Training course package for extension workers

AGRO-ECOLOGICAL INTENSIFICATION IN KAMULI DISTRICT, UGANDA

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1. FoodLAND technical innovation for local food supply chains: concepts and approaches

The FoodLAND project has the ambition to impact on a large number of supply chains and communities, hence the process of food operators' capacity development has to be tailored and as much participative as possible. Accordingly, one of the assumptions of FoodLAND is that sustainable and nutrition-responsive farming systems can be achieved basically by strengthening the capacity development, and specifically by **a)** empowering farmers and processors through the implementation of capacity building processes and concrete opportunities; **b)** creating or consolidating cooperation and shared knowledge to overcome the lack of coordination among food operators; **c)** addressing the inefficient use of resources; **d)** trying to address and build resiliency to the high vulnerability of food systems to climate change; **e)** enhancing the integration of supply chains by creating commercial and stakeholders' networks; **f)** improving the responsiveness of the production sector to the market demand.

To implement these elements of capacity development, FoodLAND proposed the adoption of specific innovations, among which the organizational ones, to create strong and responsive links between producers and encompassing all the intermediate actors along the food value chain, such as researchers, SMEs, NGOs, local and national authorities. In order to ease the creation of those links and guarantee the sustainability over time of the results, 14 Food Hubs will be created in 6 countries as part of the organizational innovations. Food Hubs are conceived as multi-actors centers of innovation where to develop or enhance the organizational and operational conditions enabling local food supply chains (D3.6).

Functional to the implementation of the Food Hubs and of the innovations, the training courses were designed – in form of capacity development activities – as a two-phase process. Firstly, a training session focused on general, preparatory topics was provided to farmers as described and reported in D3.5 ("Group Introductory Training", GIT). According to the project GA, GIT broad set of goals

were: to enhance the knowledge of consumers' nutritional needs and market opportunities, and to boost the notions about climate change, sustainability, resilience, and food culture. Secondly, a specific training session were organized to provide food operators with practical information on the adoption and management of the innovations tested at lab / small scale level and to contribute to validating them at appropriate scale.

However, as the whole approach has been designed by FoodLAND to ensure the inclusion of the local actors from the first moment, both the training sessions were set up accordingly. Indeed, yet in the inception phase of the project, an assessment on participatory methods has been run and Participatory Learning and Action (PLA) approach has been eventually assessed as the best one to ensure the inclusion of multiple perspectives. The main purpose of PLA is to support people within communities to analyze their own situation, rather than have it analyzed by outsiders, and to ensure that any learning is then translated into action (Gosling and Edwards 2003). In addition, a gender-sensitive approach has been applied to the trainings that have been designed considering gender roles and power relations; they have provided equal opportunities to participate in the process by caring to times, venues and use of local languages.

The GITs have been conceived as the first step towards the innovation validation and aim at involving the producers, yet from the inception phase. They are just the first step in a sequence of 6, summed up in **Table 1**. After the GITs, where farmers and processors meet and share their vision and goals for the Food Hubs and exchange information about specific topics, the Food Hubs were created and the innovation tested (first in pre-test, then in pilot phase). The constant iteration between researchers and local actors is a key feature of the project: specifically, the practical trainings focused the single innovations (step 5) are aimed at validating the innovations at adequate scale and planned to trigger feedback loops of control and improvement involving developers and adopters.

Table 1. Activities with farmers and food processors (SMEs) and participatory approach

Step	1	2	3	4	5	6
Task	**T3.3**	**T3.3**	**T3.4**	**T4.1¸T4.5**	**T5.1¸T5.5**	**T5.1¸T5.5**
Activity	Group introductory training	Food Hubs creation	Innovation undertaking	Innovation tests	Individual and group practical training	Innovation pilot and validation

2. FoodLAND practical training: aims and scope

According to the project bottom-up and participatory approaches, following the courses on introductory topics GIT organized in the early project phase (T3.3), and as component creating / strengthening the Food Hubs as local innovation centres, FoodLAND has organized a second set of training activities with food operators based on active learning methods and gender equality principle (Task 5.1-5.9). In this regard, specific mechanisms (being aware of the gender roles and power relations; providing equal opportunities to participate in the process by putting attention to the times, venues, use of local languages, etc.) will be lifted to ensure women's participation. These training packages are aimed at providing the local farmers and food processors with operational instructions on the adoption and management of the validated innovations.

This second set of training activities has been organised – triggering PLA approach – as individual and group practical (demonstration/capacity building) activities to be conducted in parallel to the implementation of the technological research (where relevant) and of the innovation pilots and validation. These technology-centred trainings aim at strengthening the participants' understanding of novel production and post-harvest techniques, innovative tools and systems (e.g., climate smart/precision agriculture, hydroponics, and integrated aquaculture), new technologies for primary and secondary processing, and supply chain management. Thus they aim at fostering knowledge and operational capacity to deploy, manage, and maintain the validated technological innovations – documented by the released guidelines D4.1 ÷ D4.11 (e.g., training pamphlets, user manuals, flow diagrams, and operational recommendations) and practice abstracts D6.5 – validated jointly at appropriate scale.

3. Second training packages on the adoption and management of the tested innovations: an overview

The second training course aimed at consolidating the food operators' knowledge and practical skills to adopt, manage and validate the project innovations and complement the related guidelines. Specifically, the realized training materials provide local farmers and food operators with a set of notions and concrete information on a series of innovative tools and systems as per the following **Table 2**. It is clear that both the contents and formats of the learning packages widely differ across technologies as well as Food Hubs (when the same type of innovation must be validated in different contexts). The diversity that emerges from the proposed solutions reflects the different needs highlighted by farmers and stakeholders as well as the conditions and opportunities characterizing the local communities. Nevertheless, in order to take into due account the existing heterogeneity inside the local communities, the developed learning materials have been let available on the project intranet so as to be used for further training initiatives across the network of Food Hubs.

4. Second training packages on practical information on the adoption and management of the tested innovations

Agro-ecological intensification and biodegradable mulching

Agro-ecological intensification

Background

Context

A rapid baseline appraisal assessment revealed that smallholder farmers in Kamuli have limited farmland, produce a limited variety of crops with extremely few protein and micronutrient rich foods, record low yields, face seasonal hunger, register high pre- and post-harvest crop losses, have limited access to markets, among other problems. The main objective of the Food and Local Agricultural and Nutrition Diversity (FoodLand) Project is to improve food security and livelihoods of the farmers in Kamuli district. The specific objectives are;

- To assess the extent to which farmers' current production practices meet AEI principles.
- To identify, using participatory methods, crops (protein rich, micronutrient rich and food security crops) and AEI practices (e.g., inter-cropping; mulching; agro-forestry; minimal tillage; manure use; traditional plant disease management; plant residues addition to gardens) with potential for improving food security and dietary diversity.
- To promote identified crops and AEI practices among farmers in 5 farmer groups.
- To evaluate the changes in production practices, agrobiodiversity, temporal food availability, dietary diversity, and agricultural income among participating farmers.

Target users

This training manual is as a result of the collaborative work between Makerere University and VEDCO. The objective of this manual is to guide trainings offered to small resource scale famers on AEI interventions that have potential to alleviate some of the fore listed challenges faced by farmers. Farmers in Kamuli were sensitized on the potential benefits of AEI. Following farmer sensitization on AEI, they were engaged to select AEI practices that they consider most suited to them, based on their resource base and potential of the practices to contribute to productivity improvement.

Duration of the training

The period can vary with the project resource, time & or specific project needs (either such interventions will be continuous or intermittent). As participants undertake the training, they should take note of the changes they will need to make at their respective farms. These can then be fed into realistic action plans which are achievable.

Materials for preparing for the training

These materials will be used depending on the best material for the topic under study.

- Facilitator's Manual
- Power Point presentation containing the pictures and illustrations
- Data projector and laptop for PowerPoint
- Writing materials; Flip chart paper, markers, pens, paper
- Masking tape
- Demonstration sites
- Photo guides

Assessment of Learning

A pre-test helps the facilitator to gauge the level of knowledge of the participants and to plan to emphasize the weak areas during the training. The post-test will show how much additional knowledge the participants acquired. A Q&A at the end of each topic helps to assess participants' acquisition of knowledge on that topic. In addition, the facilitator will assess participants' skills through return demonstrations.

Delivering the training

Different training methods will be used during the course and are described below;

Interactive Facilitation

It is best if the facilitator does not read all the points word by word as a lecture but uses a more interactive style. The facilitator can ask participants some questions say their experiences, what do they think about some practices say will this practice work in this area or not?

Discussions

Discussions give an opportunity for participants to share ideas and raise questions. These discussions may be in plenary for the whole group or in small group of not more than 10. If one participant dominates discussion, the facilitator will need to intervene. If the facilitator dominates, it becomes a lecture or question-and-answer session and is not a discussion.

Working in small groups gives participants an opportunity to share ideas and experiences. These small group discussions are very important for changing attitudes, not just to share facts.

Facilitators can rotate from group to group to ensure the information shared supports the topics and practices under discussion. In general, do not spend time reporting back from the groups, especially if all groups were discussing the same topic. Each group should have a reporter who summarizes the main points and questions on a large card or sheet of paper to post for all to see. The facilitator can provide relevant information as the course continues and discuss the questions raised.

Pair practice

Pair practice allows participants to practice communication skills with one another. The facilitator will group participants at random so that they have an opportunity to work with different people. If someone ends up alone, a facilitator can pair with the extra person.

Gallery walks

Information is displayed on board or wall and participants walk around to review and discuss the information. The facilitator guides the gallery walk.

Role plays

When facilitators use role-plays and demonstrations as a learning tool, they should rehearse the general direction of the role-play before the session. As an alternative, selected participants can be asked to participate in a role

play/demonstration with a facilitator. Role play/demonstrations should be informal, small dramas that take only a few minutes. Role play/demonstrations can be used to stimulate discussion, to model certain kinds of interaction, and to introduce a case study for further role playing between participants. Role plays and demonstrations are suggested at several points throughout the course. However, it is hoped that individual facilitators will utilize their own teaching skills and talents to present material in creative ways. Have fun with role plays, and provide as many opportunities as possible for participants to join in.

Case studies

The case studies present a situation that the participants are asked to discuss or to use as the basis for a role-play. Participants may want to adapt their case study to fit national, cultural, or management situations. Names and character details can easily be changed. If class time does not permit the use of a case study, participants may be asked to do a homework assignment based on it.

Photographs and Illustrations

While topics may be presented without the use of PowerPoint slides, they are helpful whenever possible. The facilitator should explain what the participants are to look for in the picture. Participants can be asked to come to the front of the room to point out what they see in a picture

Q&A, plenaries, group work, field visit

Plenaries are used by trainers either during or at the end of a lesson, to review the aims and consolidate the participants' learning. It is an evaluative part of a lesson, where participants reflect on what they have learnt and achieved during that teaching period.

Field visit is when the participants are taken to see the real situation.

Group work is where the participants are given assignments or take homes in groups.

Commitment.

After training, each farmer can have some form of commitment to enable the trainer know what they have learnt and what they plan to practice. The table below is a sample of the format of the commitment form.

