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Green Resilient Agricultural Productive Ecosystems

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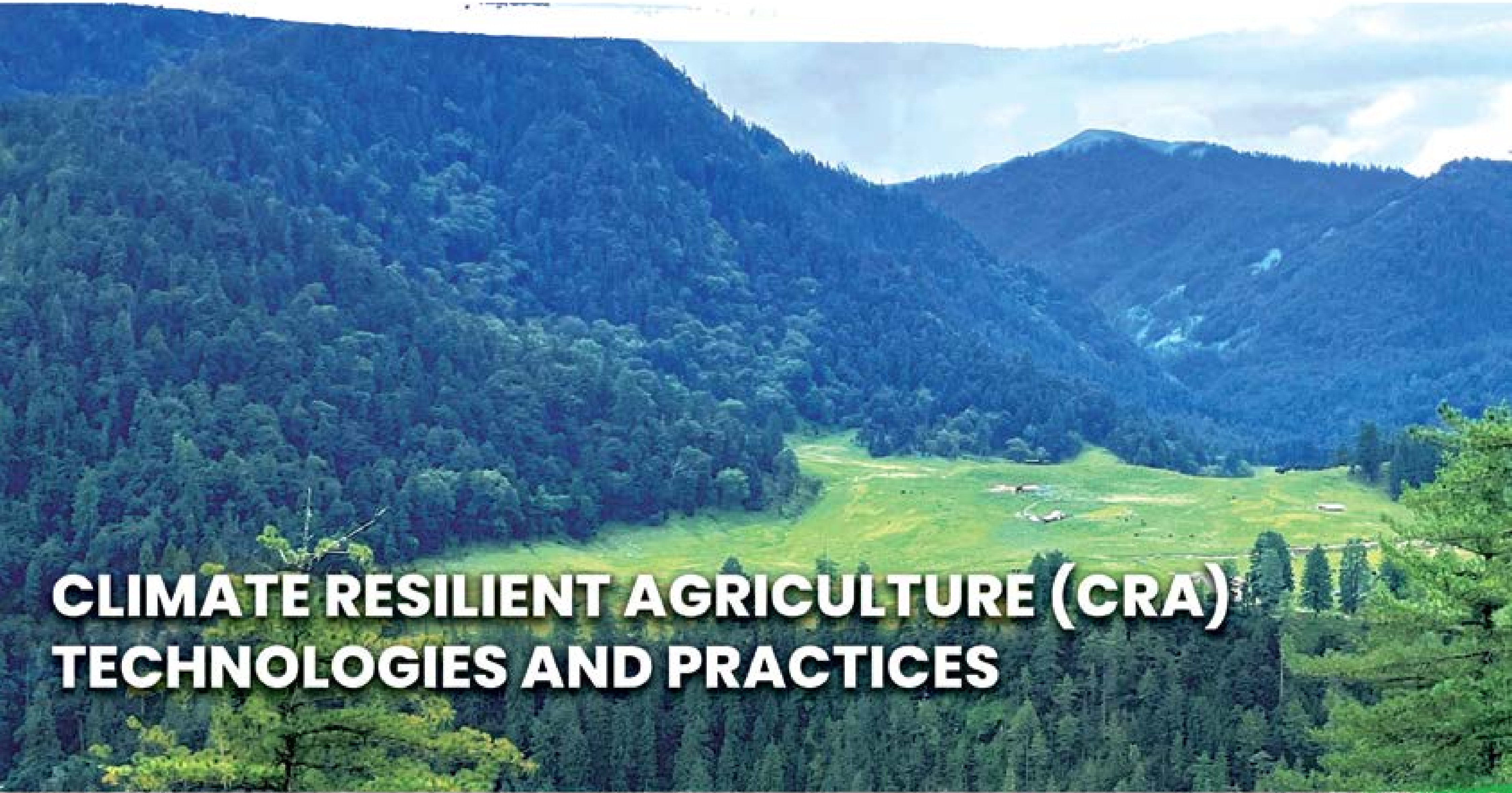

# CLIMATE RESILIENT AGRICULTURE (CRA) TECHNOLOGIES AND PRACTICES

Co-funded by the European Union

SUOMI FINLAND

जर्मन सहयोग
DEUTSCHE ZUSAMMENARBEIT

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**A PICTORIAL BOOKLET**
**ANSAB 2024**

# Acronyms

**ANSAB:** Asia Network for Sustainable Agriculture and Bioresources
**AWD:** Alternate Wetting and Drying
**CRA:** Climate Resilient Agriculture
**DBM:** Diamond Black Moth
**EM:** Effective Microorganisms
**FYM:** Farm Yard Manure
**GIZ:** Deutsche Gesellschaft für Internationale Zusammenarbeit
**GRAPE:** The Green Resilient Agricultural Productive Ecosystems
**IKI:** International Climate Initiative
**MASL:** Meters above sea level
**MHS:** Manfred-Hermsen-Stiftung Foundation
**PPCA:** Public Private Community Alliance
**PTM:** Potato Tuber Moth
**USDA:** United States Department of Agriculture

## Preface

Climate change presents significant challenges to agriculture, particularly for farmers who must adapt to unpredictable weather patterns, droughts, floods, and outbreaks of diseases and pests. In response, there is a critical need for practical solutions that help farmers adapt and thrive in these uncertain conditions. To address this challenge, 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 environment, create jobs, and provide income for the rural poor in remote but resource-rich areas of Nepal.

This booklet aims to bridge that gap by providing essential knowledge and tools for adopting Climate Resilient Agriculture (CRA) practices. This booklet draws more than a decade of ANSAB's experience through various projects from donors such as blue moon fund, Aveda, Estée Lauder Companies (ELC), International Climate Initiative (IKI) of the German Federal Government, Manfred-Hermsen-Stiftung (MHS), and GIZ in implementing climate resilient/smart agriculture, organic agriculture, and ecosystem-based commercial agriculture programs across various agro-ecological zones in Nepal. It incorporates field evidence, practical experiences from farmers, and research findings to provide readers with critical information, tips, and techniques that are easy to understand and apply.

This booklet is mainly targeted for farmers, agricultural extension workers, community leaders, and organizations involved in agricultural development. It is designed to be a practical resource for those working directly in the field, as well as a training tool for workshops and educational sessions. Government and development agencies can also use this booklet to increase awareness and promote collective efforts toward adopting CRA practices.

We are thankful to the Green Resilient Agricultural Productive Ecosystems project led by GIZ which is jointly financed by European Union (EU), the Ministry of Foreign Affairs and Economic Affairs of the Government of Finland, and German Federal Ministry for Cooperation and Development for providing the grant that allowed us to design and translate this booklet.

The main contributors of the booklet are Mr. Shankar Bhattarai, Mr. Puspa Lal Ghimire, Ms. Shova Khadka, and Ms. Rusta Bidari. A number of ANSAB staff namely Mr. Sudarshan Khanal, Ms. Aakriti Poudel, Mr. Manoj Pant, Mr. Keshav Rokaya, and Mr. Rajan Sah have also contributed by providing relevant information during preparation of this booklet.

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

# Glossory

### CRA

"Climate Resilient Agriculture (CRA)" refers to agricultural practices and systems designed to anticipate, prepare for, adapt to, absorb, and recover from the impacts of climate change and extreme weather events. It emphasizes building the capacity of agricultural systems to effectively manage climate risks, ensuring long-term productivity, sustainability, and food security in the face of a changing climate.

### Composting

"Composting" is the controlled, aerobic process where microorganisms decompose organic materials, such as food scraps and plant residues, into a nutrient-rich amendment. This biological recycling enhances soil fertility and supports healthy plant growth by improving soil structure, water-holding capacity, and nutrient availability.

### Crop management

"Crop management" involves a range of agricultural practices designed to enhance the growth, development, and yield of crops. This includes optimizing planting conditions, managing soil health, and implementing pest and disease control measures to ensure robust crop production and maximize yield.

### Ropani

"Ropani" is a traditional unit of area measurement extensively used in hilly areas of Nepal for land division and property transactions. It is equal to 5,476 square feet or 1/20 hectare.

