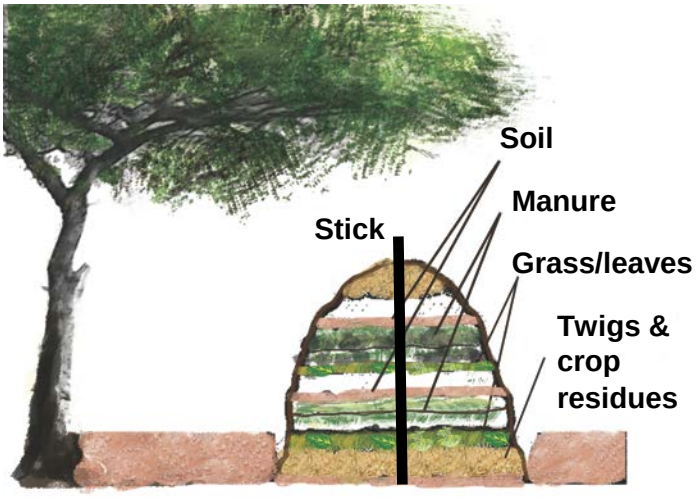
EXPLAIN: The soil needs food so that it can feed the plants. Crops use the food which is in the soil to grow and produce leaves and grain. The higher the yields, the more food or nutrients are extracted by the plant from the soil. This empties the soil quickly and so you need to replace them. If you give nothing back or perhaps just the plant residues, you can reduce the soil nutrient losses, but the soil will soon run out of food and become exhausted. Therefore you have to add nutrients.

Compost is made from organic materials that have been broken down into a dark crumbly substance.

Picture 17: Ingredients that can be used to make compost



Picture 18: Layers of materials in a compost heap



QUESTIONS

i) What are the ingredients that can be used to make good compost? Does anyone have any experience that they would like to share?

EXPLAIN: Compost can be made of many different organic materials like household waste, grasses, weeds, leaf litter from trees. Manure and urine can provide additional nutrients.

ii) How should good compost be made?

EXPLAIN: Although compost contains a lot of plant nutrients, it does not have as much nitrogen as well matured manure. Purchased chemical fertiliser can also be used but it is still very important to increase the organic matter in the soil

A BROCHURE IS AVAILABLE ON MAKING GOOD COMPOST

IMPROVING SOIL ORGANIC MATTER

RAPID COMPOSTING USING AN EM SOLUTION

Compare two pictures (19 and 20)

Picture 19: Compost without EM after 40 days

Picture 20: Compost with EM after 40 days

QUESTIONS

i) **What can you observe in comparing these two pictures?**

EXPLAIN: While traditional composting can take 4-8 months, rapid composting can speed this process. Two common methods are the use of "Effective Micro-organisms (EM)" and "Vermi-composting".

Effective Micro-organism solutions can be purchased from local distributors in some areas

ii) Does anyone have any experience that they would like to share?

A BROCHURE ON HOW TO USE EFFECTIVE MICRO-ORGANISM (EM) SOLUTIONS IS AVAILABLE

IMPROVING SOIL ORGANIC MATTER

VERMI-COMPOSTING

EXPLAIN Using Pictures 21 to 23

EXPLAIN: Vermi-composting is a fast method of preparing enriched high quality compost with the use of earthworms that converts organic waste into humus

Picture 21: Earthworms

Picture 22: Worm bin with bedding

Picture 23: Vermi Compost

QUESTIONS

i) **Do you think earthworms can be used for making good compost?** Does anyone have any experience that they would like to share?

EXPLAIN: This requires the breeding of earth worms for production of high quality compost. This is called vermi-culture with earthworms being the primary product. The vermi-compost is the excreta of earthworm, which is rich in humus.

A BROCHURE ON VERMI COMPOSTING IS AVAILABLE

IMPROVING SOIL ORGANIC MATTER

MAKING MANURE

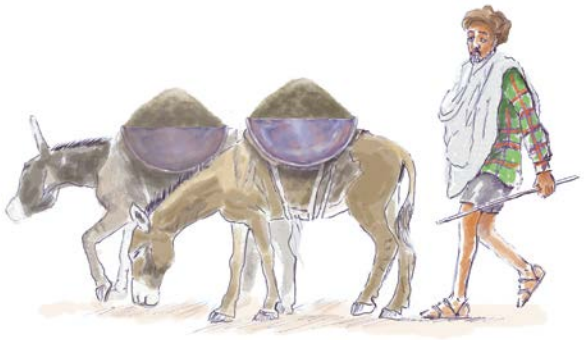
EXPLAIN Using Pictures 24 to 26

EXPLAIN: Manure is an important source of nutrients and its use is the most widely practiced means of nutrient replenishment. It is a valuable source of organic matter as well as major soil nutrients. However many farmers under estimate its value and manure is often wasted.

Picture 24: Cattle in pen with a roof

Picture 25: A manure heap

Picture 26: Manure being removed for use



QUESTIONS

i) **Does anyone have any experiences that they would like to share on making and using manure?**

EXPLAIN: To produce good quality manure, livestock also need to be healthy and well fed. Manure pits, which are shaded and protected from the sun and rain, are required, together with sufficient livestock bedding.

A BROCHURE ON MAKING MANURE IS AVAILABLE

APPLYING COMPOST AND MANURE

EXPLAIN Using Picture 27

Picture 27: Applying compost or manure

QUESTIONS

i) What is the best way of applying manure & compost?

EXPLAIN: Applying the manure along the crop row just before planting and covering with the soil benefit the plant. Crops that receive manure grow better than those, which have not received manure.

ii) How much manure & compost should you apply?

EXPLAIN: The amount of manure applied should be based on the crop, expected yield and soil type. The exact rate of application should be obtained from an extension officer or a nearby Agricultural Research Station.

iii) Do you have enough manure & compost for all your fields?

EXPLAIN: If you do not have enough manure, apply it to one area of your field each year. Do not spread it too thinly. Try to manure each portion of the field every four years. The manure should be well decomposed so that it won't harm the crop seedling.