Commitment form

Participant Name		
Contact details:		
Farm location:		
Action Activity	**Expected change**	**Expected Period of implementation**
Return the completed form to the instructors		

Evaluation of the delivery of the sessions

The participants are given a form after every module to assess the level of importance of the different sessions and explain their choice in form of a comment. A sample of the evaluation form is as in table below. On returning this form, a neutral and convenient place should be created to enable the participants give well though evaluation – say a private box provided for feedback purposes.

Trainer evaluation form

Title of module	Degree of importance Not Useful Somewhat Useful Useful Very useful	Comments
Module 3.1		
Module 3.2		
Module 3.3		
Module 3.4		
Module 3.5		
Module 3.6		
Return the completed form to the designated location		

Note; This table can be adapted depending on the topic to be delivered in the field

How the manual is organized

The manual is organized in 5 modules covering the selected AEI for famers in Kamuli district.

Module 1: The concept of agricultural extension
Module 2: The concept of agroecology
Module 3: Agroecological technologies and practices
Module 4: Application of agroecological practices in soil and water conversation
Module 5: Application of agroecological practices in crop protection

Under each module, the following are covered:

Objective
Note to the trainer
Content
Methods
Materials and tools
Advise

Module 1: The concept of agricultural extension

Objective: To be able to impart knowledge and understanding of the basic principles and practice of extension education and training, and guide on the best way to use this manual.

Note to the trainer: Please explain the terms - What is agricultural extension? What principles define the extension works in agriculture? Explain the role of extension officers, as well as the key knowledge, personal skills, and qualities relevant for an effective extension role. Identify the basic components of adult learning.

Materials and methods

Methods	A power point presentation and discussions on the basics of agricultural extension Plenary discussion. Participants can expand the discussion list based on their experiences.
Materials and tools	Power point slides Flip charts Markers Projector
Advise	This is an adult learning session and all principles of adult learning must be adhered to.

1.1 Introduction

Extension is primarily the process of introducing new knowledge and ideas into rural regions to effect change and enhance the lives of farmers and their families. The extension workers informally provide advice and information to the farmers in the rural areas to address farming and family challenges. Farmers are able to improve crop productivity and quality through agricultural extension. Extension workers informally provide advice and information to the farmers in the rural areas to address farming and family challenges. Farmers are able to improve crop productivity and quality through agricultural extension. Extension also attempts to improve the efficiency of the family farm, enhance productivity, and overall raise the standard of living of the farm families.

1.2 Principles of agricultural extension

Several principles must be in place for an efficient and effective agricultural extension service: (i) Extension works with people, not for them, (ii) Extension is accountable to its clients, (iii) Extension employs two-way communication, (iv) Extension works with different target groups, (v) Extension collaborates with other rural development organizations, (vi) Equitable Services delivery to farmers, (vii) Efficient/Effective Services Delivery, (viii) Decentralization/Local Decision Making, (ix) Demand-driven Extension Services, (x) Working largely with Farmers Groups, (xi) Strong Extension Research Linkage, (xii) Capacitating Extension Personnel, (xii) Appropriate Extension Methodology, (xiii) Integrated Extension Support Services, (xiv) Coordination of Agricultural Extension Services, (xv) Improved Environmental Support.

1.3 The role of an extension agent

Extension agents/workers are essential components of all extension efforts because the entire extension process revolves around them. Therefore, the success or failure of an extension program is dependent on the effectiveness of the extension agent. An education and trained professional working with farmers, many of whom have no formal education and have different lifestyles from his own, is known as an extension agent.

An extension agent performs the following functions: (i) Assist farmers to identify and overcome problems, (ii) Assist farmers to make better use of resources/technology, (iii) Introduce new technologies (new varieties, crops, breeds, etc.), (iv) Provide information on new promising research results, (v) Create opportunities for farmers (processing, marketing, etc.), (vi) Help

farmers to put new information into use/apply it, (vii) Assist farmers to get a clear vision of their development.

1.4 Key knowledge, personal skills, and qualities for extension workers

Knowledge critical for extension agents	Personal skills	Personal qualities
Technical knowledge on the subject, Acquaintance with rural life. Must be aware of the different governing policies, Understanding of adult education principles, Cultural knowledge, etiquette & language, Religious protocols	Organization and planning Communication Analysis and diagnosis Leadership Initiative Public speaking Report writing	Commitment to extension work Reliability Humility in his work with the farmers Confidence in his own abilities and determination to achieve something

1.5 Basics of adult learning

Adult learners have different needs and requirements than kids and teenagers. The following traits can be used to describe adult learners, with the obvious implications for agricultural extension being as follows:

Adults are autonomous and self-directed
Adults have accumulated a foundation of life experiences and knowledge
Adults are goal-oriented
Adults are relevancy-oriented
Adults are practical,
As do all learners, adults need to be shown respect

Module 2: The concept of agroecology

Objective: To be able to create awareness about the agroecological practices and the governing principles among the farmers.

Note to the trainer: Please explain the terms – Why is time right to adopt agroecological practices? What principles define the agroecological practices? Explain the elements of agroecology to the farmers.

Materials and methods

Methods	A power point presentation and discussions on the basics understanding of AE Plenary discussion. Participants explain their local understanding of Farmers can expand the list of varieties based on their experiences. Groupwork – to help the participants synthesize the principles of AE
Materials and tools	Power point slides Flip charts Markers Projector
Advise	Encourage open discussion. Participants can give their own understanding the principles with specific examples based on their experience

2.1 Introduction

Agriculture has turned out to be capital intensive. This is attributed to the various farming challenges not limited to loss of soil fertility due to over cropping, erosion, leaching; the unfavorable climatic patterns, high infestation of weeds and pests thus affecting the overall crop yields among others. This has called for intensive use of inorganic fertilizers, irrigation water, pesticides, herbicides, thus resulting in an increase in overall production costs. As a result, various research initiatives are now working on solutions that not only enable sustainable food production but equally reduce the overall production costs for the farmer. Agroecology (AE) has been overly cited as the most viable solution to this growing issue.

Agroecology. What does it mean anyway??

Agroecology (AE), in a nutshell, is the application of ecological concepts and principles to agriculture. AE maximizes the interactions of plants, animals, humans, and the environment while also protecting the social aspects of a sustainable and equitable food system. It is believed that AE can deliver food security and ecosystem health, while still promoting economic stability. AE approaches are location and situation specific, enhancing applicability and adoptability among the desired communities. AE farming methods include crop rotation, mulching, intercropping, use of cover crops, agro-forestry, integrating the landscape with agricultural areas, organic soil fertilization, and the use of natural insecticides. Some of the socio-economic benefits of AE include (i) Increase income, (ii) Maintain/create jobs, (iii) Saving on chemicals, (iv) Increase food security.

2.2 Principles of agroecology

Because AE involves the application of ecological concepts to agriculture, the design of an AE agricultural system is based on the following principles:

Increase biomass recycling while improving nutrient availability and balancing nutrient flow. An enormous amount of biomass is produced year after year on an agricultural land (cow dung, corn stover, bean and coffee husk etc.). Farmers reuse this biomass to raise the soil's nutrient content. AE practices enable farmers to effectively utilize the biomass available to increase productivity.

Maintain favorable soil conditions for plant growth, namely through regulating organic matter and increasing soil biotic activity. Organic matter assists favorable soil conditions for better plant growth.

Reduce losses due to flows of solar radiation, air, and water through managing microclimates, harvesting water, and managing soil through improved soil cover.

Species and genetic harvesting of the agroecosystem in time and space at the field and landscape levels. Selective breeding of plants leads to monocultures of genetically identical plants, which makes crops extremely susceptible to widespread diseases. In contrast, species and genetic diversity helps plants adapt to changing environments.

Promote essential ecological processes and services by increasing favorable biological interactions and synergies among agrobiodiversity components. An organism's interactions with its environment are fundamental to its survival and to the functioning of the ecosystem as a whole. Biological interactions are the effects organisms in a community have on one another. In the natural world, no organism exists in isolation, and thus every organism is connected to the environment and to other organisms.

2.3 The 10 elements of agroecology

The framework of the ten elements of AE is offered as a tool to aid in the building of various approaches for the transformation of agriculture and food systems. The 10 elements enable practitioners, extension, and other stakeholders to make better decisions in many circumstances at various levels and sizes.

Diversity - AE emphasizes the importance of diversity as a fundamental precondition and adaptive trait, particularly in the context of global change, whether it is diversity of species or ecological functions, or knowledge held by different actors within an agricultural system or diversity of activities and livelihood options within food systems. For example, in Busoga, most small-scale farmers integrate beans and maize in their gardens and rear a few livestock. The beans and maize can be a source of food for both humans and animals while livestock can provide animal manure and alternative source of income through the sale of animals and their products such as milk and eggs.

Co-creation and sharing of knowledge - A key factor influencing AE decision-making is the co-creation and sharing of knowledge, practices, science, and innovation. Agroecology can encourage transdisciplinary engagement through the co-creation process, which can facilitate the blending of knowledge from various actors, such as traditional and indigenous knowledge on agricultural biodiversity and management experience for specific contexts held by men and women, practical knowledge of producers and traders related to markets, and global scientific knowledge and practices. For instance, adoption of readily available materials such as urine and ash for pest and disease management. This would be a great alternative to the very expensive inorganic fungicides and pesticides, thus promoting sustainable plant growth.

Synergies - AE takes careful attention when designing diverse and synergistic systems that include trees, animals, aquatic life, annual, perennial, and cover crops. It is crucial to purposefully use biological diversity and market linkages in redesigning agricultural and food systems to reap multiple concurrent benefits from component interactions. AE transitions should stress the value of collaboration, partnerships, and ethical leadership, including various actors at different stages, including multi-stakeholder partnerships. Mixed farming (integrating crop and livestock production) enhances complementarities and synergies. Mixed farming can occur at the plot, farm, community or landscape level in either a spatial or temporal interaction. For instance, farmers often exchange resources like manure or straw between neighboring farms. Tomato farmers often rely on banana farmers for supply of dried banana leaves for use as mulch to control spread of soil fungal based diseases.

Efficiency - The goal of redesigning the food and agricultural systems with synergies in mind is to use resources more efficiently. Innovative agricultural and food production systems that aim to further increase productivity while maximizing the use of external inputs should be able to migrate from input-intensive systems to information and knowledge-based systems. Agroecological techniques primarily evaluate efficiency at the level of the entire farm or ecological network rather than at the level of a single component. For instance, farmers can reduce costs, use fewer external resources, and reduce the negative environmental impacts of external resources by enhancing biological processes and recycling nutrients, biomass, and water.

Recycling - Producers can boost profitability by utilizing fewer external resources while maintaining or increasing production, lowering costs and having a negative environmental impact. This is done by strengthening biological processes and recycling biomass, nutrients, and water.

Resilience - Enhanced sustainable agriculture and food systems depend on the resilience of individuals, communities, and ecosystems. By encouraging a diverse community of interconnected species, agroecological practices strive to work with the biological complexity of agricultural systems and enable the ecosystem to self-regulate in the face of pest and disease outbreaks. For instance, some agroecology practices such as community seed banking (store and manage seeds that aim to provide community members with seeds for future use) ensure that farmers have reliable access to affordable, diverse varieties of locally adapted seeds in a timely manner to ensure continued production amidst pandemics and other stresses.

