

White Paper

FOM Feeds Soil, Soil Feeds Sustainability!

Decentralized Energy Solution for establishing a Circular Economy



“ Organic is the soul of our soil, and it is our responsibility to nurture it. ”

— Dr. A. R. Shukla

KEY HIGHLIGHTS



India's soils are losing their fertility, SOC levels have declined to 0.3%



What if we stop feeding crops and start feeding the soil?



FOM from biogas plants turns waste into soil nutrition



A small shift in approach can lead to big outcomes: healthier soil, better yields, and reduced input costs



Backed by the 2025 Fertilizer Control Order (FCO) reform



Designed for farmers, policymakers, and the industry together



Unlocks a circular economy for agriculture

Executive Summary

Fermented Organic Manure (FOM) derived from Biogas plants presents a scalable solution to address the widespread depletion of soil organic carbon (SOC) in India. This white paper evaluates the role of FOM in restoring SOC levels by analysing its composition, soil-interaction mechanisms, and field-level application practices across different states of India.

Findings indicate that sustained application of FOM improves soil carbon content, enhances water retention, and supports microbial activity, thereby contributing to long-term soil fertility. The paper further examines policy alignment, including recent amendments to the Fertilizer Control Order (FCO, 2025), and proposes integration of FOM into subsidy frameworks and national programmes. Leveraging FOM not only supports circular bioeconomy and waste valorization but also strengthens India's climate resilience and sustainable agriculture goals.

Keywords: Agriculture, Biogas, Fermented Organic Manure, Waste management, Soil Organic Carbon.

Introduction

As India advances its commitment to sustainable energy and agriculture, significant emphasis is being placed on developing Compressed Biogas (CBG) and biogas plants that utilize multiple feedstocks, such as agricultural residue, cattle dung, and press mud. These plants not only produce clean energy but also generate valuable by-products like Fermented Organic Manure (FOM) & Liquid Fermented Organic Manure (LFOM) derived from the biomass after CBG production. The nutrient rich FOM and liquid fermented organic manure (LFOM) offer a potent solution to India's widespread problem of soil organic carbon (SOC) deficiency.

Over the past seven decades, Soil Organic Carbon (SOC) levels in India have declined sharply from around **1% to nearly 0.3%**, highlighting a serious concern for the sustainability of the agriculture sector. This significant depletion is largely attributed to intensive farming practices, excessive reliance on chemical fertilizers, and inadequate recycling of organic residues. The continuous loss of organic carbon has weakened soil structure, reduced water retention capacity, and accelerated processes of land degradation and desertification, particularly in arid and semi-arid regions.

In this, the integration of CBG plants into the agricultural ecosystem creates a circular economy, where digestate from multiple feedstocks is converted through fermentation into organic carbon enhancers. Unlike conventional fertilizers that primarily feed crops, Fermented Organic Manure (FOM) functions by feeding the soil ecosystem itself, enhancing microbial activity, improving soil structure, and rebuilding organic carbon reserves. This soil-first approach enables sustained nutrient availability and long-term agricultural productivity.

Current estimates based on the GOBARdhan portal indicate that commissioned CBG plants in India can generate **over 2,000 tonnes per day (TPD) of Fermented Organic Manure (FOM)**, underscoring its substantial potential to support soil organic carbon restoration at scale as the sector continues to expand. However, the maximal levels must be prioritized along with capacity building and aware-

-ness programs among farmers. This synergy between renewable energy generation and sustainable soil management aligns with India’s broader goals of reducing chemical fertilizer dependency, improving farm incomes, and achieving environmental sustainability.

Policy & Regulatory Framework

The Fertilizer Control Order (FCO), issued under the Essential Commodities Act, establishes the quality standards and specifications for fertilizers marketed in India, including organic inputs such as Fermented Organic Manure (FOM).

In a significant policy development, the Ministry of Agriculture and Farmers’ Welfare amended the FCO on February, 2025, introducing Schedule VIII – Organic Carbon Enhancers, under which FOM and LFOM have been formally defined and standardized. This marks a critical step toward mainstreaming organic carbon based inputs in Indian agriculture.