### 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.

# Table of Content

# About this Booklet

## Objectives of the booklet

This booklet is designed to help farmers understand and adopt Climate Resilient Agriculture (CRA) inputs, technologies and practices. CRA practices are essential to cope with the challenges posed by climate change, such as unpredictable weather patterns, droughts, floods, and outbreak of disease and pests improving the overall productivity of farms with minimum negative impact in soil health and overall environment. Specifically, it provides critical information, practical tips and techniques that are useful in crop production and improve crop yields, making farming more sustainable and resilient.

## How is this booklet developed?

This booklet is developed compiling about one and half decades long experiences of ANSAB implementing various agriculture programs - organic agriculture, ecosystem-based commercial agriculture (ECA), climate resilient/smart agriculture, across various agro-ecological zones in Nepal. It incorporates mostly the field evidences and the practical experiences of the farmers along with the findings from the researches. This booklet provides simple illustrations and brief explanations to ensure the information are easy to understand.

## Who is this booklet for?

This booklet is mainly targeted for farmers, agricultural extension workers, facilitators, students, researchers, community leaders, and organizations involved in agricultural development.

## How it can be used?

- Farmers can use this booklet as a quick reference to choose and adapt appropriate CRA solutions and practices.
- Trainers can use the booklet to train farmers about CRA technologies and practices during workshops and training sessions.
- Government and development agencies can use the booklet to train farmers in their respective programs.

# 1. Water management

## 1.1 Technologies for addressing drought and water stresses in plants

The conservation of available water resources, along with the collection, storage and efficient use of water in agriculture is crucial to address climate change induced droughts and water scarcity. Common water resources that can be conserved, stored and utilized during dry seasons include nearby springs, rivers and streams (through channeling or lifting via pipes), rainwater, snowmelt, wastewater, and excess pipe/drinking water. Below are some cost-effective water-storage solutions for agricultural purposes in the Nepalese context.

**Soil cement pond**

Soil cement ponds are durable (last for 10 to 15 years), cost effective (NRs. 1 per liter capacity), and easy to construct, that stores water from springs, streams, rain, and excess form for dry season use.

Source: ANSAB

**Soil cement pond with jute bags lining**

Soil cement ponds with jute bag linings are durable (last for 10-15 years), weather-resistant, and cost-effective (NRs. 1.5-2 per liter capacity), making them a reliable water storage solution in extreme climatic conditions in Himalayan region.

Source: ANSAB

**Circular ferro-cement pond**

A circular ferro-cement pond is a durable (last for 25 years), cost-effective (NRs. 3-5 per liter capacity) water storage solution constructed by specialized technicians, ensuring water availability for small scale vegetable farming and kitchen gardening.

Source: ANSAB

**Natural water recharge pond**

A natural water recharge pond captures rainwater and runoff to enhance groundwater recharge and provides a vital water source during droughts, supporting agricultural needs in times of scarcity. This is more common practice in terai region of Nepal.

Source: ANSAB


**Grey water collection**

Grey water collection is an eco-friendly method that captures and reuses household and farm wastewater for irrigation, conserving fresh water and minimizing environmental impact.

Source: ANSAB

## 1.2 Water use efficiency technologies and practices

Effective practices to conserve water and maximize the efficiency in scarce water use can help meet critical irrigation requirement, improving agricultural productivity per unit of water use. Key techniques include mulching, drip irrigation, alternate wetting and drying (AWD), partial root zone drying, irrigation at appropriate depth, and monitoring of crucial phenological stages of crop for critical water needs.


**Drip irrigation**

Drip irrigation delivers water directly to the plant's root zone at a slow pace, ensuring over 90% water utilization. It saves time by efficiently irrigating and fertigating crops at a time.

Source: ANSAB

**Mulching**

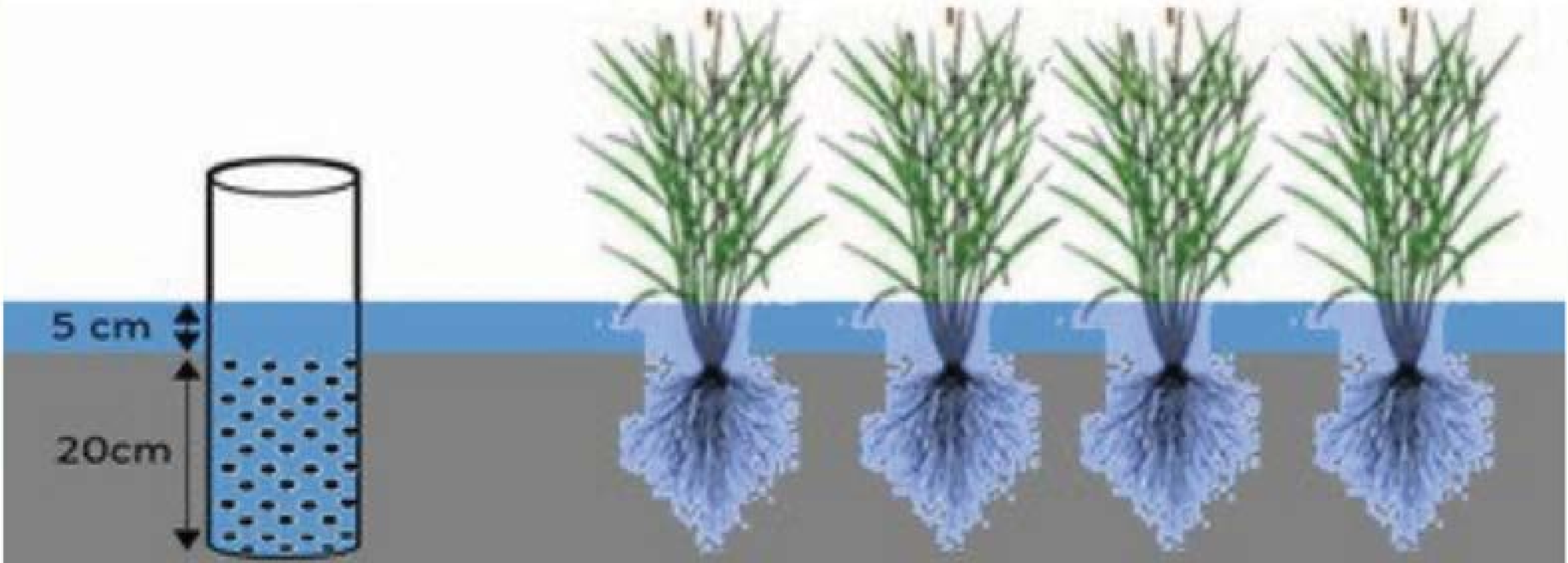
Mulching utilizes agro and forest wastes like straws, sawdust, husk, and plant leaves that reduces water loss, regulates soil temperature, and minimizes evaporation, benefiting crops.

Source: ANSAB

**Alternate wetting and drying (AWD)**

AWD is a water-saving, eco-friendly technology that uses 25%-70% less water than conventional methods, by watering one side of the root zone at a time to encourage deeper root growth, improve nutrient uptake, and enhance drought resistance in arid and semi-arid environments.

Source: ANSAB




## Irrigation at appropriate depth

Irrigating crops at the optimal depth of the active root zone minimizes water wastage and nutrient leaching, enhancing water resource use for most vegetables. For most of the crops, the ideal root zone is 5 cm to 20 cm.