Human and social values - AE should place a high emphasis on human and social values, including those related to gender and inter-generational equality, inclusion, and justice, as well as access to decent employment, all of which support the improved livelihoods dimension of SDGs. The goals and requirements of individuals who produce, distribute, and consume food should be at the center of food systems. AE supports and empowers women who are the major food producers and care givers to equitably access and control production resources such as land and financial services as well as fairly benefit from returns of agriculture production. This therefore contributes to increased productivity and equitable development at household and community level thereby reducing overall social vulnerability.

Culture and food traditions - When balanced, diverse, and culturally acceptable diets are encouraged, AE helps to ensure food security and nutrition while preserving the health of the ecosystem. Food and agriculture are important parts of the human heritage; thus, they have a significant impact on how people behave. In order to promote the production and consumption of healthful foods, agroecology rebalances traditional and modern eating behaviors.

Responsive governance - Implementing sustainable food and agriculture practices requires effective governance structures at various scales, from local to global. For producers to transition their systems to AE practices and concepts, it is crucial to establish an inclusive, responsible, and transparent governance framework.

Circular and solidarity economy - Living within the limits of the earth is made easier by a circular and solidarity economy, which also provides a solid social framework for inclusive, sustainable development. AE prioritizes local markets and supports regional economic growth by reuniting farmers and consumers through a circular and solidarity economy.

Module 3: Agroecological technologies and practices

3.1 Mulching

Objective: To be able to carry out participatory village diagnostics in order to identify the main problems leading to the use of mulching, their management and the agroecological alternatives already known to farmers.

Note to the trainer: Please explain the terms - What is mulching? How does it happen? Explain the advantages and drawbacks of using mulching as an agroecological practice.

Materials and methods

Methods	A power point presentation and discussions on the basics of mulching Testimonies on the use of IPM – Participants share their experience with the use of mulching on their gardens. Well labelled illustrations of the different mulching approaches Videos Field illustrations or Miniature gardens to illustrate the approach
Materials and tools	Power point slides Flip charts Markers Projector
Advise	Engage the participants to ensure that they relate the concept of mulching

3.1.1 Introduction

Mulching is the process of covering topsoil with plant material such as leaves, grass, twigs, crop residues, straw, etc. Mulch increases the activity of soil organisms like earthworms. They contribute to the formation of a soil structure with numerous smaller and bigger holes through which rainwater can easily infiltrate, minimizing surface runoff. As the mulch material decomposes, it enhances the organic matter content of the soil. Organic matter in the soil aids in the formation of a good soil with a stable crumb structure. As a result, mulching is critical in preventing soil erosion.

Some of the common farmer challenges that could be managed using mulching

- Excessive runoff and soil erosion during the rainy season
- Excessive weed growth for example in banana plantation
- Excessive soil water loss especially in the dry season Protecting the soil from wind and water erosion: Soil particles cannot be washed or blown away.

Advantages of mulches

- Protecting the soil from wind and water erosion: Soil particles cannot be washed or blown away.
- Improving the infiltration of rain and irrigation water by maintaining a good soil structure: no crust is formed; the pores are kept open.
- Keeping the soil moist by reducing evaporation: Plants need less irrigation or can use the available rain more efficiently in dry areas or seasons.
- Feeding and protecting soil organisms: Organic mulch material is an excellent food for soil organisms and provides suitable conditions for their growth.
- Suppressing weed growth: With a sufficient mulch layer, weeds will find it difficult to grow through it
- Preventing the soil from heating up too much: mulch provides shade to the soil and the retained moisture keeps it cool.
- Providing nutrients to the crops: While decomposing, organic mulch material continuously releases its nutrients, thus fertilizing the soil, and eventually forming the humus.

Note: In annual crops, covering the soil with dead plant material is an easy technique to manage weeds and protect the soil. This approach is adaptable to most existing cropping systems. However, it is critical to have appropriate plant material.

Challenges associated with mulches

Some organisms can proliferate excessively in the damp and protected conditions of the mulch layer. Under a mulch layer, slugs and snails can multiply rapidly. Ants and termites that cause crop damage may also find optimal living circumstances.

When crop residues are utilized for mulching, there is an increased risk of pests and diseases persisting. Stem borers, for example, can live in the stalks of crops such as cotton, corn, and sugar cane. Plant material contaminated with viral or fungal diseases should not be used if the disease has the potential to spread to the following crop. Crop rotation is critical to mitigating these drawbacks.

When carbon-rich materials such as straw or stalks are used for mulching, microbes may use nitrogen from the soil to decompose the material. As a result, nitrogen may be temporarily unavailable for plant growth.

The availability of organic material is typically the primary constraint for mulching. Its production or collection usually requires labor and may conflict with crop production.

3.1.2 Selection of Mulching material

Note to the trainer: Now that farmers understand the concept of mulching, identify one or two farmers who are using mulch on their farms. Please request that the farmers explain why they use one material over another. This will set the stage for a lengthy discussion about material selection.

The type of material used for mulching has a significant impact on its effectiveness. Material that decomposes quickly will protect the soil for a limited time but will supply nutrients to the crops while degrading. Hardy materials degrade more slowly and thus cover the soil for a longer period. To accelerate the breakdown of the mulch material, organic manures such as animal dung can be sprinkled on top of it, increasing the nitrogen concentration. This increases nutrient release into the soil. Slowly decomposing mulch material (low nitrogen content, high C/N) will provide longer-term protection against soil erosion than swiftly decomposing material (Figure 1).

3.1.3 Sources of Mulches

Note to the trainer: Please ask the farmers to identify some of the mulching materials commonly used in their communities

Weeds or cover crops e.g., Pumpkin as cover crop in maize

Crop residues such as maize stovers (Lusoga: Ebidhumadhuma), banana waste leaves (Lusoga: ebyayi)

Grasses such as papyrus (Kitoogo – Luganda dialect)

Pruning material from trees

Cuttings from hedges

Wastes from agricultural processing or from forestry such as wood shavings

Biodegradable films (Figure 2a)

3.1.4 Application of Mulch

Note to the trainer: Please guide the farmers on how to effectively apply mulch under varying farming conditions.

If feasible, apply the mulch before or at the start of the rainy season, when the soil is most fragile. If the mulch layer is not excessively thick, seeds or seedlings can be sown or planted directly in between the mulching material. On vegetable plots, apply mulch only after the young plants have become slightly hardier, as the results of decomposition from fresh mulch material may damage them. If mulch is put prior to sowing or planting, it should not be too thick so that seedlings can penetrate it. Mulch can also be put to existing crops; however, it is best done immediately after digging the soil. It can be applied between the rows, directly around single plants

(especially for tree crops) or evenly spread on the field. During application of mulch, care should be taken not to cover the leaves of the plant as observed in Figure 2b.

Note to the trainer: Use the following video to enable farmer understand the actual practice. https://youtu.be/_jViflR_epc

Figure 1: Mulching in vegetable garden

Figure 2: Comparison of mulching approaches (a) Beans mulched with biodegradable film (b) Mulch material covering bean leaves

3.2 Mixed farming

Objective: To be able to carry out participatory village diagnostics in order to identify the main problems leading to the use of mixed farming, their management and the agroecological alternatives already known to farmers.

Note to the trainer: Please explain the terms - What is mixed farming? How is it done? Explain the advantages and drawbacks of using mixed farming as an agroecological practice.

Materials and methods

Methods	A power point presentation and discussions on the basics of mixed farming Testimonies on the use of mixed farming – Participants share their experience with the use of mixed farming.
Materials and tools	Power point slides Flip charts Markers Projector
Advise	Engage the participants to ensure that they relate the concept of mixed farming – Participants that have used the practice should share their experience to create a by-in for the technology.

Mixed farming is when a farmer decides to combine two or more agricultural activities on the same farm. Mixed farming is a type of farming which involves both the growing of crops and the raising of livestock. In mixed farming, the land is used for growing food (crop production) and fodder crops and rearing livestock. The cultivation of crops alongside the rearing of animals for meat or eggs or milk defines mixed farming. For example, a mixed farm may grow cereal crops such as maize and also keep cattle, sheep, pigs or poultry. Often the dung from the cattle serves to fertilize the cereal crops.

Some of the common farmer challenges that could be managed using mixed farming

Limited land available for different farm operation
Declining soil fertility
Lack of feed for animals
Uncertainty surrounding the crop yields due to climate change

Advantages of mixed farming

It enhances the productivity of the farm land
Both farming enterprises complement each other.
Farmers can keep their fields under continuous production.
It enhances the productivity of the farmer also.
Reduce dependency on external inputs and costs. Because the mixed farming system recycles much of its wastes, this reduces external inputs (like fertilizers and pesticides). This in turn reduce greenhouse gases emissions, whether directly or indirectly because less fossil fuels are required in the production and distribution of fertilizers and pesticides due to lower demand.
It stabilizes the income of the farmer because the farmer is not depending solely on one activity. Should one activity fail (due to low price or pests or diseases), the farmer can still get income from the other activities.
Increased biodiversity means less risks of pests and diseases outbreak in the farm. Outbreak usually occurs in monoculture where there is uniformity of species especially over a large area.

Drawbacks associated with mixed farming

Because a mixed farming system consists of multiple activities running simultaneously, this makes the control, monitoring, and maintenance of the farm more difficult than a monoculture where only a single activity is run.
Sometimes one activity may hinder the other activity. In a mixed farming system, animals may interfere with the crops as they are growing. Animals can feed on them and stampede them. this can still happen even when the animals are restricted, because they can always detach from their restricted zone whenever they find their way. Farm animals may feed on crops before harvest stage, thus resulting in loss of yield and reduction in market value.
For the same reason above, the farmer needs to be knowledgeable (or an expert) in more than one area as compared to a monoculture farmer. A mixed farming farmer is running several activities at once, there may be management problem.

It may become capital intensive as more resources are required for caring for your crops and raising your animals.

Note to the trainer: At the end of the session, engage the farmers to find if mixed farming is a common practice in their community. Ask some of them to explain how they have been impacted by mixed farming. This will create a buy in for the practice among farmers.

3.3 Integrated pest management (IPM)

Objective: To be able to carry out participatory village diagnostics in order to identify the main problems leading to the use of integrated pest management, their management and the agroecological alternatives already known to farmers.

Note to the trainer: Please explain the terms - What is integrated pest management? Under what circumstances do we use IPM? How is it done? Explain the advantages and drawbacks of using IPM as an agroecological practice.

Materials and methods

Methods	A power point presentation and discussions on the basics of IPM Testimonies on the use of IPM – Participants share their experience with the use of intercropping on their gardens. Well labelled illustrations of the different intercropping approaches Videos on making pesticides
Materials and tools	Power point slides Flip charts Markers Projector
Advise	Engage the participants to ensure that they relate the concept of IPM – Participants that have used the practice should share their experience to create a buy-in for the technology.

