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Federal Ministry for Economic Affairs and Climate Action
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IKI INTERNATIONAL CLIMATE INITIATIVE

Manfred-Hermsen-Stiftung for Nature and Environment

Organic Farming Practices

A TOOLKIT FOR FACILITATORS TO BUILD CAPACITY OF FARMERS WITH SPECIAL EMPHASIS ON INPUTS PREPARATION AND APPLICATION IN ORGANIC FARMING

ANSAB

Citation: ANSAB, 2022. Organic Farming Practices: A Toolkit for facilitators to build capacity of farmers with special emphasis on inputs preparation and application in organic farming, Asia Network for Sustainable Agriculture and Bioresources (ANSAB). Kathmandu, Nepal.

ISBN:

First edition: 2023

Designed and printed in Nepal.

Disclaimer: *This toolkit is a work-in-progress material. This toolkit will be updated based on field applications and learnings.*

Preface

Green, fair and inclusive economic development presents an immense challenge both to theorists and practitioners in the field. Many such development end up in utter frustration because they are not equipped with effective methods and tools. ANSAB itself has tried various approaches since its establishment in 1992. We have developed a practical combination of environmental, social and economic interventions that conserve biodiversity, create jobs and provide income for the rural poor in remote but resource-rich areas of Nepal.

This toolkit aims to contribute to transform subsistence farming communities towards enterprising organic producers by providing practical knowledge and skills on organic farming. This toolkit has been developed to provide guidance and technical content on designing curricula, developing training plans, and building the capacity of farmers through training, technical supports and capacity building activities. More specifically, it provides guidance and tools for facilitators to prepare and assist farmers in adopting organic agriculture practices.

This toolkit is mainly targeted for field facilitators and program managers working for development organizations and government agencies that are interested in and responsible for the promotion of organic agriculture. This toolkit can also be useful for organic producer groups and can serve as a reference material for researchers, students and agriculture professionals who are interested in organic agriculture.

We are thankful to International Climate Initiative of the Government of Germany and Manfred-Hermsen-Stiftung (MHS) Germany for providing the grant that allowed us to develop this toolkit and for encouraging us to translate ANSAB expertise into a simple-to-use toolkits. In the preparation of this toolkit, there was an overall guidance from Dr. Bhishma Subedi- Executive Director of ANSAB.

The main contributors of the toolkit are Mr. Puspa Lal Ghimire, Mr. Shankar Bhattarai, Mr. Sudarshan Khanal and Mr. Amrit Dumre. A number of ANSAB staff (current and former) namely Ms. Aakriti Poudel,

Ms. Neelam Tripathi, Mr. Chandika Amgain and Mr. Anil Gautam contributed by providing relevant information during preparation of this toolkit.

We are thankful to Mr. Johannes Burmeister, Dr. Wolfgang Kathe (the independent consultant) and Mr. Mauricio Villarreal of MHS; Basudev Kaphle (Joint Secretary, Ministry of Agriculture and Livestock Development); and Mr. Sanu Krishna Maharjan for detail review of the toolkit and providing inputs and suggestions.

We welcome suggestions and feedback from readers and users as we are very much keen on periodically updating this document based on our field applications and learnings to make it more productive and useful.

Bhishma P. Subedi, PhD
Executive Director, ANSAB

Acronyms

AFU	Agriculture and Forestry University
AKC	Agriculture Knowledge Center
ANSAB	Asia Network for Sustainable Agriculture and Bioresources
BFIs	Banks and Financial Institutions
DAP	Diammonium Phosphate
ECA	Ecosystem based Commercial Agriculture
EU	European Union
FYM	Farm Yard Manure
GMOs	Genetically Modified Organism
ICS	Internal Control System
IFOAM	International Federation of Organic Agriculture Movements
IMO	Indigenous Microorganism
JAS-Organic	Japanese Agriculture Standard
LEISA	Low-external-input Sustainable Agriculture
LRPs	Local Resource Persons
MOP	Muriate of Potash
NARC	Nepal Agricultural Research Council
NASAA	National Association for Sustainable Agriculture Australia
NCCOAPPS	National Coordination Committee for Organic Agriculture Production and Processing Systems
NOAAB	National Organic Agriculture Accreditation Body
NOP	National Organic Program
OMP	Organic Management Plan
PGS	Participatory Guarantee System
TU-IAAS	Tribhuvan University – Institute of Agriculture and Animal Science
USDA-NOP	United States Department of Agriculture-National Organic Program

Glossary

Remunerative agriculture
"Remunerative agriculture" refers to a type of agricultural activity that generates sufficient income to provide a reasonable standard of living for farmers and their families. Remunerative agriculture is often achieved through the adoption of modern technologies, improved agricultural practices, and better access to markets and credit. The ultimate goal is to make farming a viable and profitable business, thereby promoting economic growth, reducing poverty and improving food security.

Conventional agriculture
"Conventional agriculture" is a system of agricultural practices that relies on synthetic fertilizers, pesticides, herbicides, biofortified seeds, and varieties and genetically modified organisms (GMOs) as well as intensive tillage and monoculture crops.

Organic agriculture
"Organic agriculture" is an approach of farming that considers ecology, environment and human health, and avoid use of chemicals and unsustainable practices in farming.

Organic certification
"Organic certification" is a process by which farmers, food processors and handlers promote their products as organic. A third-party body often grants certification, which validates that the products fulfill specified standards and rules for organic production.

Agro-ecosystem
"Agro-ecosystem" is a dynamic and interactive system composed of the living components of a farm and the non-living components of the soil, water and air as well as human communities, and social and economic structures that support them.

Biopesticides
"Biopesticides" are natural or microbial-based products used for pest management in agriculture, forestry and public health which are safe and environment friendly alternatives to synthetic chemical pesticides.

Biofertilizers
"Biofertilizers" are microbial inoculants containing living microorganisms that enhance soil fertility and plant growth by fixing nitrogen, solubilizing phosphorus and producing growth-promoting substances.

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About the toolkit

This toolkit provides guidelines to facilitate farmers on how to produce crops organically. It provides approaches, methods, practices, and information and technologies that are appropriate to promote organic agriculture, especially in rural areas of Nepal, and can be applied in similar settings. This toolkit is prepared primarily based on ANSAB's action research and experiences in promoting organic agriculture practices through implementation of Ecosystem based Commercial Agriculture (ECA) for over a decade. It is enriched with experts' inputs, and review of the best practices and relevant literature.

Why has this toolkit been developed?

The main aim of developing this toolkit is to assist facilitation process to transform farmers from subsistence to remunerative organic agriculture. More specifically, the toolkit supports facilitators to build capacity of farmers with special emphasis on cultural practices, inputs preparation and application that are suitable for organic production. It provides guidance and technical content to facilitators on designing curricula, developing training plans, and building the capacity of farmers through training and extension services.

Who is this toolkit for?

This toolkit is mainly targeted for field facilitators and program managers of development organizations and government agencies who are interested in and responsible for the promotion of organic agriculture. This toolkit can also be useful for organic producer groups and can serve as a reference material for researchers, students and agriculture professionals who are interested in organic agriculture.

What does this toolkit contain?

This toolkit is divided into four chapters. The first chapter explains how to get prepared for capacity building of farmers in organic farming and provides a suggested session plan for the training. The second chapter discusses the rationale and importance of organic farming. The third chapter covers the major methods and inputs used in organic farming, including cultural methods, soil nutrient management and pest control. The fourth and final chapter presents facilitation strategies at the field level.

The toolkit can be used as a whole or in parts. However, all the chapters are interlinked and the toolkit's best use can be achieved by combining all of these components. The toolkit is arranged in a sequential order of tasks and it is best to follow the toolkit's progression from beginning to end. However, depending on the area of work, users can certainly choose necessary components for their work.

Figure 1: Framework of the toolkit

1		2	
Understand		**Get prepared**	
»	Impacts of conventional agriculture	»	Be familiar with the farmers and know their interest
»	Scope of organic farming	»	Undertake training need assessment
»	How to get transformed to organic agriculture?	»	Develop a training plan
3		**4**	
Select technologies and practices		**Facilitate and support**	
»	Cultural practice	»	Develop a facilitation plan
»	Soil nutrient management	»	Access government program and facilities
»	Diseases and pest management	»	Access inputs, technologies, finance and market

Chapter 1: Why and how to go for organic agriculture

Conventional agriculture is known for the heavy and indiscriminate use of chemicals such as inorganic fertilizers, pesticides, herbicides, large machinery, and GMOs which is not a sustainable solution in agriculture. Excessive and disproportionate use of these chemical inputs and practices with the intention of boosting agricultural productivity has led to harmful effects on the soil, microflora, human health and the environment.

1.1 Impacts of conventional agriculture

Different types of chemical pesticides such as insecticides, fungicides, bactericides, herbicides and rodenticides are used globally for the management of insects, fungal and bacterial diseases, weeds, and rodents. The indiscriminate use of these chemicals and synthetic fertilizers in agriculture has adverse impacts on human health, environment, society and economy, which are discussed below.

On human health

Pesticides can cause short-term adverse health effects, called acute effects, as well as chronic adverse effects upon long exposure. Acute health effects include stinging eyes, rashes, blisters, blindness, nausea, headaches, dizziness, diarrhea and death. Similarly, the known chronic effects are cancers, birth defects, reproductive harm, immunotoxicity, neurological and developmental toxicity, and disruption of the endocrine system.

On environment

Pesticides contaminate surface and groundwater, harm non-targeted organisms like pollinators, predators, fish and other animals, and beneficial microorganisms. The repeated use of pesticides increases the risk of pest resistance to agro-chemicals and increases the risk of pest resurgence. Through various routes of exposure (ingestion, inhalation, or absorption through the skin), the synthetic chemicals accumulate within the organism's tissues i.e. liver, fat cells over time, and these chemicals remain stored for long period known as bio-concentration. The bio-concentration potentially can have a serious health impact to the organism itself. The impact of bio-concentration does not remain within the organisms that they directly exposed to pesticides, but also amplifies at higher levels of the food chain through consumption of the organism that are exposed to pesticides known as bio-magnification.

On soil

In Nepal, the chemical fertilizers mostly used in farmland are urea, diammonium phosphate (DAP) and muriate of potash (MOP). The heavy use of these chemical fertilizers has resulted in soil acidification and soil crust formation, thereby reducing organic matter and humus content, and altered soil pH. The increase in soil acidity inhibits the microbial activity in the soil and degrades soil biodiversity. The decomposition process of organic matter is retarded resulting in a negative effect on nutrient availability. Because of the conventional agricultural practices, the physical, chemical, and biological properties of soil are being gradually degraded leading to desertification of agricultural land and making it unsuitable for farming in the long run.

On society and economy

We can observe various social costs of chemical pesticides such as psychosocial pressure on the users and increased cases of suicides with pesticide self-poisoning and prevalence of increased birth defects. Indigenous knowledge and many technologies have been lost with the increasing trend of intensifying agriculture. Additionally, dependency on agro-chemical imports can lead to a loss of foreign currency reserves. For example, in 2020/2021, Nepal imported 379,000 metric tons of chemical fertilizers[1] worth Rs. 22821 million[2] ; and 16.31 thousand tons of pesticides worth USD 45.56 million (Figure 2).

Figure 2: Trend of pesticides import in Nepal {Data source: (ITC 2022)}

[1]Source: statistical information on Nepalese agriculture 2020/21
[2]Source: foreign trade records, Nepal custom office

Therefore, it is crucial to transform the prevalent conventional agricultural practices, which rely on synthetic fertilizers and pesticides, into more sustainable and organic forms of farming based on agro-ecological principles.

