IFAD
Investing in rural people

MUSHROOM FARMING

SKILLS DEVELOPMENT PROJECT

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Preface

Mushroom cultivation has emerged as an increasingly valuable component of sustainable agriculture due to its ability to convert agricultural waste into nutritious food and income. As demand for high-quality mushrooms continues to rise in local and global markets, growers require practical guidance that is both scientifically sound and easily applicable. This manual has been prepared to provide learners, farmers, and entrepreneurs with clear and step-by-step knowledge on mushroom farming practices, from substrate preparation and spawn production to harvesting and post-harvest management.

It is hoped that this manual will serve as a useful resource for students, extension workers, rural development organizations, small-scale farmers, and anyone interested in beginning mushroom cultivation as a livelihood activity or business enterprise. By encouraging sustainable farming practices and efficient resource utilization, mushroom cultivation can play a vital role in enhancing food security, generating income, and supporting environmental conservation. We sincerely hope that the readers will find this manual informative, practical, and inspiring as they embark on or expand their journey in mushroom farming.

The modules are organized to help trainers deliver lessons in a systematic, hands-on way, combining classroom discussions with real-world farm demonstrations. Trainers are encouraged to adapt examples to local contexts, engage participants actively, and promote environmental and ethical awareness throughout the course.

Module 1: Introduction to mushroom

Module Duration:

- **Theory: 02 Hour**
- **Practical: 09 Hours**

1.1 Module Objectives:

By the end of this module, trainees will be able to:

1. Understand the basic biology and nutritional value of mushrooms.
2. Identify different mushroom species suitable for cultivation.
3. Describe and apply steps involved in mushroom cultivation.

1.2 Learning Units (LUs):

Learning Unit	Description	Key Learning Outcomes
LU 1: What are mushrooms	Mushrooms are edible fruiting bodies of fungi that grow on organic materials such as straw, wood, or compost. Mushrooms are highly nutritious, rich in protein, vitamins, and minerals, and are widely cultivated as a healthy food and profitable agricultural crop	- Understand the classification and types of mushrooms. - Identify different mushroom species and their uses. - Recognize the role of mushrooms in ecosystems. - Understand the nutritional and medicinal benefits of mushrooms.

LU 2: The fungal kingdom	The fungal kingdom includes organisms such as mushrooms, molds, and yeasts. Fungi are different from plants because they do not contain chlorophyll and cannot make their own food**.** Instead, they absorb nutrients from organic matter in the environment. Some fungi are edible and useful, while others can cause diseases in plants, animals, and humans	- Understand the classification of fungi. - Recognize the importance of fungi in ecosystems. - Identify the different types of fungi (e.g., yeast, molds, mushrooms). - Learn the role of fungi in medicine and industry.
LU 3: Types of mushrooms	Mushrooms can be grouped into different types based on where and how they grow. Edible mushrooms such as oyster, button, and shiitake are safe to eat and are cultivated for food. Medicinal mushrooms like reishi and lion's mane are valued for their health benefits. Wild mushrooms grow naturally in forests, but some of them can be poisonous, so they	- Identify different types of mushrooms. -Understand the characteristics of edible vs. poisonous mushrooms. - Recognize common culinary and medicinal mushrooms. - Differentiate between wild and cultivated mushrooms.

	should only be collected by trained people.	
LU 4: Mushroom Identification Basics	Mushroom identification is the process of recognizing different mushroom types by observing their shape, size, color, smell, and where they grow. Key features include the cap, gills or pores, and stem. Some mushrooms are edible, while others can be poisonous, so it is important to identify them carefully.	Understand key features used in identifying mushrooms. - Learn to differentiate between different mushroom types. - Recognize important characteristics such as cap, gills, stem, and spore print. - Identify safe and unsafe mushrooms.
LU 5: Mushrooms in Culture and History	Mushrooms have been used by humans for thousands of years as food, medicine, and in cultural traditions. Many ancient societies valued mushrooms for their nutritional and healing properties, while some considered them special or sacred. In Asia, mushrooms like shiitake and reishi were used in traditional medicine	- Understand the cultural significance of mushrooms in different societies. - Explore the historical use of mushrooms in food, medicine, and rituals. - Recognize the role of mushrooms in folklore and traditions. - Examine the global spread of mushroom cultivation.

