

TURNING WASTE INTO WEALTH: THE POTENTIAL OF FERMENTED ORGANIC MANURE IN SUSTAINABLE AGRICULTURE

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Introduction

The extensive use of chemical fertilizers in modern agriculture has led to a decline in soil fertility in India, making the soil increasingly acidic and posing a significant threat to the long-term sustainability of Indian agriculture. This situation endangers both the environment and the livelihoods of farmers. Excessive application of inorganic fertilizers has also resulted in severe environmental and health concerns, including soil erosion, pesticide toxicity, water pollution, depletion of groundwater levels, waterlogging, and loss of biodiversity. To mitigate the adverse effects of chemical fertilizers on soil health, the use of organic manure is strongly recommended. Organic amendments enhance the soil's physicochemical properties, maintain soil quality, and improve crop productivity. Soil quality encompasses both fertility and biological activity, which are closely interconnected, as the mineralization of essential organic nutrients depends on microbial biomass transformation. The increased fertilizer input and intensive land use result in multiple environmental problems, including the pollution in the watersheds caused by nitrogen (N) loss.

Carbohydrates, fiber, and proteins decompose most efficiently under specific pH levels and retention times. By optimizing environmental conditions based on the stage of decomposition, the breakdown of waste can be enhanced and accelerated. One effective approach to addressing this issue is anaerobic fermentation of manure and its effluents, followed by their application as fertilizers. The use of fresh manure is associated with certain agrotechnical difficulties, which leads not only to the contamination of cultivated areas with weed seeds but also carries the risk of environmental pollution.

To eliminate the negative phenomena discussed, a special technology of manure treatment is needed, which allows for increasing the concentration of nutrients, eliminating unpleasant odors, suppressing pathogenic microorganisms, and reducing the content of carcinogenic substances. There is need producing high-value organic fertilizers/manure through fermentation in a bioreactor, resulting in a natural biofertilizer rich in biologically active compounds and trace elements. Compared to traditional fertilizers such as manure and litter, biofertilizers offer several advantages in terms of nutrient availability, balanced composition, and a higher degree of humification of organic matter. These fertilizers/manures contain easily degradable organic nutrients that support microbial decomposition, enhance soil fertility and structure, and contribute to ecosystem stability. This holistic approach not only addresses climate change and soil degradation but also contributes to a more resilient and equitable agricultural system for the future. Additionally, they have high moisture content and a well-balanced mix of macro- and microelements that plants gradually release and absorb. Raw manure, a common farm waste, often becomes an environmental issue as it is typically left in piles, leading to water and air contamination and contributing to global warming. Despite the large volume of livestock feces, it holds significant potential for use as organic fertilizer/manure, supporting sustainable organic farming with higher export opportunities. A cow produces approximately 23.6 kg of solid feces per day, and with most farmers owning 6 to 7 cows, an individual farmer generates around 141.6 kg of feces daily or 4,248 kg per month. However, many farmers still rely on costly inorganic fertilizers such as urea. While raw manure can naturally decompose into organic fertilizer, this process is slow. When composted in a loosely folded black plastic bag at room temperature during summer, it takes about 16 weeks to fully break down.

The composting process can be accelerated to 2–3 weeks by adding activators or decomposers. Certain animal waste, including cow, goat, rabbit, chicken and quail feces, contains beneficial decomposing microorganisms known as Indigenous Micro-Organisms (IMO), which can enhance the breakdown of manure efficiently. Raw manure contains essential nutrients such as nitrogen, phosphorus, potassium, and water, with varying compositions depending on the animal source. Rabbit feces are rich in nitrogen and phosphorus, goat feces have higher potassium levels, while cow feces contain more water. Manure serves as a natural food source for microbes, fostering their growth and activity. It contains beneficial microorganisms such as *Nitrosococcus* sp., *Pseudomonas striata*, *Nitrosomonas* sp., *Mycorrhiza*, *Pseudomonas fluorescens*, *Streptomyces*, and *Trichoderma* sp.. Additionally, Indigenous Micro-Organisms (IMO) present in manure include *Rhizobium* sp., *Azospirillum* sp., *Azotobacter* sp., *Pseudomonas* sp., *Bacillus* sp., and phosphate-solubilizing bacteria. Preliminary studies on IMO have also detected lactic acid bacteria, along with other beneficial bacteria and fungi. Composting cow manure with IMO for 21 days produces organic fertilizer with a higher nitrogen content. Compared to inorganic fertilizers, organic fertilizers provide superior plant nutrition, improving soil fertility and boosting crop yields.