3.3.1 Introduction

Integrated Pest Management (IPM) was developed in response to steadily increasing pesticide use, which led to crises in pest management (e.g., secondary pest outbreaks and pest resurgences following the emergence of pesticide resistance) and increasing awareness of the full costs of pesticide use to human health and the environment. IPM is the methodical evaluation of every pest management method already in use, followed by the incorporation of the most appropriate controls to prevent the spread of pest populations. It combines biological, chemical, physical, and crop-specific (cultural) management approaches to grow healthy crops while using less pesticides, decreasing or limiting the dangers that pesticides bring to human health and the environment, and achieving sustainable pest management.

IPM is a dynamic process that employs an ecological systems perspective and encourages the user or producer to explore and implement the complete range of optimal pest control alternatives currently available given economic, environmental, and social factors. IPM is highly grounded on ecology, aimed at sustaining ecosystem functions. It supports the development of a wholesome crop while causing the least amount of harm to agro-ecosystems, and it supports organic pest management techniques.

Some of the common farmer challenges that could trigger the use of IPM

Rampant pest and disease outbreak leading to yield losses

High costs of pesticides and fungicides
Invasion by perennial weeds that result into total losses
Pests and weed persistence in fields

Examples of approaches used in IPM include; Crop rotation, Use of traps (e.g., pheromone traps, pull and push technology), use of organic pesticides, use of repellant plants (Napier grass, red pepper, American maly Gold, Chinese Chive among others among others).

3.3.2 Principles of IPM

Integrated pest management is based on eight principles (Figure 3) as discussed below:

Principle 1: Prevention and Suppression - Prevention is adoption of measures to reduce the chance of occurrence of pest. Suppression is reducing the impact of the pests. Prevention and suppression can be done by applying the different techniques. It is a method of preventing the spreading of harmful organisms by hygiene measures (e.g., by regular cleansing of machinery and equipment). One of the methods of prevention and suppression is crop rotation where it would break the life cycle of the pests. Prevention and suppression also include use of adequate cultivation techniques (e.g., stale seedbed technique, sowing dates and densities, under-sowing, conservation tillage, pruning and direct sowing).

Principle 2: Monitoring - Harmful organisms must be monitored by adequate methods and tools, wherever available. Monitoring can be done through observations, use of scientifically sound warning, forecasting and early diagnosis systems, advice from professionally qualified advisers, etc. Many countries like France, Denmark have adopted this monitoring and forecasting technique

Principle 3: Decision making - Decision making is done based on the results of the monitoring IPM focuses on threshold-based intervention in most of the cases. Threshold is the defined pest density, or population level, which when exceeded, management should occur. However, threshold is difficult to define in most of the cases and in case of tolerant species, decision of intervention is based on the general observations. We should also be aware that specific crops, pest life cycle, climatic condition, etc., should be considered before making any kind of decisions.

Principle 4: Non-Chemical Methods - Non-chemical methods are prioritized over chemical methods if they can produce satisfactory results. As chemical methods are often not sustainable and creates more pest problems, non-chemical methods are always preferred at first hand as they are more sustainable with less biological and environmental hazards. Examples of non-chemical methods include soil-solarization or biological control. Use of live natural enemies is one of the major non-chemicals (biological) intervention method. Other non-chemical methods include biological, physical and ecological methods.

Principle 5: Pesticide Selection - IPM doesn't totally avoid the use of the pesticides. When the alternative methods are not properly used then the pesticides are used for pest control. The pesticides used however needs to be as specific as possible for the target. The pesticides shouldn't possess any threat to the health of human, non-target humans and environment.

Principle 6: Reduced Pesticide Use - Reduced pesticides use refers to the reduction in the frequency and doses of the pesticides. This method needs to be supported by the other means of intervention. It helps in reducing the side effects of the pesticides

Principle 7: Anti- resistant Strategies - IPM focuses on the anti-resistance activities as: - Unmanaged and haphazard use of the pesticides have created the problem of resistance and Pests have developed the resistance and the use of pesticides have less effect on them. This is also the major reason for the IPM. Anti-resistant strategies include use of combination of different pesticides that has different mode of action, applied in different time.

Principle 8: Evaluation - Evaluation is the important aspect of the IPM program. Evaluation is done based on the records of the use of the pesticides, its effects and many

more. Evaluation is necessary in studying the effectiveness of the plan protective measures and plan further.

Figure 3: The chorological flow of the principles of IPM

3.3.3 Advantages and disadvantages of Integrated Pest Management

Advantages of IPM

Lower cost intervention: Traditionally, the use of the pesticides to control the pest invasion would account to lots of cost. Also, these pesticides need to be imported as well. The application of IPM would lessen the financial burden. Moreover, different techniques involved in IPM are more sustainable with long lasting benefits.

Benefits to the environment: Use of the pesticides are often linked degradation of the environment causing some more additional problems. IPM is an eco-friendly approach and the effects on the environment is always considered before the application of any interventions. Less use of pesticides won't affect the fertility of soil.

Minimizes residue hazards of pesticides: It is obvious that in an IPM schedule the use of pesticides will be considerably reduced, hence the pesticide residue hazards will also get automatically minimized.

Anti-Resistance: The IPM model in itself is the anti-resistant mode for pest control. It discourages the use of chemicals and thus creates less cases of anti-resistance. Pesticides are used only when the other alternatives are not satisfying.

Useful and best intervention for the general public: Assurance of safe, reliable and low-cost pest control. The pest control will not affect the crops. Moreover, it is safe and affordable for the general public as well.

Disadvantages of Integrated Pest Management

More involvement in the technicalities of the method: IPM needs to be planned. IPM demands more attention and dedication. Requires expertise of various field. All those involved in the IPM need to be educated and trained which often requires much time.

Time and energy consuming: Application of IPM takes time. Much time is needed in planning itself. As IPM strategies differs from region to region, a separate plan is required for each region. The expected results of intervention may take long time to be achieved.

3.3.4 The push and pull technology

Note to the trainer: Please explain the push and pull technology in detail – Under what cropping systems has the push and pull mechanisms used? What are some crop pests and weeds managed using this technology? How is the technology used?

Push–pull technology is an intercropping strategy for controlling agricultural pests by using repellent "push" plants and trap "pull" plants. For example, cereal crops like maize or sorghum are often infested by stem borers.

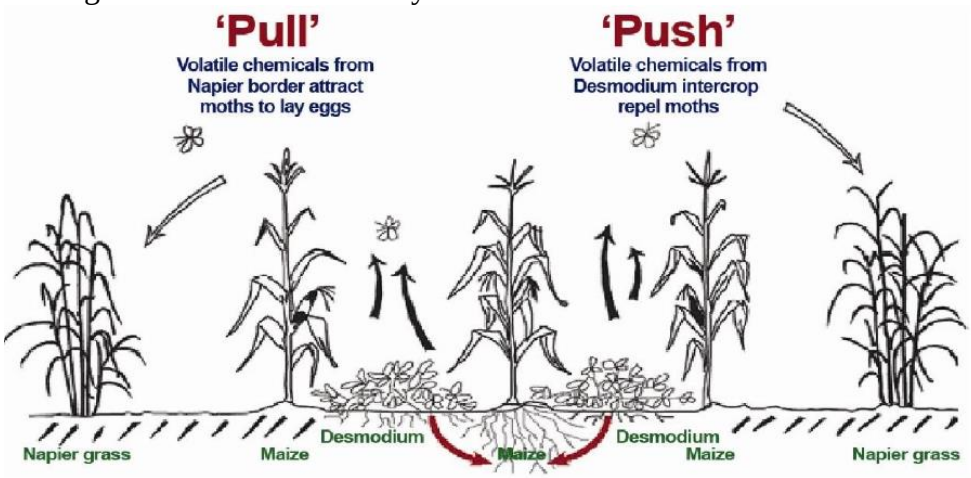

Figure 4: Demonstration of how the intercrop facilitates the push and pull mechanism

How it works for maize protection: Push-pull is a simple cropping strategy whereby farmers use Napier grass and desmodium legume (Silverleaf and Greenleaf desmodium) as intercrops (Figure 4, Figure 5). Desmodium is planted in between the rows of maize. It produces a smell or odor that stemborer moths do not like. The smell 'pushes' away the stemborer moths from the maize crop. Napier grass (*Pennisetum purpureum*) is planted around the maize crop as a trap plant. Napier grass is more attractive to stemborer moths than maize, and it 'pulls' the moths to lay their eggs on it. However, Napier grass does not allow stemborer larvae to grow and survive on it. When the eggs hatch and the small larvae bore into Napier grass stems, the plant produces a sticky substance like a glue that traps them, and they die. So, very few stemborer larvae survive, and the maize is saved because of the 'push-pull' strategy.

In addition, a ground cover of desmodium (*Desmodium uncinatum*, or Silverleaf), interplanted 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 exists. As a legume, desmodium also fixes nitrogen in the soil and thus acts to enrich the soil.

Note to the trainer: Use the following video to enable farmer understand the actual practice. https://youtu.be/ZwChseDEe3E

Figure 5: Layout of the pull and push technology in maize production

Note to the trainer: Identify one or two farmers that have practically used the push and pull technology? Allow them explain how the technology compares to their other methods available for pest and weed management.

3.3.5 Pheromone trap

Note to the trainer: Please explain the pheromone trap technology in detail – Under what cropping systems has the pheromone trap mechanisms used? What are some crop pests managed using this technology? How is the technology used?

A pheromone trap is a type of insect trap that uses pheromones to lure insects. Sex pheromones and aggregating pheromones are the most common types used. A pheromone-impregnated lure is encased in a conventional trap such as a bottle trap (Figure 6), Delta trap (Figure 7), water-pan trap, or funnel trap. Pheromone traps are used both to count insect populations by sampling, and to trap pests such as clothes moths to destroy them.

Pheromone traps use chemical signals (pheromones) emitted by females to attract a male (therefore pheromone traps only catch males of that species). Sorting through large numbers of insects can be extremely time consuming, and pheromone traps have the advantage of being much more specific than pitfall, sticky, or light traps, reducing the number of incidental insects caught.

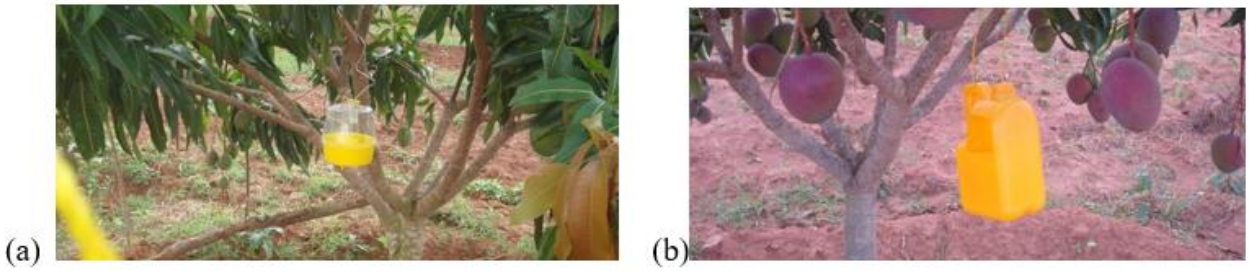

Figure 6: Bucket traps (a) Imported type (b) Locally made trap

Types of pheromone trap

The most used pheromone traps are the bucket traps and delta traps. Both trap types are suitable for use in a wide range of crops, easy to set up, and re-usable (except for the single-use delta traps)

Bucket traps: Bucket traps consist of a lid containing the cage that holds the lure above a funnel leading to a holding bucket (Figure 6). The assembled trap is suspended by a wire hanger. The target insect is attracted to the lure, falls through the funnel and into the bucket, where an insecticide-infused cube prevents escapes and minimizes damage

(making it easier to confirm identification). They are relatively weather-proof and can hold more insects than delta traps.
Delta traps: Delta traps are tri-folded to create a sheltered triangular area open at each end with a sticky side (Figure 7). They are available as single use, or with a replaceable sticky sheet.