Source: Google

## 1.3 Irrigating crops at critical phenological stages

Irrigating crops at critical phenological stages is essential to maximize yield and prevent significant reductions in crop production. Proper irrigation during these crucial growth phases ensures optimal plant development. The critical phenological stages vary for different vegetables, and maintaining the appropriate soil moisture levels during these stages is key to achieving the best results. The critical phenological stages of different vegetables, along with the appropriate soil moisture percentage are as follows:

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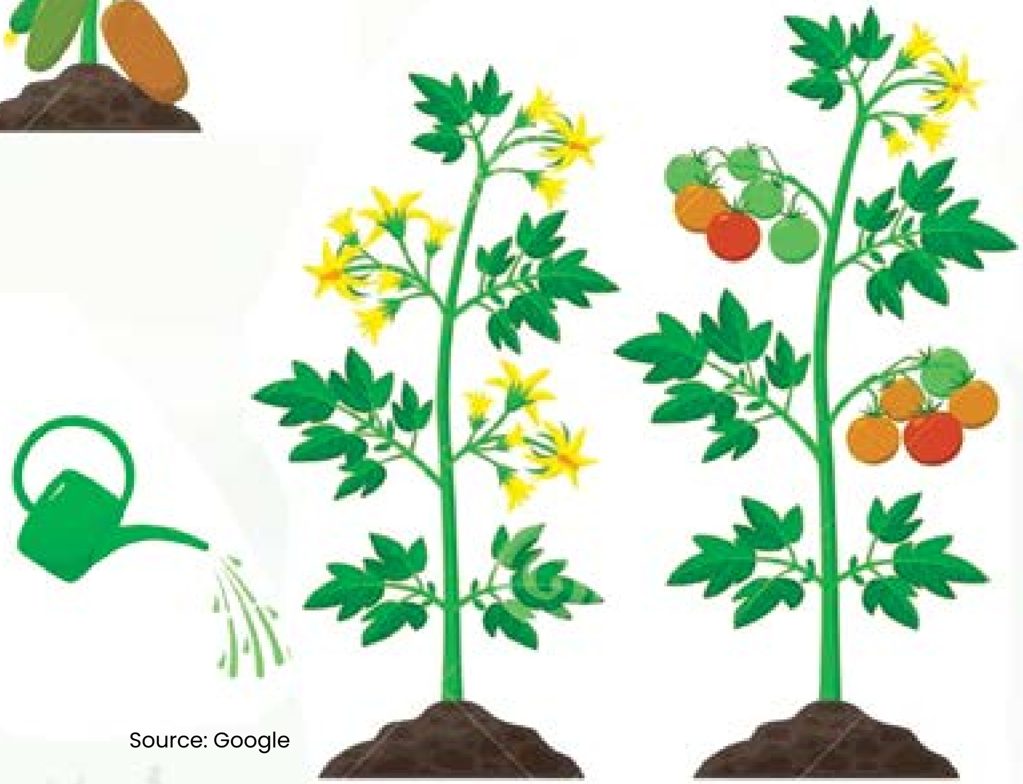
Source: Google

### Cucurbits

For optimal cucurbit yield, maintaining soil moisture at around 50% during flowering and fruit development is crucial for healthy growth and maximum fruit production.

### Tomato

For optimal tomato yield, maintaining soil moisture at around 60% during flowering, and fruit development stage is crucial for healthy growth and maximum fruit production.



Source: Google

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## Eggplant

For optimal eggplant yield, maintaining soil moisture at around 50% during flowering, and fruit development is essential for healthy growth and maximizing fruit production.

Source: Google

## Chili

For optimal chili yield, maintaining soil moisture at around 50% during fruit development is crucial for supporting healthy growth and maximizing fruit production.

Source: Google

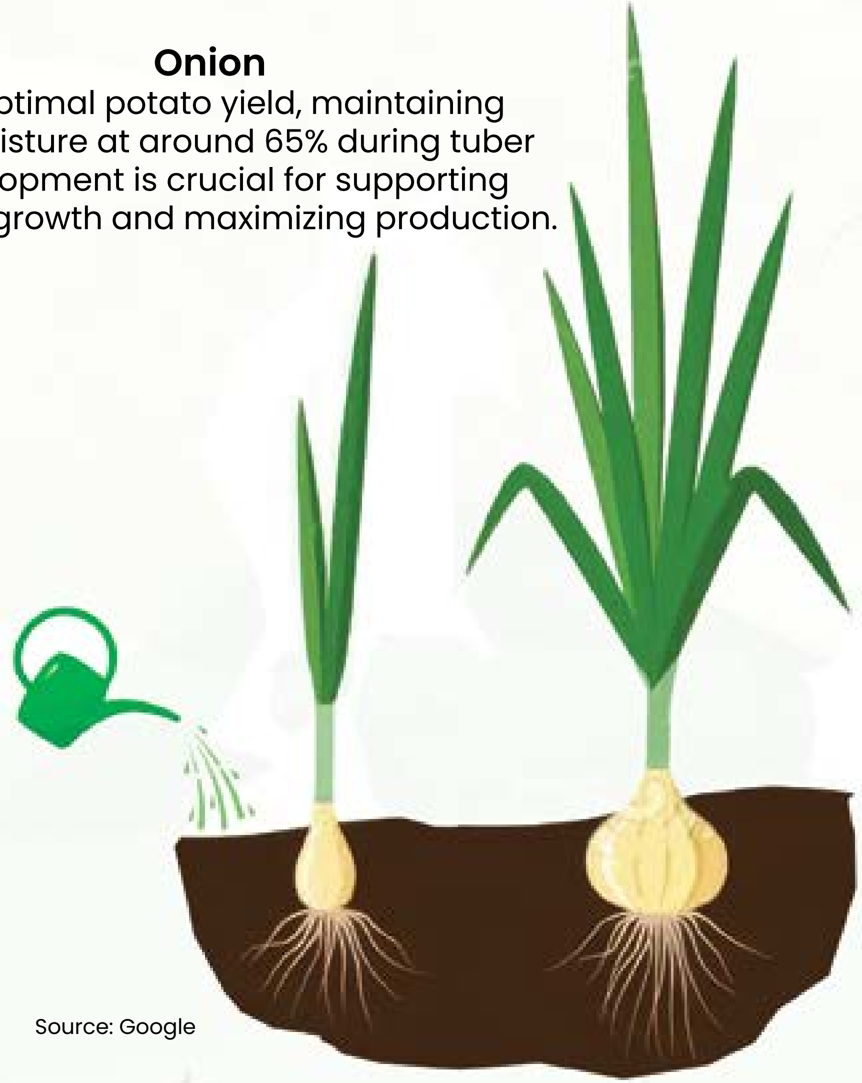
**Potato**

For optimal potato yield, maintaining soil moisture at around 65% during tuber development is crucial for supporting healthy growth and maximizing production.

Source: Google

**Onion**

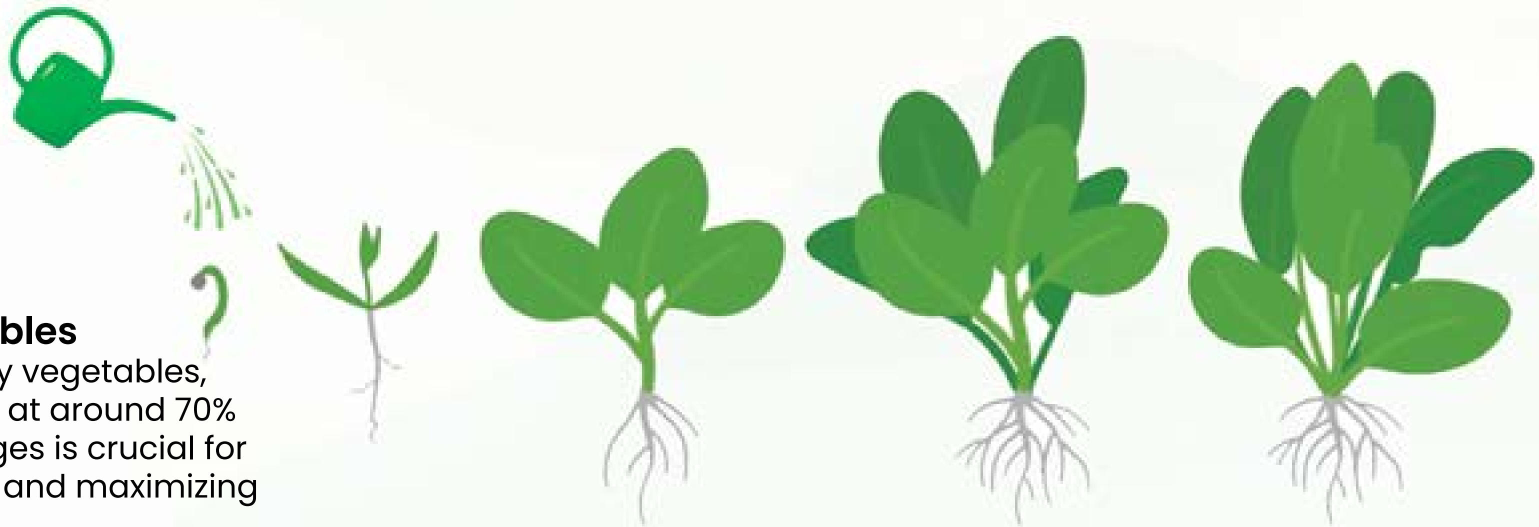
For optimal potato yield, maintaining soil moisture at around 65% during tuber development is crucial for supporting healthy growth and maximizing production.