1.2.1 What is Mushroom cultivation?

Mushroom cultivation is a specialized form of farming that involves growing mushrooms under controlled conditions to optimize yield and quality. It requires knowledge of various factors such as substrate preparation, spawn production, environmental control, and pest management. Mushrooms are grown on a variety of organic materials, including straw, sawdust, and compost, which serve as the substrate for fungal growth. Successful mushroom farming depends on creating the right temperature, humidity, light, and airflow conditions. With increasing demand for mushrooms in culinary and medicinal industries, mushroom cultivation has become a valuable agricultural practice, offering high economic returns.

1.2.2 Importance of Mushroom Cultivation in the National Economy

Mushroom cultivation plays a significant role in the national economy by generating employment, supporting rural development, and creating opportunities for small-scale agribusiness. It requires low investment and can be practiced in small spaces, making it suitable for farmers, women, and unemployed youth. Mushrooms are an excellent value-added product that can be sold fresh or processed, contributing to household income and poverty reduction. Moreover, mushroom farming promotes efficient use of agricultural waste, converting straw, husks, and other residues into nutritious food, which supports environmental sustainability. With increasing domestic and export demand, mushroom cultivation has strong potential to contribute to economic growth and food security.

1.2.3 What is Food Security?

Food Security means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs for an active and healthy life. Food security depends on four main pillars:

1. Availability – having enough food produced or imported.

2. Accessibility – people's ability to afford and reach food sources.

3. Utilization – proper use of food through safe preparation and nutrition.

4. Stability – consistent access to food even during economic or climatic shocks.

1.2.4 Institutional Ethics and Professional Practices:

Working in agriculture requires professionalism, safety, and ethics.

Trainees must learn to:

- Follow safety guidelines during fieldwork handling of machinery or chemicals.
- Show honesty, punctuality, and teamwork.
- Respect farmers, local communities, and environmental rules.
- Keep accurate records of training and field observations.

1.2.5 Success Stories in Pakistani Agriculture:

Trainers can share real-life examples to motivate trainees:

- **Example 1:** A farmer named Fazal Rabi reported that after returning to the area he faced financial trouble, but found mushroom cultivation to be a decent source of income.
- **Example 2:** A local expert, Sher Muhammad, based in Peshawar, has decades of experience in mushroom cultivation and provides free training to farmers in K-P. He estimated that the production cost of one kilogram was around Rs 100 while market price was around Rs 400, demonstrating good profit margins
- **Example 3:** The provincial government of Khyber District (Khyber Pakhtunkhwa) started promoting mushroom cultivation in the valley to create high-income legal work and discourage poppy cultivation.

These cases highlight how innovation, training, and technology adoption can transform small farms into sustainable enterprises.

1.3 Practical Units (PUs):

PU CODE	Activity	Expected output
PU 1.3.1	Identify and classify different mushroom species from provided samples or images, noting their uses, benefits, and ecological roles.	Ability to distinguish mushroom species using morphological traits

PU 1.3.2	Observe and identify different types of fungi under the microscope, classify them based on their characteristics, and discuss their ecological and industrial significance.	Correct identification of fungal structures under the microscope.
PU 1.3.3	Identify and classify mushroom samples based on their characteristics, distinguishing between edible and poisonous types, and discussing their culinary and medicinal uses.	Distinguish between edible, non-edible, and poisonous mushrooms based on structural characteristics.
PU 1.3.4	Use provided mushroom samples and identification charts to identify and classify mushrooms, paying attention to key features like cap, gills, stem, and spore print.	Understand the importance of careful identification, especially for safe consumption.
PU 1.3.5	Research and present a historical or cultural story or practice involving mushrooms, highlighting their significance in a specific culture or tradition.	Understand how mushrooms can hold symbolic, cultural, and historical significance.

Trainer Notes:

- Begin the session by engaging trainees with a short discussion: “What does mushroom farming mean to you?”
- Use local and national examples to illustrate how mushroom farming drives economic growth.

- Encourage trainees to link food production with sustainability and environmental balance.
- Use multimedia resources (e.g., YouTube documentaries, FAO visuals) to highlight global perspectives on food security.
- Reinforce ethics and discipline by connecting professional behaviour to success in agricultural careers.

1.4 Assessment Criteria:

Domain	**Indicators of Competence**	**Assessment Method**
Knowledge	Defines mushroom farming and explains Pakistan's agricultural importance.	Written and oral assessment
Skills	Demonstrates ability to relate theory with practical examples and reports.	Observation of field visit participation and presentation.
Attitude	Shows respect, responsibility, and teamwork during sessions.	Trainer's observation checklist.