According to the FCO guidelines, FOM must comply with the following specifications:

Parameter	Specification/Limit
Moisture (% by weight, maximum)	30–70%
Total Organic Carbon (minimum)	12-14%
C: N Ratio	<20
Practical Size	Minimum 90% material should pass through the 4.0 mm IS Sieve
pH	6.5–8.0
Pathogens	NIL
Conductivity (as dS/m, not more than)	4
Heavy Metal Content (maximum, mg/kg):	
- Arsenic (as As ₂ O ₃)	10
- Cadmium (as Cd)	5
- Copper (as Cu)	50
- Chromium (as Cr)	300
- Mercury (as Hg)	0.15
- Nickel (as Ni)	50
- Lead (as Pb)	100
- Zinc (as Zn)	1000

Table 1 - FCO guideline for FOM

Status Quo of Soil Health in India

Soil health assessment across India reveals widespread deficiencies in organic carbon and essen-

tial nutrients critical for sustainable crop production. The Soil Health Card (SHC) scheme of the Union Ministry of Agriculture and Farmers Welfare tested a total of 90,80,251 Soil Samples collected between 2025-26, indicating that approximately 54% Of soil samples are deficient in organic carbon and 28% of soil sample has medium in organic carbon, with 24 states and Union territories having at least half of their tested soils below adequate organic carbon levels.

Soil organic carbon (SOC) level

SOC Level (%)	Soil Health Category	Interpretation
> 1.0%	Healthy	Indicates good soil structure, adequate organic matter, and strong microbial activity
0.5% – 1.0%	Moderate	Moderate depletion of organic carbon and water retention
< 0.5%	Critical	0.5% SOC is the minimum threshold; below this indicates poor soil health.

Table 2 - SOC levels

The widespread decline in SOC across Indian soils highlights the urgent need for targeted interventions to restore organic carbon levels. Assessing SOC deficits at a state-wise level provides a scientific basis for determining the quantity of organic inputs required to achieve sustainable soil health benchmarks and improve long-term agricultural productivity.

Organic soil amendments play a crucial role in rebuilding soil carbon stocks. Their application supports the formation of stable organic matter, which enhances soil functionality over time. In this context, Fermented Organic Manure (FOM) serves as an effective input by contributing to improved soil structure, increased water-holding capacity, enhanced microbial activity, and better nutrient buffering.

In addition, FOM introduces humic substances that strengthen soil fertility and resilience. Being derived from organic waste streams, it is non-toxic to soil microorganisms, relatively easy to handle, and can be produced at scale, making it a practical and sustainable solution for soil carbon restoration.

Methodology

The data on state-wise soil organic carbon (SOC) deficiency were compiled based on the Soil Health Card dataset representing the standard topsoil layer (0–15 cm) considered under the SHC framework. The analysis used SOC deficiency thresholds based on a strong recommendation of a minimum 0.5%, abysmally 1%, and a healthy level above 1% organic carbon content for healthy soils. SOC deficiency was calculated as the difference between the recommended (below 0.5%/1% /above 1%) and the observed SOC value for each state or Union Territory ¹.

The deficiency percentage was then translated into the amount of organic carbon (kg/ha) required to achieve the recommended level using the formula:

Organic Carbon Deficiency(kg/ha)=

$$\frac{\text{SOC Deficiency (\% in different states/UT's)}}{100} \times 1,95,000$$

¹ Note: Actual SOC sequestration may vary depending on soil type, climatic conditions, and microbial activity.

where 1,950,000 kg/ha represents the soil mass of the top 15 cm layer per hectare, accounting for typical bulk density and soil depth.

To estimate the amount of fermented organic manure (FOM) required (in tonnes per hectare) to meet the organic carbon deficit, the available organic carbon content in FOM was used as a divisor.

This calculation assumes direct proportionality between carbon content in FOM and soil organic carbon replenishment. And the application practice is done on a multiple crop cycle basis, not on a single application.

State-wise Soil Organic Carbon (SOC) Status in India

Soil organic carbon is a critical indicator of soil fertility, water retention capacity, and agricultural productivity. However, due to intensive farming, excessive use of chemical fertilizers, and land degradation, many states in India are experiencing a decline in SOC levels, threatening long-term soil health and crop sustainability.