Source: Google

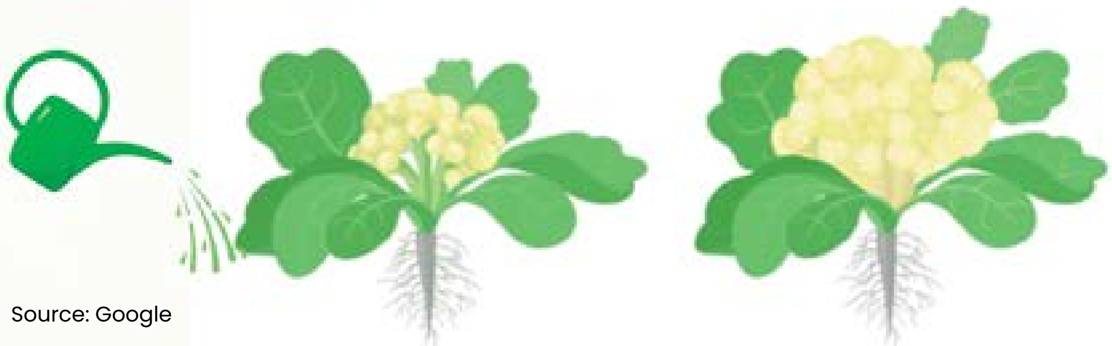
Source: Google

**Peas and Beans**
For optimal yield of peas and beans, maintaining soil moisture at around 50% during flowering and pod development is crucial for healthy growth and maximizing production.



**Leafy Vegetables**
For optimal yield of leafy vegetables, maintaining soil moisture at around 70% throughout all growth stages is crucial for supporting healthy growth and maximizing production.

Source: Google



Source: Google

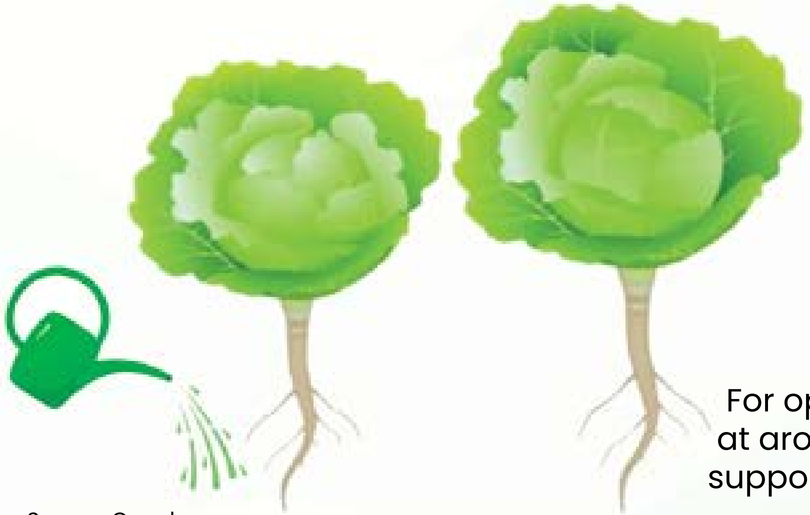
**Cauliflower**

For optimal cauliflower yield, maintaining soil moisture at around 70% during curd development is crucial for supporting healthy growth and maximizing production.

Source: Google

**Okra**

For optimal okra yield, maintaining soil moisture at around 50% during flowering and pod development is crucial for supporting healthy growth and maximizing production.



Source: Google

**Cabbage**

For optimal cabbage yield, maintaining soil moisture at around 60% during head development is crucial for supporting healthy growth and maximizing production.

## 1.4 Monitoring of soil moisture

Monitoring soil moisture is essential for effective irrigation management and can be done through various methods. Visually, soil moisture is assessed by observing the soil's color and texture, which can indicate its moisture content. The hand feel method involves physically touching the soil to evaluate its moisture level by its consistency, whether it's dry, moist, or wet. For more accurate measurements, a moisture meter can be used, providing precise data on the soil's moisture content, which helps in making informed irrigation decisions.

### Estimating Soil Moisture Conditions for Medium Texture - Sandy Clay Loam, Loam, and Silt Loam (USDA-NRCS, 1998)

- <25 percent available: Dry, soil aggregations break away easily, no moisture staining on fingers, clods crumble with applied pressure.
- 25-50 percent available: Slightly moist, forms a weak ball with rough surfaces, no water staining on fingers, few aggregated soil grains break away.
- 50-75 percent available: Moist, forms a ball, very light water staining on fingers, darkened color, pliable, forms a weak ribbon between thumb and forefinger.
- 75-100 percent available: Wet, forms a ball with well-defined finger marks, light to heavy soil/water coating on fingers, ribbons between thumb and forefinger.
- 100 percent available: Wet, forms a soft ball, free water appears briefly on soil surface after squeezing or shaking, medium to heavy soil/water coating on fingers.

## 2. Soil and Plant Nutrient Management

Soil and plant nutrient management involves optimizing the availability of essential nutrients to crops through various practices. By regularly analyzing soil conditions and adjusting nutrient inputs accordingly, farmers can enhance crop growth, improve soil health, and sustain agricultural productivity. Incorporating organic materials and practicing efficient water management further supports nutrient availability and maintain soil fertility over time.

### 2.1 Composting

**Vermi-compost**

Vermi-composting transforms biodegradable waste into nutrient-rich compost, utilizing species like Eisenia foetida and Eisenia andrei which improves soil fertility with essential nutrients and microorganisms, and is effective with in areas up to 2,000 masl.