Trainer's Reflection Notes:

- Did trainees relate national concepts to their local realities?
- Which examples or activities generated the most interest?
- Note improvements needed for the next delivery.

Module 2: Mushroom culture

Module Duration:

- **Theory: 01 Hour**
- **Practical: 09 Hours**

2.1 Module Objectives:

By the end of this module, trainees will be able to:

1. To develop knowledge of mushroom biology and growth requirements**.**

2 To learn practical skills in spawn inoculation, substrate handling, and cultivation techniques**.**

3. To enhance income-generating opportunities

2.2 Learning Units (LUs):

Learning Unit	**Description**	**Key Learning Outcomes**
LU 1: Introduction to mushroom cultivation	Mushroom cultivation is a simple and profitable farming practice where mushrooms are grown by providing suitable food material, moisture, and temperature. It uses agricultural waste such as straw, husk, or sawdust as the growing medium, making it an environmentally friendly	- Understand the basics of mushroom cultivation. - Learn about the required conditions for mushroom growth. - Recognize different methods of mushroom cultivation (e.g., indoor, outdoor, on logs, in bags). - Identify the materials and equipment needed

	enterprise.	for cultivation.
LU 2: **Mushroom Farm Setup and Infrastructure**	A mushroom farm can be established with simple and low-cost facilities. The main requirements include a clean growing room, proper ventilation, controlled temperature and humidity, and access to clean water. Depending on the scale of production, farmers may use a small room, shed, or purpose-built growing house	- Understand the essential infrastructure required for mushroom farming. - Learn about the layout of a mushroom farm. - Recognize the importance of environmental control (temperature, humidity, ventilation). - Identify the tools and equipment needed for farm setup..
LU 3: **Substrate Preparation and Pasteurization**	Substrate preparation involves selecting and treating materials such as straw, sawdust, or husks to provide food for mushroom growth. The substrate is chopped, soaked, and drained to achieve proper moisture. Pasteurization is then done by heating the substrate to kill harmful insects, molds, and bacteria.	- Understand the importance of substrate in mushroom cultivation. - Learn how to prepare different types of substrates. - Understand the pasteurization process to ensure substrate quality. - Recognize the role of pasteurization in preventing contamination.
LU 4: **Spawn Production and**	Spawn production involves growing pure	- Understand the process of spawn

Inoculation Techniques	and healthy mushroom mycelium on grains or other suitable materials, which serve as the "seed" for cultivation. Quality spawn ensures fast and strong mycelial growth in the substrate. Inoculation is the process of mixing or adding this spawn into the prepared substrate under clean and hygienic conditions to prevent contamination	production for mushroom cultivation. - Learn the different methods of inoculating substrates with spawn. - Recognize the importance of sterile techniques during spawn production and inoculation. - Identify equipment needed for spawn production and inoculation.
LU 5: Environmental Conditions for Growth (Temperature, Humidity, Light, CO_2)	Mushrooms require specific environmental conditions to grow properly. Temperature must be kept within the suitable range for each mushroom species. Humidity should remain high to prevent the mushrooms from drying out. Mushrooms need low light**,** mainly for guiding their growth direction rather than for making food. Carbon dioxide (CO_2) must be controlled through proper ventilation so that mushrooms develop well-	- Understand the ideal environmental conditions for mushroom growth. - Learn how temperature, humidity, light, and CO_2 levels affect mushroom development. - Recognize the importance of controlling environmental factors in mushroom farming. - Identify tools for measuring and controlling environmental conditions.

	shaped caps and stems. Maintaining these conditions ensures healthy growth and good yield	

2.2.1 Mushroom cultivation

Mushroom cultivation is the controlled process of growing edible or medicinal mushrooms under specific environmental conditions. It involves preparing a suitable substrate (such as straw, sawdust, compost, or agricultural by-products), sterilizing or pasteurizing it to remove competing microbes, and then inoculating it with mushroom spawn (the fungal mycelium). The mycelium colonizes the substrate under warm, humid, and dark conditions. Once fully colonized, the environment is adjusted (light, fresh air, and humidity) to trigger fruiting, leading to the formation of mushroom bodies. Proper hygiene, temperature, moisture control, and ventilation are essential throughout the process to ensure good yield and prevent contamination. Mushroom cultivation is widely practiced due to its low land requirement, fast production cycle, and ability to convert waste materials into high-value nutritious food