Steps for Preparation of FOM at farm

1. Collection and Mixing:- Collect the organic material (cow dung, crop residue, etc.) and place it on a clean surface.

- Dissolve jaggery in water and mix it with the cow urine. Add the EM solution.

2. Layering: Spread a layer of organic material (10-15 cm thick).

- Sprinkle the prepared microbial mixture on the layer to inoculate it with beneficial microbes.

3. Moisture Control: Ensure the mixture is moist but not waterlogged (about 60% moisture).

- Cover the pile with a jute sack or plastic sheet to retain moisture and protect it from direct sunlight or rain.

4. Fermentation Process: Leave the mixture for 15–30 days. Turn it every 5–7 days to uniform fermentation and aeration.

- The temperature will rise initially, indicating microbial activity. It will gradually stabilize as the process nears completion.

5. Completion: The manure is ready when it turns dark brown, has a crumbly texture, and emits a pleasant earthy smell.

Preparation of FOM at large scale (CBG):

- The leftover rice straw is collected for further processing instead of being burned.
- Rice straw undergoes pre-treatment to break down its structure and improve its usability for digestion.
- The pre-treated rice straw is fed into a biogas plant, where it undergoes anaerobic digestion to produce biogas (methane-rich gas).
- The byproduct of anaerobic digestion is digestate, which is a nutrient-rich material.
- Digestate can be further processed into fermented organic manure for improved agricultural productivity.
- The organic manure is applied to fields, completing the cycle by enhancing soil fertility for the next round of rice cultivation.



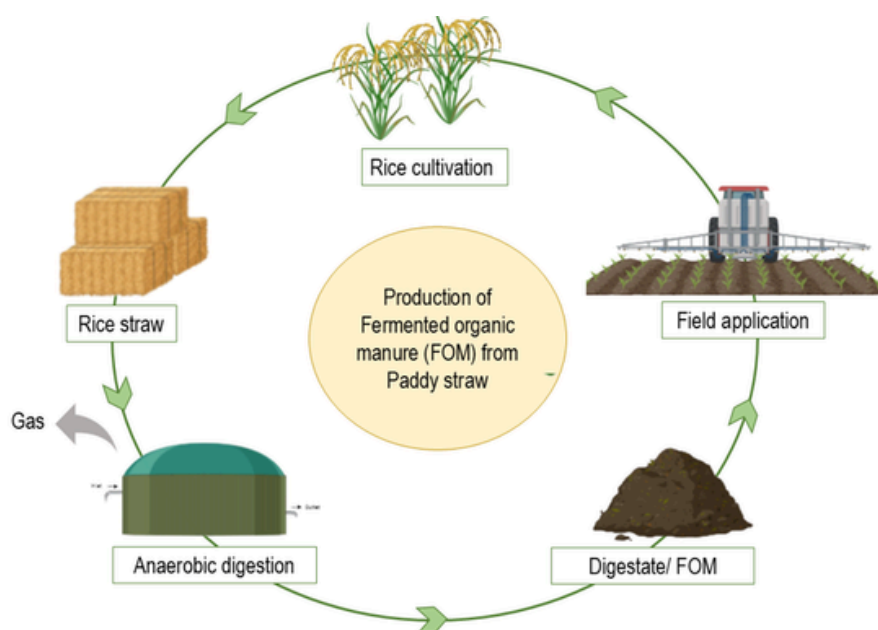
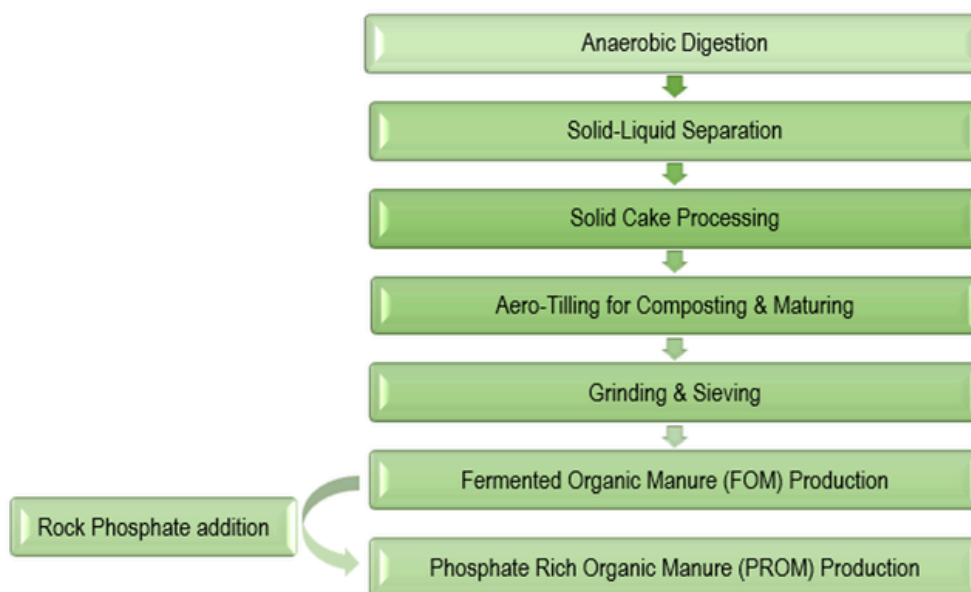