Note to the trainer: Use the following video to enable farmer understand the actual practice. https://youtu.be/rkyLWX5rweA

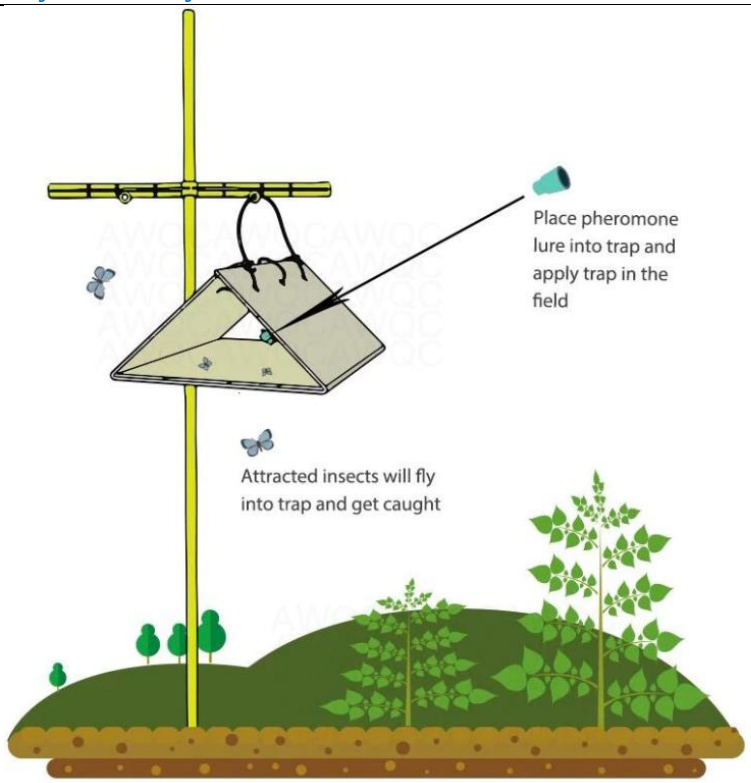

Figure 7: Arrangement of delta trap system

Note to the trainer: Identify one or two farmers that have practically used the pheromone trap technology? Allow them explain how the technology compares to their other methods available for pest management.

3.3.6 Use of organic pesticides

Organic pesticides are usually considered as those pesticides that come from natural sources. Some of the plants used in making pesticides are presented in Table 1.

Table 1: Some of the plants used in making pesticides

No	English name	Scientific name	Lusoga Dialect	Luganda Dialect
1	Neem tree	*Azadirachta indica*	Nimu tri	
2	Fish bean	*Tephrosia vogelii*	Muluku	
3	Hot pepper	*Capsicum annuum*	Kamulali	
4	Pawpaw leaves	*Carica papaya*	Amakola gha mapapali	
5	Bitter leaf	*Vernonia amygdalina*	Olubirizi	Omululuza

6	Napier grass	*Pennisetum purpureum*	Ebigadha	Ebisagazi
7	American Malgold	*Tagetes erecta*	Mukazi muchafu	

Note to the trainer: Use the following video to enable farmer understand the actual practice. https://youtu.be/g_Qoqu_qhjM

3.4 Intercropping

Objective: To be able to carry out participatory village diagnostics in order to identify the main problems leading to the use of intercropping, their management and the agroecological alternatives already known to farmers.

Note to the trainer: Please explain the terms - What is intercropping? Under what circumstances do we use intercropping? How is it done? Explain the advantages and drawbacks of using intercropping as an agroecological practice.

Materials and methods

Methods	A power point presentation and discussions on the basics of intercropping. Testimonies on the use of intercrops – Participants share their experience with the use of intercropping on their gardens. Well labelled illustrations of the different intercropping approaches Group work Plenary discussion
Materials and tools	Power point slides Flip charts Markers Projector
Advise	Engage the participants to ensure that they relate the concept of intercropping – in small groups, ask the participants to come up with intercropping patterns for the crops available in their community. Let them share their ideas with the rest of the participants for feedback and general understanding.

3.4.1 Introduction

Intercropping is the practice of growing two or more crops on the same plot of land at the same time. Intercropping, on the other hand, necessitates additional management to keep competition between intercropped species in check. When two or more crops are grown together, each must have enough space to maximize cooperation while minimizing competition. To accomplish this, four factors must be considered: (i) Spatial arrangement, (ii) Plant density, (iii) Maturity dates of the crops being grown, (iv) Plant architecture.

Some of the common farmer challenges that could trigger the use of intercropping

Limited land available for different farm enterprises
Declining soil fertility
Uncertainty surrounding the crop yields due to climate change

Advantages of Intercropping

It improves soil structure: Some crops have strong, deep roots. They can break up hardpans and tap moisture and nutrients from deep in the soil. Others have many fine, shallow roots. They tap nutrients near the surface and bind the soil. They form many tiny holes so that air and water can get into the soil.

It increases soil fertility: Legumes (such as groundnuts and beans) fix nitrogen in the soil. When their green parts and roots rot, this nitrogen can be used by other crops such as

maize. The result is higher, more stable yields, without the need to apply expensive inorganic fertilizer.

Inter-crops maintain the soil fertility as the nutrient uptake is made from both layers of soil

Intercropping gives additional yield income/unit area than sole cropping. It produces different types of output: Growing a mix of grain, beans, vegetables and fodder means a more varied diet and more types of produce to sell.

It acts as an insurance against failure of crops in abnormal year. Intercropping can be the insurance that farmers need, especially when the region is vulnerable to weather extremes

In some ways, intercropping takes the place of ploughing the soil: it helps aerate the soil, recycles nutrients, and helps control weeds, pests, and diseases.

Reduction in soil runoff and controls weeds.

Intercrops provide shade and support to the other crop.

Inter cropping system utilizes resources efficiently and their productivity is increased

Better utilization of space available with the time dimensions.

Disadvantages of Intercropping

Yield decreases as the crops differ in their competitive abilities. In intercropping, special attention must be paid to avoid competition between the crops for light, nutrients and water. This requires knowledge on arrangements, which promote growth of at least one of the crops.

Management of an intercrop having different cultural practices seems to be difficult task.

If the crops aren't wisely chosen when intercropping, it may lead to soil exhaustion.

Sometimes intercrops work as alternate hosts for various pests and diseases.

Differential maturity and sometimes harvesting may become difficult.

It becomes difficult to control various pests and diseases.

Intercropping is a labor-intensive practice.

Allelopathic effect - This is a natural phenomenon describing the ability of certain plant species to produce compounds that affect the growth of other plants in their surroundings.

Possibility of problems in carrying out intercultural operations.

3.4.2 Methods of intercropping

Note to the trainer: Please explain the different intercropping methods. Under what circumstances do we use the different intercropping methods? How are the various intercropping methods done? Explain the advantages and drawbacks of using intercropping as an agroecological practice.

There are at least four basic spatial arrangements used in intercropping, and most practical systems are variations of these namely.

Row intercropping: Growing two or more crops at the same time with at least one crop planted in rows (Figure 8). This can be beneficial in situations when using tall crops to reduce drought or heat stress of shorter crops, by providing shade and reducing wind speed.

Figure 8: Row intercropping of maize and beans

Strip intercropping: Growing two or more crops in strips broad enough to allow independent crop production with machines yet close enough for the crops to interact, such as intercropping beans and maize (Figure 9). Nitrogen-fixing bacteria are found in the roots of legumes. As a result, they compete for resources with non-legumes and, in some situations, supply nitrogen to adjacent plants.

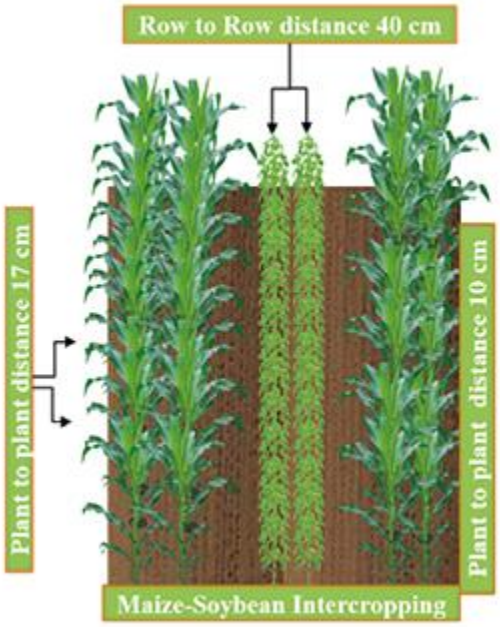

Figure 9: Strip intercropping of maize and soybean

Relay intercropping: Planting a second crop into a standing crop at a time when the standing crop is at its reproductive stage but before harvesting (e.g., transplanting lettuce next to tomatoes plants) (Figure 10). The lettuce will use the space that is not yet occupied by the tomatoes and is harvested about the time the tomatoes are branching out to cover the width of the bed.

Figure 10: Relay intercropping

Mixed intercropping: Growing two or more crops simultaneously on the same piece of land with no distinct row arrangement (Figure 11). Some crops may also be sown as a border crop or as a trap crop at the hedges of the main crop to reduce pests. The pest, arriving in the field from the edges, encounter the trap crop (which is strongly preferred than the main crop) and stops. The trap crop may be sprayed with natural insecticide to control the pest before it moves to the main crop.