2.2.2 Substrate preparation

Substrate preparation is the process of selecting, treating, and conditioning the material that will support mushroom mycelium growth. Common substrates include wheat straw, rice straw, sawdust, sugarcane bagasse, cotton waste, or composted manure, depending on the mushroom species. The substrate is chopped to increase surface area, then soaked to achieve proper moisture (usually 60–70%). It is pasteurized or sterilized to eliminate harmful microbes and competing fungi. After cooling, the substrate is mixed with mushroom spawn under clean conditions. Properly prepared substrate provides nutrients, moisture, aeration, and structural support for rapid and healthy mycelium colonization, which directly influences mushroom yield and quality.

2.2.3 Spawn production

Spawn production is the process of preparing and multiplying the mushroom mycelium on a nutrient-rich carrier material so it can be used to inoculate the bulk substrate. Common carrier materials include sterilized cereal grains such as wheat, sorghum, millet, or rye. First, pure mycelium is isolated and grown on a culture medium (e.g., potato dextrose agar). This culture is then transferred to sterilized grains under aseptic conditions. The grains are incubated at an optimal temperature until they are fully colonized by the mycelium. The resulting colonized grains are called spawn. High-quality spawn ensures fast mycelium growth, reduces contamination risk, and directly influences mushroom yield and uniformity.

2.3 Practical Units (PUs):

PU CODE	Activity	Expected output
PU 2.3.1	Discuss and demonstrate the process of setting up a basic mushroom cultivation setup, focusing on selecting the right substrate, containers, and environmental conditions	Demonstrate substrate preparation techniques
PU 2.3.2	Design a basic mushroom farm layout on paper, considering space for growing rooms, ventilation, and environmental control systems, and present the key infrastructure components.	Recognize how space is organized in a mushroom farm, including separate zones for substrate preparation, inoculation, incubation, and fruiting.
PU 2.3.3	Prepare a substrate sample, pasteurize it using appropriate methods, and test its readiness by checking temperature and consistency, ensuring it is free from	Gain practical skill in preparing, pasteurizing, and evaluating substrate quality**,** ensuring it is suitable and safe for successful mushroom spawn inoculation.

	contaminants.	
PU 2.3.4	Produce mushroom spawn using sterilized grain, inoculate prepared substrate with the spawn, and demonstrate proper sterile technique to prevent contamination.	Production of high-quality mushroom spawn using sterilized grain.
PU 2.3.5	Set up a controlled environment for mushroom growth, adjusting temperature, humidity, light, and CO_2 levels, then monitor and record their impact on growth over time.	Understanding of essential environmental conditions (temperature, humidity, light, CO_2) for optimal growth.

Trainer Notes:

- Reinforce safe spawn handling and proper disposal of chemicals.
- During field exercises, ensure trainees with proper practice and techniques.
- Encourage trainees to link spawn production with sustainability and environmental balance.
- Use multimedia resources (e.g., YouTube documentaries, FAO visuals) to highlight global perspectives on food security.
- Reinforce ethics and discipline by connecting professional behaviour to success in agricultural careers.

2.4 Assessment Criteria:

Domain	**Indicators of Competence**	**Assessment Method**
Knowledge	Defines spawn and	Written and oral assessment

	inoculation techniques.	
Skills	Compost preparation.	Practical performance observation.
Attitude	Shows care for environmental protection and safety.	Trainer's observation checklist.

Trainer's Reflection Notes:

- Were trainees able to correctly identify substrate types and deficiencies?
- Did the practical sessions reinforce theoretical understanding?
- What improvements can be made for the next batch?

Module 3: Spawn production and spawning

Module Duration:

- **Theory: 01 Hour**
- **Practical: 09 Hours**

3.1 Module Objectives:

By the end of this module, trainees will be able to:

1. Understand the concept of spawn.
2. Learn spawn production techniques:
3. Practice sterile techniques
4. Develop skills to handle spawn and inoculate substrates without contamination.