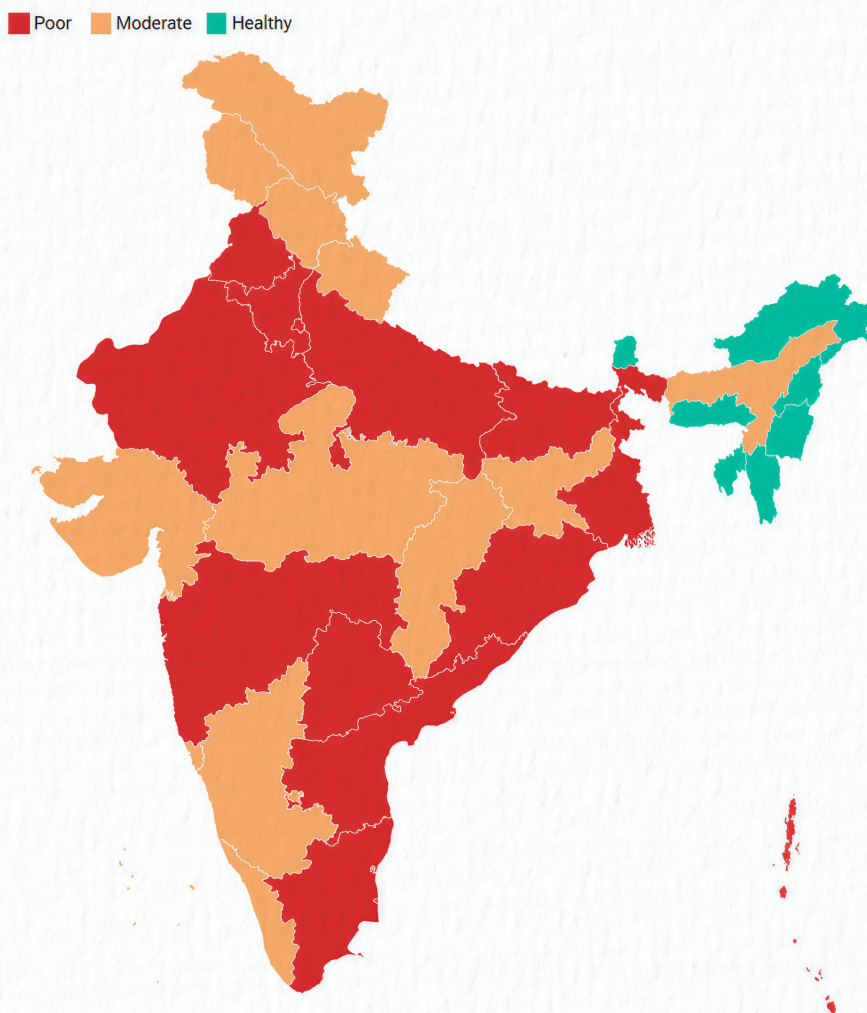


Figure 1. Soil Organic Carbon status in the Indian States/UT's

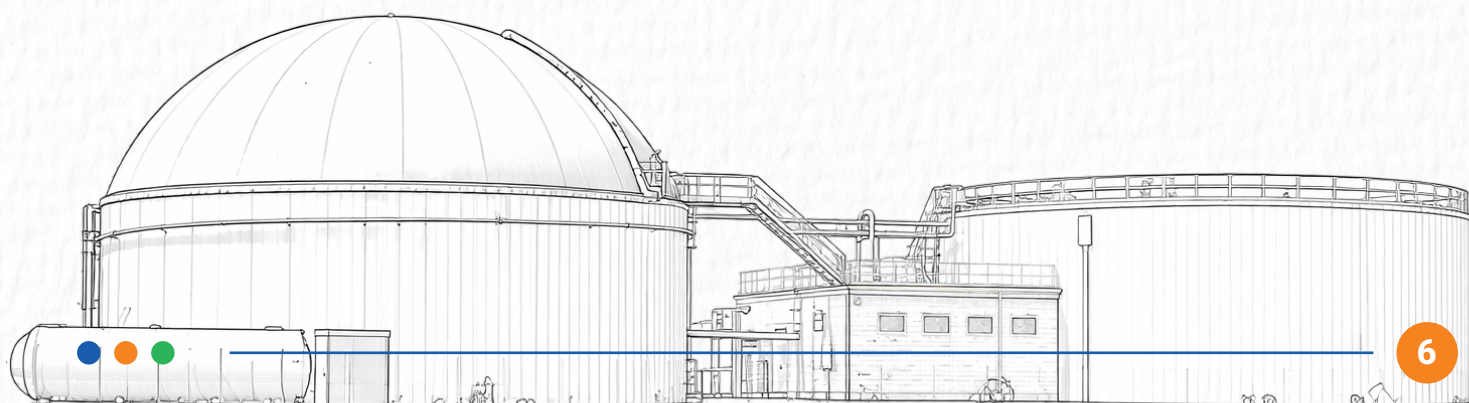


Figure 1 presents a heat map of average soil organic carbon (SOC) levels across Indian states, categorized as Healthy, Moderate, and Poor. The map clearly shows that many northern and north-western states, such as Punjab, Haryana, Rajasthan, and Uttar Pradesh, fall into the critically low category, indicating severe soil degradation.