Source: ANSAB

**Compost manure**

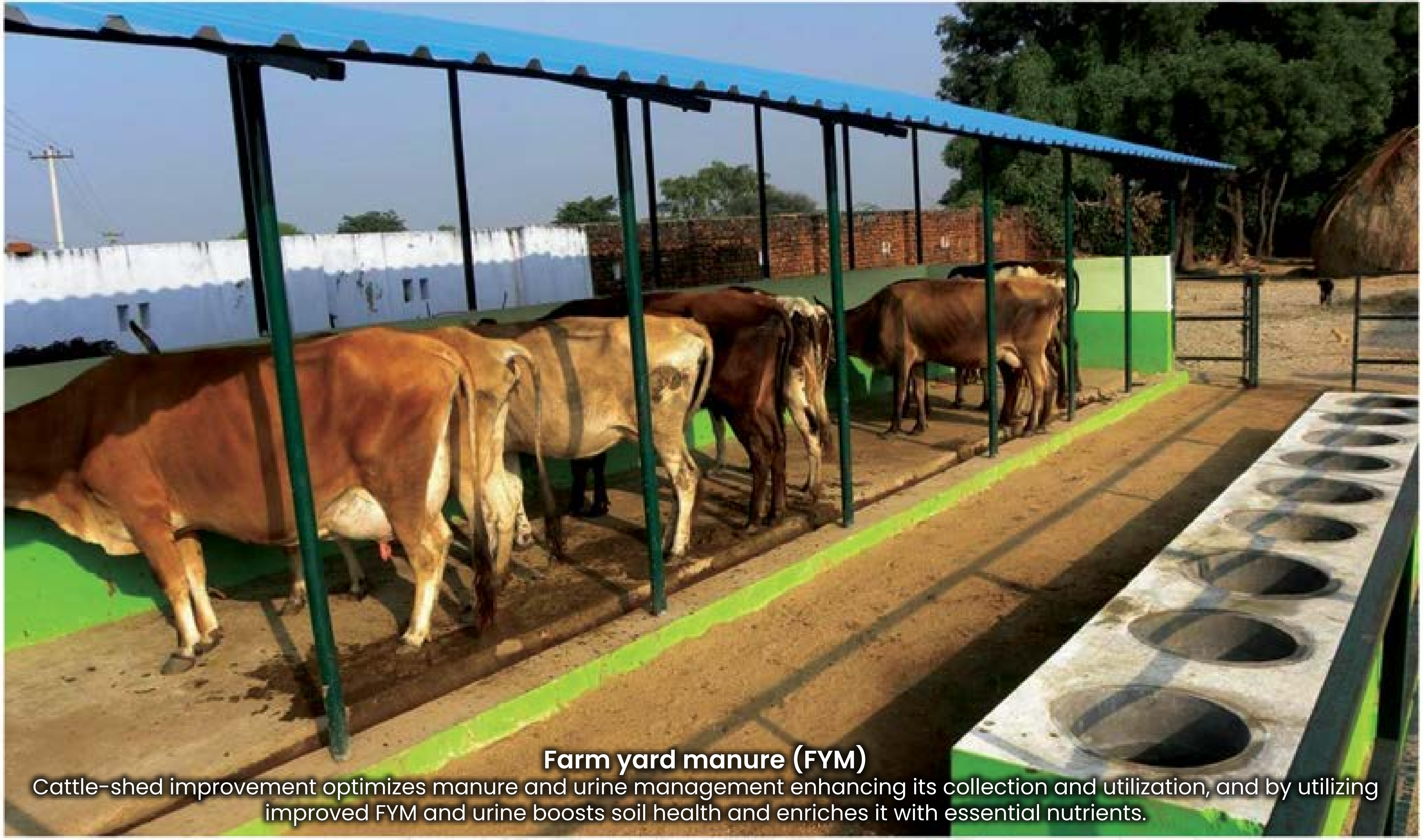
Compost manure, made by decomposing organic matter with microorganisms, enriches soil with essential nutrients and improves its water-holding capacity.

Source: ANSAB

**Vermi-wash**

Vermi-wash, a nutrient-rich liquid fertilizer from vermi-compost, enhances microbial activity and promotes healthy plant growth when applied to soil or foliage, making it a sustainable choice for boosting productivity.

Source: ANSAB



**Farm yard manure (FYM)**

Cattle-shed improvement optimizes manure and urine management enhancing its collection and utilization, and by utilizing improved FYM and urine boosts soil health and enriches it with essential nutrients.

Source: Google

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**Bokashi manure**

Bokashi manure, made by fermenting organic waste, enriches soil with nutrients and beneficial microorganisms, boosting fertility and overall soil health.

Source: Google

**Tricho-compost**

Tricho-compost is organic compost enriched with Trichoderma species, a beneficial fungus that improves soil health, acts as a bio-control agent, and promotes plant growth.

Source: Google

## 2.2 Crop management

**Green manure**

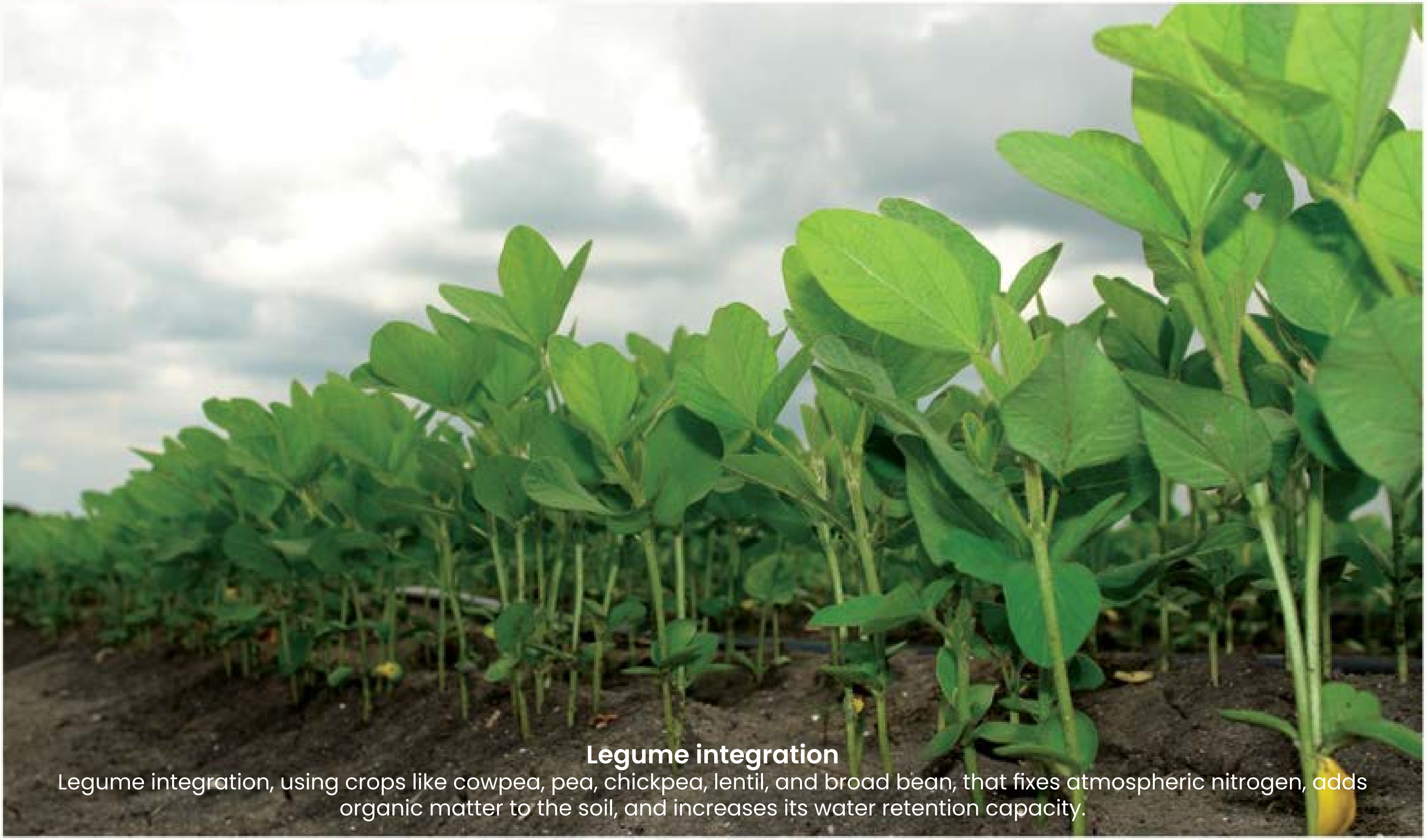
Green manure, made by growing and incorporating leguminous cover crops like Dhaincha or cowpea into the soil, enhances soil fertility and improves its structure.

Source: Google

**Mulching**

Mulching adds organic matter to the soil by improving its physical properties, controlling weeds, preventing soil compaction, and reducing erosion along with reducing evaporation from soil.

Source: Google



## Legume integration

Legume integration, using crops like cowpea, pea, chickpea, lentil, and broad bean, that fixes atmospheric nitrogen, adds organic matter to the soil, and increases its water retention capacity.

Source: Google

**Crop rotation**

Crop rotation, by planting crops from different families, optimizes soil nutrient use and aid in pest management.

Source: Google

**Cover crop**

Cover crops like cowpea, broad bean, soybean, and clover boost soil organic matter, improve soil structure, and maintain soil moisture by reducing evapotranspiration.

Source: Google

**Minimum tillage**

Minimum tillage protects soil structure, minimizes nutrient, moisture loss, and reduces soil erosion.