3.2 Learning Units (LUs):

Learning Unit	Description	Key Learning Outcomes
LU1	Mushroom spawn is the	- Understand what

Introduction to Mushroom Spawn and Its Importance	vegetative growth of the fungus (mycelium) that is used to inoculate the prepared substrate for mushroom cultivation. It acts like the “seed” for mushroom production. This module introduces the concept of spawn, the types of spawn (such as grain and sawdust spawn), and the steps involved in producing and handling it under hygienic and sterile conditions.	mushroom spawn is and its role in mushroom cultivation. - Learn the different types of mushroom spawn (e.g., grain, sawdust, liquid). - Recognize the importance of high-quality spawn for successful mushroom farming. - Understand how spawn is used to inoculate substrates.
LU2 **Types of Spawn (Grain, Sawdust, Liquid, etc.)**	**Grain Spawn:** Made using sterilized grains like wheat, sorghum, or millet. It provides high nutrition to mycelium, allowing fast colonization of the substrate. Most commonly used in commercial cultivation. **Sawdust Spawn:** Prepared from sterilized or pasteurized sawdust. It is suitable for wood-loving mushrooms and is often used to inoculate logs or sawdust blocks.	- Understand the different types of mushroom spawn used in cultivation. - Learn the characteristics and advantages of each type of spawn. - Recognize the appropriate type of spawn for different mushroom species. - Understand how to handle and store various types of spawn.

	Liquid Spawn: Mycelium is grown in a nutrient-rich liquid. It can be injected directly into substrates and is fast to propagate, but requires careful sterile handling	
LU3 **Mother Culture Selection and Maintenance**	Mother culture refers to the pure, original fungal strain grown under sterile conditions, which serves as the source for further spawn production. Selecting a strong mother culture involves choosing mycelium that is fast-growing, disease-free, and genetically stable. The culture is usually maintained on agar plates or slants and stored under controlled temperature to prevent contamination and genetic degeneration.	- Understand the role of mother cultures in mushroom cultivation. - Learn the criteria for selecting a healthy and viable mother culture. - Recognize the importance of maintaining and rejuvenating mother cultures. - Identify contamination risks and how to avoid them during culture maintenance.
LU4 **Preparation of Culture Media (PDA, MEA, etc.)**	Culture media like Potato Dextrose Agar (PDA) and Malt Extract Agar (MEA) provide the nutrients needed for mycelium to grow in laboratory	- Understand the importance of culture media for mushroom cultivation. - Learn how to prepare different types of culture

	conditions. PDA is made from boiled potato extract and dextrose, while MEA uses malt extract as the nutrient source. These media are mixed, sterilized in an autoclave, and poured into sterile Petri plates or culture tubes. Such nutrient-rich, contamination-free media support healthy mycelial growth and are essential for developing pure mother cultures	media (e.g., Potato Dextrose Agar (PDA), Malt Extract Agar (MEA)). - Recognize the key components and their functions in the media. - Learn sterile techniques for preparing and sterilizing media.
LU5 **Sterilization and Aseptic Techniques**	Sterilization ensures that all equipment, media, and work surfaces are free from microorganisms before handling fungal cultures. This is commonly done using autoclaving, flame sterilization, and disinfectants. Aseptic techniques involve working in clean environments, such as laminar flow hoods, using sterilized tools, minimizing exposure to air, and avoiding direct contact with culture	- Understand the importance of sterilization and aseptic techniques in mushroom cultivation. - Learn the different sterilization methods (e.g., autoclaving, dry heat). - Recognize the importance of maintaining aseptic conditions to prevent contamination. - Learn proper aseptic techniques for handling culture media, tools, and spawn.

	surfaces. These practices prevent contamination and maintain the purity and health of mushroom cultures and spawn.	

3.2.1 What is spawn?

Spawn is the **planting material** used in mushroom cultivation. It consists of **mycelium** (the white, thread-like fungal growth) that has been grown on a carrier material such as grain, sawdust, or wooden dowels. Spawn works like a **seed** in mushrooms, because mushrooms do not produce seeds like plants. Instead, the spawn is mixed into a prepared substrate (such as straw, compost, or wood), where it spreads and eventually produces mushrooms.

3.2.2 Types of spawn

1. **GrainSpawn**
   Made using sterilized grains like wheat, sorghum, or millet. It provides high nutrition to mycelium, allowing fast colonization of the substrate. Most commonly used in commercial cultivation.
2. **SawdustSpawn**
   Prepared from sterilized or pasteurized sawdust. It is suitable for wood-loving mushrooms and is often used to inoculate logs or sawdust blocks.
3. **LiquidSpawn**
   Mycelium is grown in a nutrient-rich liquid. It can be injected directly into substrates and is fast to propagate, but requires careful sterile handling.
4. **StickorDowelSpawn**
   Wooden sticks or dowels colonized by mycelium. Commonly used for inoculating logs by inserting the dowels into drilled holes.