Several other regions fall in the deficient range, while only a few areas mainly in parts of the northeast show healthy SOC levels. Overall, the heat map highlights widespread low organic carbon levels across the country and the need for improved soil management through organic inputs like FOM.

The application practice is done on a multiple crop cycle basis, not on a single application. As mentioned in Table 3.

Application of FOM

Fermented organic manure (FOM) is valued for its high organic carbon content, which is crucial for enhancing soil health, stimulating microbial activity, and improving crop productivity.

Priority for FOM application should focus on states with documented SOC deficiency such as Rajasthan, Andhra Pradesh, Haryana, Punjab, Uttar Pradesh, Odisha, West Bengal, Maharashtra, Jharkhand, Puducherry, Telangana, and Tamil Nadu. These states face critical SOC levels below 0.5%, necessitating urgent intervention to sustain soil fertility and crop productivity.

No. of State/UT	SOC- level	SOC Level- Poor/Moderate /Good	FOM Required for above 1% to reach 1.5% SOC (t/ha)	FOM Required for 1.0% SOC (t/ha)	FOM Required for 0.5% SOC (t/ha)
14 States/ UT's*	Below 0.5%	Poor	154.76	85.1	15.5
13 States/ UT's**	0.5-1%	Moderate	100.93	31.3	-
7 States/ UT's***	1% Above	Good	31.34	-	-

*Rajasthan, Haryana, Odisha, Punjab, Uttar Pradesh, Puducherry, Telangana, Tamil Nadu, Andhra Pradesh, Jharkhand, Maharashtra, A&N Islands, Bihar, West Bengal

**Chhattisgarh, Daman & Diu, Lakshadweep, Goa, D&N Haveli, Gujarat, Jammu & Kashmir, Himachal Pradesh, Madhya Pradesh, Uttarakhand, Assam, Karnataka, Kerala

***Tripura, Sikkim, Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh

Table 3 - State/UT-wise Soil Organic Carbon Status and Fermented Organic Manure (FOM) Requirement for Soil Organic Carbon Restoration

- For soils with SOC < 0.5% carbon-deficient states, apply 5–6 tons/ha/year of FOM.
- For SOC between 0.5–1.0%, the Carbon Equivalent state apply 3–4 tons/ha/year.
- For SOC above 1.5%, apply 2 tons/ha/year.

Adjust application based on C: N content of the FOM batch and crop nutrient demand.

The application can be done based on the crop cycle at the time of field preparation. For reaching the level of 1% and above 1% SOC.

Crop Rotation System	Crops Cultivated	Region / State Examples	FOM Application
Cereal-Cereal Rotation	Rice-Rice, Rice-Wheat, Maize-Wheat	Punjab, Haryana, West Bengal	5 TONNES
Cereal-Legume Rotation	Wheat-Chickpea, Rice-Pigeon pea, Maize-Mung bean	Tamil Nadu, Odisha, Gujarat	4 TONNES
Cereal-Cash Crop Rotation	Wheat-Cotton, Maize-Sugarcane, Rice-Groundnut	Maharashtra, Karnataka	5 TONNES
Short-term Rotations	Maize-Potato-Tobacco, Sorghum-Berseem	Rajasthan, Madhya Pradesh	2 TONNES
Multi-year Rotations	Cotton-Fenugreek-Sorghum Wheat, Paddy-Pulse-Sugarcane	Central India, Telangana	4 TONNES
Inclusion of Green Manure	Sesbania, Crotalaria before Rice	Eastern states like West Bengal, Assam	2 TONNES
Pulse-Based Rotations	Pigeon pea-Maize, Chickpea-Wheat	Rajasthan, Haryana, Uttar Pradesh	3 TONNES
Oilseed Crop Rotations	Mustard-Wheat, Groundnut-Maize	Rajasthan, Gujarat	5 TONNES

Table 4 - Crop rotation-wise FOM Application

Economic Feasibility and Farmer Incentives

The widespread use of Fermented Organic Manure (FOM) depends on how cost effective it is for farmers. FOM is a locally available organic input that is cheaper than traditional fertilizers, especially now that the cost of inputs in Indian agriculture is going up.