1.2 Scope of organic farming

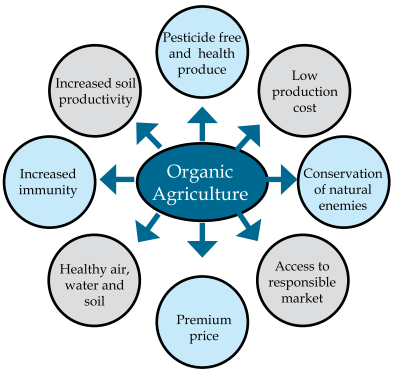
The existing challenges mentioned in Section 1.1 justify the need to transform agriculture from conventional to organic farming. Organic approach of farming promotes human health, conserve the agro-ecosystem, increase agro-biodiversity, addresses climate change challenges in a sustainable manner, and improves overall productivity of land and labour if adopted properly while reducing the long-term adverse impact on economy and society.

Realizing these overall benefits, the organic agriculture has grown significantly in the last 20 years. The global land area increased from 11 million hectares in 1999 to 76.4 million hectares in 2021, which is by about 7 folds (Figure 3). This growth is due to greater awareness and concern for health, food, and the environment, as well as increased purchasing power of consumers. In 2021, retail sales of organic products reached 124.8 billion Euros, a substantial increase from 15.1 billion Euros in 2000 [FiBL & IFOAM – Organics International (2023)].

Figure 3: Global trend of organic production and retail sales {Data Source: FiBL & IFOAM – Organics International (2023)}

At the market side, there is a growing trend mainly among urban citizens for organic products, especially for vegetables and fruits. An increase in purchasing power, education and awareness about health and quality of organic foods, and the willingness to pay for healthy foods among consumers have supported for this increased demand for organically produced food crops. The retailers and restaurants are responding to this trend by increasing their offerings of organic products, and many are even making commitments to source more of their ingredients from organic farms. In response to growing demand, more farmers are transitioning to organic farming methods to meet the market requirements. This shift towards organic agriculture has the potential to benefit both the environment and the economy. While the growth of the organic market presents new opportunities for farmers and businesses, it also poses some challenges, such as the need for increased education and training on organic production methods, standards and certification processes. ANSAB Nepal developed this toolkit as a way to help address these challenges.

Figure 4: Benefits of organic agriculture

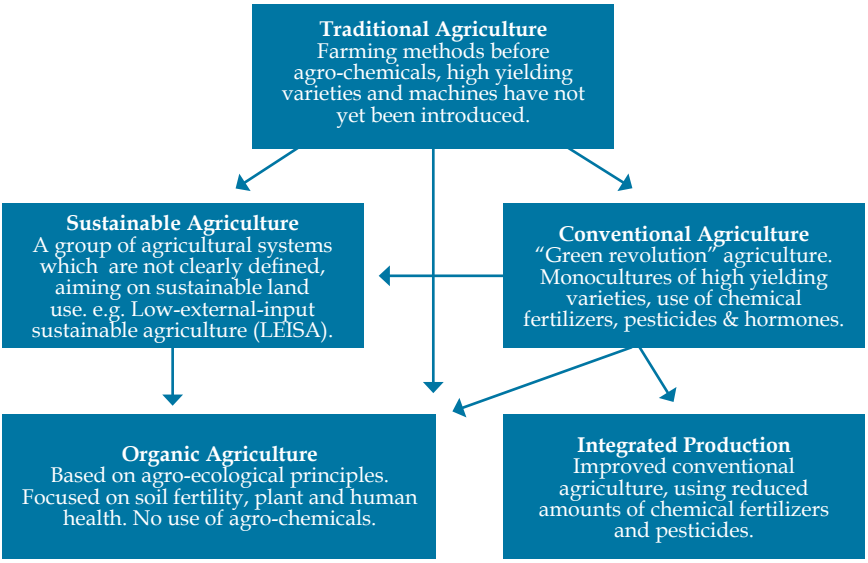


1.3 How to get transformed to organic agriculture ?

Evolution of organic agriculture

Before the green revolution, farming was traditionally practiced without the use of agro-chemicals, high-yielding varieties and machines. At that time, most of the produce was organic by default. After the period of prevailing traditional agriculture, there are mainly two types of agricultural practices: a) sustainable agriculture and b) conventional agriculture or high input based, intensive farming. Realizing the negative impacts of conventional agriculture and low productivity in traditional agriculture, two options of farming systems emerged as way forward: i) organic agriculture, which is based on agro-ecological principles and focuses on soil fertility and plant health without the use of agro-chemicals, and ii) integrated production/ improved conventional agriculture. In Figure 5, some commonly used agriculture systems are defined and explained, along with their potential for transformation from one type to another.

Figure 5: Some commonly used terms of agricultural systems and their relation on how they can transform from one type to another (Adopted from IFOAM, 2003)



At present in Nepal, there are three main farming scenarios: i) organic farming by default, ii) limited use of chemical inputs and fertilizers and iii) conventional commercial agriculture. Organic by default products can be sold as such in potential organic markets with proper labeling. Farming done in areas, where there is limited use of chemicals, can be converted into organic in a relatively short transition period. However, high input based commercial farm areas takes a longer time and more effort to transition to organic as this requires significant changes in farming practices, such as reducing or eliminating the use of synthetic inputs, and implementing new practices to improve soil health and fertility.

Principles of organic agriculture

According to IFOAM Organics International, the principles of Health, Ecology, Fairness and Care are the roots from which organic agriculture grows and develops. They express the contribution that organic agriculture can make to the world, and a vision to improve all agriculture in a global context. IFOAM Organics International has further elaborated on the principles of organic agriculture in order to provide an understanding of the general and practical levels, which are presented in Table 1.

Table 1: Summary of the principles of organic agriculture

General level	Practical level
» Improve and maintain the natural landscape and agro-ecosystem	» Maintain and increase the long-term fertility of the soil
» Avoid over-exploitation and pollution of natural resources	» Enhance biological cycles within the farm, especially nutrient cycles
» Minimize consumption of non-renewable energy and resources	» Provide nitrogen supply by intensive use of nitrogen fixing plants
» Produce sufficient quantities of nutritious wholesome and high-quality food	» Biological plant protection based on prevention instead of curing
» Provide adequate returns, within a safe, secure and healthy working environment	» Diversity of crop varieties and animal species, appropriate to the local conditions
» Acknowledge indigenous knowledge and traditional farming systems	» Animal husbandry appropriate to the needs of the animals
	» Ban on synthetic chemical fertilizers, plant protection, hormones and growth regulators
	» Prohibition of Genetic Engineering organisms and its products
	» Ban on synthetic or harmful methods, processing aids and ingredients in food processing

Source: IFOAM Organics International

Globally, there are number of certification initiatives led by NGOs, business sector or governmental institutions. Some of the popular organic standards are the USDA-National Organic Program (NOP), the EU Organic, the Japanese Agriculture Standard (JAS-Organic), the National Association for Sustainable Agriculture Australia (NASAA) and IFOAM. ECOCERT (France), One Cert Asia (USA), IMO (Switzerland), Control Union (Netherlands) and CertAll are some of the organic certifying institutions that are currently operating in Nepal (Aryal Khanna, 2018).

Organic certification is not yet widely popular in Nepal, except for the export. However, Nepal also has its own national standards for organic agriculture production and processing. The "Nepal National Standards of Organic Agriculture Production and Processing 2007" sets out the requirements for organic farming in Nepal, including a prohibition on chemical contamination, genetically modified organisms and radioactive devices, and limits on the use of synthetic fertilizers and contaminated manures. The standard also emphasizes the use of local-variety, organic seed sources and prohibits chemical seed treatments. It has also established organizational structures for organic certification and accreditation

in Nepal, such as the National Coordination Committee for Organic Agriculture Production and Processing Systems (NCCOAPPS) and the National Organic Agriculture Accreditation Body (NOAAB) (Atreya, 2015).

Process of organic certification

The process of obtaining organic certification generally involves the following four steps:

- Initial application: The producer or handler submits an application to a certifying agency. This includes information on their farming or handling practices and other relevant documentations. Additionally, the producer or handler should fill out the Organic Management Plan (OMP) which includes detail on production areas, products, processing description, productivity, and other detailed activities related to organic production, management, and traceability maintenance.
- On-site inspection: An inspector visits the farm or processing facility to verify that the practices described in the application are being followed. This may involve reviewing records, observing farming practices, and testing soil and water.
- Review and approval: The certifying agencies review the inspection report and any other relevant information to determine whether the farm or product meets the organic standards. Certification agencies provide the Non-compliance if any, which should be shut down by producer or handler.
- Annual renewal: Organic certification is typically valid for one year, and the producer or handler must submit an annual renewal application and undergo a yearly inspection to maintain their certification.

The organic certification may vary by standards set by country or region, but generally requires producers and handlers avoid the use of synthetic pesticides, fertilizers, and genetically modified organisms (GMOs), promote soil health, biodiversity, and animal welfare.

The organic labels are backed by a certification system, which verifies that farmers or handling facilities located anywhere in the world comply with the specific standards (e.g., USDA-NOP, EU, JAS). As a guide to the facilitators, Annex 4 provides some examples of the certification standard and process for USDA-NOP and OneCert International respectively.

Chapter 2: Get prepared for the training and field facilitation

Transitioning from conventional to organic approach requires sufficient supports (skills, knowledge) and provision of access to technical, financial, and market-related solutions. This should justify the higher profits and income compared to existing farming practices. Therefore, facilitating producers and handlers to help adopting organic approach of farming and handling practices is crucial.

In order to facilitate the learning process and to motivate farmers to go for organic farming, the trainers and facilitators need to be familiar with the current context of farming practices, technologies and inputs (pesticides, fertilizers) use in the target area. Based on the current context of farming, the facilitators will design a facilitation plan, create a learning atmosphere, motivate farmers and promote farmers self-confidence towards organic farming.

2.1 Be familiar with the farmers and know their interest

The effect of the training depends on how and to what extent the concerns of farmers are addressed. Therefore, facilitators need to be familiar with the background, knowledge, attitude and interest of the targeted farmers so that he/she can design and adopt the appropriate training curriculum. Based on this toolkit, the training curriculum can be tailored to the local needs and conditions.

As the farmers and their interests are known, the first step is to provide a short orientation on organic agriculture and its importance from the perspective of human health, environment, and overall society (Chapter 2).

2.2 Training need assessment

Before designing a training curriculum and capacity development plan, facilitators should identify exactly what is lacking in terms of farmers' capacity towards organic farming. For this, a brief training need assessment could be carried out. The needs could be arranged in a logical order to ensure that the respective topics are covered during the training and in field activities.

Know the status of fertilizer and pesticide use: For the selection of specific topics to be covered during the training and application of specific inputs,

facilitators should know on the current status of fertilizer and pesticide use in the target area. It is recommended to list all such inputs, including both chemical and organic, used in the target area. For organic fertilizers and organic pesticides, please refer to chapter 3 of this toolkit.

Know about the availability of organic fertilizers & pesticides: A brief assessment should be carried out of the site-specific resources regarding both final products and raw materials that could be used to prepare organic fertilizers and pesticides. Along with this, a list of the currently available input suppliers in the area should be developed. Chapter 4 of this toolkit provides a general description of inputs, technologies and service providers at the field level.

2.3 Develop training plan

The training program would include a mix of conceptual presentations, discussion among the participants, classroom exercises, and practical exercises to prepare and apply various organic inputs. A sample of a 3-day training session, as a 'Training of Trainers' designed for the facilitators is presented in Table 2. This training is designed for facilitators who want to work as local resource persons (LRPs) after the training. For detail on the selection and mobilization of LRPs, please refer to the *Toolkit on the development and mobilization of local resource persons (LRPs)* (ANSAB 2010).