5. **Compost Spawn / Brick Spawn (less common now)** Made using composted materials compressed into blocks. It is primarily used for large-scale or traditional mushroom farming.

3.2.3 Preparation of PDA medium

- Peel and cut potatoes into small pieces, boil them in water until soft.
- Filter the potato extract through a cloth or sieve and collect the clear broth.
- Add dextrose and agar to the potato broth and mix thoroughly.
- Heat the mixture until the agar dissolves completely.
- Adjust the final volume to 1 liter with distilled water.
- Pour the medium into flasks or bottles and autoclave at **121°C for 15–20 minutes**.
- After sterilization, cool slightly and pour into sterile Petri plates inside a clean environment (e.g., laminar flow hood).

3.3 Practical Units (PUs):

PU CODE	Activity	Expected output
PU 3.3.1	Inoculate a substrate with mushroom spawn, demonstrating the proper handling and techniques to ensure the spawn remains uncontaminated, and discuss its critical role in the cultivation process	Trainees successfully inoculate the prepared substrate with mushroom spawn using proper sterile techniques.
PU 3.3.2	Demonstrate the inoculation of substrates using different types of mushroom spawn (grain, sawdust, liquid), highlighting their advantages, handling, and storage techniques for each type.	Demonstrating proper handling and techniques to keep the spawn uncontaminated.

PU 3.3.3	Select a healthy mother culture, transfer it to a fresh medium using sterile techniques, and store it under the appropriate conditions while discussing the importance of culture maintenance and contamination prevention.	Trainees will be able to explain the importance of maintaining pure cultures and discuss strategies for preventing contamination in mushroom cultivation
PU 3.3.4	Prepare PDA and MEA culture media, sterilize them, and pour them into petri dishes using sterile techniques, then discuss their uses and the role of each ingredient in supporting fungal growth.	Trainees will be able to prepare PDA (Potato Dextrose Agar) and MEA (Malt Extract Agar) culture media accurately.
PU 3.3.5	Demonstrate proper sterilization of culture media using an autoclave, prepare a sterile workspace, and perform aseptic techniques to transfer mushroom culture into petri dishes under sterile conditions.	Trainees will perform aseptic transfer of mushroom culture into petri dishes, ensuring minimal risk of contamination

Trainer Notes:

- Reinforce safe spawn handling and proper disposal of chemicals.
- Sterilization and aseptic techniques must be followed strictly.
- Organize a visit to a nearby mushroom house to observe overall mushroom cultivation process.
- Highlight the role of climate and local weather patterns in mushroom cultivation.
- Reinforce ethics and discipline by connecting professional behaviour to success in agricultural careers.
- Environmental conditions (temperature, humidity, and hygiene) must be controlled throughout.

3.4 Assessment Criteria:

Domain	Indicators of Competence	Assessment Method
Knowledge	Define spawn and types of spawn.	Written and oral assessment
Skills	Spawning techniques.	Practical performance observation.
Attitude	Shows teamwork and care for environmental protection and safety.	Trainer's observation checklist.

Trainer's Reflection Notes:

- Were the trainees able to correctly perform the spawning techniques?
- Which practical demonstrations worked best?
- Note improvements for next delivery.

Module 4: Compost formulation

Module Duration:

- **Theory: 02 Hour**
- **Practical: 12 Hours**

4.1 Module Objectives:

1. Understand the concept and importance of compost in mushroom cultivation.
2. Identify and select suitable raw materials (carbon and nitrogen sources) for compost preparation.
3. Learn the formulation of compost mixtures based on mushroom species requirements.
4. Demonstrate preparation, mixing, and conditioning of compost for optimal fungal growth.
5. Recognize the role of moisture, pH, and aeration in compost quality and productivity.
6. Understand methods for testing compost readiness before inoculation

4.2 Learning Units (LUs):

Learning Unit	Description	Key Learning Outcomes

LU1 **Introduction to Composting and Its Benefits**	Composting is the biological decomposition of organic materials into a nutrient-rich substrate that supports mushroom growth. It improves soil fertility, enhances substrate quality, recycles agricultural waste, and provides an economical and sustainable way to produce high-yielding mushroom crops.	- Understand the process of composting. - Learn the benefits of composting for mushroom cultivation. - Identify the types of compost used in mushroom farming. - Recognize the environmental advantages of composting.
LU2 **Principles of Compost Formulation**	Compost formulation involves selecting and combining organic materials in the right proportions to provide optimal nutrients, moisture, and structure for mushroom growth. It is guided by principles such as balancing carbon and nitrogen sources, maintaining proper moisture and aeration, and ensuring the substrate is free from contaminants	- Understand the key principles of compost formulation for mushroom cultivation. - Learn the ratio of carbon to nitrogen (C:N) in compost. - Recognize the importance of moisture content and aeration in composting. - Identify the role of various materials used in compost formulation.
LU3 **Types of Composting**	Composting can be carried out using different methods:	- Understand the differences between aerobic, anaerobic, and