Farmers can use FOM to make the soil's organic carbon better, make better use of nutrients, and hold more water, which can help them use less chemical fertilizers over time. These changes help lower the costs of fertilizers and irrigation, and they also help keep crop yields stable over time. The benefits of FOM are slow to show up, but they lead to long-term improvements in soil productivity and farm resilience.

From a market standpoint, the presence of FOM as an organic amendment facilitates the creation of localized supply chains, encompassing aggregation, storage, and distribution systems. Making these systems

stronger can make them easier to use and make sure that farmers can get what they need on time.

Support from policymakers will be crucial for speeding up adoption. Adding FOM to current programs like soil health programs and nutrient-based subsidy frameworks can make them more affordable and encourage more people to use them. Also, campaigns to raise awareness, demonstration projects, and extension support are all important for building farmers' confidence and encouraging smart use of technology.

FOM can be a good and long-lasting way to improve soil health and boost long-term agricultural productivity if it is supported by a system of affordability, accessibility, and policy.

Challenges & Limitations

Fermented Organic Manure (FOM) has a lot of potential to improve soil health and bring back organic carbon, but it is still not widely used

because of several practical problems:

1. **Low Awareness:** A majority of farmers don't know how to use FOM correctly or how it can help them. They often choose chemical fertilizers because they work quickly.

2. **Concerns about quality:** Farmers are hesitant because the quality of FOM can change depending on the feedstocks used and there is no standard testing.

3. **Transportation and Accessibility:** The fact that the transportation system isn't very good makes them harder to get, especially for small farmers.

4. **Weak Supply Chain:** Regular access is hard because there aren't any established market networks for storage, distribution, and sales.

5. **Limited Policy Support:** Right now, subsidies and financial incentives favor chemical fertilizers, which makes FOM less appealing.

6. **Gradual Soil Impact:** Farmers who want quick results are less likely to use it because the effects on soil health are slow to show.

7. **No Usage Guidelines:** Without clear, localized instructions for use, people use it in different ways and not in the best way.

Recommendation

To unlock the full potential of Fermented Organic Manure (FOM) in transforming India's soil health, its promotion must be strategically

embedded within flagship government initiatives such as the Nutrient-Based Subsidy (NBS) framework, Soil Health Card (SHC) scheme, and Paramparagat Krishi Vikas Yojana (PKVY). Recognizing FOM as a qualified and subsidized input particularly through the inclusion of **organic carbon as a nutrient parameter within the NBS framework** will enable balanced fertilization, reduce excessive reliance on chemical fertilizers, and restore soil vitality.

Additionally, promoting integrated nutrient management practices such as blending organic and inorganic fertilizers can optimize nutrient use efficiency and improve soil health outcomes. Support for research and development through institutions like Indian Council of Agricultural Research and State Agricultural Universities will be crucial for developing region-specific application protocols and improving FOM formulations.

A coordinated institutional approach, supported by policy alignment, capacity building, and stakeholder engagement, is essential to position FOM as a mainstream input in India's agricultural system. This foundation sets the stage for a dedicated national programme to scale and sustain these efforts.

Introduction of SuBiCulP: A National Programme

Building on policy recommendations proposed by the Indian Biogas Association (IBA), there is a strong case for launching an umbrella scheme



that is **SuBiCulP (Sustainable Biogas–Organic Fertilizer Based Cultivation Programme)** under the vision of “SuBiCulP se Samridhi”. This programme can serve as a national platform to integrate renewable energy generation with sustainable agriculture by ensuring 100% offtake and utilization of Fermented Organic Manure (FOM) produced from biogas and CBG plants of all capacities.

Positioning SuBiCulP as a “**National Soil Carbon Restoration Programme**” would enable convergence across agriculture, energy, and rural development sectors. It aligns with national priorities such as Atmanirbhar Krishi, climate-resilient farming, and circular bioeconomy development by promoting decentralized FOM production, aggregation, and distribution systems.

1. Integration of Organic Carbon into NBS

Including organic carbon in the NBS framework will promote balanced fertilization, enable fair pricing and subsidies for FOM, support long-term soil regeneration, and reduce dependence on chemical fertilizer imports.

2. Soil Organic Carbon (SOC) Restoration

With SOC levels critically low (~0.4%), targeted interventions under SuBiCulP using SHC data, improved labs, and monitoring tools—can enhance soil fertility, water retention, and climate resilience while supporting India’s LiFE and NDC commitments.