Source: Google



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## 2.3 Biofertilizer

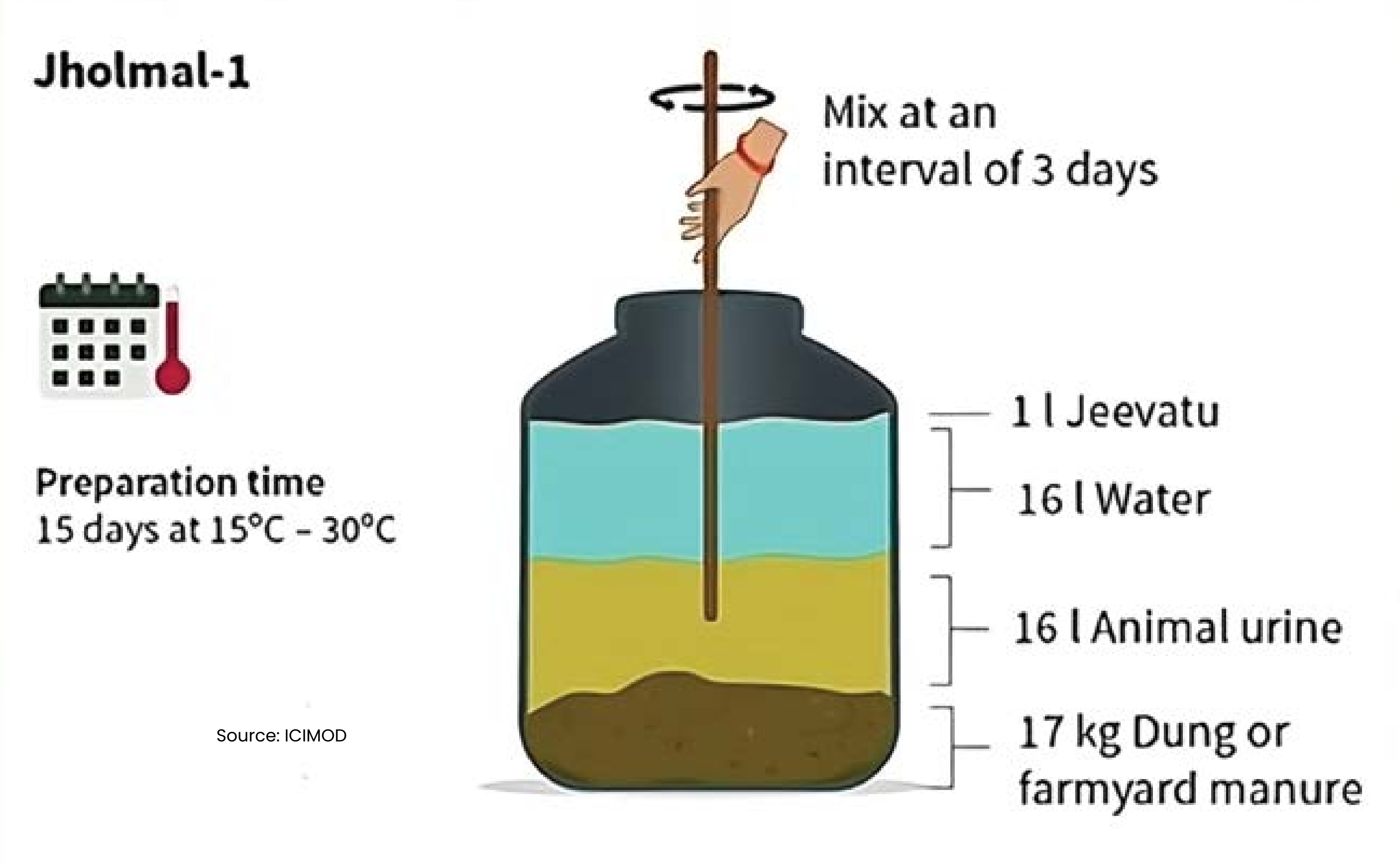
**Panchagavya**
Panchagavya, prepared by fermenting cow dung, cow urine, milk, curd, and ghee, enhances plant growth and soil health when used as a foliar spray or soil additive.

Source: Google

**Bio-fertilizer**

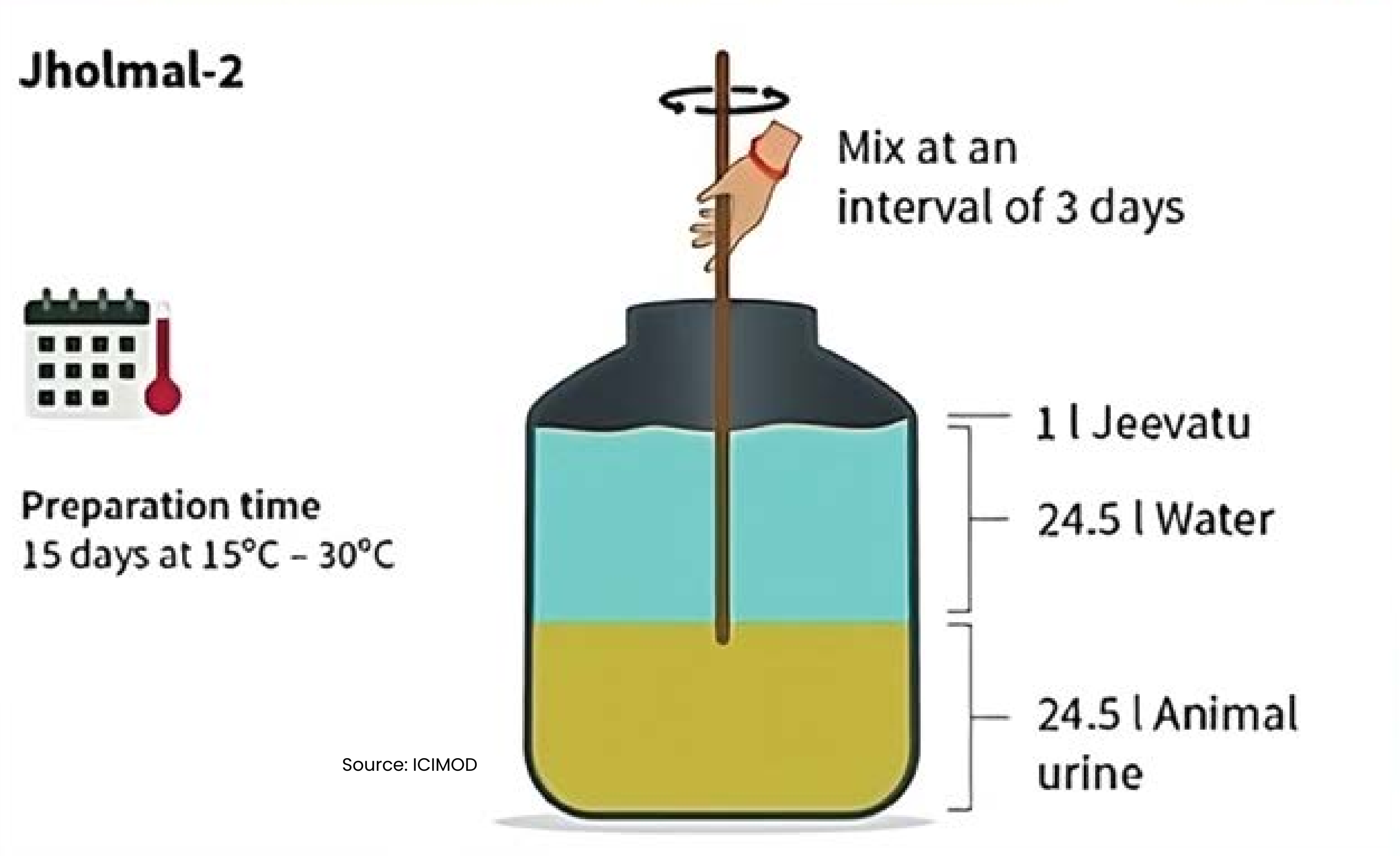
Bio-fertilizers are made from living microbes such as Azotobacter, Rhizobium, Clostridium, Trichoderma that boost plant growth by enhancing nutrient uptake from the soil.

