



Efficacy of liquid fermented organic manure (LFOM) on rice productivity, soil fertility and economic returns in Barabanki district, Uttar Pradesh, India

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ABSTRACT

The declining soil health and over-dependence on chemical fertilizers among smallholder farmers is a major problem in Uttar Pradesh and demand urgent sustainable alternatives. This study was conducted to evaluate the agronomic efficacy, improving soil health and economic viability of Liquid Fermented Organic Manure (LFOM) prepared from livestock waste and used as a substitute to minimize the use of chemical fertilizers in rice cultivation. Field experiments were conducted across six farmer fields in two villages viz. Khaira and Karondi, in Fatehpur block of Barabanki district during the Kharif season (July-October 2025). The experiments consisted of six treatments: T1: 100% RDF (N₁₂₀ P₆₀ K₄₀), T2: 50% RDF + 50 L/ha LFOM as soil application, T3: 50% RDF + 50 L/ha LFOM as foliar spray; T4: 100 L/ha LFOM as soil application, T5: 100 L/ha LFOM as foliar spray, T6: 50 L/ha LFOM as soil application and 50 L/ha LFOM as foliar spray. Results indicated that while the maximum grain yield (68.31 q/ha) was recorded under the treatment T1 comprised of 100% RDF but the highest benefit-to-cost (B:C) ratio of 1.92 was observed under treatment T4 (100% LFOM as soil application at 100L/ha). Application of 100% LFOM in two equal splits in soil at the time of transplanting and foliar application at the time of tillering (T6) provided a balanced outcome with acceptable grain yield (65.05 q/ha) and improved soil organic carbon buildup. Post-harvest soil analysis confirmed improvements in organic carbon and available NPK under LFOM treatments. These findings highlight the economic and ecological promise of LFOM as a viable alternative to minimize chemical inputs in rice. However, multi-year field trials may be required to draw a robust conclusion.

Keywords: Rice, Liquid fermented organic manure, Crop growth, Yield attributing characters, Yield

INTRODUCTION

Rice serves as a staple food for over 60% of the global population and is primarily cultivated in China, India, and other Asian countries. Ensuring rice food security is increasingly vital due to shrinking cultivated land area caused by rapid industrialization and rising global food demand driven by population growth (Pramanick *et al.*, 2014; Du *et al.*, 2018). To date, chemical fertilizers remain

a primary method for boosting rice yields. However, widespread over-application of fertilizers in rice production not only reduces fertilizer use efficiency and causes environmental problems (such as greenhouse gas emissions and groundwater contamination) but also threatens production sustainability (Ding *et al.*, 2020; Chen *et al.*, 2018). Agriculture in Uttar Pradesh is predominantly practiced by small and marginal farmers who face

multiple challenges including limited access to quality inputs, inadequate financial support and deteriorating soil health. Barabanki district, known for the cultivation of mint, potato and rice, exemplifies these challenges with farmers exhibiting a high dependence on chemical fertilizers. While chemical inputs can enhance short-term yields, their excessive and continued application has led to soil degradation, disruption of microbial ecology, water contamination and loss of agro-biodiversity. However, excessive use of chemical fertilizers poses serious risks both to the environment and to human health (Lal, 2020).

Under the Soil Health Card Scheme, soil health assessments confirm widespread deficiencies of nutrients. Nearly all soil in India lacks nitrogen, over 80% lack phosphorus and organic carbon levels have dropped from 1% to just 0.3%. Fertilizer use is also uneven, Haryana applies more than 200 kg/ha, while Rajasthan uses less than half the national average. In addition, global price shocks, such as those caused by the Russia-Ukraine war, have increased pressure on India's fertilizer subsidy system (Meena *et al.*, 2025). Bio-Input Resource Centres (BRCs) under National Mission on Natural Farming (NMNF) has been on priority of Indian Government. For successful adoption of Natural Farming, access to livestock and plants for preparing animal and plant based Natural Farming (NF) bio-inputs are essential. Therefore, 10,000 need based BRCs are supposed to be established under NMNF, in enterprise model, across States/UTs to support local production and availability of NF bioinputs (GOI, April, 2025). With a thought towards developing self-sustainable through animal and plant based NF bioinputs, GIZ established a BRC unit in a Gaushala located in Kunsara village in Fatehpur block of Sitapur district in Uttar Pradesh. By scaling up Compressed biogas (CBG) production, the government is indirectly promoting the availability and adoption of FOM and LFOM by-products of anaerobic digestion in biogas plants. These organic fertilizers have the potential to partially substitute chemical fertilizers such as urea, contributing to reduced subsidy burdens and improved soil sustainability. To further support this transition, the government introduced a Market Development Assistance (MDA) of € 17.02/MT (Rs. 1,500/MT approx.) for CBG producers, incentivizing the production and market distribution of FOM, LFOM, and Phosphate Rich Organic Manure (PROM) (PIB, 2024).