Table 2: Training session plan on organic agriculture for training of trainers

Topic/Activity	Duration	Materials/Methods	Expected outputs
Day 1			
Registration, introduction & expectation collection, & sharing of session plan	60 min	Register, cardboard Training schedules	List of expectations Become familiar with overall session plan
Introduction to organic agriculture & its advantages over conventional agriculture (chemical dependent farming)	90 min	Presentation & discussion	Participants know about the basic concept of organic agriculture
Introduction to organic certification systems	90 min	Presentation & discussion	Participants know about certification process in general

Lunch break	60 min		
Standards of organic certification	90 min	Presentation & discussion	Participants have an overview of the most relevant standards
Internal Control System (ICS) and Participatory Guarantee System (PGS)	90 min	Presentation & discussion	Participants know how ICS and PGS work
Reflection of the day 1			
Day 2			
Cultural practices compatible with organic farming	90 min	Presentation & discussion	Participants know about the cultural practices
Overview of organic fertilizers (FYM, vermi/ compost, green manure)	90 min	Presentation & discussion	Participants know about various organic fertilizers
Lunch break	60 min		
Preparation and application of FYM and compost	105 min	Practical exercise	Participants develop skills on preparation & application
Preparation & application of Lactobacillus serum and Panchagavya	105 min	Practical exercise	Participants develop skills on preparation & application
Reflection of day 2	15 min		
Day 3			
General overview of organic pesticides	90 min	Presentation & discussion	Participants get knowledge on organic pesticides
Preparation of amino acid & Jivamrit	90 min	Practical exercise	Participants develop skills on preparation & application
Lunch break	60 min		
Preparation of Jholmol	90 min	Practical exercise	Participants develop skills on preparation & application
Implementation planning Participants' evaluation	90 min	Discussion	Detail plan of each participant
Training evaluation & closing	30 min	Reflection from the participants	

Chapter 3: Select appropriate inputs, technologies and practices

Organic cultivation practices involve the sustainable package of production while considering the promotion of health of soil, ecosystem and the human beings. This toolkit is an attempt to incorporate such sustainable practices for adopting organic agriculture which is summarized in three sections i.e., cultural practices, soil nutrient management and pest management.

3.1 Cultural practices

Organic production system is not only the avoidance of conventional chemical inputs, but rather it is a way of production which focuses on farming practices that limit the need for external and off-farm inputs, often called cultural practices. The appropriate manipulation of the existing agricultural practices can be instrumental in increasing the crop production without using any synthetic chemicals for pest management. Cultural management practices are based on the habitat management and require a comprehensive knowledge of different components of ecosystems. Therefore, this is also called 'ecological management'. This approach attempts to create a less favorable environment for pests and a more favorable environment for natural pest control mechanisms. Some of the cultural methods are described below.

Use of an appropriate variety of seed

Selecting the right crop variety is very important to optimize crop production. Organic farmers must use local and certified organic seeds or seedlings, as far as possible. If the desired variety is not available, untreated seeds can be used, and seed treatment can be done with organic means like cow urine, compost, vermicompost, herbal oil, hot water or steam, salt water, and bio-agents such as *Trichoderma, Bacillus* and *Rhizobium.* GMO seeds and seedlings are not allowed in organic farming.

Use of appropriate fertilizer sources

Using fertilizers at the right time and in appropriate amounts is crucial for successful crop production. For example, overuse of nitrogenous fertilizers can lead to an increase in sucking pests, while using raw cow dung can increase the chances of white grubs' infestation. Organic growers are allowed to use only organic sources i.e plant, animal and mineral based of fertilizers. Various types of compost and some mineral products, such as limestone, rock phosphate, and potassium/magnesium sulfate can be

used in organic farming. Raw animal manure can also be used, but with specific restrictions on the time between application and harvest. For crops that touch the soil, there must be a lag time of 120 days after the application of raw manure, while for crops that do not touch the soil, the lag time must be 90 days. Further details about different organic fertilizers and their application methods, timing, and amounts are described in Section 3.2 and Annex 1.

Crop rotation

Crop rotation is a useful technique in organic farming. This involves planting different crops in a particular piece of land in each growing season. It helps to prevent soil diseases, insect pests and weeds, and is effective in building healthy soil. A basic principle of crop rotation in organic farming is to avoid growing the same crop in the same land repeatedly. There should be an appropriate gap between successive plantings of the same or similar crop on the same piece of land. When selecting crops for rotation, farmers should choose those that can maintain or improve soil organic matter content, help in pest management, manage deficient and excess plant nutrients, and control erosion. Examples of crop rotations include rice-vegetable-legume, rice-legume-vegetable, and leguminous vegetable-wheat-vegetable such as cucumber.

Mixed cropping

Mixed cropping is the process of growing two or more crops together in the same land. It provides extra benefits to the farmers from the same piece of land with the use of same inputs. In mix cropping, crops should be selected based on their ability to complement each other in terms of nutrient uptake, pest control and resource use. For example, legumes such as beans and peas can be mixed with corn or other grain crops to improve soil fertility through nitrogen fixation and reduce pest infestation. Mixed cropping helps to optimize yields, reduce risk of crop failures and promote biodiversity.

Agroforestry

Agroforestry is the deliberate combination of agriculture and forestry to create productive and sustainable land use practices. These practices take advantage of the interactive benefits of growing trees and shrubs together with crops and/or livestock.

Cover cropping

Cover crops are grown either together with the main crop or in between two main crops. Integrating cover crops has a significant ecological impact

on the farming system. It can improve soil properties; supply nitrogen; reduce leaching of nutrients; mitigate damage from plant pests and attract beneficial insects. Legumes can serve as the best cover crops.

Trap cropping

Trap crops are plants that are grown near the main crops to attract pests away from them. Some examples of trap cropping are sorghum and sunflower, okra and cotton, sesame and cabbage. The *Solanum viarum* (tropical soda apple, *Kanthakari*) is identified as a potential dead-end trap crop against the management of tomato fruit worm (*Helicoverpa*), one of the widely persistent insect pests (Gyawali et al., 2021). The commonly using trap crops, their plantation methods and targeted pests are presented in Annex 3.

Mulching

Mulching is a technique that involves covering the soil to create favorable conditions for crop growth and development, resulting in improved crop yield. Mulching can be done by using various locally available resources, such as dry leaves, straw or sawdust. Mulching offers several benefits, including conserving soil moisture, reducing weed growth, protecting seeds and seedlings from birds, adding organic matter to and improving water retention capacity of the soil.

Other practices

In organic farming, there are several other cultural practices that can be used to manage pests and diseases. These practices include adjusting the timing of sowing or planting to avoid peak periods of pest or disease occurrence, practicing clean cultivation to reduce weed populations and disease pressure, using proper methods of irrigation, such as sprinkler irrigation to control aphids, and summer deep ploughing to expose pathogens to solar radiation and kill them. These practices can help improve crop health and reduce the need for chemical inputs in organic farming systems.

3.2 Soil and plant nutrient management

The soil needs to be fed in order to feed the plants and make the food rich in nutrients. Maintaining a good level of humus in the soil is important for optimal crop production while maintaining the soil health, and this can be achieved through adding organic matter to the soil. The soil contains millions of microorganisms, insects and other plant species. The

microorganisms in the soil decompose dead plants, organic and mineral wastes into soil nutrients and humus. The soil nutrients serve as plant food. The soil rich in humus content is more porous. Porous soils retain more water and are more fertile. Henceforth, one of the most essential jobs in farm management is to add organic matter to the soil. Soil organic matter serves as food for the soil organisms; acts as storehouse of plant nutrients; improves soil structure; enhances the soil nutrient exchange capacity; increases the infiltration of water and prevents erosion; and acts as buffer during rapid changes in soil acidity.

It is good to know how organic matter for agricultural fields can be obtained at the local level. Common organic fertilizers that are available at local level or can be prepared using locally available materials are briefly presented below. Details on the preparation and application of organic manures from locally available materials are provided in Annex 1.

Farmyard manure

Farmyard manure (FYM), a varying mixture of animal faeces, urine, bedding materials, fodder resides, and other components, is the most common form of organic manure applied in Nepal. Cattle manure has been used for a long time, but lack of proper management has limited its ability to improve the soil. Cattle return 80% of the nitrogen they consume to dung and urine, with 52% of that nitrogen coming from urine alone (Table 3). Therefore, proper management of urine is important for maximizing the benefits of FYM.

Table 3: Nutrient content in FYM and cattle urine

Nutrients	FYM	Cattle urine
Nitrogen (%)	0.54	0.51
Phosphorous (%)	0.29	0.02
Potassium (%)	0.40	0.61

Source: Veeresha et al., 2014

Compost manure

Compost manure is prepared by decomposing organic matter such as weeds, crop/plant residues and kitchen waste by mixing them in piles or pits with the help of microorganism. It is a rich source for essential

micronutrients, improves soil quality and water-holding capacity, as well as promote beneficial microbial activity in the soil. The Table 4 shows the nutrient contents of compost from different types of biomasses.

Table 4: Nutrient content of composts from different biomass

Biomass type	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Reference
Banana peels	1.69	2.92	0.84	(Pangankorn, 2006)
Garden compost	0.8	0.35	0.48	(Adhikary, 2012)
Water hyacinth	1.78	0.93	0.75	(Kafle et al. 2009)

Vermicompost

Vermicompost is an excellent source of organic matter and plant nutrients. Moreover, vermicompost is rich in beneficial microorganisms, such as bacteria and fungi, which help to improve soil health and promote plant growth. Vermi-compost is high-quality compost made from organic waste using earthworms to decompose the organic waste. Among several suitable species for vermicomposting, *Eisenia foetida* and *Eisenia andrei* are the most commonly used species. Vermicomposting converts kitchen scraps and other green waste into rich dark soil. The nutrient content in vermicompost is presented in the Table 5.

Table 5: Nutrient content in vermicompost

Nutrients	Nutrient content (%)
Nitrogen	2-3
Phosphorous	1.85-2.25
Potassium	1.55-2.25
Others: Calcium, Magnesium, Copper, Zinc, Molybdenum, Cobalt (Adequate)	

Source: Sinha et al., 2009

Vermicompost can also be fermented to prepare vermicompost tea, which is rich in nutrients and beneficial microorganisms. The primary mechanism for the creation of vermicompost tea is the transformation of microbial biomass, organic microparticles and soluble chemical components in vermicompost into a liquid solution that can be added to the soil or sprayed on plants (Alkobaisy et al., 2021).

Bokashi manure

Bokashi manure is a type of organic manure that is made by fermenting organic waste materials. It is rich in nutrients and beneficial microorganisms that can help increase soil fertility, improve plant health and repel insects. Bokashi manure can be made at home using locally available resources, making it a cost-effective and environmentally friendly option for farmers. The nutrient content of bokashi manure is presented in the Table 6.

Table 6: Nutrient content in Bokashi manure

Nutrients	Nutrient content (%)
Nitrogen	1.90
Phosphorus	0.17
Potassium	2.85
Calcium	1.39
Magnesium	0.72

Source: Adiarti et al., 2019

Green manure

Green manure is a type of organic manure that is derived from plants that are grown for the purpose of being ploughed back into the soil to improve its fertility and structure. Leguminous crops, in particular, are known to be effective in fixing atmospheric nitrogen and adding it to the soil. By incorporating green manure into the soil, the nutrients from the plant matter are slowly released over time, improving soil health and supporting plant growth. Dhaincha, mung bean, bitter gourd, banmara *(Eupatorium adenophorum)* sun hemp, azolla, malabar nut (Asuro), clover, gram and lentil are common sources of green manure. Green manure crops are harvested and incorporated into the soil before they bloom. The percentage of primary plant nutrients in various types of green manure is presented in Table 7.

Table 7: Amount of nutrients in green manure (%)

Crops	Nitrogen	Phosphorus	Potassium
Dhaincha (*Sesbania sp.*)	2.51	0.92	0.92
Mung bean (*Vigna radiata*)	0.80	0.46	1.15
Black gram (*Vigna mungo*)	0.80	0.46	1.15
Cowpea (*Vigna unguiculata*)	0.70	0.34	1.15
Sun hemp (*Crotalaria juncea*)	0.70	0.27	1.15

Source: Timsina, 2018

Biochar

Biochar is a product resulting from heating organic matter like wood, plant biomass or manure to a temperature of above 300°C in a low-oxygen environment. It is similar to charcoal and mainly used as soil amendment. Biochar can be prepared from various organic materials, such as crop residues, forest litters, twigs and animal residues. It increases agriculture productivity, fertility of the acidic soil, water holding capacity of the soil, and protects crops against some foliar and soil-borne diseases. In addition, biochar has also been shown to sequester carbon and mitigate climate change by reducing greenhouse gas emissions.