SOME TIPS

- Ideally 5 tonnes per ha and year should be applied for field crops; although higher rates up 10 t/ha can be used if available and no other nutrients are available.
- Spreading of manure in the field should be done in a single day; otherwise a great loss of nitrogen will be incurred, especially if it is left uncovered.
- The best time for manure application is when there is sufficient soil moisture, just before planting time. Application of manure in a dry soil will result in loss of nitrogen.
- Before planting, the manure should be applied in the planting line and should be covered with soil on the same day.

NOW THAT WE HAVE DISCUSSED SOME OF THE PRACTICES FOR IMPROVING SOIL ORGANIC MATTER CONTENT, WE ARE GOING TO DISCUSS WHAT TYPES OF ROTATION YOU CAN CONSIDER.

CROP ROTATIONS AND INTERCROPPING

EXPLAIN Using Six Pictures 28 to 33

EXPLAIN: A crop rotation is a change in the type of crop grown on a particular piece of land from year to year. Farmers have rotated different crops on their land for many centuries to produce higher yields by replenishing soil nutrients and breaking disease and pest cycles. Intercropping means that two or more crops are grown at the same time on the same field.

Picture 28: Sole maize

Picture 29: Faba beans

Picture 30: Maize + beans intercrop

Picture 31: Sole wheat

Picture 32: Haricot beans

Picture 33: Chick peas

QUESTIONS

i) What crops are shown in these pictures? Which is a legume? Are there other legume crops that you grow or are aware of?

EXPLAIN: Legume crops produce nitrogen from the air in root nodules. When the roots rot, soil fertility is increased. The leaves are also rich in nitrogen and can be ploughed into the soil to improve soil health.

ii) Do you know the benefits of using a crop rotation or intercropping?

EXPLAIN

- A good crop rotation will improve the soil fertility and yields of crops. Different crops take what nutrients they need to grow well and leave the rest in the field.
- Growing legumes increases the organic matter and nitrogen in the soil, improves soil structure, reduces soil degradation, and can result in higher yields and greater farm profitability.
- Increased levels of soil organic matter enhance water and nutrient retention, and decreases synthetic fertilizer requirements.
- Better soil structure improves drainage, reduces risks of water-logging during floods, and boosts the supply of soil water during droughts.

- Crop rotation is used to control weeds and diseases and limit pest infestations and as a result, reduce pesticide use.
- Leguminous crops fix atmospheric nitrogen and bind it in the soil, increasing fertility and reducing the need for inorganic fertilizers.

iii) Can you give examples of different crop rotations and of intercropping?

EXPLAIN: Typical rotations include: cereals followed by a legume. Sometimes the legume can be intercropped or relay planted with or after the cereal.

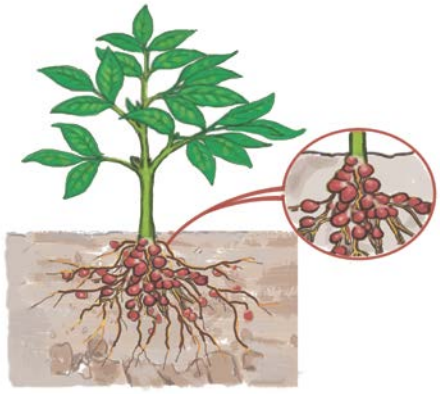
SOME TIPS

- Inoculate legumes at planting to increase nitrogen fixation
- Use a phosphorus fertiliser at planting because legumes need phosphorus for effective nitrogen fixation
- Grow a legume crop that will leave a significant amount of residue like beans, to help maintain organic matter levels
- After the legume crop plant a high-nitrogen-demanding crop such as maize or vegetables to take advantage of the nitrogen fixed by the legume
- Grow the same crop only once to decrease the likelihood of pests and diseases,

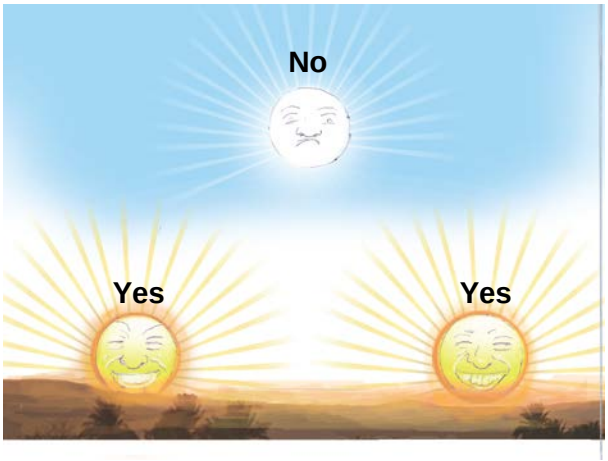
NITROGEN FIXATION AND LEGUME SEED INOCULATION

EXPLAIN Using Pictures 34 and 35

Picture 34: Nodules on a legume



Picture 35: Best time for planting



QUESTIONS

i) Has anyone any experience of inoculation of legume seed with rhizobia? Has anyone seen nodules like this on their legume crops?

EXPLAIN: Seed inoculation helps in forming root nodules and is recommended when a legume has not been grown for a long time. Rhizobia in the soil attach to the root hairs of legume plants as they grow and bacteria enter the roots and a nodule is formed. This allows the plant to fix nitrogen from the air which the plant uses to grow. Inoculation can help in fields where soil acidity is a problem, in extremely sandy soils with low organic matter content, and where soils are periodically-flooded.

ii) Do you know the best conditions for planting inoculated seed?

EXPLAIN: The best conditions for planting are when the rains are well established and the soil is moist. Also when the sun is not too hot, such as on cloudy days, early in the morning or late in the afternoon.