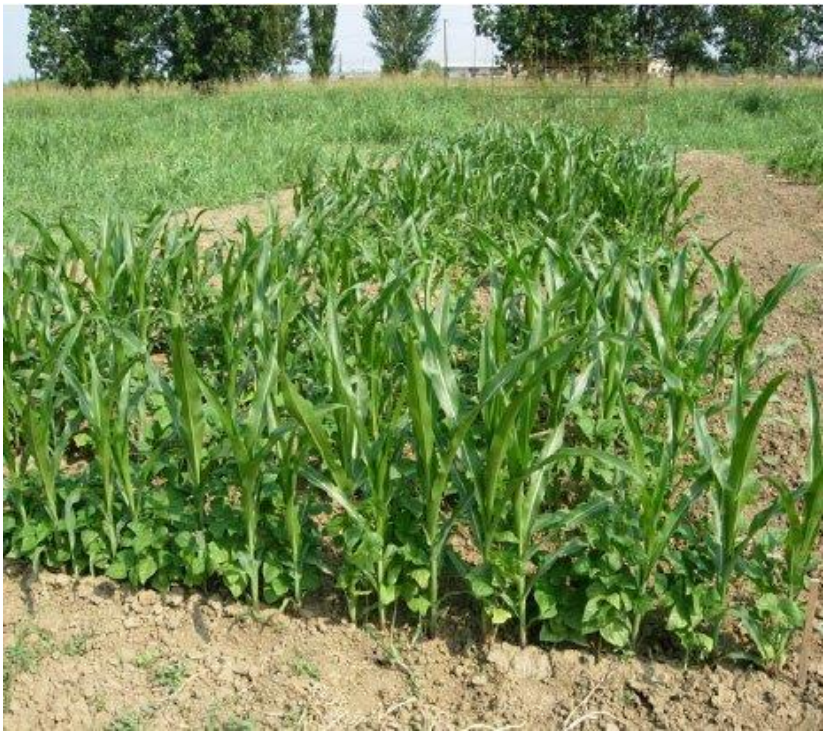

Figure 11: Mixed intercropping within rows, where the component crops are planted simultaneously within the same row (corn with climbing bean)

3.4.3 Rules to be followed in the selection of the intercropping crops

Selecting crops with diverse growth habits, duration, root growth, taxonomical families, and so on should be done with caution. The following are some of the guiding principles for intercropping:

- Grow tall-growing crops along with bushy crops.
- Select shallow-rooted crops as intercrops in the deep-rooted crop.
- Long-duration crops should be intercropped with short-duration crops.
- Grow slow-growing crops in vacant spaces of fast-growing crops.
- Selected main crops and intercrops should show a very negligible allelopathic effect.
- Need to intercrop non-legumes with legumes.
- Crops selected should be of different families to avoid various pests and diseases

Note to the trainer: Please form small groups of farmers – In those groups, task them to identify a crop grown in their locality. Identify the probable form of intercrop for the crop. Then allow the groups to present their findings as others contribute to the general discussion. Please moderate the session so that the values of adult learning as not violated.

3.5 Use of manure and crop waste recycling

Objective: To be able to carry out participatory diagnostics in order to identify the main problems leading to the use of manures and crop waste recycling, their management and the agroecological alternatives already known to farmers.

Note to the trainer: Please explain the terms - What is manure? Under what circumstances do we use manure and crop waste as soil amendments? What materials can be potentially used as manure? Explain the advantages and drawbacks of using manure as an agroecological practice.

Materials and methods

Methods	A power point presentation and discussions on the basics of manure application Plenary discussion. Testimonies on the use of manure – Participants share their experience with the use of manures and organic liquid fertilizers. Video clips of practical use of green material for manure and liquid fertilizer Demonstrations – making composite tea, composite heap
Materials and tools	Power point slides Flip charts Markers Projector
Advise	Engage the participants to ensure that they relate the concept of manure - current crops frequently used for manure in their areas, how are the waste materials actually prepared, local crops available that could be applied to making fertilizer tea. Ask if some of the participants have used fertilizer tea or compost tea before and let them share their experience Use of demonstrations would help the participants relate more with the procedures.

3.5.1 Introduction

Manure is the decomposed form of dead plants and animals, which is applied to the soil to increase production. It is a natural form of fertilizer and is cost-effective. Human and animal excreta can also be used as manure. Manure is highly rich in organic matter and humus and thus improves soil fertility. Animal manure is rich in nitrogen, phosphorus, and potassium.

Some of the common farmer challenges that could trigger the use of manure and crop waste recycling

Infertile soils that result into very low yield
High costs of fertilizers

Sources of manure

Biodegradable materials like cattle dung, urine, slurry from biogas plants
Waste products from human habitation such as human urine, night soil, sludge, sewage, domestic waste.
Droppings of livestock such as goat and sheep
Waste that is obtained from slaughterhouses such as bones, meat, horn and hoof meal, fish waste.
By-products of agricultural industries.
Waste material from crops.
Weeds like water hyacinth

Advantages of Manure

These are a good source of macronutrients.
Improves soil fertility.
Cost-effective in increasing yield
Reduces soil erosion and leaching.
Improves the physical properties of the soil and aerates the soil.
Improves the water and nutrient holding capacity of the soil.
Methane gas is evolved as the by-product of manure that can be used for cooking and heating purposes.
The crops grown on the land treated with manure produces healthy crops.

3.5.2 Types of Manure

Note to the trainer: Please explain the different types of manure. Under what circumstances do we use the different forms of manure? How are the various forms of manure prepared? Explain the advantages and drawbacks of using various forms of manure as an agroecological practice.

Manure can be grouped as farmyard manure, green manure and compost manure as discussed below.

Green Manure*:* Green manuring is the practice of growing a leguminous plant species for biomass production and incorporation into the soil (Figure 12). Green manure crops are grown in the field itself either as a pure crop, or as an intercrop with the main crop, and buried in the same field. Green manures can also be grown as improved fallows, as seasonal green manures in rotation with other crops, or in strips between crops. Green manure increases the percentage of organic matter in the soil. Some of the crops that are used as green manure include: (i) Crotalaria (*Crotalaria ochroleuca*), (ii) Mucuna (*Mucuna pruriens var. utilis*), (iii) Lablab (*Dolichos lablab*), (iv) Canavalia (*Canavalia ensiformis*).

Figure 12: Incorporation of green manure into the soil

Advantages of Green Manure

Preventing soil erosion: Green manure are also cover crops, as it covers soils, preventing it from exposure to harsh elements. Roots hold on to soil particles and hold them in place, while plant bodies shield the soil from extreme rains and the scorching sun, thereby preventing erosion.

Prevention of leaching: Green manure also minimizes the leaching of nutrients into the environment. It draws nutrients into their bodies and locks them until the crop is dug into the soil. The plants decompose and nutrients are slowly and gradually released into the soil, just in time for the next crop to utilize them for their growth.

Providing nutrients and organic matter to the soil: Using green manure results in increased levels of key plant nutrients. Leguminous green manure such as clover and vetch can grab nitrogen from the air and add it to the soil. Nitrogen, for example, is a key nutrient that promotes the healthy growth of the crops that will be planted after. Other green manure, such as buckwheat and lupin, enriches the soils with phosphorous. Lupin has been found to draw in and utilize 10 times more phosphorous than a common grain or wheat does. As such, phosphorous from the body of the lupin will be released to the subsequent crop if it is incorporated into the soil. Other green manure crops supply potassium, iron, calcium, and other trace minerals. High amounts of organic material, improved by green manures, ensure soil fertility is improved by bettering the soil's physical and biological properties.

Suppressing weeds: Green manure can suppress weeds by disrupting the growing patterns and cycle of weed plants. They also out-compete weeds for both water, nutrients, and space. Also, some species can release chemicals from their roots, which inhibit the growth of weeds and germination of seeds in the soil, in a process known as the allelopathic effect.

Providing habitat for natural predators: There are different ways of controlling pests, including boosting the number of their natural predators. Green manure crops can serve a home for predatory insects, such as ground and rove beetles. These two species of beetles are well known for being skilled hunters of pests and caterpillars. Blue flowers of Phacelia can also act as a home for hoverflies, which feed on aphids, a widespread and resistant pest to gardeners and farmers.

Improving the soil's structure: Green manure significantly improves the soil structure by adding organic matter into the soil. Such organic matter binds soil particles together and creates soil aggregates. The clusters of the improved larger particles allow for the formation of pores, which allows for proper soil aeration, nutrient distribution and water retention.

Disadvantages of Green Manure

Harboring slugs and snails: A green manure crop may be the perfect opportunity for snails and slugs in which to breed. This means their numbers will increase and might ultimately affect some crops such as vegetables.

It consumes time: Farmers should wait up to a month after cutting back and rotating green manure crops before planting a new crop. This is because some crops are allelopathic (they naturally leave toxic substances in the soil that prevent new crops from germinating)

Harboring pests and diseases: Green manure crops may harbor pests and diseases in addition to slugs and snails. Such incidences may increase if the green manure crop is not kept free from diseases and pests. Applying phosphatic fertilizers to leguminous green manure crops increases yield for rapid Rhizobia growth while also boosting phosphorus levels in the next crop.

Using moisture: Green manure crops, like any other crop, use moisture. If moisture is scarce in a particular location, they will use available moisture that would otherwise have been conserved during fallow. If moisture is not a factor, the amount taken up by green manure crops is less than that used by mature crops.

Establishment costs: There is a cost associated with growing green manure crops. It should not be more than the cost of growing other crops. It also should not outweigh the potential soil and nitrogen benefits. If it occurs, the farmer will be at a loss because they will be spending more time preparing the land than producing marketable crops.

Farmyard Manure: Farmyard manure improves the soil structure and is used as a natural fertilizer in farming. It increases the soil capacity to hold more water and nutrients. It also increases the microbial activity of the soil to improve its mineral supply and the plant nutrients.

Factors affecting the composition of Farmyard Manure

Source of manure: Composition of manures varies with kind of animal producing it. Poultry droppings is the richest followed by sheep manure for nutrient contents. Dung contains phosphate while urine contains nitrogen (N) and potassium oxide (K_2O). Amount of urine soaked in bedding material also decides the composition and vary with kind of animal.

Food of the animal: The richer the food in proteins, the richer will be the manure in 'N' which comes out in the dung and urine. The higher the quality of food the higher the quality of manure.

Age and condition of the animal: young animals need more proteins to build up their body; hence manure is poorer in N content than old animals. Manure of sick animal is richer than healthy animals.

Function of the animals: Milk cattle utilizes proteins for milk production; hence manure is poor in N, P & K content than draft purpose animals as they utilize more carbohydrates.

Nature & proportion of litter: The composition of litter varies with the kind of straw and hence will affect the quality of manure. Bajra stalks are rich in N, P & K followed by wheat & maize.

Preservation (method of storage): Under ordinary storage, there are losses of N. Potash get lost due to leaching when the manure is too moist. Should be stored in a leakproof roof and concrete floors to avoid leaching.

Age of farmyard manure - Well rotten manure has higher nutrient content.

Type of animal used - non-ruminants have a better quality of manure

Advantages of Farmyard Manure

It usually has a high content of nitrogen and phosphorous

It supplies a high amount of organic matter to the soil.

It improves on the soil physical properties such as structure and hence increases the soil capacity to hold more water and nutrients.

It also increases the microbial activity of the soil to improve its mineral supply and also the plant nutrients.

Disadvantages of farmyard manure

It is difficult to collect enough animal dropping if the animals are scattered.

Urine can only be collected when the floor is cemented and only if animals are kept indoors.
Requires a lot of labor to collect the dung.
Farmyard manure has a bad smell.

Compost Manure: Compost is a mixture of organic matter, as from leaves and manure, that has decayed or has been digested by organisms, used to improve soil structure, and provide nutrients

Benefits of using compost

Improves the soil structure, porosity, and density, thus creating a better plant root environment.
Increases infiltration and permeability of heavy soils, thus reducing erosion and runoff.
Improves water holding capacity, thus reducing water loss and leaching in sandy soils.
Supplies a variety of macro and micronutrients. (However, amounts not known)
May control or suppress certain soil-borne plant pathogens.
Supplies significant quantities of organic matter.
Supplies beneficial micro-organisms to soils and growing media.
Improves and stabilizes soil pH.