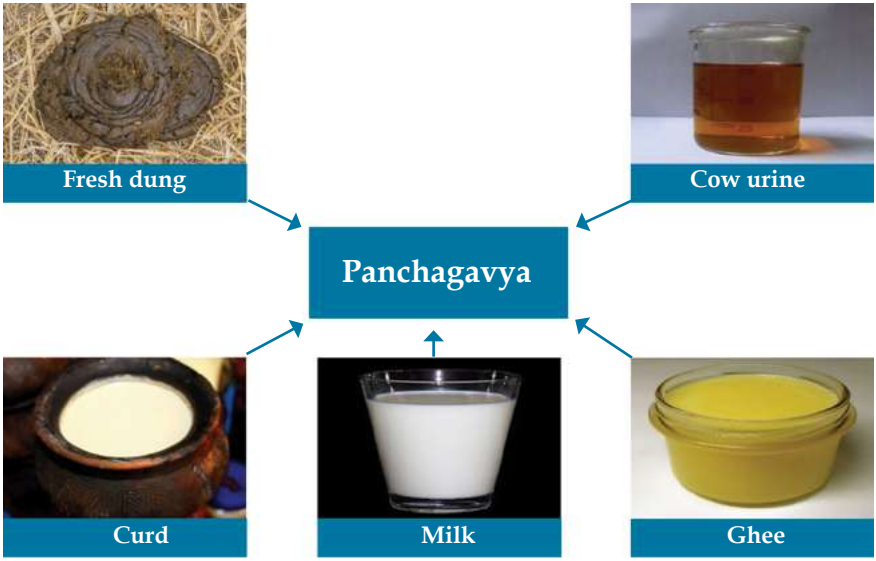
Lactobacillus serum

Lactobacillus serum is a liquid fertilizer that is produced by fermenting rice wash water or other liquid solutions including molasses with Lactobacillus bacteria. It especially used for decomposing organic manure. In addition, the use of Lactobacillus serum increases the activity of micro-organisms in the soil, enhance decomposition of organic matter and improve soil health. It enhances the disease resistance of the plant and also enhances the quality of the crop. It can also be used as a foliar spray to improve the quality of the crop.

Panchagavya

Panchagavya is believed to provide various growth-promoting substances to plants and enhance immunity in the plant system. It is prepared by mixing five products obtained from cows, including cow dung, cow urine, milk, curd, and ghee (Figure 6). These products are fermented together, and the resulting mixture is used as a foliar spray or added to the soil. Its application has been found to increase the yield and quality of crops as well as to enhance plant resistance to pests and diseases.

Figure 6: Materials used to prepare Panchagavya



Crop vitamins

The left over foods and fish residues can be used to make nutrients needed for crops, which are called crop vitamins in the local language. It contains nutrients like Nitrogen (90%), Phosphorus (2.5%), Potassium, Calcium etc. Its amino acids protect the crop from environmental stress and contribute to the growth of the plant. Its use also reduces the risk of insect and fungi infestation.

Calcium solution

Calcium is one of the essential nutrients for plants. Lack of calcium can make plants become unhealthy and stains appear especially on the fruits. Calcium solution, which can be prepared at home, can be beneficial to fight against this problem.

Biofertilizer

Biofertilizer is a product containing living microorganisms that colonize the rhizosphere, stimulates growth by increasing the accessibility and uptake of mineral nutrients to the host plant. The different groups of bio-fertilizers and the nitrogen fixation capacity of major leguminous crops are presented in Annex 1.

3.3 Diseases and pest management

Crop pests and diseases are responsible for the loss of 20-40% of global crop production each year (FAO, 2019). Therefore, effective disease and pest management practices are crucial to reducing these losses and ensuring sustainable agriculture. Managing crop diseases and pests involves various strategies, including cultural, mechanical, biological, and chemical approaches. A brief introduction of these approaches and methods of applications are discussed in the following sections.

3.3.1 Organic pesticides

Organic pesticides refer to the pesticides that are derived from natural sources, such as plants, minerals, animals or microorganisms, and are allowed for use in organic farming. These pesticides are considered safer and environmentally friendly alternatives to synthetic pesticides. Examples of organic pesticides include Neem oil, garlic, onion, pepper and marigold extract, soap sprays etc. It is important to note that though organic pesticides are generally considered safer than synthetic pesticides, they can still be harmful if not used properly. Therefore, it is important to follow the recommended application rates and safety precautions. A brief introduction of some organic pesticides is presented below. Details on the preparation and application of commonly used organic pesticides are presented in Annex 2.

Jholmol

Jholmol is a versatile solution that serves as both a bio-fertilizer and bio-pesticide. It can be prepared locally by mixing cattle urine and plants with pesticidal properties. In addition to increasing yield and reducing crop pests, the application of these practices also enables smallholder farmers to reduce input costs resulting from the purchase of chemical fertilizers and pesticides (Bhusal et al., 2022). Jholmol can be prepared in several ways. Jibamrit is a type of Jholmol which is applied for increasing the microbial activity in the soil.

Bijamrit

Bijamrit is an organic pesticide that is primarily used for seed treatment to prevent fungal diseases. It has the added benefit of increasing microbial activity in the soil, which in turn increases the availability of soil nutrients. The preparation and application methods are presented in Annex 2.

Plant extracts and repellents

There are many plants, which have repellent effects on different types of insects and other pests. Some of the popular plant extracts are as follows:

- Neem and Titepati extracts: Leaves and seeds of Neem (Azadirachta indica) and leaves of Titepati (*Artemisia sp*.) are commonly used as repellent of insects and pests. These can be applied to control nematodes, beetles, borers and other insects.
- Onion extracts: Extracts of bulbs as well as leaves can be used against aphids, flies, fruit worm, white flies, mites, root knot nematodes and early and late blight in plants.
- Hot pepper extracts: Fruit skins and seeds can be used against many crawling and flying insects and also control fungal, bacterial and viral diseases.
- Marigold extracts as well as growing marigold in the garden works against thrips, aphids and nematodes. Marigold leaves, stems and flowers can also be used as a mulch.
- Liquid soap in small amounts dissolved in water can also be used to repel insect pests, such as thrips, whitefly, aphids and mites.

3.3.2 Traps

Insect traps are a type of pest control method that can be used to trap and kill insects or other arthropods. Different types of traps use different mechanisms to lure and capture pests, including food baits, visual lures, chemical attractants and pheromones.

Pheromone traps

Pheromone traps are often used in Nepal to control fruit flies, which can cause significant damage to fruits and vegetables. These traps use synthetic or natural pheromones to attract and trap male fruit flies, preventing them from mating and reproducing. Annex 3 presents the pheromone traps commonly used in Nepal, their target pests and host crops.

Mechanical traps

Mechanical traps are physical devices designed to capture pests, such as insects, rodents and other small animals. They can be made from materials such as plastic, metal or glass. Mechanical traps can be effective in controlling pest populations especially when used in combination with other pest management strategies such as cultural and biological control

methods. Commonly used mechanical traps in Nepal are mentioned in Annex 3.

3.3.3 Bio-pesticide

Microorganisms such as fungi, bacteria, viruses, nematodes, parasites and predatory insects can also be used to control pests in crops. *Trichoderma* is one of such bio-pesticides commonly used in Nepal.

Trichoderma is a type of fungus used as a bio-pesticide to control diseases such as root rot and leaf blight, and this also promotes plant growth. Its use can improve nutrient absorption by dissolving micronutrients like phosphorus. Soil moisture is important for *Trichoderma's* growth and development. Inadequate soil moisture affects negatively. Other bio-pesticides used in Nepal include fungal *(Beauveria bassiana, Verticillium lecanii)*, bacterial *(Bacillus thuringiensis, Pseudomonas fluorescens)*, and viral *(Nuclear Polyhedrosis Virus)*. Annex 4 presents popular biopesticides, their target pests and application methods.

3.3.4 IPM methods

IPM stands for Integrated Pest Management, which is an environmentally sensitive approach to managing pests in agriculture that uses a combination of pest control strategies to minimize the use of harmful chemicals and maximize the effectiveness of natural pest control measures. However, this approach may not be a purely organic as IPM allows use of synthetic chemicals as a last resort if all other alternative methods fail to keep pest infestation below economic thresholds level.

Chapter 4: Facilitation and support

The section outlines the essential actions and skill sets that organic farming facilitators should possess. These include design and delivery of technical training to farmers on organic farming; ensuring access to relevant inputs and services; initiating the organic certification and labeling process; identifying market opportunities for organic produce; and facilitating access to credit and risk-sharing instrument such as crop insurance.

4.1 Develop facilitation plan and approach

Facilitation plan varies according to the existing baseline status of farming practices and farmers skills and knowledge. Therefore, to create a good facilitation plan, a facilitator should first assess the existing farming practices; and farmers' knowledge, skills, interests, attitudes and local needs. This can be done through a capacity needs assessment which may involve activities such as focus group discussions, key informant interviews, stakeholder consultations, agro input supplier visits and sample farm visits. By identifying the capacity gaps, a facilitator can develop a plan tailored to the specific needs of the farmers to help them achieve their goals.

Smallholder farmers in Nepal often have farms that are located close to each other. This creates a risk of chemical contamination from adjoining farms. To maintain a defined organic standard, farmers within and outside of groups need to agree on the application of organic practices. One way to achieve this is by developing and signing a declaration of partnership to follow organic standards and practices. A support plan, especially for certification, may be developed depending on capacity and documentation requirements.

Organic certification guarantees transparency for consumer and maintains quality of produces. Among various approaches of organic certification, group certification is appropriate to smallholder farmers who cannot afford costly third-party certification processes. Group certification is an approach that facilitates access of smallholders to organic certification and hence to organic markets and their associated benefits (IFOAM). An Internal Control System (ICS) is the part of a documented quality assurance system that allows an external certification body to delegate the periodic inspection of individual group members to an administrative

body of or linked to the smallholder group (IFOAM).

Participatory Guarantee Systems (PGS) are locally focused quality assurance systems. They certify producers based on active participation of stakeholders and are built on a foundation of trust, social networks and knowledge exchange. IFOAM - Organics International supports the development of PGS as an alternative and complementary tool to third-party certification within the organic sector and advocates for the recognition of PGS by governments. For an example, ANSAB jointly with Jiri municipality has certified the Kiwi and Potato produced in Jiri without using chemicals, which are then marketed using a label accordingly.

4.2 Empower farmers to access government program and facilities

The organic farming facilitators should play a crucial role in organizing and managing farmers groups, holding periodic meetings and providing technical trainings on various aspects of organic farming, including production, harvesting, processing, certification, product labeling, and marketing. They should also facilitate the development of farmers' skills on capital and financial management, investment, and innovations in scaling of their production and profits. They should also facilitate the producers and local level processors on entrepreneurship development, business planning and marketing. The facilitators are also instrumental to link the farmers with organic input suppliers.

The facilitators should encourage farmers to participate in government planning, implementation, and monitoring activities, and train them

on the process of accessing government programs. In provincial and municipal level governments, they have separate department/section for agriculture development and support. So, the facilitators of the program have to encourage farmers' group and association representatives with detailed information on government programs. For this, the facilitators should understand and be familiar with the annual program and plan of local, provincial and federal governments and train the farmers on the process of how to get access to these programs. For bigger programs, the federal government has different projects, which farmer groups and cooperatives can access for support.

Facilitators should be well informed on recent developments in research and academic institutions. Agriculture Knowledge Center (AKC), Nepal Agriculture Research Council (NARC), Agriculture and Forestry Universities and Colleges are the key sources of information for agriculture in Nepal. So, the facilitators should be well informed on recent developments in these institutions and link farmers with these institutions.

There may also be different projects and programs implemented by development agencies. The facilitators should have idea on these programs and collaborate with them to increase synergies and reduce duplications.

4.3 Empower farmers to access inputs, technologies, finance and market

Inputs and technologies

Agro-vets are the major private sector input suppliers (esp. seeds, pesticides and vitamins) and service providers for smallholder farmers at local level in Nepal. For production and processing technology supply, few technology fabricators and importers are available in major cities.