Climate variability, including erratic monsoon patterns, prolonged dry spells and groundwater depletion, further compounds agricultural sustainability concerns. In this context, organic amendments derived from livestock waste have gained renewed scientific and policy attention as eco-friendly and cost-effective alternatives. Among these, Liquid Fermented Organic Manure (LFOM) has emerged as a promising biostimulant due to its enriched microbial consortia, water-soluble nutrients, and soil conditioning properties. The application of fermented liquid bio-formulations promotes soil microorganisms, plant growth and increases root biomass. These formulations play a critical role in preserving and boosting the soil's microflora population, which in turn increases the soil fertility and nutrient availability (Chatterjee and Bandyopadhyay, 2014). The regular use of FOM (fermented organic manure) enhances soil structure, thus, it retains more water, which ultimately results in maintaining higher organic carbon concentration in soils. The microbial biomass and the produced metabolites together with existing soil microbial functions to improve carbon mineralization and immobilization processes, which transform into increased SOC levels (Thakur *et al.*, 2024). Through FOM the soil ecosystem develops better microbial communities composed of phosphorus solubilizers, nitrogen fixing bacteria, and actinomycetes which creates diverse and resilient microbial functions. Soil nutrient cycling and humification receive support from the slow-release nutrient characteristics and microbial metabolite elements, which also lead to sustained fertility improvements (Yadav and Thakur, 2025).

Farming in Barabanki faces several challenges that impact profitability and sustainability. Based on available insights, primary problem includes high input costs, erratic electricity supply, lack of scientific knowledge and information, pest and disease infestations, high water requirement, inadequate infrastructure, market and policy challenges and limited access to regulated markets. Efforts to address these issues, such as improving access to scientific expertise, upgrading distillation infrastructure and stabilizing electricity supply, could enhance productivity and profitability for farmers in the region.

Liquid fertilizer has gained widespread attention due to their high solubility and convenient application. The water-soluble nitrogen (N),

phosphorus (P), and potassium (K) supplied by liquid fertilizer are more readily absorbed by rice plants, promoting growth and development and increasing photosynthate accumulation to enhance yield. Compared with solid fertilizer, liquid fertilizer reduces nutrient loss while improving N, P, and K use efficiency (Valentinuzzi *et al.*, 2020). Singh *et al.*, (2013) found that liquid fertilizer promotes wheat N uptake, improved nitrogen use efficiency (NUE), agronomic efficiency (NAE), and yield.

LFOM, prepared through anaerobic fermentation of cattle dung and urine, is known to improve soil biological activity, increase plant nutrient availability and impart resistance against minor biotic stresses. It offers a sustainable alternative to minimise dependency on chemical fertilizers, improving soil health, boosting yields and reducing input. This BRC unit includes fermentation tower, EM culture preparation unit and biodigester. Despite several studies, on-farm evidence from Uttar Pradesh, remains sparse. The present study was therefore undertaken to (i) to assess the impact of LFOM on the yield of rice crop (ii) To determine the optimal dose and application method of liquid fermented Organic Manure (iii) to evaluate the effect of liquid fermented Organic Manure on soil biochemical properties and nutrient availability and (iv) to compare the economic viability of using liquid fermented Organic Manure with chemical fertilizers.

MATERIALS AND METHODS

Study Area and Experimental Design

The study was conducted during the Kharif season (2025) across six farmer fields distributed equally between two villages, Khaira and Karondi located in Fatehpur Block of Barabanki district in Uttar Pradesh. The region falls in the sub-tropical humid agro-climatic zone with predominantly alluvial soils. Rice variety 'Mahendra' was transplanted on 4th July 2025 at Khaira and 14th July 2025 at Karondi, and harvested on 26th September and 12th October 2025, respectively.

Experiments were laid out in a randomized block design with six treatments, each replicated across three fields per village (plot size: 34 × 4 m²). The treatments were: T1: Control - 100% Recommended Dose of Fertilizer; T2: 50% RDF + 50% LFOM as soil application @ 50L/ha; T3: 50% RDF + 50% LFOM as foliar spray @50L/ha; T4: 100% LFOM as soil application @ 100 L/ha; T5: 100% LFOM as foliar spray @ 100 L/ha; T6: 50% LFOM as soil application @ 50 L/ha + 50% LFOM as foliar spray @ 50 L/ha.