Important considerations during composting

Green stuff (high in nitrogen) to activate the heat process in your compost. Perfect heat-generating materials include young weeds (before they develop seeds); comfrey leaves; yarrow; chicken, rabbit, or pigeon manure; grass cuttings; etc. Other green items that compost well include fruit and vegetables; fruit and vegetable scraps; coffee grounds and tea leaves (including tea bags – remove the staple if you wish); vegetable plant remains; plants.
Brown stuff (high in carbon) to serve as the "fiber" for your compost. Brown stuff includes dead plants and weeds (avoid weeds with seed); sawdust straw; old flowers (including dried floral displays, minus plastic/foam attachments); and hay.
'Other items that can be composted but you may not have thought of before: paper towels; paper bags; cotton clothing (torn up); eggshells; hair (human, dog, cat etc.) Use all these items in moderation.
Air. It is possible to compost without air (anaerobically), but the process employs different bacteria, and an anaerobic compost pile will take on a sour smell like vinegar. It may also attract flies or take on a matted, slimy appearance. If you believe your compost pile needs more air, turn it, and try adding more dry or brown stuff to open up the structure. Turning a compost pile can be labor intensive and hard on the back. Some people use a shovel or pitchfork. There are also compost aerating tools that aim to make the process easier that are either of the "winged" type or "corkscrew" type.
Water. Your pile should be about as damp as a sponge that has been wrung out. Depending on your climate, you can add water directly or rely on the moisture that comes in with "green" items. A lid on the compost bin will help to keep moisture in. If a pile gets too much water in it, it might not get enough air.
Temperature. The temperature of the compost pile is very important and is an indication of the microbial activity of the decomposition process. The simplest way to track the temperature inside the heap is by feeling it with your hand. If it is warm or hot, everything is decomposing as it should, but if it is the same temperature as the surrounding air, the microbial activity has slowed down and you need to add more materials that are high in nitrogen to the bin.
Soil or starter compost. This is not strictly necessary, but a light sprinkling of garden soil or recently finished compost between layers can help to introduce the correct bacteria to start the compost cycle a little more quickly. If you are pulling weeds, the soil left on the roots may be sufficient to serve this purpose. Compost starters are available, but probably not necessary.

The process of heap compositing

Materials to put in a compost heap

Nearly all organic materials can be used to make compost, but different items will take varying amounts of time to decompose, and some materials will attract pests and rodents while others will harbor harmful disease-causing organisms.

Different types of organic matter contain different proportions of carbon and nitrogen: (i) Fresh (green) materials decompose faster because they contain high levels of nitrogen and low levels of carbon. E.g., manure, food scraps, green lawn clippings and green leaves. (ii) Dry (brown) materials decompose slowly because they contain high levels of carbon and low levels of nitrogen e.g., straw, branches, stems, dried leaves, peels, bits of wood, bark dust or sawdust, papers, corn stalks, wood ash and eggshells.

Carbon provides both an energy source and the basic building block making up about 50 percent of the mass of microbial cells. Nitrogen is a crucial component of the proteins, nucleic acids, amino acids, enzymes, and co-enzymes necessary for cell growth and function.

How to build the compost heap

Start your compost heap on bare soil to allow beneficial organisms to colonize the composting materials.

Make a base 30 cm high and 2 m wide with coarse materials such as twigs for good air circulation and drainage (any material that will note decompose can be used).

Add a 10 cm layer of carbon-rich material such as maize stalks (chop bulk materials into at least 3 inches).

Add a 10 cm layer of nitrogen-rich material such as fruit and vegetable scraps.

Add 2 cm layer of animal manure or old compost to activate the compost heap and speed the process.

Spread a layer of soil to mask odors and introduce microorganisms that will accelerate the composting process.

Sprinkle ash and urine lightly onto these layers to accelerate the process of decomposition.

Water the heap thus formed.

Repeat these layers except the first layer of coarse material, until the heap reaches 1 to 1.5 m high.

Cover the heap to protect it against evaporation and heavy rain as this will wash away all the nutrients. Covering also helps retain moisture and heat. Sacking, grass thatch or banana leaves are suitable for this (Figure 13).

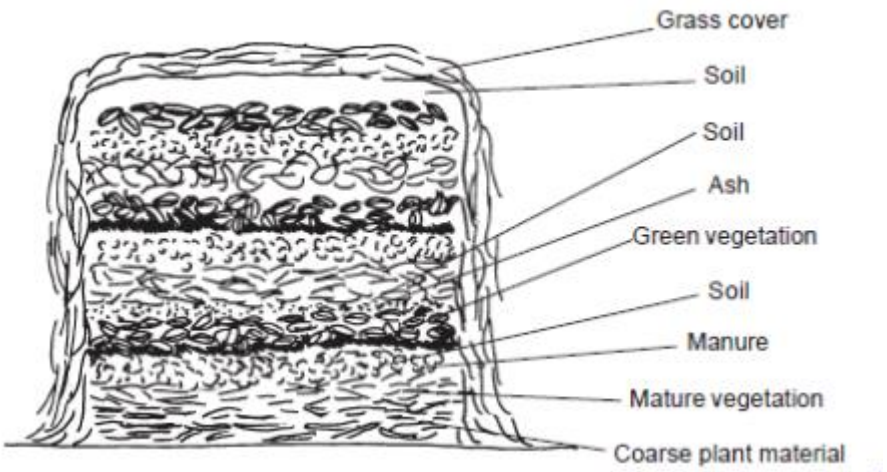

Figure 13: Structure of a compost heap

How to determine a suitable site for composting

Distance and accessibility: A compost heap should be placed in an area where it is easy to carry the materials collected. Distance and access to the fields where the compost will be applied is also an important consideration.
Water and shelter: Locate the heap where drainage is adequate, a shaded or sheltered area will help keep the pile from drying out. Ideally, the heap should also be located near a source of water. If you do not have a borehole close by, you should keep a container filled with water near to the heap.
Vermin: Pests and vermin such as rats, snakes, termites, flies and mosquitoes may be attracted to the compost heap so it should not be placed too close to the home.

Maintenance of compost heap

Maintain the desired moisture level - Dig a stick into the center of the compost heap and check if the stick is wet. A dry stick indicates that the heap is dry and requires watering.
Turning to aerate the heap - More frequent turning will help if you need to speed up the process or if your compost pile has a strong odor
Keep the pile at the proper temperature – Dig a stick into the center of the compost heap and check if the stick is warm. This indicates that decomposition is going on within the heap.

Note to the trainer: Use the following video to enable farmer understand the actual practice. https://youtu.be/WeB_Bf17VwU

Note to the trainer: Please engage farmers to identify one or two that are practicing the use of manure. Allow them to share their experience so as to allow the peer-to-peer learning.

Compost tea: Compost teas are liquid versions of the solid compost material. The term "compost tea" is used to define a wide range of aqueous solutions and/or suspensions made from different organic materials via a range of processes. Compost tea use as the sole or primary nutrient source may provide adequate nutrients to maintain plant growth and development, but that depend on application rate and frequency, strength (concentration) and crop species. Compost tea presents the best alternative liquid organic nutrient source for horticultural and agricultural use. Its origin in compost ensures that the product is sanitary and contains soluble constituents of the compost.

Note to the trainer: Upon explaining the concept, conduct a practical session with the farmers on how to prepare the compost tea and apply it to plants as a foliar fertilizer.

How to make compost tea: Compost teas were obtained by covering compost with water at a ratio between 1:5 to 1:8 (volume/volume). *Note: tap water should be dechlorinated by allowing it to sit for about 24 hours*. Put mature compost in the bag and place the bag in the bucket. Initially stir or gently massage the contents of the bag. The mixture is stirred once and allowed to ferment outdoors between 15° and 20° C for about 1 hour to 3 days. The longer the extraction period the great the potential for nutrients and microbes to be released into the water. After extraction, filter the liquid through cheesecloth, strainer, or a new nylon stocking (Figure 14). Apply the liquid immediately after preparation as a soil drench or as a foliar application. The liquid can also be further diluted with dechlorinated water as needed.

Note to the trainer: Use the following video to enable farmer understand the actual practice. https://youtu.be/bcQD0m9WfQE

Figure 14: Production of compost tea

Fertilizer tea: Fertilizer teas or weed teas are made from plants. They are easy compared to compost tea as they don't require you to pick up a load of manure or use any of your precious compost. Many gardeners regularly use this technique to feed their plants and make use of their weeds at no cost. Weed tea can also benefit plants and soil by the microorganisms it contains, which assist in breaking down organic materials in the soil into plant food. Some choose to spray this tea onto the leaves of plants with the idea that it makes them stronger and more resistant to disease or pests.

> ***Note to the trainer***: Please use some of the available weeds and herbs as identified by the farmers to demonstrate how to make the fertilizer tea.

Some of weeds and plants used for an extra nourishing fertilizer tea:

Stinging nettle (kadhumbula) is high in nitrogen, calcium, iron, vitamins A, B, & C, phosphorus, potassium, boron, iron, zinc, selenium, and magnesium.

Alfalfa is high in nitrogen, vitamin A, folic acid, potassium, calcium, and trace minerals.

Horsetail is a deeply rooted weed that draws up minerals including potassium, silica, and iron from far below the soil.

Willow is rich in growth hormones, making it especially good for getting young transplants off to a good start.

Comfrey is rich in calcium, phosphorus, potassium, magnesium, vitamins A, B, & C, and trace minerals.

Alfalfa (Olufafa;Lusoga dialect)

Stinging nettle (*Omwenyango* (Luganda dialect); *Lugenu* /kadhumbula (Lusoga dialect)	
 Comfrey (Camfule; Lusoga dialect)	 Horsetail
 Willow	

How to make fertilizer tea: Weeds are chopped and placed into a bucket (Figure 15). When the container is about half full, fill it with water. Avoid using chlorinated water; rainwater is the best. Screen the top to keep mosquitoes out. Stir daily for 3 days to 3 weeks. Alternatively, pour it from one bucket into another to mix things up and keep it aerated. Strain off the liquid to use as a fertilizer or foliar spray. After you strain off the liquid, return the solids to your compost pile. It can be diluted or used full strength on established plants. Since plant leaves tend to absorb more nutrients more quickly than roots, foliar feeding is an efficient way to fertilize versus a soil drench.

Figure 15: Preparation of fertilizer tea

Note to the trainer: Use the following video to enable farmer understand the actual practice. https://youtu.be/lce330rsG38

3.6 Crop rotation

Objective: To be able to carry out participatory diagnostics in order to identify the main problems leading to the use of crop rotation, conditions that warrant effective crop rotation and the agroecological alternatives already known to farmers.

Note to the trainer: Please explain the terms - What is crop rotation? Under what circumstances do we use crop rotation as soil amendment, weed, and pest management strategy? What are the possible crop rotation patterns that can be potentially be used by farmers? Explain the advantages and drawbacks of using crop rotation as an agroecological practice.

Materials and methods

Methods	A power point presentation and discussions on the basics of crop rotation Plenary discussion. Group work – Participants should come up with appropriate crop rotation cycles.
Materials and tools	Power point slides Flip charts Markers Projector
Advise	Engage the participants to ensure that that relate the concept of crop rotation to the current crops In groups, assign participants crops. Let each group come up with the most practical crop rotation cycles. Let each group share their findings with the rest of the participants as part of the discussion. This will help the participants relate well with the concepts of the crop rotation in a more practical manner.