Inoculants can be obtained from Menagesha Biotech which produces and supplies Rhizobia. For further information contact Dr. Asfaw Hailemariam (mobile: 0911411318, email: asfawhailemariam@yahoo.com or:asfawhailemariam@gmail.com)

A BROCHURE IS AVAILABLE ON INOCULATING LEGUME SEEDS

GREEN MANURES AND COVER CROPS

EXPLAIN Using Pictures 36 and 37

Explain: Cover crops and green manures are leguminous crops grown especially for incorporation into the soil to improve soil health and organic matter content.

Picture 36: Lablab

Picture 37: Vetch

QUESTION

i) **Has anyone either grown or seen a green manure or a cover crop?**

EXPLAIN: Cover crops cover the soil with a vegetation cover to protect it from the sun and rain as well as to suppress weeds; green manures are grown to build maximum biomass. Most green manure crops also play a role in covering the soil and protecting it from the sun and heavy rain.

Green manures supply the soil with great amounts of fresh material, easily decomposed by soil organisms, after incorporation into the soil. Nutrients are then readily available to the plants and some is transformed into stable soil organic matter contributing to a better soil structure, better aeration, drainage and water and nutrient holding capacity of the soil.

EXPLAIN: Green manures have a huge potential to produce biomass and increase soil health, however, many people are still unaware of its benefits and seed may be difficult to obtain. To avoid that green manure crops compete with our food crops, we may decide to grow them on residual soil moisture or along the edges of a field.

Green manures can be grown between rows of maize, millet or sorghum. To avoid or reduce competition with the crop, green manures are usually sown toward the middle or the end of the growing season, when the crop is well established or near maturity.

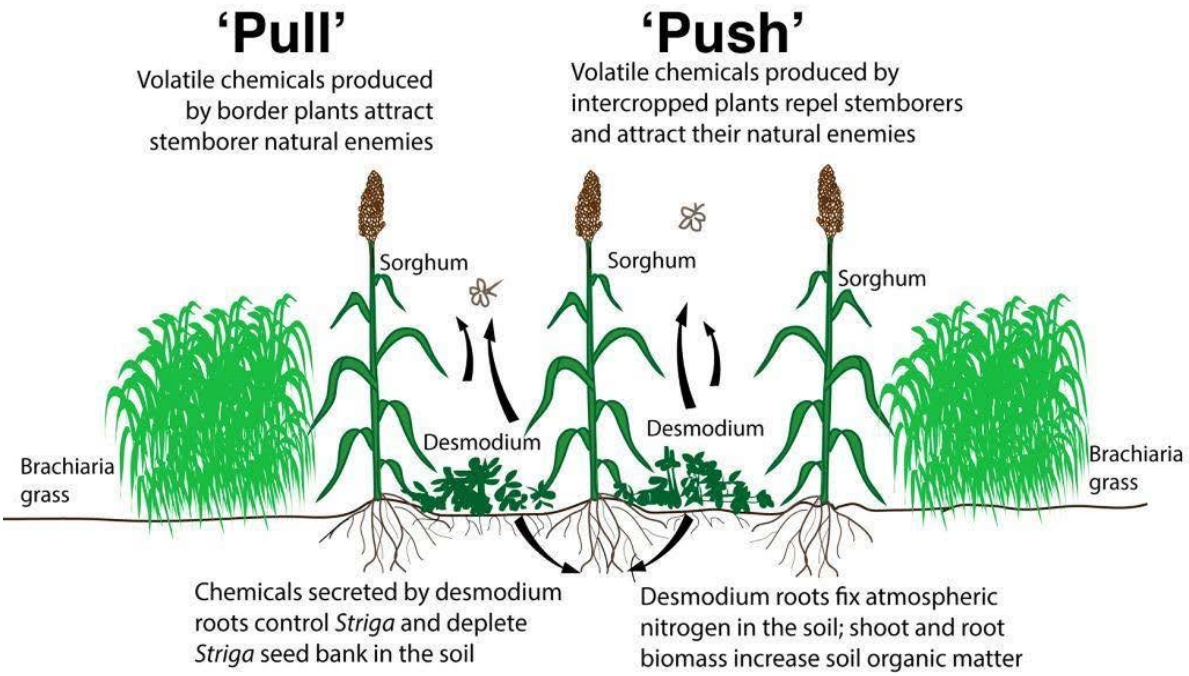
In this situation, known as relay cropping, the green manure grows mostly during the period after harvest of the main crop. This has the advantage that the green manure uses land that normally would not be under cultivation, as well as extending the period with soil cover.

PUSH–PULL

EXPLAIN Using Picture 38

Explain: Push-pull is a new practice based on inter-cropping cereals with a legume and a grass crop around the edges of the field. The cereal is intercropped with a moth repellent forage legume *Desmodium* (the Push) and a trap plant such as Napier or *Brachiaria* grass (the Pull) planted as a border crop around the intercrops.

Picture 38: Push Pull (cereal interplanted with a forage legume and grass as border crop)



QUESTION:

i) Has anyone any experience of using or seeing "Push-Pull"?

EXPLAIN: The forage legume releases a smell that repels stem borer females from the cereal crop, and simultaneously attracts them to the grass trap crop. Both the legume (*Desmodium*) and the grass (Napier or Brachiaria) can be valuable as animal fodder.

The legume *(Desmodium)* can also be effective in suppressing the Striga weed, while improving soil fertility by fixing nitrogen and improving soil organic matter.

A BROCHURE IS AVAILABLE ON PUSH PULL

AGROFORESTRY

EXPLAIN Using Pictures 39 to 41

EXPLAIN: Agro forestry is a practice that integrates trees with crops, animals or both. Trees can be used to improve soil fertility through combining crops and trees as well as providing fodder for livestock. Common practices are designed for nutrient recycling for use by crops. These include trees planted on the contour, alley cropping, and for transferring leaves onto crop land.

Picture 39: Alley cropping on contour

Picture 40: Trees planted for fertilizer

Picture 41: Biomass for transfer to fields

QUESTIONS

i) Has anyone planted trees for use in improving soil fertility? If yes, can they share their experiences?