All other agronomic practices (irrigation, weeding, plant protection) were kept uniform across treatments and sites. All the relevant observations related to plant growth, yield attributing characters and yield were recorded at an appropriate time interval and at maturity.

LFOM Preparation and Characterization

LFOM was prepared using a standardized anaerobic fermentation protocol using cattle dung and urine. Three batches were collected from the source at different intervals and analysed for pH, electrical conductivity (EC), mineral nitrogen, total potassium, and bacterial load (Table 1). The material was moderately saline (EC: 3.06-3.75 dS/m), near-neutral in reaction (pH: 6.20-7.55), and contained viable microbial populations ranging from 18-30 × 10⁵ cfu/mL.

Soil Sampling and Analysis

Before initiating the experiments soil samples from three places in each plot were collected from 0-15 and 15-30cm soil depth and mixed together to make a composite sample for each depth. Total 12 samples from each field were collected and analysed for soil chemical properties using standard analytical procedures. Initial soil properties of the experimental field are given in Table 2. To monitor the improvement in soil properties after introduction of LFOM and harvesting of rice crop, soil samples were again collected and analyzed. The baseline soil

Table 1. Physicochemical and microbiological quality of LFOM batches used in the experiment.

Sample	pH	EC (dS/m)	Mineral N (mg/L)	Total K (mg/L)	Bacterial Load (cfu/mL × 10 ⁵)
1st Batch	7.03	3.746	0.95	3.49	30
2nd Batch	6.20	3.062	0.55	3.40	18
3rd Batch	7.55	3.324	0.81	3.62	22

EC: Electrical Conductivity; cfu: Colony Forming Units

Table 2. Initial soil properties of experimental fields prior to transplanting

Soil Properties	Soil Depth	Village: Khaira			Village: Karondi		
		F1	F2	F3	F1	F2	F3
pH	0-15 cm	7.12	6.84	6.75	7.65	7.82	7.63
	15-30 cm	6.87	6.85	6.87	8.01	7.85	7.92
EC (dS/m)	0-15 cm	0.13	0.15	0.07	0.23	0.25	0.30
	15-30 cm	0.23	0.31	0.24	0.22	0.23	0.18
OC (%)	0-15 cm	0.56	0.52	0.48	0.53	0.54	0.57
	15-30 cm	0.43	0.48	0.43	0.48	0.51	0.53
Av. N (kg/ha)	0-15 cm	124.6	135.2	143.2	155.3	157.4	146.3
	15-30 cm	132.5	140.2	138.6	142.6	152.1	147.6
Av. P (kg/ha)	0-15 cm	12.4	12.6	12.3	7.80	8.01	7.75
	15-30 cm	13.2	13.2	13.4	5.60	5.60	5.30
Av. K (kg/ha)	0-15 cm	96.2	93.5	101.3	95.2	94.3	98.6
	15-30 cm	85.6	79.5	83.5	102.5	108.3	107.6

F1, F2, F3: Farmer fields 1, 2, 3 respectively; OC: Organic Carbon; Av.: Available

analysis (Table 2) revealed that the experimental fields at Khaira had slightly acidic to neutral pH (6.75-7.12) compared to the mildly alkaline soils at Karondi (7.63-7.82). Organic carbon content was comparable across sites (0.48-0.57%), while available N was generally higher in Karondi and P was higher in soils of Khaira. Available potassium was similar at both locations.

Economic Analysis

Cost of cultivation was calculated considering the prevailing rates of labour and machinery used for used for agricultural operations and market price of agroinputs involved. Gross returns were calculated by converting the yield into monetary terms at the prevailing market rate during the period of study. Net returns were calculated by deducting cost of cultivation from gross returns and the benefit to cost ratio was obtained by dividing gross returns by cost of cultivation.

RESULTS AND DISCUSSION

Plant Growth

In this study, analysis of data exhibited significant differences in plant height among the treatments. The maximum plant height (140.33 cm) was recorded under T1 (100% RDF), which is followed by T3(50% RDF + 50% LFOM (foliar @50 L/ha), T2(50% RDF + 50% LFOM (soil @50 L/ha), and T6(50% LFOM soil + 50% LFOM foliar @50 L/ha) respectively. Diedhiou *et al.* (2016) investigated the response of rice plants to inoculation with AMF and PGPB under field and green house

conditions. However, the minimum plant height amongst the treatments was recorded in treatment T4 and T5 which was significantly lower than rest of the treatments.