3. Organic–Chemical Fertilizer Blending (OMBP)

Introducing a phased FOM blending mandate can create stable demand, strengthen distribution via PSUs (IFFCO, KRIBHCO, NFL), and enable region-specific nutrient solutions.

Year	Minimum Blending Obligation (FOM : Chemical Fertilizers)	Estimated Savings by Government (₹ crore)
2026–27	1% mandatory blending (to the extent of FOM being produced)	₹1,864.75
2027–28	3% mandatory blending (to the extent of FOM being produced)	₹5,594.25
2028–29	5% mandatory blending (to the extent of FOM being produced)	₹9,323.75
2029–30	10% mandatory blending (to the extent of FOM being produced)	₹18,647.50

Based on India’s fertilizer subsidy expenditure of ₹1,86,475 crore for FY 2025–26, the proposed phased FOM blending obligation could generate indicative fiscal savings of approximately USD 197 million at 1% blending in 2026–27, USD 591 million at 3% in 2027–28, USD 985 million at 5% in 2028–29, and USD 1.97 billion at 10% blending by 2029–30, assuming proportional reduction in chemical fertilizer subsidy outgo.

This highlights the significant potential of FOM blending not only as a soil carbon restoration strategy but also as a fiscal optimization pathway for reducing the Government of India’s fertilizer subsidy burden.

4. Institutional Ecosystem & Market Linkages
Onboarding FOM producers through FMCs, developing district-level supply chains, and recognizing FOM (including from small plants) under FCO as “Organic Carbon Enhancers” will ensure scalability and market access.

5. Farmer Guidelines & R&D Support

Adoption requires region-specific application protocols, multilingual extension support, strong institutional collaboration (ICAR, ICRISAT, SAUs), and standardized quality certification backed by decentralized testing.

Such integration aligns with India’s commitment to regenerative agriculture and climate resilience. It represents a visionary pathway to revitalize soil ecosystems, enhance crop productivity, and safeguard environmental sustainability for future generations.

Scaling adoption requires focused farmer training, strict quality certification, and robust awareness campaigns. Continued R&D and tailored regional formulations will enhance nutrient efficiency and soil resilience. Policies must foster collaboration across ministries, academia, and extension to embed FOM in climate-smart agriculture.

This strategic integration will revitalize soil health, boost crop productivity, and strengthen India’s commitment to sustainable agriculture and climate resilience.

Conclusion

Fermented Organic Manure (FOM) represents a transformative opportunity to address the growing challenge of soil organic carbon depletion in India. By enhancing soil organic carbon, improving nutrient use efficiency, and strengthening soil resilience, FOM offers a sustainable pathway toward long-term agricultural productivity and environmental stability.

FOM is different from regular fertilizers because it focuses on the soil ecosystem itself. It does this by increasing microbial activity, improving soil structure, and rebuilding organic carbon reserves. This change from farming that uses a lot of inputs to farming that restores soil is very important for making sure that India's farming systems can last.

The Fertilizer Control Order (FCO) was changed in 2025 to include FOM in the "Organic Carbon Enhancer" category. This gives a strong regulatory basis for its widespread use. Using this policy momentum through structured programs like **SuBiCulP** and including it in nutrient management frameworks by placing soil at the center of policy and economics, SuBiCulP has the potential to reshape India's agricultural landscape into a model of

regenerative and fiscally sustainable growth.

To optimize soil health, FOM application should be calibrated to existing Soil Organic Carbon (SOC) levels applying 5–6 tons/ha/year for carbon-deficient soils (<0.5%), 3–4 tons/ha/year for moderate levels (0.5–1.0%), and 2 tons/ha/year for soils above 1.5% while adjusting for batch C:N ratios and specific crop requirements during field preparation. As shown in the regional application data, these rates are strategically adapted to various crop rotation systems, ranging from 2 tonnes for short-term or green manure rotations to 5 tonnes for intensive cereal and oilseed cycles, ensuring that organic nutrient delivery consistently meets regional agricultural demand.

Given the scale of soil degradation in India, immediate and coordinated policy action is essential to mainstream FOM as a core component of the national agricultural strategy. With the right institutional support, market linkages, and farmer engagement, FOM has the potential to drive a transition toward regenerative agriculture which enhancing soil health, improving farm incomes, and strengthening India's climate resilience for the future.



Fertilizing Energy.



Fertilizing Energy. Energizing Fertilizer

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