Financial services

For commercial production, access of farmers to Banks and Financial Institutions (BFIs) is important. It requires facilitation by developing appropriate business plans and negotiate with BFIs. There is a provision of subsidized interest loan for agriculture as a priority sector and the BFIs are bound by laws to invest in agriculture. Farmers can access these loans from BFIs for investment in remunerative agriculture. However, the access of such credits is difficult for reasons including agriculture is a

low-profit marginal sector, and the farmers lack knowledge and capacity to access loan, and lack enough collateral to support loan processing.

Markets

Product inherent quality, proper packaging, labeling and positioning in the appropriate markets is important in the marketing of agri-products. As the scale for the individual marketing of produce by small farmers is too small, the involvement of a group or cooperative in marketing is needed. To access markets, the facilitators can organize meetings between local collectors, cooperatives and farmer groups; facilitate the development of MoUs between producer groups and community-based enterprises, as well as between community-based enterprises and buyers; organize B2B and B2C meetings; and support their participation in trade fairs and exhibitions. Provision of facilities such as collection centers, central warehouses, and proper packaging and labeling is important to access market.

Annexes

Annex 1: Organic fertilizers: Methods of preparation and application

1.1 Farmyard manure (FYM)

Materials required

Animal faeces, urine, bedding materials, crop residues and green waste that are nutrient rich and can be decomposed well.

Preparation method

The FYM can be prepared in various ways. The commonly used methods are composting methods that include pit method and heap method. The detail process is presented in the following section (compost).

Application method

- Regardless of the preparation methods, it's crucial to manage FYM properly to ensure it's safe, nutrient-rich, free of pathogens and contaminants, and promote efficient nutrient uptake by plants.
- Management of urine: The proper collection of urine is important to ensure that it does not go to waste and can be used as a valuable source of nutrients for crops. To collect urine properly, the floor of the barn should be constructed in a proper way that is smooth and sloped towards a collection tank or drain. This will prevent urine from pooling on the floor and ensure that all urine is channeled to the collection tank. Additionally, it is important to prevent contamination of the urine by keeping the collection tank covered and ensuring that it is emptied regularly to prevent overflow. Use of dry leaves, plants or their residues can absorb urine and speed up decomposition process.
- Nitrogen is sensitive to sunlight, evaporates easily and goes waste by dissolving into water. So, it is important to keep the urine and manures (dung) away from sunlight and water. For this, we can construct a roof or cover it by leaves or sacks along with plastic.
- Scattering FYM in small heaps over a field for an extended period leads to nutrient loss. So, it is better to spread the manure and mix it into the soil by ploughing immediately after the application.

» It is recommended to apply well-decomposed farmyard manure (FYM) immediately before/after sowing. However, if the FYM is only partially decomposed, it should be applied three to four weeks before sowing (TNAU, 2016).

1.2 Compost manure

Materials required

» Residues from pulse crops, such as beans, cowpeas, soybeans, dhaincha and lucerne, which are rich in nitrogen.

» Tender weeds and plants, such as water hyacinth, Asuro, bitter gourd, Khirro, Banmara and Uttis can also be added.

» Decomposable waste from the kitchen, such as vegetable peels and leftover food are also suitable for composting.

» Coffee grounds, tea bags, eggshells, rice husk, wheat straw, maize husk, wood husk, grass clippings and shredded paper and cardboard are some other materials that can be added to compost. These components not only provide additional nutrients and help balance the carbon-to-nitrogen ratio in the compost, but they also keep the pile from becoming too compact and stimulate oxygen circulation which is crucial for the activity of the microbes that breakdown the organic matter.

» Soft and tender materials with a low carbon-to-nitrogen ratio are ideal for composting because they decompose quickly. In contrast, hard materials with a high carbon-to-nitrogen ratio are not appropriate.

» The microorganism in compost pile breaks down the organic matters and releases nutrients that become available to plants. The addition of starter (also called Joran or Jordan in Nepali) such as cow dung and urine solution, sludge from biogas and old compost enhance rapid decomposition. Lime, ash, bone dust and other materials can be added to the compost pile to provide essential nutrients such as calcium and phosphorus. This enhances the growth of soil microorganisms and improves their activities.

Preparation method: Compost can be prepared in two different ways.

1. Pit method: The pit method is suitable for the preparation of compost in dry or winter season. In this method, the structure of a pit should not be more than 1m deep and also the width should not be more than 1m. The length can be adjusted as required. In a pit of 1m depth, 1m width and 1m height, 1 ton (40 doko) of manure can be prepared. The structure of the pit should be made accordingly.

Process

Prepare materials: Cut the composting materials into small pieces and check the moisture content of the sliced material. If the moisture is too low, sprinkle water, and if it's too wet, mix it with dry materials.

- Prepare the pit for composting: At the bottom of the pit, place a thick composting material about 2 inches and add 2 inches of bulk agent on top of it.
- Fill the pit with the prepared compost materials and cover it with soil, plastic or any other material, taking into account the seasonal variations in moisture and temperature. In winter or cold places, black plastic is recommended. In summer, due to high evaporation and low humidity, special attention should be given to moisture management.
- Check the progress of the decomposition process: In order to check the progress of decomposition process, insert an iron or wooden stick 30 to 60cm deep and keep it for 5-10 minutes. If it is hot, the decomposition process has been started.
- To decompose all the composting materials properly, it is necessary to improve the air circulation in the manures which increases the activity of micro-organisms. For this, it is recommended to turn the compost manures at least twice in a 1.5 month interval. In colder places, it is recommended to turn the manure three times.
- Regularly monitor and control the moisture level and temperature of the compost manure during the decomposition process.
- The time to prepare compost may vary depending on several factors such as the materials used, the size of the compost pile and the conditions of the composting process. However, in general, it can take from a few weeks to several months for compost to be ready to use.

» The well-rotten manure is black or gray in color, odorless, and non-sticky. It is ready to be used as a fertilizer for plants in garden or in pots.

2. Heap method: The heap method is suitable for rainy season and when there is a shortage of workers, as it requires less labor. This can be easily scaled up or down depending on the available materials. Moreover, this method is useful in areas where water levels are raised and pit digging is not practical.

The preparation method for the heap method is similar to that of the pit method. Organic materials are cut into small pieces and layered with bulking agents, such as straw or sawdust, to create a compost pile. The pile is then covered with a layer of soil, plastic sheet, or other materials to retain moisture and heat. The compost pile must be turned occasionally to ensure proper aeration and mixing of materials. With proper care and attention, the heap method can produce high-quality compost in a relatively short period.

1.3 Vermicomposting

Materials required

Suitable species for Vermicomposting: Epizoic worm species are suitable for making manure. These worm species live only in the soil and eat only organic matter. The species mainly used for preparing manure are: *Eisenia foetida, Eudrilus eugeniae, Perionyx ecavatus, Lumbricus rubellus,* and *Lampito mauritii***.** *Eisenia foetida* is the most widely used worm because of its ability to eat, digest and prepare faeces faster than any other species.

Wooden boxes/baskets/buckets (with drainage system), earthworms suitable for composting (such as *Eisenia foetida*), soil, compost or wood dust, dried dung, stale foods coming out of the kitchen, vegetables, fruits, etc. are the essential materials required for the vermicomposting.

Preparation method

At household levels

» **Choose a suitable location:** The vermicomposting can be done indoor and outdoor. The location should be well-ventilated and protected from extreme temperatures.

» **Choose a suitable container:** It can be a plastic or wooden box, a bin or any container. The container should have a lid, be at least 8-10 inches deep and have drainage holes at the bottom.

» **Add bedding materials:** The bedding materials can be coarse substance such as coconut husk, straw, sorghum, or piece of paper; soak the bedding materials in water; and place the bedding materials on the bottom of the box and spread the substance evenly, making it about two inches thick. On top of the bedding materials, put soil, compost or wood dust.

» **Add earthworms:** In a box of 1 square meter size, about 2000 earthworm specimens are required.

» **Add vermicomposting** raw materials that can be food scraps such as vegetable and fruit peels and stale foods coming out of the kitchen.

» **Keep the bedding moist:** Earthworms need a moist environment to survive and work effectively. Spray water on the bedding material occasionally to keep it moist but not soaking wet; and/or always cover the container/box with a damp bag.

» **Wait for the compost:** The earthworms will consume the food scraps and bedding materials and convert them into compost. This process takes a few weeks to several months (2-3 months) depending on the number of earthworms and amount of food scraps.

» **Harvest the vermicomposting:** Harvest the vermicomposting: When the materials are turned into dark and crumbly compost, it is ready to harvest and use. Keep the prepared compost in one side of the container and add fresh bedding materials and food scraps to the other side. The worms will migrate to the fresh materials. Now, the compost can be collected for use. Alternatively, you can collect the upper layer of the compost from the bed. In a short while, the worms go deeper, then repeat the process again.

» **Use the compost:** It can be used as a fertilizer for plants in gardens and pots.

At commercial levels

» Choose a place where water does not accumulate, and which is not affected by flooding. Harden the surface (cement it if possible) and level it. Alternatively, use the black plastic to floor the bed.

» Spread a jute bag on it.

» Arrange a roof to protect it from direct sun and water.

» Soak dry weeds and other organic waste thoroughly on the leveled surface.

» Mix the agricultural waste in a semi-circular shape with one hand and keep it covered with a jute bag or straw for 3 weeks.

» If the temperature of the stored material reaches about 10-25 and if moisture is felt when touching it, release the worms from one side (at the rate of 2000 worms per square meter).

» The manure is ready after about 2-3 months.

Precaution

» Earthworms feed on rotten garbage, grass, weeds, straw, dung, bio-gas slurry, and organic waste from the house and kitchen. They cannot feed on plastic, tree stumps or non-perishable items. Therefore, avoid such items as vermicomposting materials.

» Avoid sweet foods since ants and red ants are enemies of earthworms. Also, do not use meat or fish waste, sour or oily foods.

» The composting materials should be cut into small pieces.

» Since earthworms cannot live in very dry environment, it maintains the appropriate moisture level in the composting materials.

» Protect earthworms from predators such as rats, lizards, ants, etc.

» Earthworms are nocturnal creatures, so they are more active in the dark or at night. They should not be exposed to sunlight and arrangements such as a hay or straw hut should be made to protect them from the sun and rainwater.

» The pH level for optimal earthworm growth should be maintained at around 7.

1.4 Bokashi manure

Materials required

The following materials with given quantities is required for making Bokashi manure.

Materials	Quantity
Well rotten manure	25kg
Forest soil	35-60kg
Rice coarse husk	5kg
Rice soft husk	5kg
Wood dust	5kg
Ash	5kg
Mustard oil cake	5kg
Bitter gourd, salty, sour plants (in pieces)	15kg
Water	As per requirement

Benefit of Bokashi composting over other composting

- Bokashi composting system allows use of the waste materials (such as fats, meats, cheeses, cooked leftovers, etc.) that can compost by none of the other composting methods.
- This methods can be used by anybody who does not have worm and/or composting methods
- This makes highly efficient use of food scraps
- It is a quicker process of making compost – that is prepared in a week.

https://www.youtube.com/watch?v=0k3PTUnDHSI

Preparation method

- Collect the materials listed in the table above and mix them thoroughly. Make sure to add them in the right proportions, as indicated in the table.

» Choose a location for your compost pile. This should be away from the direct sunlight. Sunlight can dry out the pile and slow down the composting process.

» Turn the compost pile upside down at least once a week using a pitchfork or shovel. This helps to mix the materials and ensure that oxygen reaches all parts of the pile, which is necessary for the decomposition process.

» Cover the compost pile with a jute bag or other breathable cover to help retain moisture and prevent the pile from drying out. Make sure to choose a cover that allows air to circulate freely.

Application method

The process typically takes around 2-4 weeks to complete, although the exact time can vary depending on factors such as temperature, humidity and the types of materials being composted. When the manure is well prepared, there is no heat inside the jute bag cover. A good yield can be obtained by applying about half a kg of Bokashi manure in the pit prepared for planting vegetables (particularly in tomato) one week before planting.