3.6.1 Introduction

It is a cropping practice that entails the successive planting of different types of crops in different regions of the field and at different seasons. It entails producing a variety of crops in the same region over the course of several growing seasons. The crop succession is meticulously planned to ensure that soil nutrients are maintained, pest populations are controlled, weeds are repressed, and soil health is built. Crop rotation is the process of changing crops over time and space. Rotation plans that are well-planned help soil fertility, healthy soils, weed and insect management, and disperse labor needs throughout time.

Some of the common farmer challenges that could trigger the use of crop rotation

Infertile soils that result into very low yield
High costs of fertilizers
High prevalence of persistent pests, diseases and weeds

3.6.2 Principles of Crop Rotation

Crop rotation basically means rotating crops in a certain region such that no bed receives the same crop in consecutive seasons. The main objective is to maintain soil pH and nutrient levels stable so that each crop species may get the most out of the soil in each season.

There is no set crop rotation plan that all farmers must follow. The rotation duration might range from a single planting season to several years or even longer. Commodities in a field can be rotated based on a farmer's individual needs, soil type, climatic and environmental conditions, markets for diverse crops, and budget.

Some farmers, for example, may rotate two different crops, such as maize and soybeans, on a single field on alternate years. Others may pursue a more diverse approach, rotating five or six crops in a field over several years (Figure 16). The following are some basic crop rotation principles to assist you choose the correct crop to grow on the right soil at the right time.

Crops belonging to the same natural order (family) should not follow one another. Crops from the same family should not be grown in succession since they serve as alternate habitats for pests and illnesses. For example, avoid planting tomatoes, pepper, eggplant, or tobacco in the same row because they all belong to the same family (Solanaceae), and hence share common pests. Also, avoid planting maize, millet, sorghum, barley successively as they share common weeds and pests. To help accomplish the goal, it is therefore recommended to follow such with crops from a different order and family, for instance following maize with soybean.

The deep-rooted crop should be followed by a shallow-rooted crop and vice versa. Crops having deep roots, such as carrot, should be followed by crops with shallow roots, such as wheat, rice, and maize. Cassava and other deep-rooted crops should be followed by shallow-rooted crops like okra. This guarantees that while the cassava feeds from the deep soil, the nutrients in the shallow soil are still available for the Okra to use when it is planted. This enables for the efficient and homogeneous utilization of soil nutrients.

More exhaustive crops (e.g., cereals which take more nutrients from the soil and do not add anything to it) should be followed by restorative crops (e.g., legume crops which not only take nutrients from the soil but at the same time also add nutrients to the soil). Because of their importance in soil fertility, legumes must be included in the rotation scheme. Most legumes incorporate nitrogen into the soil, which enriches it and minimizes need for fertilizers. As a result, the farmer's production costs are reduced. Plant legumes such as beans and soybean after non-leguminous or cereal crops such as maize. Legumes increase soil organic content and atmospheric nitrogen.

Green manure preferably legume crops should be included in the rotation. Green legumes serve as cover crops, and they also help prevent erosion while enriching the soil.

Long-duration crops should be followed by short-duration crops.

Broadleaved crops should be rotated by narrow-leaved crops. This ensures that crops with different physiologies are alternated.
Crops with taproot should be followed by crops with a fibrous root system. This helps in the proper and uniform use of soil nutrients from different depths of the soil. For example, rotating maize with beans.
Crops with minimum water requirements such as cowpeas and tomatoes should be grown in periods of water deficiency.
Crops that involve heavy irrigation and intensive labor such as rice should be grown after crops requiring less water and labor such as beans.
Crops such as vegetables susceptible to soil borne pathogens and parasitic weeds should be grown after tolerant crops. Examples of crops that are susceptible to soil borne pathogens are; Tomatoes, tobacco, legumes, cucurbits, sweet potatoes and bananas. Crops that are affected by the parasitic weeds include cereal grains (e.g., sorghum and maize). For instance, tomato should be rotated with legumes like beans but not within the Solanaceae family (eggplant, chili, potato etc.) to reduce Fusarium wilt (F. oxysporum).

CROP ROTATION: a suggested plan.

	Year 1	Year 2
Plot A	Legumes - add well rotted manure	Brassicas - add compost and fertiliser
Plot B	Potatoes - add manure or compost, and fertiliser	Legumes - add well rotted manure
Plot C	Roots and Onions add fertiliser	Potatoes - add manure or compost, and fertiliser
Plot D	Brassicas - add compost and fertiliser	Roots and Onions add fertiliser
	Year 3	**Year 4**
Plot A	Roots and Onions add fertiliser	Potatoes - add manure or compost, and fertiliser
Plot B	Brassicas - add compost and fertiliser	Roots and Onions add fertiliser
Plot C	Legumes - add well rotted manure	Brassicas - add compost and fertiliser
Plot D	Potatoes - add manure or compost, and fertiliser	Legumes - add well rotted manure

Figure 16: A four-year crop rotation plan

Module 4: Application of agroecological practices in soil and water conversation

Objective: To be able to carry out participatory diagnostics in order to identify the related agroecological practices relevant for soil and water conversation.

Note to the trainer: Please allow the farmers to relate with the prior information shared. Engage them to identify some of the related practical agroecological strategies relevant for soil and water conservation during the discussion.

Materials and methods

Methods	A power point presentation and discussions on the basics of soil and water conservation. Plenary discussion.
Materials and tools	Power point slides Flip charts Markers Filed illustrations or Miniature gardens to illustrate the approach
Advise	Use as many illustrations as possible to create a relationship between the approach and the actual conversation of soil and water

Farmers have long recognized declining/poor harvests as their key issue. This has a fundamental connection to soil erosion, soil drying out, and soil fertility loss. Healthy soil is the foundation for profitable, productive, and environmentally sound agricultural systems. An integrated soil fertility management (ISFM) is encouraged as it entails integrated use of mineral fertilizers with organic matter. Other ISFM strategies include crop rotation, legume introduction, and crop-livestock integration systems.

Constraint	Approach	Examples
Soil erosion	Mulching	Material should be relatively dry to stay longer on the soil surface. These include the use of grasses, wood chips, wood fiber, straws, old hay
	Intercropping	Intercropping broad-leafed crops with cereals. The broad-leaved crops prevent direct interaction of soil erosion agents such as wind and running water with the soil surface. For example, integration of beans/cowpea/soybean with maize. Incorporation of trees in crops. The soils are protected from wind and water induced erosion. The adverse effects temperature and wind on soil fertility, soil flora and fauna are effects are ameliorated by agroforestry systems.
Soil fertility loss	Intercropping with agroforestry trees	Agroforestry trees, particularly leguminous trees, enrich soil through biological nitrogen fixation, addition of organic matter and recycling of nutrients.
	Application of manure	Animal manure applications can increase soil organic matter in medium / long term application periods. Consequently, manure contributes to reducing soil bulk density and

		compaction, as well as increasing soil aggregate stability, water infiltration and retention.
	Cover crops	Cover crops can also reduce nutrient losses from soil due to surface runoff. Leguminous cover crops fix nitrogen to soil.
	Crop rotation	Improve soil health by increasing biomass from different crops' root structures and increase biodiversity on the farm. Rotating with green manure and nitrogen fixing crops to the rotation schedule is therefore recommended.
Soil water loss	Intercropping with agroforestry trees	Most important beneficial effect of the trees on the soil can include improvement of soil structure to reduce water loss through erosion and leaching
	Cover crops	Cover crops reduce the intensity of direct sun light to the soil, thus, reducing rate of water loss through evaporation
	Irrigation	Irrigation is to water crops by bringing in water from pipes, canals, sprinklers, or other man-made means, rather than relying on rainfall alone. Places that have sparse or seasonal rainfall could not sustain agriculture without irrigation. Irrigation can be done on all scales ranging from small, medium to large scale. For instance, the mineral water bottles irrigation demonstrated by President Museveni.

Module 5: Application of agroecological practices in crop protection

Objective: To be able to carry out participatory diagnostics in order to identify the related agroecological practices relevant for crop protection.

Note to the trainer: Please allow the farmers to relate with the prior information shared. Engage them to identify some of the related practical agroecological strategies relevant for crop protection during the discussion.

Material and methods

Methods	A power point presentation and discussions on the basics of crop protection. Plenary discussion. Filed illustrations or Miniature gardens to illustrate the approach
Materials and tools	Power point slides Flip charts Markers
Advise	Use as many illustrations as possible to create a relationship between the approach and the actual crop protection

Crop protection is the combination of pest-resistance methods, tools, and products. Diseases, viruses, weeds, and insects are examples of these. They can all drastically reduce or even kill plants. Rather than dealing with the problem's consequences, it is preferable to control the situation by lowering the risks. Agroecological approaches to pest management for sustainable agriculture emphasizes the incorporation of ecological principles into pest management while ensuring high productivity and profitable harvests without causing harm to the environment.

Constraint	Approach	Examples
Weed management	Push and pull technology	The approach involves trapping stem borers on highly susceptible trap plants (the pull) and driving them away from the maize crop using repellent intercrops (the push). For instance, in maize, Stem borers are attracted to Napier grass (*Pennisetum purpureum*), a trap plant (pull), and are repelled from the main cereal crop using a repellent legume intercrop (push), desmodium (*Desmodium spp*.).
	Cover crops	Cover crops may affect weeds at various points in their life cycle: (a) reducing the intensity and altering the quality of light reaching the soil surface; (b) acting as a physical barrier on the soil surface; (c) altering soil moisture and nutrient dynamics; (d) introducing allelochemicals; and (e) providing habitat for granivorous arthropods, mammals, and other weed seed consumers
Pest management	Push and pull technology	The approach involves trapping stem borers on highly susceptible trap plants (the pull) and driving them away from the maize crop using repellent intercrops (the push). For example,

		management of stem borer moth. The desmodium is planted in between the rows of maize produces a smell or odor that stem borer moths do not like. The stem borers are trapped by the Napier grass.
	Crop rotation	It breaks the pest cycles. If there is a break of several seasons or even several years when other crops (of a different crop family) are grown, the pest populations or disease incidence may be reduced and eventually disappear. For example, alternating maize with leguminous crops like maize breaks the life cycle for stem borer. Crop rotation replaces a crop that is susceptible to a serious pest with another crop that is not susceptible.
	Use of high-quality seed	The seed should germinate well, be disease-free and be of the variety the farmer wants to plant. Good pest management depends on healthy plants
	Timely planting	Late or staggered planting (plots of different ages) should be avoided. For instance, female moths (Fall army worm) have a favorite stage of maize to lay eggs on. If your field is one of the few late planted plots, all the female moths in a region will come to your plot, where she will lay her eggs

Area-wide management

For effective results, implement an integrated approach on an area-wide scale against the pests and diseases by combining cultural, biological, physical and (only as a last resort) synthetic pesticides.

Note to trainer- *It is advisable for farmers to use AE practices in combination for best results. However, farmers may also choose what practices to use based on their resources. The trainer can advise farmers before they invest.*

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