EXPLAIN

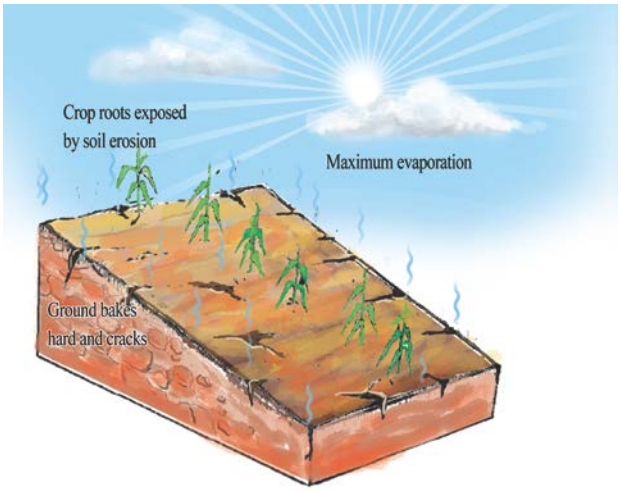
- **Trees planted along the contour** are means of improving soil fertility because they can also control erosion. They can be kept as hedges to reduce the land they use and may require less labour than ditch structures or grass strips.
- **In alley cropping**, crops are sown between the trees.
- **Trees incorporated into fields,** such as *Faidherbia albida* can increase soil fertility, improve moisture conservation and sometimes provide feed for livestock
- **Biomass transfer** involves growing trees away from crop land. The leaves are then harvested, transferred to cropping land and applied as mulch or incorporated into the soil before or after the crop is planted.

MULCHING WITH CROP RESIDUES

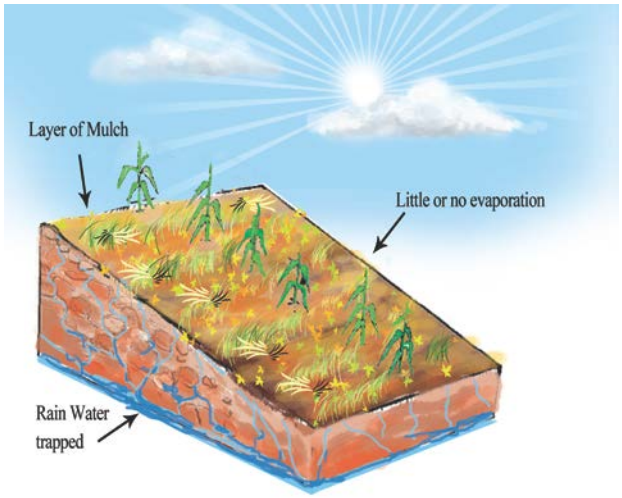
EXPLAIN Using Pictures 42 and 43

EXPLAIN: Mulching is the covering of the soil with crop and weed residues, leaf litter and dry grasses. Once rotten and decomposed, mulch forms humus and adds to the organic matter in the soil.

Picture 42: A maize field with no mulch



Picture 43: A well mulched maize field



QUESTION

i) Can you tell the difference between these two pictures?

EXPLAIN: Mulching is important for the prevention of soil erosion, addition of organic matter to the soil, regulating the soil temperature, increasing soil micro-organism and biological activity, weed suppression, increasing water retention, and decreasing evaporation from the soil surface. It is also important to ensure that sufficient mulch is maintained as soil cover to reduce evaporation of soil moisture and to discourage growth of weeds

ii) How do people use their crop residues

EXPLAIN: There are a number of uses for crop residues: 1) mulching, 2) animal feed, 3) composting, 4) cooking, 5) construction and 6) for sale. Although using crop residues as mulch is the best option for controlling soil erosion, conserving soil water, and replenishing plant nutrient reserves, other uses may also be important.

ADDRESSING SOIL ACIDITY PROBLEMS

EXPLAIN Using Pictures 44 and 45

Picture 44: Farmer applying organic matter

Picture 45: Farmer applying lime

QUESTION

i) What can be done to reduce soil acidity?

EXPLAIN: two methods can be used

Adding organic matter: Applying **c**ompost or manure or using green manures are good practices not only to increase organic matter but also to help in reducing soil acidity. Using crop rotations and legume intercropping also helps.

However, adding organic matter, especially where soils are very acidic, is not a total substitute for using lime. Liming not only reduces acidity, but also helps in removing aluminium from the soil.

Adding lime: Lime must be mixed with the soil to ensure a uniform distribution, ideally by deep ploughing. The amount applied should be done in close consultation with regional soil laboratories and research institutes. Lime needs to be reapplied regularly. This is labour-intensive and can be expensive.

Selection of tolerant crops: Some acid-tolerant crops or varieties can be used producing reasonable yields in acid soils.

INORGANIC FERTILISER, QUALITY SEED AND LINE SEEDING

EXPLAIN Using Picture 46 and 47

Many different blends of fertiliser are now becoming available and it is important that the correct ones are used. This depends on the soil type, the nutrient content of the soil and the crop being grown. Most farmers are aware of DAP (used at planting and containing phosphate and nitrogen) and Urea (used as a topdressing and containing nitrogen).

Picture 47: Farmer applying fertiliser

Picture 46: Planting in line

QUESTIONS

i) Has anyone used an inorganic fertiliser? Which one and on which crops? What have been farmers' experiences?

EXPLAIN: Use of inorganic fertilisers, when soil health is poor, can be disappointing with a poor response and unhealthy crops. The reasons for this may be due to poor soil organic matter content or acid soils, both of which prevent the plant absorbing nutrients from the soil. It may also be due to the lack of other important nutrients such as potash, sulphur, zinc or boron.

IT IS USUALLY BEST TO COMBINE THE USE OF INORGANIC FERTILISER WITH ORGANIC FERTILISER, SUCH AS THE ONES WE HAVE BEEN DISCUSSING

ii) Do farmers know the different names of blends of fertiliser?