Methods (Aerobic, Anaerobic, Vermicomposting)	Aerobic composting, which relies on oxygen and microbial activity to rapidly decompose organic matter; Anaerobic composting, which occurs without oxygen and produces slower decomposition with methane as a by-product; and Vermicomposting, which uses earthworms to convert organic waste into nutrient-rich compost, ideal for enhancing soil fertility and mushroom substrates	vermicomposting. - Learn the advantages and disadvantages of each composting method. - Recognize the appropriate method for different materials and conditions. - Identify the role of microorganisms and worms in composting.
LU4 **Raw Materials for Composting (Carbon and Nitrogen Sources)**	Compost for mushroom cultivation is made by combining carbon-rich materials (like straw, sawdust, and dried leaves) with nitrogen-rich materials (such as manure, soybean meal, or green plant waste). The right balance of carbon and nitrogen is essential for microbial activity, substrate nutrition, and successful	- Understand the role of carbon and nitrogen in composting. - Identify common carbon and nitrogen sources used in composting. - Learn the proper balance of carbon and nitrogen for effective composting. - Recognize how different raw materials contribute to compost

	mushroom growth	quality.
LU5 **Moisture Content and Aeration in Composting**	Proper moisture and aeration are critical for composting, as they support microbial activity and prevent contamination. Adequate moisture keeps microbes active, while good aeration ensures oxygen supply, avoids anaerobic conditions, and promotes uniform decomposition, resulting in high-quality substrate for mushroom cultivation	- Understand the importance of moisture content and aeration in composting. - Learn how moisture affects microbial activity. - Recognize the role of aeration in preventing anaerobic conditions. - Identify tools and techniques for monitoring and adjusting moisture and aeration levels.

4.2.1 Principles of Compost Formulation

1 **Balanced Carbon-to-Nitrogen Ratio (C:N):**

- Ensure an optimal balance of carbon-rich (straw, sawdust) and nitrogen-rich (manure, legumes) materials to support microbial activity and fungal growth.

2 **Adequate Moisture Content:**

- Maintain sufficient moisture to allow microbial decomposition without waterlogging, typically around 60–70% for most composts.

3 **Proper Aeration:**

- Ensure oxygen availability through turning or proper substrate structure to prevent anaerobic conditions and contamination.

4 **Substrate Structure and Texture:**

- Materials should provide a loose, porous structure for mycelial colonization and uniform growth.

5 **pH Management:**

- Maintain a near-neutral to slightly alkaline pH to favor microbial activity and mushroom mycelium development.

6 **Contamination Prevention:**

- Use clean, uncontaminated raw materials and follow hygienic handling to avoid unwanted microbial growth.

7 **Maturity of Compost:**

- Ensure compost is fully decomposed and stabilized before spawning to support healthy mushroom growth.

4.2.2 Types of Composting Methods:

1. **Aerobic Composting:**
    - Decomposition occurs in the presence of oxygen.
    - Microbes break down organic matter quickly, generating heat and producing nutrient-rich compost.
    - Requires regular turning or aeration to maintain oxygen levels.
2. **Anaerobic Composting:**
    - Decomposition occurs without oxygen.
    - Slower process that produces methane and may have an odor.
    - Often used when oxygen supply is limited or for wet, dense materials.
3. **Vermicomposting:**
    - Uses earthworms to decompose organic waste.
    - Produces highly nutritious, fine-textured compost.
    - Ideal for enriching mushroom substrates and improving soil fertility.

4.2.3 Raw Materials for Composting

1 **Carbon Sources (Browns):**

- Straw, sawdust, dry leaves, corn cobs, paper, and other lignocellulosic materials.
- Provide energy for microbes and structure to the compost.

2 **Nitrogen Sources (Greens):**

- Farmyard manure, green plant waste, soybean meal, poultry litter, or other protein-rich materials.
- Supply nitrogen for microbial growth and rapid decomposition.