Figure 1. Diagrammatic representation of production process for preparation of FOM at large scale (CBG):



Flow chart 1. Production process outline of FOM/ LFOM/ PROM

- **Anaerobic Digestion:** Organic material undergoes anaerobic digestion in a biogas plant, producing slurry as a byproduct.
- **Solid-Liquid Separation (SLS):** The slurry is separated into liquid (used for LFOM) and solid cake (used for FOM & PROM production).
- **Solid Cake Processing:** The solid cake undergoes windrow formation and microbial culture addition to initiate composting.
- **Aero-Tilling for Composting & Maturing:** The composting process is accelerated using aero tilling, which ensures proper aeration for microbial activity.
- **Grinding & Sieving:** The matured compost is subjected to hammer milling/grinding to reduce the particle size. The material is then sieved to <4mm for uniform texture.
- **Fermented Organic Manure (FOM) Production:** The sieved material is bagged and packed as FOM (Fermented Organic Manure).
- **Phosphate Rich Organic Manure (PROM) Production:** Rock phosphate is added to the sieved material, followed by pelletization to create PROM

Table 1: FOM specifications

Particulars Particle	Content	Heavy metals	Maximum Quantity (mg/kg)
Moisture percent by weight	30-70%	Arsenic	10
NPK nutrients should not be less than	1.20%	Cadmium	5
Total Organic carbon (minimum)	14%	Chromium	50
C:N ratio	30:1	Copper	300
Particle size	Minimum 90% material should	Mercury	0.15
pH	6.5-8.4	Nickel	50
Pathogens	NIL	Lead	100
Conductivity (as dS/m) not more than	4	Zinc	1000

Initiatives of Government of India: Government is implementing dedicated schemes for promotion of organic farming in the country viz. Paramparagat Krishi Vikas Yojana (PKVY) and Mission Organic Value Chain Development in North East Region (MOVCDNER) since 2015-16. Under these schemes, farmers are encouraged to take up organic cultivation using organic inputs and the schemes provide end to end support to farmers' i.e. from production to marketing of organic produce. Hands-on training to farmers about on-farm production of organic fertilizers and its use are integral part of these schemes. In order to promote the use of bio-fertilizers, ICAR has developed improved and efficient strains of bio-fertilizers specific to different crops and soil types. Liquid Bio-fertilizer technology with higher shelf-life has also been developed.

Benefits of Fermented Organic Manure

- Improves soil structure and fertility
- Enhances microbial activity in the soil
- Boosts plant immunity and growth
- Reduces dependency on chemical fertilizers

Conclusion

The excessive use of chemical fertilizers in agriculture has led to soil degradation, environmental pollution, and health risks, threatening the sustainability of farming. Organic amendments, particularly biofertilizers, manures produced through fermentation, offer a viable alternative by enhancing soil fertility, improving microbial activity, and ensuring balanced nutrient availability. Anaerobic fermentation and the use of Indigenous Micro-Organisms (IMO) accelerate the decomposition process, making organic manures more efficient and eco-friendly. Utilizing manure effectively through composting and fermentation can help mitigate pollution, reduce dependency on inorganic fertilizers, and promote sustainable agriculture. Transitioning to organic biofertilizers is crucial for preserving soil health, improving crop productivity, and ensuring long-term environmental stability.