1.5 Green manure

Materials required

Seeds of appropriate cover crop (clover, alfalfa, dhaincha, mungbean, etc.), farm tools and machineries, fertilizers and water for irrigation.

Methods

» For green manure, the seeds of the cover crop should be sown in the area where the green manuring is required. It is important to choose the right type of cover crop based on the specific soil conditions and climate in the region.

» Once the cover crop has grown to maturity (basically knee height), it should be ploughed into the soil before it blooms. This ensures that the plant material is still fresh and full of nutrients that can benefit the soil. The ploughing process helps to break up the plant material, making it easier to incorporate into the soil. This also helps to speed up the decomposition process, which releases nutrients back into the soil.

» After the cover crop has been ploughed into the soil, it should be left to decompose. The microorganisms in the soil break down the plant material, releasing nutrients such as nitrogen, phosphorus, and potassium back into the soil.

1.6 Biochar

Materials required

The list of biomass that can be used for making biochar as well as the process of making it is presented in the Figure 7 below.

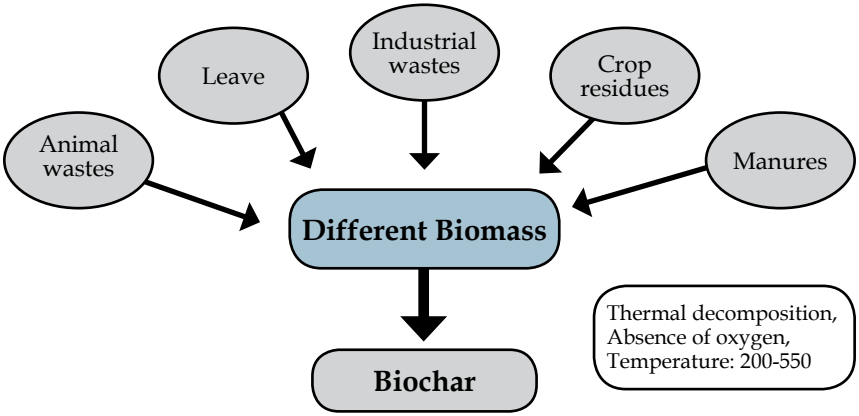


Figure 7: Biochar production technique from organic material

In addition to the raw biomass, a drum, pit or a Biochar kiln is needed to burn the biomass in the absence of oxygen. Moreover, the other equipment and materials that are required in making Biochar include a rake or shovel, water and some compost or manures to enrich nutrient contents in the Biochar.

Preparation method

The Biochar is a product of the incomplete burning of the organic matter in the limited supply of oxygen. The organic matter is heated to high temperatures (typically between 300-500°C) in the presence of low oxygen levels, resulting in the release of volatile organic compounds, water vapor, and other gases. Depending on the type and volume of biomass and the available structure to prepare the Biochar, the methods can be cone and trench/drum method (*Source: https://rosysoil.com/blogs/news/how-to-make-Biochar*).

Cone method

- Get a burning structure ready according to the volume of materials that you need to burn
- Put the dry twigs or leaves at the bottom of the pit/ kiln
- Set the fire on the biomass-once the fire is strong, add the biomass, particularly the larger branches and woods.
- As the fire intensifies and a layer of white ash forms on the initial woods, add more biomass. Keep repeating this process until you reach the top of the kiln/pit, using progressively larger pieces of wood each time.
- When the top layer of wood turns white, extinguish the fire using water
- The Biochar is ready now.
- This Biochar can be mixed with the compost (50:50 ration) to enrich it with plant nutrients.

Trench/drum method

- Pile biomass into the drum or trench
- Light the pile from top to bottom
- When smoke turns grayish blue, add a layer of soil on the top
- Leave the pile to burn slowly
- Once the biomass is charred, put out the fire with water

Application method

The well ground Biochar is applied two week before sowing of the crops. Dahal et al., (2022) reported that Biochar at the rate of 10 t/ha in combination with cattle manure showed significant higher plant growth and marketable yield in radish.

1.7 Lactobacillus serum

Materials required

Materials	Quantity
Rice	1 part
Milk	10 part
Jaggery	1 part

Preparation methods

» Mix equal parts of rice and non-chlorinated water, and wash the rice thoroughly.

» Collect rinsing water in a glass jar or plastic container, filling it halfway.

» Cover the container with a cloth and let it stored for two to seven days to allow fermentation. It depends upon the temperature of storage area. During summer and in tropical climate, it takes two three days while in winter and temperate climate, it takes about a week.

» When ready, the fermented liquid will have three layers: a thick top layer (carbohydrates and molds), a clear middle layer (lactic acid bacteria and other bacteria), and a turbid bottom layer (a byproduct of starch and by-product of fermentation).

» Carefully pour off the middle layer into a separate container. For this purpose a syringe can also be used.

» Mix ten parts milk with the middle layer of the extract.

» Store the mixture in an airtight container in a dark place for a week to month depending upon storage temperature. The container should be half filled to allow space for fermentation and expansion.

» After a week to a month, the mixture will have separated into two layers. The top thick layer is not needed and can be used for composting or as feed for livestock.

» The lower layer, which remains in liquid form, is the desired Lactobacillus serum.

Storage method

» Prepare a jaggery solution with water 1:1 ratio

» Add an equal amount of Lactobacillus serum to the jaggery solution.

» Such mixture can be stored in an airtight bottle in a cool and shady place for up to 3 years.

» It can also be stored in refrigerated condition for 2 weeks without mixing jaggery.

Application method

» Mix Lactobacillus serum (Mixture of Lactobacillus and jaggery solution) with water in a ratio of 1:500.

» In case of pure Lactobacillus serum, 1:1000 part of Lactobacillus serum and water should be mixed.

» Stir the mixture well.

» Use the Lactobacillus serum mixture to irrigate plants or soil.

» This mixture can also be used to accelerate the decomposition process of compost. For this, spray the Lactobacillus serum mixture (completely soaking the manures) onto the manure while turning over.

1.8 Panchagavya

Materials required

Table below shows the list of materials and their quantities required to make panchagavya.

Materials	Quantity
Fresh dung	5kg
Fresh urine	3liter
Ghee	1kg
Milk	2liter
Curd	2 liter
Ripe banana	1dozen
Jaggery	1kg in 1lit
Yeast	100 g
Honey	½ liter

Preparation method

» Take an open-mouth jar or container. Mud jar should be preferred.

» Mix 1kg ghee with 5kg dung and incubate for 3 days.

» Stir the mixture.

» Mix cow urine with the ghee-dung mixture.

» Mix and stir milk and yogurt.

» Mash bananas and mix it with honey and yeast. Then mix it with above mixture.

» Mix jaggery solution.

» Cover the jar/container with mosquito nets or cloth.

» Keep the mixture in a shady place and stir it twice a day for 18-21 days.

» When ready, the Panchagavya will have a sweet smell.

Application method

Mix 1-unit of Panchagavya with 33 units of water. The diluted mixture of Panchagavya and water should be used during soil preparation (once), during crop growth and flowering (twice), and during fruiting (once).

1.9 Crops vitamins (Fish Amino Acid)

Materials required

Table below shows the list of materials and their quantities required to make crop vitamins.

Materials	Quantity
Fish or Fish Waste	1kg
Jaggery	1kg
Hing (*Asafoetida*) powder	50gm (Optional)
Earthenware vessel	1

Preparation method

» Chop fish or fish waste into small pieces.

» Put the sliced garbage in layers in a clay pot.

» Put jaggery on each layer (one layer fish, one layer jaggery).

» Sprinkle 50 grams of *Asafoetida* powder on top of the layers. *Asafoetida* accelerates the decaying process and provides additional amino acids to the plants. It is optional.

» Pour 1 liter of water into the pot.

» Cover the pot with a cloth.

» Dig the hole in the soil or manure and bury the pot with mouth in the air. It can be stored in pit for one year and stored in bottle in cold and dry place for six months.

» Provide shadow in the buried place.

» It will take almost a month to be ready.

» Fish Amino Acid ready for use will be as thick as honey.

Application method

To use the prepared solution as a fertilizer:

- Mix 1 part of prepared Fish Amino Acid with one part of water and sieve with cloth or net.
- Mix 500 parts of water with one part of the sieved solution.
- The prepared solution can be used in soil as irrigation.
- The concentration can be increased by mixing one part of Fish Amino Acid solution with 16 parts of water and use as foliar application.
- When spraying on plants, completely soak the leaves either in the morning or evening.
- It's best to use it once a week.
- Do not apply after flowering, as it may increase vegetation growth.

Benefits

- Amino acids present in the solution minimize the effect of environmental stress such as high temperature, low temperature, moisture stress to the plants.
- It consists of different nutrients such as nitrogen 90%, phosphorous 2.5%, potassium and calcium, which improves plants growth and development.
- It reduces the infestation of diseases and pests. Use of Fish Amino Acid solution in lower part of leaves reduces infestation of white fly.
- It increases the activities of microbes and earthworm in the soil.
- It is found the use of Fish Amino Acid increases yield upto 20%.

1.10 Calcium solution

Materials required

Egg shells or animal bones (buffalo, chicken, goat, etc.) and vinegar.

Preparation method

- Crush the egg shell into small pieces. Remove membrane and fry till brown.
- Burn the small pieces of bones until they turn black (if less burnt it appears gray and if more burnt it appears as white ash).
- Put the burnt bones or roasted shells in a bowl and add 10 times vinegar to them.

» Air bubbles will appear on the bones or shells after applying vinegar.
» Cover the vessel with cloth and leave it for 5 to 10 days.
» The calcium solution is ready when air bubbles stop appearing.
» Store the solution for up to 2 years in a mesh-sorted and nonairtight container.

Application method

Dilute the calcium solution by mixing 1 part of it with 1000 parts of water, and then spray the resulting mixture.

1.11 Biofertilizer

The table below shows various groups of Biofertilizer that are commonly used in agriculture.

Different groups of Biofertilizers

Groups	Examples
1. Nitrogen fixing Biofertilizer	
Free-living	*Azotobacter, Clostridium, Anabaena, Nostoc*
Symbiotic	*Rhizobium, Frankia, Anabaena azollae*
Associative symbiotic	*Azospirillium*
2. Phosphorus-solubilizing Biofertilizer	
Bacteria	*Bacillus megaterium var.phosphaticum, Bacillus circulans, Pseudomonas striata*
Fungi	*Penicillium sp., Aspergillus awamori*
3.Phosphorus-mobilizing Biofertilizer	
Arbuscular mycorrhiza	*Glomus sp., Gigaspora sp., Acaulospora sp., Scutellospora sp., Sclerocystis sp.*
Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
Orchid mycorrhiza	*Rhizoctonia solani*
***4.* Biofertilizer for micronutrients**	
Silicate and zinc solubilizers	*Bacillus sp.*
5. Plant growth promoting rhizobacteria	
Pseudomonas	*Pseudomonas fluorescens*

Source: Barman et al., 2017

Preparation method

These fertilizers are produced in a sophisticated labs and rarely can be made at farmer's level. The products are available in the market with their trade names. Farmers should be aware on the choice of suitable products according to the host crop and the type of pests to be controlled.

Application method

- Choose the right type of Biofertilizer according to your purpose.
- The purpose may vary such as for seed treatment, seedling treatment and soil treatment/application
- Follow the instructions provided by the manufacturer.
- Regularly monitor the plants to assess their growth and health.
- Biofertilizer may take several weeks to show noticeable results.

Seed treatment

- Weigh the seeds and calculate the amount of Biofertilizer required (10-20 gram per kg of seeds).
- Mix the calculated amount of Biofertilizer with a small amount of water.
- Add adhesive material, such as jaggery, gum etc., to the mixture and stir well.
- Gradually add more water to make a slurry and mix well to ensure uniform distribution of Biofertilizer.
- Add the seeds to the slurry and mix well to coat the seeds uniformly with the Biofertilizer mixture.
- Keep the treated seeds in the shade for 30 minutes before sowing to allow the Biofertilizer to adhere to the seed surface and start colonizing the root system.
- Sow the treated seeds in the field or in pots as per your requirement.