Source: Google



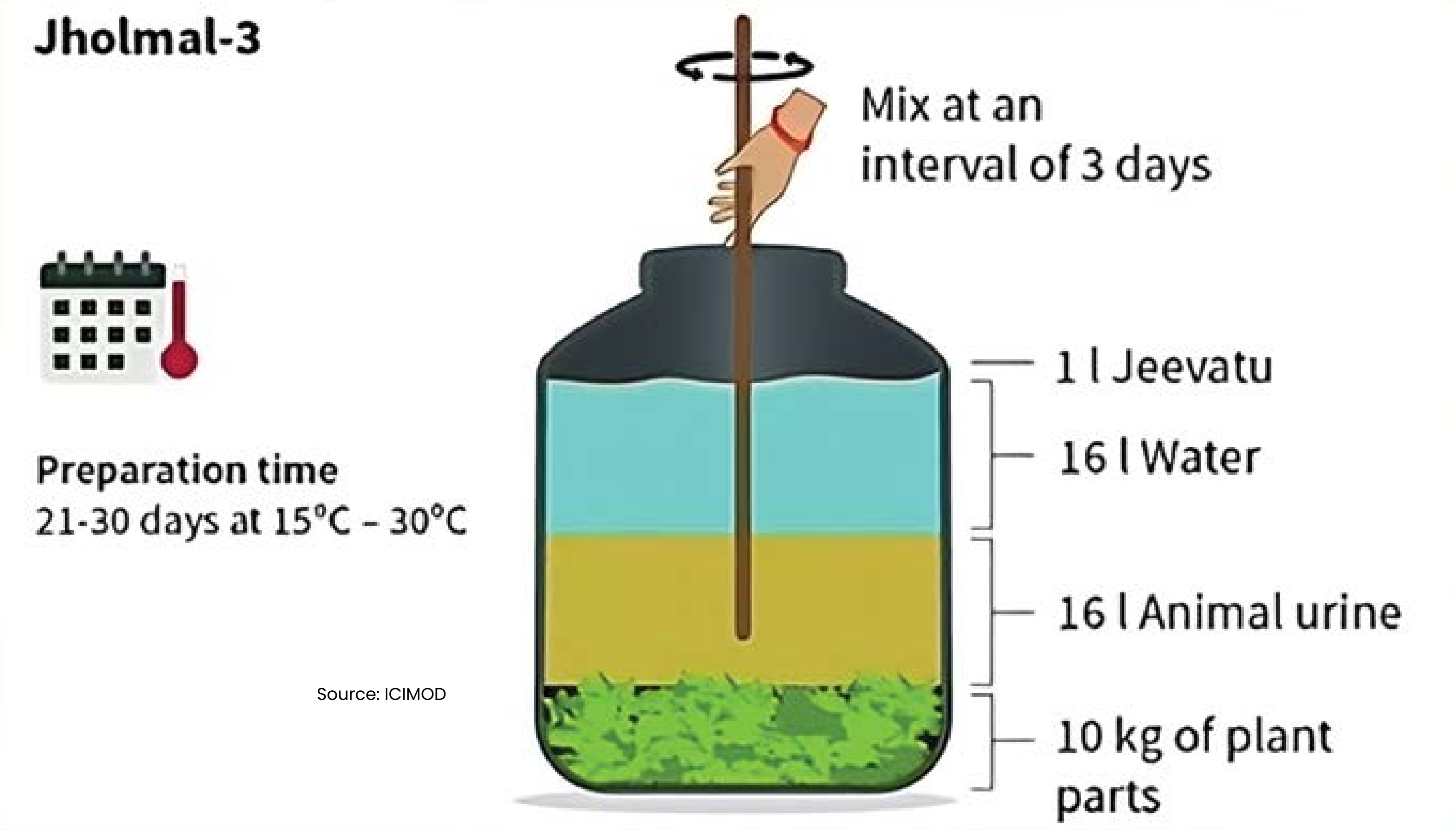

**Jholmol-1**

Bio-fertilizers are made from living microbes such as Azotobacter, Rhizobium, Clostridium, Trichoderma that boost plant growth by enhancing nutrient uptake from the soil.




**Jholmol-2**

Jholmol-2, made by mixing cow urine and water in a 1:1 ratio with 1 liter of Jeevatu/EM added to 50 liters of the mixture is applied at a 1:3 ratio with water to enhance soil health and boost plant immunity.




**Jholmol-3**

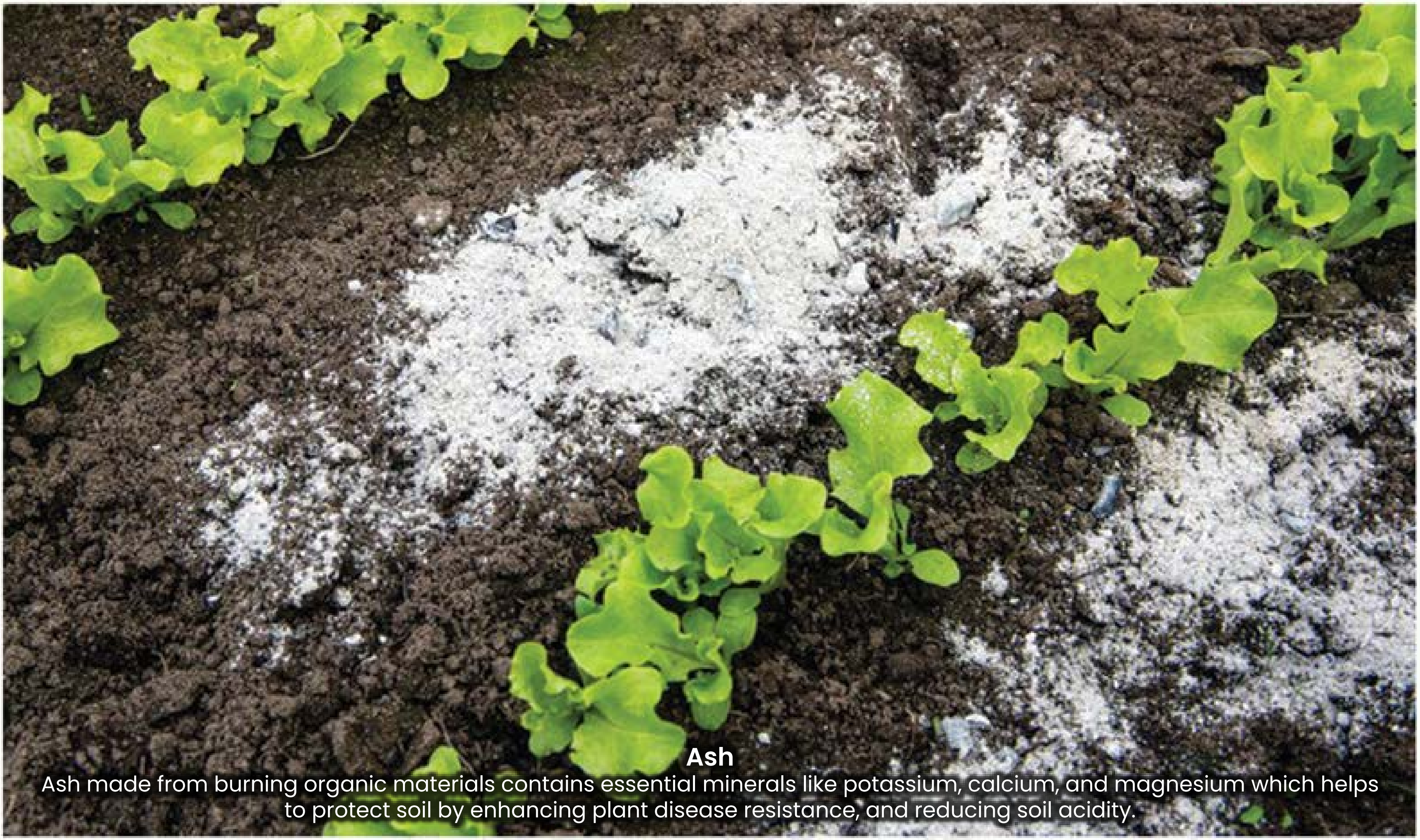
Jholmol-3, made by mixing plant insecticides, cow urine, and water in a 1:2:2 ratio with 1 liter of Jeevatu/EM added to 50 liters of the mixture is applied at a 1:5 ratio for seedlings and 1:3 for month-old crops, serving as both bio-fertilizer and bio-pesticide.