EXPLAIN: Fertilisers are labelled according to the names and nutrient contents they contain. These are some examples:

Blend of fertiliser	Nutrients contained
NPK	Nitrogen, Phosphate, Potash
NPS	NP and Sulphur
NPKSZnB	NPK and Sulphur, Zinc and Boron
NPS Zn	NPS and Zinc
NPSZnB	NPSZn and Boron
NPSB	NP Sulphur and Boron

It is always important to seek advice on the type and quantity of inorganic fertiliser to use. This will depend on the existing health status of the soil, the crop being considered and other soil fertility practices being used.

ii) How many farmers use good quality seed?

EXPLAIN: When farmers invest their time and labour in making compost or buying fertilizer, it is important that good quality seed is used for planting. Only quality seed can make use of your compost and fertilizer, otherwise your effort and investment may be wasted.

iii) Why is it important to plant in lines?

EXPLAIN: Planting in lines allows you to apply fertilizer, lime and manure directly in the planning line. You can therefore reduce the amounts of inputs and save money. Also planting in line ensures that the correct plant population is obtained as well as making weeding easier.

- The best yields can be achieved using good seed, planted in lines using a mix of organic and inorganic fertilizer.

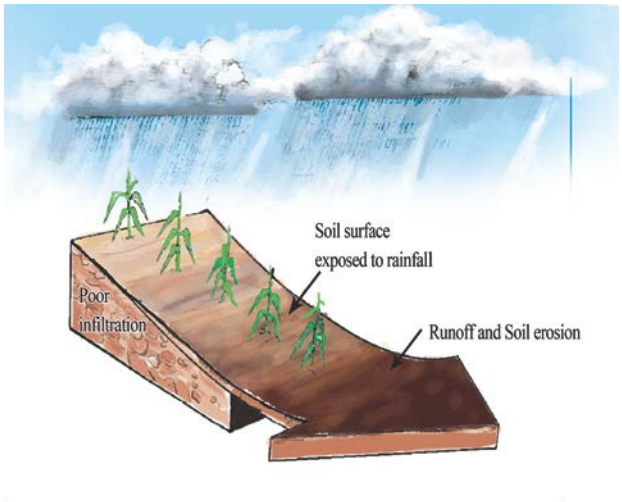
THE COMBINED USE OF ORGANIC INPUTS AND INORGANIC FERTILISER TOGETHER WITH GOOD WELL PLANTED SEED IS CALLED "INTEGRATED SOIL FERTILITY MANAGEMENT"

CONSERVATION AGRICULTURE

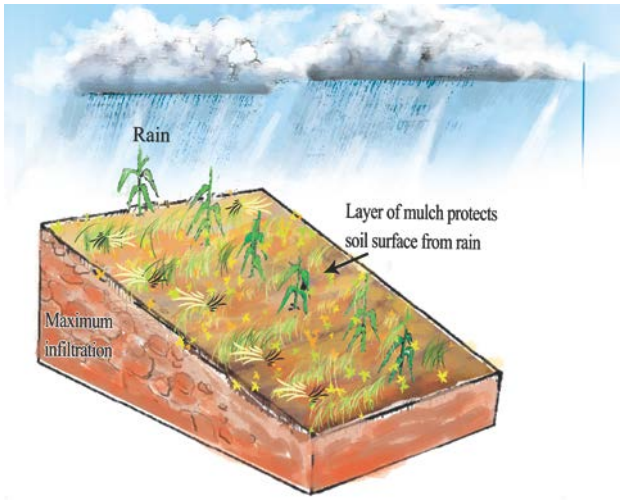
EXPLAIN Using Pictures 48 and 49

EXPLAIN: These are the same pictures used to explain mulching and can involve reduced or zero tillage, sometimes called “Conservation Agriculture”. Crop residues should be left in the field and seeds planted directly into the soil without ploughing.

Picture 48: Crop planted without crop residues as a mulch



Picture 49: Crop planted with residues as mulch



QUESTIONS

i) Has anyone used reduced or zero tillage (Conservation Agriculture) before?

EXPLAIN: This method aims to reduce soil disturbance by tillage to a minimum, using crop residues as a mulch to protect the soil from erosion as well as improving soil structure and soil fertility.

Various methods can be considered. These include:

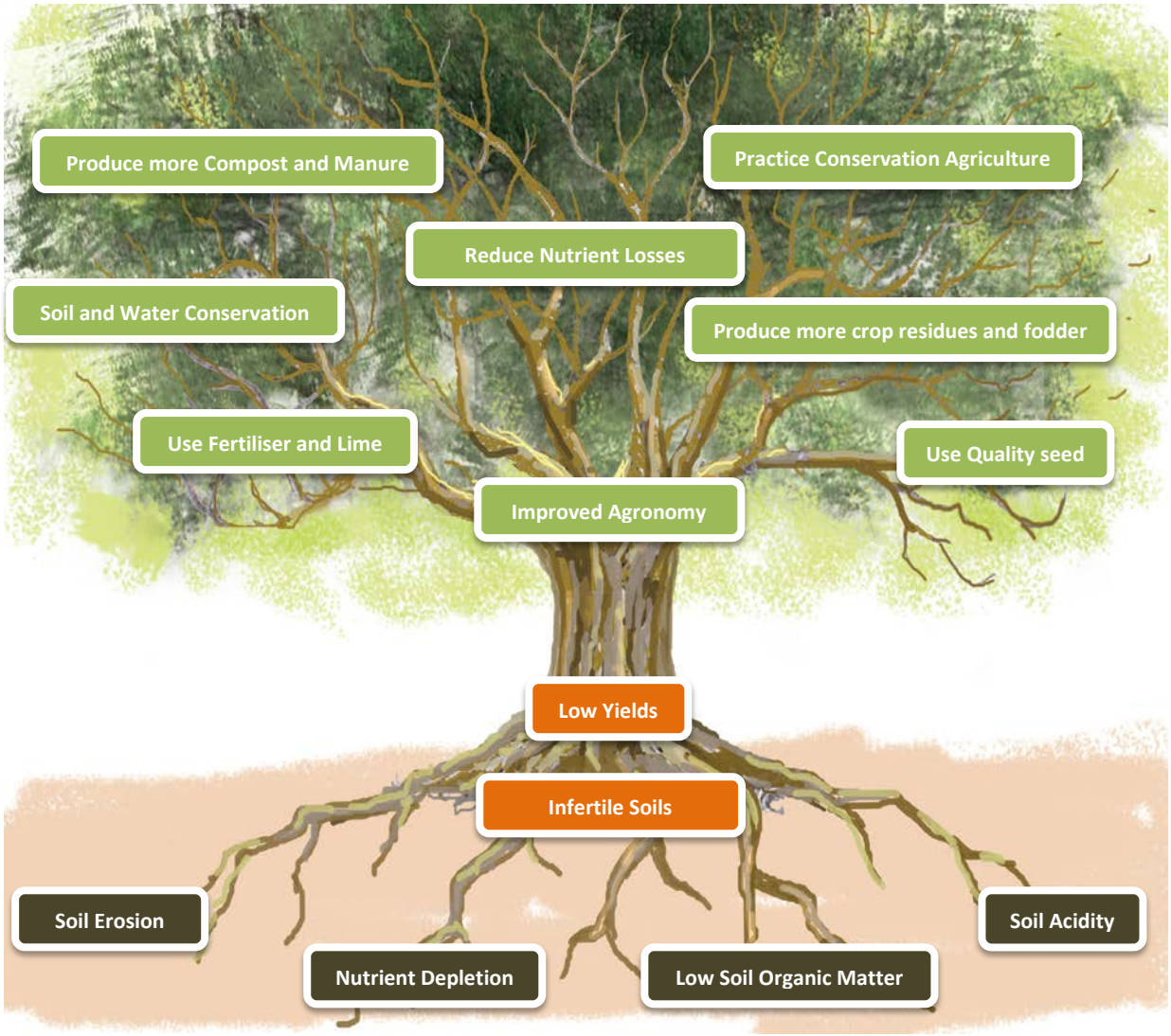
- Hand planting into residues of previous crops.
- Opening planting lines into residues of the previous crop using a plough
- Planting with a ripper tyne with a seeder attachment.

It is important that planting lines made with the plough or ripper follow the contour to avoid soil erosion.

There are both benefits and challenges to using these methods

Benefits	Challenges
• Reduction of soil erosion and increase in moisture conservation • Improvement in soil fertility and soil structure through organic matter build up • Reduced labour demand for land preparation • Crops can be planted earlier and therefore yields improved • Improves infiltration and the amount of water held in the soil	• Increased weed growth, which can be controlled using herbicides • Livestock competition for crop residues • Soil can become hard requiring tillage to loosen the soil • May not be suitable for late planting as weeds are well established at time of sowing • Pests and diseases can be encouraged through the presence of crop residues

SECTION 3: TRYING NEW PRACTICES COMBINING DIFFERENT PRACTICES

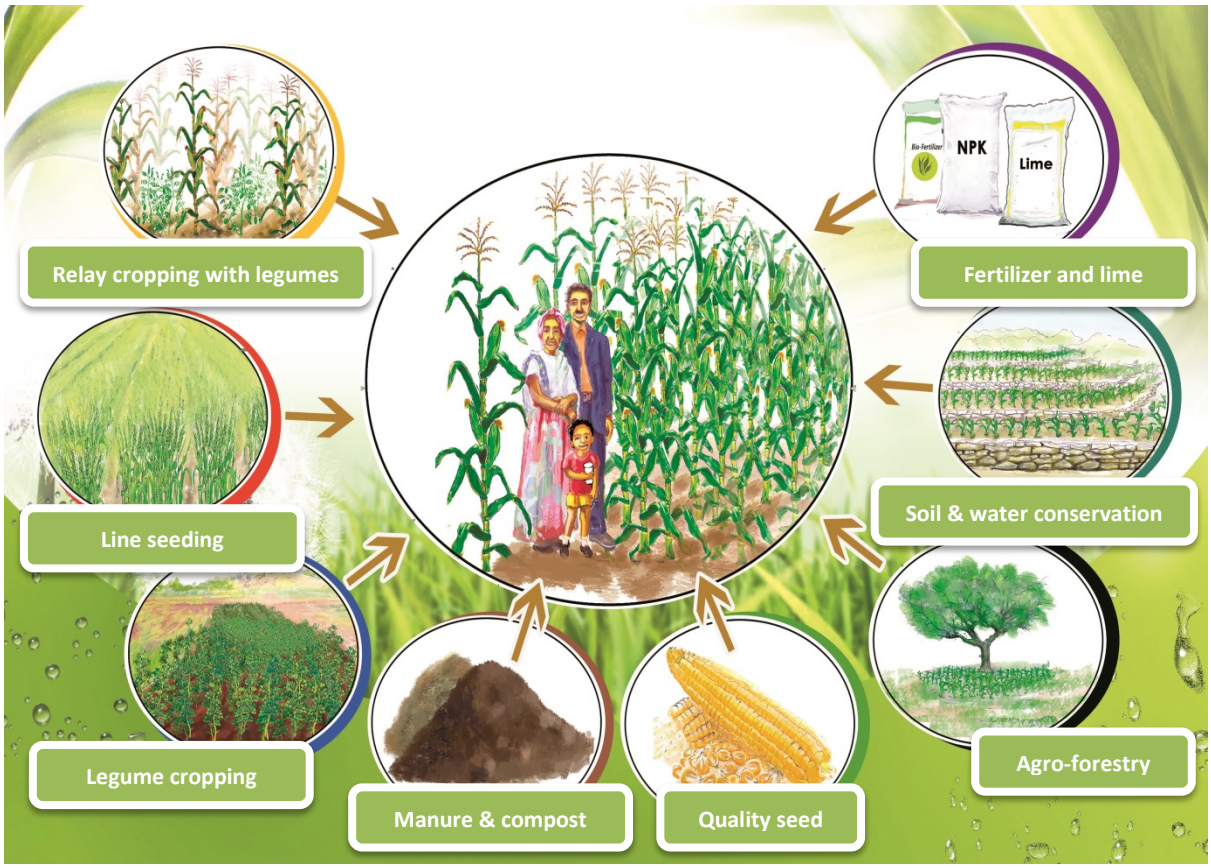


INTEGRATED SOIL FERTILITY MANAGEMENT

EXPLAIN Using Picture 50

EXPLAIN: We have discussed the use of many different practices, many of which can be combined to ensure the health of our soils improves. This is known as **"Integrated Soil fertility Management"** Each practice has its own benefits and challenges, but when they are combined additional benefits should be apparent. For example, by combining quality seed with organic & inorganic fertilizer and with line seeding, crop yields are very likely to increase substantially.