Seedling treatment

- Prepare a slurry of bio-fertilizer by mixing it with water.
- Dip the roots of the seedlings into the slurry for about 15 minutes to allow the bio-fertilizer to adhere to the roots.

» Take out the seedlings from the slurry.

» Transplant the treated seedlings into the field or into pots, as per your requirement.

Soil application

» Take 5-7kg of Biofertilizer for one hectare of land

» Take 60-70kg of soil or compost and add the Biofertilizer to it.

» Mix the Biofertilizer with the soil/compost thoroughly to ensure uniform distribution.

» Broadcast the Biofertilizer mixture on the entire one-hectare land using a suitable applicator.

» Apply the mixture either at the time of sowing or 24 hours before sowing.

Nitrogen fixation capacity of various crops

The nitrogen fixation capacity of legumes can vary depending on various factors, including environmental conditions, crop management, and genetic traits of the plant and the bacterial strain. The following table presents the nitrogen fixation capacity of various leguminous crops.

Crop name	Nitrogen fixation rate kg/ha.
Horse gram	45-52
Peas	52-57
Soyabean	60-168
Chickpea	103
Cowpea	73-354
Beans	40-70
Lentil	88-114
Pigeon pea	168-280

Annex 2: Organic pesticides: methods of preparation and application

2.1 Neem extracts

Materials required

Neem leaves (2kg), seeds (2kg), Neem cake (2kg) (when, where and how to use them – has to mention in the preparation method) and water (16 liters).

Preparation method

- Collect mature Neem leaves from healthy Neem trees.
- Wash the leaves thoroughly to remove dirt or debris.
- Chop the leaves into small pieces and put them in a clean container.
- Add clean water to the container at a ratio of 1:8.
- Cover the container with a lid and let it stay for 3-5 days.
- Strain the mixture through a fine sieve or cloth to remove solids.
- The resulting Neem extract can be used immediately or stored in a cool, dark place for future use.

Note: Many Neem-based Biopesticides are available in the market with different trade names such as Neemix, Ralli Neem, Neemgold, etc. Farmers can purchase and use these from reliable sources.

Application method

The Neem extracts and Neem-based pesticides can be used against worms, sucking insects like aphids, nematodes, larvae, rice leaf eating insects, beetle, borer, leaf folding, and fruit piercing insects.

- Mix one part of the Neem extract with 16 parts of water.
- Spray the diluted solution on the plants for controlling worms, and sucking insects like aphids.
- Spray 200ml of the solution at the base of the plant to control nematodes.
- Neem fruit extracts control larvae, rice leaf eating insects, beetles, borers, leaf folding, and fruit piercing insects.
- Apply Neem extract solution once a week or as per needed.

2.2 Titepati extracts

Materials required

Titepati leaves and water.

Preparation method

- Collect bitter leaves from healthy plants before flowering.
- Wash the leaves thoroughly to remove any dirt or debris.
- Chop the leaves into small pieces and put them in a clean container.
- Add clean water to the container at a ratio of 1:10 (1kg Titepati leaves to 10 liter of water).
- Cover the container with a lid and let it stay for 16-24 hours.
- Strain the mixture through a fine sieve or cloth to remove solids.
- The resulting extract can be used immediately or stored in a cool, dark place for future use.

Application method

- Mix one part of the Titepati extract with 3 parts of water.
- Spray extract on infected plants to control targeted insects.
- Titepati can control aphids and caterpillars.
- Mulching with Titepati protects against the infestation of insects living in the soil.

2.3 Jholmol

Materials required

Properties	Plants
Milky weed	Khirro, Papaya leaves
Bitter leafy vegetation	Neem, Titepati, Bakaino
Bad smelling vegetation	Banmara, Bojho
Good smelling vegetation	Bavari (Basil), Marigold, Mint
Repellent vegetation	Asuro, Bojho, Naurang
Others	Ginger, Turmeric, Chilli, Mustard oil seed cake, Cattle urine

Preparation method

- Collect plants which have repellent, growth inhibitor, inedible and toxic properties as mentioned in the above table.
- Chop the leaves into small pieces (approximately 2cm) and put them in a clean container.
- Mix ginger powder, green chilies, ashes, mustard seeds, etc.
- Mix cattle urine at the rate of 2 liter per kg of leaves.
- Close the container and keep it in the shade.
- Stir the mixture once a week with a wooden stick.

Application method

- Mix pesticide and water with 1:4 ratio for adult plants.
- Mix pesticide and water with a 1:8 ratio for nursery plants.
- Spray the organic pesticide at intervals of 3-7 days.
- Use jug, sprayer or brush for spraying.
- It is suitable for field application in 21-40 days.

2.4 Jibamrit

Materials required

Materials	Quantity
Water	180 liter
Cow urine (local/indigenous)	10 liter
Fresh cow dung	10 kg
Jaggery	1 kg
Soil (from forest or near the root of Peepal (*Ficus religiosa*))	500 g
Legume flour	1 kg
Plastic drum	1

Preparation method

» Collect the above mentioned materials in the plastic drum/container.
» Stir the mixture with a stick.
» Put the container in the shade and stir the mixture in every 2 days.
» Jibamrit is ready after 10-15 days.

Application method

» It is used as foliar spray/surface on the plants.
» Mix Jibamrit and water with 1:4 ratio.
» 25 liter of Jibamrit is enough to apply in 1 *Ropani* of land.
» Spray the prepared Jibamrit solution.
» It is suitable to apply in 7-15 days interval.

2.5 Bijamrit

Materials required

Materials	Quantity
Fresh cow dung	500 g
Cow urine	500 ml
Forest soil	1 handful
Agricultural lime	5 g
Water	2 liter
Bucket	1 piece
Cotton cloth	1 piece

Preparation method

» Take 500g fresh cow dung and wrap it in cotton cloth
» Soak the wrapped dung in 2 liters of water for 12 hours
» Squeeze the cloth to collect the liquid
» Mix 500ml cow urine, 1 handful of forest soil, and 5g lime with the collected liquid
» Put the mixture in a cool place for 24 hours
» Bijamrit is ready to use
» Use the prepared Bijamrit within 48 hours

Application method
It is used to treat seeds.
Soak the seed in Bijamrit for about 6 hours in shade.
Sow the seed immediately after treatment.

2.6 Biopesticides

Commonly used biopesticides in Nepal: target pests, and hosts

Pathogen	Host range	Application
	Bacteria	
Bacillus thuringiensis var. kurstaki (Bt)	Lepidopteran larva, diptera	Paralyze and destroy the gut cells of insect pests, Moths and butterfly
Bacillus thuringiensis var. israelensis (Bt)	Diptera	Mosquito, blackfly, fungus gnat larva
Bacillus thuringiensis var. tenebrinos	Coleoptera	Colorado potato beetle, elm leaf beetle larva,
Bacillus thuringiensis var. aizawai	Lepidoptera	Wax moth, diamond back moth caterpillar
Bacillus popilliae and Bacillus lentimorbus	Soil dwelling pests	White grub
Bacillus sphaericus		Mosquito
	Fungi	
Beauveria bassiana	Soil and on plant pests	Whiteflies, aphids, grasshoppers, termites, Colorado potato beetle. Boll , weevil, bark beetle, white grubs
Metarhizium anisopliae	Orthoptera, dermaptera, hemiptera, lepidoptera, coleoptera, diptera, hymenoptera	White grub, rhino ceroceros beetle, Corn rootworm, some root weevil, Grasshoppers, Locusts, Spittle bugs in sugarcane and alfalfa

Verticilium lecanii	Sucking pests	Aphids, whiteflies, thrips
Lagenidium giganteum	Mosquito	Mosquito larva
Viruses (kipd.com)		
Gypsy moth nuclear polyhedrosis (NPV)	Lepidoptera	Gypsy moth caterpillar
Tussock moth NPV	Lepidoptera	Tussock moth caterpillar
Pine sawfly NPV	Lepidoptera	Pine sawfly
Codling moth granulosis virus (GV)	Lepidoptera (apple, pear, walnut, plum pests)	Potato tuber moth, Codling moth
Cydia Pomonella GV	Lepidoptera	Codling moth on fruit trees
Phthoriaea opercullela GV	Lepidoptera	Potato tuber moth (PTM)
Baculovirus (Bvs)	Lepidoptera, hymenoptera pests	Flies, wasps, bees, ants, moths and butterfly
Ach NPV	Lepidoptera	Castor semilooper
Am NPV	Lepidoptera	Red hairy caterpillar
Heli NPV	Lepidoptera (cotton, vegetables)	*helicoverpa armigera,* cotton bollworm
Spodo NPV	Lepidoptera (vegetables, cotton, maize, tomatoes, tobacco)	Spodoptera litura,
Virus based products	Variety of insect pests	Cabbage moth, corn earworms, cotton leaf worms, bollworms, celery loopers, tobacco budworms
Entomogenous nematodes		
Steinernema feltiae *(=Neoaplectana carpocapsae) S. riobravis, S. carpocapsae* and other *Steinernema* species	Lepidoptera, coleoptera, mushrooms, orchards	Cutworms, armyworms, webworms, wood borers, mole crickets, citrus weevils, saw fly

Heterorhabditis heliothidis	Lepidopteran coleopteran larva	Strawberry root weevil, cranberry girdler, white grub
Protozoa		
Nosema locustae	Orthoptera	Grasshoppers, crickets, locusts
Nosema pyrausta	Lepidoptera	Maize/corn borer
Vairimorpha necatrix	Lepidoptera	Black cutworm
Pathogen		
Steinernema scapterisci	Orthoptera	Grasshoppers, crickets

Application method

Seed treatment:

- Soak seeds in water and clean them
- Mix the *Trichoderma* powder at the rate 4 gram per kg
- Dry the treated seeds for 4-6 hours in the shade

Compost/manure treatment:

- Mix 1 kg of *Trichoderma* with 25 kg of manures
- Cover the mixture with plastic for 7 days and use the manures

Treatment of plants:

- Make a solution: Mix 10 gram of *Trichoderma* in a liter of water
- Soak the roots of plants in the solution for 30-50 minutes before planting (Adiarti, Pujiasmanto, & Dewi, 2019)

Annex 3. Commonly used traps in Nepal

3.1 Commonly used pheromone traps, target pests, and hosts in Nepal

SN	Lure	Traps	Insect	Crop
1	Methyl Eugenol	Pheromone trap	Fruit flies	Citrus and mango[1]
2	Cue Lure	Pheromone trap	Fruit flies	Cucumber and pumpkin and similar crops[1]
3	Bactocera Compositae		Fruit flies	Both above[1]
4	Heli Lure	Funnel trap	Tomato fruit borer	Tomato, pigeon pea[1]
5	Spodo Lure	Funnel trap	Tobacco leaf eating borer	Cauliflower, cabbage, potato and tomato[1]
6	DBM/ Protula Lure	Delta trap	Diamond Back Moth	Cauliflower and cabbage[1]
7	Leucinodas	Funnel trap	Fruit and steam borer	Brinjal
8	PTM1, 2 Lure	Delta trap	Mealy bugs, potato tuber moth	Potato
9	Scirpo Lure		Yellow borer	Rice
10	Pectino Lure	Funnel trap	Pink bollworm	Cotton
11	Ermit & Eirmin lure		borer	Cotton
12	TLM lure	Wota-T trap	Tuta absoluta (leaf miner)	Tomato

Source: [1]NARC Diary, 2079

3.2 Commonly used mechanical traps in Nepal for pest control: target pests, and hosts

- **Light trap:** armyworm, bugs, cutworm, flies, gnats, tomato fruit worms, leafhopper, plant hopper, stem borers (www.hillagric.ac.in).
- **Yellow sticky trap:** aphids, cabbage root maggot, carrot rust fly, cabbage white fly, cucumber beetle, fungus gnat, onion fly, thrips, whiteflies.
- **Blue sticky trap:** thrips.
- **white sticky trap:** flea beetle and tarnished plant bug.
- **Bird perches:** feed on pests of cotton, peanuts, cowpea, vegetables pests.
- **Scarecrow:** manmade human (to keep animals like donkey, cow, buffalo, etc. away from crops).
- **Pitfall trap:** soil crawling insets.