The effect of LFOM on the number of effective tillers per plant was studied and the data are presented in Table 2. 50% RDF +application of LFOM@50L/ha through soil application (T2) as well as foliar application (T3) showed number of tillers per plant at par with control (100% RDF). However, number of tillers in treatment T4 and T5 were significantly lower than that of treatment T1. Activities of LOFM result in increased N uptake, phosphate solubilization. Various biologically significant metabolites and enzymes are promoted by the increased nutrient absorption caused by LFOM. Similar results have also been reported by Yuan *et al.* (2010). Similarly, Nayak *et al.* (2019) reported that combining the application of microalgal-based organic fertilizer with chemical fertilizer helps to improve the plant height, tiller number, biomass, and grain yield of rice.

Yield Parameters and Yield

Yield is the product of the yield parameters including length of panicle and 1000 grain weight. Analysis of yield parameters from one season data exhibited significant difference in panicle length among all the treatments when compared to the control. The highest length of panicle (34.39cm) was recorded in treatment T1 followed by T2 (29.58cm) and T3 (27.57cm). However, there was no significant difference in 1000 grain weight among the treatment. The highest 1000 grain weight was recorded in

Table 3. Plant growth parameters and grain yield of rice under different treatments

Treatment	Plant height (cm)	No. of Tillers/Hill	1000 Grain Wt (g)	Panicle Length (cm)	Grain Yield (q/ha)	B:C Ratio
T1 - Control (100% RDF)	140.33a	14.63a	36.28	34.39a	68.31a	1.62
T2 - 50% RDF + 50% LFOM (soil @50 L/ha)	138.08a	12.28c	34.28	29.58b	65.05b	1.69
T3 - 50% RDF + 50% LFOM (foliar @50 L/ha)	139.93ab	13.57ab	35.25	27.57b	64.27b	1.70
T4 - 100% LFOM (soil @100 L/ha)	131.78c	10.88c	33.16	26.23b	63.78b	1.92
T5 - 100% LFOM (foliar @100 L/ha)	133.28bc	11.45c	33.65	27.30b	61.17b	1.84
T6 - 50% LFOM soil application (50 L/ha) + 50% LFOM foliar @50 L/ha	136.88ab	12.00bc	34.06	27.36b	64.00b	1.71
CD (0.05)	5.54	3.74	NS	2.34	3.63	

RDF: Recommended Dose of Fertilizer; LFOM: Liquid Fermented Organic Manure; B:C: Benefit-to-Cost

treatment T1 (36.28g) followed by T3 (35.25g), T2 (34.28g) and T6 (34.06g).

From the yield data shown in Table 3, it is evident that the highest grain yield (68.31q/ha) was recorded in treatment T1 (100% RDF) followed by T2 (65.05q/ha) and T3 (64.27q/ha) from one season data, whereas lowest grain yield was recorded in treatment T5 (61.17q/ha). However, there is no significant difference in these treatments. The yield reduction with reduced dose of chemical fertilizers (T2 & T3) with LFOM over the control were 4.8 and 5.9%, respectively. Similar results were reported by Singh *et al.* (2019).

Economic Viability

The effect of different treatments on economics is presented in Table 3. The data proved that treatment T4 produced maximum benefit cost ratio among all the treatments and treatment T1 was recorded minimum benefit cost ratio using a single season experimental data. The B:C ratio analysis revealed a notable reversal in economic performance compared to yield rankings. T4 (100% LFOM, soil application) returned the highest B:C ratio of 1.92, followed by T5 (1.84) and T6 (1.71). The higher B:C ratio was found due to the lower cost of production and least difference in grain yield. The conventional chemical fertilizer control (T1) recorded the lowest B:C ratio of 1.62, reflecting the higher input cost of synthetic fertilizers. T2 and T3, representing partial substitution, yielded B:C ratios of 1.69 and 1.70 respectively, indicating economic competitiveness even at 50% chemical fertilizer replacement. Similar observations was reported by several workers (Upadhaya *et al.*, 2022; Choudhary and Gautam, 2007; Latake *et al.*, 2009; Singh *et al.*, 2017; Ashwani and Rajesh, 2017; Rani *et al.*, 2019).

Post-Harvest Soil Properties

Post-harvest soil analysis indicated improvements in soil organic carbon across most LFOM treatments relative to initial values. The highest surface soil OC was recorded under T6 at Khaira (0.68%) compared to the initial 0.48-0.56% range. Available N in the surface layer at Khaira ranged from 135.89 to 163.07 kg/ha, with T6 recording the maximum. Soil pH remained largely stable and no significant EC buildup was observed, indicating that LFOM application did not cause salinization.