Picture 50: Components of integrated soil fertility management



QUESTIONS

i) **Which of the practices that we have spoken about, do you think you can use on your fields?**

EXPLAIN: Ask the participants to list all the practices that have been discussed and then identify the benefits and challenges associated with each.

Then ask the farmers which ones they think would like to try next season

THIS WILL SERVE BOTH AS A REMINDER OF THE DISCUSSIONS THAT HAVE TAKEN PLACE AND CAN BE USED TO AGREE WHICH PRACTICES FARMERS WANT TO TRY NEXT SEASON.

Table to be completed through discussion with farmers

Practice	Benefits	Challenges	Use by
Normal Compost			
Rapid composting (using EM solution)			
Vermi Compost (made by worms)			
Manure			
Crop rotations			
Legume seed inoculation			
Green manures			
Mulching with crop residues			
Push-Pull			
Conservation agriculture using reduced or zero tillage			
Agro-forestry			
Liming			
Inorganic fertilizer			
Quality seed			
Line seeding			

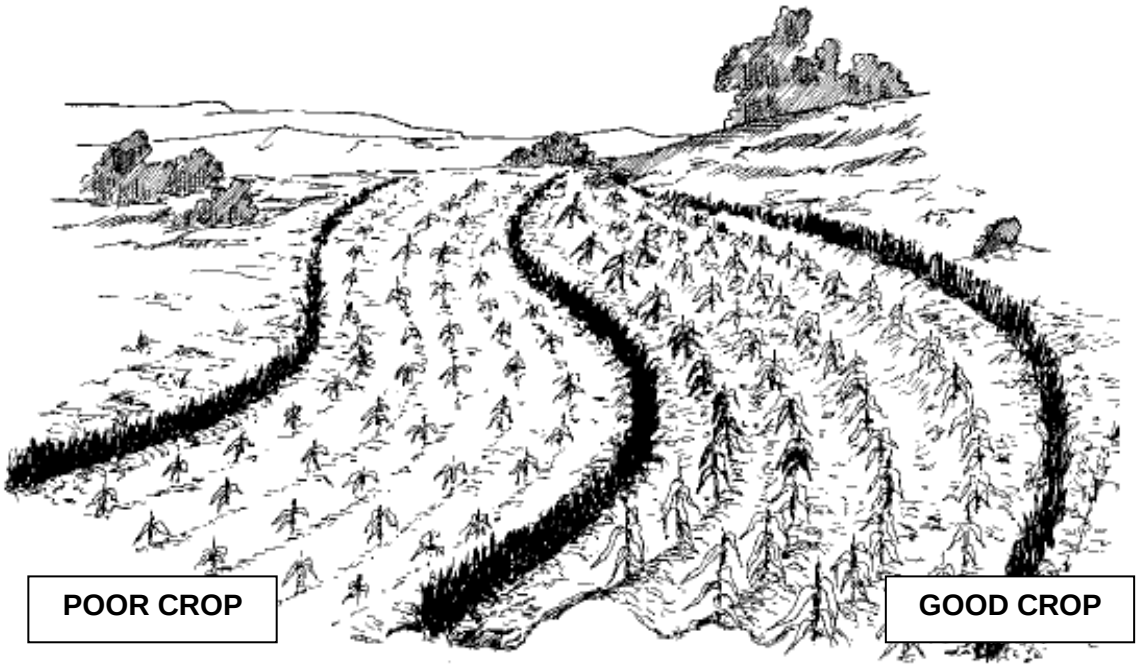
AGREEING OPTIONS TO TEST, MONITOR AND EVALUATE

EXPLAIN Using Picture 51 to53

EXPLAIN: In order to see whether new practices will improve production they need to be compared with farmers' normal practices. Without a comparison

it is difficult to know whether new practices are better or worse than the existing ones. .

Picture 51: Field layout in comparing new practices



Picture 52: Farmers comparing crop performance performance during growing season

Picture 53*:* Farmers discussing crop at the end of the season

QUESTION

i) What can you see in picture 51?

EXPLAIN: The best way to compare a new practice with an existing one is to test them side by side in the same field. If possible divide the field along the contour so that each plot is the same size. This will help you to avoid loss of crop if the technique fails. If you are concerned how a new technique or idea will perform, try it on a small piece of land only Remember testing not only results in success but also in failure.

- Use the same seed and the same spacing on both sides (unless comparing varieties and spacing)
- Plant both sides on the same day to ensure that plants on both sides have the same conditions
- Apply the same amount of fertilizer on both sides unless comparing how the plants grow with different amount of fertilizer or manure
- Weed on the same day in the same way on both sides unless observing the effect of different types of times of weeding

ii) What can you see in Picture 52?

EXPLAIN: Farmers are inspecting crops in the field having tried some new practices. Observing your trials helps you to identify the reasons why certain practices perform better or worse than other ones. When the crops are grown with two different techniques side by side in the same field you can see the differences more easily. For example, on one side the crop might grow faster or be higher than on the other side. Such observations need to be recorded so that they are not forgotten and can be analysed in future.

iii) What can you see in picture 53?

EXPLAIN: Farmers are now discussing the yields that were achieved from the trial plots after harvest and will make a decision on what of the new practices was best or worst.

iv) Why is it important to keep records of trials?