3.3 Commonly used trap crops in Nepal

Trap crop	Main crop	Method of planting	Target pests
Marigold and Basil	Garlic	Border crops	Thrips
Mustard, Radish, Chinese Cabbage	Cabbage	Planted in every 15 rows of cabbage	Cabbage webworm, flea hopper, mustard aphid
Collards	Cabbage	Border crops	Dbm (diamond back moth)
Dill and Lovage	Tomato	Row intercrop	Tomato hornworm
Horse radish	Potato	Intercrop	Colorado potato beetle
Marigold	Solanaceous, Crucifers, Legumes, Cucurbits	Row/strip intercrop	Nematodes

Medic, Medicago litoralis	Carrot	Strip intercrop in between carrot plots	Carrot root fly
Napier and Desmodium	Corn/Maize	Intercrop/ border crop	Fall army worm and stem borer
Onion and garlic	Carrot	Border or barrier in between crop	Carrot root fly, thrips
Radish	Cabbage Family	Row intercrop	Flea beetle, root maggot
Sesbania/Rye/ Sickle pod	Soyabean	Row intercrop at 15 cm apart or strip intercrop	Corn seedling maggot, stink bug, velvet bean caterpillar, green stink bug
Tomato	Cabbage	Intercrop (tomato planted 2 weeks before at the plots border)	Diamondback moth (dbm)
Tropical soda apple, *Kanthakari* (*solanum viarum*)	Tomato, Potato		Tomato fruit worm (*helicoverpa armigera*)

Annex 4: Organic certification process: some examples

Box 1: Steps of organic certification in USDA-NOP

STEP 1: Develop an organic system plan. The organic system plan is the foundation of the organic certification process. Created by the producer or handler seeking certification, it details how an operation will comply with the regulations based on its unique characteristics.

STEP 2: Implement the organic system plan. Have it reviewed by a certifying agent. Organic operations are certified by private, foreign or State entities that have been accredited by USDA. These entities are responsible for certifying around the world. Certifying agents audit producers and processors as well as traders to ensure that organic products meet all criteria and indicators of the organic standard(s) for which certification is requested.

STEP 3: Receive inspection. Every operation that applies for organic certification is first inspected on site by a certifying agent. These comprehensive top-to-bottom inspections differ in scope depending on the farm or facility. Audits include inspection of fields, soil conditions, crop health, approaches to management of weeds and other crop pests, water systems, storage areas and equipment. At a handling or processing facility, an inspector evaluates the reception, processing, and storage areas used for organic raw materials, ingredients and finished products.

STEP 4: Have a certifying agent review the inspection report. The inspector presents findings to the certifying agent through an audit report, which includes observation of practices on the farm or facility and their comparison with the organic system plan. In addition to the inspection points mentioned above, the inspector also presents an assessment of the risk of contamination by prohibited substances and might even take soil, tissue or product samples as needed. The inspector also analyzes potential hazards, critical control points and procedures to prevent contamination. All findings are communicated to the certifying agent for review.

STEP 5: Receive a decision from the certifier. If an operation complies with the rules, the certifying agent issues an organic certificate listing products that can be sold as organic from that operation. The organic farm or facility continues to update its plan as it modifies its practices, and an inspection is done at least once a year to maintain certification.

Box 2: Steps of organic certification adopted by OneCert International

STEP 1: Registration & application: For obtaining organic certification the first step is send request to OneCert International who in turn will provide you with an application packet. The packet contains the application form, agreement, organic system plan, field history sheet (for crop - incl., grower group, wild harvest), farm product & inventory list, organic product profile and grower group questionnaire (for crop production grower group) etc. In organic system plan information about record keeping, production detail, detail of input use (for fertility, pest and disease management), preventive measures, and the methods used for prevention of contamination and commingling are required. While submitting the organic system plan one must attach the facility map, soil and water test, product label presently in use or to be used in future.

STEP 2: Application review: Once your complete application is received, we will review the same on the basis of applicable standards. If any incomplete information/non-compliance if found on any additional information is needed, we will contact you. Once required information is gathered or noncompliance is over, an onsite audit is planned on a mutually agreed date and time. This reviewing of application usually takes about a couple of days based on the information provided by applicant.

STEP 3: On-site inspection: On the prescribed date a trained organic inspector, familiar with your type of operation will reach your facility. The inspector will thoroughly examine each method production and documents of your operation and facility for the verification of your plan in an accurate description of organic standard compliance. During an exit interview he will summarize his findings and asks for any additional information, if required. Inspection normally takes half a day to 3 days depending upon the complexity of operations.

STEP 4: Secondary review: After submission of the inspector's report, it is reviewed to evaluate compliance with the applicable standards. During the secondary review if more information is required, we will contact you. After the receipt of report from the inspector, the secondary review generally takes 2-4 days.

STEP 5: Certification decision: After completion of the secondary review, the file is sent for the final decision. After receiving the final decision, you will receive your organic certificate along with a covering letter containing the conditions for awarding certificate. The organic certificate contains name of your company, address, category of certification and list of certified organic product. The entire certification process may take about 4-16 weeks depending upon documents and co-operation provided.
Source: https://onecert.com/how-to-steps/

References

Adhikary, S. (2012). Vermicompost, the story of organic gold: A review. Agricultural Sciences, 905-917.

Adiarti, Y. E., Pujiasmanto, B., & Dewi, W. S. (2019). Effect balance of bokashi and inorganic fertilizer on growth simplicia yield and content of sinensetin of kumis kucing (Orthosiphon aristatus (Blume) Miq.). Journal of Soil Science and Agroclimatology, 13-23.

Alkobaisy, J. S., Ghan, E. A., Mutlag, N. A., & Lafi, A. S. (2021). Effect of Vermicompost and Vermicompost tea on the Growth and Yield of Broccoli and Some Soil Properties. IOP Conference Series: Earth and Environmental Science (p. 761). ICCMAT.

Aryal Khanna, S., 2018. Organic Certification: A Case Study of Organic Valley, Nepal. Int. J. Appl. Agric. Sci. 4, 14. https://doi.org/10.11648/j.ijaas.20180401.13

Atreya, K. (2015). In search of sustainable agriculture: A review of national policies relating to organic agriculture in Nepal. Kathmandu, Nepal: Asia Network for Sustainable Agriculture and Bioresources.

Bajracharya, S. (2012). Vermi compost: An introduction and production technology. Bi-monthly magazine. Agriculture Information and Communication Centre

Barman, M., Paul, S., Choudhury, A. G., & Roy, P. (2017). Biofertilizer as Prospective Input for Sustainable Agriculture in India. International Journal of Current Microbiology and Applied Sciences, 1177-1186.

Bhusal, K., Das, U. E., & Bhatta, L. D. (2022). Ecosystem-based adaptation for increased agricultural productivity by smallholder farmers in Nepal. PLoS ONE.

Dahal, S., Vista, S. P., Khatri, M., & Pandit, R. N. (2021). Effect of Biochar blended organic fertilizers on soil fertility, radish productivity and farm income in Nepal. Archives of Agriculture and Environmental Science, 416-425.

Dhital, B. K. (2018). Promotion of organic fertilizers and soil fertility management. Value Chain Development of Fruit and Vegetables Project. Kathmandu, Nepal

Dhital, M., Dahal, D. and Poudel, K. P. (2012). Fundamental Technologies for Sustainable Agriculture. Forest Action Nepal, Satdobato, Lalitpur
FAO 2015 Training manual for organic agriculture https://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Compilation_techniques_organic_agriculture_rev.pdf

FAO (2015) Training manual for organic agriculture https://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Compilation_techniques_organic_agriculture_rev.pdf

FAO (2019). The State of the World's Biodiversity for Food and Agriculture. Commission on Genetic Resources for Food and Agriculture Assessments. Food and Agriculture Organization of the United Nations. Rome.

Gyawali, K. (2018). Pesticide Uses and its Effects on Public Health and Environment. Journal of Health Promotion, 6: 28-36

Gyawali, P., Hwang, S., Sotelo-cardona, P., Srinivasan, R., 2021. Elucidating the Fitness of a Dead-End Trap Crop Strategy against the Tomato Fruitworm, *Helicoverpa armigera*. Insects MDPI 12.

http://www.npponepal.gov.np

https://www.ifoam.bio

IFOAM. 2003. Training Manual for Organic Agriculture in the Tropics. https://resources.peopleinneed.net/documents/654-ifoam-training-manual-for-organic-agriculture-in-the-tropics-0.pdf

Kafle, M. R., Kafle, G., Balla, M. K., & Dhakal, L. (2009). Results of an Experiment of Preparing Compost from Invasive Water hyacinth (Eichhornia crassipes) in Rupa Lake Area, Nepal. Journal of Wetlands Ecology, 17-19.

Kaphle, B.D. 2022. Vedic Wisdom on Agricultural Development: Lensing through the Perspective of Agricultural Extension in: S.G. Shrestha eds.

Proceedings of Conference on Strengthening Linkage Among Agriculture, Research, Extension and Education for the Effective Service Delivery in Federal Nepal. Nepal Agriculture Extension Association and Department of Agriculture, Kathmandu.

FiBL & IFOAM – Organics International (2023): The World of Organic Agriculture. Frick and Bonn

ITC, International Trade Centre. 2022. "Trade Map - Trade Statistics for International Business Development." International Trade Centre.

Maharjan, S. K. (2022). Organic pesticide preparation training manual. Jiri, Dolakha

Maharjan, S. K. and Bhattarai, D. R. (2022). Kitchen garden technology for mid-hills. Shechen Karuna, Nepal.

PAN International. (2007). A position on synthetic pesticide elimination: A PAN international position paper-working Group 1. Pesticide action network international

Pangankorn, U. (2006). Valuable added the agricultural waste for farmers using in organic farming groups in Phitsanulok, Thailand.

Poudel, D. (2014). Organic vegetable production technology. Rural Agriculture and Animal Development Organization Nepal. Taulihawa, Kapilvastu

Shah, R. B. and Neupane, G.(2021). Booklet on organic vegetable cultivation. Prime Minister Agriculture Modernization Project, Project Implementation Unit. Garuda, Rautahat

Sinha, R., Herat, S., Valani, D., & Chauhan, K. (2009). Earthworms Vermicompost: A Powerful Crop Nutrient over the Conventional Compost & Protective Soil Conditioner against the Destructive Chemical Fertilizers for Food Safety and Security. American-Eurasian Journal of Agricultural & Environmental Sciences, 01-55.

Tahir, Rai Mukkram Ali, Noor-us-Sabah, Afzal, Muhammad, Ghulam Sarwar and Noorka, Ijaz Rasool. (2019). Smart Nutrition Management of Rice Crop under Climate Change Environment.

Timsina, J. (2018). Can Organic Sources of Nutrients Increase Crop Yields to Meet Global Food Demand? Agronomy, MDIP.

TNAU. (2016). Organic Farming: Organic Inputs and Techniques. Retrieved from TNAU AGRITECH PORTAL.

UN. (2019). World Population Prospects 2019: Highlights. United Nations Department of Economic and Social Affairs

Veeresha, S. and Gopakka, P. (2014). Effect of Organic Production Practices on Yield and Soil Health of Irrigated Maize (Zea mays L.) as Influenced by Various Levels of FYM and Cattle Urine Application. Environment and Ecology, 627-630.

WHO. (2009). World Health Organization, Regional Office for South-East Asia. Health implications from monocrotophos use: a review of the evidence in India. New Delhi.

Yadhav, D. N and Yadhav, B. P. (2012). Information on faulty farm yard manure management practices adopted by farmers and recommended scientific practices. Bi-monthly magazine. Agriculture Information and Communication Centre

Nation Institute of Food and Agriculture, United States Department of Agriculture (NIFA-USDA). Accessed January 23, 2023. Organic Agriculture. https://www.nifa.usda.gov/topics/organic-agriculture

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