In Karondi, similar trends were observed, with T4 and T3 showing relatively higher OC content post-harvest (Table 4). The available K showed marginal improvements in some LFOM treatments compared to controls, suggesting positive contributions to potassium cycling from fermented manure applications.

The findings of this study are broadly consistent with emerging evidence that LFOM can sustain competitive crop yields at a lower cost than conventional chemical fertilizers. The marginal yield reduction in LFOM treatments relative to full RDF agrees with reports from the Indo-Gangetic Plain, where organic liquid amendments partially compensated for mineral nutrient inputs while improving soil biological health. The application of FOM and FYM (applied in rice) significantly affects the growth yield and yield attributes (plant height, number of effective tillers, panicle/spike length, panicle/spike weight, grains per panicle/spike) of rice and wheat (Yadu *et al.*, 2025).

The superior B:C ratio under T4 and T5 compared to T1 underscores the economic rationale for transitioning toward organic inputs, especially

Table 4. Changes in soil properties after harvesting of rice crop

Treatments	pH		EC (dS/m)		OC (%)		Av.N (kg/ha)		Av.P (kg/ha)		Av.K (kg/ha)		Na (ppm)	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Village Khera														
T1	6.72	6.86	0.12	0.18	0.62	0.59	135.89	133.80	150.02	122.81	141.46	105.35	42.78	46.83
T2	7.00	6.94	0.07	0.13	0.63	0.56	135.89	158.89	120.66	127.60	130.29	103.12	53.17	51.67
T3	6.85	6.89	0.14	0.17	0.68	0.61	156.80	160.98	130.48	133.95	82.58	86.95	56.43	75.52
T4	6.83	6.78	0.17	0.30	0.89	0.59	142.16	140.00	124.97	141.95	89.38	86.87	61.78	70.35
T5	6.65	6.71	0.19	0.15	0.54	0.38	150.53	137.99	126.41	146.89	87.81	82.43	64.40	54.62
T6	6.69	6.73	0.17	0.16	0.44	0.38	163.07	154.71	144.36	145.96	84.60	76.57	63.05	63.38
Village Karondi														
T1	7.87	7.94	0.25	0.19	0.46	0.21	162.74	200.70	89.75	82.98	118.01	122.00	49.90	59.53
T2	7.86	7.98	0.23	0.27	0.47	0.32	163.07	150.53	74.58	45.00	106.14	105.65	45.03	49.78
T3	8.10	7.97	0.22	0.23	0.49	0.18	181.89	152.62	76.46	61.42	103.60	130.15	58.35	52.58
T4	8.02	8.06	0.26	0.22	0.62	0.35	169.34	173.52	82.90	73.12	93.23	100.46	53.03	49.67
T5	7.98	7.98	0.16	0.14	0.56	0.40	167.25	137.98	80.94	37.82	100.24	117.12	50.15	48.60
T6	7.88	7.94	0.17	0.13	0.64	0.43	150.53	121.26	95.78	65.22	118.06	104.42	39.30	50.25

for resource-constrained smallholder farmers. The cost reduction from eliminating or reducing chemical fertilizer purchases outweighs the marginal yield gap.

The build-up of soil organic carbon in LFOM treatments is of long-term significance. Organic matter serves as the foundation of soil fertility, improving water-holding capacity, nutrient cycling, and microbial diversity. The sustained application of LFOM over multiple cropping seasons is therefore expected to generate compounding soil health benefits that are not fully captured in a single-season trial.

CONCLUSIONS

This on-farm preliminary study in Barabanki district demonstrates that Liquid Fermented Organic Manure (LFOM) can effectively reduce dependence on chemical fertilizers in rice cultivation without proportionate yield penalties and with significantly superior economic returns. Post-harvest soil data confirmed measurable improvements in organic carbon and available nutrients under LFOM treatments, indicating a positive trajectory for long-term soil health. Given the preliminary nature of this single-season trial, multi-year field experiments encompassing rice, potato, and mint crops are strongly recommended to establish robust agronomic recommendations and capture residual soil health benefits.

The adoption of LFOM aligns with India's national goals of promoting natural farming, reducing subsidized fertilizer burden and transitioning smallholder agriculture toward

sustainability. Policy support for LFOM production infrastructure, quality certification and farmer training can catalyse wider adoption in similar agro-ecological contexts. Application of LFOM and reducing chemical fertilizers in turn reduced cultivation cost and increased income per rupee invested. It needs to be further tested and validated for multi-season experimentation.

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