EXPLAIN: It is difficult to rely on memory only. Through recording observations season by season, reference material for individual farms can be built up alongside individuals' farming knowledge. Farmers will also get to know their farms well through this process. The benefit of keeping records is that mistakes will not be repeated and farmers and extensions workers will be able to recall experiences of the best practices.

It is important that farmers are honest when comparing new practices with the usual ones. Often farmers become 'blind' to a practice when it is not as promising as they thought it would be. As already said, experiments do not always result in success.

Typical records should comprise farmer observations:

- At crop emergence
- Before first weeding
- Mid-season, and
- At harvest

BENEFITS FROM INTEGRATED SOIL FERTILITY MANAGEMENT

EXPLAIN Using Picture 54 to 56

Picture 54: No inputs

Picture 55: Compost only

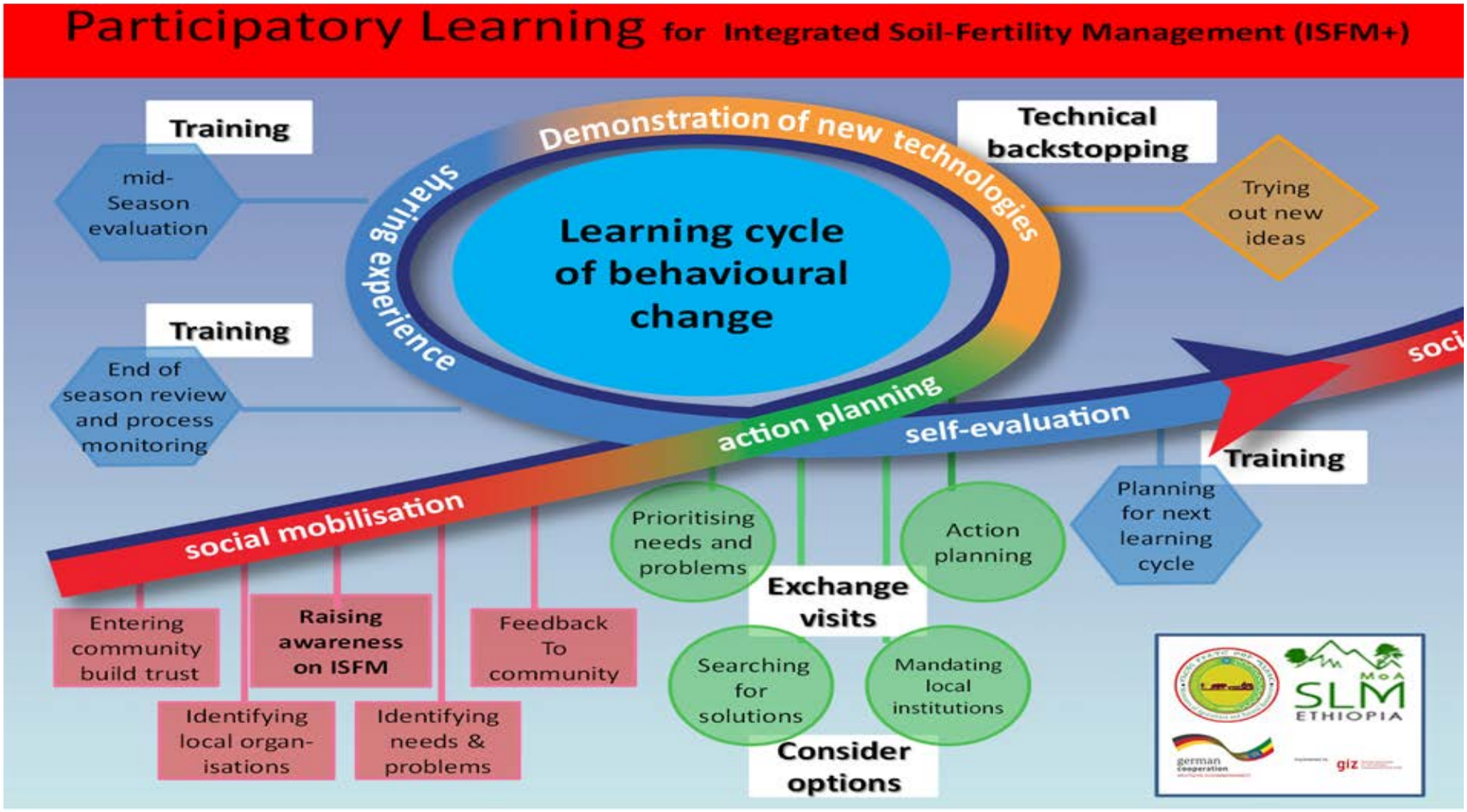
Picture 56: ISFM

Explain: The final three pictures show the long-term effect of a combination of methods to raise soil fertility.

The pictures tell the story of a husband and wife, who work together on the farm. Before they started improving the soil fertility of their fields their situation was very bad. Their fields were infertile and their crops were stunted. They used no inputs and the yield of their maize was very low.

Then they started using some compost and their yields improved and their lives improved. Then after discussions with other farmers they started practicing integrated soil fertility management (using purchased fertiliser, compost and manure and some lime) adapting their use to their own fields and after a short time their crops grew better and yields increased.

Now after a number of years of improved soil fertility management, their maize and other crops grow very well. They are now growing plenty of food and even have a surplus to sell.


Participatory Learning for Integrated Soil-Fertility Management (ISFM+)
Training
mid-Season evaluation
Training
End of season review and process monitoring
Demonstration of new technologies
sharing experience
Learning cycle of behavioural change
Technical backstopping
Trying out new ideas
action planning
self-evaluation
social mobilisation
Training
Planning for next learning cycle
Prioritising needs and problems
Action planning
Exchange visits
Searching for solutions
Mandating local institutions
Consider options
Entering community build trust
Raising awareness on ISFM
Feedback To community
Identifying local organ-isations
Identifying needs & problems
MOA
SLM
ETHIOPIA
german cooperation
giz

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