## 2.4 Others

## Bio char

Biochar, produced by thermal decomposition of organic material in the absence of oxygen at over 300°C, enhances soil fertility, increases water-holding capacity, reduces soil acidity, and helps mitigate climate change by lowering greenhouse gas emissions.

Source: Google



**Ash**

Ash made from burning organic materials contains essential minerals like potassium, calcium, and magnesium which helps to protect soil by enhancing plant disease resistance, and reducing soil acidity.

Source: Google

# 3. Pest Management

## 3.1 Mechanical traps use

Mechanical traps offer an effective, chemical-free approach to pest control in crop fields. These traps physically capture or deter pests, using methods like sticky surfaces, barriers, or attractants. By preventing pests from reaching or damaging crops, mechanical traps help manage pest populations and reduce the reliance on chemical pesticides, promoting sustainable agricultural practices.

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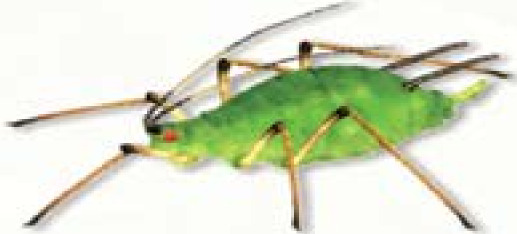

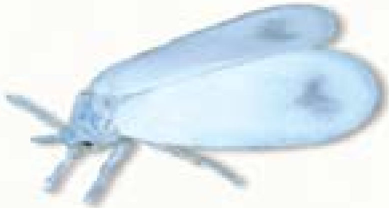

## Yellow sticky trap

Yellow sticky traps are used to capture small flying insects like aphids, whiteflies, and fruit flies. Install 7-10 traps per ropani at plant canopy height or slightly above, and replace them regularly when full for effective pest control.

Source: ANSAB

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## Blue sticky trap

Blue sticky traps are effective for capturing thrips. Install 7-10 traps per ropani at 1.5 m above the ground and replace them regularly when full to ensure effective pest control.

Source: ANSAB

## Light trap

Light traps use UV light to attract and capture nocturnal pests like moths and beetles. Hang 1-2 traps per ropani, 1-2 m above the ground, to reduce their population in the crop field.

Source: ANSAB


Source: ANSAB

## Pitfall trap

Pitfall traps capture ground-dwelling insects and flightless arthropods. Bury 5-6 small containers with bait in the soil where insect activity is high, and check them regularly to remove captured pests and refresh the bait.

**Note:**
» Regularly monitor traps to protect beneficial insects from being trapped.
» Use these trap mostly in spring and summer season due to increased insect activity, and year round in regions with mild climates.

## 3.2 Pheromone traps use

Pheromone traps utilize synthetic chemicals that generates natural insect pheromones to attract pests. These traps are designed to lure insects, often males to a sticky surface or trapping mechanism where they are captured. By attracting and capturing pests, these devices help monitor pest populations and control infestations, making them a valuable tool for effective pest management in agricultural fields.

## Cue lure

Cue lure is used control fruit flies in cucurbits, place 5-7 traps per ropani at 1.5 m height above the ground before flowering to monitor and manage infestations effectively.

Source: Google



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**Methyl eugenol**

Methyl eugenol is used to control fruit flies in crops like citrus and mango, place 5-7 traps per ropani at 1.5-2 m height one week before flowering to effectively monitor and manage populations.

Source: Google

## Bactrocera compositae

Bactrocera compositae is used to control fruit flies in cucurbits and fruits, place 5-7 traps per ropani at 1.5-2 m height before flowering begins to effectively monitor and control infestations.

Source: ANSAB

Source: ANSAB

## Tomato leaf minor lure

Tomato leaf miner lure is used to control tomato leaf miners, place 4-5 traps per ropani at 20-60 cm height before transplantation to effectively attract and manage these pests.


**Spodo lure**

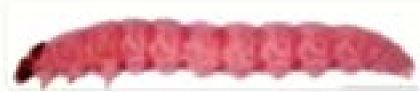
Spodo lure is used to control tobacco caterpillar and army worms in crucifers, tomatoes and potatoes, place 4-5 traps per ropani at above 30 cm height before transplantation to effectively attract and manage these pests.

Source: ANSAB


## Lucinodes lure

Lucinodes lure is used to control fruit and stem borer in eggplant, place 4-5 traps per ropani at 30-40 cm height in 15-20 days after transplantation to effectively attract and manage these pests.

Source: ANSAB

**PTM (Potato Tuber Moth) 1, 2 lure**

PTM 1, 2 lure is used to control potato tuber moth, place 4-5 traps per ropani at plant canopy height or slightly above when tubers begin to form or at least 60 days prior to harvest to effectively attract and manage these pests.

Source: ANSAB

## DBM (Diamond Black Moth)/Protula lure

DBM/Protula lure is used to control diamond black moth in crucifers, place 4-5 traps per ropani at plant canopy height or slightly above before planting to effectively attract and manage these pests.

Source: ANSAB


## Heli lure

Heli lure is used to control tomato fruit borer in crops like tomato, chickpea, and pigeon pea, place 4-5 traps per ropani at plant canopy height or slightly above during flowering stage to effectively monitor and manage these pests.

**Note:**
» Regularly monitor traps to protect beneficial insects from being trapped.
» Use these trap mostly in spring and summer season due to increased insect activity, and year round in regions with mild climates.

Source: ANSAB

## 4. Optimizing resources by micro climatic modification

Microclimatic modification involves altering the local climatic conditions within a specific area to improve crop growth and productivity. This method helps to regulate temperature, humidity, and light levels around crops, thus enhancing plant health, reducing stress from extreme weather, and improving overall agricultural outcomes, by creating a more favorable environment.


**Customized iron structured tunnel**

Customized iron structure tunnels provide a cost-efficient and durable solution, reducing expenses by two-third while offering long-lasting agricultural benefits.

Source: ANSAB



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**Vertical farming inside of tunnel**

Vertical farming maximizes productivity and income by stacking crop layers vertically, optimizing land use and enhancing yield per square meter.

Source: Google

**Appropriate crop choice inside the tunnel**

For optimal crop production, choose short-duration crops for quick yields under 60 days and indeterminate varieties for multiple harvests to enhance overall productivity.

Source: ANSAB



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**Efficient crop cycle inside the tunnel**

Optimize crop cycles by using tunnel crop calendars to select suitable vegetables and schedule planting, optimizing space and time for enhanced productivity.

Source: ANSAB

## Disposal of non-degradable materials

Disposing of non-degradable materials, such as certain types of traps and plastics used in agriculture, is vital to minimizing environmental impact and promoting sustainability. Proper disposal practices help prevent pollution, safeguard ecosystems, and contribute to overall environmental health. By following the right guidelines, we can ensure these materials are managed responsibly.

1. **Disposal of Different Types of Traps:**
   - **Single-use traps:** Seal and dispose of household trash. For example, sticky traps are designed for one-time use and should be properly contained before disposal.
   - **Reusable traps:** Clean according to the manufacturer's instructions. Wash with soapy water and reset with new attractants. This applies to traps like delta traps which can be used multiple times.
   - **Chemical-based traps:** Dispose of safely following the manufacturer's instructions. This includes traps such as pheromone traps and chemical bait traps, which require careful handling to ensure environmental safety.

2. **Disposal of Plastics Used in Agricultural Tunnels:**
   - **Recycling:** Collect and send plastic films to recycling facilities. Ensure the material is clean and free from soil, plant debris, or chemicals to facilitate the recycling process.
   - **Reuse:** If the plastic is in good condition, consider reusing it for the next growing season or for other purposes, such as weed control mats or temporary protective covers.
   - **Proper Disposal:** For non-recyclable plastics or those contaminated with chemicals, follow local regulations for hazardous waste disposal. Do not burn or bury these plastics to avoid releasing toxic substances into the environment.
   - **Adoption of Biodegradable Plastics:** Consider using biodegradable alternatives that break down more quickly and reduce the volume of non-degradable waste, minimizing environmental impact.

## References


1 Soil Cement Pond (Ansab image)

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