4.3 Practical Units (PUs):

PU CODE	Activity	Expected output
PU 4.3.1	Create a small compost pile using available materials, monitor temperature and moisture levels, and discuss how composting helps improve substrate for mushroom growth.	Trainees will be able to create a small compost pile using available organic materials
PU 4.3.2	Formulate a small compost batch with proper C:N ratio, adjust moisture levels, and ensure adequate aeration, then discuss the impact of each element on compost quality.	Trainees will be able to explain the impact of C:N balance, moisture, and aeration on compost quality, decomposition rate, and suitability for mushroom cultivation
PU 4.3.3	Set up small-scale composting systems for aerobic, anaerobic, and	Trainees will be able to discuss the advantages, limitations, and challenges of

	vermiculture methods, compare their processes, and discuss the advantages and challenges of each approach.	composting approach and their suitability for mushroom substrate preparation.
PU 4.3.4	Mix various carbon and nitrogen sources to create a balanced compost mixture, monitor the C:N ratio, perform turning of compost and observe the effect of different materials on compost quality.	Trainees will monitor the carbon-to-nitrogen (C:N) ratio and perform regular turning of the compost to ensure proper aeration
PU 4.3.5	Measure the moisture content of a compost sample, adjust moisture levels, and demonstrate aeration techniques by turning the compost, ensuring proper conditions for microbial activity.	Trainees will be able to measure the moisture content of a compost sample accurately

Trainer Notes:

- Demonstrate each technique step-by-step, emphasizing hygiene and contamination prevention.
- Use visual aids or small-scale models to illustrate aerobic vs anaerobic vs vermicomposting.
- Encourage trainees to observe and record temperature, moisture, and compost texture throughout the process.
- Highlight the link between compost quality and mushroom yield to reinforce practical importance.

4.4 Assessment Criteria:

Domain	Indicators of Competence	Assessment Method
Knowledge	Explain aerobic, anaerobic and vermicomposting.	Written and oral assessment
Skills	Discuss how composting helps improve substrate for mushroom growth.	Practical demonstration.
Attitude	Observes safety rules and shows attention to quality assurance.	Trainer's observation checklist.

Trainer's Reflection Notes:

- Were the trainees able to correctly perform substrate mixing and turning**?**
- Which practical demonstrations worked best?
- Record key challenges and suggestions for the next session.

KP-RETP – Component 2: Classroom SECAP Evaluation Checklist

Purpose:

To ensure that classroom-based skills and entrepreneurship trainings under KP-RETP are conducted in an environmentally safe, socially inclusive, and climate-resilient manner, in line with the Social, Environmental, and Climate Assessment Procedures (SECAP).

Evaluator: _____

Training Centre / Location: _____

Trainer: _____

Date: _____

Category	Evaluation Points	Status		Remarks /Recommendation
		Yes	NO	
Social Safeguards	Is the training inclusive (equal access for women, youth, and vulnerable groups)?			
	Does the classroom environment ensure safety and dignity for all participants (no harassment, discrimination, or child Labor)?			
	Are Gender considerations integrated into examples, discussions, and materials?			
	Is the Grievance Redress Mechanism (GRM) process, along with the relevant contact number, clearly displayed in the classroom			
	Are the Facilities and			

	activities being accessible and inclusive for specially-abled (persons with disabilities)			
Environmental Safeguards	Is the classroom clean, ventilated, and free from pollution or hazardous materials?			
	Is there proper waste management (bins, no littering)			
	Are materials used in practical sessions environmentally safe (non-toxic paints, safe disposal of wastes)?			
	Are lights, fans, and equipment turned off when not in use (energy conservation)?			
Climate Resilience	Are trainees oriented on how their skills link with climate-friendly practices (e.g., renewable energy, efficient production, recycling)?			
	Are trainers integrating climate-smart examples in teaching content?			
	Are basic health and			

	safety measures available (first aid kit, safe exits, fire safety)?			
	Is the trainer using protective gear or demonstrating safe tool use (where relevant)?			
Institutional Aspects	Is SECAP awareness shared with trainees (via short briefing, posters, or examples)?			
	Are trainees encouraged to report unsafe, unfair, or environmentally harmful practices?			
Overall Compliance	Overall SECAP compliance observed	☐ High ☐ Medium ☐ Low		

Overall remarks/ recommendations			
Name	**Designation**	**Signature**	**Date**